Northern States Power Company

Before the

MN Public Utilities Commission

Application for Certificate-of-Need for Prairie Island Spent Fuel Storage Docket No. E002/CN-91-19

April, 1991

Volume 2 of 2
Environmental Impact Statement

FINAL

ENVIRONMENTAL IMPACT STATEMENT

PRAIRIE ISLAND INDEPENDENT SPENT FUEL STORAGE INSTALLATION

MINNESOTA ENVIRONMENTAL QUALITY BOARD

APRIL 12, 1991

PROPOSED PROJECT: Prairie Island Independent Spent Fuel Storage Installation

RESPONSIBLE GOVERNMENTAL UNIT: Minnesota Environmental Quality Board

LOCATION: Goodhue County

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DOCUMENT STATUS: FINAL Environmental Impact Statement

ABSTRACT: The Final EIS describes NSP's proposed project, eleven alternatives and the impacts associated with the proposed project and the alternatives. The proposed dry metal cask design has been chosen by NSP on the basis of operational, environmental and economic considerations. The proposed project and alternatives described are feasible, and can be implemented within the bounds of federal regulatory authority, though with varying implications for operation of the Prairie Island Nuclear Generating Plant, environmental impacts and costs to NSP customers. Comments on the Draft EIS and responses to those comments are incorporated.

CLOSE OF COMMENT PERIOD: May 6, 1991

Interested persons may submit written comments on the adequacy of the Final EIS until the date shown above. Written comments should be submitted to Bob Cupit at the EQB address shown above. The EQB will determine the adequacy of the Final EIS at its May 16, 1991 meeting, in accordance with Minn. Rule 4410.2800.

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This document has been prepared under Minnesota Rules, Chapter 4410. In December, 1989, the MEQB ordered preparation of an EIS under the provisions of 4410.2000, subp. 3 (Discretionary EIS). Pursuant to those provisions, Northern States Power Company agreed that an EIS should be prepared.

After review of a draft document and public meetings in April, 1990, the EQB approved a Scoping Decision Document in May, 1990, which identified alternatives and impacts which would be addressed in the EIS. The Draft EIS was released in November, 1990, public meetings were again held in December, and comments were received until January, 1991. EQB staff revised the Draft EIS in response to substantive comments. After a ten day comment period, the EQB is expected to consider adequacy of the Final EIS at its May 16, 1991 meeting. Minnesota Rules 4410.2800, subp. 4 provides that the Final EIS shall be determined adequate it it:

A. addresses the issues raised in scoping so that all issues for which information can be reasonably obtained have been analyzed;
B. provides responses to the substantive comments received during the Draft EIS review concerning issues raised in scoping;
C. was prepared in compliance with the procedures of the act and parts 4410.0200 to 4410.6500.

If the EQB determines that the Final EIS is inadequate, it shall have 60 days in which to prepare an adequate EIS and the revised EIS must be distributed to all persons who received the Final EIS.

The following documents which have been incorporated by reference and is available for public review at the Red Wing, MN and Minneapolis, MN central public libraries and at the EQB offices:

License application and Safety Analysis Report submitted by NSP to the Nuclear Regulatory Commission on August 31, 1991.

Probable Maximum Flood Study, Mississippi River at Prairie Island, Minnesota, in Updated Safety Analysis Report, December, 1985.

Revisions to the Draft EIS are shown as underlined in the Final EIS. Entire new sections are not underlined, but are noted as new material.

Common acronyms used in this document are:

ISFSI - Independent Spent Fuel Storage Installation
PI - Prairie Island
EQB - Minnesota Environmental Quality Board
NSP - Northern States Power Co.
NRC - U.S. Nuclear Regulatory Commission
DOE - U.S. Department of Energy
PUC - Minnesota Public Utilities Commission
DOH - Minnesota Department of Health
DPS - Minnesota Department of Public Service
DEIS - Draft Environmental Impact Statement

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CHAPTER 1

SUMMARY
(Revised)

Northern States Power Company (NSP) owns and operates the Prairie Island Nuclear Power Generating Plant. The Prairie Island Nuclear Generating Plant is located within the city limits of the City of Red Wing, Minnesota, on the west bank of the Mississippi River, about 6 miles northwest of downtown Red Wing. The Prairie Island Indian Reservation abuts NSP property on the north and west sides. As the generating capability of the nuclear fuel assemblies used to operate this plant is exhausted, it is necessary to remove the fuel assemblies from the reactors and provide interim storage for those fuel assemblies. Currently, these assemblies are stored under water in a spent fuel pool at the Prairie Island plant until the U.S. Department of Energy (DOE) develops either a storage or disposal facility. DOE is under contract to begin accepting the spent fuel from this plant and all commercial power reactors beginning in 1998, but it is not certain that DOE will be able to fulfill their part of the contract since there is currently no federal storage or disposal facility. NSP's current interim storage capacity is not sufficient to allow continued full-capacity operation of the Prairie Island plant beyond 1994.

To meet Prairie Island's spent fuel storage needs, NSP proposes to build an Independent Spent Fuel Storage Installation (ISFSI) within the fenced Prairie Island plant site. For this project, NSP is proposing to use metal casks supplied by the Transnuclear Corporation which hold 40 spent fuel assemblies of the type used at Prairie Island. These casks are large, heavy containers, equipped with an internal basket for holding the spent fuel assemblies and external radiation shielding, each about 16.5 feet tall and 8.5 feet in diameter. Fully loaded, each cask weighs about 120 tons. NSP's current proposal is for an ISFSI large enough to accommodate 48 casks. Only spent fuel which has been stored in the pool 10 years or more would be transferred to the ISFSI.

The following approvals of this project will be necessary:

1. Federal License: A Part 72 license must be issued by the U.S. Nuclear Regulatory Commission (NRC). NSP filed its application in August, 1990, and anticipates completion of the review process in late 1991.

2. Certificate of Need: A Certificate of Need from the Minnesota Public Utilities Commission is required pursuant to Minnesota Rules, Chapter 7855. NSP intends to apply for PUC certification in spring, 1991. This Environmental Impact Statement will be part of the record in this filing.

3. A local building permit will also be required.

Findings and Issues:

Construction of the proposed ISFSI will not cause significant impacts to the natural and human environment in the vicinity of the Prairie Island Nuclear Generating Plant. The area proposed for the ISFSI is now extensively disturbed, being used for the storage/disposal of primarily earthen fill and dredged material. NSP states that construction dust and noise as well as run-off water will be controlled, mitigating any off-site impacts. Off-site land use will not be impacted.

As presently designed, operation of NSP's proposed Independent Spent Fuel Storage Installation (ISFSI) at full capacity (48 casks) will deliver a dose of gamma radiation to off-site residents resulting in a cancer risk above the acceptable or tolerable risk limit established by the Minnesota Department of Health (MDH). The acceptable level for incremental lifetime carcinogenic risk from any single source of environmental pollution, is a lifetime risk level of one in 100,000, or 10^{-5}. MDH estimates that the cancer risk to nearby residents from the proposed facility may be as much as 6 per 100,000. Moving the facility two hundred yards or more to an alternative site to the south would enable the ISFSI to be built and still achieve the Minnesota criterion for acceptable risk for involuntary exposure to environmental pollutants.

A lifetime cancer risk of 6 in 100,000 is a small risk, well within the range of risks that people voluntarily accept. It is about the risk incurred from 3 to 4 chest x-rays over a lifetime. Further, because of the uncertainties in risk assessment, MDH uses conservative risk estimates; the true risk from the proposed ISFSI is most likely smaller than 6 in 100,000. The criterion of 1 in 100,000 was established in order to ensure that involuntary environmental exposures, such as radiation exposures from the ISFSI, will not produce significant health risks for any individual.

A key issue is the length of time storage will be required. Many of the comments received on the DEIS focused on the uncertainties in the federal process for waste acceptance. As previously stated, the DOE is under contract with NSP to begin accepting spent fuel in 1998. It is not clear that DOE can meet this date, and longer-term storage could result. The length of the license currently applied for is 20 years, and any license renewals or modifications would be subject to additional review.

Continued operation of the Prairie Island Nuclear Generating Plant has also been raised as a concern and appears to be an area of controversy. The Minnesota Public Utilities Commission will consider the need for the proposed ISFSI and the feasibility of alternatives in the Certificate of Need process. The PUC does not have authority under its rules to take actions which will result in plant closure during the NRC-licensed period of operation.

A number of possible alternatives to the proposed project exist. The following alternatives are examined in the EIS:

Alternative site: The use of an alternative site within the existing plant property boundary would enable the ISFSI to be built and still achieve the Minnesota criterion for acceptable risk for involuntary exposure to environmental pollutants.

No action: This alternative would result in NSP filling the existing spent fuel storage capacity at the Prairie Island plant by January, 1994, thereby forcing shutdown of the plant. The plant would then be mothballed or decommissioned. Shutdown of Prairie Island would create the need for NSP to acquire 1000-1100 megawatts of baseload-type generating capacity by January, 1994.

Reduced operation of the Prairie Island plant: NSP may be able to reduce operation at the Prairie Island plant in order to reduce fuel consumption and thereby conserve storage capacity for spent fuel at the plant. This could potentially delay the date when Prairie Island expects to run out of storage capacity. This is a variation of the no action alternative, which could permit phasing out operation of the generating plant as energy replacement options are implemented.

Increased customer conservation: This alternative assumes that by significantly increasing its customer conservation programs, NSP can eliminate some or all of the need for operating the Prairie Island plant. This alternative received considerable emphasis in comment letters.

Other dry spent fuel storage technologies: Alternate dry spent fuel storage technologies examined include; other metal casks, modular concrete storage systems, concrete casks, a vault, and dual-purpose storage/transport casks. Each of these technologies must meet the same technical performance criteria for safety and radiation exposure minimization.

Increased in-pool spent fuel storage: Several options for expanding the in-pool storage capacity at Prairie Island are examined.

Shipment to another spent fuel storage facility: Options for shipping spent fuel from Prairie Island to other storage facilities are examined.

Shipment to a federal storage or disposal facility: The U.S. Department of Energy is under contract with NSP to accept NSP's spent nuclear fuel beginning in 1998. The feasibility and impacts of this alternative are analyzed, and issues relating to timing discussed.

Reprocessing (recycling) of spent fuel: Reprocessing is the chemical process of dissolving spent fuel in order to extract the residual uranium and plutonium for recycle into new fuel assemblies. The remaining fission products are high level radioactive waste and are concentrated and solidified into a stable form, such as glass, for storage and permanent disposal. There is no reprocessing plant in the United States for commercial spent nuclear fuel, so the spent fuel would need to be shipped to Europe for reprocessing.

Use of higher burnup fuel: Burnup is a measure of how much energy a fuel assembly produced during the time it was in the reactor. For a given amount of energy production by the reactor, the number of spent fuel assemblies generated will be less if each assembly can provide more energy; that is, if fuel can achieve a higher burnup.

Combinations of alternatives: By combining alternatives which extend the capacity of the existing pool with the alternative of shipping spent fuel to a federal facility, it is possible that NSP could avoid the necessity of building the ISFSI. All of the combinations assume continued operation of the generating plant, but at reduced levels. Some possible combinations include:

1) No increase in storage capacity, but reduce operation of the plant until the DOE begins to accept spent fuel. If acceptance begins in 1998 as required by contract, Prairie Island could operate at 46% of full operation until 1998, and resume full operation thereafter. If acceptance does not begin until 2010 (a date chosen for illustrative purposes only) the plant could only operate at 15% of full capacity until that time.

2) Implement an increased pool capacity option through reracking, two-tiered racks, or consolidation (maximum increase in space of 33% or 480 spaces), and reduce operation to 43% of full capacity through the remaining license period.

3) Increase pool capacity as above, and then ship spent fuel to the DOE when they begin accepting. If they begin accepting spent fuel in 1998 Prairie Island could operate at full capacity through the license period. If spent fuel is not accepted until 2010, Prairie Island would need to reduce operation to 52% of full capacity until that time.

4) Use of higher burnup fuel, if allowed by NRC in license modification, would result in up to 6% less spent fuel being generated. This could be used in conjunction with the above combinations to recover that portion of the lost production.

5) Conservation would have system-wide effects, and could be used to offset the loss of production in the scenarios described above.

Environmental impacts, including human health and safety, have been analyzed for each of the alternatives. Feasibility and cost comparisons are also included to the extent data was available.

CHAPTER 2

PERMITS REQUIRED FOR THE PROPOSED PROJECT

STATE OF MINNESOTA

A Certificate of Need from the Minnesota Public Utilites Commission is required pursuant to Minnesota Rules, chapter 7855. NSP intends to apply for PUC certification in early 1991. The Final EIS will be incorporated into that proceeding.

A local building permit will be required.

FEDERAL

A Part 72 license must be issued by the U.S. Nuclear Regulatory Commission. NSP filed its application in August, 1990, and anticipates completion of the review process in late 1991. MEQB sought intervenor status in this proceeding, with results as described below.

State and Tribal Participation in the Federal License Process

The Nuclear Regulatory Commission process for licensing nuclear facilities is formal, long and complex. NSP filed their ISFSI license application on August 31, 1990. The application was reviewed by the NRC for completeness, and then notice of the application was published in the Federal Register. Anyone who wished to be a party to the proceedings was directed to seek intervenor status by November 19, 1990. (Short of this, there is no public process involved in granting these licenses.) MEQB staff (on behalf of the Board), jointly with the Department of Public Service, sought intervenor status, basically to hold open all options should major issues arise during the public process review of the DEIS. The Prairie Island Indian Tribe filed a late intervention request in February, 1991.

The next step in the process was the filing of "contentions", or issues which the intervenors believe will not be addressed adequately or satisfactorily in the federal license. MEQB staff worked with staff from the Department of Public Services and the Attorney General's Office to identify issues, work with a technical consultant, and develop the contentions. These contentions would then be rebutted by both NSP and NRC staff, and their strength weighed at a pre-hearing conference. At this point, a three-member Atomic Safety and Licensing Board established by the Nuclear Regulatory Commisssion would decide upon the need for a public hearing on the license.

An alternate course of action is to develop agreements between the parties to address the concerns identified. This was the course finally chosen here. Agreements were developed to address specific technical issues relating to cask decontamination and monitoring, and to provide a framework to further define potential health impacts from the radiation which would be emited. Discussion of the health impacts is provided in chapter 6 of this EIS. Once the agreements were finalized the request to intervene was withdrawn, but the right to intervene again was reserved. Contentions were not filed. As a condition of the agreements, the state agencies and Tribe now receive all correspondance which goes between the NRC and NSP. Thus, MEQB staff will be aware of any issue which surfaces in the federal license proceeding and could impact the analysis provided in this EIS. Significant modification of the project as proposed could result in development of a Supplemental EIS. All parties now on the mailing list for the EIS would be notified of this development should it occur.

CHAPTER 3

DESCRIPTION OF PROPOSED PROJECT

A. Introduction

Northern States Power Company (NSP) owns and operates the Prairie Island Nuclear Power Generating Plant. As the generating capability of the nuclear fuel assemblies used to operate this plant is exhausted, it is necessary to remove the fuel assemblies from the reactors and provide interim storage for those fuel assemblies. Currently, these assemblies are stored under water in a spent fuel pool at the Prairie Island plant until the U.S. Department of Energy (DOE) develops either a storage or disposal facility. NSP's current interim storage capacity is not sufficient to allow continued full-capacity operation of the Prairie Island plant beyond 1994.

All nuclear utilities, NSP included, have signed contracts with the DOE which require DOE to begin accepting spent nuclear fuel in 1998. However, since there are no federal facilities for storing or disposing of the waste, the likelihood of DOE being able to take the spent fuel on schedule is far from certain. The DOE is now searching for a volunteer site for a storage facility, but no site has yet been found. The DOE disposal facility is not expected to be available until the year 2010 at the earliest and further delays beyond that date are quite possible.

To meet Prairie Island's spent fuel storage needs, NSP proposes to build an Independent Spent Fuel Storage Installation (ISFSI) on the Prairie Island plant site. The Prairie Island ISFSI would use a dry, metal storage cask technology. Although pool storage will continue to be necessary for recently discharged fuel, dry storage is an option for fuel which has been discharged from the core and has cooled for at least five years. (NSP is proposing to store only fuel cooled ten years or more.) NSP states that dry storage can be used without significant changes in Prairie Island's existing plant facilities; can be accomplished without affecting power generation; can be operationally efficient; and can be installed incrementally, on an as-needed basis.

Prairie Island is one of several nuclear plants in the U.S. which faces shutdown in the early to mid 1990's because their spent fuel pools will be full. Monticello will have the same problem in 2005 if the DOE is not able to begin taking utilities' spent fuel for disposal by that time. Each of the plants which has taken action to address this problem has chosen to develop an on-site Independent Spent Fuel Storage Installation (ISFSI), using a dry storage technology. Currently ISFSI's are in place at Virginia Power's Surry Plant, Carolina Power and Light's H.B. Robinson Plant, and Duke Power's Oconee Plant; and more are planned for Baltimore Gas and Electric's Calvert Cliffs Plant, Consumers Power's Palisades Plant, and Wisconsin Electric Power's Point Beach Plant. None of these plants are using or plan to use the Transnuclear casks proposed in the NSP project.

Dry storage of spent fuel in metal casks has been tested and demonstrated in the United States since 1984. The DOE cooperative program to demonstrate dry cask storage was initiated in 1984. Virginia Power Company, the Electric Power Research Institute, and cask manufacturers GNSI, Westinghouse and Transnuclear, Inc. were the other partners in this program. For this project, NSP is proposing to use metal casks supplied by the Transnuclear, Inc. which hold 40 spent fuel assemblies of the type used at Prairie Island. These casks are large, heavy containers, equipped with an internal basket for holding the spent fuel assemblies and external radiation shielding, each about 16.5 feet tall and 8.5 feet in diameter. Fully loaded, each cask weighs about 122 tons.

The number of casks which will be required at Prairie Island is dependent on the progress made by the DOE in moving toward spent fuel acceptance. The numbers projected range from 12 casks if the DOE begins accepting fuel at a possible interim storage facility in 1998 to a maximum of about 75 casks if the DOE does not accept spent fuel before the plant, including the spent fuel pool, is decommissioned (retired) at some point following closure. This maximum figure is based on the life of the current operating license for the Prairie Island plant. NSP's current proposal is for an ISFSI large enough to accommodate 48 casks. If the Nuclear Regulatory Commission grants a license extension for the plant to operate beyond their current 2013-2014 expiration dates, more spent fuel storage would be needed.

B. General Site Description

The Prairie Island Nuclear Generating Plant is located within the city limits of the City of Red Wing, Minnesota. The plant is located on the west bank of the Mississippi River, about 6 miles northwest of downtown Red Wing. Highway access is available to U.S. Highway 61 via Goodhue County Road 18. Railroad access is available via a spur from the main line, which runs along the southwest boundary of the plant. Goodhue County, in which the site is located, and adjacent Pierce county in Wisconsin, are predominantly rural. Land use within a radius of five miles of the plant is primarily agricultural. The closest residence is about six-tenths of a mile south-south-east of the reactor buildings. Estimated population figures from 1985/1986 show 174 residents within one mile of the plant, and 290 people within two miles. A total of 1,222 people live within five miles of the plant, primarily in the Red Wing area. Figures 3-1 and 3-2 show the area surrounding the Prairie Island plant.

The proposed ISFSI would be located within the plant boundary, on about seven acres of land located northwest of the reactor buildings. This area of the plant site is now used for storage of earthen materials and demolition debris. Due to proximity of the plant to the Mississippi River, flood impacts on the ISFSI have been raised as a concern by several commenters. Flood potential, impacts and mitigation are discussed in more detail in Chapter 4. Figure 3-3 shows the layout of the major features of the Prairie Island plant.

Four alternative sites for the ISFSI were considered on the Prairie Island plant property. These are shown in Figure 3-4. Area II was not chosen because the area is constricted by the presence of the plant access road and the microwave and meteorological towers. Area IV was not chosen because it has less useful area, and because of the presence of a resin disposal site and monitoring wells. Area III was not chosen because it lies closest to the plant site boundary, and would require substantial earth fill to bring it up to the desired elevation.

Area I was chosen for the following reasons:
- Site grading cost will be low since the area is fairly level.
- There is no heavy vegetation growth and no foreign material deposits as compared to Site IV.
- Existing road is available almost up to the ISFSI installation.
- Land is available for expansion to the east and north side of the site.
- The cost of providing electricity will be minimized since the site is close to the existing substation.

An off-site location for the ISFSI was also considered. Use of a site other than Prairie Island could require land acquisition, unless land already owned by NSP was chosen. A greater effort would be necessary to qualify and license a remote site, since the Prairie Island plant site is already covered by an NRC license. Spent fuel would have to be transported from the Prairie Island plant to the storage site. The transportation mode, whether rail, road, or barge, would depend on the location of the storage site, availability of transport equipment, cost, etc. A fuel handling and cask loading facility would be required at the storage site to transfer spent fuel from transport casks to storage casks. The storage facility would look and function the same as if it were located at the Prairie Island site. Personnel and facility resources would be required to operate, monitor and provide security for the storage facility. For these reasons, and because a suitable area was readily available on the plant site, the remote-site option was not considered further.

C. Characteristics of the Spent Fuel to be Stored in the Dry Casks

The radiological and thermal characteristics of the spent fuel to be stored in dry casks constitute the major source of potential risks associated with the proposed Prairie Island Independent Spent Fuel Storage Installation (ISFSI). After spent fuel assemblies are removed from the reactor core and placed in the spent fuel pool, their radioactivity and thermal output decrease rapidly during the first year following discharge. However, even after 10 years cooling time in the pool, the spent fuel remains highly radioactive and thermally hot. Figures 3-5 and 3-6, respectively, show the decay curves for radioactivity and heat associated with the fuel following its removal from the reactor.

The ISFSI is designed to accommodate a total of 48 storage casks. Each of the casks is capable of accommodating 40 spent fuel assemblies. The total capacity of the fuel to be stored at the facility is 715.29 metric tons of uranium. This is based on storage of 482 Westinghouse standard assemblies (400 kilograms of uranium (kgU) each), 481 Exxon's standard and TOPROD assemblies (370 kgU each) and 957 Westinghouse optimized design assemblies (360 kgU).

The following fuel assembly characteristics constitute limiting parameters for storage of specific assemblies at the ISFSI. Only spent fuel assemblies which meet these criteria will be stored at the ISFSI.

- Initial fuel enrichment: 3.85 percent uranium-235 by weight,
- Fuel burnup: maximum burnup of 45,000 megawatt days per metric ton uranium,
- Decay time: minimum of 10 years after removal from the reactor, and
- Physical configuration/condition: fuel assemblies shall be intact, shall have no known cladding defects and shall not have physical damage which would inhibit insertion or removal from the cask fuel basket.

(See additional fuel specifications on page 3.10. For an explanation of the terms used here, and of the nuclear fuel cycle in general, please refer to Appendices A and B of this EIS.)

The thermal and radiological characteristics for the spent fuel were generated using the ORIGEN2 computer code (cited in the Safety Analysis Report (SAR) filed by NSP as part of the ISFSI license application to the Nuclear Regulatory Commission). These characteristics for the Westinghouse 14x14 assembly are shown in Table 3-1. For the thermal and radiological characteristics, the Westinghouse 14x14 OFA assembly with an enrichment of 3.85% U-235 was assumed. This fuel will bound all other fuel types to be stored in the TN-40 casks with respect to thermal and radiological characteristics. The specific analyses are available in Section 3.3.4 of the SAR, and radiological results summarized in Tables 3-2 and 3-3 of this EIS.

Table 3-1
Thermal, gamma and neutron sources for the design basis fuel

U-235 Enrichment	3.85% by weight
Burnup (megawatt days per metric ton uranium)	45,000
Specific power (megawatts per metric ton U)	37.5
Cooling time (years from reactor discharge)	10
Decay heat (kilowatts)	0.675
Gamma source (photons/second)	2.44E+15
Neutron source (neutrons/second)	2.10E+8

Table 3-2

Gamma and neutron radiation sources

Data presented is for the reference Westinghouse14x14 array, 3.85% U-235 enrichment, 45,000 megawatt days/metric ton uranium burnup, 10-year cooled fuel assembly, assumed to the bounding condition for ISFSI storage.

Fission product activity (curies/assembly)	1.55E+5
Neutron source (neutrons/second/assembly)	2.19E+8
Fuel zone gamma source * (gamma radiation/second/assembly)	2.44E+15
Plenum zone gamma source * (gamma radiation/second/assembly)	8.10E+9
End zone gamma source * (gamma radiation/second/assembly)	2.06E+11

* These zones are the three longitudinal parts of the fuel assembly.

Table 3-3

Fission product activities for the reference fuel assembly

Values are shown at the time of discharge from reactor, 10 years after discharge and 20 years after discharge. All values expressed in curies per metric ton uranium.

Nuclide	Discharge	10-years later	20-years later
H-3	7.44E+02	4.25E+02	2.42E+02
Kr-85	1.21E+04	6.26E+03	3.33E+03
Sr-90	9.52E+04	7.51E+04	5.92E+04
Y-90	1.01E+05	7.51E+04	5.92E+04
Y-91	1.07E+06	1.74E-13	4.80E-31
Zr-95	1.60E+06	1.05E-11	6.10E-29
Nb-95	1.61E+06	2.32E-11	1.21E-30
Ru-106	7.12E+05	7.84E+02	8.09E-01
Rh-106	7.90E+05	7.84E+02	8.09E-01
Ag-110	2.44E+05	3.67E-03	1.46E-07
Sb-125	1.84E+04	1.52E+03	1.23E+02
Cs-134	2.57E+05	8.90E+03	3.08E+02
Cs-137	1.41E+05	1.12E+05	8.86E+04
Ba-137	1.33E+05	1.06E+05	8.38E+04
Ce-144	1.27E+06	1.73E+02	2.34E-02
Pr-144	1.29E+06	1.73E+02	2.34E-02
Pm-147	1.29E+05	9.57E+03	6.94E+02
Sm-151	4.79E+02	4.51E+02	4.17E+02
Eu-154	1.72E+04	7.70E+03	3.44E+03
Eu-155	1.10E+04	2.73E+03	6.74E+02
Total	1.77E+08	4.07E+05	3.00E+05

Fuel with various combinations of burnup, specific power, enrichment and cooling time can be stored in the TN-40 cask as long as values for decay heat and gamma and neutron sources, including spectra, fall within the design limits specified in Table 3-1. Figures 3-7 and 3-8 show the total gamma and neutron sources, respectively, as a function of cooling time for the design basis 14x14 fuel assembly.

D. Storage Cask Description

Casks are large, heavy containers, equipped with an internal basket for holding the spent fuel assemblies. Dry storage of spent fuel in metal casks has been tested and demonstrated in the U.S. since 1984. Virginia Power uses metal casks at the Surry ISFSI which were supplied by General Nuclear Systems, Inc. The casks NSP proposes to use at Prairie Island are designed by Transnuclear, Inc. The maximum capacity of this cask is 40 spent fuel assemblies of the type used at Prairie Island, so it is called a TN-40 cask. Each cask is about 16.5 feet tall and 8.5 feet in diameter, and weighs about 120 tons when fully loaded. The casks are designed to perform the following functions: contain the spent fuel and provide structural protection; control fuel temperature through conduction, convection and thermal radiation; maintain an inert, non-oxidizing atmosphere for the fuel; contain radionuclides; and provide shielding of radiation. Monitoring systems are also included on the casks to ensure that the required conditions for containment are met.

The fuel that will be placed into the TN-40 casks will have been discharged from the core at least ten years earlier. After this long of a cooling period, the level of heat generated by spent fuel is lower and is conducted through the walls of the cask and to the cask's outer surface, where it then dissipates to the atmosphere. Discussion of the nuclear fuel cycle is presented in more detail in Appendix B.

The cask is designed to withstand severe environmental conditions and natural phenomena such as earthquakes, tornados and tornado missiles, lightning, hurricanes and floods. The casks, seals, and pads must also be capable of withstanding prolonged periods of extremely cold temperatures and prolonged periods of contact with ice and snow. Additionally, the casks are designed to maintain safe storage and containment of the spent fuel during design basis loading, handling, storage or accident conditions.

Comments 11A and 13M questioned the design of the crane and its lifting ability. NRC regulations found in NUREG-0612 "Control of Heavy Loads at Nuclear Power Plants" and NUREG-0554 "Single Failure Proof Cranes" identify the acceptable designs for cranes, lifting yokes an cask handling trunnions in order to essentially eliminate the probability of a cask drop. The cask will be handled with the 125 ton auxiliary building crane. This crane will be modified to a single-failure-proof configuration before any cask handling takes place. The design of the cask lifting yoke and handling trunnions will also be in accordance with these regulations.

NSP has not analyzed the effects of dropping a cask in the Auxiliary Building because such a failure is not considered credible by the NRC. The crane used to move the cask will be a single failure proof design as defined in NUREG 0612, "Control of Heavy Loads at Nuclear Power Plants." The upper lifting trunnions on the cask are also designed according to NUREG 0612. A load of six times the weight of the cask does not produce stresses exceeding the yield strength of the trunnions. Also, a load of ten times the weight does not exceed the ultimate strength of the trunnions.

Nonetheless, if an accident such as a cask dropping 50 to 60 feet from the crane in the Auxiliary Building did occur, the cask would suffer some minor damage, and could possibly become imbedded in the concrete floor. The fuel basket would shift but the fuel would reamin within the compartments. It is most likely that the cask seal would remain intact, though perhaps with a measurably increased leakage rate. However, even if the seal were fully breached and all of the fuel rods released their available inventories, the consequences of such a release are within acceptable occupational and off-site exposures (for an accident) as discussed in the ISFSI SAR.

D.1 Development of the TN-40 Cask design:

NSP has selected Transnuclear, Incorporated of Hawthorne, New York, as cask vendor for the proposed project. Incorporated in 1965, Transnuclear has a long history of involvement in nuclear fuel cask development both in the United States and in Europe. Six Transnuclear cask designs have been approved for use by the NRC for either storage or transport of spent nuclear fuel, and more than 100 Transnuclear Group casks are in use today world-wide.

Transnuclear's TN-24 cask is the cask most closely resembling the TN-40 proposed for use in this project. (The TN-24 holds 24 larger fuel assemblies, the TN-40 holds 40 of the smaller type fuel assemblies used at Prairie Island.) The TN-24 is NRC-approved for storage of spent nuclear fuel. It has been tested in demonstration projects at the Idaho National Engineering Laboratory and as part of the Virginia Electric Power Company's cooperative program with the DOE.

In designing the TN-40 the following development objectives were used: reduce emphasis on transportability, select materials which can be fabricated in the United States, separate the containment and shielding functions, reduce basket material costs, increase storage capacity, and maintain the operating characteristics of the TN-24. The TN-40 meets these objectives through use of a multi-shell body, and a lighter and more efficient basket design. The TN-40 was designed specifically for NSP's Prairie Island plant, and has not yet been approved by the NRC. This approval process will be part of NSP's federal license application and approval for the ISFSI, and is discussed in more detail later in this chapter.

Comments 4A, 13H, 13J, 19R, and 19S asked why NSP chose metal casks as a storage media, why Transnuclear was chosen as a cask supplier, why the TN-40 cask was chosen rather than a cask already in use elsewhere and what the safety record of the TN-24 casks reveals. The first question is answered in NSP's comment letter on the DEIS (comment letter #10) on page 6: Why NSP Chose Large Capacity Metal Cask Design. Transnuclear, Inc. was chosen by NSP as cask supplier through a competitive bid process, and is now working with NSP under a fixed-cost contract. The third question, why TN-40?, is also answered in the reference for the first question. The safety record of the dry storage in general is also discussed in NSP's comment letter on page 6: Experience Base for Cask Use and Environmental Effects. The TN-24 cask was successfully demonstrated at the Idaho National Engineering Laboratory in a joint Department of Energy/Electric Power Research Institute program, and the Nuclear Regulatory Commission approved the TN-24 Technical Safety Analysis Report in July of 1989. There are no TN-24's in commercial use at this time. Cask design and testing are also discussed in NSP's comment letter on page 7: Cask Design and Testing.

Cask design and fabrication:

Table 3-4 shows the general design parameters of the TN-40 cask. The cask is constructed of several components, shown in Figure 3-9. The fuel assemblies are placed into an interior fuel basket. The basket structure consists of an array of rectangular cells, or boxes, constructed of stainless steel. Sandwiched between the walls of the cells are plates of aluminum and boral. The boral plates contribute to criticality control, and the aluminum plates provide a conduction path to transfer heat from the inside of the cask to the cask walls. The strength of the basket meets applicable NRC requirements.

Surrounding the fuel basket is the two-layer cask body, consisting of the containment vessel (innermost) and the gamma shield. The containment vessel is designed to meet the requirements of the American Society of Mechanical Engineers' (ASME) Code Section III Class 1 design. It will be constructed of SA203 ferritic steel and SA350 forged steel and welded using full-penetration welds, each of which will be inspected by both dye-penetrant and radiographic methods. This welding and inspection procedure will insure that the welds have at least the same level of integrity as the steel in the containment vessel. The lid will be bolted on using 48 bolts, with double metallic seal rings to provide secure, redundant containment and isolation of the spent fuel. Following fabrication, the containment vessel is hydrostatically tested by filling it with water and pressurizing it to a level of 125% of the design pressure to assure there are no leaks in the vessel itself.

The outer layer of the cask body is the gamma shield. Designed to meet NRC shielding requirements, it will be constructed of SA105 forged steel in several sections and have backing rings and through-wall welds at axial joints. It will then be welded to a bottom plate and to the closure flange. The gamma shield helps to support the containment vessel, and is the part of the cask which provides protection from tornado missiles.

TABLE 3-4: TN-40 GENERAL DESIGN PARAMETERS

PARAMETER	VALUE
Design life	At least 25 years
Maximum weight	120 tons
Max. gross weight on crane (with lift beams)	125 tons
Number and type of fuel assemblies	40 Westinghouse or Exxon 14x14 assemblies
Spent fuel characteristics:	
-Initial enrichment	3.85% uranium-235
-Maximum burnup	45,000 megawatt days per metric ton uranium
-Burnup credit	1.8% effective enrichment
-Min. decay time	10 years
-Decay heat	27 kilowatts (total)
Maximum fuel cladding temperature	340° Centigrade
Maximum k_{eff}*, inc. bias and uncertainties	≤0.95 Normal <0.98 Accident
External dose rate	125 mrem/hour contact (maximum)
Internal cask atmosphere	Helium
Max. internal pressure	100 psig
Ambient temperature	-40° Fahrenheit to +120° Fahrenheit
Solar heat load (max)	135 BTU/hour per square foot
Tornado wind velocity	300 miles per hour (rotational)
Tornado missiles**	4"x12"x144" plank at 300 miles per hour 4000 pound automobile at 50 miles per hour
Snow and ice	50 pounds per square foot
Seismic	3.86 feet/second^2 horizontal acceleration 2.57 feet/second^2 vertical acceleration
Cask drop	18" bottom drop onto storage pad
Cask tip	Tip onto ISFSI pad

* k_{eff} is a measure of how close the stored fuel would come to reaching criticality, which occurs when k_{eff} reaches 1.0.

** A tornado missile is an object propelled by tornado-force winds.

Outside the cask body a neutron shield is fitted. It will consist of an array of long, rectangular, aluminum elements filled with a neutron-absorbing resin, surrounded by an outer shell of SA516 carbon steel. The aluminum elements will be tightly fitted between the gamma shield and the outer shell for effective transfer of heat from the cask body to the outer shell. A disk of polypropylene is attached to the cask lid to provide neutron shielding during storage.

Completing the cask will be a protective cover which fits over the lid and is fastened to the cask body. Monitoring devices are placed inside this cover, and provide the means to monitor cask seal integrity throughout the storage period. Lifting trunnions are also provided at the top and bottom of the cask body (two on each side) to facilitate safe cask handling.

Comments 11B, 19B and 19V requested additional discussion of cask testing. Pressurizing the cask interior to 125% of its design pressure is done to verify the strength of the welds, not to determine whether helium or water can diffuse through the weld. Properly executed welds are as impermeable as the surrounding material. Using water to pressurize the cask interior rather than a gas is the safest, most reliable method to verify weld strength, and is the standard method used for pressure vessels. Radiographs and dye-penetrant tests of the cask welds will also be performed to verify weld integrity. For further discussion of cask testing, see NSP comment A.2 (NSP comment letter, #10), for a response to 19B, and NSP comment A.9 (same submittal) for a response to 19V.

Operating controls and limits:

Fuel:

1. Specifications: The spent nuclear fuel to be stored at the Prairie Island ISFSI shall meet the following requirements:

- Only fuel irradiated at the Prairie Island plant may be used.
- Maximum initial enrichment shall not exceed 3.85% U-235 by weight.
- Maximum assembly average burnup shall not exceed 45,000 megawatt days per metric ton uranium.
- Fuel shall have cooled a minimum of 10 years after reactor discharge and prior to storage in the ISFSI.
- Fuel shall be intact, unconsolidated fuel. Partial fuel assemblies, that is, fuel assemblies from which some individual fuel rods are missing, must not be stored unless dummy fuel rods are used to displace an amount of water equal to that of the displaced rods.
- Fuel assemblies known or suspected to have structural defects sufficiently severe as to adversely affect fuel handling shall not be loaded into a cask for storage, unless canned. In response to comment 11C,"canning" refers to placing a fuel assembly into a container so that the container can then be handled and moved without directly handling the

assembly. A fuel assembly with structural damage that precludes normal handling procedures may be canned to allow use of existing handling tools. Canning would be done in the pool. Of all the Prairie Island spent fuel assemblies generated to date, none of those which will be placed into dry storage will require canning.

2. Applicability: These specifications are applicable to all fuel to be stored in the TN-40 casks at the Prairie Island ISFSI.

3. Objective: The specifications were derived to ensure that the peak fuel rod temperature, surface doses, and nuclear subcriticality are below design values.

4. Action: If these specifications are not met, additional analysis and/or data must be presented demonstrating that the nonconformance does not exceed safe operating limits before the spent fuel can be placed in the cask for storage.

5. Surveillance: Prior to cask loading, the fuel selected to be loaded shall have been reviewed to ensure that it is within the cask-specific functional and operating limits. This information shall be documented for each assembly to be loaded into the cask.

6. Basis: The design criteria and subsequent safety analyses of the ISFSI and storage casks assumed certain characteristics and limitations for the fuel that is to be stored.

Comments 11D and 13G questioned reference to nonconforming fuel rods. Table 3-4 shows the requirements, or "specifications", which must be met by fuel stored in the TN-40, including maximum fuel enrichment, maximum burnup, and minimum cooling time. There are no Prairie Island spent fuel assemblies with broken fuel rods, and even if there were, no such fuel would be placed into dry storage. Fuel assemblies known or suspected to have structural defects sufficiently severe as to adversely impact fuel handling will not be placed into dry storage, unless such assemblies are canned to provide a safe handling configuration. Of all the Prairie Island spent fuel assemblies generated to date, none of those which will be placed into dry storage will require canning.

When spent fuel is eventually shipped offsite to an MRS or repository, assemblies with damaged fuel rods may require canning or further containment before being placed into the shipping cask. The specific requirements will depend on the shipping cask design and then-current NRC regulations.

Casks:

1. Specifications: The spent fuel storage casks used at the ISFSI shall meet the following requirements:

- Cask surface temperature shall be less than 250^{o} Fahrenheit.
- The cask surface dose rate shall be less than 125 mrem per hour.
- Removable surface contamination levels on the cask shall be less than 1000 disintegrations per minute per 100 square centimeters (dis/min/100cm^2) from beta and gamma emitting sources and 20 dis/min/100cm^2 from alpha emitting sources.
- Maximum lifting height of a cask by a non-redundant lifting device shall be less than 18 inches.

2. Applicability: These specifications are applicable to the TN-40 casks.

3. Objective: The objective is to ensure that the casks have been loaded and handled in accordance with design basis criteria.

4. Action: If temperature, surface dose rates, or contamination levels exceed limits, the cask shall not be transported to the ISFSI. If maximum lift height is exceeded, the transport activities shall be stopped and the cask lowered to within the acceptable limit.

5. Surveillance: The following surveillance measures will be taken to ensure that the specifications are met:

- A minimum of 24 hours after cask loading and prior to moving the cask to the storage pad, the surface temperature of the cask shall be measured to ensure that it is within the functional and operating limit.
- Prior to moving a loaded cask to the storage pad, gamma and neutron measurements shall be taken on the outside surface of the cask surface. These dose rates shall be less than the surface dose rate limit.
- Prior to moving a loaded cask to the storage pad, the cask removable surface contamination levels shall be measured to ensure they are less than the contamination limits.

6. Basis: The design criteria and subsequent safety analysis of the TN-40 cask assumed certain characteristics and operating limits for the <u>size</u> of the casks. This specification assures that those design criteria are not exceeded.

Confirmation that the cask surface temperature is within the prescribed limit will ensure that the cladding temperature of the fuel assemblies is less than the maximum design basis temperature of 340^{o} Centigrade. This will protect the integrity of the spent fuel stored in the ISFSI by ensuring that the thermal analyses are valid for the fuel stored in the ISFSI.

Confirmation that cask surface dose and surface contamination levels are below prescribed limits will protect employees against occupational exposures by ensuring compliance with occupational dose limits and ALARA principles. (ALARA principles are described in more detail in Appendix G of this document.)

Confirmation that cask lifting heights are within the prescribed limit will protect the cask integrity and guard against uncontrolled release of radioactive material by ensuring the thermal, criticality, and radiological analyses remain valid following and accidental cask drop.

Comment 5D raised several questions about heat generation and heat flow calculations. Spent fuel heat generation is not related to the criticality of the array of spent fuel assemblies. The thermal analysis of the cask design is done to show that the rate of heat transfer from the spent fuel to the cask exterior will keep the fuel rod cladding temperature below a maximum value of 340°C (644°F). As given in Table 3.3-1 of the SAR, the maximum cladding temperature under average storage conditions is 314°C (598°F), and a maximum cladding temperature for very hot and sunny conditions is 336°C (636°F). The heat generated by spent fuel is a consequence of the radioactivity of the spent fuel. As the spent fuel becomes less radioactive during its time in storage, its heat generation rate also decreases. As the spent fuel heat generation rate decreases, cladding and cask surface temperatures decrease.

Cask Internal Temperatures During Loading: The thermal analysis of the TN-40 cask shows that it will reach thermal equilibrium within 24 hours after it is sealed. During the vacuum drying step of the cask preparation procedure, the cask internal temperature would be higher than the equilibrium temperature reached after sealing. This is because there is no helium in the cask during vacuum drying, and the helium contributes to the heat transfer from the fuel to the cask walls. The effect of helium is to lower the fuel cladding temperature by about 70°C. Therefore, the maximum fuel cladding temperature expected to be reached during vacuum drying is about 384°C (314, from preceding paragraph, + 70). This maximum temperature would persist only until the subsequent step of the cask preparation procedure, when the cask is backfilled with helium. A fuel clad temperature of 384°C is not a concern for the brief period in question; for comparison, the maximum allowable fuel cladding temperature for transportation casks is about 500°C.

Criticality Design Criteria: When an array of nuclear fuel assemblies goes critical, a self sustaining chain reaction is achieved. The parameter called k-eff must be equal to 1.0 before an array of fuel assemblies could go critical. It is impossible for PWR or BWR nuclear fuel assemblies to go critical without water. Because the cask is sealed, and because the cask seal is above the highest flood level, there is no credible event which would allow water inside the cask. Nonetheless, the TN-40 cask is designed so that the array of spent fuel assemblies in the cask would be subcritical (i.e., k-eff less than 1.0) even if the cask interior were to become filled with water. The NRC requires spent fuel storage configurations be designed so that k-eff does not exceed 0.95 under normal storage conditions. The NRC has previously licensed storage configurations for which k-eff does not exceed 0.98 under certain off-normal and improbable circumstances. For comparison, reactor cores must be designed so that insertion of all the control rods will stop the nuclear reaction, and keff will be no greater than 0.98.

The calculation of k-eff is performed using input data and computer codes which have been benchmarked against measured data, and methods which incorporate additional margin to address calculational and statistical uncertainties. In reviewing the cask design and analysis, the NRC verifies that criticality calculations are performed using approved methods and codes. Reactor core design and criticality analysis are performed using essentially the same method as is used for cask criticality analysis.

Cask Internal Helium Pressure:

1. Specification: The cask shall be backfilled with a helium cover gas to a pressure of 20 $\pm$ 1 psia (5.3 $\pm$ 1 psig) at 77^{o} Fahrenheit.

2. Applicability: This specification is applicable to the TN-40 casks.

3. Objective: The objective is to ensure that the cask is backfilled with helium in accordance with design basis criteria.

4. Action: If internal pressure is not within specified limits, the cask shall not be transported to the ISFSI.

5. Surveillance: Prior to moving a loaded cask to the storage pad, the helium pressure shall be measured to ensure it is within the pressure limit.

6. Basis: The thermal and pressure analyses performed for the cask assume use of a cover gas. Compliance with this limiting condition will ensure long term maintenance of fuel clad integrity. Periodic testing is not required due to the reliability of the redundant monitoring system.

Cask Leakage:

1. Specification: The cask leakage rate shall be less than 10^{-4} atmosphere per cubic centimeter per second.

2. Applicability: The specification is applicable to the TN-40 cask.

3. Objective: The objective is to ensure that cask leakage is within limits assumed in the radiological dose calculations.

4. Action: If leakage is above the specified limit, the cask shall not be transported to the ISFSI.

5. Surveillance: Prior to moving the cask to the storage pad, the cask seal shall be tested using a helium leak detector to ensure that the seal leak tightness is within the leakage limit.

6. Basis: Compliance with this limiting condition will ensure long-term maintenance of cask integrity. Periodic testing is not required due to the reliability of the redundant monitoring system.

Additional surveillance and control measures:

ISFSI Safety Status: A visual surveillance of the ISFSI shall be performed on a quarterly basis to determine that no significant damage or deterioration of the exterior of the emplaced casks has occurred. Surveillance shall also include observation to determine that no significant accumulation of debris on cask surfaces has occurred.

ISFSI Area Dose Rate: Thermoluminescent dose monitors located on the ISFSI site fence shall be read quarterly.

Design Features: The ISFSI cask storage pads will be constructed of reinforced concrete, with nominal dimensions of 36 feet by 216 feet by three feet thick. The top of the concrete pad is at elevation 697.0 feet minimum, in order to ensure that non-borated water could not get into the cask in the event of the maximum hypothetical flood.

Administrative Controls: The ISFSI will be located on the Prairie Island plant site and will be managed and operated by NSP/Prairie Island staff. The administrative controls shall be in accordance with the requirements of the Station Facility Operating License and associated Technical Specification.

D.2 Long-term performance of the cask and its components:

The design of the TN-40 cask is based on Transnuclear's experience in the design, development, testing, licensing, manufacture and operation of dry storage and transport casks. Over ninety large spent fuel transport casks, the predecessors to the TN-40, are currently in use throughout the world. Transnuclear asserts that the functional performance of these casks has been excellent and the experience gained over the years has been incorporated into the TN-40 design.

Generally, the two largest factors in the corrosion of metallic systems exposed to the environment are high temperatures and oxygen. Industrial pollutants such as acid rain or atmospherically dispersed chemicals (e.g., accidental releases of chlorine) have little short term impact, and as a result, their effects, if any, are detected over time, which allows inspections and preventive maintenance to accommodate any impact they may have. In general, such contaminants have extremely low concentrations compared to threshold values for damage over a period of 25 years.

Spent fuel storage casks are not made of delicate architectural or sculptural materials. Such materials can have chemical reactions with industrial pollutants that, over prolonged periods, can cause cracking and spalling. The metals in spent fuel storage casks do not react in such a fashion with these pollutants.

Since exposure to high temperatures and oxygen are the major threats to metallic systems which are stored in the open, the design of the TN-40 cask has been based upon protecting all metal surfaces from the oxidation that can result from such exposure. In addition, the neutron shield, which is made of a polyester resin, must also be evaluated for its long term performance. The major cask system components that could be subjected to environmental threats are the cask body material, the cask internals, the cask sealing system, and the neutron shield.

The design and analysis of the TN-40 cask are in accordance with the American Society of Mechanical Engineer's (ASME) Boiler and Pressure Vessel (B&PV) Code requirements for Class I components, such as nuclear power plant reactor pressure vessels, which are expected to operate under much more severe conditions during normal operation than the TN-40 storage cask. The transient conditions to which a reactor vessel is subjected are also much more severe than the transient or off-normal conditions the storage cask will experience. The cask, under normal conditions, experiences low loading conditions (i.e., comparatively low pressure, low temperature and low thermal gradients) over its lifetime which have an insignificant effect on cask performance. Although the probability that a cask would experience an accident, e.g., tornado missile, is low, it would survive and remain functional because it is designed for accidents with significant safety margins.

The design incorporates standard materials which have been used in the nuclear industry for many years. The cask body and basket materials are ASME B&PV Code materials. The basket poison (neutron absorbing) material (Boral) is a standard material in the nuclear power industry which has been used in spent fuel storage racks of many nuclear power plants, as well as in other cask designs. Cask internals are basically comprised of materials that are highly resistant to oxidation. Additionally, even though the cask internals are exposed to high temperature, the cask design incorporates a method to preclude oxygen entry into the cask. The cask containment vessel and the basket materials are made of high quality steels with high alloy content (e.g., the basket has a large quantity of stainless steel which is the main basket structural material). While the containment vessel is a high alloy steel, over a long period of exposure to oxygen under ideal conditions, it would still have a tendency to form very thin layers of ferrous and ferric oxide. Even though such oxide layers tend to be self-limiting (i.e., the formation of the layer tends to retard further oxidation of the base metal) and would have no material impact on the effectiveness on the containment structure, it is always a design objective to take active steps to control corrosion. Therefore, to prevent oxidation of the containment vessel, it is clad with a non-oxidizing, metallic spray (Zinc/Aluminum), which has a similar effect as galvanizing of metal surfaces. The metallic spray, however, is a more stable and durable coating than galvanization.

The defense-in-depth approach comes from the internal atmosphere that is maintained within the cask which surrounds the non-oxidizing coating and containment vessel. The only time the internal surfaces of the cask experience a potentially corrosive environment is during loading in the spent fuel pool. This exposure lasts for only a few hours and the pool water chemistry is very closely controlled to minimize impurities. After the cask is loaded with fuel and removed from the pool, it is drained. Before the cask is sealed, moisture is removed through the use of a vacuum drying system to insure that radiolysis of water that could occur in the high radiation fields within the cask (e.g., the separation of water into its constituent parts, hydrogen and oxygen) is held to minimal values. As a further backup in the defense-in-depth, the cask is then backfilled with an inert gas (helium) at a higher pressure than atmospheric to assure that outside air cannot leak into the cask.

The cask sealing system is comprised of metallic seals which are highly resistant to corrosion. Since the seals are non-ferrous, their oxidation characteristics are even better than those of the containment vessel. As with the containment vessel, the cask seals are dried after the cask is loaded and are surrounded by the helium atmosphere from both the backfilling of the cask and from the monitoring system. The stability and performance of the metallic seals have been demonstrated in both the laboratory and in actual operation with a variety of applications.

The seal for the weather protective cover is made of an elastomeric (non-metallic) material, with excellent corrosion and temperature properties. This seal is not critical to the functioning of the cask sealing system, but has been designed for both long life and easy replacement.

The cask body is also a high quality steel which meets the requirements for pressure vessel materials of the ASME code. The cask body is sealed by structural welds around the containment vessel so that air and water cannot come in contact with the outer wall of the containment vessel or inner wall of the cask body. The external surfaces of the cask body are also given a defense-in-depth treatment to insure that oxidation of the cask body is minimized. This is accomplished by coating the cask body with the same metal spray used within the cask for the containment vessel. For added protection, a rugged epoxy paint is applied on all body surfaces that are exposed to the elements. The epoxy paint is routinely inspected for damage and, where necessary, is repaired and repainted.

However, even without protective coatings, corrosion would not be a problem in this environment and for this design. First, the outer cask surface exposed to the environment is the gamma shielding, not the fuel containment boundary. Secondly, the lid and top of the cask are covered by the protective cover which could be replaced if required. Third, the corrosion rate in air at the low temperature of storage is insignificant. The depth of corrosion would be less than 2 mils in 100,000 hours at a temperature of 850^{o}F, or less that 5 mils in 25 years. (One mil is equal to one-thousandth of an inch.)

Environmental conditions due to sun, rain, snow or sleet will have little or no effect on the cask. The sun will cause temperature changes, but because of its large mass and thermal inertia, the cask response is very slow, resulting in small thermal gradients. The effect of solar insolation, which is included in the thermal evaluation, is not significant. Snow and sleet will melt due to the decay heat from the contained spent fuel assemblies. The cask has been evaluated to determine the effects of rain at 32°F on a hot cask. The cask could sustain 22,000 such cycles (i.e., rain showers twice a day for 25 years) without exceeding the design requirements.

The neutron shield is a non-metallic material and is, therefore, not very sensitive to oxidation. Such material has been used as an exposed, external surface on a number of Transnuclear transport cask systems, and its performance, even in the presence of air, boric acid, and much higher temperatures than in the TN-40, has been excellent throughout two decades of service. The material is sensitive to temperatures above 300°F, and, therefore, the design of the cask must insure that the peak temperature of the shield is less than this temperature. In the TN-40 design, the neutron shield is sealed within compartments to assure that it is never exposed to the environment. A significant ameliorating effect that is conservatively omitted from consideration in the design of the storage cask is that the cask temperatures (as well as radiation levels) decrease over time as the spent fuel decays. Consequently, the neutron shield is realistically exposed to its highest temperature only for a short time at the beginning of its storage life.

The TN-40 storage cask and its components have been designed to minimize the effect of environmental factors during prolonged storage that could contribute to material degradation. The only components which have some degree of vulnerability (seals, bolts, overpressure system, etc.) can be replaced, if required, on the pad or by moving the cask into the spent fuel building. These components are monitored constantly to ensure their continued effectiveness.

Through the selection of appropriate materials which have been tested and proven in operation, the use of multiple layers of protection, and the performance of regular inspection and maintenance, the TN-40 cask will not experience reduced safety margins as the result of exposure to environmental factors.

E. Storage Installation (ISFSI) Description

1. Physical Description

The Independent Spent Fuel Storage Facility (ISFSI) proposed for the Prairie Island plant would be located within the fenced plant boundary, approximately 1500 feet northwest of the reactor buildings. The ISFSI would cover about seven acres of land, in a disturbed area now used for storage of earthen materials and demolition debris. The functional part would consist of two concrete pads (each 36 feet wide by 216 feet long, and 3 feet thick) upon which the casks would be placed (up to 24 casks per pad, maximum capacity). The two pads would be 100 feet apart. The casks themselves do not require any sort of enclosure.

An eight foot high security fence would surround the pads at a distance of 100 feet. The security fence would be ringed by a 20 foot wide "isolation zone", which would be enclosed within an eight foot nuisance fence. Double swing gates would provide access at only one point in the containment. 10 feet beyond the outer fence, a 20 foot gravel road would be placed around the perimeter of the site so it could be patrolled regularly. An earthen berm would also be constructed along the north and west sides of the ISFSI, to aid in reducing the amount of off-site radiation which would be generated. This berm would be approximately 70 feet wide at its base, 10 feet wide at its crest, and approximately 16 feet tall. All these details are shown in Figure 3-10, which is a schematic of the Prairie Island ISFSI. The area would be well lit at all times. A 30 foot by 50 foot storage building is also planned for inside the security fence, where the cask moving equipment would be stored, along with four slightly contaminated intact spent fuel storage racks from the spent fuel pool.

Comment 19T questioned the integrity of the earthen berm. The earthen berm will be formed of ordinary earth available on site or from local suppliers. Grasses and landscaping will be planted on and around the berm to resist erosion. NSP states that if any significant erosion does occur, the berm will be restored by plant staff. Even if a large section, or all, of the berm is washed away from heavy rains or flooding, it could be restored in a matter of days. Additional discussion is provided in NSP comment letter (10), p. 4.

Comment 13K sought more discussion on the concrete pad design and integrity. The concrete pads are designed to be stable for the lifetime of the storage installation. The earthen berm will be formed of ordinary earth available on site or from local suppliers. Grasses and landscaping will be planted on and around the berm to resist erosion. The fill under the concrete pads will be the same as is typically used for concrete foundations, and will consist of sound, durable, granular material. Culverts and drainage pipes will be located in the fill to provide the necessary drainage. An earthquake or flood will not affect the functionality of the ISFSI site or concrete pads. Refer to NSP's comment A.3, (Comment letter #10), for discussion of flood effect on the earthen berm.

Comments 11E, 13G and 17B requested more information about the four slightly contaminated spent fuel racks to be stored in the storage building. The subject racks were last used in the Prairie Island pool about 10 years ago. These racks are completely functional, and have been stored on site for the last 10 years. The racks were cleaned when they were removed from the pool, leaving them with low levels of fixed contamination. When within the ISFSI, they would be subject to a level of control and surveillance equivalent to that applied to slightly contaminated items within the plant. The total calculated dose due to ISFSI operations includes the contribution from the racks, which is much smaller than from any single cask. NSP does not believe there is any additional risk to storing these racks in the ISFSI as compared to their current storage conditions in the plant.

2. <u>Security and monitoring of the ISFSI and casks:</u>

Security coverage for the ISFSI will be provided by the plant security force. Access to the ISFSI will be very limited, and will be controlled by the plant security force. The ISFSI will be surrounded by with a security fence equipped with an intrusion detection system wired to Plant Security's alarm stations. This system would alert the plant security force in the event of an unauthorized attempt to enter the cask storage area. Lighting and video cameras installed along each side of the ISFSI fence will assist the security force in monitoring the area surrounding the ISFSI. The ISFSI perimeter will be patrolled by plant personnel at least once per shift.

Monitoring of the casks themselves would be done at several levels. The cask exteriors would be visually inspected periodically for signs of weathering of the cask shell. Additionally, each cask is equipped with a pressure monitoring system which will indicate a loss of seal. It is important to ensure that air doesn't leak into the cask. Air is not a desirable environment for spent fuel storage, because of the potential for oxidation of the fuel cladding. Each cask monitoring system feeds into an alarm panel located outside the ISFSI fence. This panel will indicate whenever any cask monitoring system detects a loss of cask seal or the monitoring system itself malfunctions.

The TN-40 monitoring system functions as follows:

Prior to placing the TN-40 cask on the storage pad, the pressure inside the cask cavity is raised to about 2.0 atmospheres by pressurizing it with helium. This assures that cask cavity pressure is always above atmospheric during the storage period to prevent the in-leakage of air which could be harmful to the fuel.

After the cavity is pressurized, an overpressure tank is installed <u>on</u> top of the lid. The tank is connected to the gaps between the two metallic seals on the lid and lid penetrations. The tank and the inter-seal gap are pressurized to about 6 atmospheres. This pressure is monitored by a transducer which sends an electrical signal to the ISFSI monitoring panel. A decrease in the pressure of the monitoring system would be signalled by this pressure transducer. Since the helium in the monitoring system is at a much higher pressure than that of the cavity, any seal leakage would result in helium from the monitoring system (non-radioactive) leaking either into the cavity through the inner seal (if it has failed) or into the space between the lid and the protective cover through the outer seal (if it has failed). In either case, no leakage of radioactive material from the cask to the environment would occur.

For protection of the monitoring system from the environment, the protective cover is fitted over the lid and monitoring system and equipped with an elastomer (i.e., rubber) seal. In the unlikely event that unacceptable leakage were detected in the monitoring system and the leak occurred in an outer seal, the space between this protective cover and the lid would trap the escaping monitoring system helium, thereby retarding the drop in the monitoring system pressure. This space between the protective cover and the lid would also act to retain any material from within the cask and retard cask depressurization in the highly unlikely event that an inner seal, as well as an outer seal, were to fail.

Comment 5C questioned whether backup monitoring systems were needed for the casks. The pressure monitoring systems on the casks are designed in such a way that if they fail, they will fail showing that a problem exists with the cask. This will trigger a response by plant personnel, who will determine whether the problem is in the cask or in the monitoring system, and then take appropriate measures to correct the problem. The environmental monitoring of the ISFSI will also serve to backup the casks' monitoring systems.

Comment 7B suggested that "Chapter 3, Section E. 2. ... should include a description of the existing radiological monitoring systems." NSP conducts a monitoring program at Prairie Island as required by the U.S. Nuclear Regulatory Commission (NRC). The results of the program are reported both to the NRC and to the Minnesota Department of Health (MDH). The MDH conducts verification monitoring for the NRC, and generally finds agreement between NSP's reported results and their own findings. Appended to this response document as Appendix U is Part 4.0 Results and Discussion, taken from NSP's April 27, 1990 report to the NRC of their 1989 data from the program. In addition, NSP states in the SAR that 16 additional thermoluminescent dosimeters will be place around the ISFSI to monitor that facility specifically. The results of this monitoring will be folded into the annual radiological monitoring report.

F. Cask Loading and Movement to ISFSI

Receiving:

1. Unload empty cask and separately packaged seals at plant site.

2. Inspect the following for shipping damage: exterior surfaces, sealing surfaces, trunnions, seals, accessible interior surfaces and basket assembly, bolts, bolt holes and threads, neutron shield vents.

3. Install plug in neutron shield vent hole (threaded hole in the top of the steel shell surrounding the resin which contains a pressure relief valve during storage).

Comment 11F inquired about the purpose of the neutron shield vent hole. The neutron shield material is a polyester resin, enclosed in aluminum boxes and encased by the thin outer shell of the cask. The cask surface temperatures will range between about 100 and 200°F. In this temperature range, the resin material undergoes a small amount of off-gassing over the lifetime of the cask, releasing minute quantities of helium, hydrogen and various hydrocarbons. None of these gases are radioactive.

4. Remove lid bolts and lid.

5. Install protective plate over cask body sealing area.

6. Attach lid seal to lid by means of six retaining screws.

Spent Fuel Pool Area:

1. Lower cask into cask loading pool.

2. Load preselected spent fuel assemblies into the 40 basket compartments.

3. Verify identity of the fuel assemblies loaded into the cask.

4. Remove protective plate from cask body flange.

5. Lower lid and place on cask body flange over the two alignment pins.

6. Lift cask to surface of pool and install lid bolts.

7. Connect drain line to quick-disconnect coupling in the drain port.

8. Bolt special adapter, with quick-disconnect coupling, to vent port bolt holes.

9. Connect plant compressed air line to special adapter quick-disconnect coupling.

10. Pressurize cavity to force water from cavity through drain port to the spent fuel pool.

11. Disconnect plant compressed air line and drain line from their quick-disconnect couplings.

12. Move cask to the decontamination area.

Decontamination Area (Rail Bay):

1. Decontaminate cask until acceptable surface dose levels are obtained.

2. Torque lid bolts using the prescribed procedure.

3. Remove plug from neutron shield vent and install pressure relief valve.

4. Connect Vacuum Drying System (VDS) to vent port.

5. Evacuate cavity to remove remaining moisture using prescribed procedure.

6. Break vacuum by closing vacuum valve and opening air valve to admit dry air into the cavity.

7. Disconnect VDS at vent port and install vent port cover with seal and bolts.

8. Connect Vacuum Backfill System (VBS) to quick-disconnect coupling in the drain port.

9. Evacuate cavity to 10 millibar and backfill with dry helium gas.

10. Pressurize cavity to about 2 atmospheres with helium.

11. Disconnect VBS at the drain port quick-disconnect coupling and install drain port with seal and bolts.

12. Perform helium leak test of lid seals.

13. Remove overpressure port cover.

14. Install top neutron shield drum.

15. Install leak detection system with pressure transducers.

16. Torque the bolts using prescribed procedure.

17. Connect pressure transducers to pressure recorder.

18. Pressurize overpressure system (seal interspaces) with helium to a pressure of about 5.5 atmospheres.

19. Perform leak test on overpressure system.

20. Check external surface temperatures using an optical pyrometer.

21. Check surface radiation levels.

22. Install protective cover with seal and bolts.

23. Load cask on transport vehicle.

24. Move cask to storage area.

Storage Area (ISFSI):

1. Unload cask from transport vehicle.

2. Position cask in preselected location on storage pad.

3. Check for surface defects.

4. Connect pressure instrumentation to monitoring panel.

5. Check that pressure instrumentation is functioning.

6. Check surface radiation levels.

It will take about one week to complete the loading and installation of a cask at an ISFSI. NSP proposes to place about seven casks into service in the first two to three years of operation of the Prairie Island ISFSI. Thereafter, casks will be placed into service only as needed, at an anticipated rate of two per year.

Once in place at the ISFSI, the cask requires minimal surveillance and maintenance. When the time for off-site shipment of spent fuel approaches, NSP will investigate the possibility of obtaining NRC approval to use these casks for transportation. If the storage casks cannot be used for transport, spent fuel will be removed from the storage cask using a reverse of the loading procedure. A cask would be taken back to the plant, placed into the pool and the lid would then be removed. The spent fuel assemblies would be taken out of the storage cask and placed back into pool racks, and the storage cask would be removed from the pool. The assemblies would then be available to be loaded into a transportation cask.

G. Dry Storage Capacity Requirements

The dry storage capacity required at Prairie Island will depend on several factors: the spent fuel generation rate, how long the plant operates, when NSP can begin shipping spent fuel off-site to the U.S. Department of Energy (DOE), and the rate of off-site shipment.

According to the current schedule for the DOE's spent fuel and high level waste disposal program, the earliest a permanent repository could be operational is 2010. The DOE could take spent fuel from utilities before repository operation, if it receives congressional authorization to build a Monitored Retrievable Storage (MRS) facility. Significant delays in this schedule may yet occur, further slowing the federal project.

Four scenarios were developed for projecting the amount of additional storage which would be needed. The following assumptions were used to develop the first three scenarios:

1. Prairie Island spent fuel generation rate for 1994 and later is 72 assemblies per year.

2. Rate of spent fuel shipment to the DOE for the first 10 years of MRS or repository operation will follow the schedule in the DOE Annual Capacity report.

3. Rate of shipment for the eleventh and later years of MRS or repository operation is at least equal to the generation rate.

The fourth scenario uses the first assumption, but does not take into account any spent fuel acceptance by the federal government.

The scenarios examined were as follows:

(A) Assumptions: MRS operational in 1998, repository in 2010. Prairie Island Unit 1 shutdown in 2013, Unit 2 in 2014 (40 year life).

Results: Additional storage for 480 spent fuel assemblies is needed, and can be met with 12 TN-40 casks. Dry storage would only be needed through 2005.

(B) Assumptions: MRS or repository operational in 2010, 40 year plant life.

Results: Additional storage for 1280 spent fuel assemblies is needed, and can be met with 32 TN-40 casks. Dry storage would be needed for about 3 years after plant shutdown.

(C) Assumptions: MRS or repository operational in 2025, 50 year plant life (assumes a 10 year plant life extension granted by the NRC).

Results: Additional storage for 2160 spent fuel assemblies is needed, and can be met with 54 TN-40 casks. Dry storage would be needed for about 6 years after plant shutdown.

(D) Assumptions: No federal acceptance of spent fuel before the plant is to be decommissioned, 50 year plant life.

Results: Storage for 3546 spent fuel assemblies is needed, and would require a total of about 90 casks. This number cannot be specifically projected, due to the presence of non-standard (either previously consolidated or damaged) fuel currently in pool storage. Storage would be needed until all fuel is accepted by the DOE.

Since the cost of acquiring the storage casks is expected to be the major cost component of the ISFSI, the overall cost of the installation will be determined largely by the number of casks required.

H. Nuclear Regulatory Commission License Process and Issues

NSP submitted in August, 1990, an application to the Nuclear Regulatory Commission (NRC) for a license to build and operate the Prairie Island ISFSI. This application contains information on cask design and handling procedures, storage facility design, security system design, a security plan, and plans for radiation protection, surveillance and maintenance activities.

The NRC has been asked by NSP to approve the TN-40 cask as being environmentally safe, based upon a determination that it meets the requirements of Chapter 10 of the Code of Federal Regulations (10 CFR), Part 72, with respect to design, operation and decommissioning. The NRC must also approve the specific design of the proposed Prairie Island storage facility, which will use the TN-40, based upon a determination that the proposed facility is in compliance with 10 CFR Part 72.

NRC licensing requirements:

The Nuclear Regulatory Commission's requirements for the licensing of independent storage facilities are covered under 10 CFR Part 72. In the application NSP will be required to submit the information below.

a. A description and safety assessment of the site, to include assessment of potential interactions between the ISFSI and the nuclear power plant with which it shares the site.

b. A description and discussion of the ISFSI with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations.

c. The design of the ISFSI in sufficient detail to support the findings in the license to be granted, including:

    1. design criteria for the ISFSI,
    2. design bases and their relationship to the design criteria,
    3. information relative to materials of construction, general arrangement, and dimensions of principal structures and descriptions of all structures, systems and components important to safety.

d. An analysis and evaluation of the design and performance of structures, systems and components important to safety, with the objective of assessing the impact on the public health and safety resulting from operation of the ISFSI, including:

    1. margins of safety during normal operations, and
    2. adequacy of structures, systems and components provided for the prevention of accidents and the mitigation of their consequences, including natural and man-made phenomena and events.

e. The means for controlling and limiting occupational radiation exposures and for maintaining exposures as low as is reasonably achievable.

f. ISFSI features for design and operation which reduce to the extent practicable radioactive waste volumes.

g. Identification and justification for the selection of those subjects that will be probable license conditions and technical specifications.

h. An operational plan for the ISFSI, including planned managerial and administrative controls, the applicant's organization, and program for training of personnel.

i. If the proposed ISFSI design incorporates safety features not previously demonstrated effective by prior use or widely accepted engineering principles, a schedule must be submitted for resolving any remaining safety issues prior to initial receipt of spent fuel.

j. The technical qualifications of the applicant to engage in the proposed activities.

k. Plans for dealing with emergencies.

l. A description of the equipment to be installed to maintain control over radioactive materials in gaseous and liquid effluents produced during normal operations and expected operational occurrences, including:

  1. an estimate of the quantity of each of the principal radionuclides expected to be released annually during normal ISFSI operations,
  2. a description of the equipment and processes used in radioactive waste systems, and
  3. a general description of the provisions for packaging, storage and disposal of solid wastes containing radioactive materials.

m. Analysis of the potential dose equivalent or committed dose equivalent to an individual outside the controlled area from accidents or natural phenomena events that result in the releaseof radioactive material to the environment or from direct radiation from the ISFSI.

n. A description of the quality assurance program for all ISFSI components relating to safety.

o. A description of the detailed security measures for physical protection.

p. A description of the program covering preoperational testing and initial operations.

q. A description of the decommissioning plan, including financing and record-keeping.

An environmental report must also be filed which meets the requirements of Subpart A of 10 CFR Part 51. That environmental report will cover environmental interfaces and impacts.

Comment 11K asks what are the state and federal administrative steps necessary to switch from one (spent fuel storage) design to another. This switch would come in response to NRC's non-approval of the TN-40 cask as proposed. At the federal level, minor modifications to the cask design may be made as part of the approval process, with no resulting changes in administrative procedures. The final approval would cover the final design. Should the TN-40 prove to be unable to be approved, NSP would have to withdraw their current application and start over.

There are two options here. First, NSP could opt to submit an ISFSI application which would include use of a cask which has already been approved by the NRC, such as the TN-24. In this case, the plants' operating license under 10 CFR Part 51 would be amended to include an ISFSI, and a Part 72 license would not be needed. The ISFSI would still be required to meet the same license requirements for safety, emission levels, etc. The second option would be for NSP to submit another new cask design, which would mean that the process which is now going on would be repeated.

At the state level, the Environmental Quality Board would need to determine whether the change in casks creates a "significant modification" to the project, in which case a Supplemental Environmental Impact Statement would be prepared. If the project were to change in a more radical way, such as shifting from dry storage to enlarging the pool, it is likely that the environmental review would be more extensive.

Comments 11M and 19Y urged continued state involvement in the federal license process. This is now occurring through the state's intervention in that process. An updated discussion of the intervention is presented on page 2.1.

Anticipated schedule for license processing:

Application filed with NRC: August, 1990.

Initial cursory review by NRC staff. Notice of the application published in the Federal Register: October 19, 1990.

NRC will publish an Environmental Report on the proposed project six to eight months after application: February-April, 1991.

License would be issued about 18 months after application: February, 1992.

Review of the license application will be handled by two groups. Staff of the NRC will be responsible for procedural review. Technical review of the cask and the environmental report will be done by Lawrence Livermore Laboratories under contract to the NRC.

TN-40 licensing issues:

It is not likely that these will be known during the timeframe in which this EIS is developing. Transnuclear, Inc. has postulated that the following areas may be issues in TN-40 licensing: Properties of selected materials, containment material fracture toughness, boron/burnup credit, conservative assumptions/initial conditions, and conservative analysis methodology (e.g. approved codes, quality assurance, elastic stress limits).

Comment 13BB questioned the procedure for and wisdom behind recertification of the casks if they are still to be used beyond their initial 20 year license. The DEIS states that the design life of the TN-40 cask is 25 years, and the commenter states that this should be a deciding factor in recertification. Recertification of the casks would be decided by the Nuclear Regulatory Commission, and NSP would need to show that the casks could continue to meet the required storage conditions throughout the extended license period. In the December 17 public meeting on the DEIS in Red Wing, Laura McCarten of NSP stated that the 25-year life is for the cask monitoring system, which is designed to operate 25 years without required maintenance. She noted that after that time, the monitoring systems would need to be recharged or replaced. Other casks components would not be subject to similar aging.

Potential for licensing the TN-40 as a dual-purpose cask:

The NRC has established specific design criteria for casks used to transport spent fuel; these criteria are found in 10 CFR Part 71. Many of the transport cask design criteria are essentially the same as storage criteria, but there are also significant differences. The TN-40 cask design does not meet all the transport criteria, and so could not get a normal transport license. However, Part 71 does give the NRC the authority to allow limited use of such a cask with a normal transport license. The NRC would select the special transport measures it judges are necessary to provide an adequate margin of safety. Also see discussion of dual purpose cask as an alternative in Chapter 5.

References: Chapter 3

1. License application and supplemental information submitted by NSP to the Nuclear Regulatory Commission on August 31, 1990.

2. Meeting notes and prepared material from Prairie Island EIS workgroup meeting dated 4/3/90. Included a presentation by NSP/Transnuclear on ISFSI operation and cask design.

3. Meeting notes from meeting with Laura McCarten and Donn Eiden (both of NSP) on 5/30/90. Included discussion of NRC licensing process.

4. Material provided by NSP in preliminary draft version of Scoping Decision Document prepared as part of the EIS development effort, dated 2/13/90.

5. Material provided by NSP in development of the final version of the Scoping Decision Document as part of the EIS development effort, dated 5/17/90.

6. Memo from Scot Johnson, Minnesota Department of Natural Resources hydrologist on the Mississippi River System Team, to Gretchen Sabel, Environmental Quality Board, dated 6/4/90, discussing flood potential at proposed Prairie Island ISFSI.

7. "Probable Maximum Flood Study, Mississippi River at Prairie Island, Minnesota", 4/12/85, which was incorporated into the Updated Safety Analysis Report as Appendix F.

8. Notes from June 26, 1990 Meeting of the Prairie Island EIS Interagency Workgroup.

9. Supplemental material provided by NSP in 8/15/90 transmittal.

10. 10 CFR Part 72. Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste.

11. Letter from Transnuclear, Inc, to Laura McCarten, NSP, dated September 14, 1990.

12. Letter from Laura McCarten, NSP, to Robert Cupit, EQB, dated September 25, 1990.

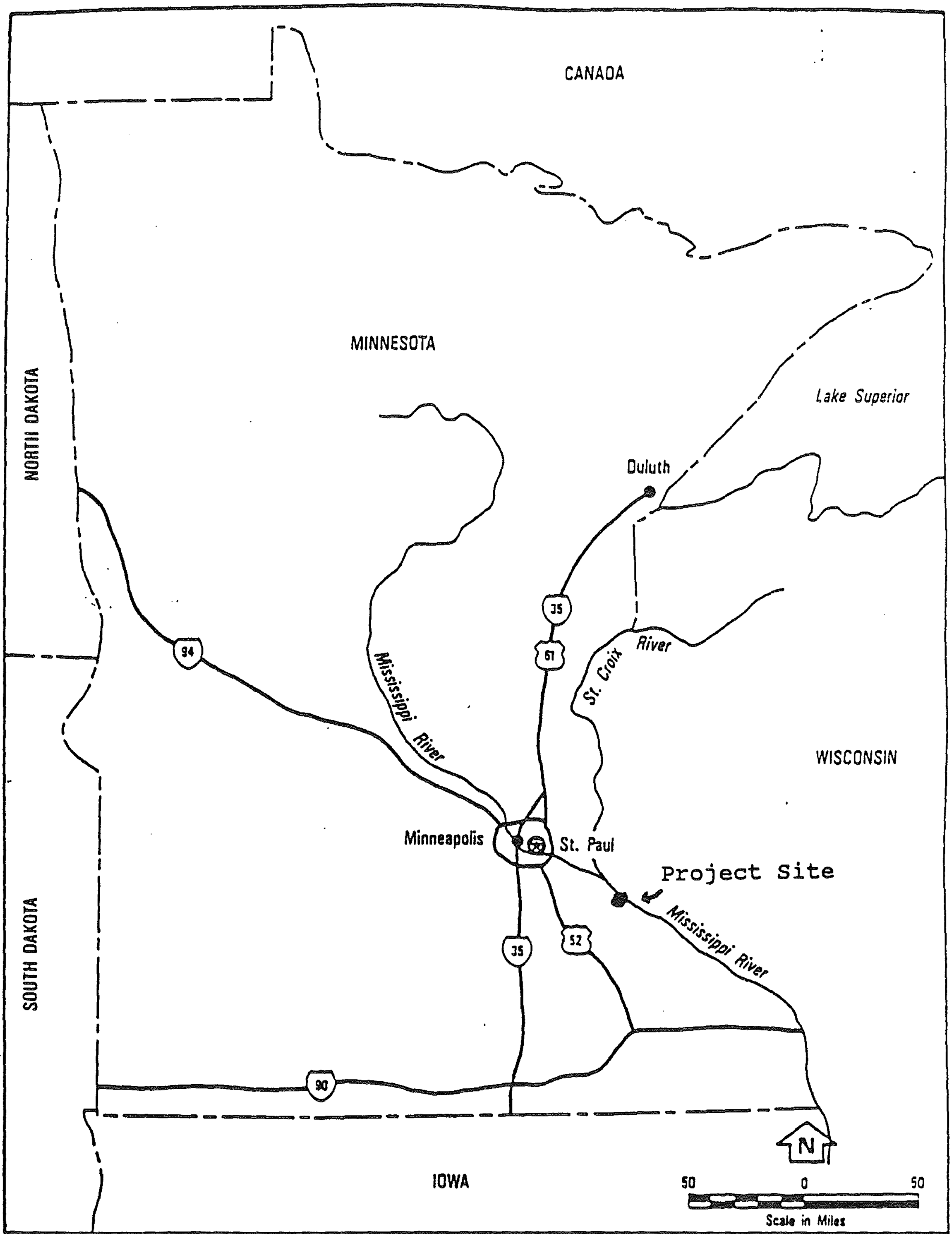


Figure 3-1

REGIONAL MAP

PRAIRIE ISLAND ISFSI

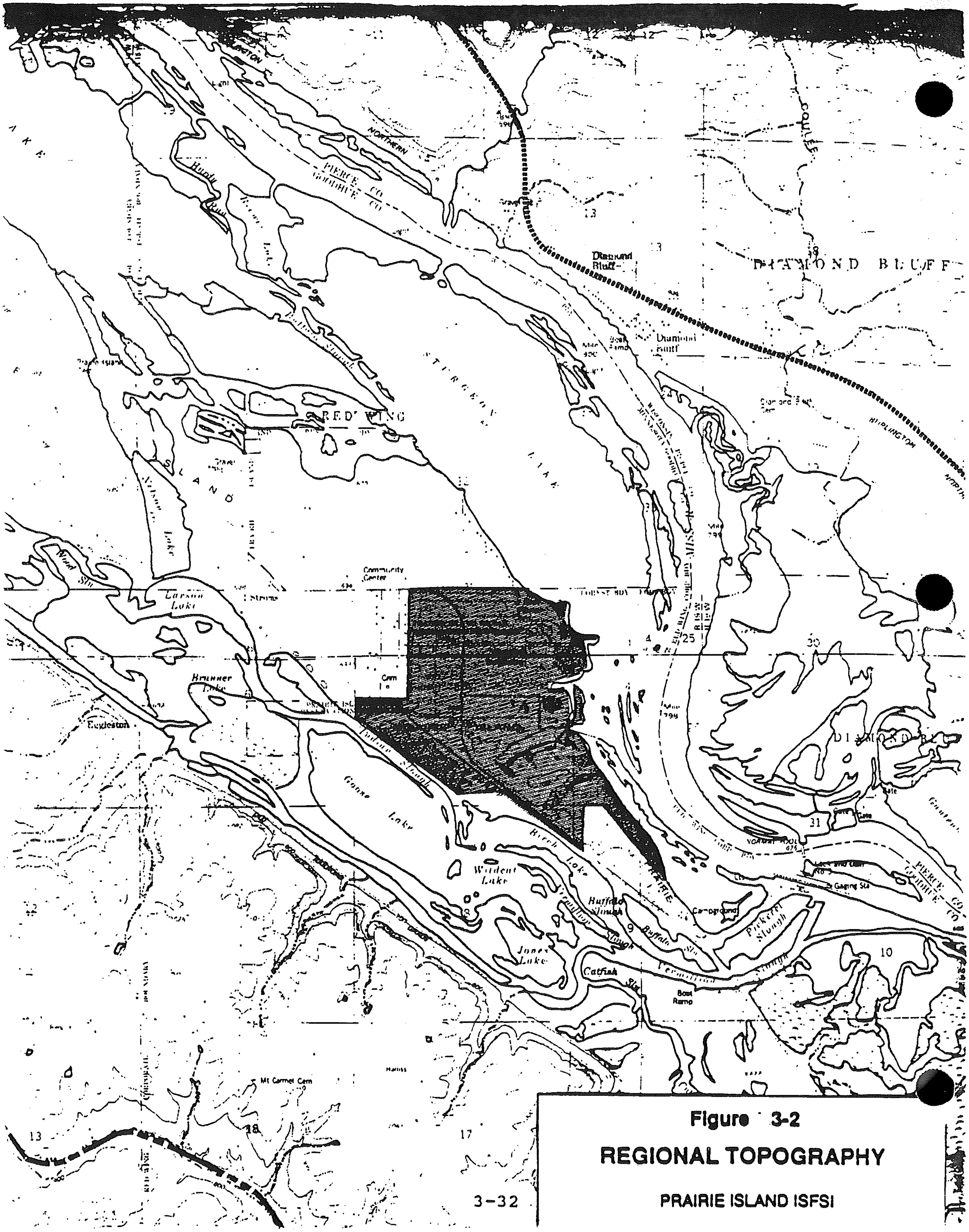
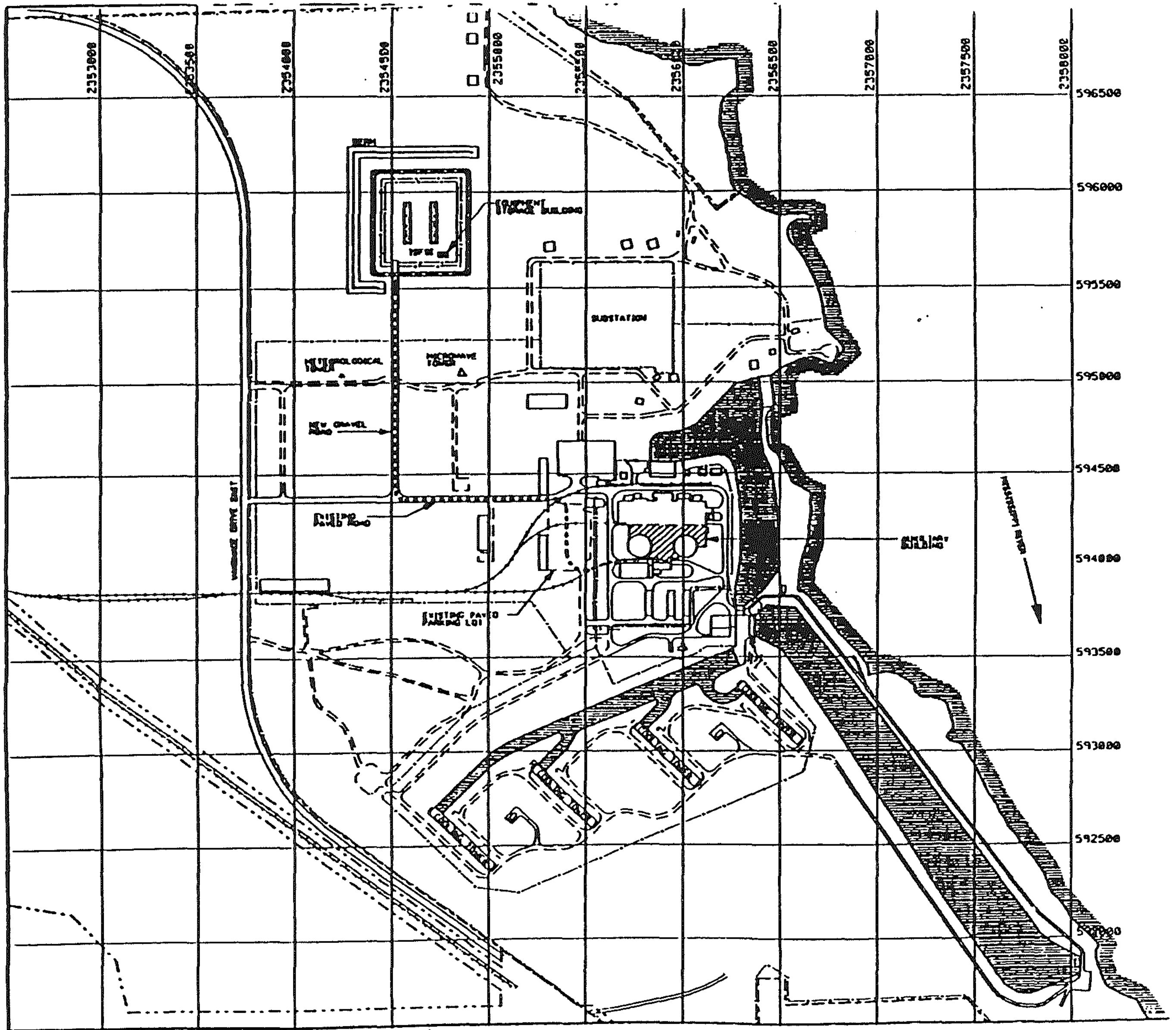


Figure 3-2

REGIONAL TOPOGRAPHY

PRAIRIE ISLAND ISFSI



NOTE:

1. REF: NSP PRAIRIE ISLAND DRAWING NO. NF-92700, REV. A

Figure 3-3

ISFSI SITE LOCATION

PRAIRIE ISLAND ISFSI

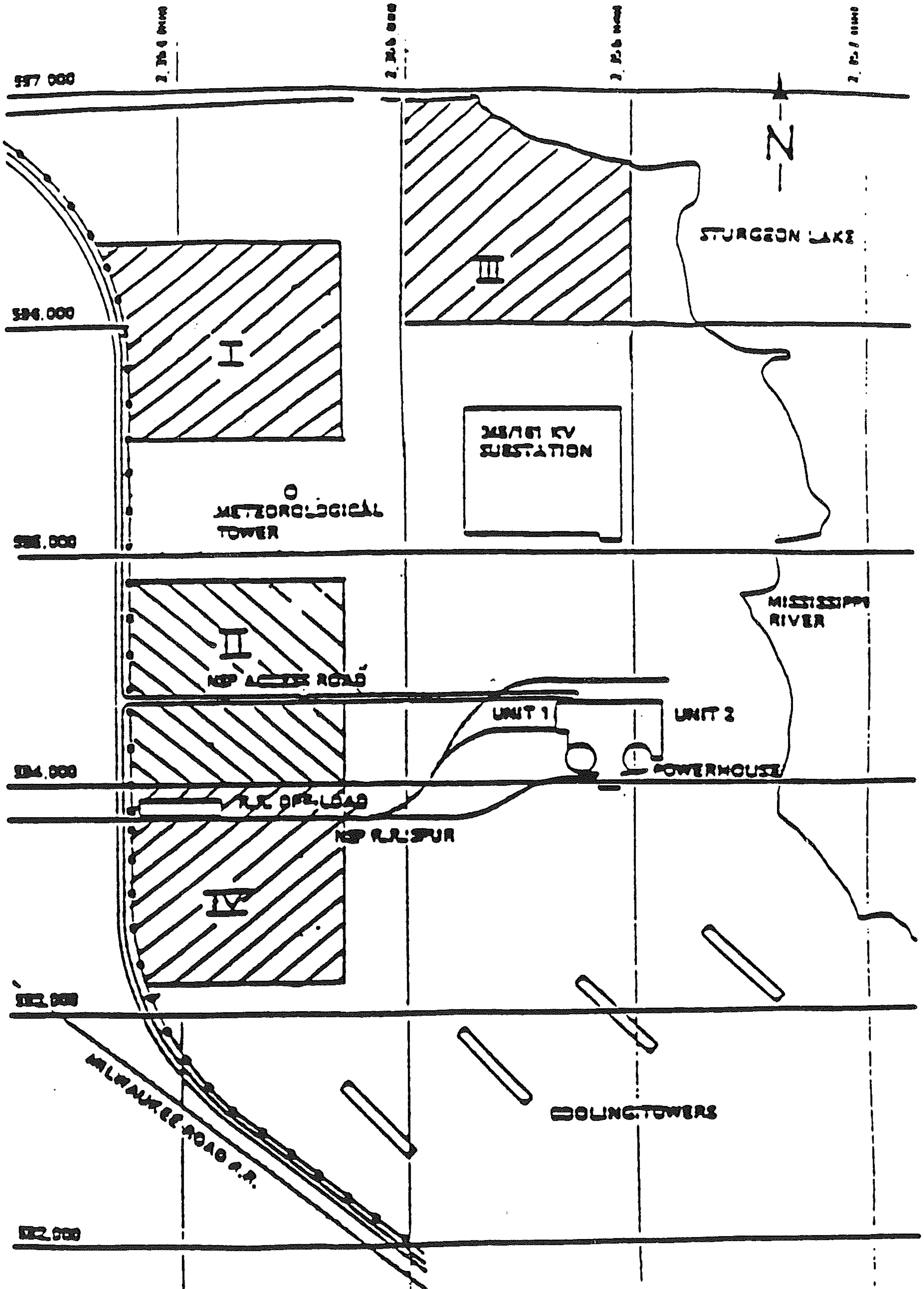


Figure 3-4

AVAILABLE SITES FOR ISFSI

PRAIRIE ISLAND ISFSI

Figure 3-5

SPENT FUEL DECAY HEAT vs TIME

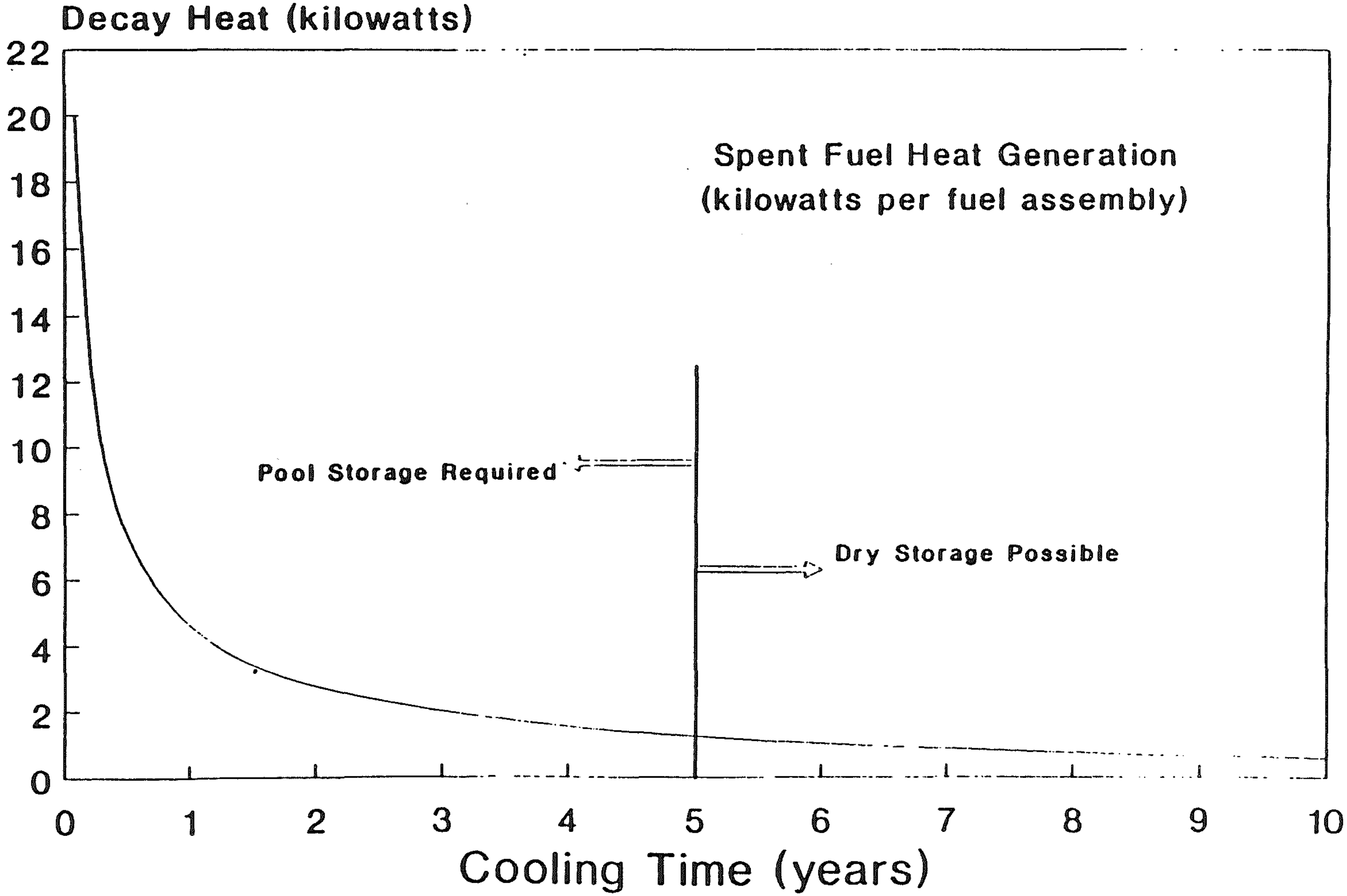
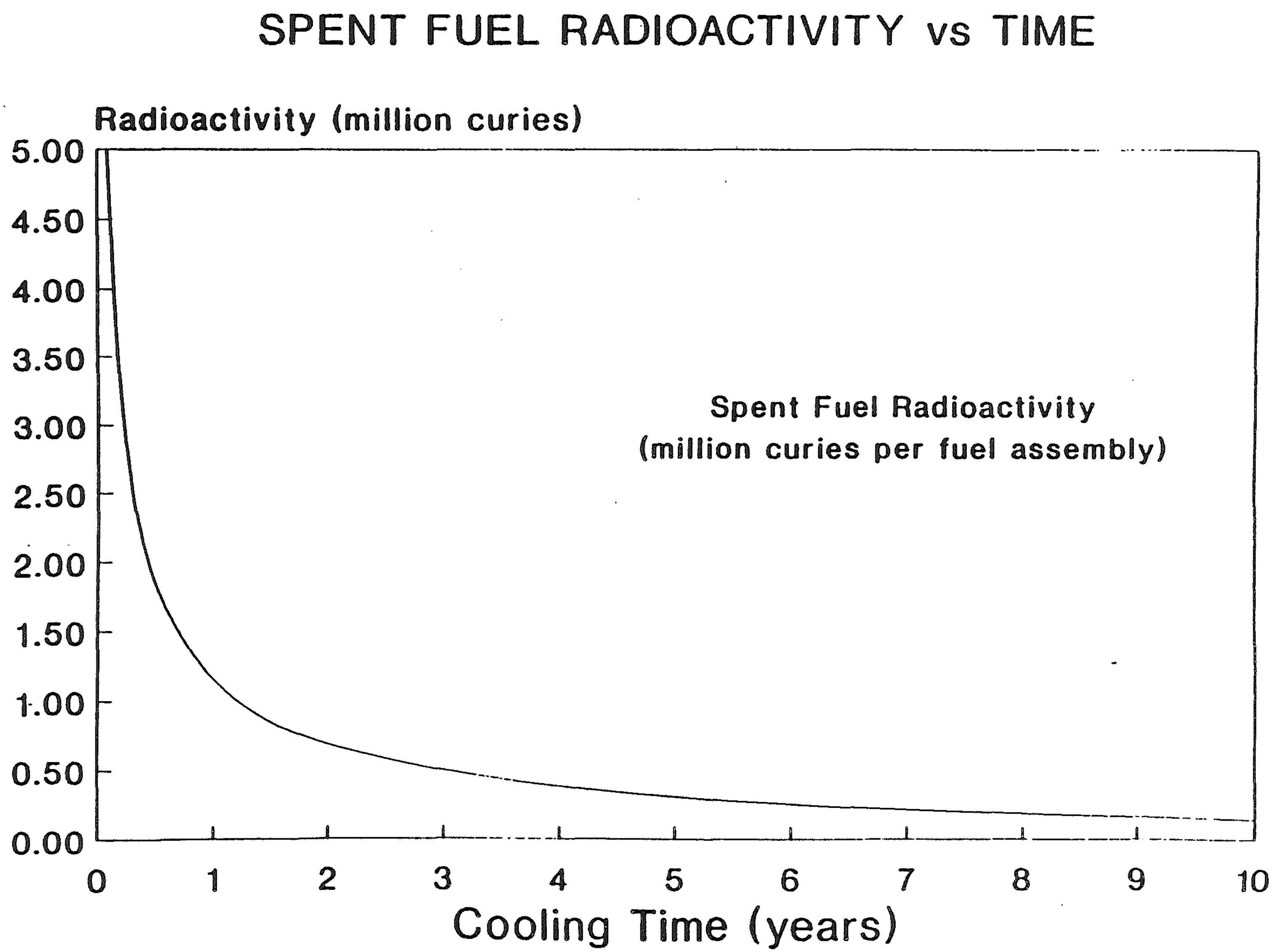


Figure 3-6



SPENT FUEL RADIOACTIVITY vs TIME
Radioactivity (million curies)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
1
2
3
4
5
6
7
8
9
10
Cooling Time (years)
Spent Fuel Radioactivity
(million curies per fuel assembly)

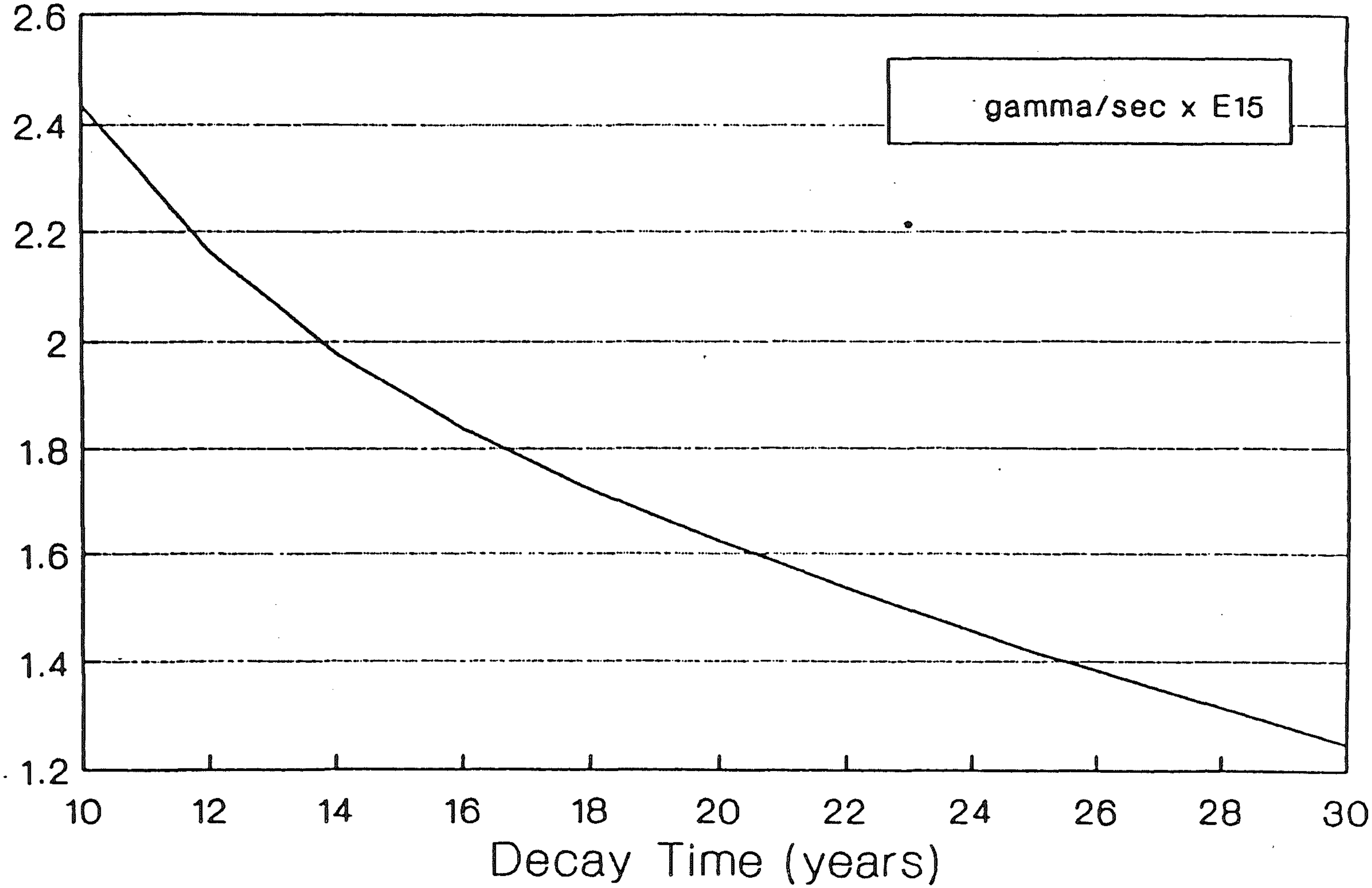


Figure 3-7

GAMMA SOURCE
DESIGN BASIS FUEL ASSEMBLY

PRAIRIE ISLAND ISFSI

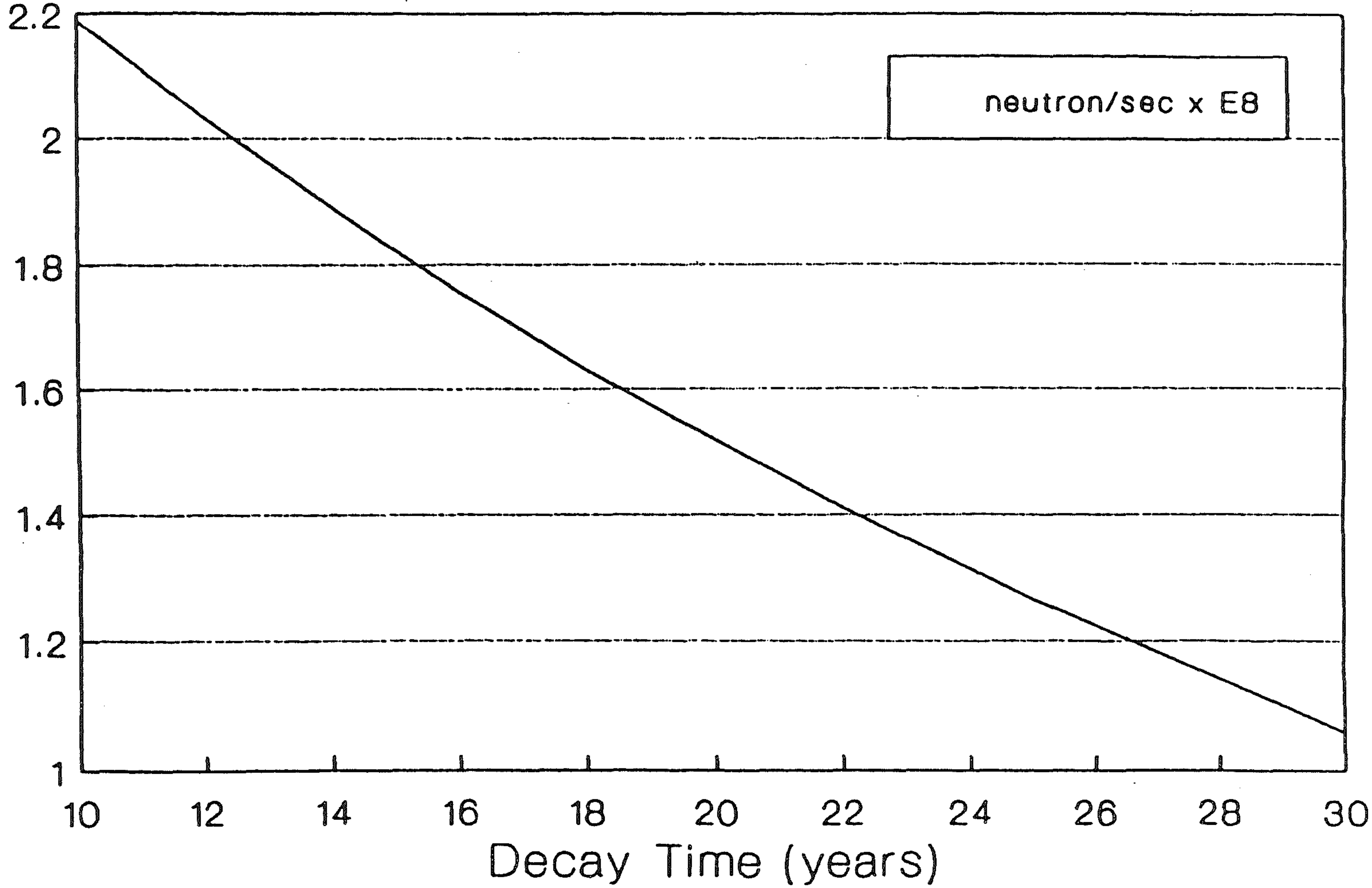
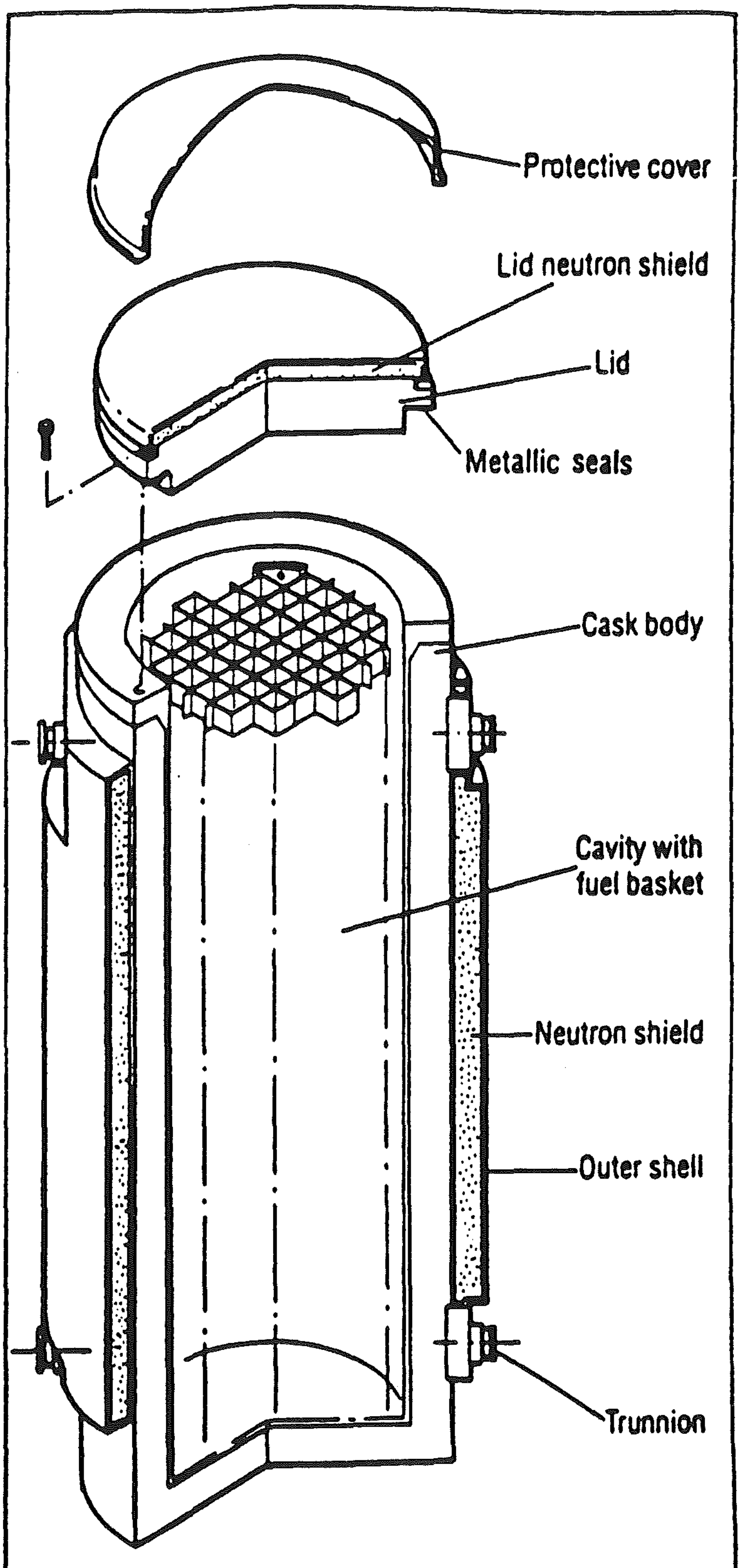


Figure 3-8

NEUTRON SOURCE
DESIGN BASIS FUEL ASSEMBLY

PRAIRIE ISLAND ISFSI



TN-40 CASK

Figure 3-9

HEIGHT: 16.5 FEET
DIAMETER: 8.5 FEET
WEIGHT: 120 TONS

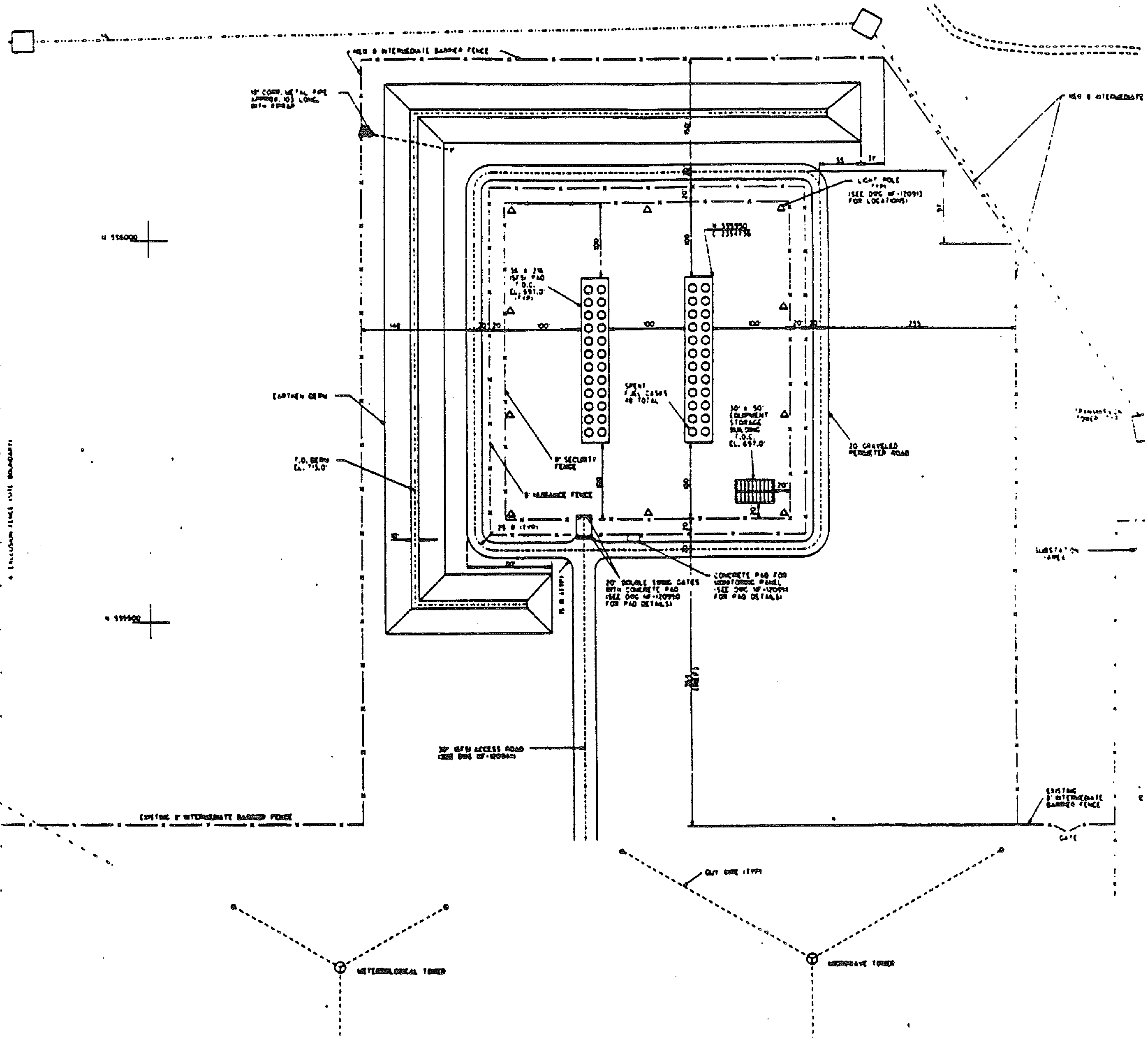


Figure 3-10

ISFSI SITE PLAN

PRAIRIE ISLAND ISFSI

CHAPTER 4

ANALYSIS OF PROPOSED PROJECT

A. Wastes and emissions

Operation of the ISFSI will not result in the generation of gaseous, liquid, or solid radioactive wastes other than those resulting from the decontamination of the outside surface of the casks. Decontamination of the casks will take place in the Auxiliary Building prior to transfer of the casks to the ISFSI. These radioactive wastes will be treated using existing Prairie Island radioactive waste control systems.

Contaminated pool water removed from the loaded storage casks will normally be drained back into the spent fuel pool with no additional processing. A small amount of liquid waste will result from storage cask decontamination. The decontamination procedure will result in a small amount of a detergent/demineralized water mixture being collected in the cask decontamination area. Liquid wastes collected in the cask decontamination area are directed to the aerated waste sump tank, where it will be mixed with other plant liquid wastes, treated or held up for decay, and released.

Potentially contaminated air and helium purged from the storage casks following spent fuel loading will be handled by the spent fuel pool ventilation systems, or by the gaseous radwaste system. Air in the spent fuel pool area is normally exhausted through filters which decontaminate the air before it is discharged. In the event of a high radiation signal, ventilation is performed by the spent fuel pool special ventilation system, which has additional activated charcoal filters.

A small quantity of low level solid waste will be generated as a result of storage cask loading operations and transfer cask decontamination. The solid waste generated will consist of disposable anti-contamination garments, tape, blotter paper, rags, etc. It will be handled as a part of Prairie Island's low-level waste stream, and will not create any additional impacts.

B. Construction impacts

Land use and vegetation:

Construction of the ISFSI, including the ISFSI site area, berms and access road, will affect approximately 10 acres of the 560 acre Prairie Island Plant site area. Most of the construction area is covered with prairie grass and weeds. Portions of the ISFSI site and adjacent areas have been used for the disposal of dredged material taken periodically from the station intake channel. Trees will need to be removed from an area approximately 250 feet wide by 1000 feet long. The tree types found in this area are 70% cottonwood, 20% willow, and 10% a combination of box elder, Siberian elm and sumac. Six oak trees will also be removed.

Timber resulting from the clearing operation will be collected for appropriate disposal.

The area to be occupied by each concrete storage pad will be excavated separately. Approximately 4,000 cubic yards of material will be removed per slab, replaced with more suitable fill and then compacted. A spoil area, located near the excavation site, will be graded and used for storage during construction. Explosives will not be used in any of these construction activities. Following excavation and compaction, each concrete slab will be formed using ready-mixed concrete transported to the site by truck. The approximate dimensions of each slab will be 36 feet wide by 216 feet long and three feet thick, thus requiring approximately 863 cubic yards of concrete. At 10 yards per truck, approximately 87 truck loads of concrete will be required for completion of the two ISFSI pads. More would be needed for the equipment building also to be built in the ISFSI area, which would bring the total number of truckloads of concrete to around 100.

Temporary buildings at the site will be erected for use during the construction period. These buildings will be removed upon completion of the facility.

The principal terrain alterations to the site area will come from clearing, excavation, and grading of the approximately 10 acre site. After construction of the facility is complete, the area immediately surrounding the slabs will be covered with crushed rock. The disturbed area around the ISFSI will be reseeded with grasses.

The construction of the ISFSI will not impact off-site land use.

Wildlife:

The ISFSI will displace approximately 10 acres of habitat consisting primarily of prairie grasses and weeds. The habitat is used by common small mammals, insects and birds. The habitat is not unique or critical to wildlife. The ISFSI site area is not used for nesting or feeding by bald eagles or migratory birds. Disruption of wildlife activities is expected to be minimal.

Several comments were received on the impacts of the proposed project on wildlife, specifically birds. Comments 12C and 13U asked whether the effects of radiation on birds could be greater than its impact on humans, and raised particular concern about possible effects on the fertility of herons and the survival rates of infant birds. Comments 12B and 13T asked about harmful effects on endangered bald eagles either nesting or fishing in the area near Prairie Island.

Research indicates that wild birds are less sensitive to gamma radiation than humans. Two Canadian wildlife biologists, Reto Zach and Keith Mayoh, have experimented in the wild with swallow embryos and recently-hatched swallows and wrens. No bird embryos or nestlings died from doses of up to 600,000 millirad. A dose this high would have been fatal to more than half of a group of humans exposed to the same amount of gamma radiation. They conclude "our results suggest that radiation protection for man . . . is more than adequate for wild birds such as Tree Swallows and House Wrens. There is no need for separate limits [on maximum permissible doses of radiation]." Doses of 100,000 to 450,000 millirad had no effect on hatching or fledging success rates, but were found to cause retarded growth in young birds. Embryos and newly-hatched birds exposed to doses of 40,000 to 80,000 millirad showed no effects on growth (millirad, a measure of energy, are on a similar scale to millirem, a measure of effect on human tissue; for a fuller discussion of measurement of radiation, see Appendix G.

There is a pair of nesting bald eagles on the Wisconsin side of the river approximately one mile from the proposed ISFSI location. At about the same distance as the residence 1540 meters SSE of the ISFSI, the maximum dose would be less than 4 millirem from a year of continuous exposure, as compared to 100-125 millirem per year from natural background radiation outdoors in Minnesota (radon can only become a significant source of radiation in enclosed areas). The largest concentrations of bald eagles in the vicinity of Prairie Island are over the Mississippi near Prescott, Wisconsin (about 20 miles upstream), and the next most important area for wintering bald eagles is near Trenton and Bay Point Park (below Lock & Dam No. 3, about four miles SE from the ISFSI). Bald eagles have been observed in the winter over the portion of the river below the power plant (half a mile or more SE of the ISFSI site), but only briefly and in small numbers.

David F. DeSante has performed research on the relationship between dramatically reduced reproductive success of birds in 1986 and fallout from the Chernobyl accident. His article in The Condor does not discuss radiation, but only points to it as a possible explanation for the drop in the numbers of young birds in that year. He hypothesizes that radioactive iodine-131 fell on vegetation and was eaten by caterpillars and other grazing insects, which in turn were fed to young birds, with the result that the radioactive iodine concentrated in the growing birds' thyroids and eventually caused many of them to die. He has done further research comparing fallout patterns with mortality of young birds, but because it is still unpublished, he was unwilling to share the results of this research with the preparers of the EIS.

This research is not directly relevant to the ISFSI, which would emit very low levels of direct radiation (less than 4 millrem per year at the plant boundaries), but would not release any radioactive materials into the environment. Radioactive materials with long half-lives continue to irradiate organisms from within long after they are ingested, and may concentrate as they move up the food chain. Direct radiation, on the other hand, does not make insects, vegetation, or other food radioactive; irradiation occurs only as long as a person or animal is directly exposed to the source of radiation, and the radiation comes from outside rather than from inside of the organism.

Sources:

DeSante, David F. and Geoffrey R. Geupel, 1987, "Landbird Productivity in Central Coastal California: The Relationship to Annual Rainfall and a Reproductive Failure in 1986" The Condor, Vol 89:636-653.

Guthrie, John E. and Janet R. Dugle, 1983, "Gamma-Ray Irradiation of a Boreal Forest Ecosystem: The Field Irradiator - Gamma (FIG) Facility and Research Programs," The Canadian Field-Naturalist, Vol. 97:120-128.

Sturges, F.W., 1968, "Radiosensitivity of Song Sparrows and Slate-colored Juncos," Wilson Bulletin Vol. 80:108-109.

Zach, Reto and Keith R. Mayoh, 1982, "Breeding Biology of Swallows and House Wrens in a Gradient of Gamma Radiation," Ecology, 63(6):1720-1728.

Zach, Reto and Keith R. Mayoh, 1984, "Gamma Radiation Effects on Nestling Tree Swallows," Ecology, 65(5):1641-1647.

Zach, Reto and Keith R. Mayoh, 1986, "Gamma Irradiation of Tree Swallow Embryos and Subsequent Growth and Survival," The Condor Vol. 88(1):1-10.

Comments 11G and 11H pointed out that it is likely that migratory birds, most notably songbirds, do presently use the 10 acres of grassland and woods, and that the figures on the heron rookery could be out-of-date.

The DNR reports that the Great Blue Heron rookery located three miles southeast of Prairie Island in the Cannon River Bottoms was reported active as of May, 1990. At this time it contained at least 230 nests. No egrets were reported present.

A list of rare natural features within two miles of the Mississippi River in the vicinity of the Prairie Island facility from the Minnesota Natural Heritage Database indicated no reports of such features within a mile of the proposed ISFSI site. The nearest reported occurrence was a gopher snake (a species of special concern, not considered threatened or endangered) seen a mile-and-a-half west of the ISFSI site in 1984. Two sitings of bald eagles had been reported to the Natural Heritage Foundation, one near the Lock and Dam No. 3 in 1988 (two miles from the ISFSI site) and one near Round Lake (a little more than four miles distant). All other reports of rare features have been three miles away or more, most of these along the Cannon River (predominantly wood turtles and red-shouldered hawks). While not all observances are reported to the Natural Heritage Database, and rare species may be present but not be observed, more detailed studies conducted in the vicinity of the plant in earlier years did not indicate any species which would be threatened by the construction of the ISFSI. Plant and wildlife populations within 1.5 miles of the Prairie Island plant were studied during 1972-1979, with particular studies carried out on Herons/Egrets, Doves/Grackles, and Bald Eagles within a much larger area from 1974 to 1981.

Sources:

Minnesota Department of Natural Resources, Wildlife Section "Natural Heritage Database Print-out: Rare Natural Features within Two Miles of Mississippi River in the Vicinity of Prairie Island Nuclear Facility", February, 1991.

Memorandum from Bonnie Brooks, Nongame Wildlife, Rochester Region, Minnesota Department of Natural Resources, January 1991.
Water Bodies and Aquatic Resources:

Water Bodies and Aquatic Resources

Construction of the ISFSI will not impact local water supplies. Concrete for the slab will arrive on the site ready-mixed. Drinking water and water for the cleaning operations and fugitive dust control (spraying) will be transported to the site by truck. The portable rest rooms provided during construction require no on-site source of water. During clearing and excavation operations a temporary drainage system may be constructed to collect the runoff into temporary settling ponds. More permanent drainage will be installed as soon as area excavations and backfill allow. This system will be maintained to handle surface drainage through the construction period to minimize erosion.

The runoff will be directed to a natural swale which eventually leads to the low marshland north of the plant property. The drainage system will not alter the natural drainage patterns. Excavated material and/or fill will not be dumped into existing water bodies.

Other activities such as dredging, construction of shore-side facilities (jetties, piers, etc.) or construction of cooling ponds will not be done as part of the proposed project. As the construction of the ISFSI involves no use or degradation of the regional water, its impact on navigation, fish and wildlife resources, water quality, water supply, and aesthetics should be negligible.

Socioeconomics:

A peak construction force of about 20 workers, including all employees of contractors and their subcontractors working at the site, is anticipated. Since local construction forces will be utilized whenever possible, relocation of construction personnel families and provisions for housing, transportation, and educational facilities are not anticipated.

Site preparation is scheduled to commence in October, 1991 and should be completed by the end of the year. Construction of the ISFSI, including concrete pouring, building erection and other related activities, is scheduled to begin in the spring of 1992. The ISFSI is scheduled to be operational by February, 1993.

Fugitive Dust:

The fugitive dust emission associated with the construction of the ISFSI would likely come from clearing, excavation, hauling of fill, traffic on unpaved roads, grading, open burning of brush and timber, and wind erosion of excavated materials. Fugitive dust control measures, such as watering of unpaved roads, will be implemented to limit impacts on air quality to acceptable levels.

Noise:

Construction activities associated with the ISFSI, in particular clearing, hauling of fill, compaction, and concrete pouring, will generate noise. Noise produced during construction can potentially impact construction workers, the surrounding community and the surrounding wildlife.

By complying with all applicable OSHA (Occupational Safety and Health Administration) noise regulations, the impact of noise on the construction workers will be limited to acceptable levels. In the surrounding community, the closest residence is over 1000 feet from the ISFSI site. This distance will provide some attenuation of noise levels resulting from construction. In addition, construction activities will be limited to normal working hours. Accordingly, construction noise impacts are expected to be minimal.

Displacement of resident fauna within the proposed ISFSI is likely to occur due to construction activities which produce noise. Since wildlife egress from the area immediately surrounding the construction site is unrestricted, the construction noise impact on wildlife is expected to be minimal.

Cultural Resources:

The area where the Prairie Island Plant is located is one of past Indian and early French trader activity. Therefore, NSP commissioned a thorough archaeological survey of the entire Prairie Island Plant site area in the summer of 1967 prior to plant construction activities. This survey, under the direction of Dr. Elden Johnson, then Minnesota State Archaeologist, was conducted to assure that construction activities would not destroy evidence of Indian and the early French trader's activities. The report from this study is summarized below.

The 1967 survey found nothing significant in the immediate power plant or ISFSI area. However, at the south edge of the plant site, the excavation team located eight Indian burial mounds of which they excavated five. The acid soil has apparently destroyed most of the bones that might otherwise have been found. The mounds were estimated to have been made between 500 BC and 800 AD.

The archaeological team also found signs of an Indian village (about 1000 feet by 400 feet in oval shape) at the south boundary of the plant site. This Indian village, called the Bartron Archaeological Site, is located partially on NSP property. NSP has designated that portion of its plant site in which the Bartron village is located to archaeological interests, both to preserve the Bartron site and to make it available for future intensive field research. In February, 1971, the Bartron Archaeological site was added to the National Register of Historic Places.

A number of other archeological and historic sites were found within a five mile radius of the Prairie Island plant, but no more were located within the plant boundary and so are not discussed herein.

Of special recreational interest is the Mississippi River Valley in the vicinity of Red Wing and the Prairie Island Plant. This section of the valley is about three miles wide and 340 feet deep. Typical of old river systems, steep wooded bluffs rim the valley floor. The main channel of the Mississippi River is a popular recreational spot for sport fishing, boating, and water skiing.

Some picnicking occurs in the area as well. Picnic facilities have been established by the Red Wing Wildlife Protective League in a region east of Diamond Island. In Wisconsin, two parks are presently proposed to be developed, one on the Trimbelle River and one in the Morgan Coulee region. Camping now occurs at Commissary Point Campground, located directly southeast of the Prairie Island Plant.

The valley area is also part of the Mississippi Flyway, used by migratory birds. Through this area migrate large numbers of waterfowl. The Gantenbein/Sturgeon Lake area seems to receive the heaviest use. Extensive hunting of waterfowl does occur. The study area also contains deer and upland game. Some hunting of this type also occurs.

Two other areas of particular scientific significance are nearby. Three miles downstream from the Prairie Island Plant there is a heron rookery. In 1976 this rookery covered approximately 50 acres and contained 154 nests. Most birds were great blue herons. Some American egrets were also present. In addition, bald eagle concentrations can be found within a five mile radius of the plant in the winter months.

None of the historic, recreational or scientific areas noted will be significantly impacted by the proposed project.

C. Operation impacts

Land use and vegetation: Refer to discussion under "Construction Impacts".

Wildlife:

Operation of the ISFSI will have a minimal impact on the local wildlife. Birds are not expected to roost directly on the casks due to their high surface temperature. The fence which surrounds the ISFSI will prevent access by larger mammals.

Water bodies and aquatic resources:

Operation of the ISFSI will not require use of any water or aquatic resources. Runoff from the site will be generated following precipitation events. This runoff will not be contaminated with radiaoactivity since the exterior of the casks will be decontaminated prior to cask transfer to the ISFSI and the spent fuel pool racks will be stored in the Equipment Storage Building where precipitation will not fall upon them.

The radiological quality of the ground water on Prairie Island was brought up in comments 3B and 8A. As a part of the Radiological Environmental Monitoring Program at the Prairie Island plant, local ground water samples are collected and analyzed for tritium. Tritium is a radioactive form of the element hydrogen. It occurs in very small amounts in nature, and is formed in nuclear power plants as a by-product of power production. Tritium is also produced when nuclear weapons are exploded. For this reason, tritium is present in ground water supplies which were recharged from the 1940's through 1970. For more information, see Alexander and Alexander, "Residence Times of Minnesota Groundwater", Journal of the Minnesota Academy of Sciences, 1989.

The Prairie Island plant is allowed to discharge small amounts of tritium to the Mississippi River, within guidelines established by the Nuclear Regulatory Commission and the Environmental Protection Agency. Wastewater flows into the discharge canal, and from there into the main channel of the Mississippi River. Ground water flow on Prairie Island appears to be generally from northeast to southwest, or from the Mississippi River to the Vermillion River.

During routine monitoring, tritium has been detected in Prairie Island ground water. The highest level found was 1870 pico-Curies per liter (pCi/l). This was in a residential well south of the plant, between the discharge canal and the Vermillion River. Lower levels of tritium have been detected in other drinking water wells and ground water seeps. The intial observation was made in November, 1989, and has been confirmed in subsequent sampling. The U.S. Environmental Protection Agency allows drinking water to be consumed which contains up to 20,000 pCi/l of tritium.

The following discussion of the problem and remediation is taken from an internal NSP memo from Fred Fey to Laura McCarten, dated January 31, 1991.

"While not certain that the Prairie Island Plant is the source of the tritium found in ground water, NSP has identified a possible pathway. The discharge canal where tritium is released is located at a higher elevation than the nearby Vermillion River. The wells found to contain low levels of tritium are located between the discharge canal and the Vermillion River. It is possible that water containing tritium is traveling through ground water from the discharge canal to the Vermillion River. In orger to minimize this potential source of tritium, NSP is extending its discharge pipe to the end of the discharge canal. When this project is completed, only a short portion of the discharge canal would contain tritium during a release, thus reducing the potential for any tritium from this source reaching the ground water.

The discharge pipe extension project is expected to be completed before spring of 1991. If this is the source of tritium in the ground water, the tritium concentrations are expected to gradually go down. NSP will continue sampling well water in the vicinity to monitor ground water tritium concentrations. Results of the sampling are included in an annual Radiological Environmental Monitoring Program report."

Sampling will also be conducted by the Minnesota Department of Health on a continuing basis.

Sources:

1989 Annual Radiological Environmental Monitoring Report; NSP report to the Nuclear Regulatory Commission. Cover letter dated April 27, 1990.

January 11, 1990 letter from Donn Eiden, NSP to Jack Ditmore, Chair, Minnesota Environmental Quality Board, discussing tritium found in a residential well near the Prairie Island plant.

January 31, 1991 internal NSP memo from Fred Fey to Laura McCarten, with updated information on the tritium in Prairie Island ground water.

Socioeconomic:

Operation of the ISFSI will require no additional personnel at the Prairie Island plant, so there will be no employment impacts associated with operation of the ISFSI.

A number of comments criticized the DEIS for failure to specifically address impacts on the adjacent Prairie Island Mdewakanton Sioux Indian Reservation (several oral comments and Comment 16A). There was no willful intent to omit impacts on the Indian community. No issues relative to the reservation were raised during the scoping process in early 1990, either through written comments or at the public meetings. The purpose of the scoping process is to identify through public participation the alternatives and impacts to be included in the EIS. The Tribal Council received all mailings since the beginning of the environmental review process, and proper notices were provided in the media and by mail.

Nevertheless, concerns about the proposed project were voiced by several members of the community and others outside of the community. Comment letters were received from one resident of the reservation (1) and from the attorney for the Tribal Council (15).

Comment 15A refers to "technical and legal assistance", which, upon request, can be provided by the EQB to Indian tribes pursuant to Minnesota Statutes, section 116D.722. However, that statute was designed to provide assistance in the event that a high level radioactive waste repository was being sited in Minnesota. The statute specifically excludes the on-site storage of spent fuel from consideration. While it may be argued that some issues relevant to the proposed ISFSI are not dissimilar from a repository, the intent of the statute is clear.

Comment 15B reflects the opinion of the Tribal Council that the proposed facility will cause certain diminishment of the Community environment and culture, and is duly noted. Quantification of such impacts is difficult at best, and necessarily relates to the historical association of NSP and the reservation as neighbors since the late 1960's. The reservation is immediately adjacent to the plant and all traffic to the plant passes through the reservation. While direct, adverse impacts are not anticipated by NSP, any unanticipated offsite impacts could affect reservation resources and/or residents because of its proximity.

The potential of a major accident resulting in large radioactive releases from the casks was a concern in comments 1B, 15B, and 16B. The primary concern is that the reservation could become uninhabitable and that the Indian community would bear a major burden. While NSP and the NRC does not consider such a large release from the dry cask facility to be credible, if the technology and handling procedures are subject to massive failure for whatever reason, the reservation could be affected.

The issue of compensation by NSP to the Indian community, raised in comment 15J, is inappropriate in an EIS. There are other means to resolve this question.

There is no available information to suggest that there will be significant impacts on population levels and socioeconomics of the reservation, as raised in Comment 19C and 19D. As noted in the DEIS, the relatively small scale of facility construction may have minimnum effects on adjacent residents. There is also no information basis to estimate long term impacts resulting from residents or visitors to the reservation being uncomfortable with the dry cask facility. While it is suggested that business of the reservation's casino and bingo may be diminished by public fear of the dry cask facility, it would be speculation at this time to assume that. The NRC standards are designed to protect the nearest individual (at the site boundary), regardless of population size of a nearby community.

Aesthetic impacts were a concern of Comment 19E. The berm is proposed to be as high as the casks, and when seeded and landscaped, may be offensive to some residents, but will likely serve to screen both the casks and other existing parts of the generating plant which are presently unscreened. The additional security lighting required for the dry cask facitlity will create additional illumination at night.

Other comments made by parties interested in the Indian community are found elsewhere in this FEIS under separate topics.

Comment 9C emphasized the impact of closing the Prairie Island plant on the Red Wing community. Additional information was provided by NSP in its comment letter (10), p. 3. Premature shutdown of the plant would appear to have a significant adverse economic impact on the Red Wing community.

Comment 13V emphasized the impact on the area of building the ISFSI. There is no information basis to assume there will be adverse socioeconomic impacts on the area if the facility is built and operated as proposed and regulated by the NRC. Studies would be inconclusive and speculative.

Comment 13X raised the question of possible negative effects on property values due to the ISFSI, which would continue after the plant would be dismantled. This commenter also urged that the effect on property values for miles around and downstream of Prairie Island should be considered and accounted for.

None of the studies of house selling prices near nuclear power plants have found any negative effects on property values. One such study conducted in the area around Three-Mile Island reported a considerable drop in the number of house sales which lasted four to eight weeks after the accident, but still found no negative effect on prices near the plant. Studies using the same methods have found negative effects on prices of property near airports, highways, fossil-fuel burning power plants, landfills, and polluted bays. Given the lack of evidence correlating negative property values with nuclear power plants, there is little or no reason to expect that the ISFSI would have negative effects on the value of properties nearby. (For additional background, see Appendix K: Research on Property Values)

Sources:

Bjornstad, David J. and David P. Vogt, "Some Comments Relating to Model Specification on "Effects of Nuclear Power Plants on Residential Property Values" Journal of Regional Science 24(1):135-136, 1984.

Galster, George C., "Nuclear Power Plants and Residential Property Values: A Comment on Short-Run vs. Long-Run Considerations" Journal of Regional Science 26(4):803-805, 1986.

Gamble, Hays B., R.H. Downing and O.H. Sauerlender, Effects of Nuclear Power Plants on Community Growth and Residential Property Values, Final Report NUREG/CR-0454, Nuclear Regulatory Commission, 1979.

Gamble, Hays B. and Roger H. Downing, Effects of the Accident at Three Mile Island on Residential Property Values and Sales, Final Report NUREG/CR-2063, Nuclear Regulatory Commission, 1981.

Gamble, Hays B. and Roger H. Downing, "Effects of Nuclear Power Plants on Residential Property Values" Journal of Regional Science 22(4):457-478, 1982.

Nelson, Jon P., "Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications" Land Economics 57(3):363-372, August 1981.

Payne, B.A., S. Jay Olshansky and T.E. Segel, "The Effects on Property Values of Proximity to a Site Contaminated with Radioactive Waste" Natural Resources Journal 27:579-590, S 1987.

Webb, James R., "Nuclear Power Plants: Effects on Property Value" The Appraisal Journal, April 1980, pp. 230-235.

Fugitive dust:

Dust will be generated only when vehicles operate along the gravel road surrounding the ISFSI. This dust will be mitigated by surrounding vegetation, and will not create any environmental impacts.

Noise:

The only operational noise associated with the proposed action will result from the transfer of spent fuel from the spent fuel pool facility to the dry cask storage facility. This will only occur 48 times during the 20+ year life of the ISFSI with normal operations. Since the noise associated with this operation is expected to be minimal, and the frequency of its occurrence quite low, no adverse impacts are expected.

Cultural Resources:

Refer to discussion under "Construction Impacts".

Climatological Impacts:

Operation of the ISFSI is not expected to affect the climate of the region. As the cask surface temperature may approach 240° Fahrenheit, the air temperature in the immediate vicinity of the casks will be higher than the ambient temperature. The affected area will be relatively small and localized. During rainy days, precipitation may vaporize at the cask surface because of the relatively high cask surface temperature.

In order to determine whether a cask-generated water vapor plume would produce fogging, water vapor concentrations were calculated by using the U.S. Environmental Protection Agency Industrial Source Complex Dispersion Model. This analysis is presented in the Environmental Report which was submitted to the Nuclear Regulatory Commission as part of the ISFSI license application.

It was concluded that the fogging impacts due to the ISFSI casks at the county road and location of the nearest residence would occur less than one percent of all hours during both the May-October and November-April periods. These results are conservative since the analysis does not account for the relatively low probability of simultaneous occurrence of the proper wind direction, ambient temperature and precipitation conditions needed for cask induced fog formation at the county road or the residence north of the site.

D. Protection from natural calamity

The storage casks must meet the same standards of protection from natural calamity as the plant itself. The standards applied to the

Prairie Island plant have therefore become the design basis for the casks. A detailed analysis showing how the casks would perform under the design basis conditions is presented in the Safety Analysis Report (SAR) which was submitted to the Nuclear Regulatory Commission as part of the ISFSI license application. The results of the analysis are discussed below.

Tornado and wind loading:

The SAR presents calculations which show the wind speed needed to either move or tip the cask. The results show that a wind velocity of 407 miles per hour would be needed to cause the cask to slide on the ISFSI pad, and that a wind velocity of 549 miles per hour would be needed to cause the cask to tip over. The maximum wind speed recorded in Minnesota is 92 miles per hour and straight line winds and tornados are estimated to reach 160 and 350 miles per hour, respectively, which shows that the casks are adequately protected from mishap from tornado and wind loading.

Tornado missiles:

The potential impact of two different tornado missiles was calculated in the SAR. The first missile modeled was a 4000 pound automobile which impacts the cask at 50 miles per hour, and the second was a four inch by 12 inch by 12 foot hickory plank. The analysis in the SAR shows that the impact of either of these missiles would not be sufficient to tip the cask over, even if accompanied by tornado-force winds. In both cases, some local damage to the neutron shield may result, but containment of the fuel would remain secure.

Comment 11I requested more information on missile impact. The outer layer of the cask is comprised of a thin outer shell which encases the aluminum cans containing neutron shield material (polyester resin). The outer shell would be punctured if the cask were struck by a tornado missile, resulting in some damage to the resin material at the impact location. The damaged resin could be replaced, and the puncture in the outer shell repaired. The steel containment layers of the cask could not be penetrated by the tornado missile.

Flood impacts:

Due to the proximity of the plant to the Mississippi River, flood potential and possible impacts must be taken into account in design of the ISFSI as well as all structures at the Prairie Island plant. Figures developed by the U.S. Army Corps of Engineers predict a 500 year flood elevation of approximately 690 feet. The ISFSI is proposed to be built at an elevation of 693 or greater, and so impacts from a 500 year flood event should be minimal.

Additional analysis done by NSP as part of their plant safety analysis report describe the probable maximum flood which could ever be experienced at Prairie Island. This is the hypothetical flood that would result if all the factors that contribute to the generation of the flood were to reach their most critical values that could occur concurrently. The probable maximum flood is derived from hydrometeorological and hydrological studies and is independent of historical flood frequencies. It is the estimate of the boundary between possible floods and impossible floods. Therefore, it would have a return period approaching infinity and a probability of occurrence, in any particular year, approaching zero. The probable maximum flood projected for the Prairie Island plant was determined to have a flow rate of 910,300 cubic feet per second and to have a corresponding peak stage of 704.1 feet.

If a flood of this magnitude were to occur, the lower half of the casks would be standing in the flood waters. The lids and seals would not be submerged. Calculations of force upon the casks at this point have shown that the casks would not tip over at the expected flood velocities, and so the containment and isolation of the spent nuclear fuel would not be jeopardized. The drag force from the probable maximum flood was calculated to be less than 20% of that needed to cause the cask to slide or tip.

The probable maximum flood level used in the SAR was an elevation of 706.7 feet above mean sea level, with a water velocity of 6.2 feet per second. This includes wave run-up The ISFSI would be sited and designed such that the lowest point of potential leakage into the cask is above the level of the probable maximum flood. For this reason, no inleakage of water can occur. Also, the interspace between the containment seals and the containment vessel cavity are pressurized to approximately 6 atmospheres and 2 atmospheres, respectively, to further preclude any possibility of water inleakage.

(The above referenced NSP analysis, "Probable Maximum Flood Study, Mississippi River at Prairie Island, Minnesota, Appendix F in Updated Safety Analysis Report, December, 1985", is available upon request from the EQB or for review at the Red Wing Public Library, the Minneapolis Public Library or the EQB offices.)

Seismic forces:

The analysis in the SAR shows that the design-basis earthquake would not create sufficient forces to cause the casks to slide or tip.

Snow and ice loading:

The decay heat of the contained fuel will maintain the storage cask outer surface well above 32^{o} Fahrenheit throughout the cask service life, including the end of life, even with an ambient outside temperature of -20^{o} Fahrenheit. Therefore, snow or ice will melt when it comes in contact with the cask so that snow and ice loadings need not be considered for the storage cask.

The temperature of the protective cover attached to the top of the cask above the lid could fall below 32^{o} Fahrenheit under certain conditions and a layer of snow or ice might build up. A snow or ice load of 0.35 pounds per square inch (corresponding to approximately six feet of snow or one foot of ice) could develop. However this load is insignificant to the TN-40 cask since the cover is a 0.38 inch thick torusphierical steel head which can withstand an external pressure over 20 pounds per square inch. Therefore, the cover will maintain its intended protective function under these snow or ice loading conditions.

Lightning strike:

Lightning would not cause a significant thermal effect. If struck by lightning on the lid, the electrical charge will be conducted by paths provided by the lid bolts to the body. The lid metallic O-ring seals can withstand temperatures of up to 600 ^{o} Fahrenheit without loss of sealing capability. It is not anticipated that lightning could result in the seals reaching temperatures above these values.

Comment 11J requested additional discussion of a lightning strike. The current from a lightning strike would be conducted along the outside surface of the cask to the ground, because the cask would act as a "Faraday Cage" just as cars or other structures with interior volumes and external surfaces do. This is why no significant effect on the metallic seals is expected. If a lightning strike did damage either seal, the pressure monitoring system would detect and indicate a loss of cask seal. In the event the cask seals are damaged, the cask would be taken back to the plant to replace the seals. Ten metal light standards, taller than the casks, are proposed to be installed around the periphery of the ISFSI. These would be more likely to be struck by lightning than would the casks, and thus would serve as lightning rods.

Thermal loading from temperature extremes:

In the SAR, the thermal analysis for normal storage concludes that the TN-40 cask design meets all applicable standards. The maximum temperatures calculated using conservative assumptions are low. The maximum temperature of any containment structural component is less than 303^{o}F (151^{o}C) which has an insignificant effect of the mechanical properties of the containment materials used. The maximum seal temperature (242^{o}F, 117^{o}C) during normal storage is well below the 570^{o}F long term limit specified for continued seal function. The minimum assumed temperature of -40^{o}F is also inconsequential to the packaging function.

The thermal analysis also considered accidental burial of the cask in a medium that will not provide the equivalent cooling of natural convection. The evaluation concluded that under the assumed conditions cask seal failure would occur 60 hours after burial. The SAR states that the ISFSI operating and emergency procedures will consider this time frame in planning for recovery from an accidental cask burial.

E. Radiological impacts during loading and storage

Refer to Chapter 6 for a discussion of radiological impacts, which has been significantly expanded from that in the Draft EIS.

Comment 4B requested an explanation of how the surface dose rate of each cask can be up to 125 mrem/hr and yet the use of the casks will only increase the net radiation output from the plant to 4-6 mrem/year. The radiation emitted by the casks drops off rapidly with distance. Table 7A-4 of the SAR shows this by giving calculated dose rates radially around the cask; 57.5 mrmem/hr at contact, 30.0 mrem/hr at 1 meter's distance, 19.7 mrem/hr at 2 meters and 13.8 mrem/hr at 3 meters. At longer distances, the dose rate continues to drop as distance increases. (The 125 mrem/hr figure quoted in the comment comes from page 3.10 of the DEIS, which states, "the cask surface dose rate shall be less than 125 mrem/hr." This is an upper-bounding condition, and not the calculated dose rate. See Chapter 6 for revised calulations.

Comment 7A suggested that a discussion of plant worker radiation exposure be included. This can be found on pages 7.4-1 through 7.4-2, Tables 7.4-1 through 7.4-6 and Figure 7.4-1 of the SAR. Also refer to Chapter 6 of this EIS. Off-site exposure would not be affected by loading or decontamination procedures, since these all occur within the Auxiliary Building. Transport of the loaded cask to the ISFSI is about a one-hour operation, over approximately 2400 feet of roadway entirely within the Prairie Island plant site boundary. Since the cask will not be taken off site, no Part 71 approvals are necessary. Off-site exposure during this period is included in the analysis of total off-site exposure. It is not calculated separately because it is not significant.

Comment 13Q noted that the DEIS was inconsistent in the discussion of radiation levels to be emitted by the ISFSI, citing discussions provided on pages 4.9 and 4.14. This is clarified in the new Chapter 6.

Comments 11L, 13L, and 4D related to "activation" of materials used in construction of the ISFSI, or radiation-induced deterioration of those materials. (Activation is the term applied to the process by which initially non-radioactive materials are made radioactive by prolonged exposure to neutron flux.) The following response was provided by Northern States Power on January 31, 1991:

> Cask materials do become slightly activated by the neutron radiation emitted by spent fuel contained within. However, because the level of neutron radiation emitted by spent fuel is so low, there is essentially no effect on the structural integrity of the cask materials. Significant changes in the cask material properties begin to occur after the material is exposed

to a cumulative neutron exposure of 10^{19} neutrons per square centimeter (n/cm^2). The highest neutron level in the cask body occurs at the beginning of storage and is about 4x10 n/cm^2-sec. Assuming the neutron radiation level remains constant instead of decreasing, the maximum total neutron exposure after 40 years would be about $5x10^{14}$ n/cm^2. Thus, after 40 years, the cask only experiences .005% of the threshold value of significant material changes. Because of the shielding provided by the cask, the neutron radiation experienced by the rebar (reinforcing bars or rods) in the concrete pad supporting the casks is less than that experienced by the cask materials, and there is no effect on the structural quality of the rebar.

The level of neutron flux outside the cask would not be great enough to cause activation of any materials besides the cask itself. This includes ISFSI construction materials and soils under the pads and in the berm. The casks will be decontaminated to the greatest extent possible at decommissioning (once unloaded), and then radiologically assessed as to whether they can be sold as scrap or must be disposed at a low-level radioactive waste landfill.

Comments 1C, 4E, 13W, 15F, and 19G all urged that more study of the health impacts of the proposed facility was needed. The EIS preparers discussed this with staff of the Minnesota Department of Health (MDH), who recommended that a health risk assessment be performed (comment 17D). They subsequently did perform this analysis, which is included as Chapter 6 in this document.

Comment 9G states that the exposure to radiation which leads to increased risk estimates should be quantified to show where the risk is speculative. This is covered in Appendix G, p. 13, line 1.

Comment 9F questioned the use of 5 rem as a level at which radiation in a concern in Appendix G. Both Battelle Northwest Ltd. and researchers Alice Stewart, George Kneale and Thomas Mancuso have found statistically significant increases in one or more forms of cancer among the population of workers employed at the federal nuclear facility at Hanford, Washington. According to EPA and DOE standards for workers at nuclear installations, they were exposed to chronic doses of no more than 5 rem/year. It is believed that at this federal facility, many workers were in fact exposed to the maximum permitted dose of 5 rem/year. This is why p. 13, line 1 states "below 5 to 10 rem." Since there is still considerable controversy surrounding these studies, it would be more accurate to state that effects cannot be detected much below 5 rem, and that there is little or no controversy above 10 rem.

Comment 9H states that the EIS should mention the concept of radiation hormesis. It is true that a number of scientists offer the hypothesis that very low doses of radiation may actually be beneficial, or hormetic. There are also a few scientists, such as John Gofman of Lawrence Livermore National Laboratory, who believe that low doses produce more cancer per unit of radiation than high doses (thus exposing a million people to 5,000 millirem would still cause fewer additional cancers deaths than exposing each of them to

10,000 millirem, but the number of additional cancer deaths would be reduced by less than half). Both are minority views among health physicists. It is impossible to prove hormesis either true or false, since there is no group of people in the world not exposed to natural background radiation who could serve as a control in an experiment.

F. Accident impacts

The casks have been designed for safe storage of spent nuclear fuel under a series of severe natural conditions described in part D of this chapter. Since no release of radioactivity would be expected under these conditions, no resultant doses would occur.

A munition barge explosion has been postulated to occur at a location on the river approximately 2600 feet from the ISFSI. This would result in a pressure wave of 2.25 pounds per square inch at the ISFSI, which would have no effect on the storage casks or spent fuel contained within.

The Safety Analysis Report (SAR) which accompanied NSP's license application to the Nuclear Regulatory Commission examined the potential impact of several type of accidents which could result from human error or mechanical failure. One accident which was examined was the inadvertent loading of a newly discharge fuel assembly into a cask designed for ten-year cooled fuel. To prevent this accident from occurring, a final verification of the assemblies loaded into the casks and a comparison with fuel management records will be performed to ensure that the loaded assemblies do not exceed any of the specified limits. Through this, appropriate and sufficient actions will be taken to ensure that an erroneously loaded fuel assembly does not remain undetected. In particular, the storage of a fuel assembly with a heat generation in excess of 0.675 kilowatts is not considered credible in view of the multiple administrative controls which will be enacted. For this reason, this was not considered a credible accident and resultant doses were not calculated.

The SAR states that there are no credible circumstances under which a cask tip accident could be postulated to occur. It does, however, also provide an analysis which examines the performance of various casks feature should a cask tip accident occur. These calculations show that even if the cask were to tip over and crash onto the ISFSI pad the cask confinement barrier would not be breached. Therefore, no radioactivity would be released and no resultant doses would occur.

The final accident scenario examined in the SAR is also not considered credible. In this accident, a simultaneous failure of all protective layers of confinement is postulated to occur by some unspecified nonmechanistic means in the cask. An example of this type of failure could result from an incident such as a cask dropping 50-60 feet during movement on the crane into the spent fuel pool area of the Auxilliary Building. To prevent this type of accident occurring, NSP is now modifying the Auxilliary Building crane to make it single failure proof.

Should this occur, only those radionuclides which occur in the gaseous state would escape from the cask. In the case of the fuel which would be stored, Krypton-85 is the only element which would escape. For the analysis, all of the Kr-85 gas is conservatively assumed to be instantaneously released from the TN-40 cask. There is no additional decay of Kr-85 in transit from the spent fuel storage cask to the receptor and no credit is taken for personnel protection due to any structure or system.

The maximum individual dose is assumed to be located at the site boundary where the least amount of atmospheric dispersion takes place. The dose results for this location are conservative for any individual and may be reported as dose to an individual at the nearest site boundary. In this calculation, the nearest site boundary or maximum individual whole body dose for the loss of spent fuel cask confinement is determined to be 0.07 rem. This dose is well within the 5 rem criteria given in 10 CFR 72. 106(b).

Accidents during transportation of spent fuel were a concern for several commenters. Comments 1B and 19F refer to the eventual removal of spent fuel from the plant site, and comment 18C speaks to the need to analyze possible transportation accidents involving the TN-40 cask.

Transportation of the spent fuel from Prairie Island will not begin until the federal government (Department of Energy, DOE) begins accepting spent fuel either for storage at a Monitored Retreivable Storage (MRS) facility or at a repository. The earliest this could occur is in 1998, and it could be significantly delayed from that point. The terms of the DOE contract which were negotiated with all nuclear utilities require the DOE to provide transportation casks for the spent fuel and to take title to the fuel at the plant gate, assuming all liability for transportation of the fuel. There is no transportation of spent fuel off site proposed as part of this project. The fuel will only be moved within the plant site boundary in sealed casks from the Auxiliary Building to the ISFSI, a distance of approximately 2400 feet over haul roads engineered for handling heavy equipment like the cask transporter.

The DEIS discusses the possibility of using the TN-40 casks for transportation of spent fuel off-site at some point in the future. For this to occur, the TN-40 casks would need to be separately approved by the Nuclear Regulatory Commission (NRC) for transportation of spent nuclear fuel, either by granting of a transportation license or by special approval. In either case the casks must meet both NRC and Department of Transportation standards for safe transportation of high-level radioactive materials. This is why an analysis of the use of the TN-40 casks for transportation off-site was not included in the DEIS. In their comment letter on the DEIS (letter #10, page 2), NSP states, "Before any shipments are made, NSP and the DOE will work closely with all plant neighbors, as well as other affected communities and agencies, to involve them in the planning and preparations."

Comment 8D asked about the what damage an airplane could cause if it crashed into the ISFSI. This was seen by the commenter as an increasingly probable event, especially if a second major Twin Cities airport is built in the south-Metro area. The following response was prepared by Transnuclear, Inc., and submitted by Donn Eiden of NSP in a February 4, 1991, transmittal.

> "An airplane crash directly onto a TN-40 cask is an extremely unlikely event, and so is not directly analyzed in the Safety Analysis Report (SAR). The effect of a crash on the cask can be assessed on the context of the analyses that have been performed and of impact testing on similar large casks.
>
> The actual effects on the TN-40 cask from the direct impact of an aircraft would depend on two factors: the size of the aircraft and its velocity on impact. Because a relatively light material, aluminum, is used extensively in airplane construction, and because airplanes have a small weight-to-volume ratio, their impact effects on massive steel structures tends to be minimal. This is because the kinetic energy of the crash is absorbed by the body of the aircraft as it crushes during the impact. Additionally, energy would be absorbed by the aircraft as a result of tumbling and sliding during the impact.
>
> For aircraft similar to small jets, the effects of the impact on the TN-40 cask would likely be bounded by the effects of the impact of an airborne automobile or hickory plank during a tornado. These scenarios are discussed in sections 3.2.1.2 and 3.2.1.3 of the SAR. For larger aircraft, as are used for commercial flights, the direct impact of the body of the aircraft would likely cause the TN-40 to tip over, absorbing some of the kinetic energy, but with most of the energy still being absorbed by the aircraft. The only credible scenario for significant damage to the cask is if a large jet engine and its turbine rotor were to directly impact the cask. In such a case, the cask might tip and the turbine rotor would likely penetrate the outer shell and neutron shield, and perhaps even dent the gamma shield cask layer. However, there would certainly be no penetration of the innermost cask layer, which is the fuel containment shell.

G. Safeguards from theft, diversion or sabotage

The purpose of the security program for the ISFSI is to establish and maintain a physical security program that has the capabilities for the protection of spent fuel stored in the cask system. Since all ISFSI procedures are performed within the plant site boundary of the Prairie Island plant, security will be a less serious concern than it would be for other alternatives which involve transporting the spent fuel and casks off-site.

Additional information regarding the security program for the ISFSI is contained in a separate document which is withheld from public disclosure in accordance with 10 CFR 2.790(d) and 10 CFR 73.21. This document addresses the Physical Security Plan, Safeguards Contingency Plan, and Training and Qualification Plan. It must be considered by the Nuclear Regulatory Commission in making the license decision on the ISFSI, and changes deemed necessary by that body to ensure adequate protection from theft, diversion or sabotage will be made.

Spent fuel removed from light water reactors contains low enriched uranium, fission products, plutonium, and other transuranium elements (transuranics). Owing to the special nuclear material in spent fuel, safeguards for an independent spent fuel storage installation must protect against theft and radiological sabotage and must provide for material accountability.

The theft issue arises mainly from the plutonium component of the spent fuel. Plutonium, when separated from other substances, can be used in the construction of nuclear explosive devices and therefore must be provided with a high level of physical protection. However, the plutonium contained in spent fuel is not readily separable from the highly radioactive fission products and other transuranics and for that reason is not considered a highly attractive material for theft. Moreover, the massive construction of casks significantly complicates theft scenarios. For these reasons no specific safeguards measures to protect against theft are proposed other than maintaining accounting records and conducting periodic inventories of the special nuclear material contained in the spent fuel.

The NRC has carried out studies to develop information about possible adversary groups which might pose a threat to licensed nuclear facilities. The results of these studies are published in NUREG-0459, "Generic Adversary Characteristics--Summary Report" (March 1979) and NUREG-0703, "Potential Threat to Licensed Nuclear Activities from Insiders" (July 1980). Actions against facilities were found to be limited to a number of low consequence activities and harassments, such as hoax bomb threats, vandalism, radiopharmaceutical thefts, and firearms discharges. The list of actions is updated annually in a NUREG-0525, "Safeguards Summary Event List" (July 1987). None of the actions have affected spent fuel containment and, thus, have not caused any radiological health hazards.

Despite the absence of an identified domestic threat, the NRC has considered it prudent to study the response of loaded casks to a range of sabotage scenarios. The study is classified. However, an overview of the study is provided in the following paragraphs.

Being highly radioactive, spent fuel requires heavy shielding for safe storage. Typical movable storage casks are of metal or concrete, weigh 100 tons, and have wall thickness from 10 to 16 inches of metal or 30 inches of concrete. The structural materials and dimensions enable the casks and vaults to withstand attack by small arms fire, pyrotechnics, mechanical aids, high velocity objects, and most forms of explosives without release of spent fuel. After considering various technical approaches to radiological sabotage, the NRC concluded that radiological sabotage, to be successful, would have to be carried out with the aid of a large quantity of explosives.

The consequences to the public health and safety would stem almost exclusively from the fraction of the release that is composed of respirable particles. In an NRC study, an experiment was carried out to evaluate the effects of a very severe, perfectly executed explosive sabotage scenario against a simulated storage cask containing spent fuel assemblies. The amount of fuel disrupted was measured. The fraction of disrupted material of respirable dimensions (0.005%) had been determined in a previous experiment. From this information, an estimate of the airborne, respirable release was made, and the dose as a function of range and other variables was calculated. In a typical situation, for an individual at the boundary of the reactor site (taken as 100 meters from the location of the release) and in the center of the airborne plume, the whole-body dose was calculated to be 1 rem and the 50-year dose commitment (to the lung, which is the most sensitive organ) was calculated to be 2 rem.

H. Decommissioning

The storage cask design concept to be utilized at the ISFSI features inherent ease and simplicity of decommissioning. At the end of its service lifetime, cask decommissioning could be accomplished by one of the following options:

1. The intact TN-40 cask, including the spent fuel stored inside, could be shipped to a suitable fuel repository for permanent storage. Depending on licensing requirements existing at the time of shipment, placement of the entire cask inside a supplemental shipping container or overpack would be considered.

2. The spent fuel could be removed from the storage cask and shipped in a licensed shipping container to a temporary or permanent fuel repository. If desirable, decontamination of the now-empty cask could be accomplished through the use of conventional high pressure water sprays to further reduce contamination on the cask interior. The sources of contamination on the interior of the cask would be crud from the outside of the fuel rods and the crud left by the spent fuel pool water. The expected low levels of contamination from these sources could be easily removed with a high pressure water spray. After decontamination, the ISFSI cask could either be cut up for scrap or partially scrapped and any remaining contaminated portions shipped as radioactive waste to a disposal facility.

3. For surface decontamination of the storage cask, chemical etching using hydrochloric acid or nitric acid can be applied to remove the contaminated surface of the cask. Alternatively, electropolishing can also be used to achieve the same result.

A cask activation analysis has been performed to quantify specific activity levels of cask materials after years of storage.

(Activation is the term applied to the process by which formerly non-radioactive materials are made radioactive by prolonged exposure to neutron flux.) Based on the results of the analysis, the cask materials will be only slightly activated by the low level neutron flux emanating from the stored spent fuel. Consequently, it is expected that after application of the surface decontamination process as described above, the radiation level due to activation products will be negligible and the cask could be scrapped. A detailed evaluation will be performed at the time of decommissioning to determine the appropriate mode of disposal.

Due to the leak tight design of the casks, no residual contamination is expected to be left behind on the concrete base pad. The base pad, fence, and peripheral utility structures are de facto decommissioned when the last cask is removed.

The spent fuel pool at the Prairie Island plant will remain functional until the ISFSI is decommissioned. This will allow the pool to be utilized to transfer fuel from the storage casks to licensed shipping containers for shipment off-site if this decommissioning option is chosen.

Concern that the storage facility would become permanent was the subject of Comments 8C, 13R, 15D, and 19X. NSP's proposal intends that PI spent fuel will remain at the PI dry cask storage facility until the DOE is ready to accept it, which is highly uncertain as noted in the comments. NRC regulations mandate that all the support resources required for an ISFSI be maintained as a condition of the license. The required support resources include staff and facilities to provide security, radiation protection and maintenance services, and a facility to allow removal of spent fuel from storage casks, and loading of shipping casks. This facility could be the existing pool, a new pool, or a new, dry, fuel handling facility. ISFSI licenses are granted for a period of 20 years. If the need for dry cask storage at PI continues beyond 2013, NSP would have to request a license renewal from the NRC. Because this EIS and the PUC's Certificate of Need decision will be based on a capacity of 48 casks, any storage of casks beyond 48 would require additional state review and approval. However, there are no specific state limitations on how long the 48 casks (full facility) could be stored.

Prairie Island's current plant operating licenses expire in 2013 and 2014, but NSP may seek to renew the plant's operating licenses. Decommissioning will commence after the plant is permanently shut down. Spent fuel will continue to be stored in the spent fuel storage pool for a period of a least five years after shutdown, to allow an adequate cooling time before shipment of the assemblies discharged from both reactor cores at shutdown. While the plant is being decommissioned and while the pool is functional, the pool and all the support resources required by the ISFSI will be available. If, for example, NSP secures approval to extend plant operation to 2020, a total of about 3200 spent fuel assemblies will have been generated. About 1900 assemblies will be in dry storage, and the rest in the pool. If the DOE begins taking PI spent fuel in 2020, NSP may elect to delay the completion of decommissioning for the years necessary so that the pool can be used to transfer fuel into shipping casks, rather than building a new facility to perform this transfer.

If the plant is shut down well before DOE fuel acceptance begins, NSP would continue to maintain a Part 72 license for ISFSI operation, and continue to provide all the necessary support resources. At that time, NSP might elect to completely decommission the plant and build a stand-alone facility for future cask and fuel handling. It is this storage scenario which clearly goes beyond a "temporary" characterization. This situation raises numerous questions about life of the cask and its performance. The NRC would continue to regulate operation of the ISFSI through its license and would be responsible for assuring safe storage. Costs would be proportionately greater over time: how the costs would be paid is as uncertain as other elements of this scenario.

Comment 3A suggested that it was so unlikely that the DOE would ever develop a repository that the ISFSI should be designed as a permanent facility. While this may prove to be prudent in the future, current contractural, regulatory and political arrangements (and uncertainties) are driving utilities' spent nuclear fuel storage decisions at this time. A rational for longer-term storage is presented in the following excerpt from a journal paper entitled "Disposal of High-Level Nuclear Waste: Is It Possible?", by Konrad B. Krauskopf, a geologist at Stanford University:

> "Faced with this seemingly hopeless situation (development of a federal repository), one is tempted to ask: Why is building a repository so urgent? As long as the waste is not harming its surroundings, why not for a time just leave it where it is? In answer to this query, efforts to dispose of HLW in a hurry are commonly justified on three grounds. First, waste kept in containers near the earth's surface is always subject to massive release by acts of nature--violent storms or earthquakes--or by sabotage, or by carelessness on the part of those supposedly watching over it. Second, if a method of disposal cannot be demonstrated soon the nuclear energy industry is in deep trouble: opponents can claim that waste is an insoluble problem, hence that production of more should be stopped at once. And third, in a more philosophical vein, the waste that we do not dispose of now will remain as an unjustified burden for our children and grandchildren to cope with. These arguments have seemed convincing to the U.S. public but less so abroad. The drive to get repository construction under way soon is stronger in the United States than in most other countries.
>
> The other side of the question, putting off disposal to an indefinite future, can be defended with arguments that seem equally good. For one thing, waste becomes easier to handle on standing because its radioactivity steadily decreases. Also, with the rapid progress of technology, we can expect that a

half-century hence we will know more about the optimum design of repositories and about finding the best geologic locations. And finally, leaving waste in storage near the surface keeps it readily accessible, an advantage if sometime later a use is found for some of its constituents. Considerations of this sort have led most European countries to adopt a deliberate policy of postponing final disposal of HLW for at least several decades.

In the United States it looks increasingly as if a choice between these alternatives will be made for us automatically. At present schedules no HLW will be put underground until 2010 and most likely not until much later. By the time actual burial begins, much of the waste will be more than 50 years old, as old as the waste that is planned for later disposal in Europe. Despite pushes by Congress to speed up the program and well-meant efforts by DOE and other federal agencies to play their assigned roles, a combination of public dread of all things radioactive, of technical disagreements about the safety of long-term burial, and of disputes among the many federal and state agencies involved has made it impossible to accomplish waste disposal quickly.

Perhaps this is not to be deplored. If indefinite postponement is accepted as a necessary evil, the pace of the disposal program can be made less frantic, and its continued delays will seem less frustrating. The long and expensive effort to find a suitable site and to ensure compliance with accepted standards of radioactive release, discouragingly unproductive as it now appears, will not have been in vain. The years of research have taught us a great deal about repository construction and about the behavior of radioactive elements in natural environments, perhaps even about handling federal-state opposition. When a decision is finally reached for us or our children to get disposal started, this background of knowledge and experience should make it possible to complete the job in short order."

Comment 5A suggested that the facility be designed to accommodate more than 48 casks. NSP has indicated that a life extension of the plant and failure of the DOE to develop a repository would result in a need for additional casks, and that many other uncertainties limits planning beyond 48 casks. The key point is that the facility can be expanded incrementally as needed, and within the standards and regulatory perview of the NRC. The EQB has no authority to require this design modification. The Public Utilities Commission can consider this option in the Certificate of Need process.

I. Estimates of induced development

No significant induced development is expected to be associated with the proposed project.

The possibility that spent fuel from other nuclear plants would be stored at the PI facility was raised in Comments 1A, 13Y, 13DD, and 19Q. NSP can only assure that it has no plans to store any spent fuel at the ISFSI other than that from PI. The storage of only PI spent fuel is the subject of this EIS and will be basis on which the Minnesota PUC will be asked to issue a Certificate of Need and the U.S. NRC to issue an operating license. Any future intent of NSP to do otherwise will require additional approvals at the state and federal level.

The suggestion in Comment 13EE that NSP will accept spent fuel from other plants and also build a reprocessing plant is speculation. This conjecture is beyond the scope of the EIS as an action that has not been proposed, and, if proposed in the future, would be reviewed in separate proceedings.

Comment 13FF makes a connection between increasing the amount of spent nuclear fuel stored in Minnesota, and the state being drafted to "host" a nuclear waste repository. It is possible that the fact that Minnesota does have two nuclear generating plants, each with spent nuclear fuel stored on-site (whether in pools or dry casks) could make the state more attractive for such a facility. As the commenter points out, Minnesota was considered as a host state for a second repository until the Nuclear Waste Act Amendments were passed by the U.S. Congress in 1987. This act dropped the second repository program, and named Nevada as the host state for the first repository. Nevada has no nuclear power plants. Nuclear power plants across the nation are experiencing similar storage capacity problems, and many of these as well are developing ISFSI's. Because of these factors, the EIS will not address environmental impacts of siting a nuclear waste repository in Minnesota.

J. Feasibility analysis

This is a feasible technology, in use at several nuclear power plants in this country. The TN-40 cask has not yet been approved by the Nuclear Regulatory Commission. If that body fails to approve the cask, the project could still proceed by switching to another cask or dry storage technology which is already approved.

K. Cost of project

NSP has estimated the cost of the proposed ISFSI project to be between $35 and $40 million. This estimate includes costs of design, licensing and review, facility construction, 36 casks, cask handling equipment, and personnel through 2015 (Refer to Table 5-1).

Comment 13S raised questions about decommissioning costs. The cost figure of $35 to $45 million does not include decommissioning costs. NSP estimates these costs to be approximately $3.1 million in their license application. These funds would be collected as part of the plant decommissioning fund. Under the agreeement with the U.S. Department of Energy, the DOE is required to provide the transport casks once they begin accepting spent fuel, therefore there will not be added cost if the TN-40 casks proposed to be used for storing the spent fuel cannot be used to transport the fuel. The costs of the project under several storage need scenarios are given in Chapter 5. Considerations and data sources used in developing cost figures are provided in Appendix F.

L. Mitigation of identified impacts

The only impacts identified to be associated with the proposed project are construction impacts. Following are the measures which NSP proposes to employ to mitigate those impacts which were identified.

Off-site radiation exposure reduction:

Refer to Chapter 6

Construction traffic control: Areas where construction traffic may cause damage, such as undisturbed open spaces, will be avoided by construction vehicle traffic. For woodland areas, vehicular traffic will remain within the roadway, access corridor, or utility rights-of-way. Crossing stabilized drainage ways except at approved stabilized crossing locations will be avoided.

Dust and particulate emission control: Dry weather wetting and/or paving (graveling) of the heavily traveled construction roads will be performed to reduce dust generated by vehicular traffic when necessary. Also, any fill hauled to the site will be wetted when necessary. Cleared areas will be seeded to provide a ground cover or otherwise stabilized where necessary. Fuel burning equipment will be maintained in good mechanical order to reduce excessive emissions. Open burning of tree wastes resulting from site preparation will be done in a manner to reduce the quantity of ash produced and to minimize particulate emissions.

Noise control: NSP intends to minimize noise impact by providing trucks and other equipment with standard noise control devices and limiting construction activities to normal working hours.

Chemical waste management: During construction, chemical liquid wastes will be deposited or discharged into tanks for salvage or subsequent removal to appropriate off-site locations. Adequate care will be taken to avoid handling or storing liquids in close proximity to major drainage areas, thereby avoiding impact to surface waters.

Solid waste management: Construction scrap and debris will be collected in designated on-site areas for salvage, incineration, or burial.

Site clearing: The site within the ISFSI fence will be cleared and gravel placed in the area immediately surrounding the storage slabs. Unmarketable timber and timber wastes may be burned. If so, burning will be done in accordance with state regulations. Brush and tree limbs can be shredded and used as mulch for erosion control on spoil disposal. Erosion in the construction area will be controlled by providing drainage, intercept the berm ditches, controlling slope angle, seeding, and use of mats and straw.

<u>Excavation and soil deposition:</u> The construction site will be stabilized during construction. The spoil areas, used for storage during excavation, will require particular attention. During and immediately following the filling of each spoil area, the fill will be graded to acceptable slopes to minimize potential erosion problems before turf cover is established. Until the turf has stabilized, the disposal area maintenance will be performed to correct local areas of excessive erosion or inadequate turf cover. The drainage from the proposed spoil areas during and after construction will be designed to follow natural drainage patterns.

REFERENCES <u>(all new material: was inadvertently omitted from DEIS)</u>

1. License application and supplemental information submitted by NSP to the Nuclear Regulatory Commission on August 31, 1990.

2. Discussion with Laura McCarten, NSP, by phone on August 28 1990, regarding number and types of trees proposed to be removed to construct the storage facility.

3. Personal communication with Bruce Watson, former State Climatologist, regarding wind speeds; September 1990.

4. Memo from Scot Johnson, Minnesota Department of Natural Resources hydrologist on the Mississippi River Team, to Gretchen Sabel, Environmental Quality Board, dated June 4, 1990, discussing flood potential at the proposed Prairie Island ISFSI.

5. "Probable Maximum Flood Study, Mississippi River at Prairie Island, Minnesota," 4/12/85, which was incorporated into the Updated Safety Analysis Report as Appendix F.

6. Notes from meetings of the Interagency Work Group for the Prairie Island Dry Cask Storage EIS, held January through May of 1990.

7. "The TN-24 PWR Spent-fuel Storage Cask. Testing and Analysis", EPRI. April, 1987.

8. "Technical Safety Analysis Report for TN-24 Casks", approved by the NRC July, 1989.

9. Krauskopf, Konrad B., "Disposal of High-Level Nuclear Waste: Is It Possible?" Science, Vol. 249:1231, September 14, 1990.

CHAPTER 5

ANALYSIS OF ALTERNATIVES

Summary of Alternatives

A number of possible alternatives to the proposed project exist. The most significant of these are examined in this chapter. Following is a brief overview description of each alternative, which precedes the more detailed analysis.

No action: This alternative would result in NSP filling the existing spent fuel storage capacity at the Prairie Island plant by January, 1994, thereby forcing shutdown of the plant. The plant would then be mothballed or decommissioned. Shutdown of Prairie Island would create the need for NSP to acquire 1000-1100 megawatts of baseload type generating capacity by January, 1994.

Reduced operation of the Prairie Island plant: NSP may be able to reduce operation at the Prairie Island plant in order to reduce fuel consumption and thereby conserve storage capacity for spent fuel at the plant. This could potentially delay the date when Prairie Island expects to run out of storage capacity.

Increased customer conservation: This alternative assumes that by significantly increasing its customer conservation programs, NSP can eliminate some or all of the need for operating the Prairie Island plant.

Other dry spent fuel storage technologies: Alternate dry spent fuel storage technologies examined include; other metal casks, modular concrete storage systems, concrete casks, a vault, and dual-purpose storage/transport casks. Each of these technologies must meet the same technical performance criteria for safety and radiation exposure minimization.

Increased in-pool spent fuel storage: Several options for expanding the in-pool storage capacity at Prairie Island are examined.

Shipment to another spent fuel storage facility: Options for shipping spent fuel from Prairie Island to other storage facilities are examined.

Shipment to a federal storage or disposal facility: The U.S. Department of Energy is under contract with NSP to accept NSP's spent nuclear fuel beginning in 1998. The feasibility and impacts of this alternative are analyzed, and issues relating to timing discussed.

Reprocessing (recycling) of spent fuel: Reprocessing is the chemical process of dissolving spent fuel in order to extract the residual uranium and plutonium for recycle into new fuel assemblies. The remaining fission products are high level radioactive waste and are concentrated and solidified into a stable form, such as glass, for storage and permanent disposal. There is no reprocessing plant in the United States for commercial spent nuclear fuel, so the spent fuel would need to be shipped to Europe for reprocessing.

Use of higher burnup fuel: Burnup is a measure of how much energy a fuel assembly produced during the time it was in the reactor. For a given amount of energy production by the reactor, the number of spent fuel assemblies generated will be less if each assembly can provide more energy; that is, if fuel can achieve a higher burnup.

Combinations of alternatives: By combining alternatives which extend the capacity of the existing pool with the alternative of shipping spent fuel to a federal facility, it is possible that NSP could avoid the necessity of building the ISFSI.

Discussion of Alternatives

No Action

A. Description of alternative

The alternative of no action results in NSP filling the existing spent fuel pool capacity at the Prairie Island plant by January, 1994, thereby forcing shutdown of the plant in January, 1995. At shutdown, the pool would contain 1386 spent fuel assemblies, the maximum allowed under Prairie Island's current licence, and each reactor unit would contain 121 assemblies. Though the plant would not be operating, the assemblies in the reactor would remain in the reactor under storage conditions until eventual shipment to a federal storage facility.

For this alternative, a distinction must be made that the intent of this EIS is to evaluate alternative methods of spent fuel storage rather than alternative ways to replace the capacity of Prairie Island. Under the EQB's Environmental Review Rules, an assessment of whether continued operation of the Prairie Island Nuclear Generating Plant is prudent or needed is beyond the scope of this EIS. However, public interest in nuclear issues suggests some background on this issue would benefit the general public reading this document. Detailed cost and impact studies have not been conducted: information presented here is drawn from available literature and data provided by NSP.

The analysis required by rule for this alternative involves simply operating the Prairie Island plant until the existing storage pool is full and shutting down the reactors. NSP would then maintain continued storage of accumulated spent fuel until the federal government begins accepting it. NSP would have to determine whether to decommission the two generating units or to continue maintenance with the intent of again operating the plants in the future when spent fuel storage capacity becomes available.

B. Wastes and emissions

Shutdown of the Prairie Island plant in 1995 would not generate additional spent fuel until the plant is reactivated. Existing systems to control radioactive emissions below NRC standards would be maintained.

New replacement generation capacity, depending on the fuel used, would involve incremental increases in wastes and emissions, probably at another site in NSP's system.

The question was raised in the EIS scoping process regarding the need to continue operating the PI plant, or any commercial nuclear generator in the U.S., when waste storage continues to be uncertain and non-nuclear options are available.

This issue is discussed in the following conclusion (in part) from a 1989 report, "Nuclear Legacy, An Overview of the Places, Problems, and Politics of Radioactive Waste in the U.S.", by Public Citizen:

> "In the absence of a proven, safe solution to the disposal of nuclear wastes, it is irresponsible to continue generating them. Therefore, all the major activities which generate nuclear wastes should be rapidly phased out.
>
> The use of commercial nuclear reactors for power production is unneeded. Future energy needs can be met more reliably, economically, and in a more environmentally sound and socially acceptable manner through a combination of investments in energy efficiency and renewable energy technologies. Other energy technologies, such as combined cycle natural gas turbines and cogeneration systems, offer better alternatives to nuclear power.
>
> However, even if future waste production is reduced virtually to zero, the U.S. must still contend with the existing problem of managing the radioactive waste it has already generated".

The report then makes the following recommendations, again in part:

> "Congress should implement a (revised) program to thoroughly review and reassess the technical options for nuclear waste disposal, including options other than disposal in a geologic repository.
>
> All proposals for a Monitored Retrievable Storage (MRS) should be abandoned ...(because)... it is unnecessary, costly, ...and may reduce the incentives for the development of a permanent solution.

The NRC should not license any further utility proposals to re-rack irradiated fuel pools because reracking increases the probability of a major irradiated fuel accident. Nor should a utility be allowed to endanger members of the surrounding community by transporting its irradiated fuel off-site to another plant's fuel pool. If existing on-site irradiated fuel storage capacity is insufficient, the reactor should be shut down, or dry-cask storage should be implemented.

In the absence of a permanent solution to irradiated fuel disposal, the least of all evils is probably the implementation of on-site spent fuel storage with dry-cask technologies."

Impact Categories C - I

The next seven impact categories have no discussion for this alternative (construction, operation, natural calamity, radiological, accidents, safeguards, and decommissioning). Current systems, plans and regulatory controls are designed to support continued operation of the spent fuel pool.

J. Estimates of induced development

No action (no expansion) would not require any significant development at the Prairie Island Plant. The design capacity of the existing pool would be reached and the spent fuel stored under existing operations until transfer to a federal MRS or repository. If decommissioning of the plant was initiated after early shutdown of the plant, decommissioning activities would not likely be different than what is anticipated for full-life operation. Decommissioning will be affected by the timing of federal facilities to which spent fuel can be shipped.

Under this alternative, NSP would retire 1000-1100 megawatts of baseload capacity. This situation would require NSP to make major decisions about how to supply the lost capacity by January, 1995. NSP estimates large baseload facilities on the order of 400 megawatts cannot be brought into service by 1995, but rather the late 1990's at the earliest. NSP could build gas-fueled peaking plants for additional generating capacity by 1995. Reliance on peaking plants until coal-fired baseload capacity could be brought on line would have substantial cost penalities to NSP customers, as is the case with purchased power. To avoid long-term cost penalties, NSP would likely be forced to build new coal-fired capacity sooner than its forecast anticipates. NSP's 1990 Advance Forecast identifies several coal-fired base load alternatives between 200 and 400 megawatts. NSP has not determined where in its system new base load plants would be constructed. Potential locations could be in Minnesota, North Dakota, South Dakota or Wisconsin. Associated transmission lines may also be required.

The no action alternative was evaluated in detail in a generic EIS on handling and storage of spent fuel prepared by the NRC in 1979.

Though it is an older document, the NRC continues to rely on its general assumptions relating to the no-build alternative. The report concludes that coal-fired generation would likely replace early shutdown of nuclear plants due to spent fuel storage problems. It further concludes that other alternatives for spent fuel storage would be economically and environmentally preferable to replacing nuclear generated power with coal-fired power plants.

K. Feasibility analysis

As previously noted, it is feasible for NSP to continue operating the spent fuel pool until it is reaches its design capacity without substantial modification of the pool or operations.

It is also feasible, with cost penalties, to replace the lost capacity of the plant with a range of options, including purchased power; new peaking plants; increased operation of existing, less cost-efficient plants; and new, coal-fired, baseload plants. Replacement with a new coal-fired plant would require use of other interim options until the late 1990's. The feasibility of instituting conservation as a replacement option is discussed in another alternatives section. The replacement option of construction of another nuclear, base-load plant or conversion of the Prairie Island plant to burn natural gas has not been considered.

L. Cost comparison

NSP estimates that its cost to operate and maintain the spent fuel storage pool after shutdown and before decommissioning to be about 10 percent of current levels. On the assumption that decommissioning and capital cost investment will be recovered from its customers, NSP estimates the cost of this alternative to be $1.03 to $1.18 billion in 1990 dollars. This includes the cost for replacement capacity, assumed in this case to be a new coal-fired plant.

REFERENCES:

1. "Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel", NRC/NUREG-0575, Vol. 1, August, 1979.

2. "Nuclear Legacy, An Overview of the Places, Problems, and Politics of Radioactive Waste in the United States", September, 1989, Scott Saleska, available for $20 from Public Citizen, Critical Mass Energy Project, 215 Pennsylvania Ave.,S.E., Washington, D.C. 20003.

Reduce Operation

A. Description of alternative

Under this alternative, NSP would reduce operation at the Prairie Island plant in order to reduce fuel consumption and thereby conserve storage capacity for spent fuel at the plant beyond 1994. Whether the reduction would be accomplished by continuing to operate both units at a lower generating level or by temporarily shutting down one unit has not been analyzed in detail. NSP's cost estimate for this alternative assumes shutdown of one of the two units until 1999. The objective of extending available storage capacity could possibly be met by several operational modes.

This alternative assumes that the DOE would begin accepting spent fuel in 1998, which is still an uncertain date, and the two units would resume full operation when space was once again available. Because the date for DOE acceptance of spent fuel is uncertain, there is the potential that this alternative could result in forced shutdown of both units if the pool capacity is filled and the DOE has not yet begun acceptance. This situation then becomes similar to the no action alternative. A key difference is that NSP would have several additional years to determine appropriate supply- or demand-side options for replacement power. A key similarity is the added cost to NSP customers for supply-side replacement power.

B. Wastes and emissions

Reduced operation would reduce radioactive emissions and the generation of spent fuel until the time when the DOE begins accepting spent fuel and full operation of the plant is resumed. If the total shutdown scenario occurs, additional increments of radioactivity and spent fuel are not generated.

The next seven impact categories have no discussion for this alternative (construction, operation, natural calamity, radiological, accidents, safeguards, and decommissioning). Current systems, plans and regulatory controls are designed to support continued operation of the spent fuel pool.

J. Estimates of induced development

Any level of reduced operation of Prairie Island would require NSP to evaluate system needs and resources and determine an appropriate response. The uncertainty of DOE acceptance of spent fuel would make a committment to new generation capacity questionable. The construction of gas peaking plants, perhaps in combination with other options such as conservation and purchased power may be considered, dependent on overall system needs and costs. If the assumption is that Prairie Island's full capacity would again become available after a period of five years, interim system needs would likely rely less on a committment to a new, large coal plant and more on new or existing peaking plants and other short-term options.

K. Feasibility analysis

The reduced operation alternative is operationally feasible and without extraordinary technical limitations.

L. Cost comparison

Based on the assumptions that one unit is shutdown between 1991 and 1998 and that the DOE begins removing spent fuel from Prairie Island in 1999, NSP estimates that the cost would be $168 to $324 million, including cost of replacement capacity in the form of purchased power and some small generation additions.

Conservation

A. Description of alternative

The conservation alternative to construction of the proposed ISFSI assumes that end-use reductions in NSP's electrical system demand, probably in conjunction with a combination of other power supply options, would reduce or eliminate the need to expand spent fuel storage capacity at Prairie Island. This is the most difficult of the various alternatives to analyze, and requires a unique approach in this specific case. There are widely divergent opinions on what level of conservation is attainable and how effective various strategies are. This EIS will not attempt to present a comprehensive, technical analysis of this alternative. As discussed under the no action alternative, the issue of whether or not to continue operation of Prairie Island is not the subject of this EIS. A permit to continue operation of the plant is not under review.

Conservation, however, is the focus of significant public interest in reducing the depletion of nonrenewable fossil fuels and the resultant environmental impacts of their combustion in power plants. It is the policy of the state of Minnesota to "practice thrift in the use of energy and maximize the use of energy efficient systems for the utilization of energy, and minimize the environmental impact from energy production and use" (Minnesota Environmental Policy Act, Minnesota Statutes, section 116D.02, subd. 2i). While it appears infeasible to offset the capacity of Prairie Island with conservation by 1994, the public concern and management dilemmas associated with high-level radioactive wastes emphasize the need to avoid waste management problems and uncertainties by instituting appropriate conservation programs before power plant commitments are made. The Prairie Island plant was under construction before the state began requiring environmental review and permits for power plants. The capital investment in the plant was "sunk" even before the first energy crisis of 1973. (It was also assumed that utilities would never be faced with a storage problem.)

NSP's 1990 Advance Forecast reports an expanded goal of 1000 megawatts of new demand size management by 1995. Its ambitious strategy primarily relies on conservation and load management.

However, this saving is presummed to be shaved from electricity demand peaks, with the intent of postponing major base load additions rather than replacing the Prairie Island capacity.

It is important to consider where the benefits of conservation should be applied. Assuming conservation can reduce electrical demand on NSP's system, while allowing for growth and reliability, and that some existing generation could be retired, it may be more appropriate to look at existing fossil-fuel plants that are large emitters of pollutants. Early retirement of dirty, less-efficient plants would have significant environmental benefits.

Impact categories B through L are not included for this alternative.

Of the various alternatives included in the DEIS, the conservation alternative received the most comments. Comments 6A, 8F, 13B, 13II, 14A and 19H generally recommended more information on the conservation alternative should be included. This section responds to those comments. More specific comments are referenced in the following discussion.

The comments and attachments to comment letters provide information on several means to reduce electric energy demand. The perceived objectives of a reduction included shutting the PI plant down (the no action alternative), reducing operation so that the ISFSI would not be built, and permitting continued operation of PI and construction of the ISFSI but reduce generation of spent fuel and avoid construction of new generation plants.

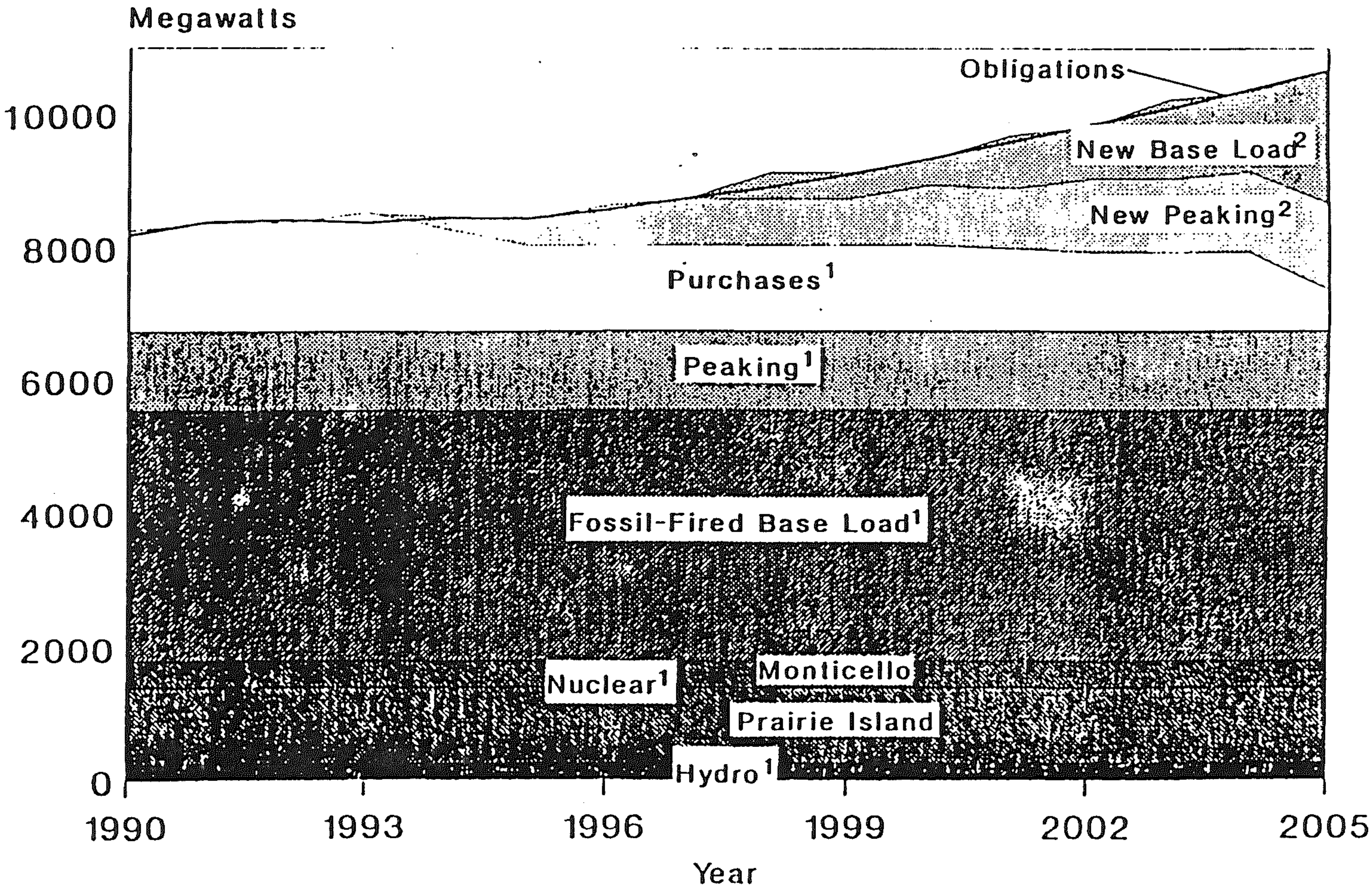
NSP's asssssessment of the conservation alternative is included in its comment letter (#10, page 3). NSP believes that given the relative magnitude of achievable energy efficiency to base load needs, conservation is not expected to be a practical solution to waste minimization at Prairie Island. The figures on the following two pages shows PI's baseload relationship to other resources and obligations and a comparison of costs to operate other generating plants relative to PI.

Financial Incentives

The need for financial incentives for utilities to reduce electrical demand is noted in comments 6B, 6E and 19J. Demand-side management and least cost planning was emphasized in comments 6D, 6F, 19I, and 19K. In its 1988 report to the Legislature, the Minnesota Department of Public Service noted:

> The loss of profits to utilities from greater investment in efficiency resources is a serious barrier to the implementation of least cost planning in Minnesota and elsewhere. A number of mechanisms to address the incentive problem are now being reviewed by regulators across the country. These include adjustment of overall rate of return based on containment of the average total utility bill, adjustment based on the difference between actual sales and sales volume used in establishing previous rates, and sharing the benefits of utility sponsored

NSP Obligations and Resources

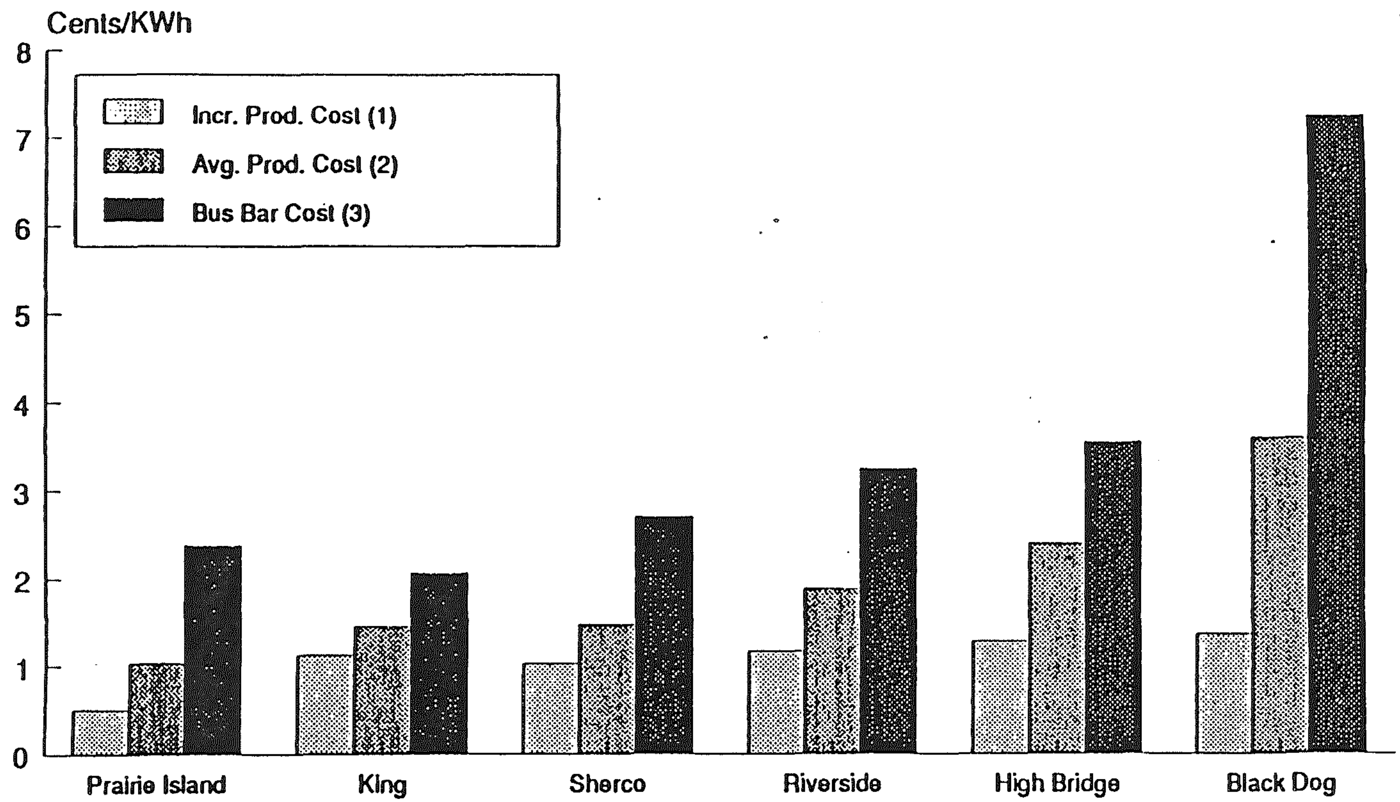


1 - Committed Resources
2 - Projected Resources

Note: April 1990 Semi High Forecast
(after Load Management & Conservation Adjustments)

01/07/91

NSP Generating Plant Cost Comparison



Notes:	(1) Incremental Production Cost -	the cost to produce additional energy once the plant is operating
	(2) Average Production Cost -	total plant operating cost (fuel, operating and maintenance)
	(3) Bus Bar Cost -	total cost of power from the plant, including decommissioning and all other fixed costs

All costs are actual 1989 costs and are not necessarily representative of typical unit operation efficiency programs with shareholders and ratepayers based on the actual performance of the efficiency measures."

Since the DEIS was released (and separate from the EIS process), the Minnesota Public Utilities Commission has completed a review of financial incentives and on February 28, 1991, issued an order requiring electric utilities to file financial incentive proposals in 1991. The PUC concluded that financial incentives for demand-side management would substantially enhance the Commission's ability to implement its statutory directives to encourage conservation and efficency in the production and distribution of electricity. It further found:

"Notwithstanding the need for and desirability of demand-side management, the current ratemaking process tends to discourage it. Utility profits are tied directly to energy sales. Simply put, a utility does not make a profit on an unsold kilowatt-hour. Therefore, measures that reduce demand generally reduce utility profits, at least in the short run. Specific conservation requirements are helpful, but their impact is limited. They tend to require substantial regulatory oversight and often result in performance at only the minimum level required by law. Financial incentives are likely to encourage utilities to pursue demand-side opportunities aggressively. This agressive involvement in demand-side management is apt to result in innovation and success beyond specific statutory mandates. Generally, this will only occur when a company's efforts to reduce demand are in its financial self-interest."

Prior to the Commission's order discussed above, NSP filed a financial incentive plan. The plan was approved by the Commission on February 21, 1991, and will be reviewed in PUC docket number E-002/M-90-1159. The Commission will likely consider the potential for financial incentives to impact the need for NSP's proposed ISFSI when it makes a decision on a Certificate of Need for the project.

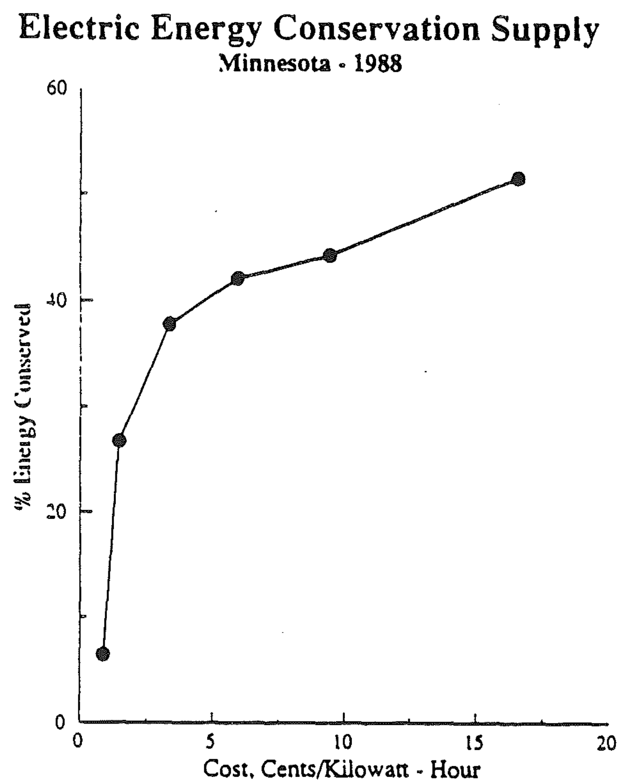
Comments 2B, 2C, and 19L recommended that additional cost analysis be included. The following discussion is in response.

A 1988 study of the electric conservation potential in Minnesota, performed by PLC Incorporated for the Department of Public Service, found that a substantial percentage of the electricity currently consumed could be saved without any reduction in convenience or standard of living. The potential savings amounts to over half of the electric energy used in Minnesota. The total energy savings could not be acheived overnight and would require some investment. However, the investment would be paid off with lower energy bills.

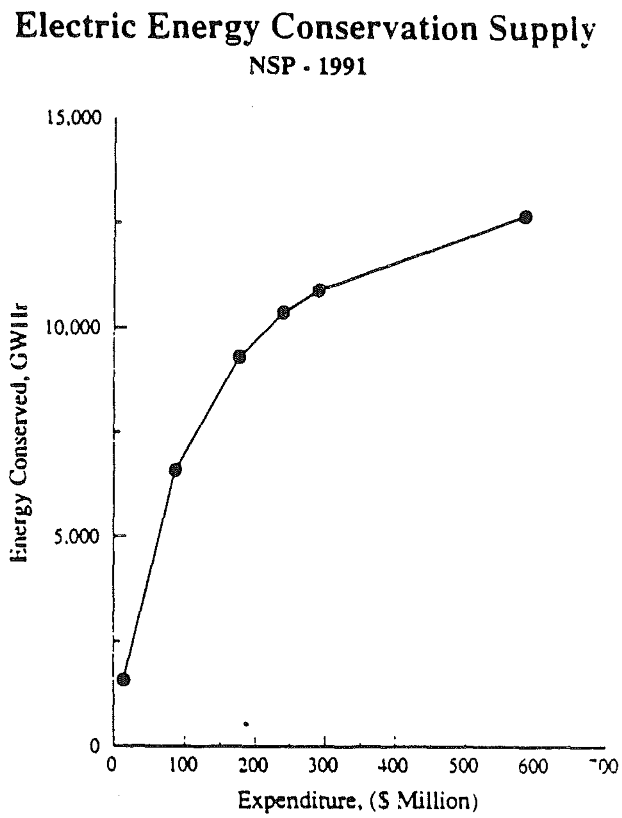
In evaluating the cost-effectiveness of a conservation measure, the impact of not saving electricity must be considered. In the absence of energy conservation, electric consumption will increase, thereby causing greater environmental impact and economic costs. The cost of electricity, therefore, must include not only the direct costs of generating electricity (fuel, operation, and maintenance) but also the costs of future capacity additions and the indirect environmental costs.

The PLC report estimates a cost that includes the direct costs and the costs of future capacity additions to determine which conservation measures should be incorporated in the total savings estimates. The estimate does not include the indirect environmental costs. The types of conservation that were very cost effective include residential refrigeration, lighting, and air conditioning, commercial lighting and refrigeration, and industrial cooling, lighting heating and refrigeration.

The first figure below shows the percent of electric energy which could be conserved in Minnesota at various conservation costs in 1988 cents per kilowatt-hour. The second figure applies this to the NSP system and shows the gigawatt-hours that might be saved for various levels of expenditures. The numbers in the second figure indicate that NSP would need to spend approximately $150 million to reduce energy demand equal to that generated by the PI plant in 1989 (8,279 gigawatt-hours).



Provided by the Department of Public Servic based on the report "Conservation Potential in the State of Minnesota," June 1988, Prepared by PLC, Inc.



Other Dry Storage Technologies

A. Description of alternative

The NRC has approved dry storage of spent fuel, pursuant to Part 72 of Chapter 10 of the Code of Federal Regulations (10 CFR Part 72). Dry storage technologies include metal and concrete casks, concrete modules, vaults, and dual-purpose (storage/transport) casks. Each of these technologies must meet the same technical performance criteria for safety and radiation exposure minimization. Federal standards and policies are described in Appendix G of this EIS. A brief description of each of the dry storage technologies follows:

1. Other Metal Storage Cask Designs

Dry metal storage casks have been developed by several companies in addition to Transnuclear, including General Nuclear Systems, Inc., Nuclear Assurance Corporation, and Westinghouse. Metal cask designs differ with respect to capacity, weight, handling features, and the materials used in fabricating the body and the internal basket which holds the assemblies. However, once a cask is loaded and sitting on a concrete pad there is very little difference between cask types. All metal storage casks are designed to the same NRC criteria and requirements.

2. Modular Concrete Storage

NUTECH is a company which has developed a horizontal modular storage system, referred to as NUHOMS (an acronym for NuTech Horizontal Modular Storage). The NUHOMS system has two main components - a dry storage canister which contains the spent fuel, and a horizontal storage module within which the canister is placed. Figure 5-1 depicts this storage system. The storage module is constructed of reinforced concrete, and provides radiological shielding and physical protection for the storage canister against natural hazards. The storage module has internal air flow passages to provide natural convection cooling for decay heat removal from the storage canister. The storage canister is welded closed to ensure the spent fuel is contained and isolated from the environment.

All canister loading and storage preparation activities take place inside the plant. A transfer cask is required to take the loaded canister from the plant out to the ISFSI site. There, the loaded canister is transferred from the cask into a storage module. Maintenance and surveillance for a NUHOMS facility are similar to that required for the metal cask facility proposed.

Carolina Power and Light has a NUHOMS storage facility installed and storing spent fuel at its H.B. Robinson plant. Duke Power is completing construction of a NUHOMS facility at its Oconee plant, and expects to load it with spent fuel in a few months. Baltimore Gas and Electric plans to install a NUHOMS facility at its Calvert Cliffs plant.

3. Concrete Casks

A concrete cask storage system is similar to NUHOMS, except it is stored vertically rather than horizontally. There are two major components - a metal dry storage canister and a concrete ventilated storage cask. These components perform the same functions as the dry storage canister and horizontal storage module of the NUHOMS system, respectively. A transfer cask which encloses the storage canister is required to load the storage canister with spent fuel, and to transfer the storage canister from the pool to the concrete cask. The transfer cask fits onto the top of the concrete cask, and the storage cask is then loaded into the concrete storage cask. Placing a loaded storage canister into a concrete cask occurs inside the plant. The concrete cask is then moved from the plant to the storage site, and placed on a concrete storage pad.

This storage system is being considered for use at the Point Beach nuclear Plant in Wisconsin, and is currently being reviewed by the NRC. A program to build and demonstrate concrete cask storage is underway.

4. Vault

A vault is a fixed, concrete building designed for dry storage of a large number of spent fuel assemblies. The basic building consists of a transfer cask receipt room, storage modules, and a fuel transfer machine to take the fuel assemblies from the cask and place them into the storage module. Within the storage module, the spent fuel assemblies are stored in individual, sealed storage containers arranged in a regular array. The spent fuel is cooled by air-flow around the outside of the storage container which circulates by natural convection. A fuel handling system would also be required within the vault, in addition to the fuel handling system currently in the plant. Figure 5-2 shows a generic vault facility.

Vault storage has been used for over 18 years in Great Britain to store spent fuel from gas-cooled reactors. The NRC has approved a Topical Safety Analysis Report for a vault designed to store U.S. type spent fuel, i.e. from water-cooled reactors. An added benefit is that vault storage can be readily modified to accomodate storage of other radioactive materials which would be generated when a nuclear reactor is decommissioned. This would not be as simple in the case of cask storage.

5. Dual-purpose Storage/Transportation Casks

NSP and Transnuclear Corp. believe that the TN-40 cask is certifiable for transport as well as storage, but do not plan to seek NRC transportation certification at this time for the TN-40. None of the currently approved storage casks are also approved for transport, but this situation is likely to change within the next 12 to 24 months.

The TN-24 was originally designed as a dual purpose cask, and has been successfully deployed in a storage demonstration project at the Idaho National Engineering Laboratory. A similar design, the TN-BRP, was recently certified for transport of spent fuel, and will be used in an upcoming storage demonstration project. 10 CFR Part 71 does give the NRC the authority to allow limited use of a cask for transportation as well. It is unknown at this time whether or not the TN-40 would qualify for this type of exemption.

Other cask vendors are also seeking dual certification for their casks. Nuclear Assurance Corporation (NAC) is currently seeking NRC approval of a dual purpose cask design similar to its already-approved storage cask, the NAC/ST, except for a new double lid designed to facilitate seal installation prior to off-site shipment. NAC expects to receive NRC approval be November, 1991. The Electric Power Research Institute, Virginia Power Company, Sacramento Municipal Utility District and other utilities are supporting development and demonstration of dual purpose casks.

Compared to storage-only casks, the potential disadvantage of dual purpose casks at the present time are the higher initial cost and regulatory uncertainty. The difference in initial cost may narrow with increased production (more than 10 casks) and life-cycle cost comparisons may be more favorable to dual purpose casks, since once loaded these can be shipped off-site without returning to the storage pool.

The cost of loading or unloading a cask is about $20,000. Use of a dual purpose cask avoids the cost of unloading a storage cask and loading a transport cask at some time 10 to 20 years after the storage cask went into service. Its also possible, but not certain, that there may be a net cost for the final disposition of the storage casks, again 10 to 20 years after the cask went into service. The current value of these costs associated with storage-only casks is about $30,000, which represents an increase of less than 5% to the cask cost. In comparison, a dual purpose cask is currently estimated to cost approximately 40% more than a storage-only cask. Thus, even when life cycle costs are included, a storage cask still costs less than a dual purpose cask.

Use of dual purpose casks could result in lower personnel radiation exposures, fewer chances for accidents during handling operations, and greater flexibility in responding to changes in DOE's national nuclear waste management program.

Comment 13N raised several questions about transportation. There is currently no spent fuel storage cask that is licensed by the NRC for both transport and storage. Some vendors state their storage casks are designed to meet transport criteria, i.e. they are dual purpose casks; however, NSP could not be certain unless the NRC actually conducted a review and granted a transortation certificate. NSP decided against selecting a storage cask designed to transport standards for the following reasons:

i) They cost more than a cask designed for storage alone (between 50% and 100% more);

ii) There is a potential for transport licensing standards to change. NRC transortation licensing standards have become more strict over the last 20 years, and it is likely this trend will continue. Thus, storage cask designs which meet transport standard today might not meet meet future standards; and

iii) The Department of Energy's (DOE) program for spent fuel transportation to a repository or Monitored Retrievable Storage (MRS) facility is uncertain. The DOE is responsible for the shipment of all spent fuel in the U.S. to an MRS, if one is licensed and built, and eventually to a permanent repository. The DOE will build a fleet of casks, whose designs will be optimized to interface with the MRS or repository as well as with with utilities. The design of these facilities has not been fixed, nor has the design of the overall waste management configuration been completed. For these reasons, NSP cannot be certain the DOE will choose to use storage casks to trnasport the spent fuel.

...As the time for offsite shipping [of spent fuel] nears, NSP may explore with the NRC the possibility of using the TN-40 storage casks for transport. The NRC might permit limited use, by imposing additional protective equipment and restricted transport conditions.

The following topics are addressed in Table 5-1 for each of the technologies listed above.

B. Wastes and emissions, pollution control equipment
C. Construction impacts
D. Operation impacts
E. Protection from natural calamity
F. Radiological impacts during loading and storage
G. Accident impacts
H. Safeguards from theft, diversion or sabotage
I. Decommissioning
J. Estimates of induced development
K. Feasibility analysis
L. Cost comparison

This information is presented in table format since the individual technologies are similar in many ways and must meet the same set of federal standards laid out in 10 CFR Part 71.

Considerations and data sources used in developing cost figures are provided in Appendix F.

REFERENCES:

1. Material supplied by NSP in preparation of the Scoping Document for this EIS.

2. Supplemental material supplied by NSP in 7/22/90 and 7/23/90 transmittals.

3. "Fuelstor: The Spent Fuel Storage Option for the 1990's" by M.K. Valentine, J. Banck, R.F. Bokelmann, H. Gunther. Presented at the INMM Spent Fuel Management Seminar VII, Washington D.C., January 17-19, 1990.

4. "Status of NuHOMS Fuel Storage Projects" by W. McConaghy at the INMM Spent Fuel Management Seminar VII, Washington D.C., January 17-19, 1990.

5. Supplemental material supplied by NSP in 8/21/90 transmittal.

Table 5-1

Comparison of Dry Storage Systems

	WASTES AND EMISSIONS, POLLUTION CONTROL EQUIPMENT	CONSTRUCTION IMPACTS	OPERATION IMPACTS	PROTECTION FROM NATURAL CALAMITY	RADIOLOGICAL IMPACTS DURING LOADING AND STORAGE
PROPOSED PROJECT	Wastes generated from cask decontamination (low-level radioactive wastes). Emissions - small increase in radiation levels-must be within NRC limits. Casks themselves are the pollution control equipment.	Area proposed for ISFSI already disturbed, environmental impacts of construction minimal. Some trees would have to be removed.	Some incremental increase in off-site radiation impacts, would fall within NRC limits.	Cask/ISFSI design must meet NRC standards for protection. Standards are both generic and site-specific.	Radiological impacts must be within NRC limits. Fuel would need to be handled to load into storage casks, again in the future for transfer to transportation casks.
OTHER METAL CASKS	Same as for the proposed project.	Essentially the same as for the proposed project. Could be larger area involved if cask capacity is lower, requiring a larger area than the ISFSI.	Same as for the proposed project.	Would have to meet the same standards of protection as the proposed project.	Same as for the proposed project.
MODULAR CONCRETE	Same as for the proposed project.	Same as for the proposed project.	Same as for the proposed project.	Would have to meet the same standards of protection as the proposed project.	Same as for the proposed project.
CONCRETE CASKS	Same as for the proposed project.	Same as for sub-alternative 1, "other metal casks."	Same as for the proposed project.	Would have to meet the same standards of protection as the proposed project.	Same as for the proposed project.
VAULT	Same as for the proposed project.	Less impact than proposed project, more compact design results in less disturbed area.	Same as for the proposed project.	Would have to meet the same standards of protection as the proposed project.	The same NRC exposure limits would apply. The spent fuel would need to be handled several times: loaded into transport cask; transferred into vault for storage; reloaded into transport cask.
STORAGE/TRANSPORT CASKS	Same as for the proposed project.	Same as for sub-alternative 1, "other metal casks."	Same as for the proposed project.	Would have to meet the same standards of protection as the proposed project.	Radiation exposure to plant personnel would be lower because the spent fuel would not need to be reloaded into transportation casks.

Table 5-1 cont.

	ACCIDENT IMPACTS	SAFEGUARDS FROM THEFT, DIVERSION OR SABOTAGE	DECOMMISSIONING	ESTIMATES OF INDUCED DEVELOPMENT	FEASIBILITY ANALYSIS	COST COMPARISON*
ROPOSED PROJECT	See analysis of potential accident impacts, page xxx.	Spent fuel would be stored within the fenced plant boundary and security measures developed to safeguard the stored fuel.	Spent fuel would have to be transferred to transport casks. Used storage casks would be disposed as low-level waste. Pad and other structures would be handled as regular construction debris.	Little induced development in the Prairie Island area. Most cask and ISFSI components are made in other states.	Feasible. Proposed cask not yet in use, and has not yet received NRC approval.	Construction and license costs = $10,950,000. Cost to store to: 1995 = $13,450,000. 2005 = $25,950,000. 2015 = $38,450,000.
THER METAL CASKS	Same as for the proposed project.	Same as for the proposed project.	Same as for the proposed project.	Same as for the proposed project.	Feasible. Some types of casks already licensed and in use.	Construction and license costs = $10,950,000. Cost to store to: 1995 = $13,450,000. 2005 = $25,950,000. 2015 = $38,450,000.
ODULAR CONCRETE	Same as for the proposed project.	Security could be easier to provide since the spent fuel would be stored in fixed concrete structures.	Essentially the same as for the proposed project, except there would be more construction debris due to the larger amount of fixed structures.	More onsite construction would be required, but could be absorbed by Twin Cities/Red Wing labor pool with little impact.	Feasible. NRC license already issued, in use at two sites now.	Construction and license costs = $12,000,000. Cost to store to: 1995 = $14,339,000. 2005 = $29,000,000. 2015 = $43,200,000.
ONCRETE CASKS	Same as for the proposed project.	Same as for the proposed project.	Same as for the proposed project.	Same as for the proposed project.	Feasible. Considered for use at Point Beach, WI plant. NRC approval not yet received.	Construction and license costs = $12,200,000. Cost to store to: 1995 = $14,310,000. 2005 = $24,900,000. 2015 = $35,500,000.
AULT	Same as for the proposed project.	Security would be easier to provide since the spent fuel would be stored within a vault.	More difficult due to the fact that there would be a greater amount of both low-level waste and construction debris.	Essentially the same as for sub-alternative 2. The larger facility to be built could result in some short term employment surge in the construction trades.	Feasible. Similar facility planned for Ft. St. Vrain reactor in Colorado. NRC approval granted.	Construction and license costs = $20,700,000. Cost to store to: 1995 = $21,150,000. 2005 = $31,550,000. 2015 = $42,000,000.
TORAGE/TRANSPORT ASKS	Same as for the proposed project.	Same as for the proposed project.	Would be easier than the proposed project because the fuel could be shipped without repackaging. Casks would be disposed as low-level waste. ISFSI pad and other structures would be disposed as construction debris.	Same as for the proposed project.	Feasible. None in use, but are under consideration. No cask has dual certification (storage/transport) yet.	Construction and license costs = $10,950,000. Costs to store to: 1995 = $26,450,000. 2005 = $44,050,000. 2015 = $71,650,000.

*Costs shown are estimates only.

Increased Capacity In Existing Pool

Description of options

Each of the options in this section involves increasing the capacity for pool storage of spent nuclear fuel at Prairie Island. Options 1 and 2 involve constructing new pool capacity, and 3, 4 and 5 involve modification of storage structures or fuel assemblies themselves to allow more to be stored. The current pool construction can only accommodate a 35% increase by weight of spent fuel and racks, and so options 3, 4 and 5 are limited in the amount of increased capacity which they can provide.

1. Modification of pool (expand pool 1)

In this option, the new-fuel pit adjoining spent fuel pool #1 would be reconstructed for use as spent fuel pool space. The new-fuel pit would be re-located within the plant.

2. Construct new pool (pool 3)

Here, an entirely new pool would be built in a separate building on the plant site.

3. Reracking existing pool for more capacity

For this option, existing spent fuel racks would be replaced with more compact racks, thus expanding the current pools' capacity for spent fuel storage.

4. Two-tiered racks

Here, an extra tier of spent fuel racks would be installed in the pool above the existing racks.

5. Spent fuel rod consolidation

In this option, the individual fuel rods would be removed from the fuel assemblies and packed into a separate fuel canister at twice the current density.

Description of Existing Pool Construction and Operation

The spent fuel pool is located within the plant's Auxiliary Building, with the top of pool elevation about 60 feet above ground level. The pool is enclosed within a reinforced concrete building having 12 to 18 inch thick walls and roof. The pool is constructed of reinforced concrete, and all inside surfaces are lined with stainless steel. A leakage detection and collection system is also provided. The pool walls vary in thickness from 3 to 6 feet, and the pool bottom is 5 feet 11 inches thick. The pool and enclosure are designed to withstand the effects of an earthquake, flood, or tornado, and still maintain safe storage of the spent fuel.

Figure 5-3 shows the spent fuel pool area. New fuel is stored dry in the new-fuel pit, at the west end of the area. The spent fuel storage pool consists of two connected compartments. The smaller compartment, adjacent to the new-fuel pit, is called pool 1, and the larger compartment is called pool 2. As shown in Figure 5-3, spent fuel assemblies are handled by a long-handled tool suspended from an overhead monorail electric hoist and manipulated by an operator standing on a moveable bridge over the pool. Each pool is filled with 40 feet of water. The water in the pools provides shielding for the radiation emitted by spent fuel, and provides cooling of the spent fuel assemblies. The pool water is continuously circulated for cooling and filtration. Levels of boron in the pool water are maintained where necessary to prevent criticality.

Spent fuel storage racks sit at the bottom of the pools. The racks are either a 7x7 or 7x8 vertical array of tubes, or cells, with each cell designed to hold one fuel assembly. Figure 5-4 shows the type of rack used at Prairie Island. Figure 5-5 is an overhead view of pools 1 and 2, showing the current configuration of racks. A total of 26 racks provide 1386 potential storage locations. Prairie Island's current license allows a maximum of 1386 spent fuel assemblies to be stored in the pool. The southeast corner of pool 1 serves as a cask set-down area, and so cannot be used for long term spent fuel storage. Figure 5-6 shows how a spent fuel cask would be removed from the pool area, using the Auxiliary Building crane. This crane has a capacity of 125 tons.

<u>Analysis of options 1 & 2</u>

Alternatives in this category involve enlarging the existing pool to accommodate the additional spent nuclear fuel generated, or building a new storage pool on the Prairie Island site.

1. Description of each option

   a. Option 1 - Expansion of Existing Pool

   Modifying the existing new-fuel pit to combine it with spent fuel pool 1 would result in an enlarged pool 1, and an increase in total pool storage capacity. The modification would entail removing the four foot thick concrete wall between the new-fuel pit and pool 1, removing the new-fuel pit floor, and relocating equipment which is presently in the area below the new-fuel pit. Structural reinforcement of the walls of the enlarged pool would probably be required. Federal and State approval of the design would have to be obtained before the modification is begun. Pool 1 could not be used for spent fuel storage during construction and until this modification is completed. Pool 2 will be at full capacity in June, 1991, and storage in Pool 1 will be necessary then. This modification would result in a storage capacity increase of about 500 assemblies.

b. Option 2 - Construction of a New Pool

This option entails construction of a building, containing a new spent fuel storage pool. The new building would need to be reinforced in a manner similar to the existing auxiliary building. The capacity of the pool would be fixed at the time of construction. Spent fuel would need to be loaded into a transfer cask to move spent fuel from the existing pool to the new pool. A new storage pool would require duplicating the same support facilities as the existing pool, i.e. fuel handling crane, large capacity overhead crane, and systems for pool cooling, clean up and ventilation. A new pool could be designed for older, cooler spent fuel, thus somewhat simplifying design and construction. This alternative would require about 5 years to design, obtain State and Federal reviews and approvals, and construct.

2. Wastes and emissions

Operation of a spent fuel pool results in generation of some radioactive wastes, the majority of which are used resins from the spent fuel pool demineralizer, and used filters from the pool filtration system. With the heavy shielding of the pool and the surrounding building, off-site radiation exposures are kept within licensed levels.

3. Construction impacts

Construction of either of these options would occur within the existing plant area, and result in little environmental disturbance, if any. Option 1, since it involves modification to both the existing pool 1 and the new-fuel pit, will cause some re-working of plant operating procedures during the construction period.

4. Operation impacts

Operation of either a larger pool 1 or new pool 3 would not result in environmental impacts over and above those currently in place.

5. Protection from natural calamity

Any increased pool capacity would need to be designed and built in such a way that all structures could withstand flood, earthquake or tornado. The design basis for these structures is the same as is applied to the plant as a whole, and would have to be approved by the NRC on that basis.

6. Radiological impacts during loading and storage

Increasing the amount of spent nuclear fuel stored on the plant site will incrementally increase the radiation exposure both of plant personnel and off-site residents. This increased exposure must fall within the total limits for the entire plant set by the NRC in the plant's operating license. These limits have been established in rule (10 CFR Part 20 and 72), and are deemed to be acceptably safe by the NRC. No additional exposure beyond those limits would be allowed due to the increased amount of fuel in storage.

Construction of an enlarged pool 1 would result in greater radiation exposure to the construction workers than would construction of a new pool 3. This is because the construction would take place in relatively close proximity to the existing spent fuel pool and the reactors, and thus in a radiation field of 1-2 millirem per hour.

7. Accident impacts

A spent fuel pool relies on active systems in conjunction with physical construction to maintain competent isolation of the spent fuel from the environment. For this reason, any accident which would interrupt the operation of the active systems or damage the physical structure of the pool could result in problems which may be minor or severe. The likelihood and severity of potential accidents are investigated in the document "Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82", published by the NRC in 1987 (NUREG/CR-4982).

This document assesses the probability of various types of severe (beyond design basis) accidents occurring, and then assesses the risk of releases of radiation due to those accidents. The types of accidents investigated were: loss of pool cooling capacity, seismic structural failure of pool, structural failure of pool from tornado missiles, structural failure from turbine missile, loss of pool water due to pneumatic seal failure, structural failure from drop of a storage cask into pool, and structural failure from drop of a storage cask after addition of safety features.

The greatest probability of severe accident was found to be for structural failure due to drop of a storage cask, such as that being proposed. The additional safety features assessed in the final scenario decreased the probability of a cask drop accident from a probability of 10^{-5} for the basic system to 10^{-8} for the improved system. For the proposed project or any of the alternatives which use casks, the Auxilliary Building crane and cask handling procedures would be assessed to ensure they meet the safety requirements of the NRC.

If structural failure of the pool were to occur, the greatest risk of radiation release would result from a fuel cladding fire which would subsequently discharge substantial releases of long lived isotopes. The findings in the document show that the greatest likelihood of a fuel cladding fire is for those pools where spent fuel has been stored in the newer-design high density racks, as is the case at Prairie Island. This is due to reduced air circulation around the fuel rods in the higher density racks. Although the document does not deal with consolidated fuel, it seems reasonable to assume that this would also pose increased risk of fire, if the water were removed. The pools at Prairie Island currently contain 18 consolidated fuel cannisters from a 1987 consolidation demonstration. If the pool were drained by accident, the likelihood of a fuel cladding fire was found to range from 10^{-5} to 10^{-12}. The risk was dependent on the age of the spent fuel in storage and the density at which it was stored.

The document also lists ways in which the risks due to storage of spent fuel in pools may be reduced. These include:

- -reduction of stored radioactive inventory in the pool,
- -improved air circulation in case of pool water loss, especially around freshly-discharged fuel,
- -additional (backup) cooling systems,
- -improved procedures and equipment, and
- -post-accident sprays.

A potential loss of pool water event is addressed by Prairie Island plant operating procedures. There is a specific procedure which identifies each of the several possible sources of make-up water for the pool.

The NRC has concluded that the risk from a Zircaloy cladding fire in the spent fuel pool is no greater than the risk from core damage accidents due to worse-than-postulated earthquakes. The NRC found that it was not necessary for plant operators to take any action on this issue, given the large inherent safety margins in the design and construction of spent fuel pools.

8. Safeguards from theft, diversion or sabotage

Any increase in pool storage would occur within the secured plant perimeter, and be handled as part of the routine plant security measures.

9. Decommissioning

Exposure of certain types of metal, such as stainless steel, to neutron radiation can cause the initially non-radioactive materials to become radioactive. Also, radioactive crud (corrosion products in the reactor's primary coolant system which deposit on fuel assembly surfaces) loosened from the surface of fuel rods can become fixed to the surface of racks, piping, and other fixtures in the spent fuel pool. For these reasons, the building of additional structures to contain spent nuclear fuel will increase the amount of materials which will require special handling when decommissioned. It would probably be more difficult to decommission a spent fuel pool than it would be for the spent fuel casks proposed to be used, due to the difficulties presented in demolition of such a large and reinforced structure.

10. Estimates of induced development

For a limited amount of time, additional construction workers would be needed. It is likely that these could be supplied from the Red Wing/Twin Cities work force, with no need for long-term resettlement of people. Most materials would be supplied by vendors qualified to supply nuclear grade materials, and most such vendors would not be in the local area. Limited amounts of standard construction materials, such as concrete, could be drawn from existing area material pools with little long-lasting impacts.

11. Feasibility analysis

Pool 2 will be full by June, 1991. Option 1, although less expensive to construct, would not be ready at this time and so plant operation would need to be curtailed until the newly-expanded pool 1 was ready. In the interim, NSP would need to run peaking plants and purchase power from other sources to make up for the missing Prairie Island capacity. Since Prairie Island is less costly to operate than these alternate sources of power, implementation of option 1 would end up being more costly than it appears.

Option 2 would not interfere with the storage of spent fuel in pool 1 as well as pool 2, stretching the existing pool capacity out to 1994. It is not likely that NSP could perform the engineering work needed and obtain the necessary federal and state approvals before that date, so again Prairie Island plant operation would be curtailed and alternate power sources located, and the previous analysis would apply.

12. Cost comparison

A new pool is estimated to cost $24.2 million (in 1990 dollars) to construct, and another $0.5 million annually for operation. Expanding pool one into the new-fuel pit area would cost an estimated $13 million dollars, and would have annual operation costs approximately equivalent to current costs for the current pool configuration.

<u>Analysis of options 3,4,& 5</u>

1. Description of each option

Options in this category involve modifying the spent fuel storage configuration to increase the capacity of the existing pools. This set of options is limited in the amount of additional storage which can be developed. Structural analysis of the existing pools show that they cannot accommodate increases of more than 30-35% in weight. A 35% storage capacity increase (about 480 assemblies) would provide storage until 2001 at full plant operation.

a. Option 3 - Reracking

Spent fuel is stored in the pool in racks. The racks are either 7X7 or 7X8 vertical arrays of square boxes about 14 feet tall, each box designed to hold one fuel assembly. Reracking means changing to racks designed with a more compact array of boxes (or cells). Prairie Island's current racks were installed in 1981, and have a much more compact design than the previous racks. Current generation rack designs are even more compact, and it may be possible to increase the Prairie Island pool capacity up to the 20% increase limit by reracking a third time.

The reracking process entails the following general sequence of installation:

1. Remove empty racks from pool 1, and install new, more compact racks in pool 1.
2. Transfer spent fuel from pool 2 to pool 1.
3. Remove empty racks from pool 2, and install new, more compact racks in pool 2.
4. Transfer the remaining spent fuel from the old racks of pool 2 to the new racks of pool 2. Remove the remaining old racks and complete the installation of new racks in pool 2. The old racks would be disposed of as low level radioactive waste.

b. Option 4 - Two-tiered Racks

This option entails placing a second tier of filled storage racks on top of the existing configuration of storage racks. The use of two-tier racks would require the addition of supports to the fuel pool walls. The existing racks are not designed for a two-tier configuration, and so would have to be replaced and disposed as low level radioactive waste. In order to have sufficient maneuvering room to install the new racks, the installation must be completed by summer of 1992.

c. Option 5 - Spent Fuel Rod Consolidation

The consolidation process entails removing all the fuel rods from two spent fuel assemblies, reconfiguring them into a close-packed triangular array, and then placing them into a canister of about the same outside dimensions as a fuel assembly. The canister is then stored in a rack cell formerly occupied by a single spent fuel assembly.

Figure 5-7 shows a Prairie Island-type 14x14 array fuel assembly before and after consolidation. The fuel rods are packed into a much tighter array after consolidation, with an effective doubling of the fuel rod density. The consolidation operation is conducted underwater in the spent fuel pool.

2. Wastes and emissions, pollution control equipment

Reracking the existing pool would result in the old racks becoming waste and needing disposal in a low-level radioactive waste landfill. The installation of two-tier racks would generate significantly less waste. Consolidating spent fuel means removing the fuel rods from the assemblies and repacking them in a denser array. The assembly hardware components would remain as waste, and because the long exposure to radiation would be highly radioactive. These would require special handling. Since there is currently no disposal place for waste of this type, the hardware would also have to be stored in the spent fuel pool or in dry casks on site at Prairie Island.

As for the previously-discussed options, the heavy shielding of the pool and the surrounding building will keep off-site radiation exposures within licensed levels.

3. Construction impacts

Environmental impacts resulting from implementation any of these options would be minimal, since all construction would occur within existing structures.

4. Operation impacts

Environmental impacts from operation of any of these options are also expected to be minimal, due to the enclosed nature of the operation. Like for options 1 and 2, the timing of the implementation of these alternatives would be dependent on the time involved to design the option and obtain the necessary approvals. This could impact the operation of the plant.

5. Protection from natural calamity

The existing structures would provide the necessary degree of protection.

6. Radiological impacts during loading and storage

Implementation of any of these options would entail a substantial amount of work in close proximity to the stored spent fuel and the reactors. This would result in some increased exposures for plant personnel and others involved in implementation. The levels of exposure allowed for nuclear workers are specified by the NRC, and would have to be met by NSP.

Off-site radiation impacts would be minimal from normal operation of any of these options. Again, any incremental increase would have to fall within the NRC guidelines and license limits.

7. Accident impacts

As for options 1 and 2, impacts from accidents could be severe. Although spent fuel casks will not be used in options 3, 4 and 5, minor likelihoods of other potential accidents exist. Examples of these types of accidents are loss of water due to failure of the pneumatic seals which separate the pool water from the transfer canals or loss of pool cooling capacity. Probabilities for these types of accidents are in the 10^{-6} range. Alternatives which increase the amount of spent fuel stored in the existing pool by increasing the density at which the fuel is packed increase the heat load in the pool and decrease the efficiency of natural cooling processes which could help alleviate the chance of fire. This is true for options 3, 4 and 5.

In addition to these general concerns, there are specific concerns for one of the options as well. The two-tier rack option would greatly diminish the available reservoir of water covering the spent fuel in the pool. Thus, if an accident were to occur which would lower the water level, the fuel in the upper tier may be exposed to the air. This would result in higher radiation exposure, particularly to plant workers, and could possibly result in a fuel cladding fire. The margin of safety offered by the very deep pool storage would be lost. There is also a chance that an upper tier rack could fall onto a lower tier rack, damaging it, contaminating the pool, and possibly releasing radiation.

8. Safeguards from theft, diversion or sabotage

As with the other options in this category, security would be handled as part of routine plant security. No greater security risks would be posed by implementing any of these options.

9. Decommissioning

Use of these options would make decommissioning the plant somewhat more difficult, by virtue of adding to the amount of spent fuel which must be stored until accepted by the federal government.

10. Estimates of induced development

Impacts of induced development would be minimal.

11. Feasibility analysis

Options in this category involve modifying the spent fuel storage configuration to increase the capacity of the existing pool.

Structural analysis of the existing pool shows that it cannot accommodate increases of more than 30-35% in weight. A 35% storage capacity increase (about 480 assemblies) would provide storage until 2001. Therefore, none of these options alone are adequate to meet Prairie Island's expected future storage needs.

NSP conducted a spent fuel consolidation demonstration in the fall of 1987. They found that the process was much slower than previously expected, and determined that this was an infeasible alternative because work would have to be conducted in the pool for six months out of the year. This could lead to conflicts with the plant's operating plan.

12. Cost comparison

Based on engineering judgement, reracking the pool to a more compact rack design would gain only 200-250 more spaces. At a spent fuel assembly generation rate of 72 per year, this would provide storage capacity for about three years at full plant operation. Reracking is estimated to cost $8-10 million. Two-tiered racks would cost more than reracking, because of the need for a special crane to lift the full racks and because of the need for additional reinforcing of the pool walls. This option is estimated to cost $12-14 million, and could result in a capacity increase of up to 480 assemblies which would provide less than seven years storage. Spent fuel rod consolidation would also cost around $12 million, and increase capacity by 480 assemblies.

References:

1. "Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82", NUREG/CR-4982. July 1987. Brookhaven National Laboratory.

2. Materials supplied by NSP in development of Scoping Document for this EIS.

3. NSP Project Description and Safety Analysis for the Spent Fuel Consolidation Project. Submitted to the NRC September 22, 1987.

4. Supplemental materials provided by NSP in August 15, 1990 transmittal.

5. NRC memorandum (internal), April 24, 1989, T. Murley to E. Beckford, "Resolution of Generic Issue 82, Beyond Design Basis Accidents in Spent Fuel Pools".

Shipment To Other Fuel Storage Facility

A. Description of options

This category covers shipping Prairie Island spent fuel to other storage facilities, such as NSP facilities (Monticello, Pathfinder), and to commercial facilities, such as GE Morris or the spent fuel storage facilities of other nuclear plants.

1. Transhipment to Monticello Pool

This alternative entails shipping Prairie Island spent fuel to Monticello, and storing it in Monticello's spent fuel pool. Monticello is the other operating nuclear power plant owned by NSP. It is a different type of plant than Prairie Island, in that it is a "Boiling Water Reactor" and not a "Pressurized Water Reactor". For this reason, Monticello's fuel assemblies are smaller than Prairie Island's and the handling tool is different. Therefore, Monticello's spent fuel pool racks and handling equipment would require modification and/or replacement in order to store Prairie Island spent fuel in Monticello's pool.

Monticello's current pool capacity will be exhausted in 2005. If Prairie Island spent fuel is stored at Monticello, NSP would need additional storage capacity at both plants by about 1998 to keep both plants operating at full capacity.

2. Transhipment to Pathfinder

Pathfinder, located near Sioux Falls, South Dakota, and owned by NSP, was originally built as a nuclear power plant but was converted to a fossil fuel plant in 1967. The conversion included dismantling all reactor storage support systems. Thus, the spent fuel storage system no longer exists at Pathfinder. Final decommissioning of Pathfinder is currently underway to remove the reactor vessel and spent fuel storage buildings. Transhipment to this facility is no longer an option.

3. Shipment to a Commercial Storage Facility

This alternative entails shipping Prairie Island spent fuel to a spent fuel storage facility at another site. NSP was able to ship Monticello spent fuel to a General Electric (GE) storage facility in Morris, Illinois,in a campaign which ran from 1984 to 1987. The GE Morris facility is now full, and there are no other commercial spent fuel storage facilities in the U.S. The only other choice is storage at a nuclear plant site owned by another utility. This alternative requires one or more utilities to agree to store Prairie Island spent fuel in their pools (or dry storage facility) until the DOE begins taking spent fuel for disposal, and to obtain required state and federal approvals.

B. Wastes and emissions, pollution control equipment

None of these options would generate significant amounts of wastes or emissions. The major potential impacts would occur during transportation of the spent nuclear fuel, which is covered in the federal Environmental Impact Statement on the Management of Commercially Generated Radioactive Waste, October 1980. The transportation casks themselves constitute the pollution control equipment used in implementing these options.

C. Construction impacts

No construction would be needed to implement these options. Option number 1 would require modification of equipment at Monticello, which would occur within the plant and have minimal environmental impacts.

D. Operation impacts

There would be very little environmental impacts due to implementation of these alternatives either on or in the surrounding vicinity of Prairie Island. Similarly, impacts at the receiving site would occur within the plant or controlled storage area and result in little increase in environmental impacts over the current level. In the case of shipping to Monticello, the increased inventory of spent fuel on site would add incrementally to the exposure of nuclear workers at Monticello, as well as to the off-site neighbors of that facility. This increased exposure would have to fall within the NRC requirements for that plant. If the spent fuel were shipped to a commercial facility or another utility, the impacts of operation would have to be assessed.

To maintain full production at Prairie Island, approximately three shipments per year of spent fuel (assuming 24 assemblies per transportation cask) would be necessary, starting in 1993.

E. Protection from natural calamity

Protection of the fuel during shipment is handled in accordance with 10CFR71. If the Prairie Island fuel were shipped to Monticello, the structures there would provide adequate protection from natural calamity, since that plant was built to the same standards as Prairie Island. If the spent fuel were shipped to a commercial facility or another utility, the protection measures necessary would have to be assessed.

F. Radiological impacts

Transportation cask designs must meet NRC standards of radiation protection before they are licensed. For that reason, radiological impacts of shipment are expected to be minimal for the amount of shipments which would take place. There would be some increase in nuclear worker exposure, due to the fuel handling operations which would occur. Off-site exposures for Prairie Island, Monticello or any other facility to which the fuel was shipped would be required to stay within NRC-established limits.

G. Accident impacts

Transportation accidents could impact human health or the environment to varying degrees depending on the location and severity of the accident. This has been discussed in detail in the "Final Environmental Impact Statement on the Management of Commercially Generated Radioactive Waste" (DOE/EIS-0046F, October 1980). This EIS found that the risk of severe impacts from accidents could be reduced to negligible by transporting only fuel which had been stored at least four years. Transportation casks are designed to provide additional protection in most credible accidents.

There is also a small risk of accident during storage of spent fuel in pools.

H. Safeguards from theft, diversion or sabotage

Shipments of spent nuclear fuel have occurred throughout the country on a continuing basis since the nuclear power industry was formed in the 1950's. NSP and the State of Minnesota has experience in shipping spent nuclear fuel from the Monticello shipping campaign in the mid 1980's. From this body of experience, safeguards have been developed and employed which have, thus far, been effective at preventing theft, diversion or sabotage of any spent fuel shipments. Transportation of spent fuel from Prairie Island would be required to be conducted under the same conditions of security as previous shipments. Examples of some conditions which may be imposed include: varying shipment routes when possible, not publicizing shipment times, and notifying police and emergency personnel along the shipment route so that preparations can be made for emergency response if necessary.

Once at the new storage site, the spent fuel would be kept secure within the secured perimeters of the plant or storage facility, following NRC-approved procedures for security.

I. Decommissioning

Implementation of these options would have little impact on decommissioning at Prairie Island, but would result in more difficulty at location stored. Environmental impacts of this increased burden would have to be assessed at the time if one of these options were chosen.

J. Estimates of induced development

There would be no induced development associated with this alternative.

K. Feasibility analysis

Transhipment to the Monticello pool, while feasible, would do little to solve NSP's long-term spent fuel storage problems. This is because the pool at Monticello currently has capacity for Monticello fuel which will be filled in 2005. Addition of Prairie Island fuel would result in filling of the Monticello pool by 1998. If the federal program for managing spent nuclear is successful in siting an MRS, this could be an alternative which would allow NSP to maintain full levels of power production at both plants. If the federal process stalls or fails, NSP would be forced to either close both plants or initiate another alternative.

Transhipment to Pathfinder is not feasible, since this plant no longer has any structures capable of spent fuel storage.

Shipment to a commercial facility would be a feasible option if one existed. This was the case when the Monticello fuel was shipped to Morris, Illinois, but Morris is no longer accepting spent fuel for storage. The possibility does exist that another utility with additional on-site storage capacity could provide storage space for spent Prairie Island fuel. There are several impediments which make this option unlikely, if not infeasible:

- The failure of the federal program to date has made all nuclear utilities carefully assess their life-of-plant storage needs for spent nuclear fuel. Most have found that some alternate form of storage will be needed if the federal government does not begin accepting spent fuel according to the agreed-upon schedule.

- For this reason, operating nuclear plants are trying to conserve and fully utilize existing storage space, not fill it up with other utilities' spent fuel.

- Prairie Island fuel is smaller than that used at most other plants, so special adaptations would need to be made to handle this fuel at another location.

NSP has not, to date, fully explored this option, judging it to be infeasible.

L. Cost comparison

Based on the cost of the last rerack at PI, NSP estimates the cost to equip the Monticello pool with racks and equipment to store Prairie Island fuel is estimated to be $3,000,000. The cost to transport 254 spent fuel assemblies from PI to Monticello is estimated to be about $2,000,000. Transferring this much fuel to Monticello would extend the Prairie Island pool capacity into 1995.

Storage costs which could be charged by another utility which may agree to host Prairie Island fuel cannot be postulated.

References:

1. "Final Environmental Impact Statement - Management of Commercially Generated Radioactive Waste" October 1980, DOE/EIS-0046F.

2. Material prepared by NSP in preparation of the Scoping Document for this EIS.

3. "Final EIS on Transportation of Radioactive Material By Rail", August 23, 1977, Interstate Commerce Commission.

<u>Shipment To Federal Facility</u>

A. Description of alternative

In this alternative, spent fuel from Prairie Island would be given to the federal government. NSP would give title to the fuel to the federal government at the plant gate. Transportation of the fuel, interim storage if necessary, and ultimate disposal would be the responsibility of the federal government.

The Nuclear Waste Policy Act of 1982, and its 1987 amendments, assigned to the U.S. Department of Energy (DOE) the responsibility for a spent fuel and high level radioactive waste management and disposal program. Under this program, the DOE is to take title to all the spent fuel generated at U.S. commercial nuclear power plants and eventually dispose of it permanently in an underground repository. Impacts from the federal nuclear waste management program (including transportation, interim away-from-reactor storage, and a geologic repository) are discussed in the U.S. DOE document "Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste", dated October 1980. For this reason, only the on-site impacts which would result from implementation of this alternative are discussed in this Environmental Impact Statement.

The DOE has signed contracts with each of the nation's nuclear utilities, formalizing the fuel acceptance agreement. The contracts state that DOE will begin to take title, arrange for transportation and dispose of the spent fuel starting in 1998. The annual acceptance ranking for each uitility is set forth in the DOE's Annual Capacity Report, most recently issued in 1988. In this schedule, the metric tons of uranium to be accepted from each reactor per year is set. Utilities may opt to use the acceptance capacity as their needs dictate. The acceptance schedule for NSP has been laid out as follows:

Year	Metric Tons Uranium
1998	41.81
1999	83.86
2000	65.16
2001	75.74
2002	113.81
2003	82.65
2004	98.96
2005	48.77
2006	51.79
2007	62.86

The Annual Capacity Report lists acceptance schedule for ten years in advance only. Additional acceptance beyond that time will be negotiated separately.

The ability of DOE to accept the spent fuel according to this or any other schedule is dependent on their success at siting and initiating timely operation of either the planned repository or some type of a storage facility. Implementation of both these options is not proceeding smoothly, and is discussed in more detail below.

1. Shipment to a DOE Repository

The Nuclear Waste Policy Act Amendments of 1987 direct the DOE to characterize a site at Yucca Mountain, Nevada, to determine if it is a suitable location for a high level radioactive waste repository. Investigation of all other sites was stopped. If the Yucca Mountain site is determined to be suitable, the earliest a repository could be operational is 2010, according to a November, 1989, DOE report on the waste management program. The State of Nevada is not amenable to siting the repository at Yucca Mountain, and has refused to issue to DOE the necessary permits to allow them to fully investigate the site. The DOE has sued Nevada, and Nevada has sued the DOE. Given the amount of legal wrangling which must be resolved, it is doubtful that 2010 is a realistic date.

If the Yucca Mountain site is not found to be permittable for a nuclear waste repository, the DOE must return to the US Congress with an alternative plan. In this case, the repository opening date would be moved back further still.

2. Shipment to a Monitored Retrievable Storage (MRS) Facility

The Nuclear Waste Policy Act Amendments of 1987 define certain conditions under which the DOE may be authorized to build and operate an interim away-from-reactor storage facility (known as a Monitored Retrievable Storage facility or 'MRS') in addition to a repository. These conditions place strict linkages between the MRS and repository development, prohibiting start of construction of an MRS until the NRC has issued a construction license for the repository. Given current DOE schedules, the earliest an MRS could be operational is 2007.

Earlier availability of an MRS would require action of the U.S. Congress to delink the two siting processes. DOE is currently preparing a new plan for MRS development as part of the Draft Mission Plan Amendment scheduled for publication by the end of 1990. The earliest date of MRS availability, assuming favorable congressional action and a volunteer site, appears to be 1998. This is also the date when DOE is required by its contracts with the utilities to begin accepting the spent fuel.

B. Wastes and emissions

The option of shipping spent nuclear fuel off-site to a federal facility of either sort reduces the on-site impacts of spent fuel storage significantly. The spent fuel would be loaded into transportation casks for shipment to the facility. Small amounts of low-level radioactive wastes would be generated in decontaminating the casks once they are filled, likely in quantities similar to those generated in decontaminating the storage casks proposed for use in NSP's proposed project. The transportation casks themselves are the pollution control equipment, with shielding to control radioactive emissions through the cask walls and other construction features that would minimize radiation hazards in case of accident.

C. Construction impacts

No construction would be necessary on-site to implement this option. Existing facilities would be used to load the spent nuclear fuel into transportation casks and ready them for acceptance by the DOE.

D. Operation impacts

Operational impacts from this alternative are minimal at the reactor site.

E. Protection from natural calamity

Plant features which were designed to protect the reactors, spent fuel pool and other plant components will also serve to protect the spent fuel during loading and cask preparation.

F. Radiological impacts

Implementation of this alternative instead of the proposed project would result in lower radiation exposure both to plant personnel and off-site residents since less spent fuel would be retained at the plant site.

G. Accident impacts

Potential accident impacts are the same for this alternative as for the loading phase of the proposed project.

H. Safeguards from theft, diversion or sabotage

Within the plant area, security would be handled according to the normal security measures employed at the plant. Once outside the gates, security would be handled by the federal government.

I. Decommissioning

Since no additional facilities would need to be built, decommissioning would be the most simple if this alternative were implemented.

J. Estimates of induced development

There would be no induced development in the Prairie Island vicinity if this alternative were adopted.

K. Feasibility analysis

This alternative will not be feasible until the federal government is able to initiate operation of either an MRS or a repository. The earliest this may be available is currently projected to be 1998. The DOE is now proceeding on the assumption that they will begin acceptance in 1998, and is developing the needed transportation infrastructure accordingly.

Assuming that DOE is successful in meeting its 1998 date, it would be possible for NSP to use the total DOE acceptance until 2004 for Prairie Island fuel. This would be a prudent option, since NSP's Monticello plant has storage capacity available for full operation to the year 2005. The schedule for acceptance could then be:

Year	# of Prairie Island assemblies
1998	104
1999	209
2000	162
2001	189
2002	284
2003	206
2004	247
Total	1401

Because the Prairie Island pool will be at full capacity by 1994, this alone is not a feasible option unless employed in conjunction with another alternative which would slow the rate of spent fuel generation.

L. Cost comparison

Funding for the DOE's nuclear waste management program comes from the Nuclear Waste Fund, into which each nuclear utility makes quarterly contributions. The amount contributed is based on a unit charge per kilowatt of power produced. NSP has been paying into this fund since July, 1983. If this alternative were implementable before Prairie Island used up all the available fuel storage capacity, this would be the least-cost alternative.

References:

1. NSP Contract with DOE for spent fuel acceptance.

2. OCRWM "Annual Capacity Report", June 1988, DOE/RW-0191

3. "Final Environmental Impact Statement - Management of Commercially Generated Radioactive Waste", October 1980, DOE/EIS-0046F

4. Nuclear Waste Policy Act of 1982

5. Nuclear Waste Policy Act Amendments of 1987

6. "Changes in the Geologic Repository Schedule" OCRWM Backgrounder, November 1989, DOE/RW-0249

7. "Final EIS on Transportation of Radioactive Material By Rail", August 23, 1977, Interstate Commerce Commission.

Reprocessing

A. Description of alternative

Unlike fuel from fossil plants that discharge ash with no further fuel content, fuels discharged from nuclear reactors contain appreciable quantities of "unburned" fissile uranium and plutonium fuel. Fuel elements must be removed from a reactor before they have been completely consumed, primarily because of fission product buildup. These fission products have a high affinity for parasitic capture of neutrons, free flow of which is necessary to sustain the chain reaction. In the interest of economic utilization of nuclear fuels and the conservation of resources, residual uranium and plutonium contained in spent fuel elements may be recovered at a fuel reprocessing plant.

In general, reprocessing of fuels entails shipping irradiated fuel elements from the reactor to a reprocessing plant, removing as much extraneous material from the fuel as possible by a variety of mechanical means, preparing the fuel for dissolution in nitric acid solutions, dissolving the prepared fuel, separating and purifying the uranium and plutonium by solvent extraction, treating the radioactive wastes, and shipping the recovered uranium to an enrichment plant to be used in nuclear fuel fabrication. Plutonium is also recovered, and may be stored for strategic purposes (nuclear weapon manufacture) or blended with uranium for production of mixed-oxide fuel, which is beginning to be used now in some European reactors in place of the more traditional uranium fuel.

Reprocessing was the spent fuel management strategy envisioned by the nuclear utilities in the 1960's and 1970's. The U.S. reprocessing industry was developing, with plants built to handle commercial spent fuel to be located in West Valley, New York; Morris, Illinois; and Barnwell, South Carolina. This did not come to fruition, however. Reprocessing was banned as a U.S. national policy by President Carter in 1977 because it makes plutonium for nuclear weapons more readily accessible. It was hoped that countries not yet having nuclear weapons would thus be discouraged from developing reprocessing facilities to obtain plutonium. In 1981 President Reagan rescinded this ban, and urged the nuclear industry to resume commercial reprocessing. Financial problems and uncertainty about future government policy, however, have discouraged U.S. industry from acting to reinitiate reprocessing here.

Other countries have proceeded with development of a viable reprocessing industry. There is currently about 1500 metric tons of annual reprocessing capacity in the world (Great Britain and France), with a significant increase expected in the next ten years as plants come into service as follows:

Great Britain	1200 metric tons	1992
France	400 metric tons	1992
Japan	800 metric tons	1995

Utilities in the following countries are now sending their spent nuclear fuel, either wholly or in part, to the existing facilities: Great Britain, Japan, France, Belgium, Italy, Switzerland, Holland, Spain, Finland and the Soviet Union. International transportation programs and cask fleets currently move about 4500 Mt/U (Metric metric tons of uranium) by road, rail, and sea; and international standards for the vitrified waste remaining after reprocessing are being developed. Spent fuel would be shipped from Prairie Island to either the Atlantic or Gulf Coast. Transportation within the United States could be by barge along a waterway, by rail or by road. All of these transportation options currently exist at Prairie Island. From the coast, the spent fuel would be shipped by sea to the destination country.

The reprocessing fuel management plan employed by a utility would be similar to the following:

1. As the fuel is routinely transported to the reprocessory for storage, the utility would receive a bill for transport and storage.

2. When the fuel is reprocessed (about 10 to 15 years from now for new customers) the utility would receive a reprocessing and waste management bill.

3. The utility would have the option of having its recovered uranium re-enriched and manufactured into new fuel, or selling the recovered uranium to others.

4. High-level radioactive waste in the form of a vitrified glass log in a stainless steel container would be returned for eventual repository disposal. The glass log would represent the high-level waste from five fuel assemblies, an 80% reduction in volume. Low-level wastes could be disposed in the country where the fuel was reprocessed for a fee, or returned as well. Depending on timing, utilities may have to take back the glass logs before the DOE has an MRS or repository operating.

Part of the institutional ground-work has been developed which would allow U.S. utilities to send their spent fuel to Europe for reprocessing. The U.S. has in place a treaty with Euratom (the European nuclear agency) which allows the movement of fuel between the U.S. and Europe. There is routine movement of U.S. origin fuel to and within Europe with all the various European and U.S. governmental approvals in place and understood. International Atomic Energy Agency (IAEA) safeguards are in place for the control and accountability of the fuel, plutonium and uranium; and a set of U.S. Codes exist to define the licensing steps to export spent fuel. What remains is for a U.S. utility to declare an interest in the reprocessing option and to apply for an export license under 10 CFR part 110, which governs the export and import of nuclear equipment and materials.

B. Wastes and emissions, pollution control equipment

The wastes and emissions produced at the Prairie Island plant would be minimal. From reprocessing spent fuel, the following high-level

radioactive wastes would be produced at the reprocessing plant for each metric tonne (1000 kilograms) of spent fuel:

Residue from Reprocessing	Weight,kg.
Fission Products	28.8
Fuel	
Uranium	4.8
Plutonium	0.04
Tranuranics	
Neptunium	0.48
Americium	0.14
Curium	0.04
Reprocessing Chemicals	68.5
Total	102.8

This waste represents about 10% of the original weight of the spent fuel. This is the portion which would be returned to the utility for eventual repository disposal. In addition, low-level radioactive wastes would be produced, which could be handled in the reprocessing country for a fee or returned to the country of origination. Some authors, cited in "Understanding Nuclear Waste" by Raymond Murray, have postulated that other elements could also be economically recovered from the spent fuel, including cesium and strontium which are used in the food irradiation industry, as well as extremely scarce minerals such as ruthenium, rhodium and palladium. In 1981, the value of these scarce minerals was estimated to be about $30,000 per metric ton of spent fuel.

The disposition of the recovered plutonium is problematic at this point, since the use of mixed-oxide fuel (uranium and plutonium) is not yet very common. Plutonium is used to fuel the Fast Breeder Reactors such as the French Super-Phenix reactors, one of which is now on line. This could be another possible outlet for the recovered plutonium.

C. Construction impacts

There would be no construction required at the Prairie Island plant site for this alternative, so there would be no environmental impacts associated with construction.

D. Operation impacts

Impacts of operation at Prairie Island would be minimal. Once the transport casks are loaded and shipped, there would be no further impact at Prairie Island. Transportation of the spent fuel for such a long distance would raise public concern, and would need to be carefully assessed for potential impacts and mitigation measures before implementation.

Impacts of operation of the reprocessing facility would be assessed in the country chosen for reprocessing. Any incremental impacts (over and above the existing level) would not be great, since the Prairie Island fuel would only represent a small fraction of the total fuel handled at the site.

E. Protection from natural calamity

Transportation of the spent fuel, and return of the vitrified waste, is the major impact area where protection from natural calamity would be needed. Transportation of nuclear fuels has been occurring globally on a routine basis and is expected to grow in years to come. IAEA standards for safety have been developed, and are enforced in international shipments. The portion of the shipping route within the U.S. would be covered by NRC and U.S. Department of Transportation standards, which would need to be met. In addition, some states have further requirements which must be met for nuclear waste shipments. Through this network of safety precautions, protection from natural calamity would be afforded.

F. Radiological impacts

Since spent fuel would be removed from the Prairie Island plant site, the radiologic impacts would be lessened in that area. Radiological impacts during transportation would need to meet the standards described in part E. Radiological impacts at the reprocessing facility are governed by that country's standards, and the incremental impact of adding the Prairie Island fuel to that already being processed would be minimal.

G. Accident impacts

Impacts from accidents could occur during cask loading (see discussion of cask drop incidents, page 5.23) or transport. Refer to the discussion of transport accidents on page 4.19.

H. Safeguards from theft, diversion or sabotage

Given the distances to be traversed, precautions to be taken to prevent theft, diversion or sabotage must be sure and effective. As discussed in part E. of this section, standards are in place to safeguard the fuel during shipment. These standards have proven to be effective to date in the ongoing programs, and would be adhered to in future shipments as well. Again, the reader should bear in mind that shipments of nuclear materials occur routinely, and the incremental added opportunity for theft, diversion or sabotage of adding Prairie Island spent fuel would not be great.

I. Decommissioning

Removal of the spent fuel from Prairie Island would facilitate decommissioning of the plant, and the incremental impact of adding the Prairie Island spent fuel to that already being reprocessed would not make decommissioning of those facilities any more difficult. This alternative may facilitate decommissioning, in that when the plant is shut down, less fuel on site means fewer shipments and hence less time to empty the pool, and hence, less likelihood there will be a delay in beginning the decommissioning of those areas and plant systems which tie into the pool. Even with maximum reprocessing, at shut down there will be several years worth of spent fuel in the pool in addition to the 242 assemblies in the reactor core.

J. Estimates of induced development

None are expected in the Prairie Island vicinity.

K. Feasibility analysis

This is a feasible alternative, currently in use in other countries and available for use in the United States. At least one other U.S. utility has been considering reprocessing, although no license applications have been filed to date.

L. Cost comparison

Simon Rippon, in a column in the December, 1989, issue of Nuclear News stated that the costs of international transport of spent nuclear fuel is currently running at about $30/kilogram of uranium. For Prairie Island, this would cost about $12,000 (1989 $'s) per fuel assembly. (Each fuel assembly has approximately 0.4 metric tons, or 400 kilograms, of uranium.) Current contracts for reprocessing are charging $500-600/kilogram of uranium, which would come to $200,000 to $300,000 per assembly. There would also be costs associated with disposal of the low-level radioactive wastes which remain, storage of the solidified waste at the reprocessor's facility and return transportation. As pointed out in part A of this section, the transportation costs would be assessed when the spent fuel is shipped and payment of the reprocessing costs deferred until the spent fuel is reprocessed in about 10-15 years. The 1989 cost figures provided would be higher at that time.

These costs may come down as the additional reprocessing capacity comes on line worldwide. It would be reasonable for utilities which are using reprocessing as a fuel management strategy to go to the U.S. Congress and seek a change in the Waste Fund legislation, to allow them to either pay in less to the fund or draw on the fund to help cover the costs of reprocessing, since the volume of waste remaining for management by the DOE is reduced by 80%. NSP comments that although the volume of reprocessed waste is much less than spent fuel, the heat content is not significantly less, and because heat concentration is a more important restriction on the repository design, there would not likely be a refund from the DOE

Costs to NSP could also be recovered, at least in part, by use of the recovered uranium in the Louisiana Energy Services fuel enrichment plant in which NSP has become a partner recently. The use of recovered uranium reduces new uranium usage by 30-40%. Other materials recovered during reprocessing could also be sold to offset reprocessing costs.

References:

1. "Understanding Radioactive Waste, Third Edition", Raymond L. Murray, Battelle Press, Columbus Ohio. 1989.

2. "Reprocessing: Another Waste Management Strategy" Presented by David Snedeker at the INMM Annual Meeting, July 15-18, 1990.

3. "The European Reprocessing Option for U.S. Utilities", testimony before the MRS COMMISSION, given Friday, December 2, 1988 by David Snedeker.

4. "NSP Involved in Nuclear Fuel Plant", byline Lucy Hood, published in the April 25, 1990 edition of the Minneapolis Star-Tribune.

5. Telephone conversation with David Snedeker, May 3, 1990.

6. "Reprocessing as an Irradiated Fuel Management Strategy" Presented by David Snedeker at the INMM Spent Fuel Management Seminar VII, January 17-19, 1990.

7. "The Best Place for Plutonium is in a Reactor", Simon Rippon's "Comment from Europe" column in Nuclear News, Dec. 1989, page 68.

Use Of Higher Burnup Fuel

A. Description of alternative

This alternative essentially stretches the existing capacity for spent fuel storage at Prairie Island by more fully utilizing the fuel and therefore generating less spent fuel. Burnup is a measure of how much energy a fuel assembly produced during the time it was in the reactor. For a given amount of energy production by the reactor, the number of spent fuel assemblies generated will be less if each assembly can provide more energy; that is, if fuel can achieve a higher burnup.

Many interrelated factors affect discharge burnup, including fuel enrichment, core design, fuel design, and reload size. The NRC has determined an acceptable limit for fuel burnup. The combination of fuel and core design currently being used at Prairie Island is achieving the maximum burnup allowed today.

It is possible that the NRC could raise the burnup limit, and higher burnup fuel could be used. The maximum fuel burnup likely to be permitted by the NRC for the forseeable future is about 48,000 MWD/MTU (megawatt days per metric ton uranium). The maximum burnup currently allowed for the fuel used at PI is about 45,000 MWD/MTU. This value was determined by the fuel vendor (i.e. the company that designs and builds PI's fuel assemblies), using NRC-approved methods. Higher burnup may be achieved in the future if the PI fuel vendor modifies the fuel design or its analytical methods, but will always be constrained by the NRC's ultimate limit. An increase in burnup of 3,000 MWD/MTU, or 6%, would decrease PI's average spent fuel generation rate from 72 to 68 assemblies per year. Because the savings in fuel costs achieved from higher burnup is generally more than the cost of a change to fuel design or analytical method, NSP has sought to achieve maximum burnups.

B. Wastes and emissions, pollution control equipment

Spent fuel with higher burnup is thermally hotter, and emits more radiation. It remains so for a significant period of time. However, it does follow a similar decay curve to that seen for spent fuel with lower burnup. There is no real difference in the handling and storage of assemblies with higher burnup. This is because fuel handling and storage takes place under about 25 feet of water, which provides enough shielding that there is no significant increase in ambient radiation fields in the pool enclosure. Also, the additional thermal output of higher burnup fuel will not exceed the heat removal capacity of the pool water cooling system It is likely that although hotter, the higher burnup fuel could be safely handled with existing equipment in the plant.

C. Construction impacts

There would be no construction associated with this alternative.

D. Operation impacts

There would be no environmental impacts associated with operation of this alternative since it would be fully implemented within the existing plant structure and would not result in increased radiation emissions.

E. Protection from natural calamity

The use of higher burnup fuel can be accomplished with no change in the plant's physical structure. Therefore, it would require no additional protection from natural calamity besides that which is now afforded by the plant to meet federal requirements.

F. Radiological impacts

There would be no increase in personnel exposure associated with higher burnup fuel. This exposure would have to fall within the limits allowed by the NRC.

G. Accident impacts

Since the fuel is incrementally hotter and more radioactive, the potential consequences of any accident would be incrementally greater. The additional impact of this increment would not be major. Any accident involving spent nuclear fuel would be dangerous.

H. Safeguards from theft, diversion or sabotage

This alternative would entail storage of the spent fuel within the existing pools, which are maintained with the same degree of security as the reactors themselves. The likelihood of theft, diversion or sabotage is less, therefore, than for the proposed project where the spent fuel would be stored in a separate facility and new security measures implemented.

I. Decommissioning

Decommissioning of the plant would be made incrementally more difficult by the addition of hotter and more radioactive fuel to the fuel already in storage. It is likely, however, that this incremental difference could be adequately handled by use of existing techniques and would not pose any obstacles which would need to be overcome before the plant could be decommissioned.

J. Estimates of induced development

There would be no induced development associated with implementation of this alternative.

K. Feasibility analysis

This alternative will not be feasible unless the NRC changes the burnup which it allows. It would also not add significantly to the storage capacity of the plant (in terms of years), and so would not allow NSP to meet their objective of full operation of the Prairie Island plant through its license period.

L. Cost comparison

Reducing the number of fuel assemblies which NSP must purchase for PI by four would result in a net savings of between $1,000,000 and $1,500,000 per year.

REFERENCES:

1. Material supplied by NSP in preparation of the Scoping Document for this EIS, February 1990.

2. "Higher Burnup Offers Attractive Possibilities", Nuclear Engineering International, pages 24-28. March, 1990.

3. "Integrated Data Base for 1989: Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics." DOE/RW-0006, Rev. 5. November, 1989.

Combinations of Alternatives

A number of combinations of several of the alternatives previously discussed would "buy time" and delay the need for the proposed dry cask storage project. However, the uncertainty of timetables associated with the DOE program for siting an MRS facility and a permanent repository limits development of a reliable strategy which would avoid NSP proposed dry cask storage proposal. Assuming full operation of the plant through its licensed life (2013-2014) and failure of the DOE to begin accepting spent fuel before 2010, there is no combination of alternatives which will likely be available to NSP and which would avoid the need for additional onsite storage capacity as proposed.

However, assuming DOE acceptance of spent fuel in 1998, the following combination scenario may be feasible. As discussed in the alternative section on increasing the existing pool capacity, specifically the options of reracking, two tiered racks, and rod consolidation, if 20 % additional capacity could be attained with either of those three options, the existing pool, if modified, could possibly provide storage until 1998. Then, as discussed in the alternative section on shipment to federal facility, NSP could, in 1998, shift its DOE spent fuel acceptance capacity for Monticello to Prairie Island. This would permit shipment of up to 1401 assemblies through 2004 from Prairie Island to the federal MRS, effectively creating enough capacity in the Prairie Island pool to continue operation through its licensed life. The capacity needs at Monticello would then have to be provided through some similar combination of options.

This scenario could also be considered with combinations of reduced operation, conservation, higher burnup fuel, and new coal-fired base load capacity. The possible combinations require complex analyses. The uncertainties of the federal acceptance plans limit meaningful assessments of feasibility, system operation, costs and environmental impacts for combinations of alternatives.

Comments 8F, 13D, 13E, 13GG-13JJ, 14A, and 19M suggested that more discussion of alternatives be included. Additional analysis of single alternatives and combinations of alternatives indicate that the following scenarios may be feasible. Assumptions used in the analysis are (1) options exercised starting in January, 1992; (2) 72 fuel assemblies generated per year; (3) linear relationship between percent operation and number of fuel assemblies generated; and (4) 200 fuel assembly capacity remaining in pool in January, 1992.

-No increase in storage capacity, but reduce operation of the plant until the DOE begins to accept spent fuel. If acceptance begins in 1998 as required by contract, Prairie Island could operate at 46% of full operation until 1998, and resume full operation thereafter. If acceptance does not begin until 2010 (a date chosen for illustrative purposes only) the plant could only operate at 15% of full capacity until that time.

-Implement an increased pool capacity option through reracking, two-tiered racks, or consolidation (maximum increase in space of 33% or 480 spaces), and reduce operation to 43% of full capacity through the remaining license period.

-Increase pool capacity as above, and then ship spent fuel to the DOE when they begin accepting. If they begin accepting spent fuel in 1998 Prairie Island could operate at full capacity through the license period. If spent fuel is not accepted until 2010, Prairie Island would need to reduce operation to 52% of full capacity until that time.

-Use of higher burnup fuel, if allowed by NRC in license modification, would result in up to 6% less spent fuel being generated. This could be used in conjunction with the above combinations to recover that portion of the lost production.

-Conservation would have system-wide effects, and could be used to offset the loss of production from Prairie Island but with economic penalties. The conservation alternative is discussed in a separate section beginning on page 5.7.

Alternative Energy Resources

Renewable Energy Resources

Comments 2A, 13CC, 15I, 19P, 8B (Also see NSP comment letter, p.4) The State Energy Policy and Conservation Report to the Legislature, prepared by the Minnesota Department of Public Service and titled, Energy, Minnesota's Options for the 1990's, (December, 1988), summarizes the potential for alternative resources to replace conventional energy sources. The discussion is relative to all types of energy.

Alternative sources in Minnesota produced 5.1 percent of the energy used in the state in 1986, up from 3.7 percent produced in 1980. The largest portion of this production comes from wood. The two historically significant sources of renewable energy have grown dramatically since 1980: hydropower has increased by 50 percent, wood by 38 percent. Other sources, although they continue to provide small percentages of total energy use, have increased significantly. See attached tables.

Finding replacements for established sources of energy is a goal that holds several attractive prospects or possibilities:

- Producing replacement or alternative energy from local and national resources would lessen our nations's dependence on foreign oil and the accompanying vulnerability to sudden disruptions and economic shocks;

- Developing alternatives from renewable resources would ensure a continuing energy source, with all the stability and security that implies;

- Developing alternative energy from Minnesota resources would strengthen our state's economy; and

- Using alternative resources would enable us to reduce the environmental problems associated with some of the established fuels.

When these prospects will be attainable is a matter of speculation. A number of cost-effective applications of alternative fuels are available, but no alternative fuel has yet developed to the point where it can significantly replace conventional fuels. In most cases, this lack of development is due to lack of economic incentive. The cost of conventional fuels has remained too low for a developing source to be competive. Without the promise of a near term economic reward, research lags on all the various aspects of production, distribution, and use.

The prospects held out by alternative fuels are, nevertheless, too important to ignore. Continued development of these sources is necessary for the long range security and health of our state and nation. Minnesota can make its own contribution to this search for alternative energy sources, especially in developing energy from biomass, a resource with which our state is richly endowed.

Estimated Alternative Energy Consumption From Minnesota Sources (Trillion Btu)[1]

	1980	1986
1. Hydro[2]	8.257	12.393
2. Biomass		
Wood (Gross Resource Consumption)		
A. Residential[3]	26.650	34.252
B. Commercial	0.181	0.770
C. Industrial	8.552	13.800
Total Wood	35.383	48.822
Biomass Ethanol	0.016	0.110
Biomass Gas Methane	——	0.020
Total Biomass	35.542	48.952
3. Municipal Waste		
Solid Waste	N/A	0.701
Sludge	N/A	1.330
Total Municipal Waste	N/A	2.031
4. Wind Energy[2]	0.016	0.025
5. Solar (Gross Output)		
A. Residential	0.120	0.367
B. Commercial	0.001	0.006
Total Alternative Energy Consumption	43.936	63.774

1. Does not include imports from alternative energy sources outside of Minnesota. However, any net imports of wood from Wisconsin are not excluded.

2. Hydro and wind electric production estimates are given in coal equivalent Btus.

3. Because of differences in sources, the 1986 residential wood estimate may not be directly comparable to the 1980 estimate.

Source: *Minnesota Energy Databook, 1980-86*. Minnesota Department of Public Service.

Biomass Resource Potential, Heat Energy Uses

ENERGY CROPS	Million Btu Per Acre[1]	Acres to Supply 10% of State Energy Use[2]
Crop Residues, Average	13	12,000
Corn Stover	43	2,700
Corn, Grain and Residue	75	1,600
Sweet Sorghum, Entire Plant	154	800
Hybrid Poplar[3]	68	1,700

SURPLUS WOOD AVAILABLE FOR ENERGY

	Trillion Btu
Limited Value Timber	10
Forest Product Industry Residue	2
Logging Residue	14
Other Forest Fiber[4]	24
TOTAL	50

1. Assumed combustion efficiencies of each biomass fuel are based on air drying to 20% moisture content.

2. State energy use of 1,177.2 trillion Btu in 1986.

3. Average annual energy production based on a growing cycle of several years.

4. Wood from land clearing, natural tree mortality, etc.

Source: *Status of Fiber Fuel Use In Minnesota*, Minnesota Department of Natural Resources, Minnesota Department of Energy and Economic Development, Fiber Fuel Institute, 1986. Minnesota Department of Public Service, Energy Division.

In a recent analysis prepared for a presentation to the Minnesota State Senate, titled Minnesota: Energy Self-Sufficiency (February, 1991), Dean Abrahamson of the U of M's Humphrey Institute of Public Affairs considered the potential of hydropower, photovoltaics, windpower and biomass as alternative sources of energy. His conclusions relative to these Minnesota options are:

- There is modest potential for increased use of hydropower in Minnesota;
- The future holds great promise for photovoltaic cells but at present photovoltaic power is practical for only special purposes;
- The Minnesota windpower potential is very large; and
- (relative to electricity) There is a very large potential for electricity production using Minnesota hardwoods as fuel.

The analysis included the following two tables which include comparisons of pollutants and costs between conventional electric power sources, including nuclear, and renewable alternatives.

POLLUTANTS FROM ELECTRIC POWER GENERATION

Emissions of Pollutants from Electric Power Generation: The Total Fuel Cycle
(Tons per Gigawatt Hour)

Energy Source	CO_2	NO_x	SO_x	TSP	CO	HC	Nuclear Waste	Total
Conventional Coal	1058.191	2.986	2.971	1.626	0.267	0.102	NA	1.066.143
Fluidized Bed Coal	1057.090	1.551	2.968	1.624	0.267	0.102	NA	1,063.602
Natural Gas IGCC	823.993	0.251	0.336	1.176	NA	NA	NA	825.756
Nuclear	8.590	0.034	0.029	0.003	0.018	0.001	3.641	12.316
Photovoltaic	5.890	0.008	0.023	0.017	0.003	0.002	NA	5.943
Biomass[2]	0*	0.614	0.154	0.512	11.361	0.768	NA	13.409
Geothermal	56.8	TR	TR	TR	TR	TR	NA	56.8
Wind	7.4	TR	TR	TR	TR	TR	NA	7.4
Solar Thermal	3.6	TR	TR	TR	TR	TR	NA	3.6
Hydropower	6.55	TR	TR	TR	TR	TR	NA	6.55

* *With Biomass Fuel Regrowth Program*
TSP: Total Suspended Particulates *NA: Not Applicable* *TR: Trace Elements*
Note: The total fuel cycle includes resource/fuel extraction, facility construction, and plant operation.

Source: American Wind Energy Association, March 1990

TOTAL COST OF VARIOUS POWER ALTERNATIVES

CENTS PER KILOWATT-HOUR

OPTION	*CONVENTIONAL*	*ENVIRONMENTAL*	*CARBON*	*TOTAL*
PHOTOVOLTAIC	*20+*	*LOW*	*NONE*	*20+*
NAT GAS PEAKING	*10+*	*1*	*1*	*12+*
NUCLEAR POWER	*8-13*	*HIGH*	*LOW*	*8-13++*
WINDPOWER	*7-9*	*LOW*	*NONE*	*7-9*
COAL	*5-6*	*3-7*	*2*	*10-15*
WHOLE TREE BURNER	*4-5*	*LOW*	*NONE*	*4-5+*

NUCLEAR POWER COSTS ARE VERY DIFFICULT TO ESTIMATE AS THEY INVOLVE SUCH UNRESOLVED ISSUES AS: THE FINAL ISOLATION OF HIGH-LEVEL RADIOACTIVE WASTES, REACTOR ACCIDENT CONSIDERATIONS, AND MEANS, NOT YET ESTABLISHED, TO DEAL WITH THE THREAT OF THE DIVERSION OF NUCLEAR FUELS FROM THE CIVILIAN NUCLEAR POWER FUEL CYCLE.

THE ENVIRONMENTAL COST FOR COAL POWER VARIATION IS LARGELY DUE TO DIFFERING SULFUR CONTENT OF THE COAL.

Sources: Previous tables.

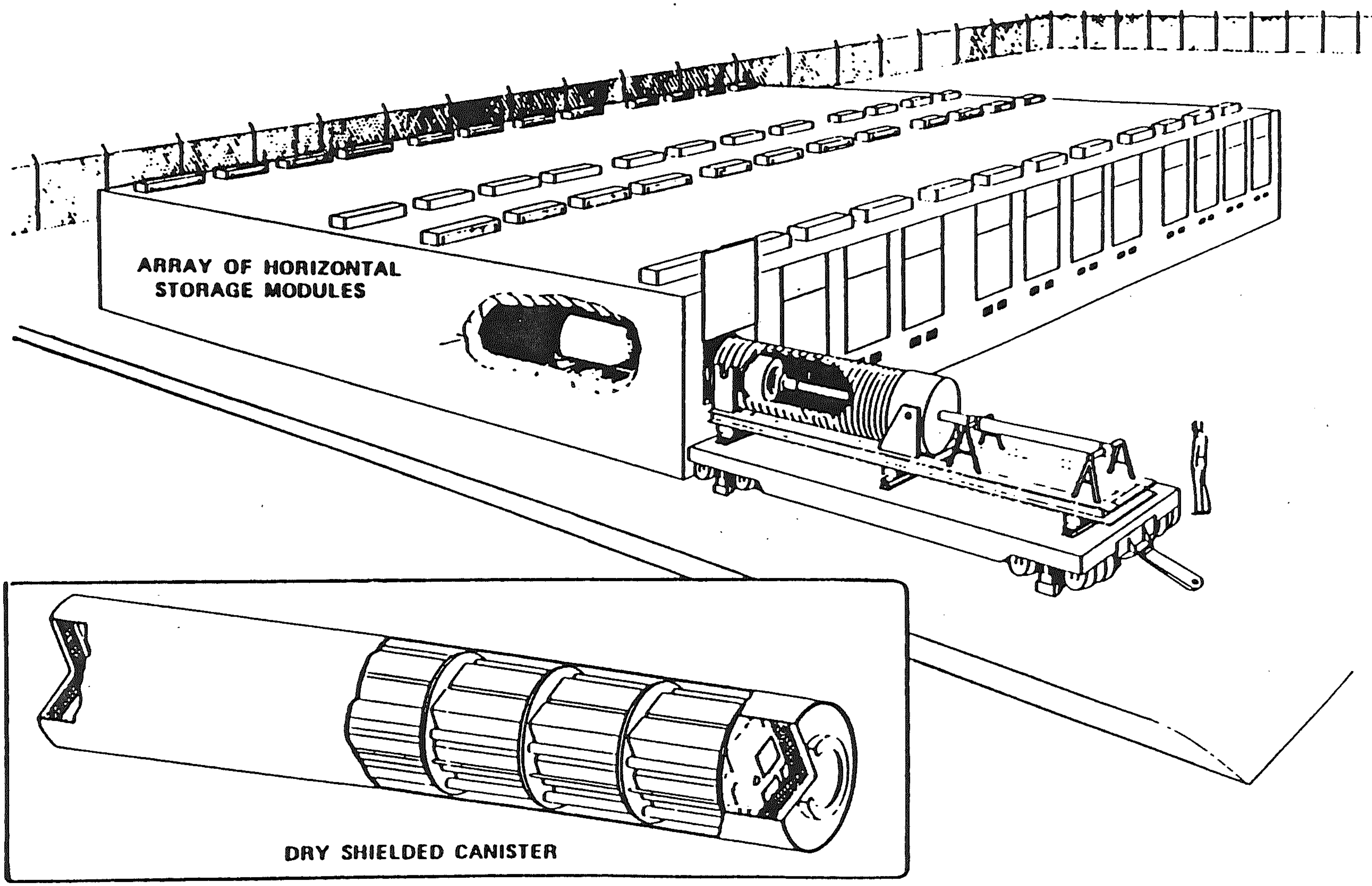
Notes: The Conventional costs are for a new generating plant. The Environmental costs are those estimated by Ottinger, et al. The carbon tax values are those for a $100 per ton carbon reduced by the $50 per ton carbon included in the Ottinger, et al. environmental cost data. All sources are those of previous tables.

Impacts of Fossil-fueled Generation

Comment 9D noted that the alternative of coal-fired power plants also have significant impacts. The impacts of coal generation are well documented in the literature and, relative to pollutants, are generally reflected in the preceeding two tables. An article in the 4-26-1990 Nuclear Waste News the following relative numbers:

> A 1000 megawatt nuclear reactor uses 25 tons of fuel/year and produces 25 tons of rad waste. A similar coal station burns 2.5 million tons of fuel and produces the following wastes: 6.5 million tons of CO2, 9000 tons of SO2, 4500 tons of NOX, and 1,500 tons of ash.

It is not useful in this EIS process to calculate specific coal extraction and transportation impacts. The commenter's observations are noted.



NUTECH HORIZONTAL MODULAR STORAGE SYSTEM FOR IRRADIATED FUEL

nutech

Figure 5-1
MODULAR CONCRETE STORAGE

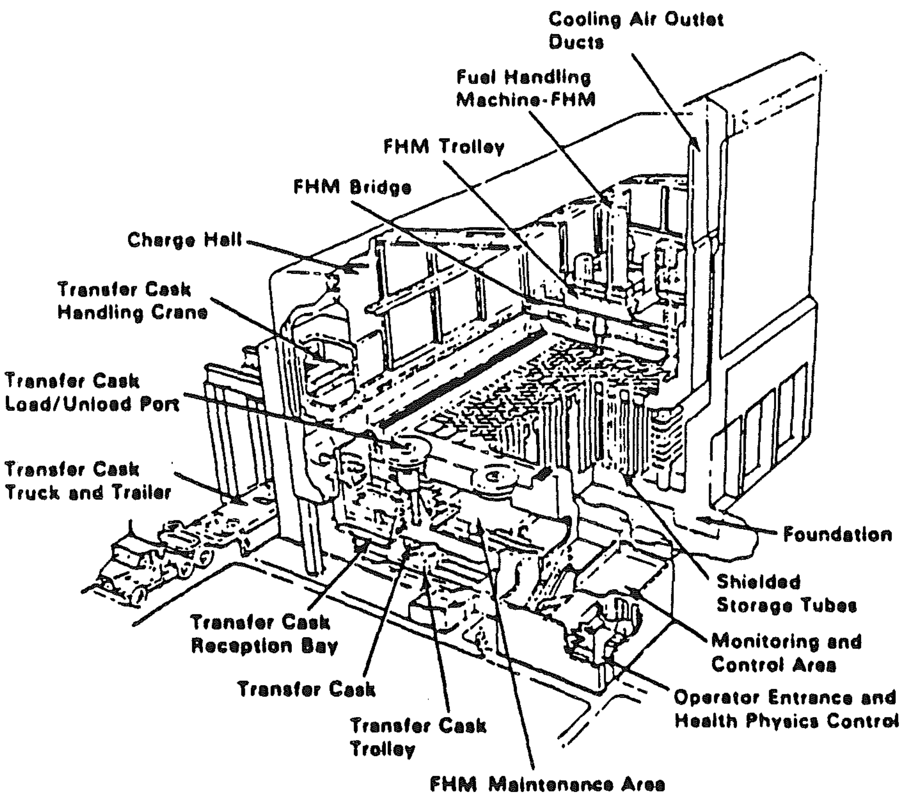


Figure 5-2 Conceptual design for a modular vault storage system.

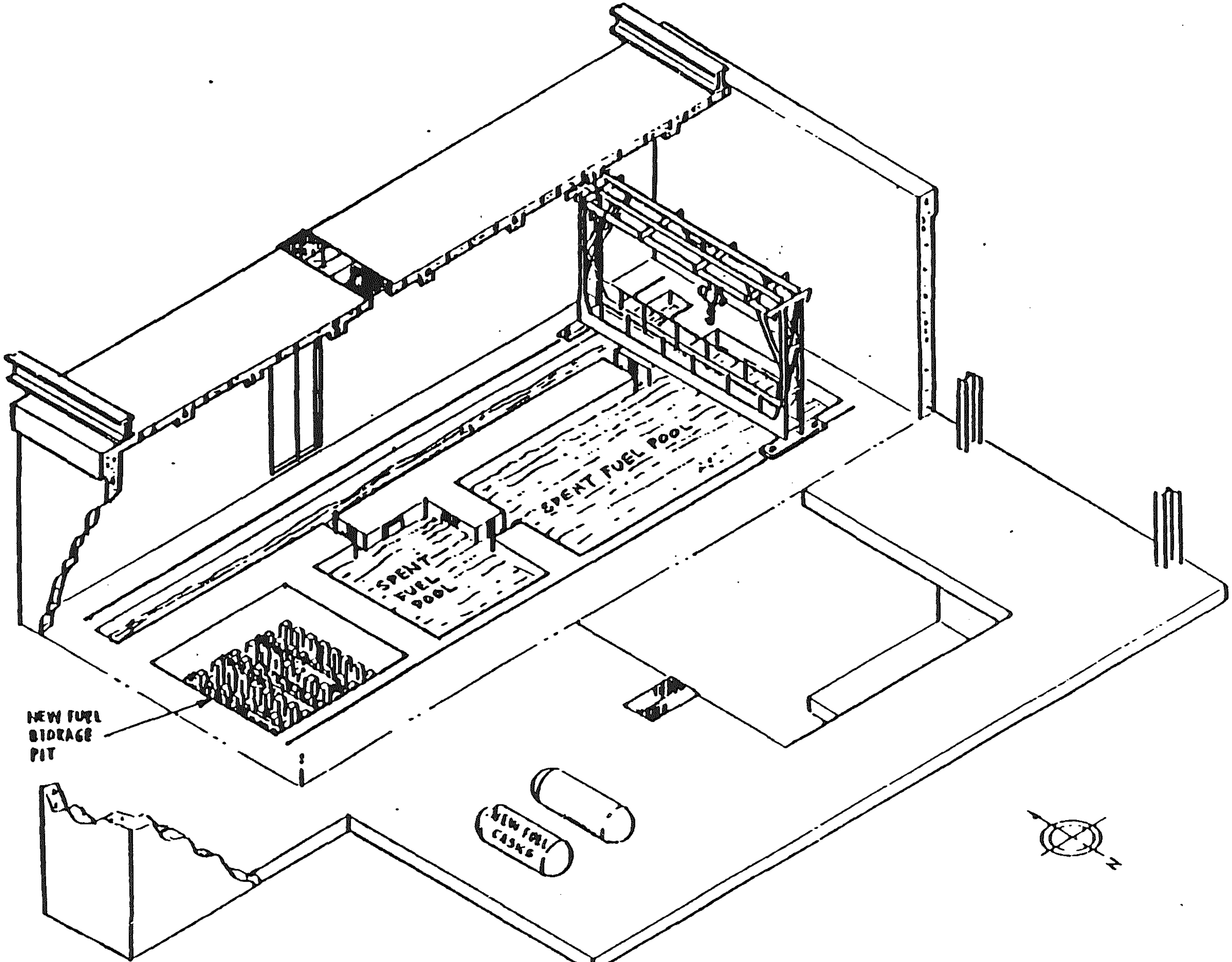


Figure 5-3

SPENT FUEL POOL CUTAWAY VIEW

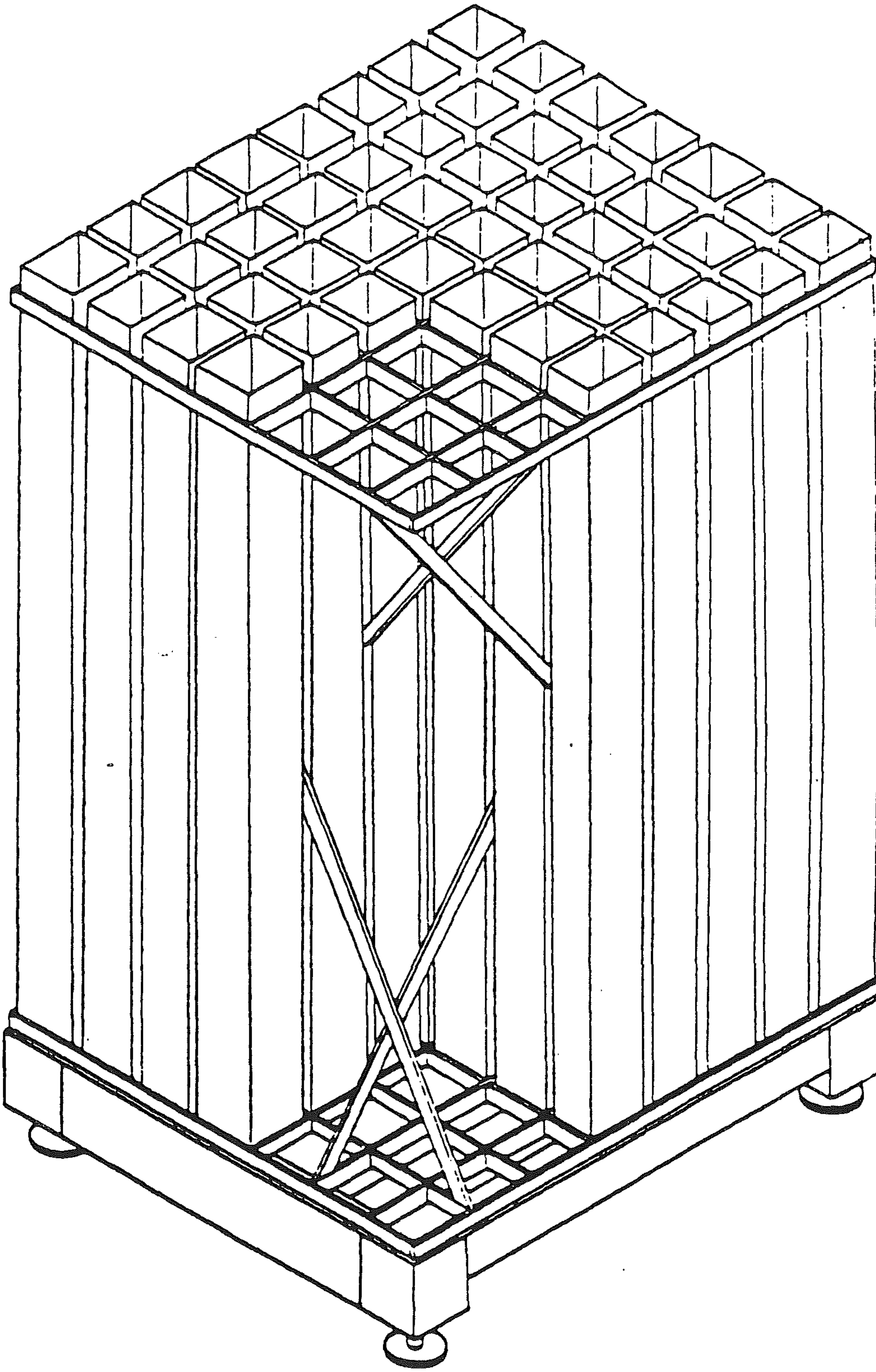


Figure 5-4

TYPICAL SPENT FUEL ASSEMBLY STORAGE RACK

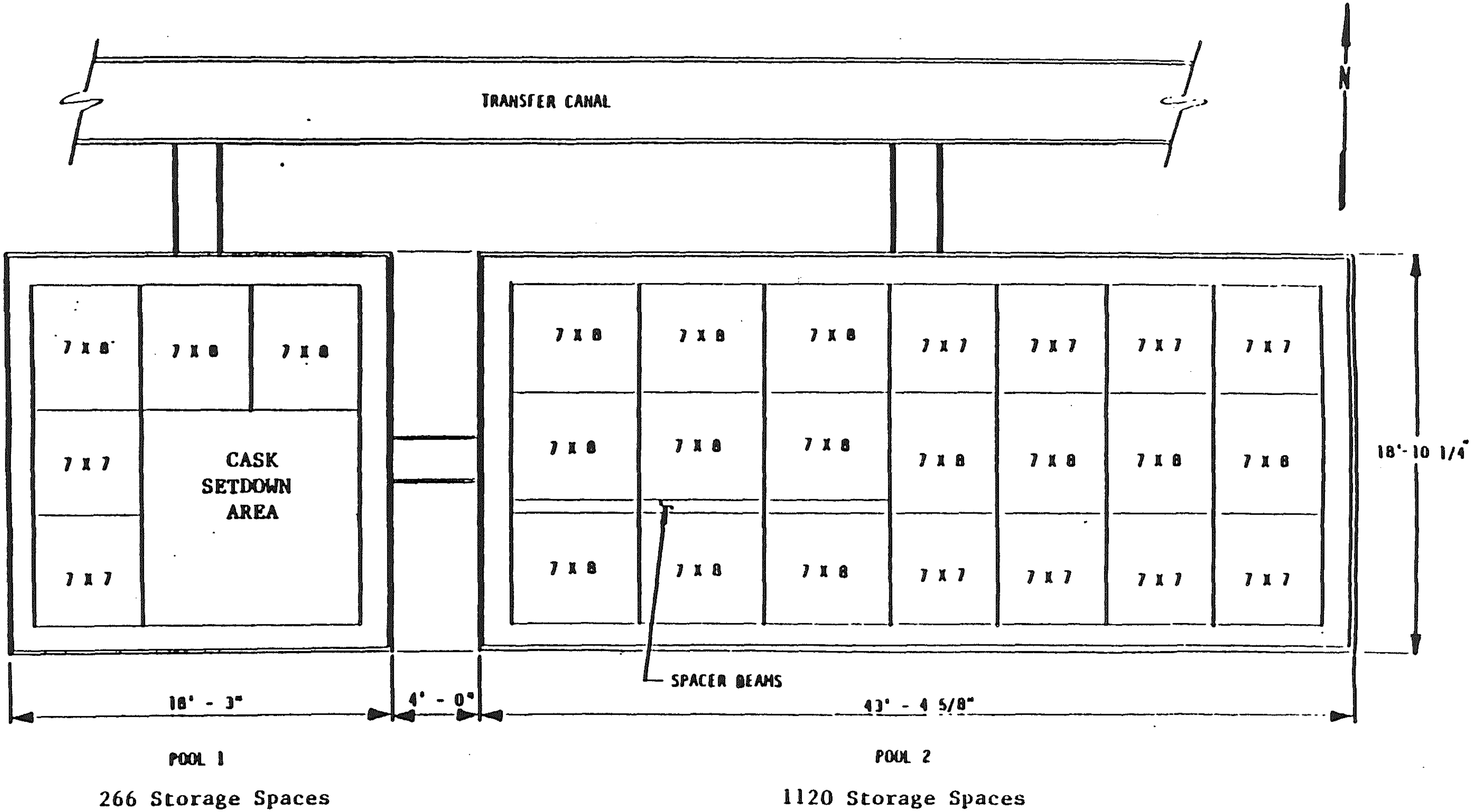


Figure 5-5

PI SPENT FUEL STORAGE RACKS CONFIGURATION

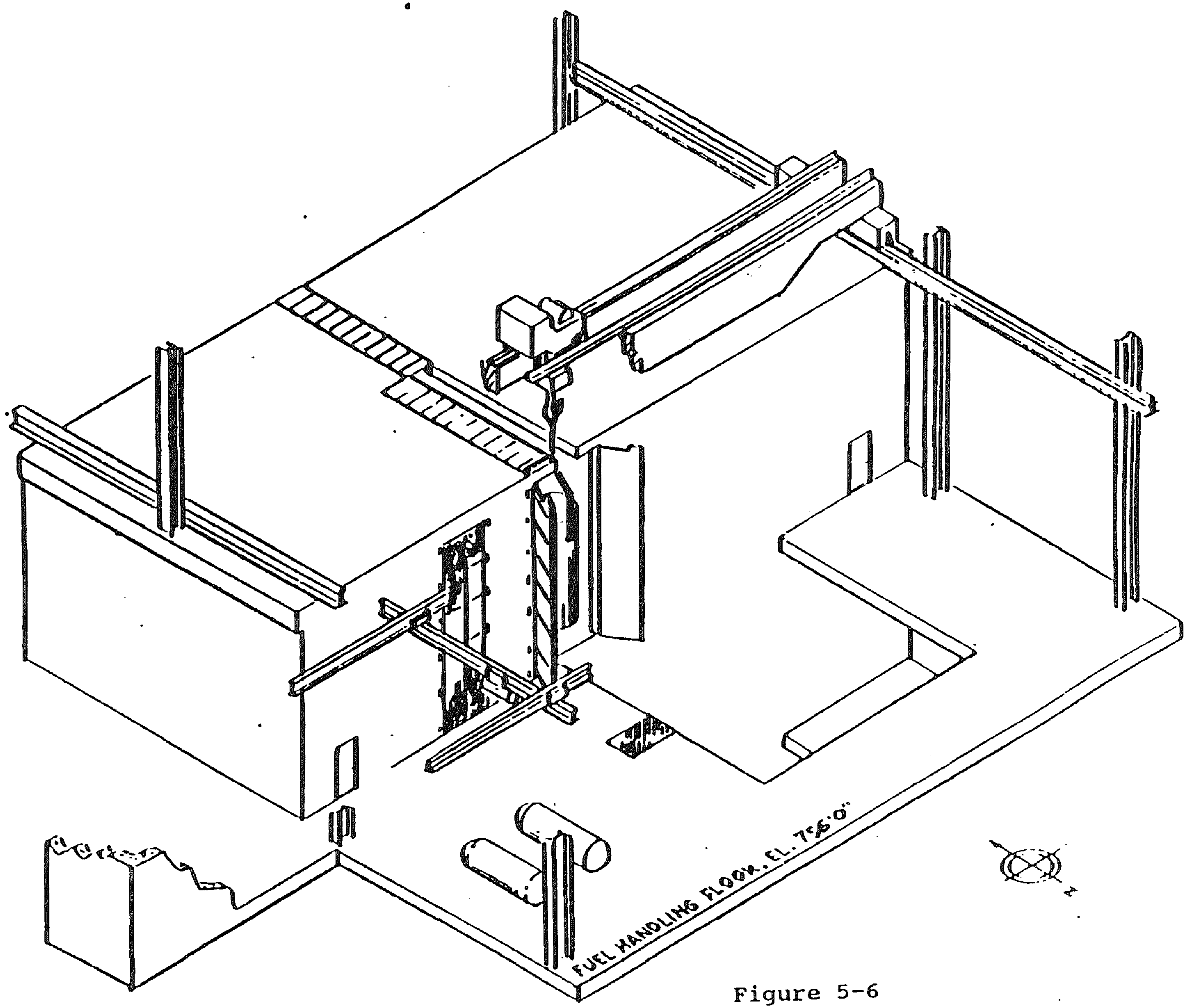
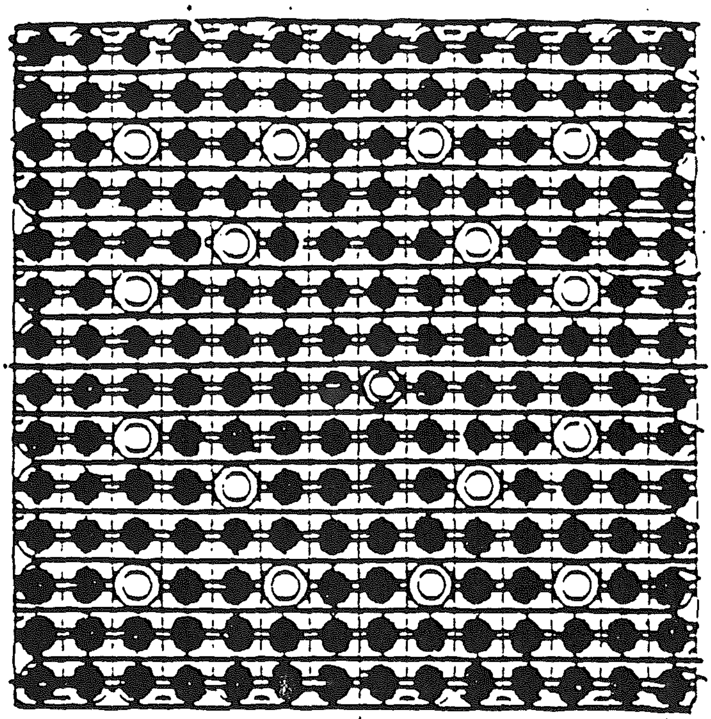
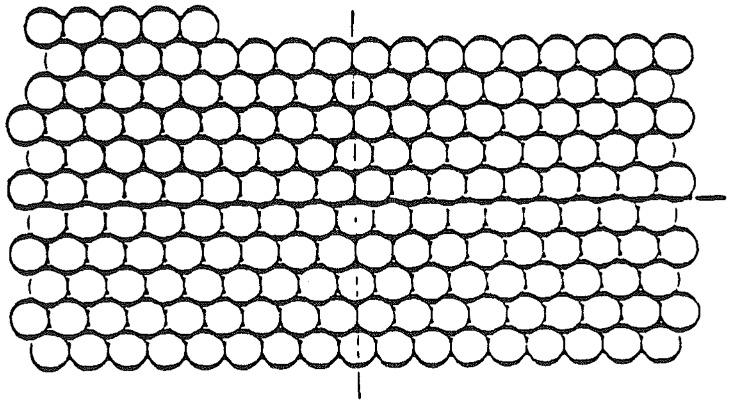


Figure 5-6

SPENT FULL POOL INCLOSURE



14 × 14 FUEL ASSEMBLY
CROSS SECTION



14 × 14 FUEL ASSEMBLY
CONSOLIDATED

Figure 5-7

CHAPTER 6

HEALTH RISK ASSESSMENT

A. Summary

As presently designed, NSP's proposed Independent Spent Fuel Storage Installation (ISFSI) will deliver a dose of gamma radiation to offsite residents resulting in a cancer risk above the acceptable or tolerable risk limit established by the Minnesota Department of Health (MDH). The acceptable level for incremental lifetime carcinogenic risk from any single source of environmental pollution, is a lifetime risk level of one in 100,000, or 10^{-5}. MDH estimates that the cancer risk to nearby residents from the proposed facility may be as much as 6 per 100,000. Moving the facility two hundred yards or more to an alternative site to the south would enable the ISFSI to be built and still achieve the Minnesota criterion for acceptable risk for involuntary exposure to environmental pollutants.

A lifetime cancer risk of 6 in 100,000 is a small risk, well within the range of risks that people voluntarily accept. It is about the risk incurred from 3 to 4 chest x-rays over a lifetime. Further, because of the uncertainties in risk assessment, MDH uses conservative risk estimates; the true risk from the proposed ISFSI is most likely smaller than 6 in 100,000. The criterion of 1 in 100,000 was established in order to ensure that involuntary environmental exposures, such as radiation exposures from the ISFSI, will not produce significant health risks for any individual.

B. Minnesota Policy Concerning Tolerable Risk

For over a decade the MDH in concert with other state agencies, most notably the Minnesota Pollution Control Agency (MPCA), has implemented a policy such that carcinogenic risk from any single source of environmental pollution should be insignificant. Based on studies of "tolerable" or "acceptable" risk, which are described in two appended documents written by the MDH Section of Health Risk Assessment, Appendix L, Tolerable Risk (1985) and Appendix M, Carcinogen Lifetime Risk (1991), MDH uses a lifetime risk level of 1 per 100,000, or 10^{-5}, as a definition of insignificant risk. Cancer risk at this low level cannot be directly measured, and must be estimated by a process of downward extrapolation from actual measurements at high levels of exposure to pollutants. In order to ensure that the lifetime risk is in reality not higher than 1 per 100,000, conservative estimates are used. This means that the upper 95% confidence limit for the estimated incremental incidence of cancer risk caused by pollutants from any one source or project should not exceed 1 per 100,000 over a 70 year lifetime.

This policy is in general agreement with policies of the United States Environmental Protection Agency (EPA) and with policies of other states. There is no one acceptable or tolerable risk value used by the EPA or by the states. However, regulatory levels used by federal and state governments are almost always established between 1 per 10,000 (10^{-4}) and 1 per 1,000,000 (10^{-6}) for lifetime cancer risk. Thus, Minnesota policy is not extreme. Furthermore, it is consistent with what is known and documented about willingness to accept involuntary risks with little or no benefit, or about acceptance of risk where benefits and risks do not accrue to the same set of individuals. These points are discussed in greater detail in the appended documents.

The Minnesota policy has been non-controversial. For instance, the advisory committee which is assisting MDH in writing rules for Health Risk Limits for groundwater, pursuant to the Minnesota Groundwater Protection Act of 1989, accepted a lifetime cancer risk level of 1 per 100,000 with no debate. The advisory committee includes representatives from the regulated community, from environmental groups and from government agencies. Thus, this lifetime cancer risk level will be used for rulemaking setting health risk limits for groundwater. A lifetime cancer risk level of 1 per 100,000 has been used for ten years in issuing advisories for contaminated private wells.

MDH is also represented on the Air Toxics Advisory Committee which is assisting MPCA in writing an Air Toxics Rule. Again, it is assumed by the committee, which represents the regulated community, environmental groups and state agencies, that Acceptable Ambient Limits for toxic air pollutants will be calculated using the criterion for acceptable lifetime cancer risk of 1 per 100,000.

These are only the latest uses of the 1 per 100,000 level for acceptable risk in Minnesota rules. This risk number occurs in the Solid Waste Rule. A copy of the relevant portion of this rule (7035.2815, Subpart 4G) is Appendix N. The 1 per 100,000 level for acceptable risk also occurs in MN Rules, chapter 7050, Standards for the Protection of the Quality and Purity of the Waters of the State. This rule was adopted on November 12, 1990. A copy of the relevant portion of the draft rule as proposed April 10, 1990 (7050.0127, Subpart 2 and 7050.0128 Subpart 2) is Appendix O. The final rule is currently being printed. This rule specifically mentions that risk shall be calculated from a linear non-threshold dose-response model used by the EPA to provide the upper 95% confidence limit of the acceptable cancer risk.

The 1 per 100,000 level of acceptable incremental lifetime cancer risk is also used in environmental review of proposals for new facilities, and in making permitting decisions for facilities. Most recently, the 1 per 100,000 level of acceptable lifetime cancer risk was used in the environmental review for the proposed municipal solid waste incinerator in Dakota County, and for permitting of the Hennepin County incinerator. Policy decisions regarding solid waste incinerators are based on a conservative estimate of lifetime cancer risk from incinerator emissions, including all routes of exposure (for example inhalation of gases and particulates, dermal contact with soil contaminated with particulate emissions, food chain exposure via contamination of soil used for crops and livestock, exposure to contaminated drinking water), of less than 1 per 100,000.

In recent years, several facilities, including those proposed by NSP, have been designed using assumptions about emissions that would result in an incremental lifetime cancer risk of less than 1 per 100,000. These projects include:

1. NSP Minnesota Valley PCB/Oil Incineration Project, in Granite Falls Minnesota.

2. NSP Wilmarth Refuse Derived Fuel Municipal Waste Combustor in Mankato, Minnesota.

3. NSP Ash Storage Facility near Becker, Minnesota.

It is important to note that many of the carcinogenic agents associated with various facilities and sites and evaluated by MDH are presumed to be, but have not been established as carcinogenic in humans. In contrast, there is abundant epidemiologic evidence that gamma radiation is a human carcinogen (see below). Thus, the cancer risk to humans from gamma radiation is a more certain risk (i.e., better known, although not necessarily larger) than the cancer risk from many other environmental carcinogens.

C. Federal Regulatory Policies

Radiological impacts from the proposed dry cask storage facility will meet the annual dose exposure standards of the Nuclear Regulatory Commission (NRC). This standard is 25 millirem (mrem) annually (see Appendix G). Clearly, the radiation dose to the residents in close proximity to the proposed facility is far below this standard, under any of the proposed alternatives.

The International Commission on Radiological Protection (ICRP), and the National Council on Radiation Protection and Measurements (NCRP) provide guidance to the NRC. The rationale for NRC policies, and how NRC policies differ from those of Minnesota, are explained below. Not all of the policies discussed are directly relevant to the ISFSI, but discussion of them is important for an understanding of the regulatory philosophy.

Appendix G, Federal Radiation Protection Standards, Appendix P, NRC's Policy Statement on Below Regulatory Concern, and Appendix R, letter from Jacob L. Fabrikant to Ms. Laura McCarten, Nuclear Projects Department, Northern States Power Company, provide statements of NRC policy. Dr. Fabrikant has served on all of the National Academy of Sciences committees on Biological Effects of Ionizing Radiation (BEIR I through BEIR V), as well as on the ICRP and the NCRP.

The purpose of the NRC policy on Below Regulatory Concern (BRC) (Appendix P) is to guide decisions on which radioactive materials are "below regulatory concern" because of the low levels of risk they pose. The "policy translates the Commission's judgement on acceptable risk into explicit and practical criteria on which to base decisions to exempt practices from the full scope of NRC's regulatory program. The BRC criteria are necessary to ensure adequate and consistent decisions on acceptable risks posed by decontaminated and decommissioned nuclear facilities, consumer products containing radioactive materials, and very low activity radioactive wastes."

The NRC (Appendix P) proposes a dose to risk conversion factor of 5 per 10,000 fatal cancers per rem of radiation dose. This translates into a lifetime risk of 350 per 100,000 fatalities for a lifetime exposure to 100 mrem per year (for an accumulated dose of 7 rem). This is in reasonable agreement with the dose to risk conversion factor for fatal cancers computed by MDH, as discussed in Section F below. MDH has used conservative assumptions, and calculated that a lifetime exposure to 100 mrem per year would result in a lifetime cancer mortality risk of 1030 per 100,000, or 3 times the estimate of the NRC. Also, MDH calculates cancer risk based on incidence, not mortality. MDH estimates that lifetime exposure to 100 mrem per year would result in a cancer incidence risk of 1840 per 100,000 (see Section F and Table 6-2, page 6.19).

NRC policy (Appendix P) is based on a concept of collective dose: the sum of individual doses received in a given period by a specified population. NRC states that "the calculated collective dose used to determine compliance with the criterion of this policy need not include individual dose contributions received at a rate of less than 0.1 mrem per year." It might be inferred that NRC considers this to be a negligible dose. Again, this is in reasonable agreement with the MDH calculation of the negligible dose of 0.054 mrem per year. (This is a dose at which MDH calculates the expected incremental cancer risk to be less than 1 per 100,000; see Table 6-2, page 6.19). This inference is supported by NRC discussion of EPA risk-based guidelines: "...a 10^{-6} lifetime risk of cancer has been used as a quantitative criterion of insignificance. Using an annual risk coefficient of 5×10^{-4} health effects per rem... the 10^{-6} lifetime risk value would approximate the calculated risk that an individual would incur from a continuous lifetime dose rate in the range of 0.01 to 0.1 mrem (0.0001 to 0.001 mSv) per year." (Note: a Sievert (Sv) is equal to 100 rem, and a milliSievert (mSv) is equal to 100 mrem.)

Thus, NRC and MDH (and EPA) appear to agree about the concept of negligible or insignificant risk, and they agree about the approximate radiation dose which is considered to be negligible. This point is underscored by the Fabrikant letter (Appendix R), numbers 4. and 12.iv.

The NRC (Appendix P) acknowledges "that although there is significant uncertainty in calculations of risks from low-level radiation, in general these risks are better understood than risks from other hazards such as toxic chemicals." The NRC then analyzes natural environmental radiation risks to individuals. These include involuntary risks (e.g., background radiation from cosmic rays, rocks and soil, radon and internal body elements, (Appendix S) and risks over which individuals have control: airplane flights (5 mrem for a roundtrip coast-to-coast flight), living in Denver versus Washington, D.C. (60-70 mrem/year), living in a brick versus a frame house. The NRC "believes that if the risk from doses to individuals from a practice under consideration for exemption is comparable to other voluntary and involuntary risks which are commonly accepted by those same individuals without significant efforts to reduce them, then the level of protection from that practice should be adequate." The NRC further notes that a lifetime radiation doses of 5-10 mrem per year "are well within the range of doses that are commonly accepted by members of the public." Thus, this policy stands in contrast to the EPA and MDH policy for chemical risks, which set standards and make recommendations based on acceptance by individuals of involuntary risks (see Appendices L and M).

Thus, NRC's criterion for exemption from regulatory control is an "average dose to individuals in the critical group" of 10 mrem per year. However, for certain "practices involving widespread distribution of radioactive material in such items as consumer products or recycled material and equipment," there is an interim average dose criterion of 1 mrem per year.

The NRC further states "that exposures to individual members of the public from all licensed activities and exempted practices will not exceed 100 mrem per year" (Appendix P). This limit is based on NCRP recommendations made in 1987. According to NCRP, continuous exposure to 100 mrem per year will entail a lifetime risk of developing cancer of about one in one thousand (see EPA, 1989, pp. 2-1 to 2-10 for discussion of NCRP and ICRP guidance to federal agencies). These risk estimates are now outmoded, with the appearance of BEIR V (1990). According to the most recent dosimetry, these risk estimates should be adjusted upward by a factor of about 5 (see BEIR V, Table 4-4 for a comparison of lifetime excess cancer risk estimates from BEIR V and BEIR III). MDH, using conservative assumptions, resulting in an additional factor of 3, estimates the risk of a 100 mrem per year lifetime dose to be about 18 per thousand (see Table 6-2). What is perhaps most important is that the criteria risk of 1 per 1,000 is above agreed upon levels for acceptance of involuntary risk, and is different from criteria used for chemical carcinogens (see above).

NRC therefore has three different dose criteria for individuals: 1 or 10 mrem per year for exempted practices, and 100 mrem per year for licensed activities. (The ISFSI is a licensed activity. Only 25% of the 100 mrem maximum may originate from a single site; hence a 25 mrem limit for the ISFSI.) The Fabrikant letter to NSP (Appendix R) further discusses these standards in numbers 7 and 11. Fabrikant then goes on to say (12. ii) "The dose limits are intentionally set high, so that exceeding them would be considered intolerable and unacceptable. It is on this basis that they provide adequate radiation protection to the worker population and the public for radiation practices that are controlled."

However, NRC also regulates on the basis of a collective or population risk, in conjunction with an "ALARA" policy (see Appendices G and P). This policy is that the collective dose to a population should be As Low As Reasonably Achievable, "economic and social factors being taken into account." The NRC collective dose criterion is 1000 person-rem per year. Combined with an individual criterion of 10 mrem, a maximum of 100,000 people could be exposed.

If the affected population is larger, then the average individual dose must be smaller in order to stay within the 1000 person-rem per year criterion. Since NRC has calculated the annual mortality risk at 10 mrem to be 5 per one million, "the number of hypothetical health effects calculated for an exempted practice on an annual basi would be less than one," (i.e., where the population is 100,000 or less). The NRC has determined that a risk of this magnitude is below regulatory concern. Thus, NRC policy is based on ensuring that expected cancer mortalities to a population are less than one per year, provided that average individual doses are no more than 10 mrem per year. (For licensed activities, such as the ISFSI, the average dose to individuals could be as high as 100 mrem per year.) Again, this policy is in conflict with EPA and Minnesota policies regulating risks from chemical exposures: chemical risks are calculated only for individuals, and never for populations. The number of people affected by an exposure is not an issue for risk assessment of chemical carcinogens (see Appendices L through O).

As already noted, NRC estimates annual cancer mortality risk from a 10 mrem dose to be 5 per 1,000,000. MDH risk estimates are based on cancer incidence, not mortality. At 10 mrem per year, MDH's conservative estimate of annual cancer incidence is about 5 times higher than NRC's estimate of mortality risk (26 per 1,000,000; see Table 6-2). These risks are significant. The annual risk from 10 mrem of excess radiation exposure is about an order of magnitude less than hazardous occupational risks (see Wilson & Crouch, 1988). The annual risk from the 100 mrem dose permitted to the general public from licensed facilities is approximately equal to the annual risk of being in a hazardous occupation. In fact, most workers at the ISFSI will experience annual doses below 100 mrem, and all will experienc doses below 500 mrem (see Section H.). (Additionally, the dose to risk conversion factor is smaller for occupational exposures; Section H.).

Excess cancer risk is masked by high background levels of cancer. This is implicit in NRC's argument in Appendix P that lifetime radiation dose of 10 mrem per year will result in a "hypothetical increase of about 0.25% in an individual's lifetime risk of fatal cancer." Related to this is the relatively high ambient level of natural radiation, which most likely contributes significantly to background cancer rates. (At the request of NSP, portions of a report by the National Academy of Sciences committee on Biological Effects of Ionizing Radiation, Health Effects of Exposure to Low Levels of Ionizing Radiation (BEIR V, 1990) are contained in Appendix S. Included in Appendix S are BEIR V pages 17-20, detailing population exposure to background and manmade ionizing radiation.) Average naturally-occurring levels of radiation are about 300 mrem. A large part of this (200 mrem, effective whole body dose equivalent) is radon gas which is inhaled and is toxic mostly to the lungs. The background level of external penetrating gamma radiation from cosmic rays, rocks and soil, which is more comparable to radiation originating from the ISFSI, is about 50 to 100 mrem. The remainder of natural ionizing radiation is from natural isotopes of elements existing within our own bodies (40 mrem).

D. Radiation-Induced Carcinogenesis

Major sources for this section are BEIR V and EPA (1989). At the request of NSP, a portion of the BEIR V discussion of carcinogenesis is included in Appendix S (pp. 4-6).

Atomic radioactive emissions occur when unstable nuclei of atoms decay to more stable forms. In the process of atomic decay, energy is lost from atomic nuclei, and energetic particles and/or electromagnetic radiation (photons) are emitted. A gamma ray is a photon emitted by an atomic nucleus.

Ionizing radiation is radiation of nuclear or non-nuclear origin which is capable of breaking molecules into electrically charged, chemically reactive fragments called ions. Examples of ionizing radiation of non-nuclear origin are cosmic rays and x-rays, both of which are similar to gamma radiation. Biological effects of ionizing radiation occur when body molecules are fragmented (ionized), causing further chemical effects, resulting in damage to body cells.

Some forms of radioactivity, such as neutrons emitted from atomic nuclei, induce very concentrated regions of ionized fragments, and are called high linear energy transfer (high-LET) particles. Photons (x-rays, gamma rays) are low-LET radiation. Biological effects of high-LET radiation are more severe than effects of low-LET radiation. Gamma radiation can exert effects at a distance, and can damage body cells even when the source of the radiation is external. It is this type of radiation which is the major health hazard associated with the ISFSI.

Ultimately, ionizing radiation causes genetic mutations in somatic (body) cells and germ (egg and sperm) cells, cancer and birth defects. The lifetime risk of reproductive effects and birth defects from a low dose of radiation continuing over many years is lower than the risk of cancer. Thus, when cancer risk is negligible, these risks will be, too. Hence, reproductive effects and birth defects will not be considered. Nevertheless, these risks may be significant at relatively high radiation doses.

Many environmental pollutants which are regulated as carcinogens have demonstrated carcinogenic effects only in animals. Evidence for carcinogenic effects in humans may be equivocal or even non-existent. This is due to the difficulty in measuring low-level cancer risks in human populations. In contrast, there is abundant epidemiological evidence for radiation-induced cancer in humans.

One difficulty in estimating cancer risk to humans arises from the necessity to extrapolate cancer risk from high doses given for relatively short time periods, to low doses over extended time periods. Another difficulty is that many carcinogens, including radiation, produce cancer only at long delays after termination of exposure. Both of these problems are true for radiation-induced carcinogenesis. The most important sources of human data are the survivors of the atomic bomb blasts at Hiroshima and Nagasaki, which produced single large doses of ionizing radiation. Even now, insufficient time has passed for all of the effects to be manifest.

Nevertheless, uncertainty about the radiation dose to cancer risk conversion factor is small compared to almost all environmental pollutants. "The human epidemiological data regarding radiation-induced cancer are extensive. As a result, the risk can be estimated to within an order of magnitude with a high degree of confidence. Perhaps for only one other carcinogen--tobacco smoke--is it possible to estimate risk more reliably" (EPA, 1989). Furthermore, while most carcinogens are organ- or tissue-specific, radiation-induced cancers can occur in any tissue.

An important concept for cancer induction by radiation and by known chemical carcinogens is the concept of a stochastic or probabilistic effect: the risk or probability of an effect (cancer) increases with increasing dose, but the severity of the effect is independent of the dose. Further, cancer induction by radiation, or by known chemical carcinogens, is generally assumed to be a non-threshold phenomenon: there is no dose below which the risk is zero.

Still, there is considerable uncertainty about whether or not the necessary extrapolations to low dose effects are linear: i.e., whether risk at low doses is directly proportional to risk at high doses. There is some evidence from animal experiments that low doses of ionizing radiation may cause less cancer than would be expected from a linear extrapolation from high doses. It is known that cells have some capacity to repair genetic damage. However, at high doses repair mechanisms may become exhausted. Therefore, protective mechanisms may be effective at low doses, but not at higher doses. As the dose increases, the carcinogenic effect could be amplified. Therefore, the carcinogenic effect of low doses of radiation would be less than expected from downward extrapolations from high doses. This has led to the employment of dose rate effectiveness factors (DREFs) to estimate effects of low levels of radiation. However, these repair mechanisms most likely vary with animal species and tissue type. Therefore, use of DREFs to estimate risks from low doses of radiation may not always be prudent. The Fabrikant letter Appendix R, point 8) further discusses the imprecision of the extrapolation process.

E. Exposure Assessment

Four hundred sixty-four residents live within two miles of the Prairie Island Nuclear Generating Plant. NSP originally estimated that the highest offsite dose to a permanent resident of Prairie Island from the ISFSI as proposed would be 3.74 mrem per year (NSP, 1990). This was a dose rate to the nearest permanent resident living 1540 meters south southeast of the ISFSI, in a direction unshielded by the berm which lies to the west and north. NSP (1991) also calculated a maximum annual dose to the nearest resident of the Mdewakanton Sioux Community, of 0.07 mrem per year, using the original assumptions. The nearest permanent resident actually lives 388 meters to the north northwest. Because of the berming in that direction, the offsite dose to that resident was originally calculated to be smaller than 3.74 mrem per year.

Several unrealistic assumptions were made by NSP which caused the calculated dose to be too high, and MDH requested that NSP re-calculate the dose based on expected conditions. When this was done, it was determined that the highest average annual dose was to the nearest resident to the north northwest. This dose was calculated to be 0.34 mrem per year (and the highest annual dose was calculated to be 0.42 mrem per year). However, this assumes that 100% of the time is spent indoors, within 4" of wood shielding. Outdoors, without wood shielding, the dose is estimated to be 29% higher. EPA (1988) has estimated that we spend, on average, 90% of our time indoors. Thus, MDH has made a slight upward adjustment in the calculated dose, to 0.35 mrem. The changes in assumptions which were used for the new calculations are described below (NSP, 1991):

1. The annual dose was originally calculated based on the highest annual dose. This will occur only in the year that all 48 casks were first in place. In reality, the offsite dose will increase as casks placement proceeds, until placement is completed. After placement of all 48 casks the dose will decrease as radioactive decay proceeds. Without consideration of more accurate modelling assumptions described below, the average annual dose was calculated to be 1.8 mrem per year, or less than half of the maximum dose. The average annual dose to the Mdewakanton Sioux Community would decrease by the same factor, and fall to about 0.03 mrem/year. (Note: using the more accurate dosimetry described below, the maximum annual dose to average annual dose ratio is changed.)

2. NSP also recalculated to better reflect expected characteristics of the spent fuel (decreased burn-up and increased cooling time) which will be placed in the casks. A further downward adjustment was made to reflect the actual shape of the cask, and the shielding effect of the steel weather cover which will be attached to the casks at the ISFSI. In the original analysis the casks were assumed, for simplicity, to be spherical, and not cylinders, and the weather cover was omitted from consideration.

3. Finally, recalculations were also done to incorporate shielding effects of trees and housing materials.

At the request of MDH, NSP also calculated the effect of attenuating the radiation further by increasing the height of the berm from 16 to 20 feet. This was determined to have a small effect, attenuating the radiation dose by 10%.

MDH also requested that NSP calculate the offsite dose at alternative locations. This information is in Table 6-1 (page 6.18), taken from NSP (1991). It can be seen from the table that moving the ISFSI about 200 meters further away from the nearest resident will reduce the dose by a factor of 8.

F. Calculation of Cancer Risk to Offsite Residents

MDH has conservatively estimated cancer incidence risk for continuous lifetime exposure to gamma radiation for males and females. For ea 100 mrem per year, these estimated lifetime risks are 1840 per 100,000 exposed persons for females, and 1520 per 100,000 for males. Using the higher value for females, and extrapolating downward to the maximum dose to the public from the ISFSI, MDH has determined that the cancer incidence risk from the ISFSI is 6 per 100,000. The basis for these calculations is explained below.

1. Rationale

Cancer mortality risks are based on BEIR V. The main data set used by BEIR V to calculate cancer risk at low doses of radiation is a cohort of 75,991 survivors of the atomic bombings of Hiroshima and Nagasaki for whom their are radiation dose estimates. Recent dosimetry for these survivors has determined that neutrons are an insignificant component of the dose, and that significant radiation consisted of gamma rays. Mortality data for this cohort is complete for 1950 to 1985, and includes 5,936 cancer deaths.

As with the A-bomb blasts, the offsite radiation dose from the ISFSI is almost all gamma radiation; the neutron component is less than 1% and can be ignored.

Referring to Table 4-2 of the BEIR V report, excess cancer mortalities can be obtained based on annual doses of 0.1 rem (100 mrem) over a lifetime. According to the table, the 90% confidence interval is 410 to 980 excess cancer mortalities per 100,000 in males and 500 to 930 per 100,000 in females. The upper end of the 90% confidence interval corresponds to the upper 95% confidence limit.

As explained above, MDH policy is that an acceptable cancer risk to the general public from any single source of environmental pollution is no more than one excess cancer per 100,00 population. This means that if the upper 95% confidence limit for the estimated incremental incidence does not exceed one per 100,000 over a 70-year lifetime, MDH policy is that the cancer risk is negligible. The acceptable risk (one in 100,000 lifetime cancer risk) is based on cancer occurrence (not mortality). BEIR V estimates are based on cancer mortalities, so it is necessary to multiply these figures by an incidence to mortality ratio.

MDH has used incidence to mortality ratios calculated by the EPA (1989, Tables 6-6 and 6-7). As with the BEIR V, the main data set used by EPA is the cohort of survivors of the A-bomb blasts at Hiroshima and Nagasaki. The EPA then used a modified version of a previous study done by the National Academy of Sciences (BEIR III, 1980) to estimate incidence to mortality risk ratios. EPA calculated that the incidence for males is 1.35 times mortality, yielding 1320 per 100,000 at 100 mrem per year, and the female incidence is 1.78 times mortality, yielding 1660 per 100,000.

Because the NSP proposed dose rate is lower than the pattern of exposure used in Table 4-2 of BEIR V, a dose rate effectiveness factor (DREF) was considered by MDH. A DREF might be indicated if radiation is mostly low linear energy transfer (low-LET) gamma. (Less than 1% is high LET neutron radiation, for which a DREF is not justified.) Page 23 of BEIR V suggests a conservative DREF of 2 for hard tumors, based on studies of laboratory animals. A DREF of 2.1, based on examination of human leukemias from the A-bomb blasts is already factored into Table 4-2 for leukemia.

However, human data can be used to argue against using a DREF for hard tumors, and indeed, BEIR V does not use a DREF in Table 4-2. The EPA (1989) notes that human data indicate a DREF is inappropriate for breast cancer, since breast cancer is proportional to the dose, regardless of fractionation (i.e., proportional to the dose, even if it is accumulated over an extended period of time) (see pages 6-5 and 6-28). They further note that a DREF appears inappropriate for radiation-induced thyroid cancer. There are no positive human data indicating a DREF for radiation-induced cancers. Additionally, the mechanism of radiation-induced carcinogenesis is fairly well understood (see Section D.), and there is no a priori mechanistic reason to assume a DREF, or tissue repair mechanisms. That is to say, it is theoretically possible for one ionizing event to initiate carcinogenesis. Thus, MDH has determined that a DREF for hard tumors is not indicated.

A recent study (Wing et al, 1991) suggests that a DREF for leukemia may also be contraindicated. This was an investigation of mortality through 1984 of white male workers hired between 1943 and 1972, and exposed to low level radiation at the Oak Ridge National Laboratory. Out of 8,318 workers studied, there were 1,524 deaths from all causes, including 346 from cancer. The median cumulative dose of radiation was 1.4 mSv (140 mrem, or about twice background levels of penetrating gamma radiation). The most salient result of this study was a 63% elevation in leukemia mortality (28 deaths, or 11 more than expected). Furthermore, the data indicate an increased cancer mortality risk of 5% for each 10 mSv (1 rem) of accumulated radiation dose. This figure is in substantial agreement with a previous study of occupational radiation exposure (Beral et al., 1988). While the Wing et al. investigation is not adequate for quantitative risk assessment (see also BEIR V, pp. 46-49 for a discussion of problems with low dose studies), the data certainly argue against a DREF for low radiation doses for cancer in general, and for leukemia in particular. Additionally, the EPA (1989) points out that the rationale for a DREF is not compelling, and that data from survivors of Hiroshima and Nagasaki are not definitive with respect to use of a DREF for either leukemia or hard cancers.

Thus, MDH has determined not to apply a DREF for leukemia. Therefore, an upward adjustment in risk estimates is necessary. Table 4-4 in the BIER V report estimates lifetime cancer risks for exposure to 100 mrem per year. For females every 600 cancer mortalities includes 60 leukemia mortalities. Multiplying 60 by 2.1 (the leukemia DREF, which is factored into the table) yields 126, or 66 more cancers than previously estimated. This results in an upward adjustment of the risk by a factor of 666/600 or 1.11. Multiplying the previously calculated upper bound risk estimate of cancer incidence in females for exposure to 100 mrem/year (1660 per 100,000) by 1.11, gives a risk estimate of 1840 per 100,000. For males, every 520 cancer mortalities includes 70 leukemia mortalities. Multiplying 70 by 2.1 yields 147, or 77 more cancers than previously estimated. This results in an upward adjustment of the risk by a factor of 597/520 or 1.15. Multiplying the previously calculated upper bound risk estimate of cancer incidence in males for exposure to 100 mrem per year (1320 per 100,000) by 1.15, yields a risk estimate of 1520 per 100,000.

2. <u>Cancer Risk</u>

The estimated risk to the most exposed individual from the ISFSI is found by multiplying 1840 (using the higher female risk estimate) by the ratio of NSP proposed dose to the 100 mrem yearly dose in Table 4-2 of BEIR V. This ratio is 0.35:100 (0.0035) and the resulting risk is 6 per 100,000. The average annual dose to the Mdewakanton Sioux Community, even using simplified assumptions, is below the MDH criterion of 0.054 mrem/year (see Table 6-2).

The health risk to the most exposed individual is higher than the Minnesota criterion for acceptable risk from involuntary exposure to environmental pollutants of 1 per 100,000. Three alternative sites for the ISFSI are discussed in Chapter 3, and mapped in Figure 3-4. Two of these alternatives are due south of the proposed site. Use of either of these sites would attenuate the maximum offsite dose by more than the amount necessary to achieve the Minnesota criterion. If one of these sites were used, it might be necessary to add berming to the south and east of the ISFSI to shield workers at the site and residents to the south.

G. Uncertainty in the Estimate of Offsite Cancer Incidence Risk

It is impossible to directly measure health risks on the order of one in one hundred thousand. Such risks are undetectable, because any adverse health effects caused by small exposures are a very small proportion of the total incidence. Therefore, we cannot know the true value of the health risk from most environmentally relevant exposures to pollutants (BEIR V, pp. 46-50 and 161-163). In order to ensure that the public is not exposed to larger than acceptable risks, the policy is to be conservative: when the value of a variable is uncertain, an upper bound estimate is used. Thus, the true value of the risk is almost certainly not higher than the criterion.

For example, there is no evidence that populations living in counties containing nuclear power plants have higher cancer rates as a result of increased radiation exposure (Jablon et al., 1991). Data for Goodhue County (Prairie Island) (Jablon et al., 1990) are consistent with national data. Among tens of comparisons, a significantly high risk ratio was found for leukemia in the 40-59 age group, but digestive cancer was significantly lower than expected in the 60+ population, and in the total for all ages. Because of the large number of statistical tests, some will be significant by chance. Thus, it is not surprising that some "significant" results were obtained. Nor is it surprising that control and exposed populations would sometimes differ from each other, in either direction (higher or lower cancer rates). These results are altogether expected, since cancer rates would have to be intolerably elevated to be detectable.

Nevertheless, it is to be expected that the precision of risk estimation will be enhanced with increasing scientific knowledge. BEIR V (pp. 7-8, see Appendix S) points out that risk estimation will be improved as the mechanisms of radiation-induced cancers become better understood, as more studies are done on possible reduced effectiveness of radiation-induced carcinogenesis when doses are fractionated or when exposure is protracted, and as more epidemiological data become available. For instance, even data for the A-bomb survivors will not be complete for about 20 years.

BEIR V (pp. 176-181, Appendix S) discusses three sources of uncertainty in the estimates of lifetime cancer risk: 1) random error, which is expressed in terms of the confidence intervals discussed above; 2) uncertainty about the correct form of the exposure-time-response model (i.e., use of a dose rate effectiveness factor or DREF); 3) potential biases in the data themselves.

The first of these sources of error is the easiest to deal with. MDH has used the upper 95% confidence limit for cancer mortality. For females (the population at greater risk of cancer incidence), this is 930 deaths per 100,000. However, the best estimate of cancer mortality rates (Table 4-2, BEIR V) is 600 deaths per 100,000, or 0.645 times the upper confidence limit.

The second of these sources of error is more difficult. MDH has decided it would be imprudent to use a DREF. However, it is highly unlikely that many human tissues lack the capacity for genetic repair. The existence of these mechanisms has been too well documented in numerous animal studies. Nevertheless, the evidence suggests that some human tissues (thyroid, female breast, and blood) may have limited capacity for genetic repair. Thus, the best estimate, i.e., the one that would produce the smallest error in either a positive or negative direction, is to assume that a DREF should be applied to one half of the expected cancers. Table 1-4 of BEIR V contains a summary of data related to DREFs. From this table it appears that a DREF of 4 is the best estimate value. Thus, overall, a DREF of 2 (0.5 x 4) appears at present to provide the best estimate of cancer incidence for low dose, prolonged radiation exposures. Thus, the best estimate of cancer incidence would be obtained by dividing by 2 (or multiplying by 0.5).

The third source of error occurs when extrapolating from the Japanese survivors of the A-bomb blasts to the present day U.S. population. While organ-specific cancer incidence is very different in the

Japanese population, overall cancer incidence appears to be very similar and there does not appear to be any reason to adjust predicted cancer rates because of the necessity to extrapolate between populations (EPA, 1989; BEIR V). However, the uncertainty inherent in this extrapolation remains.

MDH therefore estimates that cancer incidence due to low dose prolonged radiation exposure is most likely about 1/3 of the predicted incidence based on conservative assumptions. This is obtained by multiplying the upper limit of cancer incidence by 0.645 x 0.5 or by 0.325. Additionally, the risk to any one individual is likely to be less than MDH estimates, because these are based on the assumption that all of the maximally exposed person's life is spent in the same location.

These estimates generally agree with those presented by EPA (1989). EPA estimated the cancer incidence risk to females at 743 per 1,000,000 people exposed to 1 rad (equivalent to 1 rem of gamma radiation). This translates to an incidence of 520 cancers per 100,000 people exposed to 100 mrem per year for 70 years. EPA then estimated that the upper bound cancer incidence is about 3 times this best estimate, or 1560 per 100,000. This is within 20% of the estimate made by MDH.

H. Other Carcinogenic Risks

1. Occupational Risks

The NSP (1990) Technical Specifications and Safety Analysis Report for the ISFSI contains data on occupational radiation exposures. These occupational risks are significant. They are nevertheless well within NRC guidelines for occupational exposures. MDH believes that the occupational risks which will be sustained, if the ISFSI is built as proposed, are comparable to risks encountered in other hazardous occupations. MDH also believes that a significant portion of the onsite occupational radiation dose can be attenuated by additional berming along the east and south sides of the ISFSI.

The dose to risk conversion factor for lifetime occupational risks is smaller than the dose to risk conversion factor for risks to the general public, because occupational risks are incurred for about half of a 70 year lifetime, and because cancer risks from a given radiation dose are relatively higher when radiation is experienced early in life. Table 4-2 of BEIR V contains mortality estimates for a yearly radiation dose of 1 rem (1000 mrem) from age 18 to age 65. MDH made upward adjustments in these mortality risks to remove the DREF from the leukemia mortality rate (see F. above), and multiplied the resulting upper bound risks by 35/47 to obtain a 35 year occupational risk. The resulting mortality risks were then multiplied by incidence to mortality ratios, as described in Section F. The cancer incidence risk to dose conversion factor was determined to be 6310 per 100,000 for males and 6740 per 100,000 for females, for exposures of 1 rem per year. The higher risk rate for females was used in the occupational risk estimates.

Table 7.4-4 of NSP (1990) contains dose rates at onsite locations due to cask storage. With one exception, these dose rates range between 6 and 11.25 mrem per year for full time workers. The dose rate for the substation is 33 mrem per year. Two of 631 full time employees work at the substation (Table 7.4-3). Therefore, the excess lifetime cancer risk for employees at all but one site is between 4 and 8 per 10,000. The lifetime excess cancer risk for workers at the substation is about 2 per 1,000. This assumes that all workers spend all of their working lives at one site. The calculation also makes no allowance for the shielding effect of buildings. In reality, the occupational lifetime risk will be lower than 2 per 1,000.

There are additional radiation doses that will be experienced by workers for cask loading, transportation and emplacement. NSP used conservative assumptions in calculating the radiation doses which will be experienced in the performance of each operation performed in proximity to the casks. Various operations associated with cask loading, transport and emplacement will entail exposures of individual workers to between 10 and 195 mrem per cask (NSP, 1990, Table 7.4-1). These are described as one time exposures. It is unclear how many casks a given worker will actually load, transport and emplace in an occupational lifetime. It is also unclear whether a single worker will perform more than one task connected with cask loading, transport and emplacement. Multiplying the maximum dose per single cask operation (195 mrem) by 48 casks yields a maximum lifetime dose of 9.36 rem, or 267 mrem per year for 35 years. This would entail a cancer incidence risk of 18 per 1,000 if the same person actually performed the task incurring the maximum radiation dose for each of the 48 casks. This is a relatively high risk. It also does not take into account the possibility that this same person might perform other operations associated with cask loading, transport and emplacement. NSP (1990) has stated (p. 7.3-1 of the <u>Technical Specifications and Safety Analysis Report</u>) that the anticipated annual whole body dose to any individual will be well below 500 mrem in any one year. This would preclude participation by the same worker in some combinations of cask operations. MDH believes that the actual upper bound for occupational lifetime risk will be lower than 18 per 1,000.

Finally, the maximum annual radiation exposure for cask maintenance operations is 118 mrem (Table 7.4-2). The time period over which casks will need to be maintained is unclear, because it depends upon future availability of a permanent waste storage site. The lifetime cancer risk of an occupational dose of 118 mrem per year for 35 years is about 8 in 1,000. This is a relatively high risk. Again, however, it is unlikely that any single worker will encounter this risk.

These risk calculations for occupational exposures are conservative estimates, as they are for off-site exposures. The most likely values for lifetime cancer risks are about 3 times smaller, based on the uncertainty analysis (Section G). Actual radiation doses which will be experienced by individual workers will depend upon where on the site they spend the bulk of their time, and how much time during the course of their employment at Prairie Island they participate in operations requiring close proximity to the casks.

2. Accidents

The dose to an individual at the nearest site boundary in the event of an accident entailing a loss of the cask confinement barrier is 0.07 rem (Chapter 1). Table 4-2 of BEIR V contains excess cancer mortality estimates for a single exposure to 10 rem. Based on the upper 95% confidence limit, and an incidence to mortality ratio of 1.78 for females (see above), the dose to risk conversion factor is 2060 per 100,000 for a 10 rem dose. Therefore, at 0.07 rem, the cancer risk is 14 per 100,000.

However, the likelihood of an event in which cask integrity is breached such that this dose is actually delivered is extremely small (see Chapter 4). Therefore, MDH does not consider this to be a significant risk.

I. Conclusions

The ISFSI will deliver an annual average offsite radiation dose to the most exposed residents of Prairie Island of 0.35 mrem. This level of offsite radiation is well below the NRC limit of 25 mrem. However, gamma radiation from the ISFSI will produce a lifetime risk of cancer incidence to the most exposed residents of 6 per 100,000. This risk is higher than the MDH criterion of 1 per 100,000 for carcinogenic risk from any single source of exposure to an environmental carcinogen. The radiation dose rate t members of the Mdewakanton Sioux Community is below the Minnesota criterion of 0.054 mrem per year. Cancer risk below this dose is less than 1 per 100,000.

Alternative sites for the ISFSI were presented in Chapter 3. The most exposed residents live to the north northwest of the proposed facility. If the site were moved to either of the two alternatives to the south, it would be possible to build the ISFSI as proposed, while reducing the radiation dose to the most exposed residents sufficiently to achieve the Minnesota criterion for acceptable risk of 1 per 100,000. Use of an alternative site might require additional berming to the south and east of the ISFSI, in addition to the berming already contemplated to the north and west.

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Table 6-1. PRAIRIE ISLAND ISFSI
BEST ESTIMATE DOSE RATES
MAXIMUM ANNUAL DOSE VS. DISTANCE[1]

Distance (meters)	Annual Dose (millirem/yr) with wood attenuation	Annual Dose (millirem/yr) without wood attenuation
30	77.5	99.7
50	48.5	62.4
75	29.6	38.1
100	19.1	24.6
150	8.79	11.3
180	5.81	7.48
250	2.27	2.92
300	1.21	1.55
350	0.657	0.845
400	0.364	0.468
500	0.128	0.165
600	0.0443	0.0570
800	0.00601	0.00774

1 Table is from a letter to Mary J. O'Brien, Acting Commissioner, Minnesota Department of Health, from Laura McCarten of NSP, April 1, 1991.

Table 6-2. MDH Proposed Dose to Risk Conversion Factors per 100,000 People ($x\ 10^{-5}$)

1. Upper bound lifetime cancer incidence risk (exposure for 70 years) to a yearly dose of 100 mrem:

   1840

2. Lifetime risk for exposure to a yearly dose of n mrem:

   1840(n)/100

3. Annual risk for exposure to 100 mrem/year for 70 years:

   1840/70 = 26

4. Annual risk for exposure to n mrem/year for 70 years:

   26(n)/100

5. Upper limit for an an insignificant lifetime radiation dose (d) in mrem/year:

   1840(d)/100 = 1

   d = 100/1840

   d = 0.054

CHAPTER 6A

ANALYSIS OF ALTERNATE SITES

The following analysis of alternative ISFSI sites has been added to address concerns raised in the Health Risk Assessment, Chapter 6. It is all new material. Note that on page 6A.4, NSP has stated that it will berm all sides of the proposed ISFSI location. This is a change from the original proposed project, and is not reflected in earlier sections of the EIS.

Page 3.3 of this document identifies four alternate sites for the ISFSI on Prairie Island plant property. The four alternate sites are shown on Figure 3-4, page 3.34. NSP has proposed Site I for the ISFSI. In response to the statement of the Minnesota Department of Health in Chapter 6 that relocating the ISFSI from the proposed site approximately 250 yards to the south would reduce the radiological dose to the nearest permanent resident below "acceptable risk" levels. This section analyses the impacts from locating the ISFSI at alternate Sites II and IV. (Alternative Site III is not analyzed because it is approximately the same distance from the nearest permanent resident as the proposed site).

The locations of the alternate ISFSI sites are shown on the attached figures. Alternate Site II is located immediately adjacent to the plant access road, about 200 yards from the proposed ISFSI location, 80 yards from the plant boundary and 200 yards from the Administration building. The meteorological tower would have to be relocated because the heat given off by the casks could distort the readings at the tower. NSP does not prefer Alternate Site II because of its close proximity to the normal plant access route and because it offers less useful area for an ISFSI layout. Alternate Site IV is located near the cooling towers, about 560 yards from the proposed ISFSI site, 130 yards from the plant boundary and 280 yards from the Administration building. NSP does not prefer this area because it offers less useful area for an ISFSI layout, entails greater construction difficulties, and because it may have greater value for some future activity due to its position relative to the plant and cooling towers.

A. Wastes and Emissions

The wastes and emissions from the ISFSI are identical whether the proposed site or alternate Site II or IV is used. As a result, the analysis presented in Chapter 4 at page 4.1 applies to all three sites.

B. Construction Impacts

Land use and vegetation:

Construction of an ISFSI at any of the alternate sites, including berms and access roads, will affect approximately 10 acres of the

560 acre Prairie Island plant property. Use of alternate Sites II or IV, however, would likely result in a different configuration of the concrete pads and casks. Figures 6A-1 and 6A-2, page 6A.7, show possible layouts of alternate Sites II and IV.

Wildlife:

The habitat and wildlife at alternate Sites II and IV are similar to that of the proposed site. As a result, the analysis presented at page 4.2 applies to the alternate sites.

Water Bodies and Aqualic Resources:

The water bodies and aquatic resources impacted at alternate Sites II and IV are similar to those at that proposed site. As a result the analysis presented at page 4.5 applies.

Runoff:

Only a small volume of runoff will occur during the construction period. Due to the small volume of runoff and the sandy nature of the soil, runoff is expected to dissipate into the soil prior to reaching any river or wetland. Neither drainage system will alter natural drainage patterns. Excavated material and/or fill will not be dumped into existing water bodies.

Socioeconomics:

The socioeconomic impacts for alternate Sites II and IV are also similar to those for the proposed site. Any additional fill or construction at Sites II or IV will not be of a magnitude to increase worker requirements significantly. As a result the analysis presented at page 4.5 applies.

Fugitive Dust:

Fugitive dust emissions associated with construction at alternate Sites II and IV are similar to those of the proposed site. Fugitive dust control measures will be implemented at the site to keep fugitive dust within acceptable levels. As a result the analysis presented at page 4.6 applies.

Noise:

Noise resulting from construction at alternate Sites II and IV is similar to that of the proposed site. Noise will be kept within OSHA levels at the site used. As a result the analysis presented at page 4.6 applies.

Cultural Resources:

The analysis presented at page 4.6 applies to all sites on Prairie Island plant property. As discussed on page 4.6, an archeological survey of the entire Prairie Island plant site area conducted in 1967 found nothing significant in the immediate area of the power plant. The vicinities of the proposed ISFSI site and alternate Site IV have been disturbed in the period since NSP began operating the plant, but no evidence of archeological significance has been discovered. Therefore, it is unlikely there are significant archeological sites that would be disturbed by ISFSI construction at the proposed site or either of the alternate sites. NSP states that it will cooperate with the MN Historical Society if it decides additional surveys of the ISFSI site are required before construction begins. Furthermore, if such surveys uncover evidence of archeological significance, NSP will work with the Historical Society to define and implement appropriate mitigating actions.

C. Operation Impacts

Once the ISFSI is constructed the operational impacts (land use and vegetation, wildlife, water bodies and aquatic resources, socioeconomic, fugitive dust, noise, cultural resources and climatological) at either alternate Site II or IV will be identical to those at the proposed site. As a result, the analysis at pages 4.7 through 4.13 applies.

D. Protection from Natural Calamity

The ISFSI offers the same protection from natural calamities (tornado and wind loading, loading missiles, flood impacts, seismic loading, snow and ice loading, lighting strike and thermal loading) at alternate Site II and IV as at the proposed site. With regard to flooding, in particular, fill will be added at either Site II and IV to conform pad height to that for the proposed site. As a result, the analysis at pages 4.13 through 4.16 applies.

E. Radiological impacts during loading and storage

The radiological impacts during loading at alternate Sites II and IV are the same as for the proposed ISFSI location.

The radiological impacts during storage are of two types, dose to offsite persons and dose to onsite persons. For purposes of comparison, the onsite dose for the proposed and alternate ISFSI sites is calculated assuming the ISFSI is bermed on all sides. This would have to be done for alternate Sites II and IV because they are closer to site personnel than the proposed ISFSI site and so would result in significant personnel dose if they weren't bermed on all sides. NSP will berm all sides of the proposed ISFSI location, which will increase the proposed ISFSI construction cost by an estimated

$300,000. Both the offsite and onsite dose provided here are for the maximum year (i.e. when the 48th cask is installed) and are based on best estimate does-versus-distance calculations.

	Maximum Offsite Dose	Maximum Onsite
Proposed ISFSI location	0.42 mrem/yr	270 man-mrem/yr 2.5 mrem/yr to maximum exposed person
Alternate ISFSI Site II	< .054 mrem/yr	1100 man-mrem/yr 8.3 mrem/yr to maximum exposed person
Alternate ISFSI Site IV	< .054 mrem/yr	1110 man-mrem/yr 5.4 mrem/yr to maximum exposed person.

The attached figures show the proposed ISFSI location and alternate Sites II and IV. The figures also show a radius of 580 meters (approx 1750 ft) from each ISFSI location, at which distance a person present 100% of the time would receive less than .054 mrem/yr from ISFSI operation. 0.054 mrem/year is the value calculated by MDH (see page 6.19) for the upper limit for an insignificant lifetime radiation dose.

For the following impacts, the analysis in pages 4.19 through 4.28 for the proposed site applies to the ISFSI at alternate Sites II or IV.

F. Accident Impacts
G. Safeguards from theft, diversion, and sabotage
H. Decommissioning
I. Estimates of induced development
J. Feasibility Analysis

K. Cost of Project

Alternate Site II:

The major cost impact of locating the ISFSI at Site II is the cost to relocate the meteorological tower. Because the casks are a heat source, their presence would distort the readings at the current tower location. Not all, but some engineering design would have to be redone. Construction at this alternate site would present no difficulties beyond what are anticipated for the proposed site. ISFSI construction costs would be less because this site would require less effort to clear and a shorter access road.

The net cost impact to locate the ISFSI at Site II is expected to be an increase on the order of $500,000 +/- 30%.

Alternate Site IV:

The major cost impact of locating the ISFSI at Site IV is that associated with raising the site to an elevation above the 500 year flood level. The grade would have to be brought up four feet. The amount of fill required, including the berm, is about 95,000 yards; all this material would have to be brought to the plant and would cost on the order of $1,000,000. Other than the cost for filling, no other significant differences in ISFSI construction costs have been identified. A large portion of engineering design would have to be redone. Also, a small amount of nonradioactive resin was buried in that area and would probably have to be removed.

No groundwater impact is anticipated if the spent resins are excavated and relocated into another qualified landfill. No radioactive release is possible since a criteria for the original disposal was nonradioactive. Prior to any excavation a work plan outlining the excavation must be approved by the MPCA Div. of Solid Waste. The PCA has confirmed the status of this spent resin site. It must issue a letter of approval before it can be excavated.

The net cost impact to locate the ISFSI at Site IV is estimated ot be an increase on the order of $1,500,000 +/- 30%.

L. Mitigation of identified impacts

Most of the identified impacts relate to construction of the ISFSI. Of these, only the following two would differ from the proposed project (refer to pages 4.28 to 4.29):

Site clearing - Alternative site II would not require as much engineering work to develop as an ISFSI site, and so the identified impacts here would require less mitigation. Alternative site IV would require significant excavation and filling, and would result in more disruption. The mitigative measures described on page 4.28 would be followed for this alternative site as well.

Excavation and soil deposition - Measures to mitigate the identified impacts are described at page 4.29. These same mitigation measures will apply if either site II or IV are used. Due to the more intensive soils work needed for site IV, the mitigation would need to be scaled to fit the increased magnitude of the disruption.

Use of either of these alternative locations would mitigate the off-site radiation impacts discussed earlier in Chapter 6. Worker on-site exposure, however, would increase with either alternative location.

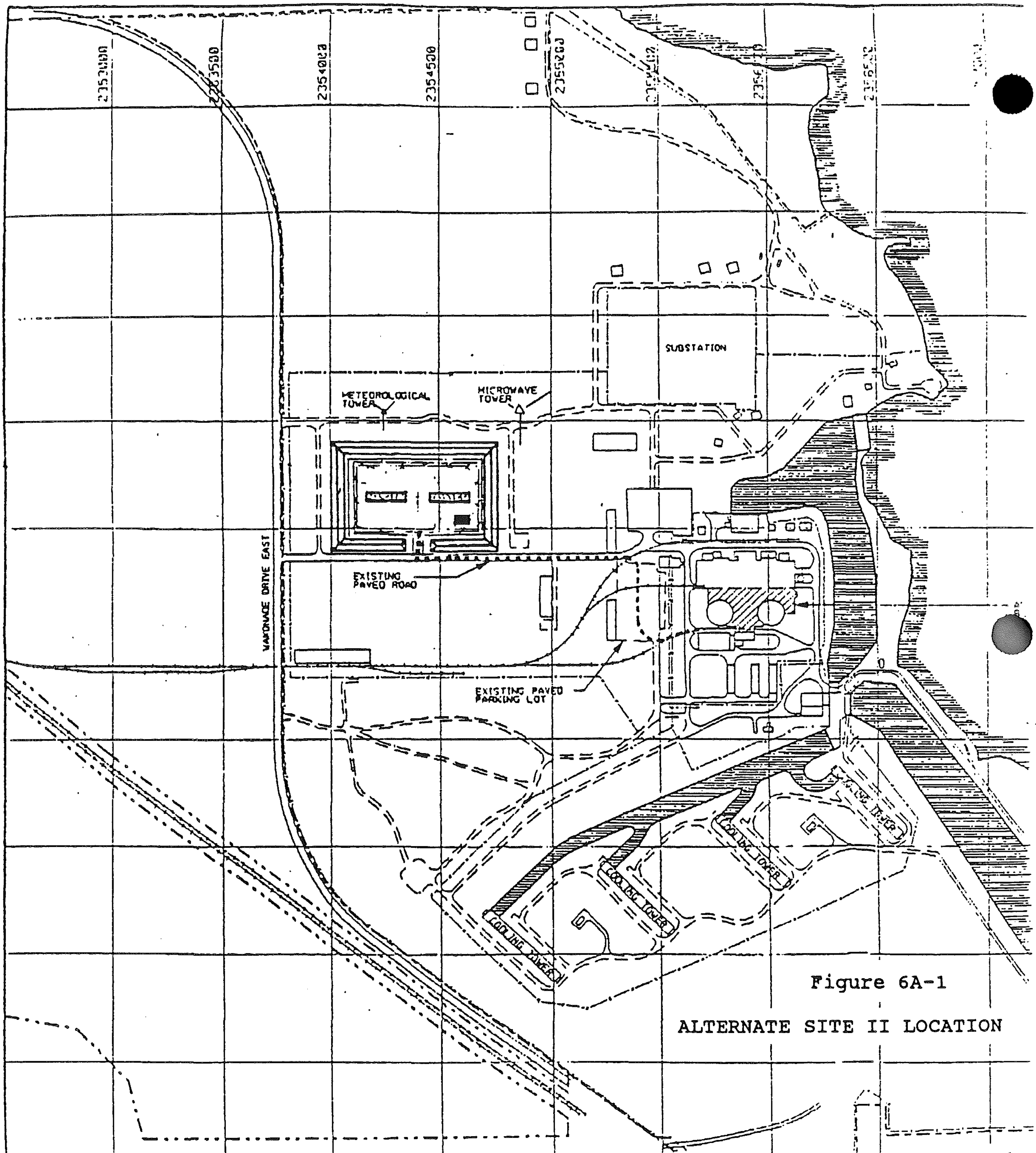


Figure 6A-1

ALTERNATE SITE II LOCATION

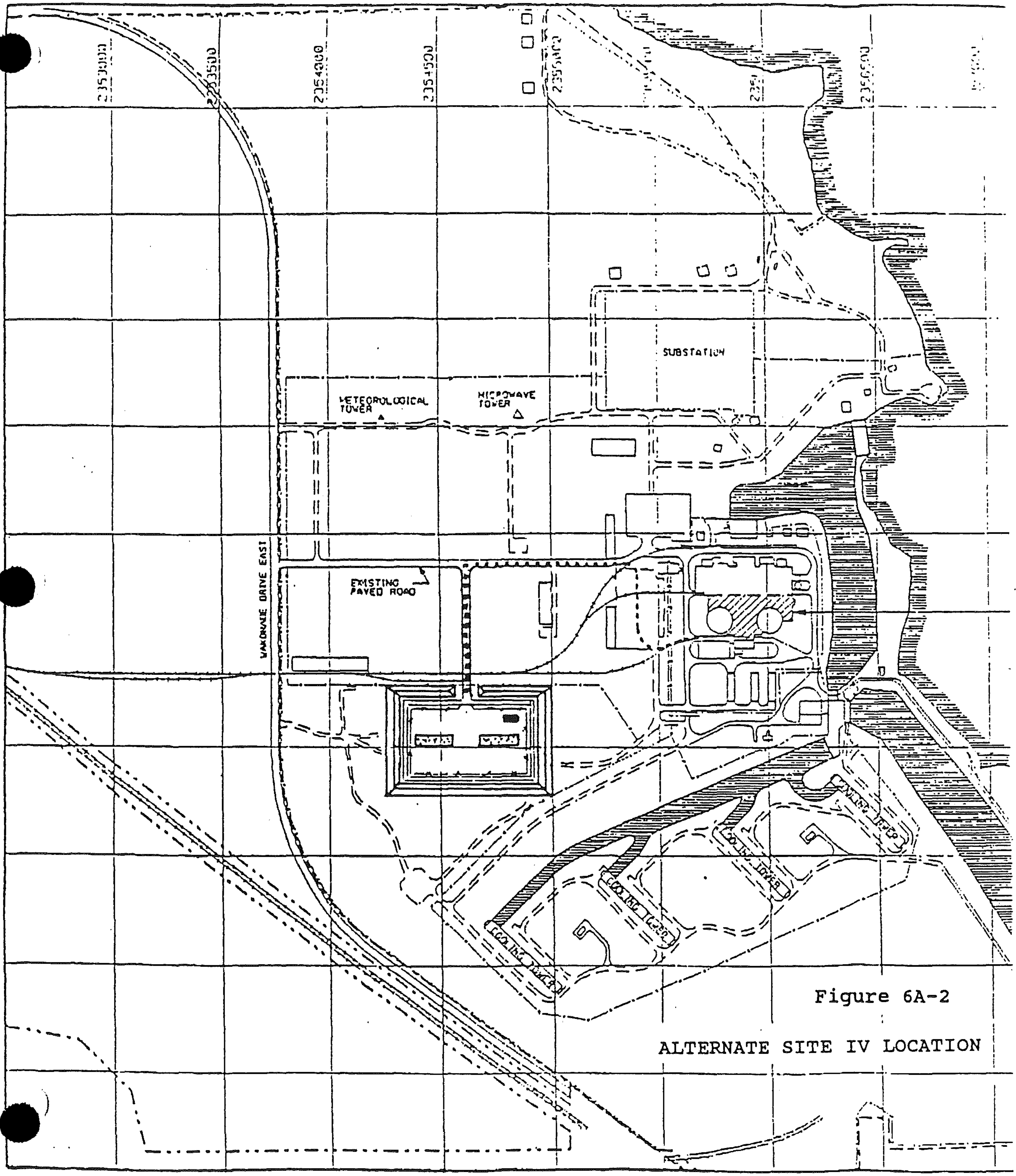
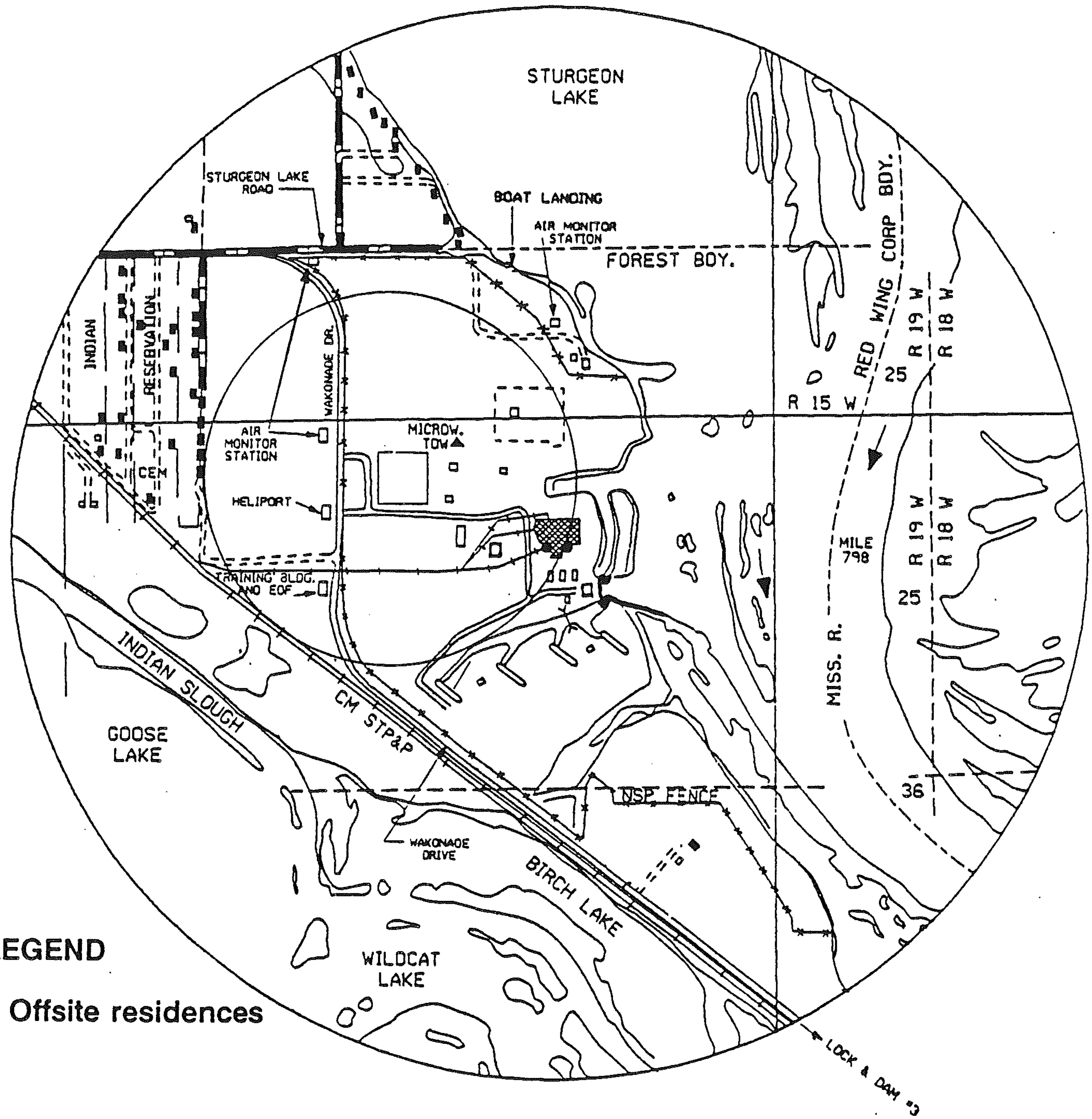


Figure 6A-2

ALTERNATE SITE IV LOCATION



LEGEND

■ Offsite residences

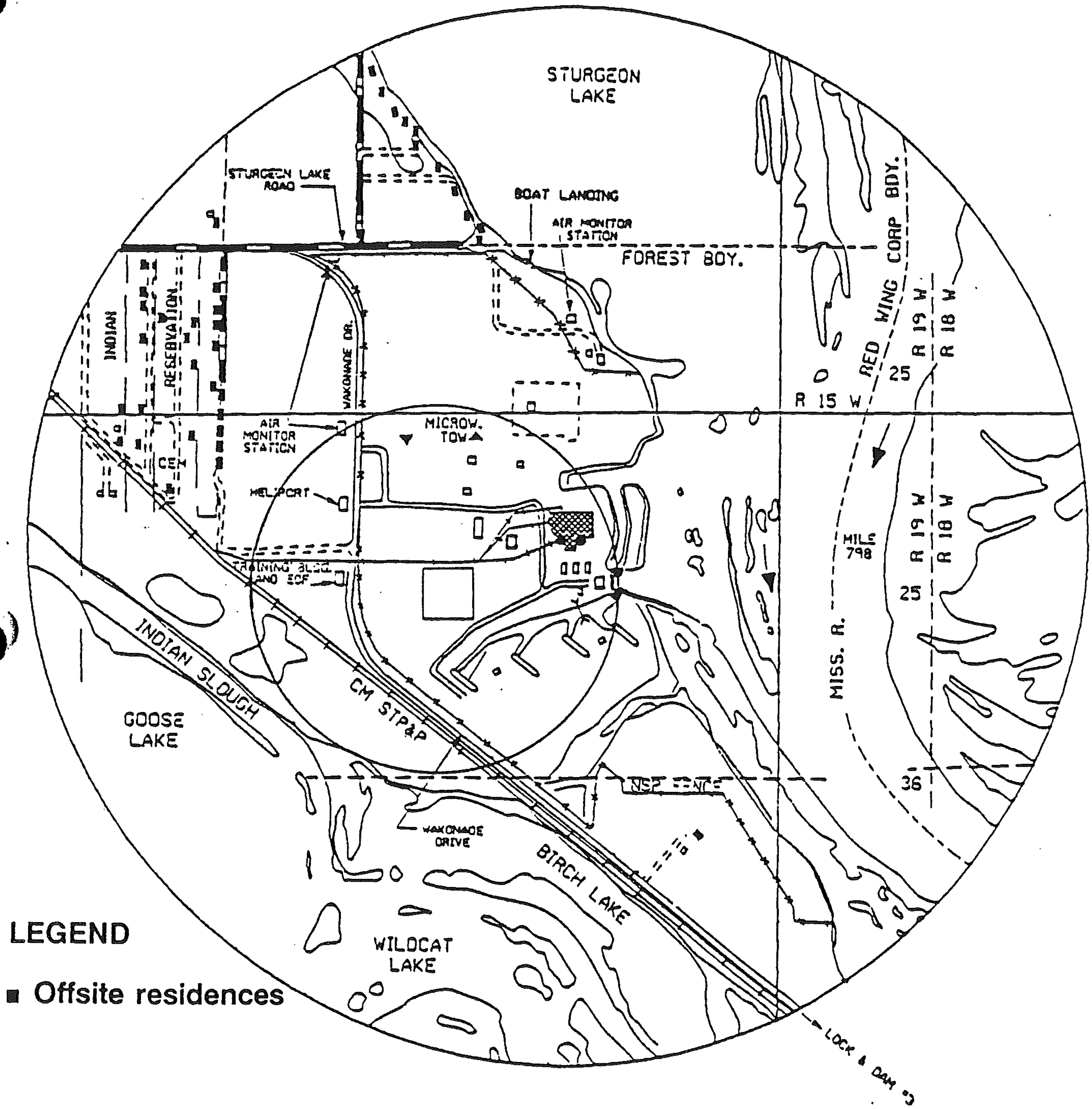
PLANT AREA ENLARGED PLAN (1.00 MILE RADIUS)

Figure 6A-3 **Alternate ISFSI Site II**

OFF-SITE RADIATION DOSE

Persons located outside of inner circle receive average radiation dose < 0.054 mrem/yr from ISFSI operation (assumes 100% occupancy: 24 hrs/day, 365 days/yr)

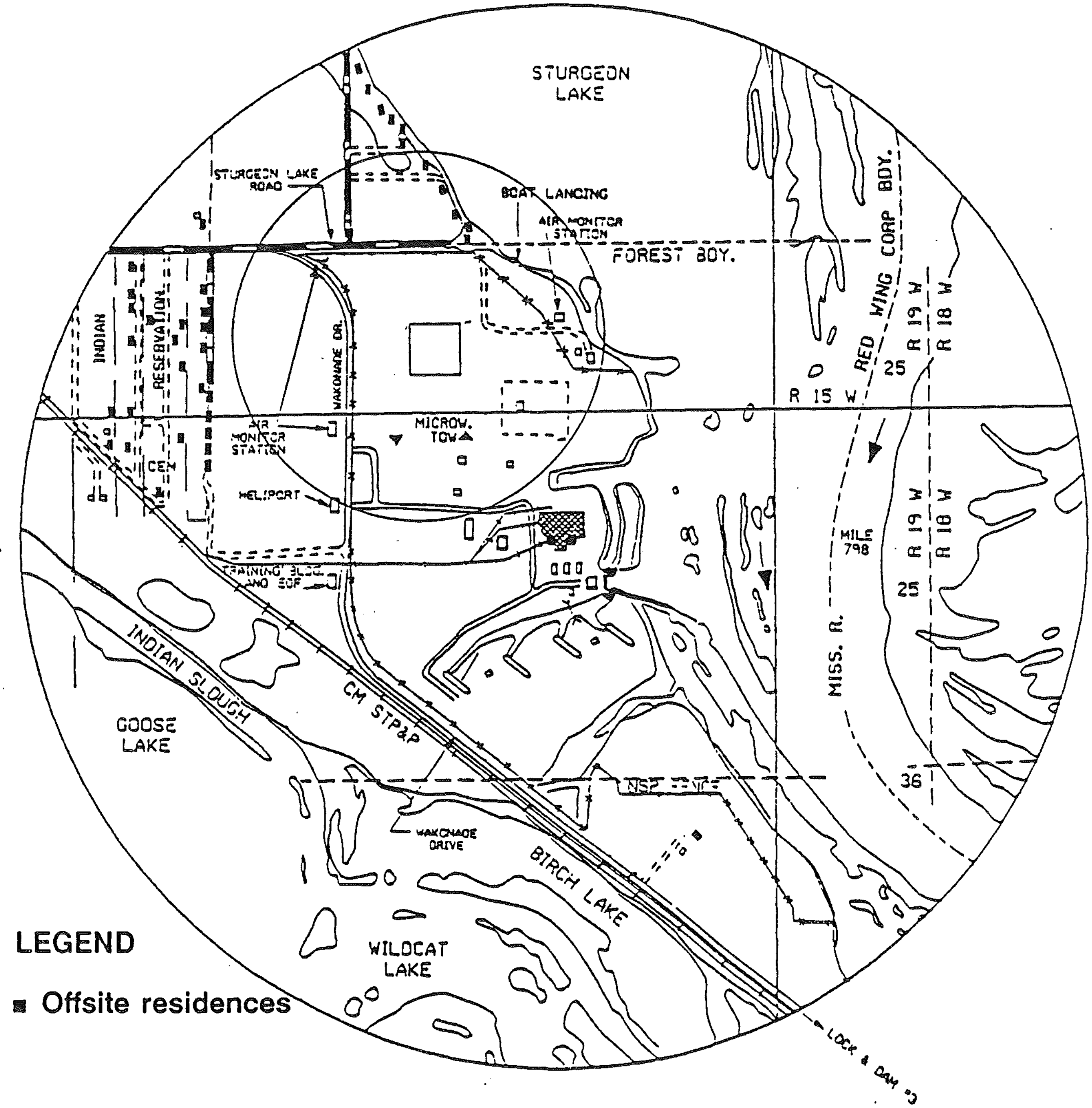
Note: Meteorological tower relocated, to as yet undetermined location.



PLANT AREA ENLARGED PLAN (1.00 MILE RADIUS)

Figure 6A-4 **Alternate ISFSI Site IV**
OFF-SITE RADIATION DOSE

Persons located outside of inner circle receive average radiation dose < 0.054 mrem/yr from ISFSI operation (assumes 100% occupancy: 24 hrs/day, 365 days/yr)



PLANT AREA ENLARGED PLAN (1.00 MILE RADIUS)

Figure 6A-5

Proposed ISFSI Site

OFF-SITE RADIATION DOSE

Persons located outside of inner circle receive average radiation dose < 0.054 mrem/yr from ISFSI operation (assumes 100% occupancy: 24 hrs/day, 365 days/yr)

CHAPTER 7

COMMENTS ON DRAFT EIS

Index of Written Comments - PI ISFSI DEIS

#	Comment Received From:
1	Vine Wells, Fern Kraushner: Prairie Island Tribal Council
2	Robert Hogg: Humphrey Institute
3	Steven Anderson-Meger
4	Todd and Jane Theissen
5	Kip Smith
6	Minnesotans For An Energy Efficient Economy
7	Minnesota Pollution Control Agency
8	Mark Lindquist
9	Donald Kosloff
10	Northern States Power Company
11	Minnesota Department of Natural Resources
12	Marilyn Strasser
13	Minnesota Public Interest Research Group
14	Citizens for a Better Environment
15	Counsel for the Prairie Island Tribal Council
16	Bureau of Indian Affairs, U.S. Dept. of Interior
17	Minnesota Department of Health
18	Dr. David Lang
19	Oral comments received at public meetings

COMMENT LETTER 1

Prairie Island Tribal Council

December 31, 1990

JAN 1991
RECEIVED
ENVIRONMENTAL
QUALITY BOARD

TO: Mr. Bob Cupit

FROM: Fern Kraushner
Vine Wells, Tribal Council Representative
prairie island tribal council
RE: Prairie Island Spent Fuel Project

We feel that the Prairie Island Site will become a dumping ground
for spent nuclear fuel in years to come because the United State
government has not found a depository for nuclear waste. We
want asssurances that only Prairie Island nuclear waste will
1A be stored at the proposed site and no waste from other nuclear
energy plants or other nuclear waste materials will be
transported in. Therefore, because of the above concerns, we
believe that the proposed storage capacity should be limited
to the Prairie Island Nuclear Plant's needs which are contingent
upon the plants operating license.

Another concern is transportation. If, and when a depository
is found, the casks will have to be transported through the
reservation. If an accident occurrs in the transportation of
the spent fuel from the Prairie Island Nuclear Plant, the Indian
people on Prairie Island will have the most to loose. One of
1B the many losses would be our soul source of income, the Bingo
and Casino Hall. But, our major loss would be the loss of our
status as a soveriegn nation and our federally designated
reservation land. It would take a special act of congress to
establish new reservation land for our tribe. As it stands
now, we do not have a guarantee from the United States government
or Northern States Power to establish a new reservation in the
event of an accident.

A third concern is the health impact on the 160 people who live
within a quarter mile radius of the plant. We feel a health
1C study should be made by the Minnesota Health Department and
the Indian Health Service on Prairie Island. In recent years,
more and more individuals have died of cancer and more people
are being diagnosed with some form of cancer. A study needs
to be done to determine if there is indeed dangerous levels
of radiation contaminating the people of Prairie Island. Special
attention should be given to the residents who live within a
few feet of the Northern States Power plant lines.

COMMENT LETTER 2

COMMENTS ON PRAIRIE ISLAND INDEPENDENT SPENT FUEL STORAGE INSTALLATION ENVIRONMENTAL IMPACT STATEMENT

By Robert M. Hogg
Humphrey Institute of Public Affairs
University of Minnesota

January 2, 1990

2A 1. The E.I.S. should discuss renewable energy sources, especially wind power and biomass.

2B 2. The E.I.S. should provide detailed calculations of the potential for energy conservation. For example, a $40 million investment in compact flourescent lightbulbs could begin to displace the need for the Prairie Island facility.

At approximately $10 per bulb, a $40 million investment could purchase 4,000,000 15-watt, 9,000-hour compact flourescent lightbulbs. Using these to replace 4,000,000 75-watt, 1,000-hour incandescent bulbs would save 960 megawatt-hours each day (average bulb use equal to four hours per day.) (See Figure 1) If lightbulb use is constant during the day, 40 MW of generating capacity would be "saved," but it would be higher if lightbulbs are used more at peak times.

Figure 1. 4 hrs/day X 60 watts/bulb X 4 million bulbs =
960 million watt-hours/day = 960 Mwhrs/day

2C 3. The E.I.S. should provide a detailed analysis of the economic impacts of alternatives, such as energy conservation measures and renewable energy sources. The example of compact flourescent lighting given above has the following economic impact.

The daily **savings for Minnesota** consumers from a 960 MWhrs reduction in electrical usage would total $57,600 at six cents per kilowatt-hour. Over a year, total savings in electrical costs would be $21,024,000. Including the savings from avoiding incandescent lightbulb replacement during the year, at 50 cents per incandescent, savings would total about $23 million. (See Figure 2)

Figure 2. 960,000 kwhrs/day X $.06/kwhrs = $57,600/day
$57,600/day X 365 days/year = $21,024,000/year
50 cents/bulb X 4,000,000 bulbs = $2,000,000

Consumers would save $23 million per year for the next six years of the life of each compact flourescent lightbulb. Total lifetime savings equals $138 million.

Wind power and biomass, using Minnesota resources, may have a similar desirable economic impact.

2D 4. The E.I.S. should analyze utility and state policies which could displace the "need" for Prairie Island's energy production, and thus the ISFSI. The E.I.S. needs such analysis to assist all decision-makers, including the state legislature. Such policies considered should include an tax on electricity and other energy.

-- end --

COMMENT LETTER 3

January 3, 1991

Bob Cupit, Senior Environmental Analyst
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

Dear Mr. Cupit,

I wish to submit the following comments in regard to the draft Environmental Impact Statement (EIS) prepared for the proposed on-site radioactive waste storage facility, and associated license application to the Nuclear Regulatory Commission (NRC) filed by Northern States Power (NSP), for the Prairie Island Nuclear Power Plant located in Red Wing, Minnesota. I write as a concerned citizen with personal ties and family the Red Wing area.

I. REQUIRE DESIGN STANDARDS THAT REFLECT THE LIKEIHOOD FOR LONG-TERM STORAGE.

3A As stated in the EIS, despite signed contracts that several nuclear utility companies have with the Department of Energy (DOE) to receive civilian nuclear waste, currently "there are no federal facilities for the storage of disposal of [high-level radioactive] waste". In fact, the false hope of counting on a federal facility to accept nuclear waste is exactly what has led to the present waste storage problem at the Prairie Island Plant. Although a date of 2010 has been envisioned by DOE for the possible availability of a permanent nuclear waste repository, "significant delays" in this anticipated schedule are expected. A realistic look at the history of nuclear waste management in the the nation strongly suggests that the availability of federal repository for nuclear waste in the in the foreseeable future is slim, at best. Prudence dictates that on-site storage be conceptualized on a de facto "permanent" basis. Therefore, the design standards for the anticipated lifetime of any storage container at the Prairie Island Plant should be engineered and built for long-term storage.

II. PROVIDE AN UP-TO-DATE ANALYSIS OF THE RADIOLOGICAL QUALITY OF THE LOCAL GROUND WATER RESOURCE.

3B One of the NRC licensing requirements is to provide an estimate of the quantity of the radionuclides and dose equivalents that may be released to the environment in gaseous and liquid states. Focusing on radionuclides in liquid effluent and leakage, it would seem important to access "ambient" radioactivity in ground water in the vicinity of the Prairie Island Plant, as well as the potential impact from plant operations. If such a ground water monitoring system currently exits, what are the present day findings as based on current data? If there is no such monitoring system, how does NSP intend to adequately fulfill this requirement of NRC licensing?

continued-

III. USE THE STATE ENERGY POLICY TO REQUIRE ADDITIONAL ENERGY CONSERVATION AS A MEANS TO LOWER CONSUMER ELECTRICAL DEMAND AND THEREBY REDUCE THE VOLUME OF HIGH-LEVEL RADIOACTIVE WASTE PRODUCED.

3C As stated in the EIS, the Minnesota Environmental Policy Act endorses energy conservation as a means to "minimize the environmental impact from energy production and use". Although the EIS acknowledges the State energy policy, there does not appear to be any specific requirement for NSP to advance consumer conservation as part of the proposed activity. Perhaps the most optimistic use of conservation would not allow closure of the Prairie Island Plant. Nonetheless, any additional gains in consumer conservation can be applied to decrease energy and waste production of the Prairie Island Plant (or another power plant), and yield real environmental benefits. A specific consumer energy conservation program should be recommended by the EIS for the proposed project as a means to mitigate overall environmental impacts.

IV. VERIFY THE ACCURACY OF INFORMATION SUPPLIED DIRECTLY BY NSP.

3D There does not appear to be credibility assurance for much of the data and information submitted by NSP, e.g. the analysis of alternatives. Thus, the draft EIS appears biased by the opinions and assumptions directly supplied by a source with obvious vested interests. This concern should be fully addressed by the final EIS.

Thank you for the opportunity to register these concerns on this proposal.

Sincerely,

Steven A-Meger

Steven Anderson-Meger
2077 Selby Avenue
St. Paul, Minnesota 55104

January 7, 1991

TO: Gretchen Sable-MN. Environmental Quality Board

FROM: Todd & Jane Theissen-Red Wing

RE: Comments on EIS for Prairie Island Spent Fuel Storage Project

Dear Gretchen:

The following are a series of questions/comments we are concerned about and think need further investigation in the EIS process. I am certain, given sufficient supporting documentation, these could develop into strong contentions in the next stage of the process. Call with any questions.

4A

1) Why have no other plants, currently using ISFSI's, or those who plan on putting them to use in the near future, chosen the ISFSI design, from Transnuclear, Inc., for the Prairie Island project?
   a. Because there has not been enough testing on the Transnuclear cask?
   b. Design flaws or inadequate specs to meet strict US guidelines?
   c. Because of the Transnuclear design's "reduced emphasis on transportability"?

4B

2) If the surface dose rate, of each cask, can be up to 125 mrem/hr, according to the EIS, how is that the use of the casks, according to NSP, will only increase the net radiation output from the plant to 4-6 mrem/yr?

3) "Earthen Berm" questions-

4C

   a. Why is the earthen berm, as stated in the EIS, only being constructed around two sides of the ISFSI facility and not all four?

4D

   b. My impression of the function of the earthen berm is to absorb/deflect radiation/mrem output given off by the casks. If this is true, does the soil in the berm actually absorb the radiation and thus become contaminated? Further, if that soil is contaminated, how will erosion of the contaminated soil effect ground water, surrounding soil, run off into the river...?

4E

4) An in depth, MN. State Health Deptartment, survey should be conducted on the Indian population at Prairie Island to ascertain effects on the peoples overall health, to include instance of cancer and cancer related deaths, frequency of birth defects, average life expectancy and others. All of these factors should be compared to a population group that is not near a nuclear facility. It is deplorable to think that NSP has not found it necessary to conduct such a study.

4F Gretchen, I hope that these issues, if not approached by other concerned citizens, can be addressed during this stage of the approval process. I don't know what it is going to take to get the people of Red Wing to WAKE UP, but, we are going to do our best to make sure everyone is aware of the inherent and potential dangers of this project. How much can one small town take? We have two solid waste incinerators, a landfill that is now going to be enlarged and now a proposed nuclear waste site. We thank you for all of your organization's help in raising the public's awareness.

Sincerely,

Todd, Jane, Erik and Megan Theissen
Red Wing, MN.
(612) 388-1890

Mr. Bob Cupit
Senior Technical Analyst
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

RE. DEIS Prairie Island ISFPI

January 7, 1991

Dear Mr Cupit,

This memo contains written comments on the Draft Environmental Impact Statement (DEIS) for the Prairie Island Independent Spent Fuel Storage Installation (ISFSI) proposed by the Northern States Power Company (NSP). The DEIS is well-written and generally informative. I commend the Minnesota Environmental Quality Board (MEQB) staff and others associated with the DEIS for making highly technical material accessible to the public. As others are likely to comment on the discussion of alternatives, I restrict my comments to the analysis of the proposed project. I urge the MEQB to correct four omissions that reduce the credibility of the proposed project.

5A 1) Why only **48 casks**? The DEIS needs to state the rationale that led NSP to this number. Statements in the DEIS suggest that 96 might be a more realistic planning criterion.

5B 2) The DEIS makes it appear that the proposed ISFSI is likely to ~~be~~ **50 times more output** to the environment than current power generation operations at Prairie Island (3.74 vs 0.0768 mrem). Is this true? When framed as a multiple of existing hazards, the risks associated with the proposed project appear substantial.

5C 3) The DEIS proposes safeguards that lean heavily on automated **monitoring systems**. Why so few provisions for mechanical backup systems and human observation? Has NSP considered the possibility that the power might go out?

4) The DEIS should document and present graphically the time-dependent **heat-generation and heat-flow calculations** that lead to three unsupported estimates. The most critical
5D relates to the small margin of error associated with 98% of criticality The second calculation should reveal the short-term increase in temperature associated with loading the casks. The third should support the 240°F estimate for long-term equilibrium temperature

The four points are discussed in turn.

1) Why <u>48</u> casks?

Section 3A, page 3.2, discusses the proposed number of casks. The discussion is all too brief. It makes clear that the number is dependent on DOE progress. The inertia of the Federal system coupled with the stridency of anti-nuclear activists make planning for maximum expected capacity the only appropriate action. Given the lack of DOE progress to date, it would appear prudent for the DEIS to reflect planning that assumes no DOE progress prior to the 2014 shutdown date. If continuation of licensing to 2024 is expected, the DEIS should plan for no DOE progress prior to 2024.

The DEIS indicates that 75 casks would be required for storage of all spent fuel were the facility to shut down in 2014. If a licence extension were granted, "more spent fuel storage would be needed". How many more? Why not plan for 75 and more? Doubling the current proposal to 96 casks strikes me as an appropriate and conservative design criterion.

The need for possible expansion of the proposed site is noted on page 3.3. The acknowledgement of the potential need for land for expansion underscores my worry that the design criterion of 48 is a stop-gap measure. Were NSP to need 72 or 96 casks in the future, would NSP have to go through this entire process again? A prudent approach might be to plan for 96 casks now and limit immediate pad construction to accommodate 48.

The MEQB should insist that NSP design the ISFSI to accommodate the maximum number of casks that the Prairie Island plant will produce The DEIS estimates of thermal and radioactive outputs should, accordingly, reflect both expected (48) and worst-case (96?) scenarios. As it stands, the DEIS design criterion is based upon unrealistic expectations of DOE action.

2) Framing Effect in Presentation of Output

People often change their minds about a situation or an action when information is presented in different ways. Different frames of reference produce a phenomenon is known as a 'framing effect'. The DEIS skillfully introduces such an effect on page 1.1 in the introduction and in section 4E, page 4.9, in its discussion of the radiological impacts during loading and storage:

> The annual dose ... due to ISFSI operations has been conservatively calculated to be 3.74 millirem (mrem) per year. The maximum annual dose ... from the Prairie Island plant has been calculated to be 0.0013 mrem ... and 0.075 mrem ... The maximum total annual dose ... therefore would be less than 3.75 mrem. (page 4.9)

> The dose ... will not exceed the 25 mrem per year limit specified by NRC regulations. (page 1.1)

When the frame of reference is the 25 mrem criteria, the ISFSIU appears 'safe'. However, the ISFSI dosage of 3.74 mrem appears to be nearly 50 times that of the Prairie Island plant (0.0013 + 0.075 mrem). When the frame of reference is the current output of the power generating station, the ISFSI appears far from safe.

This is a classic framing effect. The DEIS chooses a frame of reference advantageous to development. The alternative frame prompts reconsideration of the project. Were word to get out that

NSP proposes to increase radioactive output at Prairie Island by a factor of 50, the public would likely become alarmed. The DEIS should address more thoroughly public reaction to the alternative frame of reference

The same paragraph on page 4.9 makes allusion to another document that contains the calculations supporting these estimates. It states that "Chapter 7 of the Safety Analysis Report which was submitted to the NRC as part of the ISFSI license application" contains these calculations. Why not include that chapter as an appendix to the DEIS?

Were the capacity expanded from 48 to 96 casks, would the calculations indicate a doubling of radioactive output? Are the effects geometric rather than additive? What are the outputs that would result from 96 casks?

3) Monitoring Systems

Page 3.12 contains two chilling statements:

> Periodic testing is not required due to the reliability of the redundant monitoring system.
>
> Thermoluminescent dose monitors located on the ISFSI site fence shall be read quarterly.

It appears that NSP believes that the automatic monitoring system is failsafe. So failsafe that human observers need check radioactive output only four times a year. This position is incredibly naïve.

It is not difficult to construct scenarios that would lead the automatic monitoring system to fail. For instance, while it may be inconceivable to NSP, it is quite likely that the power might go out. A combination of events make this situation plausible. Prairie Island may have to shut down for retrofitting. It would then produce no power to support the monitoring equipment. Add a tornado or flood that knocks out incoming power lines Monitoring during this crisis would stop. Monitoring may fail precisely when it is needed the most. Built-in mechanical backup systems and/or daily human observations would go a long way to prevent over-reliance on an automatic monitoring system

Why is there no plan for routine human observation? Since "the ISFSI perimeter will be patrolled by plant personnel at least once per shift" (page 3.17), daily observation should be easy to implement. Surely security patrol could be taught how to read the thermoluminescent dose monitors located on the ISFSI site fence.

Where is the alarm panel? Page 3.17 vaguely places it somewhere outside the ISFSI fence. Is there a backup mechanical system in case the alarm panel fails?

The design of the monitoring system can easily be perceived to be inadequate.

4) Heat Generation and Heat Flow Calculations

Table 3-4, page 3.8, indicates that DEIS proposes to allow the stored fuel within a cask to reach 98% of criticality. An atomic explosion results at 100% criticality (Appendix B, page 2). This strikes me as a rather fine margin for error.

Such a fine margin can be statistically supported if the standard error of the estimate were quite small, say 0.2%. Unfortunately, the DEIS does not present formulae, calculations, and graphical displays that support such a small margin for error. The MEQB must insist that this oversight be addressed. The inclusion of heat-generation and heat-flow formulae would allow reviewers to assess sources of uncertainty in the estimates. Graphical displays that include the estimated standard error might support the claim that 98% of criticality is tolerable.

I suspect that few citizens of Red Wing would be comfortable knowing that the threshold for error is so small. The DEIS should include an estimate of the (extremely low) probability of an atomic explosion What is the worst-case scenario associated with a cask that reaches criticality?

Two related issues beg for inclusion of heat-generation and heat-flow formulae, calculations, and graphs. On page 3.11 the DEIS states that surface-temperature measurements of a cask might be made only 24 hours after loading. The mean time-dependent thermal effects of loading fuel rod assemblies into a cask can be modeled as a step function. The time lag before the new equilibrium temperature is reached is likely to be a complicated function of the materials in the cask. Do calculations of heat-generation and heat-flow indicate that 24 hours is sufficient time for thermal equilibrium? It might be more prudent to wait a significantly longer time to insure that a newly-loaded cask does not become too hot. This need for prudence is exacerbated by the minimal margin for catastrophic error.

The DEIS often implies that the casks will be hot as they sit on the pad. For instance, "birds are not expected to roost directly on the casks due to their high surface temperature." (page 4.5) However, the actual expected temperature (240°F) is hidden deep in the DEIS on page 4.6. Put this estimate up front. Include the calculations that support this estimate. Show the time decay of temperature as the heat-generation capability of the stored fuel decreases.

The MEQB should insist that the DEIS makes it clear that these casks are going to be hot, very hot. So hot that show and rain will vaporize, shrouding them in fog during a heavy storm. The fog will clearly hinder emergency monitoring activity during a crisis that disables the automatic system.

The designers of the casks must have made each of these calculations. They should all be included in the DEIS.

Minor points

5E

a) Data are plural

b) Please include a definition of "crud" in Appendix A. Not knowing the technical meaning of this slang term, I laughed aloud at the following line:

> The sources of contamination on the interior of the cask would be crud from the outside of the fuel rods and the crud left by the spent fuel pool water. (page 4.13)

c) Is the hickory tornado missile 6 feet long (page 4.7) or 12 feet long (Table 3-4, page 3.8)?

Thank you for this opportunity to comment on the DEIS.

Sincerely,

Kip Smith
548 Frontenac Place
St. Paul, MN 55104

(612) 644-8984

COMMENT LETTER 6

MINNESOTANS FOR AN ENERGY EFFICIENT ECONOMY

PROMOTING SUSTAINABLE USE
OF NATURAL RESOURCES

510 FIRST AVENUE NORTH, SUITE 400
MINNEAPOLIS, MN 55403
PHONE: 612/348-6829
FAX: 612/348-9335

January 7, 1991

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

RE: Adequacy of the Environmental Impact Statement
Prairie Island Spent Fuel Storage Project

Dear Mr. Cupit:

These comments on the adequacy of the Environmental Impact Statement (EIS) for the Prairie Island Spent Fuel Storage Project come to the MEQB from Minnesotans For An Energy Efficient Economy (ME3). ME3 is a recently established coalition dedicated to promoting the benefits of energy efficiency and renewable energy. Our focus this year is on electric utilities and the essential role they can play in energy efficiency, if their financial incentives can be restructured so that utility interests are served when consumers use electricity more efficiently. Enclosed is a ME3 Policy Statement (Attachment #1), and membership list (Attachment #2).

Extremely minute quantities of the materials to be contained in the proposed spent fuel storage installation are capable of causing major environmental damage for geological periods of time. Yet, this temporary spent fuel storage option must be considered because permanent storage technology does not exist. The idea that permanent spent fuel storage technology will exist in 20 years is speculation.

With blind faith, the public must accept that the proposed temporary facility will not be needed 20 years from now, that technology and perpetual management will effectively isolate the spent fuel from the environment for the required eons, and that during all this time, unprecedented levels of ecological and political stability will be maintained. Blind faith needs to be buttressed by more than the design features of TN-40 casks, the good intentions of NSP and its regulators, and the various possibilities considered by the EIS.

Even if the EIS answered every possible question perfectly, increasing volumes of spent fuel would still increase spent fuel management problems. Prudent spent fuel management therefore must seek to minimize the production of spent fuel, and a thorough discussion of how to do so should be included in every spent fuel EIS.

A The EIS recognizes this need in theory, and as a matter of state policy, by discussing the conservation alternative on p. 5.7,8. We agree that continued Prairie Island operation is not under review, and that this EIS should not attempt to present a comprehensive, technical analysis of the cost-effective conservation alternative. However, the EIS discussion of the conservation alternative, and the ability of this alternative to impact NSP's spent fuel management program is misleading and inadequate for several reasons.

Parties representing each of the "widely divergent opinions" about "what level of conservation is attainable" agree that a massive potential exists. NSP, Electric Power Research Institute (EPRI), MN Dept. of Public Service (MDPS), Rocky Mountain Institute (RMI), and many others all agree that cost-effective commercially available end-use efficiency improvements could reduce electrical energy requirements by 50%, or more. (See Attachments 3-7A). There is also agreement among knowledgeable persons that the primary reason for such a massive efficiency improvement potential is that when consumers use electricity more efficiently, power company revenues go down. Conversely, when consumers use more electricity, power company revenues go up. (See Attachment 7B).

Utility financial incentives reward electrical consumption and punish end-use efficiency. In other words, the faster the power company produces spent fuel while generating electricity to sell to consumers, the more money the power company makes. This situation is antithetical to rational spent fuel management, but unexamined by the EIS.

6B

To be adequate, the EIS must recognize the need to change electric utility financial incentive structures so that maximum production of spent fuel is not financially rewarded. To be adequate, the EIS must identify financial incentive structures capable of rewarding the efficient use of electricity, such as the Energy Intensity Model. (See Attachment 7A-H. Attachment 8A-E is included to provide perspective on the Energy Intensity Model. Attachment 9 lists five characteristics that every incentive structure must contain, if it is to reward the efficient use of electricity.) To be adequate, the EIS must then discuss how restructuring financial incentives will impact spent fuel management.

6C

Questions about the ability of existing or proposed NSP conservation programs to offset Prairie Island capacity (p. 5.7) miss the point. The EIS should instead examine how energy savings produced by financial incentive restructuring, combined with the other components of the "reduced operation" alternative, would impact the $168 to $324 million option presented on p. 5.7 of the EIS.

Comments about permit conditions when the Prairie Island capital investment was "sunk" (p. 5.7) may help to explain why electric utilities are such major contributors to environmental degradation, but they are meaningless in terms of providing decision-makers with information needed for rational spent fuel management.

6D

The discussion of NSP's 1990 Advance Forecast (p. 5.7) clearly illustrates the nature of the EIS's inadequacy regarding the conservation alternative. NSP's demand-side program is almost entirely capacity driven. There is no quantification in the EIS of NSP's energy reductions because they are so insignificant, accounting for about 50 gigawatthours per year out of total energy sales rising upward to 25,500 gigawatthours in 1994 (see Attachment 7E). Yet energy generation, not capacity, produces spent fuel.

NSP's demand-side program is so dominated by programs that control capacity because NSP's financial incentives already reward well-run load management programs. On the other hand, NSP's conservation programs capture such small amounts of energy because reduced energy sales reduces NSP earnings. Considering this misdirected incentive structure, and the direct relationship between electrical generation (as opposed to megawatts of capacity) and spent fuel production, it is not surprising that NSP's projected demand-side programs are incapable of having a significant impact on spent fuel management.

Restructured financial incentives, however, would produce
legitimate conservation programs and significant energy savings.
These savings, coupled with the other elements of the reduced
6E operation alternative, could significantly alter the cost/benefit
analysis used to justify the proposed TN-40 cask alternative. This
analysis must be conducted in order for the EIS to be adequate.

Finally, the EIS discussion on where to apply the benefits of
conservation (p. 5.8) puts the cart before the horse. Conservation
programs must produce significant energy savings in order to create
significant environmental benefits, but NSP's conservation programs
are not capable of producing significant energy savings. Regardless
6F of where environmental benefits should be applied, financial
incentives must reward end-use efficiency improvements. Otherwise,
there simply are no benefits to apply anywhere. Before substance can
be injected into this discussion, NSP must be financially motivated to
capture conservation potential whenever doing so is cheaper than
providing energy from the supply-side.

To be adequate, the EIS must first come to a conclusion about the
need for restructuring financial incentives. It will then be possible
6G to evaluate how much energy could be saved if financial incentive
structures such as the Energy Intensity Model were implemented. Then,
and only then, will it be possible to rationally evaluate how to most
appropriately apply actual benefits of conservation.

It is possible to correct the inadequacy in the EIS regarding the conservation/reduced operation alternative without placing continued operation of Prairie Island under review, and without attempting to present a comprehensive, technical analysis of the cost-effective efficiency improvement potential. To do so, the EIS must:

1. acknowledge the thoroughly documented and overwhelming fact
6H that inefficient end-use technologies waste 50%, or more, of
all the electricity consumed;
2. recognize that electric utility financial incentives must be restructured before the inefficiencies can be significantly reduced, and that such reductions can be accomplished by incentive structures such as the Energy Intensity Model;
3. assume a cost range for purchasing and installing more efficient end-use technologies, say \$20 to \$80 per MWh;

4. assume that NSP's annual conservation investment under restructured financial incentives will be within a certain range, say 5% to 25% of total NSP revenues; and finally,
5. present decision-makers with a cost/benefit analysis comparing the TN-40 cask option with the conservation/reduced operation alternatives resulting from the above assumptions, recognitions, and acknowledgments. This analysis must identify the level of conservation expenditure, at given ranges of cost-effectiveness, that will enable conservation/reduced operations alternatives to displace the TN-40 cask option, considering the need to appropriately apply conservation benefits.

Sincerely,

George Crocker
Administrative Procedures Coordinator
Minnesotans For An Energy Efficient Economy

Executive Director
North American Water Office
P.O. Box 174
Lake Elmo, MN 55042
(612) 770-3861

SEE APPENDIX M FOR ATTACHMENTS

List of Attachments
For ME3 Comments Regarding Adequacy of EIS:
Prairie Island Spent Fuel Storage Project.

1. ME3 Policy Statement.
2. ME3 Membership List.
3. Cost-Effective End-Use Efficiency Improvement Potential--RMI
4. " " " " " --MDPS
5. " " " " " --NSP
6. " " " " " --EPRI

7A. Draft Presentation, Energy Intensity Model.
B. Utility Rates & Earnings.
C. Energy Intensity Index.
D. Impacts of Conservation.
E. Electric Sales Scenarios (with spread sheets).
F. Earnings & Bills, NSP Scenario (with spread sheets).
G. Earnings & Bills, NAWO Scenario (with spread sheets).
H. Energy Intensity Model Equations.

8A. Description of Alternative Rate-Making Options.
B. Making Conservation Profitable: An Assessment of Alternative Demand Side Management Incentives.
C. Financial Incentives For DSM Programs: A Review and Analysis of Three Mechanisms.
D. Effect Of The ERAM Mechanism On Utility Incentives.
E. Balancing Shareholder and Consumer Interests in Incentive Ratemaking.

9. Characteristics of Appropriate Financial Incentive Structuress.

Minnesota Pollution Control Agency
520 Lafayette Road, Saint Paul, Minnesota 55155-3898
Telephone (612) 296-6300

Celebrate MINNESOTA 1990

JAN 1991 RECEIVED ENVIRONMENTAL QUALITY BOARD

January 7, 1991

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

Dear Mr. Cupit:

RE: Prairie Island Spent Nuclear Fuel Storage Project Draft Environmental Impact Statement

The Minnesota Pollution Control Agency (MPCA) staff has completed a review of the above referenced document. Relative to those areas for which the MPCA has jurisdiction, the staff believes that the Draft Environmental Impact Statement (EIS) has adequately identified and mitigated potential environmental impacts that the project may generate. However, we have the following minor comments:

7A 1. A discussion of the radiation exposure to workers on-site should be included in the document.

7B 2. Chapter 3, Section E. 2., Security and Monitoring of the ISFSI and Casks, should include a description of the existing radiological monitoring systems.

7C 3. A list of references was omitted from chapter 4.

Thank you for the opportunity to review this document. If you have any questions or concerns please contact Meri K. Nielsen of my staff at 612/297-1766.

Sincerely,

Barbara Lindsey Sims

Barbara Lindsey Sims
Acting Commissioner

BLS:pnk

JAN 1991
RECEIVED
ENVIRONMENTAL QUALITY BOARD

1-2-1990

1111 Ingerson Rd
Arden Hills, MN 55112

To: Bob Cupit

From: Mark Lindquist

Re: The Draft EIS on the dry cask storage system at Prairie Island

The Environmental Impact Statement (EIS) for the dry cask storage of high level radio active waste does not take several factors into consideration. These include the failure to respect the Native American community centered at the Prairie Island Reservation, failure to adequately considered conservation and efficiency, failure to discuss other potential forms of power generation, the outcome if the United States government does not take the waste by 1998--a virtual impossibility-- or if it fails to accept such waste before the 25 year permit expires, and finally the event of an aircraft crash at such a site.

Even though the EQB may feel that no excessive health threat for the residents of the Prairie Island Reservation is created by the proposed project, the mere presence of such a storage system will be seen as a threat. In the spring of 1990, the power plant
8A contaminated drinking wells on the reservation with tritium. Native Americans have been treated poorly consistently through out the history of the United States, this project would be yet another insult to these people. Again even if no cancer deaths result from this project, there will be harm done to the Indian community of Prairie Island.

The EIS assumes replacement for lost generating capacity must come from coal fired plants. This assumption follows from the standard organization of the electric generation industry, where base load capacity is hydro, coal or nuclear. This does
8B not mean that base load capacity must come from one of those sources.

One of the most promising fossil-fuel generating technologies coming on line is the aero-derivative gas turbine. Robert William and Eric Larson state,

> In a wide range of circumstances, new, highly efficient, gas turbine based power plants will be able to provide electricity at lower cost with less adverse environmental impacts or safety problems than coal or nuclear steam

electric plants.1

Such plants would avoid altogether the issue of nuclear waste and pose a lesser CO2 burden than coal. What makes this attractive is the costs are becoming compatible with base load coal, and the units can be installed in an incremental way.

The assumptions of the EIS that base load capacity is given, no demand side management and conservation are possible and that coal or nuclear power are the only viable base load capacity options are not sufficiently supported.

8C The third fundamental failure of the EIS is the assumption that the federal government will live up to its agreement to take all high level nuclear waste in 1998. There is a chance that Nevada will muster enough political strength to keep itself from becoming a high level radioactive waste dump for the nation. In such a case there will be significant amounts of such waste being stored in vessels with a life time of 25 years. The EIS must consider what the probability of such an event occurring is, and what the result would be.

8D One more item should be considered is the event of an airplane crash at the site. This may sound like a non-credible accident, but against all odds every year some home in the world is struck by a crashing aircraft. Odds would be tremendously increased in the event that a second airport is built to the south of the Twin Cities. Though this may not be a likely event, how much more unlikely is it than the "500 year flood considered.

8E One last comment, it would be very useful for the EQB to present a fuller discussion of the radiation exposure. What is the meaning of a increased dose of 25 mrem? These numbers are meaningless to those not well informed about radiation.

8F This EIS unfourtunatly does not concern itself with the general appropriateness of nuclear power or even the Prairie Island power plant, and thus the EIS does not adequately cover the "do nothing" option. The scope of the EIS must be enlarged to include cultural impacts on the neighboring reservation, alternative power generation, and conservation. The possible events of the federal government failing to accept such waste in a timely fashion and the event of an aircraft crash on the site are merely negligence of the the EQB, and must be rectified.

---

1 Robert Williams and Eric Larson, "Expanding Roles for Gas Turbines in Power Generation" in Electricity: Efficient End Use and New Generation Technologies and their Planning Implications Lund University Press: Lund Sweden, 1989.

Donald C. Kosloff
930 Burton Street
Red Wing, MN 55066-3829
January 5, 1991

Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, MN 55155

Dear Mr. Cupit:

Listed below are my comments on the Draft EIS for the Prairie Island ISFSI.

9A Page 4.1: Operation of ISFI will generate no radioactive waste. The waste discussed on this page are merely a diluted form of radioactive material that already exists. As the ISFSI operates the amount of radioactive material will decrease as shown on Table 3-3.

9B Page 5.3: Public Citizen's biased political conclusion on continued operation of commercial nuclear generators should be replaced with an objective scientific conclusion. If Public Citizen material is included an objective evaluation of a few of its documents should be included. Such an evaluation was done by an independent citizens panal appointed to review the restart of the Sacramento (CA) Municipal Utility District nuclear plant (1986-1988). Public Citizen should also be identified as an anti-nuclear organization which derives signifigant income from its anti-nuclear activities.

9C Page 5.8: Replacing Prairie Island should include an analysis of the socioeconomic impact on Red Wing.

9D Pollutants emitted and isolated as a result of operation of a 1000 MW coal power plant should be analyzed. Pollutants analyzed should include lead (12 tons/yr), arsenic (24 tons/yr), uranium (4 tons/yr), mercury, and radium. The amount of time these pollutants remain lethal should be disclosed as well as the methods used to insure that they remain confined while they remain lethal. If it is considered acceptable to allow such pollutants to be released or isolated without permanent monitoring the rationale for this method should be stated including the number of deaths considered acceptable. Since large amounts of coal would be transported for this option, estimates of the number of people to be killed by coal trains should be included as well as the amount of precious oil that the trains would consume. In 1984 the World Health Organization published a study that showed that the disposal of coal waste is 10,000 times more hazardous to human health than the disposal of nuclear waste. This study should be summarized. The coal miners expected to die as a result of the coal mining should be stated.

9E The 18-watt fluorescent buld and adpater that delivers as much light as a 75-watt incandescent bulb should be evaluated. If it is so good why did I have to look for it in three states for a year before I found one. Why did one of the three I bought burnout a resistor and fail after one year of use? Could such a failure cause a fire? What do you use to replace 250-watt bulbs? What do you use in enclosed fixtures. I have 40 light fixtures in my house, these bulbs are only usable in 5 of them. Is this typical? Do the bulbs contain mercury and if so, what is its impact on the environment?

9F Page 13 of Appendix G: Where did 5 rem (line 2) come from? The EIS should state that BEIR V states (Page 181) that "At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero". Therefore the EIS should state that BEIR V

concluded that the risk from doses to the public associated with normal operation
of plants like Prairie Island may be zero. Also the exposure to low level
9G radiation which leads to increased risk estimates should be quantified to show
where the risk is speculative (less than a 10 rem acute dose) and were it has
been demonstrated with some certainty (10 rem and above acute dose). The concept
9H of radiation hormesis should also be discussed. This is particularly important
in view of the emerging controversy concerning the effects of low levels of
carcinogenic substances. Please see the attached articles.

SEE APPENDIX M FOR ATTACHMENTS

Sincerely;

Donald C. Kosloff

COMMENT LETTER 10

Northern States Power Company

414 Nicollet Mall
Minneapolis, Minnesota 55401-1927
Telephone (612) 330-5500

January 9, 1991

JAN 1991
RECEIVED
ENVIRONMENTAL
QUALITY BOARD

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

Prairie Island Independent Spent Fuel Storage Installation
Comments relating to Draft Environmental Impact Statement

Attached are written comments relating to the Draft Environmental Impact Statement. Specifically, there are two general sections. The first, Section A, addresses the comments received at the two Public Meetings held in St. Paul and Red Wing, Minnesota on December 17 and 18, 1990; the second, Section B, is a page by page compilation of comments relating directly to the Draft Environmental Impact Statement document.

If you have any questions, please do not hesitate to contact me at 330-6391.

C. Gary Anderson
Manager, Regulatory Services

sw

Attachments

Draft Environmental Impact Statement
Prairie Island Spent Fuel Storage Expansion
Comments of Northern States Power

A. Preliminary response to comments received at Public Meetings

1. Site geologic characteristics.

The soil in the area where the ISFSI will be located was tested and analyzed to determine its properties, and how it would respond in the event of a flood or earthquake. This data, along with the weight and dimensions of the casks sitting on the pad, was then used to generate a concrete pad design that would not be damaged in such events. The soil boring data and a discussion of the design and analysis of the pads are in the Safety Analysis Report submitted to the NRC.

2. Increased pressure for cask testing.

In actual use, the internal pressure will be about 30 psig. There is no mechanism that can cause a significant increase in internal pressure once the cask is placed at the storage facility. The casks are, nonetheless, conservatively designed for an internal pressure of 100 psig. ASME standards require the cask be hydrostatically tested at 125 % of design pressure, or 125 psig. This test pressure is 4 times greater than the cask internal pressure when it is loaded with spent fuel, and so is an adequately severe standard.

3. Impacts on adjacent Indian community.

Radiation Dose : The Prairie Island Indian Reservation is located east of the plant site. NSP Company property extends about 2000 feet east from the position of the storage casks. At this distance, a resident would receive less than 1 millirem per year from the casks. A person located at the plant site boundary (about 1000 feet from the casks) for 24 hours a day, 365 days a year, would receive a maximum of 4 millirem a year from the casks. To put this in perspective, the average dose received by people from background radiation, including radon gas, is about 360 millirem each year.

3. Impacts on adjacent Indian community. (Continued)

Earthen Berm : The earthen berm which will extend along the west and north sides of the ISFSI will be landscaped. Trees will be located between the berm and the west and north plant site boundaries, so the berm will scarcely be visible to persons off-site. Grasses growing on the surface of the berm will resist erosion. If any significant erosion does occur, the berm will be restored by plant staff. Even if a large section, or all, of the berm is washed away from heavy rains or flooding, it could be restored in a matter of days. During that time, there would be a small increase in off-site radiation doses. In this scenario, the maximum annual radiation dose received by a person located at the plant site boundary would increase from 4 millirem to 5 millirem, still well below the NRC limit of 25 millirem.

Transportation : The dry cask storage facility will not result in an increase in the amount of spent fuel generated at the plant over that anticipated when the plant originally received its 40 year operating license. Thus, there will be no increase in the amount of spent fuel removed from the site and transported through the adjacent community. The environmental impacts and risks of spent fuel transportation have received a great deal of analysis. A comprehensive regulatory framework exists which governs all aspects of spent fuel transportation, from design of the casks to the safeguard procedures employed. The transportation safety record for spent fuel and other radioactive material is far superior to that of any other hazardous material. Eventual removal of spent fuel from Prairie Island will be performed by the DOE, in accordance with the appropriate regulations. Before any shipments are made, NSP and the DOE will work closely with all plant neighbors, as well as other affected communities and agencies, to involve them in the planning and preparations.

4. Conservation Instead of Continued Plant Operation.

Underlying the conservation commentary of some individuals seems to be the assumption that the dry spent fuel storage proposal is so dangerous that any sacrifices should be made to avoid its operation. That is not the case. The nuclear power industry has for years routinely handled, stored and shipped spent reactor fuel. Examining the environmental and safety records of these activities shows they represent virtually no risk when compared to many every-day industrial activities. There has never been a death or radiation related injury to a member of the public as a result of handling, storage or shipment of spent nuclear fuel. In particular, Prairie Island is recognized by the NRC, the Institute for Nuclear Power Operations (INPO) and the nuclear industry as one of the best operated, cleanest nuclear plants in the world. The NRC has performed detailed review of dry storage of spent fuel, and has concluded that it does not present a threat to the health and safety of the public or environment. While the cask storage facility will have virtually no environmental impact on the surrounding area and its people, closing the plant would have severe financial and social impacts.

Socioeconomic Consequences of Plant Shutdown:

In addition to the added costs of replacing Prairie Island and purchasing or generating replacement power until a new facility could be built, a plant shutdown would have other impacts. NSP currently pays about $17 million annually in property taxes for the Prairie Island facility. These funds are used to provide various public services by the city, county and local school district. If the plant were shut down, its assessed value and tax obligation would essentially disappear. Without these funds from the Prairie Island plant, funds would either have to be raised from other sources, or services would have to be curtailed. For example, 65% of the local school budget is provided from Prairie Island tax revenue.

Plant shutdown would also have an immediate impact on the approximately 390 people who are employed at the plant, at a loaded labor rate of upwards of $26 million a year. Many of these employees reside in the Red Wing area and support local businesses and services. The loss of 390 jobs at Prairie Island would have an impact on the overall economy of the community.

Conservation to Reduce Waste Generation :

NSP believes that future growth in electric demand can be significantly reduced through conservation. However, the existing core of base load requirements will still need to be met with generating plants.

NSP's Demand Side Management (DSM) goal is 1,000 mw of impact system-wide by 1995. through 1990, NSP achieved approximately 500 mw of impact on system peak using the complementary strategies of Conservation and Load Management. The Minnesota state portion comprises approximately 75% of the total. NSP projects an additional 400 mw of energy efficiency between 1995 and the end of the decade. The company is continually refining this figure and it may change as we approach 1995. The company regards this goal as extremely aggressive.

Given the relative magnitude of achievable energy efficiency to base load needs, conservation is not expected to be a practical solution to waste minimization at Prairie Island. The figure at the end of this section shows NSP's obligations and resources. Prairie Island is NSP's lowest cost base load unit. NSP's existing base load generation theoretically could be affected by conservation, but conservation's full technical potential (as opposed to realistically achievable conservation levels) would have to be realized and then some before affecting Prairie Island operations. Most coal-fired base load supplies would be removed before Prairie Island due to their higher incremental operating costs. Hence the potential of conservation to reduce waste from Prairie Island is virtually non-existent.

More Sophisticated Approaches to Energy Efficiency :

NSP is a leader in energy efficiency improvements. A recent survey, conducted by Ontario Hydro, placed NSP third in the nation in the percentage of system demand reduction due to Demand Side Management (DSM) efforts. Currently NSP has nine DSM Research & Development projects under way with a budget of over $1 million dollars. In addition, NSP is a member of the Electric Power Research Institute (EPRI) and so has access to and uses on a regular basis this basic research into sophisticated approaches to energy efficiency improvements. As noted above, however, NSP does not agree that sufficient conservation could be achieved, even with more sophisticated approaches, to reduce waste at Prairie Island.

Rate-Based Financial Incentives to Encourage Conservation by Utilities :

NSP has recently filed a plan that would increase its financial incentive for conservation with the Public Utilities Commission (PUC).

Information on Specific Energy-Efficient Technologies :

There is an enormous amount of information along these lines and NSP endeavors to keep abreast of it (note comments on EPRI and in house research above). Unfortunately much of the published information in unreliable, not applicable or redundant. However, making credible information available is only a small, first step in understanding the achievable impacts possible in actual market applications.

Cost Effectiveness of Conservation :

There is continuing debate in Minnesota over how to properly determine cost-effectiveness of conservation. NSP has analyzed the cost effectiveness of a wide variety of conservation measures using state-of-the-art benefit-cost modeling techniques and has found that substantial amounts of conservation are not cost effective when compared to generation alternatives such as Prairie Island. NSP is actively marketing the types of conservation which are relatively cost effective.

Renewable Resources as an Alternative to Prairie Island :

Renewable energy resources, such as wind and biomass, are not a practical alternative to operation of the Prairie Island plant. Biomass resources are available on a dispersed basis which does not lend itself to development of large central electric generating facilities. Development of such resources in smaller increments by non-utility generators in NSP's service territory has not been found to be economical, although a few projects have been proposed and studied by others.

NSP has recently completed a research project studying wind generation in Minnesota, and plans to conduct a thorough assessment of wind energy potential during 1991. Although wind generators are commercially available, past studies have found wind generation is not economically competitive with conventional generating technologies.

NSP believes the potential for future development of these and other renewable resources in its service territory is much less than its future need for additional generating resources. If development of renewable energy technologies is found to be economical, it will defer or replace fossil fuel-fired generating additions needed because of load growth of NSP's system. Adding renewable energy resources will not affect the continued need to maintain NSP's existing generating resources.

5. Cask Design.

Operating Lifetime : The quoted cask lifetime of 25 years does not refer to the length of time the cask is expected to be capable of safely performing its functions of shielding, cooling and containment. Rather, the pressure monitoring system was designed to function for 25 years, based on conservative assumptions on the rate of helium loss and air temperature fluctuations in our region. The NRC will only license casks for a 20 year period of use. To use the casks for more than 20 years, NSP would have to reapply to the NRC for a new license. The cask manufacturer expects the casks will remain useful for 40 or more years, because of their passive design and because the ongoing radioactive decay of the spent fuel means that internal heat and radiation levels will only decrease over time.

Protection of Pressure Monitoring System : If necessary, recharging or replacing the pressure monitoring system of a cask would be a fairly simple and quick task, and would not require opening the cask itself. Because the cask's integrity and performance capability functions do not require the pressure monitoring system, it is not necessary to protect the pressure monitoring equipment from damage from infrequent events, such as lightning or tornados. The monitoring equipment is covered by a cover which will protect it from common things, like rain, snow or hail.

6. Potential To Store Fuel From Other Reactors.

NSP currently has no plans to store fuel from other sites at the Prairie Island ISFSI, and the NRC license application explicitly covers only Prairie Island fuel. To store fuel from other sites at the PI ISFSI would require State and NRC review and approval.

7. Why NSP Chose Large Capacity Metal Cask Design.

NSP chose large capacity metal casks for dry storage of spent fuel because they are safe and cost effective, and allow us to install additional storage capacity incrementally, on an as-needed basis. Also, a larger capacity cask results in more efficient operations because fewer casks need be loaded for a given amount of fuel. One of the major requirements of all dry storage designs is to remove the heat generated by spent fuel at a rate sufficient to keep the fuel rod cladding at or below a specific temperature limit. The limit is set well below the temperatures at which degradation of the cladding metal over a long period of storage is of concern. The TN-40 cask design meets this requirement with 40 spent assemblies, generating a total maximum heat load of 27 kilowatts. The design basis spent fuel assemblies must cool for 10 years before their heat generation rates are low enough to total less than 27 kilowatts. Other metal cask designs are designed for fuel that has cooled only 5 years, which reduces the number of assemblies that can be stored in a cask without exceeding clad temperature limits.

8. Experience Base For Cask Use and Environmental Effects.

Dry storage of spent fuel in metal casks has an operating history in the U.S. of about 5 years. Other dry storage technologies have been used in Great Britain and Canada for 10 to 15 years, and the U.S. government has conducted research on dry spent fuel storage for almost 20 years. Additionally, spent fuel has been transported in dry metal casks for almost 25 years. The spent fuel management plans of countries such as France and Germany include the use of dry metal casks for storage in the future, as well as reprocessing.

The only emissions from a dry spent fuel storage facility are radiation and heat. Radiation levels and temperatures on the cask exterior surface are measured and verified to be within the license limits before the cask is moved to the storage facility. While in storage, spent fuel continues to undergo radioactive decay, resulting in ever decreasing levels of radioactivity. The heat generated by spent fuel is proportional to the level of radioactivity, so heat generation, and hence cask surface temperature, also decreases over the storage period. Thus, the only emissions from a dry metal storage cask are at their greatest when the cask is first put into service. Experience with longer operating periods would not yield any new information on the environmental effects of dry cask storage.

9. Cask Design and Testing.

The NRC has established specific design requirements for storage casks. The TN-40 cask is designed to withstand a straight drop of 18 inches without suffering significant damage to the fuel, basket structure or cask seal. When the cask is in the plant, it will be handled using a single failure proof crane, so it is very unlikely any cask drop would occur in the plant. Cask handling procedures and the design of the cask transporter will ensure that when the cask is being moved from the plant to the storage facility, it will not be raised more than 18 inches above the ground. The dimensions and weight of the cask are such that floods, tornados or earthquakes would not cause it to tip over. Even so, a cask tip-over outside the plant was analyzed and the results show there would not be significant damage to the cask or fuel, and cask seal would not be lost.

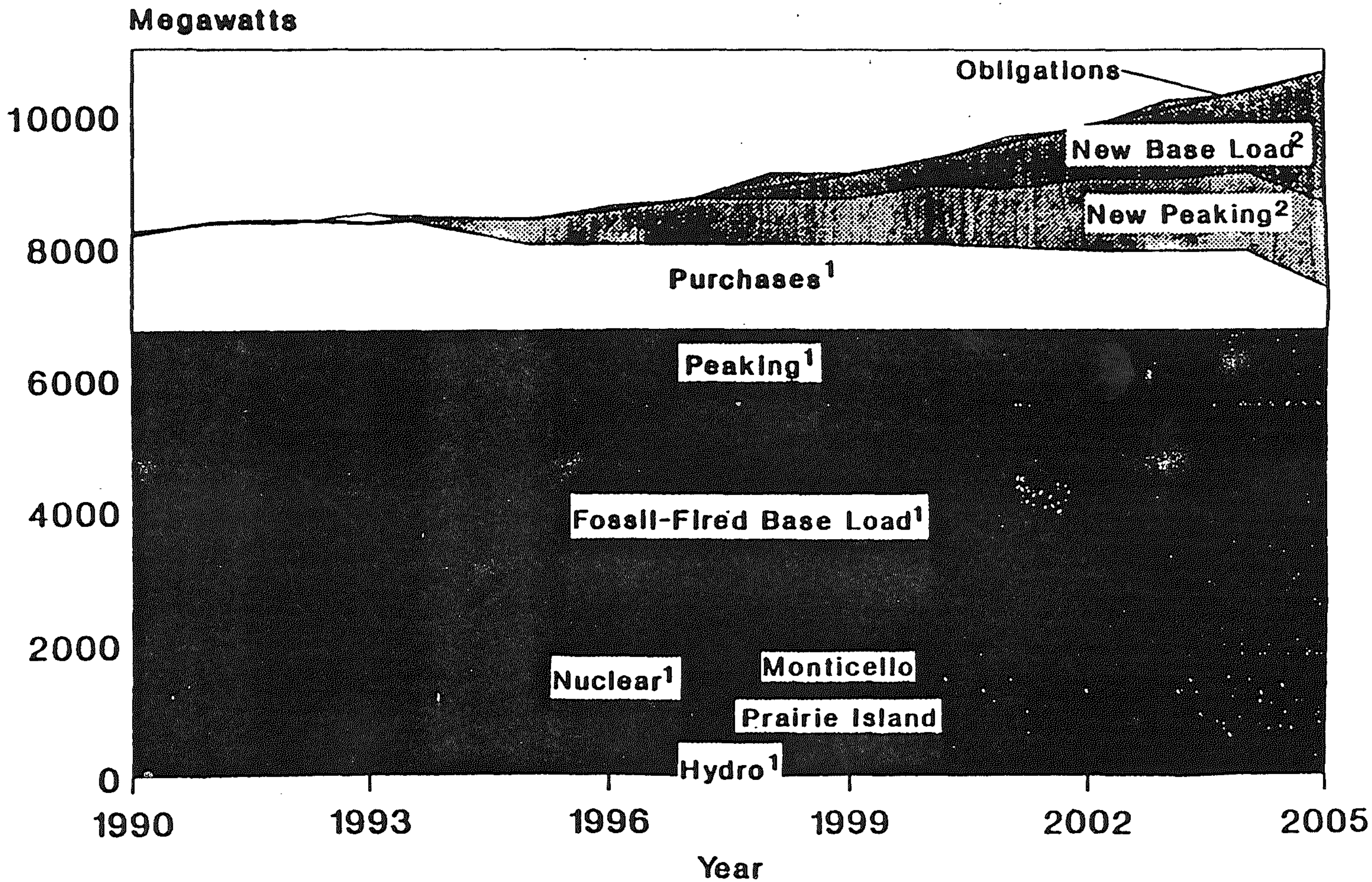
The analytical methods used in cask design have been verified and benchmarked against test data. A variety of small scale (1/4 to 1/10 of full size) and full scale drop tests have been performed on transportation and storage casks over the last 30 years, and the results have been used to validate structural analysis methods. Other test data has been gathered and used to validate the analysis of heat transfer, radiation shielding, and fuel criticality. The NRC reviews the analytical methods, assumptions and calculational methods used to design the cask in order to ensure they are appropriate and conservative.

10. Loss of Cask Seal and Cask Handling Procedures.

The cask will be sealed using two metallic gaskets seals, only one of which is necessary to prevent air in-leakage to the cask. Loss of seal does not result in the release of any radioactive material to the environment - the spent fuel itself is solid, and there is no liquid in the cask. Metallic gaskets are a very reliable sealing method, and are expected to last the lifetime of the cask. The space between the two seals is pressurized with helium and monitored by equipment installed on top of the cask. The cask interior is also pressurized with helium. A weather cover is installed on top of the cask to protect the pressure monitoring equipment from the elements and to keep the top surface of the cask clean. A rubber-type gasket seals the interface between the cask body and the weather cover. Failure of either of the redundant cask seals would be detected by the pressure monitoring equipment and would register on the indicator panel located outside the ISFSI fence. The helium in the cask is nontoxic, nonradioactive and chemically inert, i.e. it doesn't react chemically with other elements. In addition to being inert, helium aids in transferring heat from the spent fuel to the cask walls.

If both gaskets were to fail at the same time, the higher pressure helium in the cask and in the overpressure tank on the cask lid would fill the space under the weather cover. If the sealing gasket of the weather cover also fails, helium would escape until the cask interior, overpressure tank and area under the weather

NSP Obligations and Resources



1 - Committed Resources
2 - Projected Resources

Note: April 1990 Semi High Forecast
(after Load Management & Conservation Adjustments)

01/07/91

Figure 1

cover all equalized to atmospheric pressure. Once there is no pressure difference between the cask interior and the atmosphere, the only mechanism to displace the helium inside the cask is gaseous diffusion. Due to the extremely small size of any diffusion pathway created by a loss of either the weather cover seal or the cask lid seals, the diffusion process would be very slow. It would require a period of several months after seal loss before there would be any noticeable in-leakage of air to the cask interior. Surveillance procedures for the storage facility will ensure that the loss of a cask seal will be detected within 8 hours, and the proper cask storage conditions can be restored within several days. In this time period, changes, if any, in the storage conditions (internal pressure, heat transfer rate, cask internal atmosphere) would be minute and would not present any safety concerns.

If an indication is noted on the pressure monitoring panel, the most likely cause is a malfunction of a pressure monitoring system component. In most cases, the component could be repaired or replaced in the field and so it wouldn't be necessary to move the cask. If the pressure monitoring system is not malfunctioning, the indication means there is a failure of one or both of the lid seals. If a seal has failed, the cask would be taken into the plant within 24 hours. The same equipment and procedures for placing the cask into storage would be used to remove the cask from the storage facility and return it to the plant. The cask would be placed into the spent fuel storage pool to remove the lid and replace the seals; this would happen within 2 to 4 days, depending on what other plant operation activities or pool use is taking place at the time. Prairie Island will maintain spare cask lid seals on hand at the plant site. From that point on, preparation of the cask for storage would proceed just as when the cask was initially loaded. Thus, it will take 7 to 10 days before the cask is ready to be returned to the dry storage facility. It is conceivable that other circumstances might prevent immediate return to the plant of a cask whose seal has failed. It is important to emphasize that even though repairs can be made within several days under normal circumstances, there is no safety threat to the public or damage to the fuel even if the cask was not resealed for many months.

B. NSP's Comments on the Prairie Island Dry Cask Storage Facility Draft Environmental Impact Statement (EIS) Document

10A

1. page 1.1 first paragraph : the DOE may begin accepting spent fuel from utilities at either an MRS or a repository.

2. page 1.1 first paragraph : the spent fuel storage pool is located in the plant auxiliary building.

3. page 1.1 last paragraph : the postulated accident is loss of cask confinement barrier AND breach of the cladding of all fuel rods within the cask.

4. page 1.2 first subparagraph : the pool will be full after the outage scheduled to begin April, 1994.

5. page 3.2 first paragraph : the company name is Transnuclear, Inc. , not Transnuclear Corporation.

6. page 3.2 first paragraph : when fully loaded, the TN-40 cask will weigh about 122 tons.

7. page 3.2 second paragraph : 48 casks would provide adequate storage capacity for about 6 years beyond the current license expiration dates of 2013 and 2014.

8. page 3.4 second paragraph : 3.85 % is the MAXIMUM allowed initial enrichment, and damaged assemblies which are canned may be stored in the cask. These qualifiers are stated on pages 3.9 and 3.10.

9. page 3.4 third paragraph : the term OFA is used before it is defined.

10B

10. page 3.6 Table 3-3 : does the data in the last column correspond to 20 or 30 years after discharge ?

10A

11. page 3.11 <u>Casks</u>, "Basis" : "sue" should be "size".

12. page 3.12 <u>Cask Leakage</u>, Specification : units of leakage rate should be "per cubic centimeter per second".

13. page 3.13 fourth paragraph : replace the word "concretes" with "metals".

14. page 3.17 third paragraph, second subparagraph : the overpressure tank is installed **ON** top of the cask lid.

15. page 3.22 section H : both future and present tense are used in discussing NSP's license application to the NRC, so it is not clear that the application <u>has</u> been submitted.

16. page 4.7 paragraph on Tornado Missiles : the plank missile is assumed to be 12 feet long.

17. page 4.9 section E : the doses from ISFSI and plant operation add up to 3.82, not 3.75.

10C 18. page 4.10 second paragraph : NRC regulations require NSP to report the dose received by the maximum exposed off-site person, due to gaseous and liquid effluents. There are no requirements to report any off-site dose due to direct gamma radiation unless the effluent dose exceeds a particular limit. Because Prairie Island has always had very low effluent doses, off-site gamma dose have never been reported. We do not anticipate or plan any change in reporting when the ISFSI begins operating.

10A 19. page 4.13 section H.2 : the casks may be shipped to an MRS instead of the repository.

20. page 4.14 section L, second paragraph : replace the word "total: with "maximum". Also, this maximum dose is for a (hypothetical) person who is at the site boundary 24 hours a day and 365 days of the year.

21. page 5.4 section J : use of the term "high-level waste" rather than "spent fuel" may be confusing.

22. page 5.5 section L : replace "including" with "includes the".

23. page 5.17 first paragraph : exposure limits are set by 10 CFR Parts 20 and 72.

10D 24. pages 5.17 and 5.22 : this issue was covered in depth in the CON hearings for the last pool rerack. The health and safety issue of the increased severity of a loss-of-pool-water accident, if such an accident occurred with increased amounts of spent fuel stored in the pool, was discussed by experts of NSP, the intervenor group Prairie Island Project, Inc. (PIP) and MEA staff. The Findings of Fact, Conclusions and Decision issued by the Director of the MEA states, in item # 96, "NSP presented substantial and uncontroverted evidence by two panels of witnesses that the types of events postulated by the PIP witnesses are so improbable and remote that they pose a miniscule risk." For further details, please see pages 35 to 42 of the MEA director's decision. See Appendix M

10A 25. page 5.22 section 9, Decommissioning : all options which allow continued, full capacity operation of the plant result in more fuel on site. Any additional decommissioning considerations due to more fuel on site would be very minor.

26. page 5.2- third paragraph : PI fuel is smaller than that used at most other plants.

10A

27. page 5.28 section A, third paragraph : suggest a different wording for the second sentence "The contracts state that the DOE will begin to take title, arrange transportation for, and dispose of the spent fuel starting in 1998. The annual acceptance ranking for each utility is set forth in the DOE's Annual Capacity Report (ACR), most recently issued in 1988."

28. page 5.29 first two sentences : suggest these sentences be replaced with the sentence " The Annual Capacity Report provides a rolling 10 year schedule, based on the Oldest Fuel First criteria".

29. page 5.29 section 2 : suggest changing first paragraph to read " The Nuclear Waste Policy Act Amendments of 1987 define certain conditions under which the DOE may be authorized to build and operate an interim away-from-reactor storage facility (known as a Monitored Retrievable Storage facility, or MRS) in addition to a repository. These conditions place strict linkages between the MRS and repository development, prohibiting start of construction of an MRS until the NRC has issued a construction license for the repository. Given current DOE schedules, this means that the earliest an MRS could be operational is 2007."

30. page 5.31 last sentence : change "April" to "July".

31. page 5.34 first paragraph : utilities may have to take back the glass logs before the DOE has an MRS or repository operating.

32. page 5.34 : 10 CFR Part 110 governs the export and import of nuclear equipment and materials.

33. page 5.35 first paragraph : One of the Super-Phoenix reactors is now on line.

34. page 5.36 section L : costs to store the solidified waste at the reprocessors facility and return transportation costs are not included in the costs identified in this section. Thus, the total of all costs associated with reprocessing would be greater than that given in this section.

35. page 5.36 section G : references to pages xxx should be changed.

36. page 5.37 first paragraph : although payment for reprocessing services may not occur until 10 or 15 years from now, the cost would be escalated in order to equal the 1990 cost figures.

37. page 5.37 second paragraph : although the volume of reprocessed waste is much less than spent fuel, the heat content is not significantly less. Because heat concentration is a more important restriction on the repository design, there would not likely be a refund from the DOE.

38. Appendix page 2, second paragraph, last sentence : suggest change to ending "... so that a nuclear explosion is physically impossible."

39. Appendix page 3, first paragraph, last sentence : change "turbine" to "generator".

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES

DNR INFORMATION (612) 296-6157
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January 8, 1991

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To Bob Cupit	From Molly Schoder
Co. MEQB	Co. DNR - Planning
Dept.	Phone # 297-3355
Fax # 296-3698	Fax # 296-6047

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, MN 55155

RE: Prairie Island Independent Spent Fuel Storage Installation
Draft Environmental Impact Statement (DEIS)

Dear Mr. Cupit:

The Department of Natural Resources has reviewed the above-referenced document; we offer the following comments for your consideration.

Specific Comments

Page 3.6 Storage Cask Description: The weight of a fully loaded cask is estimated to be 120 tons. Table 3-4 puts the maximum gross weight on the auxiliary building crane (with lift beams) to be 125 tons. It is our understanding the crane to be used to lower the loaded casks from the pools down 60 feet to the ground elevation is rated at 125 tons and that NSP is developing a single failure proof crane design. The SAR (page 2.2 of intro) states that if the casks are lifted greater than the design height of 18 inches then a redundant lifting device should be used. Is a single failure proof crane design the same as a redundant lifting device? The possibility of dropping a cask from 60 feet above the ground is probably the most serious accident possible during the handling of the loaded casks and every effort should be made to prevent this from occurring.

11A

11B Page 3.9, paragraph 1. Would pressurizing the cask with helium instead of water be a better test of the integrity of the cask? Helium is the gas that will be used in the cask. Since helium is a gas it may be able to permeate the cask welds more easily than liquid water and it may be a more accurate reflection of whether the cask will perform as planned.

11C Page 3.10, fourth bullet down. It is unclear what "unless canned" means.

11D Page 3.10, 4. Action: It may be prudent not to allow nonconforming fuel rods to be placed in the casks rather than allowing NSP and Transnuclear an opportunity to change specifications as they go along.

11E Page 3.16, last sentence. "...along with four slightly contaminated intact spent fuel storage racks from the spent fuel pool." This is the first we have heard that anything besides spent fuel in dry casks were to be stored at the ISFSI. EQB should provide more information on these contaminated spent fuel storage racks. The facility is designed for spent fuel storage in casks and we do not believe that contaminated materials should be stored in anything but casks.

11F | Page 3.18, F.3. What is the purpose of the neutron shield vent hole?

11G | Page 4.2 Wildlife: Contrary to the statement in the document, it likely that some migratory birds, primarily songbirds, do utilize the grassland and wooded areas.

11H | Page 4.5 second paragraph. The discussion of the heron rookery and other natural resources is scant and not up to date. The Safety Analysis Report (SAR) includes much more detail but may not be current.

11I | Page 4.7, Tornado missiles: What is the significance of "...some local damage to the neutron shield..."?

11J | Page 4.9, Lightning strike: The discussion in the draft EIS and SAR dismisses the possibility that lightning could cause seal failure without providing any scientific justification. If the metallic O-ring seals can only withstand conditions below 600 degrees, then additional calculations and discussion should be provided that show why the seals would not be impacted by a lightning strike.

11K | Page 4.14, J. Feasibility analysis: "If that body (NRC) fails to approve the cask, the project could still proceed by switching to another cask or dry storage technology which is already approved." What are the state and federal administrative steps necessary to switch from one storage design to another?

11L | Page 4.13, H. Decommissioning, paragraph 5. The casks were evaluated for possible activation activity due to low level neutron flux but the concrete, fence and auxillary buildings were not evaluated. The decommissioning plans call for disposal of these materials at a regular everyday solid waste facility. Do these materials need to be evaluated for activation due to the low level neutron flux associated with the spent fuel in the casks in order to determine where they should be properly disposed?

General Comments

11M | The DEIS relies rather heavily on the SAR and Environmental Report (ER) for technical information and environmental impact analysis. Neither report has been formally reviewed by the Nuclear Regulatory Commission (NRC). Review of these documents by the NRC could result in some substantial changes in the information presented in the DEIS. We request that the EQB follow the federal licensing procedure, and inform the DNR of any significant developments. We would be available to participate in the preparation of a supplemental EIS if necessary.

11N | We question the wisdom of continuing to issue new permits and extensions to existing permits for nuclear power plants when the federal government cannot predict with any certainty when they will be able to accept spent nuclear waste in a permanent repository. The generation of additional waste only compounds the unresolved problems the nation is faced with.

11O | You are undoubtedly aware of the November 27, 1990 memo that our Mississippi River Team sent to Gretchen Sabel. In the future, the Department would appreciate the EQB not trying to hurry a document through the process at the expense of the public review time. We also acknowledge that the review time was extended one week, which was helpful in our timing process.

Thank you for the opportunity to review this draft. If you have any questions, please contact Molly Shodeen of my staff at (612)297-3355.

Sincerely,

Thomas W. Balcom, Supervisor
Natural Resources Planning & Review Services
Office of Planning

c: Bill Johnson
Steve Colvin
Tom Lutgen
Gregg Downing, EQB
Robert Welford, USFWS
Steve Johnson
Gary Anderson, NSP

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January , 1991

Marilyn Strasser
204 Dolph Road
Mankato, MN 56001

Minnesota Environmental Quality Board
Attn: Bob Cupid
300 Centennial Bldg.
658 Cedar Street
St. Paul, MN 55155

Dear Sir:

As a resident of the state I would like to comment on the application from Northern States Power Company for a permit to construct a dry cask radioactive waste storage facility on the Prairie Island power plant site. Of the few options available for storing spent fuel rods, I do believe the most responsible one at this time is on-site, above ground storage, provided every possible step is taken to ensure that it has causes no further degredation of the environment.

12A

In the impact statement section entitled, "Cultural Resources", notes that there is a heron rookery within three miles of the proposed site, and also that eagles and other migratory birds are present in the area at different times, for example when the heat of the plant keeps water open in cold months. When looking at this nothing is said as to what was considered? Did the report check with the Wisconsin Dept. of Natural Resources about eagle nests on that side of the river? Also, what sources were consulted about the significance of the general increase of the level of radioactivity in the area on the fertility of the herons and the survival rate of infant birds? David DeSante observed at Pointe Reyes, CA, a significant decline in the reproduction of certain bird species the summer of 1986. He atributes the decline to an elevated exposure to radioactivity due to the fallout from the Chernobyl accident. His research indicates that even a small increase has a negative impact on the environment, especailly certain species of birds.

12B

12C

Enclosed is a copy of a summary of DeSante's testimony regarding the Nuclear Regulartory Commission's plan to deregulate low-level radioative waste. The increase of exposure levels from that plan is comparable, I believe, to the increase (from one millirem to four millirem) that is predicted by the dry cask environmental impact statement, so DeSante's research and comments should be relevant to the dry cask proposal.

12D

12E The best solution to the radioactive waste management problem is to stop producing it; therefore, as a concerned citizen I object to the construction of any facility that will increase waste storage capacity beyond the minimum needed for that one plant's current operating license. Any request which anticipates an extension of the operating license, or a shifting of waste from pools to dry casks that allows the holder of the license to bring waste from another reactor to the Prairie Island site should be denied.

Sincerely,

Marilyn Strasser

Marilyn Strasser

P.S. Please add my name to your mailing list, as I have a long-standing interest in environmental quality issues, especially those regarding exposure to ionizing radiation.

THE INSTITUTE FOR BIRD POPULATIONS

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Statement of
David F. DeSante, Ph.D.
Executive Director and Chief Scientist

presented to the
Nuclear Regulatory Commission
at the scheduled public hearing on
"Below Regulatory Concern"

September 27, 1990

Thank you for this opportunity to speak to the "Below Regulatory Concern" policy proposed by the Nuclear Regulatory Commission to deregulate low-level nuclear waste and other radioactive materials. This proposal represents an unprecedented reversal of current policy that will inevitably result in increased exposure to low-level radiation, and that has the potential to endanger both the public health and the health of natural populations of animals, including populations of songbirds. I base this statement upon the results of over four years of research that I have completed on the effects of low-level radiation released from the April 26, 1986, Chernobyl nuclear power plant accident on North American bird populations.

I previously documented a drastic, unprecedented and highly significant 62.3% decrease in the number of young birds fledged for most species of small landbirds in northern and central California during the summer of 1986 (DeSante, D. F. and G. R. Geupel, 1987, Landbird productivity in central coastal California: the relationship to annual rainfall and a reproductive failure in 1986, Condor 89:636-653). Several characteristics of this 1986 reproductive failure strongly suggested that it may have been caused by radioactive fallout, particularly of Iodine-131, from Chernobyl. These characteristics included its timing (the reproductive failure did not occur throughout the entire 1986 breeding season, but only after the passage of the Chernobyl cloud in early to mid-May), its geographical extent in California (incidences of significantly reduced reproductive success were recorded only in areas where rainfall was coincident with the passage of the Chernobyl cloud), and the composition of the species most affected (they were small arboreal insectivores that feed large numbers of grazing insects to their young).

These characteristics prompted the hypothesis that radioactive fallout of Iodine-131 from Chernobyl was adsorbed on the surfaces of leaves, was eaten by grazing insects, such as caterpillars, that fed on the leaves, and was transferred to nestling birds by their parents who fed the grazing insects to their young. The Iodine-131 then concentrated in the thyroids of the nestling birds and adversely affected their development, eventually causing their death. These results and this hypothesis were published in August 1987 in a leading scientific ornithological journal The Condor.

In order to test this hypothesis, I more recently examined changes in the Breeding Bird Survey population indices between 1986 and 1987 for all 289 species of North American landbirds. These population indices are derived from data taken on over 2,000 standardized roadside counts conducted across the United States by the U.S. Fish and Wildlife Service. I first calculated the % change in the population indices between 1986 and 1987 for each of eight regions of the United States, and then examined the correlation between these % changes and the mean peak concentrations of Iodine-131 from Chernobyl in pasteurized milk (as reported by the EPA) for each of those eight regions. I used this measure of radiation as an index of the dose potentially ingested by nestling birds, because it is measured at the same level in the food chain as the grazing insects fed to nestling birds.

As predicted, small arboreal insectivores, the group of species that feed their young large numbers of grazing insects, showed a highly significant correlation between changes in their population indices and radiation such that birds exposed to higher levels of Iodine-131 showed greater population decreases between 1986 and 1987. The probability of this correlation occurring by chance alone was less than one in a thousand. These data provide strong evidence that the extremely low levels of radiation from Chernobyl that fell out over North America (only 10-100 times background levels) caused the deaths of many thousands (if not millions) of baby songbirds in the United States. These last results are currently unpublished but were presented at the June 1990 joint meeting of the American Ornithologists' Union and the Cooper Ornithological Society.

A similar correlation, that was also highly significant, was reported by other researchers between the drastic and unprecedented increase in human mortality in the United States during May to August of 1986 and the amount of Iodine-131 in pasteurized milk (Gould, J. M. and E. J. Sternglass, 1989, Low-level radiation and mortality, Chemtech 19:18-21). This increase in human mortality, which involved about 35,000 excess human deaths in the United States, was also attributed to fallout from Chernobyl.

These extremely low levels of radiation are what the Nuclear Regulatory Commission now proposes to classify as "Below Regulatory Concern." In doing so they propose to allow the unregulated and routine dumping of nuclear wastes into our environment -- into our landfills, our water supplies, and even into consumer goods that may be made from recycled radioactive materials. It seems incredible that such a proposal should appear now, now when the weight of scientific evidence, as recently summarized by the National Academy of Sciences, strongly points to the conclusion that low-level radiation, especially low-level radiation given at low dose-rates, is much more hazardous than was previously believed, and that there seems to exist no threshold level below which radiation is safe and of no concern (Committee on the Biological Effects of Ionizing Radiation, 1990, Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V, National Academy Press, Wash., DC).

In the name of science and common sense, I most strongly urge you to revoke the proposed "Below Regulatory Concern" policy. Thank you very much.

MPIRG Minnesota Public Interest Research Group
2512 Delaware Street Southeast
Minneapolis, Minnesota 55414
(612) 627-4035

Jan. 9 1991

To: Bob Cupit
From: Michael Lee, Research Director

Attached are our comments on the Prairie Island ISFSI.
Thanks for allowing us to get this in.

''· F. ⊥ . K. G.

Commentary on Draft Environmental Impact Statement
Prairie Island Independent Spent Fuel Storage Installation

I. Sufficiency of the Environmental Impact Statement
Under the State Environmental
Policy Act, Minn. Stat. ch. 116D

Purpose and Policy

13A The DEIS for the proposed ISFSI fails to pursue the purpose and policies underlying the State Environmental Policy Act, Minn. Stat. ch. 116D. One of the purposes on the Act is "to promote efforts that will prevent or eliminate damage to the environment and stimulate the health and welfare of human beings." Minn. Stat. sec. 116D.01.

The DEIS fails to consider fully numerous policy objectives of the Act, Minn. Stat. sec. 116D.02, subd. 2, including the state's responsibility to:

(a) Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

(c) Discourage ecologically unsound aspects of . . . technological growth . . . ;

(d) Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever practicable, an environment that supports diversity, and variety of individual choice;

(i) Practice thrift in the use of energy and maximize the use of energy efficient systems for the utilization of energy, and minimize the environmental impact from energy production and use;

(j) Preserve important existing natural habitats of rare and endangered species of plants, wildlife, and fish, and provide for the wise use of our remaining areas of natural habitation, including necessary protective measures where appropriate;

(p) Reduce the deleterious impact on air and water quality from all sources. . .

13B The most egregious shortcoming of the DEIS is its failure to pursue "thrift in the use of energy and maximize the use of energy efficient systems." Conservation, i.e., energy efficiency, is not given serious consideration in the DEIS's analysis of alternatives and their environmental and economic impacts.

Environmental Impact Statements, Minn. Stat. sec. 116D.04

An environmental impact statement must be prepared whenever "there is potential for significant environmental effects resulting from any major governmental action." Minn. Stat. sec. 116D.04, subd. 2a. The DEIS arbitrarily concludes that the proposed ISFSI "will not cause significant impacts to the natural and human environment," DEIS, 1.1, even though there is a potential for significant environmental effects (see, e.g., DEIS, 4.9, thermal loading) and the approval of the ISFSI is a major governmental action. Thus, the requirements of the Environmental Policy Act must be fulfilled before the proposed ISFSI may be approved.

> An environmental impact statement must be:
> an analytical rather than an encyclopedic document which describes the proposed action in detail, analyzes its significant environmental impacts, discusses appropriate alternatives to the proposed action and their impacts, and explores methods by which adverse environmental impacts could be mitigated. The environmental impact statement shall also analyze those economic, employment and sociological effects that cannot be avoided should the action be implemented.

Minn. Stat. sec. 116D.04, subd 2a. The purpose of the Act is to balance the need for electric power with the goal of environmental protection. People for Environmental Enlightenment and Responsibility (PEER) v. Minnesota Environmental Quality Board, 266 N.W.2d 858 (1978). State agencies must consider both environmental and economic impacts when dealing with
13C environmental matters. Reserve Mining Co. v. Herbst, 256 N.W.2d 808 (1977). The DEIS is insufficient because it does not provide an objective analysis of the environmental and economic impacts of the proposed ISFSI or of the alternative actions (see, e.g., DEIS 5.2, decision not to analyze the costs and impact of no action, DEIS 5.7, 5.8, claim that impacts of conservation cannot be quantified).

The state has an affirmative duty to maintain the quality of the environment and may not take any action or grant a permit that will or is likely to impair the environment, "so long as there is a feasible and prudent alternative consistent with the reasonable requirements of the public health, safety and welfare and the state's paramount concern for the protection of its air, water, land and other natural resources from pollution, impairment, or destruction." Minn. Stat. sec. 116D.04, subd. 6. Economic considerations alone are insufficient. Id. If an action is likely to be materially adverse to the environment, it cannot be permitted unless there is no reasonable alternative. Minnesota Public Interest

Research Group v. Adams, 482 F. Supp. 170 (D.C. Cir. 1979); In re Application of City of White Bear Lake, 311 Minn. 146, 247 N.W.2d 901 (1976). Once a person or group has made a prima facie showing that an agency's action or inaction will materially adversely affect protected natural resources, the agency must rebut this showing or demonstrate that no feasible and prudent alternative exists and that its conduct will promote the public health, safety, or welfare. People for Environmental Enlightenment and Responsibility (PEER) v. Minnesota Environmental Quality Board, 266 N.W.2d 858 (1978). A nuclear storage facility, which may exist indefinitely at the Prairie Island facility, does materially affect

13D protected natural resources, such as wildlife, and water and air quality. The cursory treatment given to alternatives to the proposed ISFSI is insufficient under Minn. Stat. sec. 116D.04, subd. 6. The DEIS must analytically demonstrate that no feasible and prudent alternative exists rather than dismiss alternatives out of hand.

Environmental Impact Statement Content, Minn. Rule 4410.2300 and Worst Case Analysis, Minn. Rule 4410.2500

The State Environmental Policy Act requires the EQB to create specifications for the content of environmental impact statements, Minn. Rule sec. 116D.04, subd. 5a. Minnesota Rule 4410.2300 lists the required contents of an environmental impact statement. The provisions pertinent to a critique of the proposed ISFSI's DEIS are the requirements for the summary; alternatives; environmental, economic, employment, and sociological impacts; and mitigation measures. [2] The

[2] The EIS must be written in plain and objective language. The EIS fails to satisfy the following requirements of MN Rule 4410.2300:

> B. Summary: the summary shall stress the major findings, areas of controversy, and the issues to be resolved including the choice among alternatives.
>
> G. Alternatives: the alternatives section shall compare the environmental impacts of the proposal with other reasonable alternatives to the proposed project. Reasonable alternatives may include different sites, design modifications including site layout, magnitude of the project, and consideration of alternative means by which the purpose of the project could be met. Alternatives that were considered but eliminated shall be discussed briefly and the reasons for their elimination shall be stated. The alternative of no action shall be addressed.

(continued...)

scientific uncertainty of using a new technology mandates the application of Minn. Rule 4410.2500, Incomplete or Unavailable Information:

> When an RGU is evaluating significant effects on the environment in an EIS and there is scientific uncertainty or gaps in relevant information, the RGU shall make clear that the information is lacking. If the information relevant to the impacts is essential to a reasoned choice among alternatives and is not known . . . the RGU shall weigh the need for the project against the risk and severity of possible adverse impacts were the projects to proceed in the face of uncertainty. The EIS shall, in these circumstances, include a worst case analysis and an indication of the probability or improbability of its occurrence.

Id. (emphasis added).

EIS Insufficiency

The DEIS fully meets the requirements for the format of the cover sheet, table of
13E contents, list of preparers, project description and governmental approvals. Minn. Rule 4410.2300 (A),(C),(D),(E),(F). The project description contains matters which should have been discussed in the analysis of the proposed project and in the alternatives section. This commentary will include those topics in its discussion below.

(...continued)

> H. Environmental, economic, employment, and sociological impacts: for the proposed project and each major alternative there shall be a thorough but succinct discussion of any direct or indirect, adverse, or beneficial effect generated. The discussion shall concentrate on those issues considered to be significant as identified by the scoping process. Data and analyses shall be commensurate with the importance of the impact. . . . The EIS shall identify and briefly discuss any major differences of opinion concerning impacts of the proposed project and the effects the project may have on the environment.
>
> I. Mitigation measures: this section shall identify those measures that could reasonably eliminate or minimize any adverse environmental, economic, employment, or sociological effects of the proposed project.

The summary must stress areas of controversy and the issues to be resolved among alternatives. Minn. Rule 4410.2300 (B). The DEIS's summary merely states the major findings and lists the alternatives. The controversy surrounding the need for an ISFSI, the possibility that the ISFSI would become a permanent nuclear storage facility, and the scientific uncertainty involved in using a new technology must be raised in the summary. The relative strengths and weaknesses, both economic and environmental, of the alternatives must also be addressed.

Viable alternatives that involve a combination of simple alternatives, such as gradually reducing plant operation, while gradually increasing efficiency and conservation over time, should be part of a complete EIS. Options that involve "least-cost planning" should not be ignored since the Minnesota Public Utilities Commission has endorsed this type of planning.

II. Comments on The Project

A. Comments on Project as Proposed

Introduction: The Need for Worst-case Analysis

13F If it is not possible to resolve the scientific uncertainties, the EQB "shall weigh the need for the project against the risk and severity of possible adverse impacts were the project to proceed in the face of uncertainty." Minn. Rule 4410.2500. The DEIS must also include a worst case analysis and indicate the probabilities of its occurrence. Id.

Damaged Components

13G Although assurances are given that damaged spent fuel rods will not be stored in the ISFSI, on 3.10, the DEIS states that canned fuel assemblies with defects may be stored and that "If these specifications are not met, additional analysis and/or data must be presented demonstrating that the nonconformance does not exceed safe operating limits before the spent fuel can be placed in the cask for storage." Id. Does this mean that damaged fuel rods will be stored in the ISFSI? What further specifications must be met? Who will determine what these specifications are and who will monitor compliance? How will the damaged spent fuel rods be transported at the time of decommissioning. See DEIS, 3.22.

The defective fuel rod assemblies should be described, and the number of defective rods at Prairie Island should be stated. The procedure for "canning", as mentioned in the DEIS should be described.

The DEIS mentions the possible use of "highly-enriched" uranium (HEU) fuel at Prairie Island. What is the relationship between the use of HEU and reliability of fuel rod assemblies? The DEIS should state if HEU is used at Prairie Island, was used at Prairie Island, or if NSP plans to use HEU at Prairie Island.

What will be the environmental impacts of the contaminated fuel storage racks, which will be stored in the building next to the ISFSI, and what safety measures will be taken to minimize their radiological effect? See DEIS 3.16.

Cask Design

13H The DEIS does not explain why the TN-40 dry cask model was chosen over the

other dry storage techniques. Minn. Rule 4410.2300 (G) requires alternatives that are eliminated to be discussed and the reasons for their elimination shall be
13I stated. The DEIS also fails to adequately discuss the environmental impacts and cost of increasing the capacity of the pool. DEIS 5.16, 5.23.

13J The DEIS summarily states that the TN-40 design is safe even though it has never been used at an actual site, its predecessors have only been in use for 6 years, and the NRC has not even approved the cask design yet. No statistics concerning the safety record of the TN-24 model were given, nor were the test results that prove the safety of the TN-40 model.

The DEIS must, under Minn. Rule 4410.2500, make clear the degree of scientific uncertainty that exists concerning the safety of the TN-40 cask (see 3.24, TN-40 licensing issues: properties of selected materials, containment material fracture toughness, boron/burnup credit, etc).

Scientific uncertainty must exist because the TN-40 model significantly departs from its predecessor, TN-24, DEIS 3.7; for example, the TN-40 has a multi-shell body and a "lighter and more efficient basket design." The bland assurances given on DEIS 3.13 do not satisfy the requirement to discuss environmental impacts thoroughly. The DEIS should state how long the dry storage casks and transport casks have been used, as well as their safety. Have there been any accidents? Do the casks ever leak?

Nuclear radiation can induce substantial degradation in ferrous materials, beyond that occurring naturally. Radiation accelerates corrosion in both high-strength and mild steels. [2] Further, radiation makes high-strength steel more brittle, [3] increasing the potential for catastrophic failure of a component through brittle fracture. [4]

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2. R. Reda, S. Hana, J. Kelly, *Intergranular Attack Observed in Radiation-Enhanced Corrosion of Mild Steel*, 44 Corrosion Science 632, 632 (September 1988). This study found radiation, in a pH neutral environment could increase corrosion rate nearly seven times. Note that "mild steel", here AISI 1018, characterizes typical rebar in reinforced concrete construction.

3. *See* R. Smock, *Aging Nuclear Power Fleet Faces New Regulatory Challenges*, Power Engineering, November 1988, at 27, 28 (citing "long-standing nuclear plant problems such as intergranular stress-corrosion cracking of stainless steel, steam generator corrosion and pressure vessel embrittlement").

4. T. Galambos, *Basic Steel Design* ( ).

Knowledge about this phenomena is incomplete. The Prairie Island plant was one of the places where unexpected steam generator tube degradation was discovered when this process was almost unknown.

The TN-40 cask was reportedly designed under the requirements that must be met by nuclear power plant pressure vessels.[5] Therefore the same uncertainties affecting the long-term performance of nuclear power plant pressure vessels accompany the TN-40 cask, including radiation-induced degradation.

In particular, if later research discovers that the effect of radiation-induced degradation has been underestimated, the cask may undergo stresses that it was never designed and/or tested for. One example is the 125% over-pressure hydrostatic test (see DEIS 3.9) which may not prove sufficient under this scenario. No doubt there are other safety margins which, while adequate under today's knowledge-base, may be inadequate under foreseeable new findings.

Pad Design

13K Is the 3 foot concrete platform going to be stable for the maximum projected lifetime of the storage installation? What is the earthen berm comprise of? What is the fill under the concrete platform made of? How will the berm, concrete platform or the fill under the platform abe affected by rain, flood or other calamity?

The DEIS does not disclose more about the design of the concrete pad directly supporting the TN-40 casks beyond its overall thickness. Presumably the pads would contain reinforcing steel -- if only to accommodate the shrinkage and temperature stresses that concrete components are subject to.[6]

If so, these reinforcing steels would be subject to radiation effects as well. In typical construction, reinforcement may be just a few inches from the top edge of the pad, thus subjecting the steel to about as much gamma and neutron radiation as it would receive were it not covered at all. Further, unlike steel components inside the cask, the rebar would quickly be in contact with water given past experience with concrete pavements in Minnesota.

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5. Minn. Environ. Quality Bd., *Draft Environmental Impact Statement, Prairie Island Independent Spent Fuel Storage Installation* 3.13 (November 30, 1990) [*hereinafter* the "DEIS"].

6. C. Wang, C. Salmon, *Reinforced Concrete Design* 289 (4th ed. 1985).

Were pad-reinforcing steel to fail, casks would have to be moved and the failed section would have to be repaired. This would be expensive and subject workers and the surrounding area to additional hazard. Both of these factors affect the costs and benefits of the ISFSI project.

13L Therefore, before the preferred alternate is approved, measures must be taken to account for radiation-induced degradation of all ferrous components incorporated into the proposed facility. Additional costs, and newly-discovered hazards must be accounted for in the Final EIS. If adequate precautions have already been taken by facility planners, these precautions should be fully disclosed.

Also, such uncertainties are material to deciding whether to proceed with the preferred alternate, since the project is not wholly necessary. Feasible alternatives exist that make Prairie Island's continued operation beyond the capacity of its existing spent fuel storage pool unnecessary.

On-site Transportation

13M A loaded cask must not be raised more than 18 inches from the ground. Doesn't this happen when the cask is raised from the pool? Is this safe? Please explain the procedure for moving the cask from the pool to the storage site. Please explain the modification being made on the transport crane that will make it "single failure proof." How can a cask be loaded onto a transport vehicle without being raised 18 inches? What transport mode does not involve raising cargo less than 18 inches above the ground?

Off-site Transportation

13N The TN-40 storage cask does not meet federal standards for transporting off-site, however, NSP may ask NRC to allow these casks to be licensed as dual-purpose casks. Which transport criteria are not met by the TN-40 cask? As the casks age, how does this complicate transportation problems? What special transport measures would NRC judge necessary to provide an adequate margin of safety? What would these measures cost NSP? If NRC withholds licensing the TN-40 as dual purpose, what will it cost to recask the spent fuel in transportable casks?

Geological Characteristics of the Site

13O The DEIS fails to describe the soil and rock formations, and the groundwater depth at the proposed site, yet these factors are critical to determine the potential environmental impact of the project. Does the geological characteristics of the proposed site preclude the possibility of excessive thermal loading? If not, what emergency procedures must be in place in case of cask-seal failure? What would the environmental impact of such an accident be?

13P The EIS, which will be used in the determination of the Certificate of Need, fails to provide much of the information required under Minnesota Rule 7855, concerning the environmental and economic information required for an application. For example, Minn. R. 7855.0640, Description of Alternative Site, requires descriptions of each site, including the nature of the terrain, general soil types, types and depth of bedrock, depth to groundwater, etc. None of these factors are covered in the EIS. Other serious deficiences include the failure to discuss the precise emissions of the plant, 7855.0650, pollution control and safeguard equipment, 7855.0660, historical and forecast datta, 7855.0620, and a full description of the alternatives, 7855.0610. If the EIS will be relied upon for environmental impact information, it needs to be revised to take these requirements into account.

Radiological Impacts

13Q The DEIS seems to be inconsistent in its analysis of the radiation emitted from the proposed ISFSI. On 4.9 the radiological impacts of the liquid and gaseous effluents are stated to be .0013 mrem and .075 mrem, respectively. On 4.14 the off-site radiation exposure is calculated to be 22 mrem. Yet, the DEIS claims that the ISFSI would not emit any radiation. Does this figure reflect the radiation emitted during the loading of the casks? If so, what is the purpose of the earthen berm? On 4.14 it states that it "serves to mitigate the radiation emanating from the casks filled with spent nuclear fuel." What happens to the radiation absorbed/adsorbed by the earthen berm? Does the calculation take into account the damaged spent fuel racks stored on the site?

If the project is completed as planned, what measures can be introduced later should the BEIR-V, [7] or ongoing studies cause exposure standards for workers and neighboring residents be tightened? Will the latest NRC radiation exposure standards, published December 13, 1990 compel any design modifications?

No DOE Depository

13R The DEIS fails to discuss the environmental and economic costs if a federal

7. Biological Effects of Ionizing Radiation, National Academy of Sciences, 1990.

permanent storage facility is not developed. The DEIS must discuss all reasonable alternatives under state and federal law, and it is likely that a federal facility will not be established for decades, or may never be established. 'omic cost of maintaining the ISFSI project for, 50 years, 10,000 years be? What would be the environmental impact be of long-term storage (100-500 years) be? How would it affect the area sociologically? What would the effect be on future development?

Accounting of Project Costs and Disbenefits

13S An ISFSI is only a stop-gap solution to NSP's spent fuel storage problem and the cost of decommissioning must be realistically reported in the DEIS. The DEIS states that the project will cost between $35 to $40 million, DEIS 4.14. How much will decommissioning add to that cost? How much will it cost if alternative casks must be purchased to transport the spent fuel? The DEIS should project the costs of each of the four scenarios presented on 3.21, not just one scenario favorable to the project.

Effects on Wildlife

13T The DEIS greatly underestimates the amount of wildlife in the Prairie Island area, particularly bald eagles. Joan Galli, nongame division of DNR, reports that just last week (approximately Jan.1 1991) there were between 40 and 50 eagles within 12 river miles of the Prairie Island plant. Also that in the summer of 1990 there were 2 nesting pairs of bald eagles within the same stated area. In the winter, the eagle population varies between 12 and 48. Lock and Dam No. 3 and the Prairie Island nuclear plant's hot water discharge keep the river open in the winter, thus attracting wildlife.

13U At Prairie Island, eagles and other birds, are exposed to radiation. Do birds, particularly raptors, have a greater vulnerability to radiation than the human subjects primarily protected by federal and state radiation exposure standards?

There in enough scientific uncertainty surrounding the issue of radiation's effect on eagles to warrant further investigation. Are endangered american bald eagles being drawn to Prairie Island like a moth to a flame?

Socioeconomic Impacts

13V The DEIS is incomplete regarding socioeconomics in the Prairie Island area. At the very least there should be studies undertaken to appraise the effects of a nuclear waste site on: the Prairie Island Bingo Hall. the Prairie Island Indian Community's planned hotel and their planned marina. The area's (Hastings, Welch. Red Wing, Diamond Bluff etc.) hunting and fishing industry. The area's tourism industry. The price of life and health insurance. The area's land values.

The ISFSI should not be allowed to be implemented. The Prairie Island Indian community is protected under federal equal protection laws, and the ISFSI would cause further discriminatory impacts.
There are many discriminatory impacts to be considered. To name a few:

13W
- Their land value is affected more than others
- Their bingo revenue.
- Health effects from being closer to the source of radiation others.
- They use the natural resources more than others and, are at the end of the food chain.

13X The ISFSI project will significantly change the scope of Goodhue County's involvement with nuclear power. When Prairie Island was first proposed, it was envisioned that the plant would be quickly dismantled upon its eventual closure. The site would be decontaminated and would be available for other uses.

The ISFSI project is likely to involve rural Goodhue County with nuclear energy for decades beyond the planned closure of Prairie Island. The DEIS admits that an actual HLW depository may not open until 2010 or later.[9]

Consequently Prairie Island's negative effect on property values will continue beyond the time it would cease were the ISFSI project not built. Moreover, the perceived hazard from a lightly-monitored nuclear waste storage site may be greater than the present actively-managed nuclear power plant. The degree and effect of the ISFSI on property values for miles around and downstream of Prairie Island should be considered and accounted for.

13Y Further the impact of the foreseeable future development of the Prairie Island site, including reprocessing and disposal of nuclear waste should be considered and added to the disbenefits of the ISFSI project.

Effect of State Below Regulatory Concern Waste Law

9.

13Z Is the proposed facility in any way in conflict with Minnesota Statute 116C.851-.852 concerning BRC radioactive waste? Specifically, could any aspect of the project's construction, maintenance, operation, decommission or cleanup be in conflict with this law? What costs should be added

Accident Potential

13AA The DEIS mentions an accident in 1985, however, it does not mention the accident that happened in the spring of 1978 where a steam cloud was released and drifted through the Prairie Island Indian Community. The accident was serious enough to evacuated Prairie Island plant workers. Attorney William Hardacker, 893-1813 and council member, Vine Wells, 1-800-862-7089 can provide witnesses and documentation on this incident.

The DEIS should, at the very least, address: What caused the accident. What was in the steam cloud. KR-85? Was there any actual or potential harm to humans or wildlife. Why there was not a notice, or a later explanation given to area residents. Why the EQB doesn't seem to know about the incident. Why the accident wasn't mention in the DEIS. What has been done to prevent a reoccurrence of such an accident. Is there is, and why not if there isn't, a plan to notify area residents of similar incidents.

What are NSP's emergency procedures regarding accidental release of krypton-85 as discussed in NRC information notice no. 90-08: KR-85 hazards from decayed fuel. We have enclosed a copy with our written comments.

Was KR-85 released in the 1985 incident? Was anybody exposed? This issue should be addressed because it raises the potential for accidental, or compelled radiation releases from containment systems similar to those used in the Prairie Island nuclear power plant.

Cask Recertification

13BB The TN-40 cask is designed for a 25 year lifespan, and if approved, will be certified by NRC for 20 years. It is possible that NRC will recertify the casks after the initial 20 years. What are criteria for certifying a cask for 40 year that is only designed to last 25 years. Is it likely that the casks would be certified twice or more? Is NSP willing to assure that the cask will not be recertified or recertified only once.

Alternatives to Continued Operation of Prairie Island

13CC While closure of Prairie Island would idle about 1100 megawatts of capacity, that does not mean 1100 megawatts of fossil fuel-fired capacity would be needed immediately.[10] Rather the amount of new capacity needed could be sharply reduced by an effective conservation program, perhaps made additionally effective by explicitly connecting it to the closure of nuclear, and eventually fossil fuel power plants in the Upper Midwest. New fossil-fueled capacity of less than the 1100 megawatts postulated in the report would cost less than the $1.0 to $1.2 billion assumed by the DEIS.[11] Further, an especially effective conservation program, one along the lines of that studied in *Energy: Minnesota's Options for the 1990s, The State Energy Policy and Conservation Report to the Legislature*, Department of Public Service, would make new plant unnecessary.

If new plant is needed, but for short periods of time on rare occasions, gas-turbine plants could be quickly installed to meet the need. Other utilities may have surplus capacity which may or may not require construction of new transmission lines. But cogeneration and renewable energy are much more preferable, because they have little to no environmental impact, and often can supply power at lower cost than other new sources.

Issues like the use of alternative sources of power by NSP are not outside the scope of inquiry because the ISFSI project has no purpose except to make continued operation of the Prairie Island nuclear plant feasible. Therefore alternatives that envision Prairie Island being shutdown before the year 2000 should be given more consideration before the fateful decision to construct the ISFSI project is made.

B. Foreseeable development of the Prairie Island site

Off-site waste

13DD On 3.9, the DEIS states that only fuel from the Prairie Island facility will be stored at the ISFSI. In the past, however, facilities have been forced to accept spent fuel from other nuclear facilities. How does NSP plan to fulfill this obligation? The state cannot constitutionally prohibit out of state nuclear wastes under the Commerce Clause,[12] no legally binding assurances that non-Prairie

10. DEIS 5.4.

11. DEIS 5.5.

Island nuclear waste will not be stored at the proposed ISFSI. The ISFSI could become the "interim" storage facility for a number of nuclear power plants, creating an adverse environmental impact due to transportation of spent fuel and the increased capacity of the site.

Prairie Island could be a storage site for waste from NSP's Monticello plant, about 80 miles from Prairie Island. Dairyland Power Cooperative's La Crosse plant, shutdown because it was too expensive to continue operating, is about the same distance. NSP's Pathfinder plant, mothballed years ago, may contain highly-irradiated components attractive for dry-cask storage.

Other nuclear plants with easy access to Prairie Island include Iowa Electric Light and Power Company's Duane Arnold plant near Cedar Rapids, Iowa, Wisconsin Public Service Corp's Point Beach plant and Kewaunee plants on Lake Michigan.

The DEIS states that while only one site will be developed for the ISFSI, four similarly-sized sites are available within NSP's Prairie Island property. [13] What measures will be taken to prevent off-site nuclear waste from being stored at the ISFSI?

Reprocessing

13EE One reason NSP may allow other utilities to store spent fuel at Prairie Island is that it is possible for NSP to reprocess the spent fuel at Prairie Island. Far-fetched this may be, but NSP has already entered a global consortium to build and operate a private uranium enrichment plant in Louisiana. [14] Constructing a reprocessing plant would allow NSP to hold part ownership of a complete fuel cycle, allowing NSP's shareholders to reap additional profit.

The construction of a reprocessing plant in Minnesota would create immense environmental and security problems. The growing possibility that a reprocessing plant will be built in the U.S., [15] the potential for the ISFSI project to lead to a reprocessing plant, and the benefit to Minnesota of not constructing a reprocessing plant in Minnesota should be discussed in the FEIS and accounted for if the preferred alternate is selected.

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13. DEIS 3.3.

14. Dep't of Pub. Svc Discovery Request from Nor. States Pwr., Docket No. E-002/GR-89-865, DPS Sequence No. 601 (Rec'd by DPS, December 27, 1909).

15. DEIS 5.32-5.37.

Depository

Although the proposed depository at Yucca Mountain, Nevada is supposedly the only high-level nuclear waste site being considered, political opposition and site characteristics, may cause a renewed search for HLW depository sites in the U.S.

The continental U.S. contains many areas apparently equally suitable for an underground nuclear waste depository. Because it is not clear precisely what conditions are best for long-term disposal of nuclear waste, it is not clear precisely where it is best to bury nuclear waste.

In the early 1980s, two sites were sought, one in the arid wastes of the West, and one in the old granites and gneisses of the East. By direct Congressional intervention, the Eastern search was terminated, and as a result Western opposition has grown.

Therefore it is becoming increasingly likely that, as with low-level nuclear waste, great regions of the U.S. will be set off into high-level waste disposal districts. Each district will be responsible for disposing of high-level nuclear waste somewhere in its territory.

If such a program is launched, the gneisses, basalts and granites of Minnesota and Wisconsin will be attractive places to bury nuclear waste. The cliffs flanking the ancient bed of the Mississippi River, which have experienced repeated glacial advances, may be considered sufficient for the task. If not, areas west, north and northeast of Prairie Island are easily accessible from Prairie Island.

13FF The attractiveness of Minnesota and northern Wisconsin for nuclear waste burial is increased if a significant amount of nuclear waste is stored nearby. The ISFSI project will supply this attractiveness. The possibility of this occurring, and the resulting consequences should be discussed in the FEIS and added to potential impacts of the project if the preferred alternate is selected.

III. Alternatives

13GG The discussion of the first alternative, no action, shows a bias against alternative measures. The DEIS contends that the alternative of no action is really a decision to close the plant. This is a fallacious and dangerously biased assertion. The issue is whether to build the ISFSI, and one alternative to building the ISFSI is to do nothing about the growing space shortage. The decision to do nothing does not shut down the plant, the lack of space for spent fuel does. The EQB is required to examine the economic and environmental, as well as employment and sociological impacts of doing nothing and fails to do so. It states, 5.2, that "[d]etailed cost and impact studies have not been conducted," yet these are expressly required by Minn. Rule 4410.2300 (H). The EQB must realistically examine the costs and benefits of not taking action in the EIS.

13HH The discussion of reduced operation is inherently flawed because it bases its decision on the premise that a federal facility will be available in 1999, even though the earliest opening date is now 2010. DEIS 5.6, DEIS 3.21. The EIS must actually evaluate the costs of induced development, i.e., how much would it cost to replace lost capacity with existing facilities, how much would it cost if consumer efficiency was increased, or how much would it cost to replace the lost capacity with alternative forms of energy? The environmental, employment and sociological impacts of this option are not addressed at all.

13II The discussion of the option to conserve, i.e., to operate more efficiently, again shows a bias against exploring alternatives. Conservation would not require the Prairie Island facility to close, the eventual lack of storage space would cause it to shut down, DEIS 5.7. This section contains no economic or environmental analysis whatsoever and is egregiously insufficient under Minnesota law. The direct and indirect, adverse and beneficial effects must be discussed. The basis for NSP's predictions for energy demand need to be explained, 5.7, as well as the rationale for dismissing conservation as an alternative. What would the costs of a "dirty, less-efficient plant" be compared to the cost of storing nuclear waste at the ISFSI for 50 years or 100 years?

13JJ The alternative of combining alternatives received cursory discussion and must be rewritten to genuinely evaluate the cost and environmental impacts of alternatives. It is legally impermissible to simply conclude that "uncertainties of the federal acceptance plans limit meaningful assessments of feasibility, system operation, costs and environmental impacts for combinations of alternatives." DEIS 5.41. One is left with the impression after reading the DEIS that there are no differences in opinion about these various alternatives. All differences in opinion must be discussed in the DEIS.

For example, information is currently available in Minnesota which could be used to evaluate an alternative combining the reduced operation of the Prairie Island facility over time with the concomitant increase in conservation and efficiency.

This alternative would:

A. Gradually reduce operations of the Prairie Island facility between 1991 and 1998 (or a similar period of time).

B. Gradually reduce the production of high-level nuclear waste so that the existing pool storage is adequate.

C. Replace the lost capacity with conservation and efficiency.

This combined alternative would not "close" the Prairie Island plant, but would decrease the amount of high-level waste produced until decommissioning. If the pool storage was adequate for the waste produced it then does not matter when, if ever, the DOE depository site begins operation.

Information regarding combined options such as the one above is available since Minnesota is engaged in "least-Cost Planning" which is precisely the study of options which have the least total costs, once all of the costs are indeed counted.

A Minnesota Department of Public Service report titled Minnesota's Energy Options for the 1990's, December, 1988 states:

> "Minnesotans could cut in half their electric consumption by taking advantage of all available, cost-effective energy efficient technologies"

A chart detailing these savings is attached to these comments. (See appendix I).

Many other reports have documented similar existing efficiency technologies just waiting for implementation. A Public Citizen report titled Saving Our Way Out of Nuclear Power, September, 1987 stated:

> "Widespread adoption of these energy efficient technologies on a massive scale can lead to reductions in electricity use greater than the total output of all the nuclear reactors currently operating in this country".

In spite of the documentation of near 50% reductions with efficiency, the combined option given as an example above would only require the replacement of about 15% of Minnesota's electricity consumption over a 7 to 10 year period of time. Given the fact that currently Minnesota endorses "Least-Cost Planning", options that explore the possibilities of efficiency and reduced usage with the same service should be allowed to compete on an equal basis with traditional models. At the very least a complete discussion of several "Least-Cost" options should be included in any EIS completed in Minnesota in 1991.

National Environmental Policy Act (NEPA-Sufficiency of EIS

13KK Because the EQB requested additional commentary on the sufficiency of the DEIS due to its intervention in the NRC's review of NSP's application, the adequacy of the DEIS under NEPA will be addressed. Essentially, the DEIS fails to satisfy NEPA, both under the language of the Act and under the rule of reason adopted by the courts.

NEPA, 42 U.S.C.S. sec. 4332(C)

Federal agencies must include an environmental impact statement in every proposal for a major federal action significantly affecting the environment. The EIS must examine:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

42 U.S.C.S. sec. 4322(C). The content of the EIS is determined by applying the "rule of reason." The agency must discuss all reasonable alternatives and their environmental effects. NRDC v. Morton, 458 F.2d 827 (D.C. Cir. 1972); Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519 (1978). The less likely an alternative is, the less detail is needed in the discussion of the alternative. The test applied is whether a reasonable person would think that an alternative was sufficiently significant to warrant extended discussion. NRDC v. Morton. The consequences of each alternative must be discussed in detail. Carolina

Environmental Study Group v. U.S., 510 F.2d 796 (D.C. Cir. 1975). Although the CEQ rescinded its requirement to include worst case scenarios, at least one court has held that agencies are still required to prepare worst case analyses.[16] The long-term effects of allowing plant operators to increase the capacity of on-site spent fuel pools must be considered. Potomac Alliance v. United States NRC, 682 F.2d 1030 (D.C. Cir. 1982). According to Judge Tamm's concurring opinion in State of Minnesota by Minn. Pollution Control Agency v. United States NRC, 602 F.2d 412 (D.C. Cir. 1979), both sec 102(2)(c) of NEPA and sec. 103(d) of the Atomic Energy Act require a factual determination of whether it is reasonably probable that an off-site repository will be available when plant licenses expire. If the availability is not reasonably probable, the agency must decide whether it is reasonably probable that the spent fuel could be stored safely and indefinitely at the site. Id.

On its face the draft EIS would not satisfy NEPA's requirements to look at adverse environmental effects that cannot be avoided if the proposal is implemented, the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, nor the irreversible and irretrievable commitments of resources that would be involved in the proposed action. The DEIS, as seen above, fails to look at all reasonable alternatives and their impacts -- especially "least-cost planning", where considerable information is available in Minnesota.

The DEIS should also be rewritten to address the probability that a federal permanent storage site will not be available when the Prairie Island facility closes, and whether the propose ISFSI could safely store the spent fuel rods over an indefinite period of time (beyond the 25 year expected life of the casks).

In conclusion, all of the problems and questions raised, require a serious and detailed discussion of a variety of "least-cost" and efficiency/conservation options for Prairie Island. Therefore, the project should be delayed, pending a full, complete, careful, non-generic EIS, meeting all federal and state requirements for such documents.

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[16] R. Findley & D. Farber, Environmental Law 49 (1988).

COMMENT LETTER 14

Citizens for a Better Environment

January 8, 1991

Lisa Doerr - Minnesota State Director

Greg Downing
Minnesota Environmental Quality Board
300 Centennial Office Building
658 Cedar Street
St. Paul, MN 55155

JAN 1991 RECEIVED ENVIRONMENTAL QUALITY BOARD

Dear Mr. Downing,

Citizens for a Better Environment (CBE) appreciates the chance to comment on the:

Draft Environmental Impact Statement
for
Prairie Island
Independent Spent Fuel Storage Installation

CBE is a nonprofit environmental research and community organizing group with more than 5000 members in Minnesota.

14A CBE feels that the Draft Environmental Impact Statement (DEIS) now under consideration by the Environmental Quality Board does not adequately address the alternatives available to Northern States Power for increasing spent fuel storage at the Prairie Island plant.

Specifically, we are concerned that two options, reduced operation and conservation, are given limited discussion. These are the two areas that offer the most potential for solving NSP's storage problem and should not be written off in cursory one page analyses.

The DEIS' discussion of conservation alternatives is especially inadequate. The only data included is from NSP's 1990 Advance Forecast. Not surprisingly, this information leads to statements such as that on page 5.7 in which NSP's "expanded goal of 1000 megawatts" is deemed "ambitious."

The DEIS does not even include data from the state's own Department of Public Service which outlines statewide efficiency potential of nearly 52 percent. Why is the EQB giving such a limited discussion to increased efficiency as a viable alternative when both the Public Utilities Commission and the DPS view it as a key area for state policy development?

3255 Hennepin Avenue South, Minneapolis, MN 55408
(612) 824-8637

Prairie Island Tribal Council

COMMENTS OF THE PRAIRIE ISLAND INDIAN COMMUNITY ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

Explanation

The Prairie Island Indian Community submits these Comments in response to the Draft Environmental Impact Statement "Prairie Island Independent Spent Fuel Storage Installation" prepared by the Minnesota Environmental Quality Board and dated November 30, 1990.

Prairie Island Tribal Council members participated in the public hearings held in St. Paul and Red Wing and will participate in any future information gathering proceedings. The Tribal Council expects to be fully informed of any such proceedings.

These Comments are by no means complete and are not a comprehensive expression of all Community concerns. These Comments have been prepared after a cursory study of the Draft Environmental Impact Statement (DEIS) by non-technical personnel including legal counsel. The Community has been in contact with the United States Department of Interior regarding the issues surrounding the proposal but has not had the opportunity to utilize all Department of Interior resources to do a thorough study of the DEIS. 15A Moreover, under state law, the Tribal Council can request technical and legal assistance from the Minnesota Environmental Quality Board,[1] an option it wishes to consider.

The Community, therefore, views these Comments as a very preliminary statement in response to these important issues pertaining to Community members, the environment in general, the Reservation in particular, and the potential diminishment of all.

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[1] See, Minn. Stat. 116C.722. It is unclear whether the Minnesota Environmental Quality Board has determined whether the Prairie Island Indian Reservation is a "potentially impacted area" as defined by Minn. Stat. 116C.711 subd. 18. The Community respectfully requests documentation of any decision made regarding such determination.

Introduction

The Prairie Island Indian Community, organized under federal statutory authority (98 Stat. 984), and represented by the duly elected Tribal Council, finds it necessary to express concerns regarding the Northern States Power proposal to construct and operate a nuclear spent fuel storage site at the Prairie Island nuclear plant and to object to the lack of recognition given the Community and its status as a sovereign. The Community wishes to remind participating governmental agencies that it is a sovereign entity entitled to the respect afforded in any government-to-government relationship[2] and since the Prairie Island Indian Community members live in close proximity to the nuclear plant and stand to be those most effected by the proposed site, all licensing branches of the State of Minnesota and the federal government should show deference to the Community's concerns and wishes.[3]

15B The Community harbors deep concerns about the storage of spent nuclear fuel so near the Community's Reservation/trust land.[4] Its main concerns pertain to potential safety issues and to the certain diminishment of the Community environment. The Community's objections lie in the fact that the drafters of the DEIS failed to mention the Community and the potential impact of the NSP proposal on the Community, its members and the Community's Indian culture.[5]

The Community clearly understands the importance of the NSP

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[2] See, Federal Register, Vol. 44, No. 26 (February 6, 1976), for documentation that the Prairie Island Sioux Indian Community enjoys a government-to-government relationship with the United States.

[3] Courts often show deference to a governmental agency that is deemed to have a particular expertise. See, Goldman v. Weinberger, 475 U.S. 503, 106 S.Ct. 1310 (1976): "Judicial deference...is at its apogee when legislative action under the Congressional authority to raise and support armies and make rules and regulations for their governance is challenged." 475 U.S. at 509, 106 S.Ct. at 1313. Similar use of judicial deference might be exercised with an Indian tribe, when the issue before a court is the well-being of the tribe, its members and homeland.

[4] The definition of Indian country is found at 18 U.S.C. 1151: "the term "Indian country", as used in this chaper, means (a) all land within the limits of any Indian reservation under the jurisdiction of the United States Government....."

[5] The Community does not consider itself wholly "assimilated" with the surrounding non-Indian culture and shall strongly resist any attempts to characterize it as such.

proposal and the value the storage facility will have for what might be perceived by some as the "greater good." However, the Community also understands that risk is involved since the storage facility will be the home of an interesting and uninvited guest; one with whom we would prefer not to shake hands or invite to a pow-wow. Those who truly believe in the greater good will stop to read these Comments and consider, with a respectful sense of seriousness, what the Community has to say. The Community enters into this important process of deciding what to do with the spent fuel as a senior member of this negotiating team. The Community is prepared to participate in these negotiations and fulfill its responsibilities as the keeper of its peoples' land.

Culture and History

The Community will not present a lesson in history at this point in time.[6] The Community does however draw from times past and the stories of those times while presenting its concerns in these Comments.[7]

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[6] Strong evidence exists that Indian people have been subject to intolerant attitudes since the arrival of European settlers: "Those Americans who felt remorse over the mistreatment of the Indians were still unable to understand the Indian attitudes toward property. To Americans the greatest civilizing force in the world was private property, and many men could not appreciate the Indians' refusal to embrace the American way of life and devote themselves to acquiring property. The Indians preferred, and many still do, tribal ownership of land to private ownership. As early as 1812 one American noted with bewilderment,'All they do is for the common weal, and private interest scarcely finds any place to enter.'... A more extreme point of view on Indian rights to land was expressed by Hugh Brackenridge in 1782: 'On what is their claim founded---Occupancy. A wild Indian with his skin painted red, and a feather through his nose, has set foot on the broad continent...; a second wild Indian with his ears cut in ringlets, or his nose slit like a swine...also sets his foot on the same extensive tract of soil...I wonder if Congress or the different states would recognize the claim? I am so far from thinking the Indians have a right to the soil, that not having made better use of it...I conceive they have forfeited all preference to claim, and ought to be driven from it." From, Forked Tongue and Broken Treaties, ed. Donald E. Worcester, Caxton Printers: Caldwell, Idaho (1975), p. xvii-xix, Introduction.

[7] "Through two hundred years of United States history, American Indians have had their lands and resources exploited, their culture and traditions vilified, and their integrity degraded." See, Lauren Holland, "The Use of Litigation in Indian

The Tribal Council desires everyone to have a clear understanding that the Community has absolutely no desire to consider the possibility of leaving the Prairie Island Indian Reservation. To be forced to move from the Reservation would cause disruption to a way of life.[8] Community members can easily recall and cherish family members who lived on the Reservation over one hundred years ago. Many Community members find solace and counsel in ancestors who are found on the Reservation.[9]

15C However, due to circumstances beyond the Community's control, the Community must consider the possibility of being forced to leave the Reservation, for, if the NSP proposal is approved and brought to fruition, that distasteful possibility exists. Before the Community addresses its concerns about the "worst case scenario," it strongly urges us all to seriously consider all alternatives to the NSP proposal. One alternative is to approach the proposal, with a mind to critique it, from a perspective all together different from the one utilized by the drafters of the DEIS. We might call this alternative perspective the "Indian perspective."

Natural Resource Disputes, Journal of Energy Law & Policy, Vol. 10, no. 1 (1989), p. 54.

[8] "In Grant Foreman's Indian Removal there is a passage quoted from a letter by Col. George S. Gaines to the Mobile Commerical Register (November 12, 1831). Gaines was in the Choctaw country of central Mississippi, assisting some of the people in the tribe who were making preparations for removing to Indian Territory. Gaines noted: 'The feeling which many of them evince in separating, never to return again, from their long cherished hills, poor as they are in this section of country, is truly painful to witness...' See, Introduction, The Remembered Earth, ed. Geary Hobson, Red Earth Press: Albuquerque, 1979, p. 10.

[9] "We are the land. To the best of my understanding, that is the fundamental idea embedded in Native American life and culture in the Southwest. More than remembered, the earth is the mind of the people as we are the mind of the earth. The land is not really the place (separate from ourselves) where we act out the drama of our isolated destinies. It is not a means of survival, a setting for our affairs, a resource on which we draw in order to keep our own art functioning. It is not the ever-present 'Other' which supplies us with a sense of 'I.' It is rather a part of our being, dynamic, significant, real. It is ourself, in as real a sense as our notions of 'ego,' 'libido' or social network, in a sense more real than any conceptualization or abstraction about the nature of the human being can ever be." See, Paul Gunn Allen, "Iyani: It Goes This Way," The Remembered Earth, ed. Geary Hobson, Red Earth Press: Albuquerque, 1979, p. 191.

The "Indian perspective" might be considered a way of relating to the natural world in which the human is just another species, and the well-being of the human species is of no greater or lessor importance than the well-being of every other species, or the collective well-being of the ecological community.[10] Simply put, the Indian perspective recognizes the importance of all life, including the life of the Earth itself.[11]

> Although they varied significantly between different cultures, Native American relationships with the natural world tended to preserve biological integrity within natural communities, and did so over a significant period of historical time. These cultures engaged in relationships of mutual respect, reciprocity, and caring with an Earth and follow beings as alive and self-conscious as human beings. Such relationships were reflected and perpetuated by cultural elements including religious belief and ceremonial ritual...
>
> In contrast, invading Europeans brought with them cultures that practiced relationships of subjugation and domination, even hatred, of European lands. They made little attempt to live with their natural communities, but rather altered them wholesale.[12]

Perhaps, as may be suggested, the agents of the European cultures significantly injected life into the course of history that brings us to this time when we must discuss what to do with spent fuel. Perhaps, as may be suggested, the Indian perspective should be used to shape the future course of events surrounding the spent fuel.

The Community argues that it is not cost-prohibitive to consider the long-term effects of the current practices that generate the spent fuel. Specifically, the Community would be very desirous to see an environmental impact statement (EIS) written with an emphasis on alternative ecological perspectives. The drafters of such an EIS might analyze the NSP proposal while utilizing the argumentative structures and thematic premises of the "deep ecology," "ecofeminism," or "Indian perspective"

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[10] See, Annie L. Booth and Harvey M. Jacobs, "Ties That Bind: Native American Beliefs as a Foundation for Environmental Consciousness," Environmental Ethics, Vol. 12, Spring 1990, p. 29.

[11] Ibid, p. 30.

[12] Ibid, p. 31.

alternative ecophilosophies.[13] These alternative ecophilosophies are studied areas in which scholars and students have generated a substantial amount of documented scientific, legal, historical, and cultural authority. Such authority is not novel and cannot be ignored.

The State of Things

15D In the early 1980s, "federal policy with respect to nuclear waste disposal was in disarray...The basic assumption, made by the Nuclear Regulatory Commission (NRC) in civilian nuclear power reactor licensing proceedings, that disposal facilities for spent nuclear fuel and high-level radioactive waste would be available when needed, was under challenge."[14] There is a strong argument that the current legal structures leave open the opportunity for the various levels of government to become deadlocked and paralyzed in the search for storage facilities, giving rise to a situation where there is nowhere to store spent fuel.[15]

With this type of documented uncertainty among the elected governments of the United States, among those who presumably have access to state of the art technology, the Community feels uncomfortable with the "assumptions" on which the drafters of the DEIS base their conclusion that "[c]onstruction of the proposed ISFSI will not cause significant impacts to the natural and human environment in the vicinity of the Prairie Island Nuclear Generating Plant."

The Community understands that our spent fuel guest is interesting for compelling reasons.[16]

> Spent fuel is the intensely radioactive material withdrawn from the core of a nuclear reactor following irradiation but before constituent elements are separated by reprocessing. Spent nuclear fuel contains hazardous concentrations of fission by-products such as cesium and strontium, as well as transuranics such as plutonium-239. Exposure to radiation

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[13] See, Booth and Jacobs, "Ties That Bind: Native American Beliefs..." Environmental Ethics, Vol. 12, Spring 1990, p. 29.

[14] See, Charles H. Montange, "Federal Nuclear Waste Disposal Policy," Natural Resources Journal, Vol. 27, Spring 1987, p. 310-311.

[15] See, Orlando E. Delogu, "'NIMBY' is a National Environmental Problem," South Dakota Law Review, Vol. 35, 1990, p. 199.

[16] "Activities such as nuclear weapons testing and waste disposal...cause incalculable harm." See, Mark Allen Gray, "The United Nations Environmental Programme: An Assessment, Environmental Law, Vol. 20, no. 2 (1990), p. 291-292.

from spent nuclear fuel, even for a short time, can be lethal. Spent nuclear fuel must accordingly be handled with great care. To make matters even more difficult, such material is thermally hot due to intense radioactive decay. It is therefore all the more difficult to handle. Spent nuclear fuel is generally solid in form.[17]

Since none of the casks used to store the spent fuel have burst open in an accident, the effect of a cask releasing its contents is truly unknown.[18] However, studies have been conducted and the effects of a nuclear accident are not attractive.[19]

15E The DEIS drafters chose not to investigate and present the "worst case scenario" and perhaps such a presentation will be counter-productive and cost-prohibitive, however, the Community feels it is necessary to understand the reality of certain possibilities. As mentioned above, the Community does not wish to leave the Reservation and if there is a possibility of a forced evacuation, whether on a temporary or permanent basis, the Community needs to consider what would cause the necessity of an evacuation and the viability of potential evacuation plans.[20] The Community, therefore, respectfully requests that a study of these issues be conducted and results therefrom documented for the Community's review.

Other Considerations

The Community finds itself in a vulnerable position, a position in which most groups of Indian people have found themselves since the arrival of European settlers. The Community lacks resources and knowledge to provide an informed critique of the scientific issues involved in the NSP proposal. There is

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17 See, Montange, "Federal Nuclear Waste Disposal Policy," Natural Resources Journal, Vol. 27, Spring 1987, p. 376

18 See, Michele Mattsson, "Transportation of Radioactive Materials in Our Backyards---A State's Perspective," Journal of Energy Law and Policy, Vol. 9, 1988, p. 49.

19 "Roger D. Norton, a Professor of Economics at the University of New Mexico, has also studied some possible accident scenarios...a nuclear waste transportation accident could be severe enough to warrant evacuation of hundreds and perhaps thousands of people. People in the immediate vicinity of the accident would be killed instantly, but it is unknown how many would die later due to contaminated soil and and particles of radioactive materials in the air." See, Mattsson, ibid, p. 49-50.

20 See, Minn. Stat. 116C.711 regarding "emergency response plans."

much the Community can do in assisting its members and the general public to better understand the forces at work in this story of nuclear spent fuel and where to store it. The Community wishes to make many more suggestions and demand access to the information crucial to a complete understanding of this story. In doing so, we shall all become better informed.[21]

15F The Community maintains ongoing concerns about the ramifications of the nuclear plant has on the health of its members. The Community requests that a thorough study of potential health risks be conducted and presented to the Community.

15G The Community also maintains a particular interest in alternatives to those mentioned in the DEIS.[22] The Community would like to review studies of disposal methods such as deep-space disposal by rocket propulsion devices. 15H The Community would like to review a more comprehensive study of the "unknown risk factors" involved at Prairie Island.[23] 15I The Community wishes to understand why there is not a greater push toward developing alternative fuel sources such as solar and wind generated energy.[24] 15J And importantly, the Community wants to know what it can receive in the event that the NSP proposal becomes a reality. There is a strong sentiment that potentially impacted communities

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[21] An incident occurred a few years back at the NSP Prairie Island plant that apparently required the evacuation of plant workers; the Community was never properly informed of the circumstances surrounding these events.

[22] It has been suggested that the spent fuel storage facility be located at alternative sites such as the White House yard in Washington, D.C. or the State Capitol grounds in St. Paul. At the minimum, the Community would like the opportunity to study more closely viable site alternatives.

[23] See, Bill Muschenheim, "Save Prairie Island," Northern Sun News, August/September 1990, p. 1.

[24] "The Luz Corporation based in Los Angeles and Jerusalem, now operates nine central solar generating stations with a combined capacity in excess of 350 megawatts. The newest units deliver peak electricity at eight cents per kilowatt hour, well under the twelve cents coming out of Seabrook, with none of the environmental, health, or meltdown liabilities....Renewable technologies are advancing far more rapidly than atomic reactors, and the industry is undoubtedly feeling the heat." See, Harvey Wasserman, "Nuclear Power's Desperate Comeback," Nuclear Times, Winter 1990-91, p. 3-4.

should be compensated.[25]

Conclusion

The Prairie Island Sioux Indian Community finds it necessary to play an integral part in this process to determine whether to place high level nuclear waste in a cask on a cement slab not more than a half-mile from the Indian Reservation. The Community respectfully requests the assistance from all involved parties in its endeavor to raise the consciousness of the people regarding this place we call home.

15K At this point in time, the Community is not aware of any cause of action it might have against any party with regard to the construction of the spent fuel storage facility. The Community wishes to preserve all legal rights and potential causes of action that emanate from the NSP proposal.

Dated: January 10, 1991

Dale R. Childs

Dale Childs, President

---

25 "A third essential feature of the proposed federal legislation would recognize a duty, and require each state's siting mechanism, to compensate: 1. Landowners whose property is earmarked for a NIMBY-type use. 2. Adjoining property owners whose land values will be depressed to a greater or lessor degree by their proximity to an earmarked site. 3. Municipalities that must bear the infrastructure costs associated with being host to a NIMBY-type activity or facility.

These payments should not be delayed until there is an actual sale or taking of property for the NIMBY use or until actual construction begins." See, Delogu, "'NIMBY' is a National Environmental Problem," South Dakota Law Review, Vol. 35, p. 215.

Compensation can take the form of health insurance payments, comprehensive medical care, a permanent health clinic, medical studies regarding the effects of the plant on Community members, wellness programs, educational scholarships, electricity, etc.

BLUEDOG LAW OFFICE

SOUTHGATE OFFICE PLAZA, SUITE 555
5001 WEST 80TH STREET
BLOOMINGTON, MN 55437
(612) 893-1813
FAX (612) 893-0650

January 11, 1991

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, MN 55155

RE: Prairie Island Indian Community Comments to the Draft Environmental Impact Statement

Dear Mr. Cupit:

Enclosed please find the original of the Prairie Island Indian Community's Comments to the DEIS. I faxed the Comments to you today as well. Again, let me apologize for the delay.

If I can be of further assistance, please call.

Sincerely,

William J. Hardacker

Enclosure

COMMENT LETTER 16

[redacted]

United States Department of the Interior

BUREAU OF INDIAN AFFAIRS

MINNEAPOLIS AREA OFFICE
15 SOUTH FIFTH STREET
MINNEAPOLIS, MINNESOTA 55402

IN REPLY REFER TO:

Hydrology

Mr. Robert Cupit
Minnesota Environmental Quality Board
658 Cedar Street
St. Paul, Minnesota 55155

Dear Sir:

This office fully supports and concurs with the comments of the Prairie Island Indian Community (Community) on the Draft Environmental Impact Statement (DEIS) for the proposed Prairie Island Independent Spent Fuel Storage Installation (ISFSI). A copy of those comments are enclosed. The Prairie Island Indian Community is a federally recognized entity and is entitled to the respect and consideration due a sovereign nation. The DEIS does not
16A mention the Prairie Island Indian Community nor its proximity to the proposed ISFSI. Since, the proposed ISFSI lies within 2000 feet of the primary residential area of the Prairie Island Indian Community, we believe that the concerns of the Prairie Island Indian Community should be specifically addressed and that the Community should be a primary participant in the development and selection of alternatives.

According to the DEIS, the ISFSI is predicted to produce an annual radiation dose of 3.74 millirem (mrem) for the nearest resident. This is approximately fifty times the 0.076 mrem calculated annual dose due to the Prairie Island plant. While the annual radiation dose, at the nearest dwelling, is predicted to remain within the Nuclear Regulatory Commission guidelines it is clear that the ISFSI will, under normal operations, be a more significant source of radiation than the plant itself. Clearly, the proposed ISFSI must be considered a major modification of the operation of the plant.

The defense-in-depth design of the ISFSI provides an apparently high degree of safety. There remains, however, a risk of unknown magnitude and indefinite
16B duration to be born principally by the Prairie Island Indian Community. If an accident results in the release of radioactive material the impacts may persist over a very long time scale. The imposition of the risk of containment failure, the increase in radiation exposure, and the emotional impact of the ISFSI upon the Prairie Island Indian Community is an unreasonable burden.

The Community resides on a small remnant of their ancestral lands; the bulk of which, have been appropriated to the ultimate benefit of the United States. The Prairie Island Indian Reservation is all that is left to this Band of Sioux Indians. The circumstances surrounding the members of the Community, their way of life and their relationship to the United States requires that their needs and concerns be addressed explicitly and that their unique perspective be given full consideration in evaluating the environmental impacts of the ISFSI. The Minneapolis Area Office requests that the Minnesota Environmental Quality Board and Northern States Power Company treat the Prairie Island Indian Community with the consideration and respect due a sovereign government and specifically address, to the satisfaction of the Community, all the concerns expressed by the Community.

If you have any questions concerning our comments, please contact Q. Brown, Area Hydrologist, at Area Code: (612) 349-3380.

Sincerely,

Earl J. Barlow

Area Director

minnesota department of health
division of environmental health
925 s.e. delaware st. p.o.box 59040 minneapolis 55459-0040
(612) 627-5100

January 16, 1991

JAN 1991
RECEIVED
ENVIRONMENTAL QUALITY BOARD

Gretchen Sabel
Environmental Quality Board
400 Centennial Office Building
St. Paul, Minnesota 55155

Dear Ms. Sabel:

Minnesota Department of Health staff have reviewed the draft environmental impact statement "Prairie Island Independent Spent Fuel Storage Installation" and offer the following comments:

17A 1. The TN-40 cask is being designed for 3.85% U-235 enrichment (maximum). According to the EIS scoping document, 4.0% and 4.2% enriched fuel was loaded into the Prairie Island core during Cycle 14 last year. Any changes in cask design should be identified so that changes in environmental impacts can be evaluated (for example, is there an increased risk in accidental criticality?).

17B 2. Damaged fuel racks will be stored in a storage building that is part of the installation. Their amounts of radioactivity and radiation levels are not stated. These impacts should be further detailed.

17C 3. The statement is made that "although no radioactive liquid or gas in the cask...could leak" it does contain krypton-85 gas, which has a half life of about 10 years, and diffuses out of the spent fuel. Estimates of Kr-85 concentrations should be made under the case where cask seals fail.

17D 4. Because, when fully loaded, the installation is predicted to have higher radiological impacts than the plant itself (3.74 mrem per year compared to 0.0763 mrem for the nearest resident), we suggest that, if resources are available, a health risk assessment be performed.

If you have questions on these comments, please contact me at 627-5065.

Sincerely,

Timothy D. Donakowski

Timothy D. Donakowski
Health Physicist
Section of Radiation Control

TDD:tdd

January 10, 1990

David S. Lang
Route 4
Milaca, Minnesota 56353

Ms. Gretchen Sable
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

Dear Ms. Sable:

Per your letter of December 27, 1990, I have briefly reviewed the Prairie Island Spent Fuel Storage Expansion Draft EIS. I am concerned the "agenda" named for this project pre-empts adequate public review and participation. I was first informed of the EIS availability via public media in late November and received the EIS in mid December. I am qualified to review a variety of environmental information, but specific post graduate expertise in the fields of health physics and nuclear engineering is necessary to support an independent understanding of this document.

Concerned citizens, like myself, face substantial obstacles in the review of information of this kind. The environmental significance is very long term, the potential for adverse impact is high, the topic is technically complex, and access to qualified independent reviewers who are also willing to devote their leisure time to
participation without compensation is low. For these
18A reasons, I believe thirty to sixty days is far to little
time as allowed for public review and comment.

The order of the EIS process also seems
inappropriate to me. I am at a loss to understand how the
18B EIS could be written prior to the time the essential
information from the NRC review was available. For
example, the casks have not been approved for transport yet the storage is obviously not permanent and the "containment material fracture toughness" (presumably a function of metal fatigue due to crystallization) remains to be
evaluated and approved. With regard to cask durability, I
am astounded to find information on snow and ice loading
18C for vessels designed to withstand internal pressures
exceeding 100 psi and various "tornado missiles" but no

information about casks which may, under transport, strike a durable concrete structure (like a bridge) while moving at 50 miles per hour.

I believe the decade of the eighties demonstrated the need for improved information and public participation on behalf of environmental interests in Minnesota. Because of the long term consequence of this environmental issue in particular, I hope that you now may find additional means to benefit those concerns.

Sincerely,

David S. Lang, Ph.D.

Summary of Public Meeting Comments

Draft Environmental Impact Statement
Prairie Island Spent Fuel Storage Expansion

The following is a summary of oral comments received at public meetings at St. Paul on December 17, 1990 and at Red Wing on December 18, 1990. Comments have been assigned a reference number corresponding to responses.

19A The geologic characteristics of the proposed site should be described and related to the potential for failure of the concrete pad to support projected loads.

19B Higher pressures during hydrostatic testing of the casks should be considered.

Impacts on the adjacent Indian community of the Prairie Island Reservation should be analyzed, specifically:

- 19C - population levels and proximity to site,
- 19D - socioeconomic impacts,
- 19E - aesthetic impacts,
- 19F - impacts from future transportation of spent fuel, and
- 19G - health impacts.

The conservation alternative should be significantly expanded to include:

- 19H - how conservation can reduce waste generation,
- 19I - how more sophisticated approaches to energy efficiencies and conservation can reduce waste and problems of waste management,
- 19J - how rate-based financial incentives for electric utilities to encourage conservation can reduce generation of waste,
- 19K - additional information on specific energy efficient technologies available to reduce consumption, and
- 19L - cost effectiveness of conservation.

19M The reduced operation alternative should also be expanded relative to the conservation discussion.

Discussion of cask design and operation should be expanded, specifically:

- 19N - design, operating life of cask, and
- 19O - protection of monitoring system, specifically from lightning strike, tornado missile.

19P Renewable alternatives, such as wind power and biomass, should be considered.

19Q The potential for the site to be used to store spent fuel from other reactors should be addressed.

19R Include a discussion on why NSP chose the dry metal cask design.

19S Explain why the larger cask was chosen over smaller volume casks.

19T Include the potential for severe erosion of the earthen berm, and the impacts which could result.

19U Describe what European countries are doing with spent fuel.

19V Expand discussion of testing of casks.

19W Discuss how environmental review of dry cask technology can be reliable when operating history is so short.

19X Include an analysis of the potential for the facility to become a de facto permanent storage site.

19Y Describe effect on state EIS process if federal review results in a change in project design.

19Z Expand discussion of handling of cask in event of seal failure or other event requiring transport back to pool.

CHAPTER 8

RESPONSES TO COMMENTS RECEIVED ON DRAFT EIS

Comment Letter 1

1A The possibility that spent fuel from other nuclear plants would be stored at the PI facility is discussed on page 4.27.

1B See text page 4.10 (Indian community impacts) and 4.10 and 4.20 (transportation accidents).

1C Health impacts on residents adjacent to the ISFSI have been given further analysis. See new Chapter 6.

Comment Letter 2

2A Discussion of renewable energy sources has been added on page 5.48.

2B The discussion of costs of the conservation alternative has been expanded, beginning on page 5.11.

2C Additional discussion of the economic impacts of conservation and renewables has been included in the FEIS. See page 5.11 and 5.48.

2D Energy policies of utilities and the state are inappropriate for analyses in an EIS for a specific project proposal. More specifically, the "need" for the Prairie Island plant and/or the proposed ISFSI is an issue that should be addressed to the Public Utilities Commission. While the commenter rightly suggests that energy policy should not be established on a project by project basis, there are more appropriate forums than an EIS to consider broad energy issues.

Comment Letter 3

3A Response provided on page 4.25.

3B Ground water monitoring is discussed in more detail in the text on page 4.8.

3C Energy conservation will be considered by the Public Utilities Commission during the Certificate of Need proceedings. Though this EIS looks generally at conservation, specific programs would be considered by both the PUC and the Department of Public Service.

3D EQB staff have attempted to qualify or verify any information provided by NSP.

Comment Letter 4

4A Response provided on page 3.7.

4B Response included on page 4.17

4C Comment questioned purpose of berm. See page 4.28, Section L. Mitigation of identified impacts; Off-site radiation exposure reduction. Also see new Chapter 6.

4D Response in text on page 4.17.

4E The Minnesota Department of Health has provided additional analysis of potential health effects. See new Chapter 6.

4F The commenter's concerns about impacts on the Red Wing community are noted. The EIS reflects what is known about specific impacts of the proposed project.

<u>Comment Letter 5</u>

5A A discussion of the proposed capacity of the ISFSI has been added on page 4.26.

5B Revised radiation calculations are provided in Chapter 6.

5C Included in text on page 3.21

5D Additional discussion has been included in the text on heat generation and heat flow calculations. See page 3.13.

5E The hickory plank tornado missile is presumed to be 12 feet long. The 6 foot length on page 4.7 of the DEIS was incorrect. It has been corrected in this FEIS.

<u>Comment Letter 6</u>

6A The revised EIS now includes additional discussion (and emphasis) on the conservation alternative, beginning on page 5.8.

6B The commenter's concept of financial incentives to conserve electric energy, with the objective of reducing environmental impacts of waste generation, has been endorsed by the EQB and the PUC. A discussion has been provided on page 5.8. However, the EQB will not be making a decision to prefer any alternative in this EIS process. The comment attachments have been included in Appendix M.

6C The PUC's Certificate of Need process will consider the economics of the alternatives in more detail. Further, the PUC will now require utilities to file financial incentive plans, permitting review of broader issues, including environmental. See page 5.8.

6D The comment is noted. Additional discussion of conservation opportunities are included beginning on page 5.8.

6E Same as 6C above.

6F and 6G Same as 6C above. Various regulatory actions and discussions over the last year indicate a heightened awareness of the potential for financial incentives to conserve to reduce pollutant emissions and waste generation.

6H The points in this paragraph are a summary of comments 6A through 6G.

Comment Letter 7

7A Response included on page 4.17.

7B Response included on page 3.21.

7C Chapter 4 references have been included at the end of the chapter.

Comment Letter 8

8A Comments on impacts on the Indian community are noted. Discussion of the tritium contamination issue has been added to the text on page 4.8.

8B Comment is noted.

8C Long-term storage concerns are discussed on page 4.24.

8D A discussion on airplane crash impacts has been added on page 4.21.

8E Radiation exposures is discussed in more detail. Refer to new Chapter 6.

8F The appropriateness of nuclear power is a policy and public opinion issue and is beyond the intended scope of this EIS. Staff believes the no action alternative is adequately discussed in the draft EIS. The remaining issues noted in this paragraph are a summary of comments 8A through 8E, which are addressed above. The conservation alternative has been expanded on page 5.8. Combinations of alternatives has been expanded on page 5.47.

Comment Letter 9

9A Comment noted.

9B Comment noted. See comment 3D.

9C Additional information was provided by NSP in its comment letter (10), p. 3. Premature shutdown of the plant would appear to have a significant adverse economic impact on the Red Wing community.

9D Response to coal/nuclear comment is on page 5.52.

9E Comment is interpreted as an opinion.

9F Question "Where did 5 rem (page 2) come from?" answered in text on page 4.18. Next line statement about BEIR V confirmed and explained in Appendix G.

9G Response included in text on page 4.18.

9H Comment regarding radiation hormesis included attachments which are found in Appendix M. Additional discussion is on page 4.18.

Comment Letter 10

10A Appropriate corrections have been incorporated in the Final EIS text.

10B The data in the last column of Table 3-3 corresponds to 20 years after discharge.

10C Comment noted.

10D Comment noted. Attachment is included in Appendix M.

Comment Letter 11

11A Additional discussion on crane design is included on page 3.6.

11B Additional discussion on cask testing with water is provided on page 3.10.

11C Definition of "canned" has been added on page 3.10.

11D Response in text on page 3.11.

11E Response in text on page 3.19.

11F Purpose of vent hole described in text, page 3.21.

11G Additional information on wildlife use of project area is included in text on page 4.4.

11H Same as 11G above.

11I An explanation of missile damage is provided on page 4.14.

11J Additional discussion on lightning strike found on page 4.16.

11K Additional discussion on regulatory review of the project is provided on page 3.27 and in Chapter 2, page 2.1.

11L Because of the degree of neutron shielding provided by the cask, no other ISFSI components become activated. Thus, the pads, fences and equipment building will not require disposal as LLW. Additional discussion on activation of materials is in text on page 4.17.

11M This comment urged continued state involvement in the federal license process. This is now occurring through the state's intervention in that process. An updated discussion of the intervention is presented on page 2.1.

11N Comment noted.

11O The DNR's Mississippi River Team unfortunately misunderstood the environmental review process. There was no attempt to "hurry" public review of the DEIS. As noted in the comment, an extra week beyond the 30 days required by rule was provided. Further, written comments were accepted which were received over a week beyond the close of the comment period.

Comment Letter 12

12A Comment noted.

12B Response included in text on page 4.2.

12C Additional discussion on radioactive impacts on wildlife is included in the text on page 4.2.

12D Comment noted.

12E Objection noted. Additional discussion of future waste storage begins on page 4.27.

Comment Letter 13

13A The comment assumes the EIS is the basis for a decision about the need for or the prudency of the Prairie Island Nuclear Generating Plant. This is clearly not the case. It is a discovery document, intended to describe known impacts of a proposed project (the ISFSI) and alternatives. While it can be argued that the Minnesota Environmental Policy Act applies to an EIS adequacy decision, the legislature's declared intent of an EIS in Minn. Stat., section 116D.04, is to provide information before a major governmental action (the Certificate of Need) is taken. It is appropriate for the preparation of an EIS to be guided by MEPA, though it is the need decision (approval) which must satisfy the requirements of the Act.

13B The conservation alternative has been expanded beginning on page 5.8.

13C MEQB staff believes the revised EIS satisfies the content requirements provided in rule. Again, the EIS was not prepared on a proposal to operate or not operate the Prairie Island Plant.

13D The alternatives section includes expanded discussion of several alternatives, particularly conservation, reduced operation and conbinations, pages 5.8 and 3.47.

13E See response 13C and 13D above.

13F Technically, the referenced Minn. rule 4410.2500 does not apply to this EIS. The rule language applies to projects proposed by a governmental unit for which the governmental unit prepares the EIS. This is not the case here. The rule language refers to "a reasoned choice among alternatives" and "weigh the need for the project", neither of which the EQB is authorized to do for the NSP project.

The SAR postulated a cask tipping event as having the maximum potential impact on the immediate environs, and contains a detailed analysis of the radiation dosage of a cask tip-over (page 8.2-4 of the SAR). The nearest site boundary or maximum individual whole body dose for the loss of spent fuel cask confinement barrier is determined to be 0.07 rem. The NRC criteria is 5 rem.

13G Response provided in text on page 3.11 and 3.19.

13H Response provide on page 3.7.

13I This comment stated that the discussion of costs and impacts of increasing the pool capacity at Prairie Island was not adequate. These areas are covered on pages 5.16 through 5.23 of the DEIS. The commenter does not state what information is missing. For this reason, no further discussion is offered.

13J A discussion on the effect of radiation on the cask materials has been added on page 4.17. Also, refer to NSP's comment letter (#10, comments A.5, A.7 and A.8 on pages 5 and 6).

13K Response in text on page 3.19.

13L Response in text on page 4.17.

13M Additional discussion on crane design has been added on page 3.6.

13N Discussion of dual purpose cask has been added on page 5.15.

13O Additional discussion on geologic characteristics is provided in NSP's comment letter, p. 1. A detailed description of site geology and related design factors are provided in the Safety Analysis Report. It was not duplicated in the DEIS because of its very technical nature and length.

13P The EIS was not intended to be used as NSP's application for a Certificate of Need. That permit information was not specifically included in the EIS pursuant to Minn. Rules, 4410.2300, subp. F.

13Q Response included on page 4.17 and in new Chapter 6.

13R Long-term storage concerns have been addressed on page 4.24.

13S Additional discussion of costs has been included on page 4.27.

13T Additional information on wildlife populations in project area is included on page 4.2 of text.

13U Expanded discussion of impacts on wildlife is included in the text on page 4.2.

13V There is no information basis to assume there will be adverse socioeconomic impacts on the area if the facility is built and operated as proposed and regulated by the NRC. Studies would be inconclusive and speculative.

13W Response is a new Chapter 6.

13X Response is additional discussion on property value effects on page 4.11.

13Y The possibility that spent fuel from other nuclear plants would be stored at the PI facility is discussed on page 4.27.

13Z This comment asked what impact Minnesota's 1990 "Below Regulatory Concern Low-Level Radioactive Waste" act would have on the proposed project. Laura McCarten, NSP project manager, stated in January of 1991 that plans for the project did not include requesting deregulation of any low-level wastes, and that all low-level wastes would be disposed in a low-level radioactive waste landfill.

13AA This comment requested more information on the 1978 steam release accident at the Prairie Island plant. The only steam release accident at Prairie Island occurred in October of 1979, and so it is assumed that the commenter is in error on the date. Though reactor operation is not the subject of this EIS, a description of the 1979 accident has been added to Appendix C on page Append. 6.

Concerning the 1985 incident, a question was raised as to the release of Krypton-85. There was no release of Krypton-85 nor was anyone exposed during this incident."

13BB Response to cask recertification question is provided on page 3.29.

13CC Comment noted.

13DD The possibility that spent fuel from other nuclear plants would be stored at the PI facility is discussed on page 4.27.

13EE The suggestion that NSP will accept spent fuel from other plants and also build a reprocessing plant is speculation. This conjecture is beyond the scope of the EIS as an action that has not been proposed, and, if proposed in the future, would be reviewed in separate proceedings.

13FF The possibility of Minnesota becoming a host state to a repository is discussed on page 4.27

13GG Staff disagrees with this comment and considers it non-substantive.

13HH
13II
13JJ The alternatives section of the EIS has been expanded. The commenter's disagreement and additional information is noted.

13KK The EQB's EIS does not have to satisfy the requirements of the National Environmental Policy Act.

Comment Letter 14

14A The alternatives section has been expanded, beginning on page 5.8.

Comment Letter 15

15A Comment 15A refers to "technical and legal assistance", which, upon request, can be provided by the EQB to Indian tribes pursuant to Minnesota Statutes, section 116D.722. However, that statute was designed to provide assistance in the event that a high level radioactive waste repository was being sited in Minnesota. The statute specifically excludes the on-site storage of spent fuel from consideration. While it may be argued that some issues relevant to the proposed ISFSI are not dissimilar from a repository, the intent of the statute is clear.

15B Comment 15B reflects the opinion of the Tribal Council that the proposed facility will cause certain diminishment of the Community environment and culture, and is duly noted. Quantification of such impacts is difficult at best, and necessarily relates to the historical association of NSP and the reservation as neighbors since the late 1960's. The reservation is immediately adjacent to the plant and all traffic to the plant passes through the reservation. While direct, adverse impacts are not anticipated by NSP, any unanticipated offsite impacts could affect reservation resources and/or residents because of its proximity.

15C Comment noted.

15D Long-term storage concerns are addressed on page 4.24.

15E See response to Comment 13F.

15F Additional health risk analysis on adjacent residents has been included in Chapter 6.

15G See response to comment 19U.

15H Comment noted.

15I Comment noted. Additional discussion on renewable energy sources have been included in the EIS on page 5.48.

15J The issue of compensation by NSP to the Indian community, raised in comment 15J, is inappropriate in an EIS. There are other means to resolve this question.

15K Comment noted.

Comment Letter 16

16A There was no willful intent to omit impacts on the Indian community. No issues relative to the reservation were raised during the scoping process in early 1990, either through written comments or at the public meetings. The purpose of the scoping process is to identify through public participation the alternatives and impacts to be included in the EIS. The Tribal Council received all mailings since the beginning of the environmental review process, and proper notices were provided in the media and by mail.

Nevertheless, concerns about the proposed project were voiced by several members of the community and others outside of the community and the text now includes discussions of issues relating to the Indian community (page 4.10).

16B Comment noted.

Comment Letter 17

17A If the design of the TN-40 cask was ever modified to accommodate enrichments higher than 3.85 wt%, all the current NRC regulations would still need to be satisfied. In particular, any change in design must meet the NRC limit on subcriticality, i.e., keff may not exceed 0.95. There would be no increased risk of accidental criticality.

17B Additional information on damaged racks provided in text on page 3.19.

17C Table 7.2-3 of the SAR provides the fission product activity of the design basis spent fuel. Ten years after discharge from the reactor, the Krypton-85 concentration is 6260 Curies per metric ton of spent fuel. A TN-40 cask will hold about 16 metric tons of fuel, and contain a total of about 100,000 Curies of Krypton-85 activity.

17D The Minnesota Department of Health performed a health risk assessment for this project. Its analysis and conclusions are provided in new Chapter 6.

Comment Letter 18

18A Comment noted. The state's environmental review rules are being followed. Review of the proposed project began in late 1989. At the conclusion of the PUC's Certificate of Need process, which has not yet begun, approximately two years of review at the state level will have been committed. The NRC's review is a minimum of one and a half years.

18B While it may seem reasonable that the state and federal should coordinate and fully cooperate in the review of nuclear issues, it doesn't happen. Because of the federal licensing procedures, it is more useful for the state to conduct its environmental review early enough in the federal process to allow the state to intervene and raise questions. Any change in the project or later discovery of significant impacts can be reviewed by the state by requiring a Supplemental EIS.

18C Transportation accidents are discussed on page 4.20.

Oral Comments Received At Public Meetings - 19

19A Geologic characteristics and pad design discussions have been expanded on page 3.19.

19B Cask testing pressures are discussed in more detail on page 3.10.

19C There is no available information to suggest that there will be significant impacts on population levels and socioeconomics of the reservation. As noted in the DEIS, the relatively small scale of facility construction may have minimnum effects on adjacent residents. There is also no information basis to estimate long term impacts resulting from residents or visitors to the reservation being uncomfortable with the dry cask facility. While it is suggested that business of the reservation's casino and bingo may be diminished by public fear of the dry cask facility, it would be speculation at this time to assume that. The NRC standards are designed to protect the nearest individual (at the site boundary), regardless of population size of a nearby community.

19D See 19C above.

19E Aesthetic impacts are discussed further in the text on page 4.11.

19F Eventual transportation is discussed on page 4.20.

19G Additional health risk analysis has been included in Chapter 6.

19H The conservation alternative has been expanded beginning on page 5.8.

19I-19L See page 5.8.

19M The alternatives of reduced operation and conservation have been expanded.

19N A discussion on the effect of radiation on the cask materials has been added on page 4.17. Also, refer to NSP's comment letter (#10, comments A.5, A.7 and A.8 on pages 5 and 6).

19O The discussion of cask design and operation has been expanded beginning on page 3.6.

19P Renewable alternatives have been included on page 5.48.

19Q The possibility that spent fuel from other nuclear plants would be stored at the PI facility is discussed on page 4.27.

19R Discussion on NSP's choice of cask design included on page 3.7.

19S Explanation of choice of cask size added on page 3.7.

19T Additional discussion on the earthen berm is included on page 3.19.

19U Some other countries are reprocessing, or recycling, their spent fuel. This is discussed on page 5.32 of the DEIS. Even if the fuel is reprocessed, a fraction remains which must be disposed. For disposal of this fraction, or of intact spent fuel if it is not reprocessed, a number of alternatives exist. Among those considered early in the U.S. program are a geologic repository, sub-seabed disposal, icesheet disposal, space disposal, island disposal, rock melting and well injection. The geologic repository concept was chosen, citing the need for very-long term isolation from the environment (10,000 years at least) and the need for a method of safely getting the high-level radioactive waste into the disposal media. This latter factor would tend to prejudice the decision away from deep-space disposal when considerations for rocket mishap are included. Other countries developing geologic repositories include Canada, Sweden, Germany, France, England and Taiwan. Canada, Germany, and France at least are also using dry storage of spent fuel in independent storage facilities as an interim measure until a disposal site is available.

19V The discussion of cask testing has been expanded on page 3.10.

19W Data reliability is a function of best judgements of experts. In this case, we are relying on the NRC to provide the technical review and operational monitoring. The entire review process, both state and federal, attempts to maximize the credibility of information. A discussion of experience, testing, and design criteria is provided in connent letter #10, page 7.

19X Long-term storage issues are included on page 4.24.

19Y This comment urged continued state involvement in the federal license process. This is now occurring through the state's intervention in that process. An updated discussion of the intervention is presented on page 2.1.

19Z This comment requested more information on the response procedures relative to cask seal failure. It is provided in NSP's comment letter (#10, page 7).

APPENDICES

A. Definitions
B. Nuclear fuel cycle
C. Fuel handling and reliability
D. History of spent fuel handling at Prairie Island
E. Role of Prairie Island plant in NSP system
F. Considerations and data (Chapter 5)
G. Federal Radiation Protection Standards

All New Material

K. Property Values Near Nuclear Power Plants
L. Tolerable Risk
M. Carcinogen Lifetime Risk Level
N. State Agency Rules: Solid Waste
O. State Agency Rules: Water Quality
P. NRC Policy Statement: Below Regulatory Concern
R. Fabrikant Letter: BEIR V
S. BEIR V Report
T. Attachments to Comment Letters
U. Prairie Island 1989 Annual Radiological Envrionmental Monitoring Report

Appendix A
Definitions

<u>Base Load Plant:</u> A base load plant is a relatively high investment cost resource with relatively low unit energy costs. Significant operation for long periods of time is expected in order to justify the investment.

<u>Burnup:</u> Burnup is a measure of how much energy a fuel assembly produced during the time it was in the reactor. Typically, the greater the initial enrichment of the fuel assembly, the greater its burnup when it is finally discharged from the reactor. Burnup is expressed in terms of megawatt days per metric ton of uranium (MWD/MTU).

<u>Curie:</u> A measure of radiation equivalent to one gram of radium or 37 billion disintegrations per second.

<u>Cycle:</u> A cycle is a period of reactor operation beginning with reactor start-up after a refueling, and ending when the reactor is shutdown for the next refueling.

<u>Cycle Capacity Factor:</u> The cycle capacity factor is the amount of energy produced during a cycle, divided by the amount of energy that would have been produced had the reactor operated at full power all the time during the cycle.

<u>Enrichment:</u> Most of the uranium in a nuclear fuel assembly is of a type referred to as U238, but the type that can fission and produce energy is referred to as U235. Thus, enrichment means the percentage of uranium in a fuel assembly that is the U235 type. Enrichment is expressed in terms of %U235.

<u>Peaking Plant:</u> A peaking plant is a relatively low investment cost resource with relatively high energy production costs. Operation is limited to peak load periods or during emergencies when less costly energy is unavailable to meet requirements.

<u>Refueling:</u> Refueling needs to occur periodically to keep nuclear plants operating. During refueling, older, less energetic fuel assemblies are removed from the reactor and replaced with new, or fresh, fuel assemblies. Nuclear plants like Prairie Island must be shutdown for refueling.

<u>Reload:</u> The fresh assemblies that replace the discharged spent fuel assemblies during a refueling.

<u>Rem:</u> A rem is a unit used in radiation protection to measure the amount of damage to human tissue from a dose of ionizing radiation.

Appendix B
Discussion of Nuclear Fuel Cycle

Fission and Radioactive Decay

Atoms of most substances are stable. They have no tendency to break up into simpler atoms. Some complex atoms, known as radioisotopes, are unstable (radioactive) and undergo a spontaneous decay process, emitting radiation until they reach a stable form. The decay process takes, depending on the type of atom, from a fraction of a second to billions of years. Some radioisotopes are fissile, meaning that they can split, or "fission", when neutrons (a form of sub-atomic particle) are added to their atomic nuclei or, in some circumstances, spontaneously. Only one fissile element, uranium-235 (U^{235}), exists in nature. Others are produced artificially when "fertile" atoms such as U^{238} absorb neutrons and subsequently decay to fissile isotopes, like plutonium-239. (In the natural state, uranium is 0.7% U^{235} and 99.3% U^{238}.)

During fission, the nucleus of the atom splits into two smaller nuclei called fission products, releasing neutrons, radiation and heat in the process. The released neutrons can cause nearby atoms to split, and, given enough fissionable material, an ongoing chain reaction can begin. Such a chain reaction generates heat, primarily from the fission process itself and secondarily from the subsequent decay of the radioactive fission products. Uncontrolled, a nuclear chain reaction could end in an atomic explosion. In a nuclear reactor, however, the fissile atoms (U^{235}) are diluted with many non-fissile atoms (U^{238}, boron and other materials) that absorb neutrons so that the chain reaction is maintained in a controlled manner which cannot produce an explosion.

Uranium Fuel Manufacturing

Figure 1 depicts the uranium fuel cycle as currently operating in the commercial nuclear power industry in the United States. In this cycle uranium ore, the raw material of reactor fuel, is extracted from surface and underground mines. The uranium ore is crushed and ground, then chemically treated to extract uranium oxides and produce yellowcake (U_3O_8). Yellowcake is then converted to uranium hexafluoride gas (UF_6), which has a concentration of U^{235} of 0.7 percent.

This percentage of U^{235} is not high enough for economical operation of light-water reactors, the predominant type used in the United States. Through a process called "enrichment" the percentage of U^{235} is increased to 3-4%. The enriched UF_6 gas is then converted to solid uranium dioxide (UO_2), shaped into pencil eraser-sized pellets, and loaded into long metal fuel rods. The rods are sealed and arrayed in fuel assemblies of 50-300 rods for use in nuclear power reactors.

Use of Nuclear Fuel for Electric Power Generation

Nuclear power generating plants which use ordinary water as the reactor coolant are called "light-water reactor power plants" (LWR). In the LWR, the fuel assemblies are immersed collectively in water within the reactor core. Control rods containing neutron-absorbing materials are interspersed among the fuel rods to control the number of nuclear reactions in the reactor fuel. Heat from fission and decay of the nuclear materials heats the water to steam. One type of LWR, called a "boiling-water reactor", uses this steam directly to turn turbines and generate electricity. In others, called "pressurized-water reactors" (like the two reactors at Prairie Island), the cooling water is pressurized to prevent boiling and is used instead to transmit heat from the core to boil water in a separate steam generator.

Keeping a reactor operating at a constant power level requires the maintenance of a delicate balance between neutron production and absorption. If the rates of neutron production and absorption are equal and at steady-state, the reactor is said to be "critical". (This term sounds bad, or at least scary, but that is not in the case. It is only the term which is used.) It is the goal of reactor operators to keep the reactor critical during all phases of power generation. This is done by inserting control rods into the reactor core and using neutron-absorbing materials such as boron in the cooling water when the fuel is fresh, and gradually diminishing these controls as the U^{235} in the fuel is spent.

Spent Fuel and the Nature of Radiation

After a period of time (about 3 years), the buildup of fission products and the depletion of U^{235} in a fuel assembly impedes the efficiency of the chain reaction. When the concentration of U^{235} in the fuel is less than 1%, the assembly is considered "spent" and is removed from the core and replaced with fresh fuel. The term "burnup" is used as a measure of how much energy a fuel assembly produced during the time it was in the reactor.

Spent fuel is extremely hot (both in terms of heat and radioactivity) when it is initially discharged from the reactor. For this reason, it is stored in water basins called spent fuel pools to provide the cooling and radiation shielding that it requires. The heat and radioactivity diminish rapidly in the first year, and more slowly in subsequent years.

Table Appen. B-1 shows the decay chain for uranium-238 (the predominant form of uranium in spent fuel), the daughter compounds produced and their half-lives. It also shows the type of radiation emitted from these compounds. Radiation is emitted by the atoms as they decay into simpler forms, and can be of three basic types: alpha, beta and gamma. Radiation is energetic and as it passes through plant or animal tissue it can kill or damage cells or cell components by tearing electrons away from molecules or atoms. The severity and type of damage is dependent upon the type of radiation exposure level and the sensitivity of the exposed cells.

The differences between the types of radiation can be summarized as follows:

Alpha radiation is the least penetrating, but most energetic type of radiation. It will be stopped by a sheet of paper, or by skin. If ingested or inhaled, alpha radiation can concentrate and cause severe damage to a localized area, such as a human organ.

Beta radiation has the ability to penetrate through skin or one-half inch of water. Beta radiation can also enter the body through ingested food and water or inhaled air. Once inside the body, some beta-emitting radionuclides tend to concentrate and remain in bones or certain organs and cause continued exposure.

Gamma radiation does not consist of particles like alpha or beta radiation. Instead, gamma radiation causes the emission of high-energy electromagnetic waves. These waves are similar to x-rays, but are more powerful. These waves require thick shielding because of their intense penetrating power and potential to damage human organs.

TABLE Appen. B-1: URANIUM-238 DECAY CHAIN

Daughter Element	Type of Radiation	Half-Life
Uranium-238	Alpha, Gamma	4.5 Billion Years
Thorium-234	Beta, Gamma	24.1 Days
Proactinium-234	Beta, Gamma	1.2 Minutes
Uranium-234	Alpha, Gamma	247,000 Years
Thorium-230	Alpha, Gamma	80,000 Years
Radium-226	Alpha, Gamma	1,622 Years
Radon-222	Alpha	3.8 Days
Polonium-218	Alpha, Beta	3.0 Minutes
Lead-214	Beta, Gamma	26.8 Minutes
Bismuth-214	Alpha, Beta, Gamma	19.7 Minutes
Polonium-214	Alpha	0.00016 Second
Lead-210	Beta, Gamma	22 Years
Bismuth-210	Alpha, Beta	5.0 Days
Polonium-210	Alpha, Gamma	138.3 Days
Lead-206	- None -	Stable

References:

1. "A Guidebook to Nuclear Reactors"; Anthony V. Nero, Jr.; University of California Press; 1979.

2. "Radioactive Waste Technology"; A. Alan Moghissi, Herschel W. Godbee, and Sue A. Hart, editors; American Society of Mechanical Engineers; 1986

3. "Managing the Nation's Commercial High-Level Radioactive Waste"; Office of Technology Assessment, Congress of the United States; 1985.

4. "The Nuclear Waste Primer, A Handbook for Citizens"; League of Women Voters, Education Fund; 1985.

Appendix C
Fuel Handling Reliability

Prairie Island has received no citations from the Nuclear Regulatory Commission related to the spent fuel pool. There have been no incidents resulting in release of radioactive materials, nor loss of normal cooling necessitating emergency shutdown. Only one significant fuel handling event has occurred during plant operation.

On December 16, 1981, during a fuel transfer operation in the Prairie Island spent fuel pool, the upper end fitting of one assembly separated from the rest of the fuel assembly. The upper end fitting stayed with the handling tool. The rest of the assembly fell a few inches to rest on top of the rack underneath it, and came to rest leaning at a 30 degree angle against the pool wall. A special tool was designed for moving this damaged assembly, and the damaged assembly was subsequently replaced in the storage rack. There was no release of radioactivity and visual examinations did not reveal any damaged fuel rods.

Studies of the fuel assembly determined that the cause of this event was corrosion, caused by an unidentified corrosive material temporarily present in the pool. Since no on-going problem was detected, the NRC investigation concluded this was an isolated event, with low potential for recurrence.

Specifically, the NRC concluded that "the spent fuel assembly top nozzle degradation event was an isolated incident and does not appear at the present time to have any generic implication regarding fuel assembly design, fabrication, handling, and storage. Therefore, the staff does not recommend modifications to fuel assembly design, manufacturing, and quality control. The staff also determined that the current guidelines on primary and spent fuel pool water chemistry specifications and monitoring techniques are adequate and, therefore, need no additional guidance. The staff concludes that a dropped fuel assembly resulting from top nozzle failure would not lead to criticality hazard, and in case of such an accident, it would generate radiation levels at the site boundary that are well within the 10 CFR 100 guidelines. The staff further finds that a potential fuel assembly nozzle separation during reactor operation is not an unreviewed safety problem. Therefor, the staff concludes that the spent fuel assembly failure inside the spent fuel pool does not constitute a safety problem, and the staff has reasonable assurance that the public safety and health are protected." (Source: "Safety Evaluation By The Office Of Nuclear Reactor Regulation, Northern States Power Company, Prairie Island Units 1 and 2, Dockets 50-282 and 50-306, Spent Fuel Assembly Degradation, December, 1981.)

Comment 13AA requested more information on the 1978 steam release accident at the Prairie Island plant. NSP has provided the following response. On October 2, 1979, a tube break occurred in #11 steam generator of the Prairie Island Nuclear Generating Plant, Unit 1. A wire coil spring lodged at the bottom of the steam generator was identified as the cause of the tube rupture. The accident resulted in an unplanned 27-minute release of a minute amount of short-lived radioactive gases into the plant and off-site environment. Readings taken from air monitoring samples were unable to detect any releases above normal background levels. Based on samples taken, the calculated maximum level at the site boundary was less than 0.2 millirem. This amounts to less than 10 percent of NSP's license limit as contained in the plant's technical specification.

It should be noted that all engineered safety systems functioned as designed and the plan operating staff accomplished safe reactor shutdown, steam generator isolation, and RCS cooldown in an expeditious manner following existing operating procedures.

Regulatory and offsite Agency notifications associated with this event were prompt. The Emergency Director declared a site emergency at 1430. Offsite notifications are not required for a site emergency; however, the Emergency Director deemed the event significant enough to alert the offsite agencies of the potential for possible offsite consequences. The Minnesota Department of Emergency Services (now Department of Emergency Management), Governor of the State of Minnesota, Nuclear Regulatory Commission, and NSP General Manager of Power Production were all notified within 15 minutes. The Minnesota Department of Health also received notification.

There was no harm to humans, plants or wildlife. Inspectors from the NRC noted that there were no items of noncompliance or deviations identified during the inspection. The environmental impact of the releases of radioactivity from the air ejector resulting from the tube rupture showed no detectable activity above background. Ninety-five percent of the release consisted of xenon-133, xenon-135, and krypton-87. No radioiodine activity was detected in the release. No detectable activity above background was found in air particulate filter samples taken from the onsite air sampling stations. In addition, health physics surveys taken onsite and offsite showed no detectable activity above background. Inspectors also collected air particulate, soil, and vegetation samples and results indicated levels were at background.

As a result of this accident, NSP has undertaken a program of conducting eddy-current testing of 100 percent of all tubing in the steam generator at each refueling outage. Most utilities only conduct sample testing. In addition, we plug degraded tubing as necessary.

An exhaustive Corporate and State Emergency Response plan is in existence to respond to any possible future incidents. This plan has been reviewed and approved by the NRC and the Federal Emergency Management Agency (FEMA). NSP also installed a telephone call-in service for the area residents to receive taped messages in order to keep them informed.

Following the accident, area residents were invited to attend a public meeting on October 11 in Red Wing, Minnesota at the First

Northwestern National Bank Building to receive information on the accident and discuss ways to effectively communicate in the future.

Concerning the 1985 incident, a question was raised as to the release of Krypton-85. There was no release of Krypton-85 nor was anyone exposed during this incident.

Appendix D
History of Spent Fuel Storage at Prairie Island

At the time the Prairie Island Plant was constructed, NSP, like other utilities, planned to ship spent fuel to a commercial reprocessing facility. Therefore, the two pools were built to provide the capacity to store 210 fuel assemblies, the normal annual 40-assembly discharge from each reactor during its holding period (60-120 days) prior to shipment for reprocessing, plus one entire reactor core (121 assemblies) in the event there was scheduled or unanticipated removal of all the fuel from one unit. The larger of the two pools was designed to store spent fuel, while the smaller pool was intended primarily to handle a spent fuel shipping cask.

In the mid-1970's, it became apparent that reprocessing facilities would not be fully operational in time to take spent fuel from the Prairie Island Plant, so the first reracking project was initiated in 1975 to increase the pool storage capacity. The new storage rack design provided 132 storage locations in Pool 1 for full core off-load capability and 555 storage locations in Pool 2 to accommodate normal annual refueling.

In April, 1977, the federal government announced a change in policy, wherein the reprocessing of spent fuel would be deferred indefinitely. For this reason, NSP decided to rerack the pool a second time, using a rack design that would achieve maximum utilization of the pool. NSP applied to the Nuclear Regulatory Commission (NRC) in January, 1980, for a license amendment, and to the Minnesota Energy Agency in September, 1979, for a Certificate of Need. (The Certificate of Need program was transferred to the Public Utilities Commission effective July 1, 1983.) An Environmental Impact Statement for this project was not required. The NRC approved the license amendment in May, 1981, and the Energy Agency granted a Certificate of Need in February of 1981. Installation of the new racks was completed in 1981, and resulted in the current pool storage capacity of 1386 assemblies.

In 1987, NSP conducted a demonstration of fuel consolidation in order to gain the experience and information needed to evaluate its potential to meet Prairie Island's spent fuel storage needs. The consolidation demonstration took place at Prairie Island in the fall of 1987, and did succeed in achieving a 2 to 1 fuel consolidation ratio. However, NSP decided against consolidation to meet Prairie Island's long term storage needs for two main reasons. First, fuel consolidation could not meet life-of-plant storage needs. The Department of Energy's High-Level Radioactive Waste Disposal Program had encountered significant delays, increasing the likelihood that life-of-plant storage would be required. Second, fuel consolidation would be more likely to interfere with normal plant operations. This stems from the fact that consolidation is a time-consuming operation and would have to take place in the spent fuel pool for six months of each year in order to keep up with the spent fuel generation rate.

Appendix E
Significance of Prairie Island to the NSP System

The Prairie Island plant consists of two nominally rated 550 megawatt nuclear units. These units provide approximately 15% of the total resource capacity owned by NSP. During 1989, the Prairie Island plant produced 8,279 million kilowatthours (KWh) of energy which was approximately 25% of the total energy requirements of NSP's retail customers.

NSP states that the Prairie Island units provide electric energy for the lowest production cost of any resource available. Consequently, these units are scheduled for full output operation during all available hours. The plant's operational availability was 88% in 1988.

A national survey conducted in 1989 by the Utility Data Institute ranked the Prairie Island plant third in the nation for least cost electricity production. Costs to produce a megawatt hour was reported to average $10.40 at the Prairie Island plant.

Appendix F

Considerations and Data Sources Used in Developing Cost Figures In Chapter 5, Alternatives: Other Dry Storage Technologies

<u>For Other Metal Casks, Modular Concrete, Concrete Casks and Storage/Transport Casks</u>:

Up front costs: Supplied by NSP in 7/23/90 transmittal

Cost of dry storage per fuel assembly (FA): Supplied by NSP, same

O&M cost per year: Supplied by NSP, same source

Number of FA generated per year: 72 - supplied by NSP in Scoping Document

Cost per year to store: 72 x [Cost per FA]

Midrange cost per year to store: Calculated by average of range

Cost to store to 1995:
(Assumes that dry storage is used in all of 1993.)
2 years x [Midrange cost per year] + Up front cost

Cost to store to 2005:
12 years x [Midrange cost per year] + Up front cost

Cost to store to 2015:
(Assumes full operation during that period)
22 years x [Midrange cost per year] + Up front cost

<u>For Vault</u>:

Up front costs: Supplied by NSP in 7/23/90 transmittal

Cost of dry storage per fuel assembly (FA): Supplied by NSP, same

O&M cost per year: Supplied by NSP, same source

Number of FA generated per year: 72 - supplied by NSP in Scoping Document

Cost per year to store: O & M cost (no modular addition of capacity)

Cost for additional capacity: Supplied by NSP in 7/23/90 transmittal

Midrange cost per year to store: Calculated by average of range

Cost to store to 1995:
(Assumes initial construction provides containment for 6 years)
2 years x [Midrange cost per year] + Up front costs

Cost to store to 2005:
Additional capacity needed in 1999, 2002 and 2005.
12 years x [Midrange cost per year] + 3[Additional cap. cost] + Up front costs

Cost to store to 2015:
More additional capacity needed in 2008, 2011, 2014
22 years x [Midrange cost per year] + 6[Additional cap. cost] + Up front costs

Appendix G
Federal Radiation Protection Standards

INTRODUCTION

Federal radiation standards are referred to repeatedly in the main text, but may require some additional explanation and background. The Nuclear Regulatory Commission (NRC) licenses and regulates all handlers of commercial nuclear fuel. In order to meet general guidelines on radiation protection set by the Environmental Protection Agency, the NRC sets more detailed radiation protection standards specific to particular handlers of nuclear fuel (nuclear power plants, storage installations, etc.). These standards take many forms. While construction and engineering specifications are an important means of ensuring that EPA radiation guidelines are met, these are covered in the discussion of cask design and fabrication in Chap. III (further detail may be found in the Technical Specifications and Safety Analysis Report). This appendix is concerned only with the regulations dealing explicitly with radiation levels. These primarily take the forms of maximum permissible doses to ISFSI workers and the public, limits on releases of radioactive materials into the environment, and the ALARA principle, which requires operators of power plants or spent fuel storage installations to reduce radiation exposures to "as low as is reasonably achievable."

BACKGROUND ON UNITS OF MEASUREMENT, BACKGROUND RADIATION, AND EFFECTS OF LOW-LEVEL EXPOSURES

Scientists use a wide variety of measures to quantify radiation and radioactivity. The federal regulations which follow use rem and curies. A rem (roentogen equivalent, man) measures different types of radiation on a single, standardized scale, according to the effect they have on human tissue (rather than according to their energy, for instance). For example, because alpha radiation is unable to penetrate the skin, external exposure to alpha radiation is weighed less heavily than external exposure to an equal amount of gamma radiation, which is far more penetrating. A millirem is equal to one-thousandth of a rem. A curie is a measure of radioactivity equal to the quantity of radioactive material producing 37 billion disintegrations per second (the rate of decay of one gram of radium). A millicurie is one-thousandth and a picocurie equals one-trillionth of a curie. Federal radiation regulations categorize nuclear power plants according to their size, using gigawatts, or billions of watts, as a measure.

Most of the following discussion will be in millirem rather than in rem. As one basis for comparison, a typical chest X-ray delivers around 20 millirem. Inhabitants of the U.S. receive approximately 360 millirem of radiation per year on average, most of this from naturally-occurring sources. Over half of this total is from exposure to radioactive radon gas, which can seep into buildings through cracks in basements and similar routes and may accumulate to reach dangerous levels indoors. The widespread extent of high levels of radon has only been recognized within the past decade. As a result, more recent estimates of radiation exposure have been revised sharply upwards. Other major sources of radiation include medical X-rays, cosmic radiation, rocks and soil, and radiation from sources inside the human body (primarily potassium-40, a naturally-occurring isotope of the trace element potassium found in many foods). The most recent estimates by the National Council on Radiation Protection and Measurements (Report No. 3, 1988) of the average dose received by individuals in the United States are:

Naturally-occurring radiation -	Total: 295 millirem,	or 82% of total
Radon	200 millirem	55%
From inside human body	40 millirem	11%
Rocks and soil	28 millirem	8%
Cosmic radiation	27 millirem	8%
Artificially-produced radiation -	Total: 65 millirem,	or 18%
Medical X-rays	39 millirem	11%
Nuclear medicine	14 millirem	4%
Consumer products	10 millirem	3%
Others		less than 1%

Of course, a single person's exposure to radiation may vary a great deal from these averages. At the two extremes, Colorado residents receive about three times as much natural background radiation (from outer space and the earth) as do people living in the parts of the country with the lowest levels. Doses from radon and medical sources vary much more than this in individual cases. While the average radon level in homes is about 1.5 picocuries per liter, levels three times higher than this are common, and levels as high as 3500 pCi/l have been found in some homes. Similarly, patients treated with radiation therapy for cancer receive doses well above 14 millirem, while most people receive little or no radiation from this source.

While there is little uncertainty about measuring and quantifying exposure to such low levels of radiation, there is far more uncertainty about the effects low levels of radiation have. The effects of high level exposures to radiation (generally understood to be short-term doses of more than 10 rem) are comparatively well-documented and understood. Exposures to 50 rem or more over a brief period of time may produce visible symptoms of radiation sickness such as reddening of the skin and a drop in blood count. Doses over 200 rem may result in death within days or weeks due to immediate damage to and death of body cells. A dose of approximately 100 rem is believed to double the normal rate of cell mutation in humans (although this estimate is more imprecise, because it is based primarily on experiments with animals). While exposures to less than 50 rem generally produce no visible effects, there is consensus among scientists that doses of 10-50 rem are clearly associated with an increased risk of contracting cancer.

There is still considerable controversy surrounding levels of radiation below 5 or 10 rem, however, and this does not appear likely to change any time in the foreseeable future. The most recent report of the Committee on the Biological Effects of Ionizing Radiation (BEIR V, 1990) now estimates the increased risks of cancer and leukemia from exposure to low level radiation to be three and four times greater (respectively) than in the last such report (BEIR III) issued in 1980. Much of the controversy has centered around the "linear, no-threshold hypothesis," which posits that lower levels of radiation are quite simply associated with proportionately lower increases in genetic mutation and risk of contracting cancer, and that there is no completely "safe" level of radiation. The contrasting argument is that, because cells are able to heal themselves up to a certain point, exposing 1,000 people to 10 millirem is far less likely to cause cancer than exposing one person to 10,000 millirem (10 rem). Whereas the majority of the committee members producing BEIR III rejected this first hypothesis, BEIR V unanimously concluded that "the new data do not contradict the hypothesis, at least with respect to cancer induction and hereditary genetic effects, that the frequency of such effects increases with low-level radiation as a linear, no-threshold function of the dose." This does not mean they believe that it is true, only that the available evidence (in studies of human populations) does not prove it false. In fact, many animal studies suggest that cancer risk is reduced by a disproportionate amount at low levels, though by how much is open to even more debate.

Comment 9F states that the EIS should report that BEIR V (Report V of the Committee on the Biological Effects of Radiation, 1990) states "At such low doses and dose rates, it must be acknolwedged that the lower limit of the range of uncertainty in the risk estimates extends to zero" (p. 181). This is true. Immediately above this line it states "Since the committee's preferred risk models are a linear function of dose, little uncertainty should be introduced on this account, but departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction of either an increased or decreased risk. Refer to Appendix G., DEIS pp. A12-14.

While scientists continue to study and observe the survivors of the Hiroshima and Nagasaki A-bombs and other groups exposed to radiation, conclusive results will be hindered more by statistical limitations than by any gaps or shortcomings in scientific theory or technology. Because approximately 20% of all deaths in the U.S. are from cancer, it is very difficult to detect a statistically significant increase from radiation exposures of 5 rem, let alone 5 or 50 millirem. To take a prominent example, it is estimated that up to 10,000 excess cancer deaths could occur among the 75 million Soviets exposed to radioactivity after the Chernobyl accident. Yet because 9.5 million people would normally be expected to die from cancer in this population, the additional cancer deaths would be about a tenth of a percent of the total. This increase would be overwhelmed by the much larger random variations, making it impossible to detect any increase in cancer due to the Chernobyl accident. Other changes over time, such as in the survival rate of cancer patients, in accurate diagnosis and determination of the cause of death, and in reductions of other causes of mortality, will further cloud a change of several thousand additional deaths. Added to this is the difficulty of estimating accurately just how large a dose of radiation a person received. It may or may not be possible to detect a statistically significant increase in cancer among the 116,000 evacuated from the most-affected areas of the Ukraine and Byelorussia, who received the highest doses.

Despite all this uncertainty, it is certainly possible to place upper limits on the cancer-inducing effects of low level radiation. Since studies have determined the effects of doses of 10-50 rem with reasonable accuracy, the effects of 5 rem or 5 millirem will clearly be only a fraction of this. By using the linear hypothesis (and often multiplying this by some factor for safety) as a conservative estimate, researchers can describe a "worst case scenario" for increase in cancer deaths. And regardless of what may be learned (or hypothesized) in the future about the effects of low level radiation, there is no question that any dose on the order of a few millirem (and any associated effects) pales in comparison with those from sources such as radon, or with the difference between living in Denver and living at sea level. BEIR V estimates that a whole-body dose of 10 rem will cause a 0.8% increase in risk of death from cancer, or one additional cancer death for every 125 people exposed to 10 rem. This is on the order of one hundred times greater than the doses which would be received by the workers with the highest exposures (those moving, cleaning, and repairing the casks), and closer to a thousand times greater than the doses received by the nearest member of the public (assuming no benefit from air attenuation or shielding by buildings, trees, and uneven ground).

ENVIRONMENTAL PROTECTION AGENCY RADIATION PROTECTION STANDARDS

The Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) are the two primary federal agencies responsible for setting radiation protection standards which apply to an ISFSI. The EPA is responsible for developing general guidelines for the handling and management of radioactive materials. This is done primarily through radiation protection guides (RPGs), or maximum allowable doses which should not be exceeded under most circumstances. Separate limits exist for radiation workers, individuals members of the public, and larger sample groups of the general population. Relevant excerpts from the Code of Federal Regulations (CFR) Title 40 (EPA) governing nuclear power and spent fuel storage operations are:

40 CFR PART 190 - ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR NUCLEAR POWER OPERATIONS (Environmental Protection Agency)

Subpart B - Environmental Standards for the Uranium Fuel Cycle
190.10 Standards for normal operations

Operations covered by this subpart shall be conducted in such a manner as to provide reasonable assurance that:

(a) The annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations.

(b) The total quantity of radioactive materials entering the general environment from the entire uranium fuel cycle, per gigawatt-year of electrical energy produced by the fuel cycle, contains less than 50,000 curies of krypton-85, 5 millicuries of iodine-129, and 0.5 millicuries combined of plutonium-239 and other alpha-emitting transuranic radionuclides with half-lives greater than one year.

40 CFR PART 191 - ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR MANAGEMENT AND DISPOSAL OF SPENT NUCLEAR FUEL, HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTES (Environmental Protection Agency)
Subpart A-Environmental Standards for Management and Storage

191.03 Standards

(a) Management and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at all facilities regulated by the Commission (NRC) or by Agreement States shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from: (1) Discharges of radioactive material and direct radiation from such management and storage and (2) all operations covered by Part 190; shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other critical organ.

(b) Management and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at all facilities for the disposal of such fuel or waste that are operated by the Department (of Energy) and that are not regulated by the Commission (NRC) or Agreement States shall be conducted in such a manner . . . (see (a) above).

NUCLEAR REGULATORY COMMISSION RADIATION PROTECTION STANDARDS

The NRC licenses and regulates all handlers of fuel for commercial nuclear power plants, and develops and implements more specific standards to fulfill the EPA's guidelines. While the Department of Transportation has a role in regulating the eventual transport of spent nuclear fuel and the Department of Energy takes responsibility for its final disposal in a geological repository, they do not have any direct influence on standards for storage-only casks for spent fuel from commercial reactors.

ISFSI's are dealt with specifically in the Code of Federal Regulations Title 10 Energy, Part 72 (10 CFR 72), which outlines the licensing, siting, design, construction, operation, and quality assurance requirements for either an ISFSI or MRS (Monitored Retrievable Storage installation). Standards are set for both normal and off-normal conditions, and for accidents. "Normal conditions" mean on a continual, day-to-day basis. "Off-normal conditions," or "anticipated events," include events which are expected to occur only occasionally, on the order of once a year, such as power outages or the need to repair the monitoring system on one of the casks. "Accidents" are events which could occur during the operating life of the system that disrupt normal operations in some way, but are not certain to occur. The most extreme conditions foreseeable, such as a tornado missile striking a cask, an earthquake, or a 500-year flood, are termed "design basis accidents." Engineering standards for such qualities as the strength of the cask are covered in the appropriate discussion of storage cask design and fabrication in Chapter III. The standards for maximum permissible radiation exposure in the excerpts which follow are essentially the same as those outlined by the EPA in 40 CFR 191 above.

TITLE 10, CODE OF FEDERAL REGULATIONS -- ENERGY
PART 72. LICENSING REQUIREMENTS FOR THE INDEPENDENT STORAGE OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE

72.104 Criteria for radioactive materials in effluents and direct radiation from an ISFSI or MRS.

[a] During normal operations and anticipated occurrences, the annual dose equivalent to any real individual who is located beyond the controlled area must not exceed 25 mrem to the whole body, 75 mrem to the thyroid and 25 mrem to any other organ as a result of exposure to:

[1] Planned discharges of radioactive materials, radon and its decay products excepted, to the general environment.

[2] Direct radiation from ISFSI or MRS operations, and

[3] Any other radiation from uranium fuel cycle operations within the region.

[b] Operational restrictions must be established to meet as low as is reasonably achievable objectives for radioactive materials in effluents and direct radiation levels associated with ISFSI or MRS operations.

[c] Operational limits must be established for radioactive materials in effluents and direct radiation levels associated with ISFSI or MRS operations to meet the limits given in paragraph [a] of this section.

72.106 Controlled area of an ISFSI or MRS.

[a] For each ISFSI or MRS site, a controlled area must be established.

[b] Any individual located on or beyond the nearest boundary of the controlled area shall not receive a dose greater than 5 rem to the whole body or any organ from any design basis accident. The minimum distance from the spent fuel or high-level radioactive waste handling and storage facilities to the nearest boundary of the controlled area shall be at least 100 meters.

[c] The controlled area may be traversed by a highway, railroad or waterway, so long as appropriate and effective arrangements are made to control traffic and to protect public health and safety.

72.126 Criteria for radiological protection.

(2) Areas containing radioactive materials must be provided with systems for measuring the direct radiation levels in and around these areas.

(d) Effluent control. The ISFSI or MRS must be designed to provide means to limit to levels as low as is reasonably achievable the release of radioactive materials in effluents during normal operations; and control the release of radioactive materials under accident conditions. Analyses must be made to show that releases to the general environment during normal operations and anticipated occurrences will be within the exposure limit given in 72.104. Analyses of design basis accidents must be made to show that releases to the general environment will be within the exposure limits given in 72.106. Systems designed to monitor the release of radioactive materials must have means for calibration and testing their operability.

Relevant excepts from 72.3 Definitions

"Controlled area" means that area immediately surrounding an ISFSI or MRS for which the licensee exercises authority over its use and within which ISFSI or MRS operations are performed.

"Independent spent fuel storage installation" or "ISFSI" means a complex designed and constructed for the interim storage of spent nuclear fuel and other radioactive materials associated with spent fuel storage. An ISFSI which is located on the site of another facility may share common utilities and services with such a facility and be physically connected with such other facility and still be considered independent: Provided, that such sharing of utilities and services or physical connections does not: (1) Increase the probability or consequences of an accident or malfunction or components, structures, or systems that are important to safety; or (2) reduce the margin of safety as defined in the basis for any technical specifications of either facility.

STANDARDS FOR PERMISSIBLE RELEASES OF RADIOACTIVE MATERIALS

All of the radiation protection regulations above also include limits on allowable releases of radioactive materials, such as krypton-85 or plutonium. While direct radiation affects a person only as long as they remain near the source, radioactive materials which are breathed in or ingested continue to irradiate internal tissues for as long as the particles or traces remain in the body and the element remains radioactive (in the case of elements such as plutonium, which are radioactive for thousands of years, the second point is not an issue). An appendix to 10 CFR 20 (NRC) lists maximum permissible concentrations in air and water for more than 300 radioactive isotopes. These limits are not relevant to the proposed ISFSI, because even in the event of a design-basis accident, no release of radioactive particles or gases is expected to occur.

ALARA - "AS LOW AS IS REASONABLY ACHIEVABLE"

In addition to the previous numerical standards on doses and amounts of radioactive materials, licensees of nuclear fuel materials are required to adopt systems and procedures to reduce exposures to "as low as reasonably achievable" (ALARA), even when existing methods and procedures fall within the above limits (See 10 CFR 72.104 [3b] above). This requirement is found in 10 CFR 20 concerning all operations licensed by the NRC, and has been applied to nuclear power plants for a considerable length of time before ISFSI's were ever developed. The Department of Energy applies this standard to its non-commercial operations and contractors as well.

TITLE 10 CODE OF FEDERAL REGULATIONS -- ENERGY
PART 20. STANDARDS FOR PROTECTION AGAINST RADIATION

GENERAL PROVISIONS
20.1 Purpose

(c) In accordance with recommendations of the Federal Radiation Council, approved by the President, persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable. The term "as low as is reasonably achievable" (ALARA) means as low as is reasonably achievable taking into account the state of technology, and the economics of improvement in relation to -

[1] Benefits to the public health and safety,
[2] Other societal and socioeconomic considerations, and
[3] The utilization of atomic energy in the public interest.

The definition of the term "ALARA" in 10 CFR 72 (the chapter on licensing ISFSI's) is identical to the one used here. There are no firm standards for what is a reasonable expenditure weighed against a given improvement in radiation protection. Nonetheless, the NRC has invoked the principle with effect in decisions regarding licenses and permits for proposed nuclear activities. As one example, in 1981 the NRC denied an application from Duke Power Company to ship 400 spent fuel assemblies from Oconee Nuclear Station to its McGuire facility for storage (12 NRC 459 (1980), on the basis that expanding storage at Oconee was estimated to result in lower exposures to workers and the public.

The principal elements of an ALARA program are precautionary procedures, training and educational requirements for employees, and standards governing records, reporting, notification, and the disposal of wastes. An ALARA program for an ISFSI would include many of the same elements as the one for the Prairie Island power plant. Given the lack of any liquid wastes and the passive nature of the dry cask storage system, many precautions and procedures used at the power plant would not be needed at the storage installation. Many others parts of the program, such as security staff and decontamination facilities, already exist at the plant and would be shared.

Appendix K
Property Values Near Nuclear Power Plants

Many studies have been carried out on the effects the surrounding environment has on property values. Such studies have been carried out since the early 1970's on housing prices near highways, airports, fossil-fuel electricity-generating plants, a landfill, and a polluted bay, among others. These effects can be studied either by examining property values in the same area before and after a project is constructed (and see whether property values fall, or rise more slowly than in a comparable control area), or by comparing property values during one time period at different distances from the site, and seeing whether property values are lower nearer than they are farther away (all other things being equal). The second type of study is more complex, since it requires taking account of the age, size, condition, amenities, lot size, scenic view, nearby employment and services, and other characteristics of the houses which also affect property values, and which may vary a great deal from one neighborhood to the next. When data is not available from the time before a site was constructed or the change occurred, this is the only method available, and it may reveal important details that a study taken only over time may not. In either case (or in a combination of both), the data on house prices (and any other factors) is analyzed using statistical regression to find whether there is a significant difference in property values, that is, one large enough that it is unlikely to occur by random chance.

The first such study on the effect of nuclear power plants on property values was carried out in 1977-78 for the Nuclear Regulatory Commission by Hays B. Gamble (Associate Director, The Institute of Research on Land & Water Resources, Penn. State Univ.), R.H. Downing and O.H. Sauerlender. House selling prices and total assessed real property values were examined for areas within twenty miles of four nuclear power plants located in the northeastern United States. There were no significant differences between house selling prices close to the plant and prices 15-20 miles away for any of the four plants (1975-77), in fact, the nearer properties sold for slightly higher prices, all other factors being equal (house size, age, condition, lot, view, proximity to employment, etc. were all controlled for). Because detailed information on houses sold before the plants began operation was not available, the researchers used total assessed property values from 1960 to 1976 for the 64 communities in the four study areas. This method found that all four areas grew more quickly after plant construction than before, and the host communities grew more quickly than communities 10-20 miles away. In order to have sufficiently large numbers of house sales and descriptions of property to perform accurate statistical analysis (a total of 540 sales for all four areas), plants located in areas with less than 10,000 people living within five miles or those without sufficient or accessible information on real property transactions were excluded. Because of this, plant employment was least likely to have an effect on the demand for housing, compared with the economic effects of plants in less densely populated areas. Because they were not chosen randomly, the report warns that the results of this study only apply to these four plants, or to plants with similar locations and socioeconomics. At the very least, this report makes it clear that it cannot be assumed that all nuclear power plants lower the value of nearby property.

Shortly after the accident at Three Mile Island on March 28, 1979, Jon P. Nelson compared values of residential property before and after in Middletown and Valley Green Estates (located three and four miles away from the plant, respectively), with methods similar to to those used by Gamble and researchers performing the other studies mentioned above. He also looked at all house sales within five miles compared with a control area. He found no effects on property values due to the accident (he did not attempt to measure if an effect already existed before the accident occurred).

At about the same time, a survey of 26 residents living near an unnamed nuclear power plant in the Midwest found that 57% believed that their property had lost value in the three months since the TMI accident, and the average estimate they gave of the loss was 16%. While these perceptions did not match the results of any studies of actual house sales, even near a plant where an accident actually occurred, only those living within sight of the plant believed it would have any effects. Only one of the respondents living more than a mile away believed it would have any effect if they tried to sell their house.

Following the accident at TMI, Gamble performed a study similar to the one he had conducted several years earlier, but including a control area similar to the area around TMI (Williamsport PA, located 75 miles north). He examined data before the accident, after, and 1977-1979 combined. Controlling for all other effects on housing prices (approximately thirty variables, as mentioned in his first study), he examined housing prices several different ways, including taking account of miles from the plant, dividing the data into two areas within 5 miles and 5-25 miles away, and into areas 2 miles and 2-25 miles away. He looked at housing prices in different directions, to see if there was an effect only "downwind", and examined low, middle and high-value houses to see if only certain types of properties were affected.

While there was a significant drop in the number of house sales which lasted four to eight weeks after the accident, there were no significant changes in property values as a result of the accident, as compared with prices beforehand and the control area. Statistical analysis by number of miles from the plant (both before and after) did determine that housing prices nearer the plant tended to be lower than those farther away. This was also true of the area within five miles of the plant, as compared with areas more than five miles away. However, it was <u>not</u> true of the area within two miles of the plant, indicating that the lower-than-expected property values were not nearest the plant, as would be expected if the nuclear plant was affecting the prices, but because of some other factor in the area three to five miles away. The principal communities in this area were Middletownwn-Steelton, old industrial towns which had been affected by the declining steel industry and the closing of Olmstead Air Force Base in the mid-1960's, which had formerly employed 12,000 civilians. Examination of property values in a five-mile radius of TMI as far back as records show (1966) indicated that the area had historically had lower property values as far back as eight years before TMI became operational, indeed, the difference between property values in the area within five miles of the plant and the area 5-25 miles away had lessened considerably between 1966 and the time the plant began operation, and had remained fairly constant since. These conclusions on the basis of sales and price data were confirmed by interviews with local realtors, building contractors, and financial institutions handling mortgages, who generally agreed that while sales dropped off dramatically for one or two months after the accident.

After these results were published in the Journal of Regional Science, there were several responses which offered possible explanations as to why Gamble's studies might not have detected the negative effects of nuclear power plants on property values. One pointed out that considerable amounts of property taxes paid by nuclear power plants allow host communities to lower residential and commercial property taxes, making property in the community more attractive (Bjornstad & Vogt). This, they point out, would explain lower property values 3-5 miles away, but not in the immediate vicinity of TMI. Gamble responded that property taxes were one of the housing variables considered in both his studies, and that this could not be a factor at TMI in any case, because power plants do not pay any local taxes in Pennsylvania.

Another contributor (Galster) pointed out that Gamble had only studied effects on property values at least three years after the plants were operational, and that even if there were no effects on property values over the long run, there could well be short-term negative effects on property values during an adjustment period, while those who object most strongly move away, leaving those who are relatively indifferent. In order to study such a short-term effect at these reactors, data on housing characteristics needed to be collected immediately after, if not before, the construction of the new nuclear reactors was announced, and again during the time period when the reactors were being constructed. While Gamble accepts that such a temporary effect on property values could exist, and that his studies would not measure such an effect before the plants began operation, he does not see evidence of it in the case of TMI or the other plants he studied.

A study has also been conducted on "The Effects on Property Values of Proximity to a Site Contaminated with Radioactive Waste" (Payne & others). In 1976, it was discovered that the Kerr-McGee radioactive waste site in West Chicago, Illinois had been contaminated with thorium ore and thorium nitrate decades earlier when it had been an industrial site. Three researchers examined property values before and after the revelation (from 1973 through 1982), within two blocks and from two blocks to a mile from the site, and for both newer and older homes. They found a significant and prolonged negative effect on the property values of older homes within two blocks after the contamination was discovered. They found no effects on older homes in the area two blocks to a mile from the site, or on newer homes at any distance, and they found no evidence that the presence of a radioactive waste site had any effect on property values before 1976. While the negative effects on values of nearby older homes likely diminished with distance rather than dropping off suddenly at a distance of two blocks, it is evident that the effect did not extend further than a fraction of a mile in any case.

It is important to stress that these results were for particular plants at particular times. Even though no negative effects on property values were found at these sites in 1979, this does not mean that they might not exist at some point in the future or at different sites. At least at the present time, it is hard to imagine that anxiety about living near commercial nuclear power plants would be as high or higher now than it was immediately after the accident at Three Mile Island. It is not at all clear whether a similar study could ever be reliably conducted near Prairie Island. The much lower population density in the vicinity of Prairie Island (less than than 30 people per square mile within three miles of the plant) means that there might well be too few house sales near the plant for statistical analysis (all five of the nuclear power plants studied were located in counties with populations of 220,000 to 700,000, compared with about 42,000 in Goodhue County).

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TOLERABLE RISK

Section of Health Risk Assessment

Minnesota Department of Health

September 1985

TOLERABLE RISK

Issue

From the standpoint of public health, possible biological effects from exposure to contaminated groundwater include: acute, subacute, or chronic toxicity; mutagenicity; teratogenicity; and carcinogenicity. It is the consensus of scientists that these end points can be considered to be either threshold or nonthreshold phenomena (NAS, 1977). Biologically, threshold represents a no-effect level explained by an organism's resistance or sum total of defense mechanisms in the face of toxicologic challenge. In contrast, chemical carcinogens are considered to be nonthreshold agents, since a single genotoxic molecule can be assumed to interact with the cell's DNA and, thereby, result in a malignant growth. While not all carcinogens are genotoxic, epigenetic carcinogens are treated conservatively using the nonthreshold hypothesis since sufficient data are not yet available to resolve this issue.

Threshold agents have long had available conventional toxicologic methods for the estimation of safe exposure levels for humans (i.e., levels below which no serious effect is expected). The most commonly used and accepted method involves the application of safety factors to the "no observed effect level" in animal studies. To achieve the same level of protection for nonthreshold agents; i.e., carcinogens, criteria or standards would have to be set at a zero exposure level.

A number of factors prohibit this approach. In some instances potential carcinogens are found in the environment at naturally occurring background levels and their removal is an impossibility eg., naturally occurring ionizing radiation. Most potential carcinogens enter the environment as a result of the activities of a technology based society. For the most part, these activities are of considerable benefit to society e.g., electric power production, chlorination of public water supplies, etc.. To require a zero exposure level associated with these activities could result in an unacceptable loss of benefits, increased economic cost, or even increased health risks (for example an increase in communicable disease as result of non-chlorination of public water supplies).

Since nonthreshold agents cannot always be prevented from entering the environment or completely removed once they have found their way into the environment, it becomes a matter of managing the risks associated with exposure to these agents in a way that is tolerable to society. This then is the central issue of this report; what level of risk is tolerable for a potential life-time exposure to nonthreshold agents?

The concept of tolerable risk is often called acceptable risk. The term "risk acceptability" conveys the impression that society purposely accepts risks as the reasonable price for some beneficial technology or activity. For some special cases, this may approach reality. Hang-gliding, race-car driving, mountain climbing, etc. are all voluntary high-risk activities in which the benefits are intrinsically entwined with the risks. These activities are exhilarating because they are dangerous. But most risks of concern are the involuntary, undesired and often unforseen by-products of otherwise beneficial activities or technologies. Since most risks are imposed on a less than fully informed risk-bearer, the reponse is more properly thought of as tolerance rather than acceptance (Kates, 1983; Kasperson, 1983).

The remainder of this report examines the issue of a tolerable level of risk for exposure to nonthreshold agents. The current MDH procedures regarding tolerable risk levels are explained. The methods used to examine this issue are outlined. The various decision analysis methods used in risk management are discussed and a recommendation is made for a tolerable risk level.

Current MDH/MPCA Procedures

In 1977 the Minnesota Department of Health formalized environmental health risk assessment activites with the creation of the Section of Health Risk Assessment (HRA) in the Division of Environmental Health. In 1980-81 HRA conducted a critical review of the risk assessment/risk management literature (Gray, 1981). Included in this review was an examination of the tolerable risk issue. This report concluded that the "benefit-risk analysis" method proposed by Starr (1969, 1972) was the best alternative for the selection of a lifetime tolerable risk. Using this method HRA derived a lifetime tolerable risk level of 10^{-5}. Since this time, whenever risk assessments have been conducted on various nonthreshold agents and there are no existing state or federal standards for these agents, the Department has made recommendations for action based on this level of risk. A lifetime risk of 10^{-5} means that during the 70 year period assumed to comprise a lifetime, one extra adverse effect (usually a cancer) will occur for each 100,000 persons exposed.

The Minnesota Pollution Control Agency has, as a matter of policy, relied on the MDH for the conduct of risk assessments and decisions regarding tolerable risk.

Methods Used to Examine the Issue of Tolerable Risk

Since this report is basically a reexamination of the issue of tolerable risk, HRA's efforts were directed toward determining what changes in philosophy, theory, methods, and actions, regarding this issue, have occurred since 1980. To accomplish this task, HRA surveyed the pertinent literature from 1980 to the present; and also, contacted a number of scientists and regulators, outside the state of Minnesota, to solicit their input.

These discussions are summarized in the following section. The literature review, which includes Gray's 1981 report and the present survey, is presented in the section on "Alternatives for the Selection of a Tolerable Risk Level". A bibliography is provided at the end of this report.

Summary of Outside Contacts

Between twenty to thirty contacts were made with state and federal scientists and regulators with experience in risk assessment and risk management. Information was obtained from seven states (California, Florida, Michigan, New Jersey, New Mexico, New York, and Wisconsin) that have been active in setting maximum contaminant levels (MCLs) for substances in drinking water. In these states, MCLs for nonthreshold agents are based on lifetime excess cancer risk levels ranging from 10^{-5} to 10^{-6}. From the information available it appears that none of these states have developed their risk management guidelines or regulations based on quantitative methods, i.e., benefit-risk, cost-effectiveness analysis, balanced risk, etc.. In several states (Wisconsin, New Jersey, and Florida) the legislature simply mandated a lifetime tolerable risk level. None of the states contacted were able to provide documented rationale for their choice of a lifetime tolerable risk level.

Numerous contacts were also made with various Environmental Protection Agency Programs including: Drinking Water Section, Office of Safe Drinking Water, Region V; Health Effects Branch, Office of Drinking Water, Region V; Environmental Criteria Assessment Office, Office of Research and Development, Cincinnati; Criteria Standards Division, Office of Drinking Water, Washingtion D.C.; EPA Science Advisory Board, Washington D.C.; and the Carcinogen Assessment Group, Office of Research and Development, Washington D.C..

EPA is at the forefront in the development of risk assessment methods and also in performing risk assessments on potentially hazardous substances found in the environment. However, for pollutants that they do not regulate or are in the process of regulating EPA will not give guidance on tolerable risk. EPA officials repeatedly indicated that decisions on tolerable risk are the responsiblity of the individual states. Their reasoning is that the factors that impact tolerable risk vary from area to area, i.e. state to state. These factors might include public perception and awareness of the seriousness of environmental contamination problems, public willingness to underwrite the costs of clean-up and control, impacts of regulatory decisons on local and state job markets, political climate, etc..

Alternatives for the Selection of a Tolerable Risk Level

Risk assessment or estimation is the measurement of consquence likelihood. Once such estimates have been generated, the meaning of the projected outcome must be evaluated. The evaluation of risk is variable and relative; however, a practical division between methods can be made by focusing the types of comparisons related solely to the risk in question, to other risks, to costs of avoidance and to benefits. What follows is a summary of methods which have been used to establish tolerable risk. These methods can provide a logical basis for the development of environmental exposure guidelines for nonthreshold hazards.

1. Aversive Methods

Aversive methods are directed toward the total avoidance of risk. Aversive risk judgements can be made by individuals or socities. Much regulatory activity is directed toward maximum aversion. Zero tolereance standards and standards at or below the dose-consequence threshold are examples of aversive risk evaluation. Wolf (1979) describes the Delaney Clause (Food Additives Admendment, 1958, Food and Drug Administration) as follows:

> ...Congress essentially said, there can never be any benefit in a food additive that is great enough to outweigh the risk of cancer, particularly if 100 million to 150 million consumers might be subject to this kind of risk over a period of time.

The effort by the Occupational Safety and Health Administration to establish a generic cancer standard is another example of an aversive approach (Kates, 1978). They suggest that for workplace exposures, the Delaney Clause approach (i.e., no exposure to carcinogens) is most efficacious. In discussing zero risk goal Starr et al. (1970) concludes the following:

> One criticism stems from the fact that in several cases, a zero risk goal has been established. This denies the concept of a trade-off between risk and benefit, and ignores the difficulty or impossibility of reaching zero risk.

Such standards often seem to be based on little logic; carcinogens are banned from food in the United States but not in water. If aversive methods involve any comparisons at all it seems to be with a higher power imperative, or postulate (Kates, 1978).

2. Balanced Risk

Balanced risk evaluation methods seek to compare and equalize the consequences of some proposed action or environmental exposure with those of commonly tolerated risks. To peform this comparison consequences need to normalized. Usually frequencies of mortality, morbidity, or damage are compared to encourage a desired action or reveal some inconsistency. An example of this approach is a study to develop earthquake codes for the City of Long Beach (Wiggins, 1972). Earthquake risks were compared with risks encountered everyday in the use of automobiles, at work, in public activities, and at home. The magnitude of these various risks differed and earthquake code standards were offered that lead to mortality of 10^{-5}, 10^{-6}, or 10^{-7} per person per year, the final selection depending on the risk aversiveness of the community.

One can gauge typical societal response to such comparisons by looking at actions commonly taken to avoid common risks as described by Otway (1970):

> Fatal accidents providing hazards on the order of 10^{-3} per person/year are uncommon. When a risk approaches this level, immediate action is taken to reduce the hazard. This level of risk appears unacceptable to everyone.
>
> At an accident level of 10^{-4} per person/year, people spend money, especially public money, to control the cause. Money is spent for traffic signs and control, and police and fire departments are maintained with public funds. Safety slogans popularized in the U.S. for accidents in the category show an element of fear, e.g., 'the life you save may be your own.'
>
> Mortality risks at the level of 10^{-5} per person/year are still considered by society. Mothers warn their children about most of these hazards (playing with fire, drowning, firearms, poisons), and some people accept a degree of inconvenience, such as not traveling by air, to avoid them. Safety slogans for these risks have a precautionary ring, 'Never swim alone,' 'Never point a gun at another person,' 'Keep medicines out of children's reach.'
>
> Accidents with a probability of about 10^{-6} per person/year are not of great concern to the average person. He may be aware of them, but he feels that they never happen to him. Phrases associalted with these occurrences have an element of resignation, 'Lightning never strikes the same place twice,' 'An act of God.'

The risks discussed above are a mixture of voluntary and involuntary risks. Starr's work (1969, 1972, 1984) indicates that the public considers involuntary risk 1,000 times less acceptable than voluntary risk. Others argue with the degree of this difference but not its existence (Lave, 1972; Rowe, 1975; Otway et al., 1975).

A fundamental concept to the notion of a balancing of risks, or any non-aversive method of evaluation, is the existence of some non-zero level of risk which is tolerable. Starr (1969, 1972, 1984) has pioneered the search for tolerable consequences embedded in broad, societal behavior. The work of Starr will be discussed in more detail in the section on benefit risk analysis.

3. Cost Effectiveness of Risk Reduction

This method involves a comparison of risk and the cost of actions necessary to prevent exposure to that risk. Such studies are sometimes referred to as cost-effectiveness studies. Such an analysis has been done by Sinclair (1972) who evaluated the effectiveness of preventive costs in industrial safety. Based on the level of risk and the cost of prevention, he calculated the implied life evaluation implicit in the preventive activity.

Comparative Risks, Safety Outlays and Implicit Life Valuations in Three United Kingdoms Industries.

Sector	Annual Risk per 1,000 workers of: Injury	Serious Injury	Death	Average Outlay (£/worker)	Valuation £
Agriculture	25.7	4.44	0.197	3 (1966-68)	15,000
Steel Handling	72.7 62.54	9.92	0.216	50 (1969)	230,000
Pharmaceutical	25.0 36.80	2.42	0.020	210 (1968)	10,500,000

The calculated life evaluation can be seen to vary widely for the various industries. This variability suggests either a difference in the perceived value of a human life between the three industries, or a difference in the awareness of hazard. In any case, such calculations can be used to evaluate and compare proposed risk reduction actions. This method can be taken one step further to cost-benefit analysis if one establishes the value of a human life for comparison with the cost of death prevention.

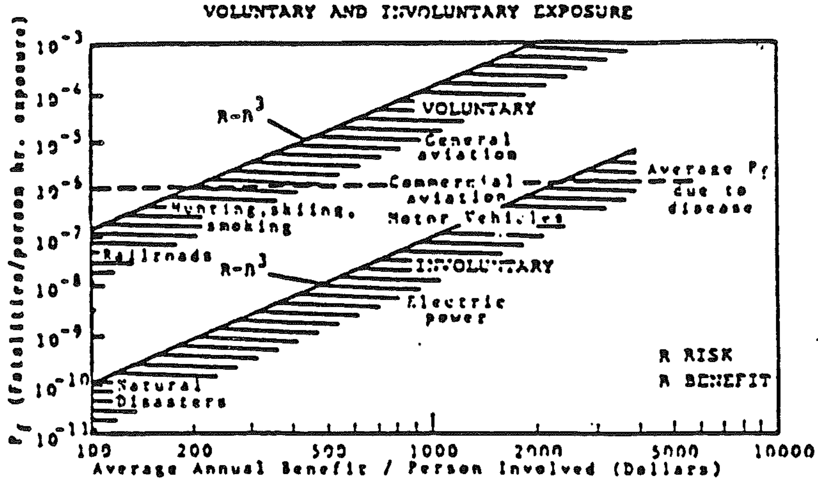
4. Benefit-Risk Analysis

Benefit-risk analysis is the comparison of risk level to benefit arising from the activity. The major distinction between this method and cost-benefit or cost effectiveness methods is the absence of any attempt to express risk in the same units as benefit for easy comparison. Rather, the relationship between benefit and risk which has been established by society is examined in an effort to predict tolerable risk for a situation of given benefit.

Estimates of mortality risk for a number of activities compared to the resulting benefits have been developed by Starr (1969, 1972, 1984). Historically, trade-off relationships between benefit and risk have been empirically determined. For example, automobile and airplane safety have continuously been weighed against the economic costs and operating performance. The trade-off process is a dynamic one with many parts of our society out-of-phase due to the separate "time constants" involved. Starr assumed that for historical situations a socially tolerable and optimum trade-off had been achieved and that the relationship between the two could be used for predictive purposes.

Starr found that risk increased approximately as the cube of benefit for both voluntary and involuntary risk.

VOLUNTARY AND INVOLUNTARY EXPOSURE

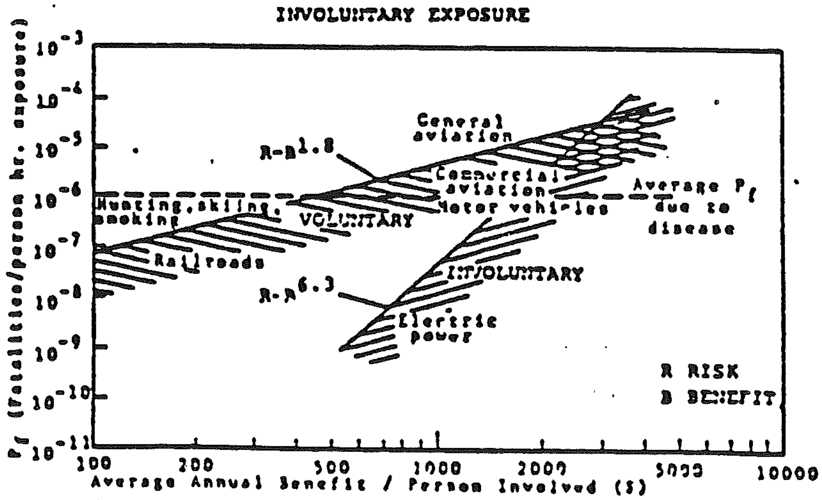


(Starr 1969)

(NOTE: An hourly risk ratio of 10^{-10} corresponds to an annual risk ratio of 8.8×10^{-7}).

Other authors have questioned the quantitative parameters of Starr's risk-benefit relationship.

B. REGRESSION LINES FOR VOLUNTARY AND INVOLUNTARY EXPOSURE



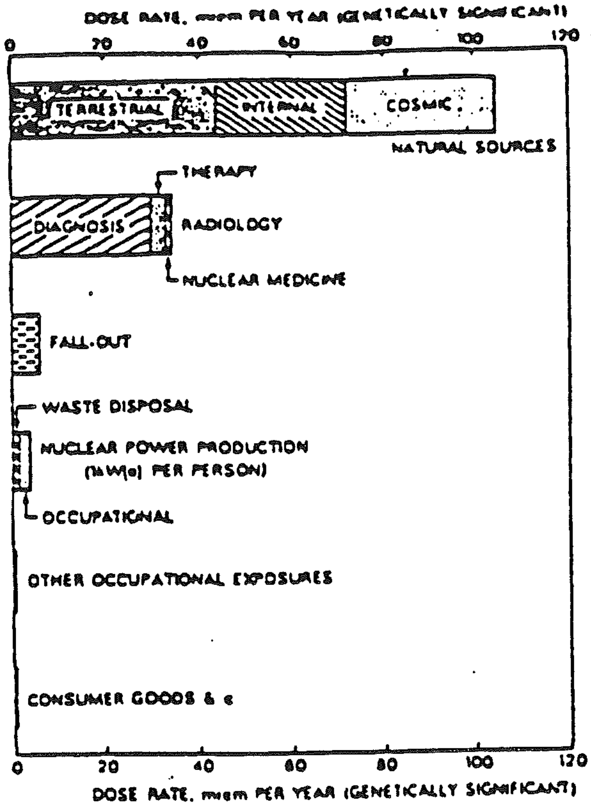
(Otway and Cohen, 1975)

Notice that the low risk region in the above curve gives similar risk-benefit ratios to Starr's; however, in the high risk region the variation in slopes significantly alter the benefit-risk relationship. Otway and others have suggested different quantitative relationships; however, Starr's basic concepts which relate benefit to risk have received general acceptance. These can be summarized by Starr (1972, pp. 38) as follows:

> 1. Rate of death from disease is an upper guide in determining the acceptability of risk - somewhat less than 1 (chance per person) in 100 years.
>
> 2 Natural disasters ('acts of God') tend to set a base guide for risk - somewhat more than 1 in a million years - similar to the intrinsic 'noise' level of physical systems. Man-made risks at this level can be considered almost negligible, and can certainly be neglected if they are several magnitudes less.
>
> 3. As would be expected, societal acceptance of risk increases with the benefits to be derived from an activity. The relationship appears to be nonlinear, with this study suggesting that the acceptable level of risk is an exponential function of the benefits (real and imaginary).
>
> 4. The public appears willing to accept voluntary risks roughly 1,000 times greater than involuntary exposure risks...

5. Risk Elevation

Somers (1979) suggests that looking at risk elevation is an additional way to estimate tolerable risk. If exposure is below the background level, the risk must be tolerable. For example, the dose of radiation routinely received from nuclear power production (does not consider accidents) can be compared with natural background exposure from other sources.



(NOTE: Annual genetically-significant dose rate as averaged through whole population).

Weinburg (1981) has also suggested this approach terming it a "de minimis" principle. He writes:

> ...a 'de minimis' principle: Below a certain level of exposure or insult, we shall simply accept whatever residual risk is incurred; we only assure ourselves that the risk is 'small'...Where the insult is a manmade addition to an existing background, as is the case for radiation, an exposure 'small' compared to the natural background seems to me to be a sensible standard...We make the implicit assumption that background radiation poses an acceptable risk, whatever that risk may be (and which we do not try to quantify).

For insults for which there is no background (e.g., many organic chemicals), Weinburg suggests a comparison of risk from exposure to that insult with risk from exposure to radiation at levels high enough so that each can be unequivocally determined. One would then invoke the following principle of consistency to determing an allowable level of exposure for the new insult.

> The allowable exposure to the chemical in question should cause no more damage than that caused by the "de minimis" level previously set for radiation. The damage caused by the "de minimis" level for radiation and for the chemical in question is determined by the linear hypothesis.

The problem with all of this is that background exposure, especially to radiation (see table on page 18, Commonplace Risks of Daily Life), is not acceptable not because the resulting risk is considered by society to be negligible, but rather because there is no alternative to its acceptance. There is no logic in adjusting our tolerance of hazard to levels which have nothing to do with our perception of or aversion to risk. Practical problems such as the wide variability of background concentrations would also arise. The above figure also demonstrates how the risks of two man-made exposures can be compared. The exposures from nuclear power production and radiology can be compared and the argument made that since the latter is higher and is tolerable, the former must therefore also be tolerable. Unfortunately, the argument ignores possible differences in benefit resulting from the two exposures.

Discussion

It is apparent from the above summary that the selection of a method to establish tolerable risk is a difficult decision. All of the methods have aspects to them that argue for and against their use. Risk-benefit analysis is intuitively appealing because it provides a quantitative methodology; however, benefits must be quantified or it must be assumed they are equal or are zero for the various alternatives. Risk elevation is also intuitively appealing, but logically flawed. The balancing of environmental risks with those commonly encountered is less objective than other methods but can be useful if one is careful not to lose sight of the magnitude of the benefits associated with the risks being compared.

Of the five methods reviewed the benefit-risk approach is, in HRA's opinion, is the most defendable. Its implications and how it was used to derive a tolerable risk level are discussed in the remainder of this section.

Starr and others have compared benefit and risk in the aggregate. Unfortunately benefits and risks are not distributed evenly over all members of society (Kates, 1978). Benefits may be concentrated and risk diffuse such as in the use of pesticides by farmers. Conversely, risks may be concentrated and benefits diffuse such as for occupational hazards. The distribution in time may also be uneven with immediate benefits and delayed risks as with the latent effects of chemicals. These inequalities make the application of benefit-risk relationships difficult to apply to individuals or special subgroups of the general population. Yet for the purpose of evaluating risk assessments, it is necessary to have an estimate of negligible risk which applies in the aggregate and which can be adjusted to accommodate the risk aversiveness of special subgroups.

It is entirely possible that special subgroups or individuals, such as those occupationally exposed, will derive considerable benefit from tolerance of a higher risk level. Clearly, tolerable risk for special population groups needs to be calculated on a case-by-case basis.

Not withstanding the above caveat, environmental risks can be balanced against commonly tolerated risks of equal or lower benefit for the purpose of establishing exposure guidelines. Starr (1969, 1972, 1984) classifies as "negligible" those risks which are lower than the probability of death by natural disaster, a probability of about 10^{-6} per year. This comparison should hold for risks of any benefit level since natural disasters have no concomitant benefits. It therefore follows that environmental exposures resulting in annual mortality risk ratios of 10^{-6} or less can reasonably considered "safe". Since this level of risk tolerance has been calculated from aggregate populations it should be applied to general population groups or "average" individuals in such a population.

One can develop a sense of how conservative such a guideline is by comparing it with comparing it with commonly experienced risks. Wilson (1980, 1982) has enumerated the following commonly tolerated risks. Wilson's data are consistent with Starr's conclusions about the risk-benefit relationship. Involuntary risks are less tolerable than voluntary risks and risks for activities with little or no benefit are less tolerable than risks with high concominant benefit. For example, tornadoes, hurricanes, and lightning have no benefit, are involuntary, and result in a low annual mortality risk. Auto racing is voluntary, with presumably a high payoff for the participating individual and a high risk level. The high air pollution risk level, while involuntary for the individual, is associated with the high societal benefits of energy production and is therefore tolerated.

		No. of deaths in 1975	Risk/years
Football	Averaged over participants		4×10^{-5}
Automobile racing			1.2×10^{-3}
Horse racing			1.3×10^{-3}
Motorcycle racing			1.8×10^{-3}
Powerboating			1.7×10^{-4}
Boxing (amateur)	40 hr/year engaged in sports		2×10^{-5}
Skiing			3×10^{-5}
Canoeing			4×10^{-4}
Rock climbing (U.S.)			10^{-3}
Sunbathing, mountain climbing (skin cancer risk curable)		300,000 cases	5×10^{-3}
Fishing (drowning)	Averaged over fishing licenses	343	1.0×10^{-5}
Drowning (all recreational causes) all over U.S.		4110	1.9×10^{-5}
Bicycling (assuming one person per bicycle)		1000	10^{-5}

Risks in sports

	Number of fatalities (in 1975 unless stated)	Risk/year
Mining and quarrying (accident only)	500	6×10^{-4}
Coal mining		
Accident (average 1970–1974)	180	1.3×10^{-3}
Black lung disease (1969)	1135	8×10^{-3}
Agriculture		
Total	2100	6×10^{-4}
Tractor driver (one driver/tractor)		1.3×10^{-4}
Trade	1200	6×10^{-4}
Manufacturing	1500	8×10^{-5}
Service	1800	9×10^{-5}
Government	1100	1.1×10^{-4}
Transportation and utilities	1600	3.3×10^{-4}
Airline pilot		3×10^{-4}
Truck driver (one driver/truck)	400	10^{-4}
Jet-flying consultant and professor		10^{-4}
Steel worker (accident only) (1969–1971)	66	2.8×10^{-4}
Railroad worker (1974) (all accidents excluding grade crossing)	688	1.3×10^{-3}
Fire fighters (1971–1972 average)		8×10^{-4}

Current occupational risks * Accuracy approximately 30%.

	No. of deaths in 1974	Risk/year
Motor vehicle (in 1975)		
Total	46,000	2.2×10^{-4}
Pedestrian (certainly involuntary)	8,600	4×10^{-5}
Home accidents (1975)	25,500	1.2×10^{-4}
Alcohol		
Cirrhosis of the liver (1974)		1.6×10^{-4}
Cirrhosis of the liver (moderate drinker)		4×10^{-5}
Air travel		
One transcontinental trip year		3×10^{-6}
Jet-flying professor		10^{-4}
Accidental poisoning		
Solids and liquids	1,274	6×10^{-6}
Gases and vapors	1,518	7×10^{-6}
Inhalation and ingestion of objects	2,991	1.4×10^{-5}
Electrocution	1,157	5×10^{-6}
Falls	16,339	7.7×10^{-5}
Tornados (average over several years)	160	5×10^{-7}
Hurricanes (average over several years)	118	4×10^{-7}
Lightning (average over several years)	90	4×10^{-7}
Air pollution		
Total U.S. estimate (sulfates)	30,000	1.5×10^{-4}
Urban U.S. (benzo(a)pyrene)—cancer risk		3×10^{-6}
Vaccination for smallpox (per occasion)		3×10^{-6}
Living for 1 year downstream of a dam (calculated)		5×10^{-6}

Commonplace and therefore accepted risks of death (noncancerous)

	Risk/year	Estimated uncertainty (factor of 3)
Cosmic ray risks		
One transcontinental flight/year	5×10^{-7}	3
Airline pilot 50 hr month at 35,000 ft	5×10^{-5}	3
Frequent airline passenger	1.5×10^{-5}	3
One summer (4 months) camping at 15,000 feet	10^{-5}	3
Living in Denver compared to New York	10^{-5}	3
Other radiation risks		
Average U.S. diagnostic medical X rays	10^{-5}	3
Increase in risk from living in a brick building (with radioactive bricks) compared to wood	5×10^{-6}	3
Natural background at see level	1.5×10^{-5}	3
Eating and drinking		
One diet soda (saccharin)	10^{-6}	10
Average U.S. saccharin consumption	2×10^{-6}	10
4 tb peanut butter/day (aflatoxin)	4×10^{-5}	3
One pint milk per day (aflatoxin)	10^{-5}	3
Miami or New Orleans drinking water (chloroform)	1.2×10^{-6}	5
½ lb charcoal broiled steak once a week (benzopyrene) (cancer risk only; heart attack, etc. additional)	4×10^{-7}	10
Alcohol		
Averaged over smokers and nonsmokers	5×10^{-5}	3
Light drinker (one beer/day)	2×10^{-5}	3
Tobacco		
Smoker		
Cancer only	1.2×10^{-3}	3
All effects (including heart disease)	3×10^{-3}	3
Person in room with smoker	10^{-5}	10
Miscellaneous		
Taking contraceptive pills regularly	2×10^{-5}	10

Commonplace risks of daily life (cancer risks)

In almost all discussions of quantitative risk evaluation mortality risk is used to estimate tolerable risk. One might question how to proceed if exposure to toxic agents could produce an effect other than death. Mortality was used by Starr and others as a measure of risk because the statistics are easily obtained. Tolerable risk for consequences other than death will surely be higher; therefore, a tolerable annual mortality risk level of 10^{-6} would provide a lower bound for tolerable risk and will introduce a measure of conservatism if used for all general population environmental exposures.

An annual mortality risk of 10^{-6} translates to a lifetime risk of 7 x 10^{-5} assuming 70 years of continuous exposure and simple additivity of risk over the entire period. Considering the admitted crudeness of Starr's calculations, the criticisms of the exact quantitative relationship (minor at the low risk end of the curve), the variable nature of tolerable risk for individuals within the general population, and the need to avoid overestimating tolerable risk, it would seem an appropriate value of tolerable lifetime general population mortality risk should be about 10^{-5}.

Recommendation

Reexamination of the tolerable risk issue has revealed no new information that changes the conclusions of HRA's 1981 report. Therefore, the Minnesota Department of Health recommends the continued use of a lifetime tolerable risk level of 10^{-5} as a basis for action regarding nonthreshold agents.

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Carcinogen Lifetime Risk Level

Introduction

The algorithm for generating the Health Risk Limits (HRLs) for carcinogens is based on the assumption that carcinogens are non-threshold agents (HRL Unit, 1990). Pursuant to this assumption, even low doses of carcinogens bear some probability of causing cancer. Thus, the only risk-free dose of a carcinogen is zero. Because economic, technological and health factors make the total elimination of carcinogens from groundwater an impractical goal, exposure to carcinogens is generally controlled to levels that avoid significant risk. This is the approach the Minnesota Department of Health (MDH) will follow in setting the HRLs for carcinogens.

The "lifetime risk level" factor in the algorithm for carcinogens converts the potency slope and ingestion constants into an "insignificant risk" exposure level (HRL Unit, 1990).

$$HRL_{Carc} = \frac{\text{(Lifetime Risk Level)(70kg)}}{\text{(Potency Slope[mg/kg/day]}^{-1}\text{)(2 liter/day)}}$$

This factor represents the probability that exposure to a chemical over a lifetime will induce cancer. MDH has typically used a lifetime risk level of 10^{-5} to set carcinogen exposure guidelines. Hypothetically, if 100,000 people were exposed throughout life to a carcinogen at a dose corresponding to a lifetime risk level of 10^{-5}, no more than one person would develop cancer. The probability of getting cancer from exposure to a 10^{-5} risk level of a carcinogen is less than the probability of dying in a natural disaster.

Defining Insignificant (Acceptable, Tolerable) Risk

Despite the considerable literature on the issue, there is no standardized method for defining an "insignificant", "tolerable" or "acceptable" lifetime risk level for carcinogens. The concept of acceptable risk involves a number of factors including individual choice, knowledge and perception of the nature of consequences and benefits, responsibility and equity. The dilemma inherent in determining an acceptable risk level is aptly expressed by two authorities,

> In a society that values individual choice, a risk that an individual is willing to take for himself may be acceptable, even though a quantitatively similar risk imposed by another is not. (Ricci et al., 1989)

> The definition of acceptable risk is a political judgment, dependent on context. Analysis can contribute to the process which determines what risk will be accepted in a given situation, but only as an aid to judgment. It is in this role that analytical methods, including cost-benefit approaches and comparisons of risk are helpful to current risk decisions. No analytical approach so far identified has proved practical for dealing with the complex objectives common to risk decisions, although such methods can help explain and defend decisions and can identify weaknesses with judgmentally developed approaches. (Whipple, 1988)

Given the elusive definition of "insignificant", "acceptable" or "tolerable" risk, it is not surprising that the United States Environmental Protection Agency (USEPA) does not provide specific guidelines on how to choose a lifetime cancer risk level. In fact, the USEPA publishes health advisories for carcinogens in drinking water at concentrations corresponding to risk levels of 10^{-4}, 10^{-5} and 10^{-6} so that, "the risk manager can make a health decision based on the specific contamination situation" (USEPA, 1990). Federal agencies, including the USEPA do not use the same lifetime risk level for all carcinogens (USEPA, 1990, Travis et al., 1987). Instead, lifetime cancer risk levels are determined for each carcinogen based on economic, technological and feasibility factors. The lifetime cancer risk levels used by the EPA generally range from 10^{-4} to 10^{-6} (ODW, 1990).

The values for lifetime risk level vary not only from state to state, but also within certain states. A recent survey, conducted by the Chemical Communication Subcommittee of the Federal-State Toxicology and Regulatory Alliance Committee (FASTRAC), shows that 21 of the 43 states that responded to the survey set their drinking water standards or guidelines for carcinogens at a specified risk level. Five states out of the 21 claim to use USEPA values. This means they use lifetime risk levels ranging from 10^{-4} - 10^{-6}. Another fifteen states set their lifetime risk levels at 10^{-6}, although some of these states qualified the use of this number. For example, New Jersey calls 10^{-6} a "target" level. Kansas uses 10^{-6} as an "alert" level, but 10^{-5} as an "action" level. Massachusetts and Pennsylvania use 10^{-6} unless this number is below the practical quantitation level or treatment limits. Finally, Wisconsin uses a risk level of 10^{-6} when USEPA numbers are not available. This poses a contradiction since the USEPA sometimes uses risk levels as high as 10^{-4}. When nine of the states that set lifetime risk levels were contacted, none could provide a justification for their choice other than "policy decision" (personal communication, HRA, 1985). The results of the FASTRAC survey - that 22 states do not set a specified risk level and that the lifetime risk level varies among the other 21 states -in addition to the apparent lack of justification for the choice of lifetime risk level, exemplifies the ambiguous nature of "insignificant" risk.

Defining "no significant risk" became a critical issue for the implementation of California's 1986 Safe Drinking Water and Toxic Enforcement Act (Proposition 65) (Kizer et al., 1989, Pease et al., 1990). Proposition 65 requires the Governor to publish a list of chemicals "known to the State to cause cancer or reproductive toxicity (CHWA, 1990)." After a chemical has been listed for 12 months, "...people may not knowingly be exposed to *significant* levels without first receiving a warning...Likewise, 20 months after being listed a chemical may not knowingly be discharged in *significant* amounts into any actual or potential source of drinking water." (Kizer et al., 1988) [Italics, added]. California settled on a "no significant risk" level of 10^{-5} in consultation with advisory groups made up of representatives from environmental and consumer advocacy groups, agriculture, industry, government lawyers and scientists (Kizer et al, 1988). Despite the involvement of these experts, the <u>Statement of Reasons</u> for Proposition 65 does not provide a detailed justification for the choice of 10^{-5} other than to say,

> The 10^{-5} risk level is commonly used as an acceptable risk level by many regulatory agencies. Generally speaking, regulatory levels range from 10^{-4} to 10^{-6} or lower...These fluctuations are often imposed due to differences in the methodologies employed in the underlying risk assessment. Under these regulations, it is intended that risk assessments based upon default assumptions will produce fairly conservative results. In effect, applying a 10^{-5} standard to a conservative risk assessment can produce the same result as applying a 10^{-6} standard to an assessment employing less conservative methodologies. (CHWA, 1989)

MDH and Lifetime Risk Level

One obvious option for determining the HRLs for carcinogens is to set the lifetime risk level at zero. Although zero is a desirable goal, this approach ignores the possible benefits of the chemicals or the processes that produce them. These benefits can be economic, technological and also health related. For example, from the view of public health, the benefit of chlorinating water - preventing the spread of disease - outweighs the small risk of developing cancer from the resulting chlorinated compounds. The decision to set a cancer risk level above zero can be justified by balancing large benefits against small risks and further, by recognizing that the presence of a low level of risk does not preclude safety. Accordingly, the USEPA sets Maximum Contaminant Level Goals for carcinogens at zero, but its Maximum Contaminant Levels above zero, with lifetime risk levels ranging from 10^{-4} to 10^{-6} (ODW, 1990).

MDH has used a lifetime risk level of 10^{-5} since 1981 (HRA, 1985). A 1985 position paper from the Section of Health Risk Assessment outlines and critiques various decision analysis methods directed towards determining "tolerable" or "acceptable" risk. MDH arrived at 10^{-5} through a benefit-risk approach. The major portion of the discussion from the 1985 position paper on "tolerable risk" is reproduced below.

> Starr and others have compared benefit and risk in the aggregate. Unfortunately benefits and risks are not distributed evenly over all members of society (Kates, 1978). Benefits may be concentrated and risk diffuse such as in the use of pesticides by farmers. Conversely, risks may be concentrated and benefits diffuse such as for occupational hazards. The distribution in time may also be uneven with immediate benefits and delayed risks with the latent effects of chemicals. These inequalities make the application of benefit-risk relationships difficult to apply to individuals or special subgroups of the general population. Yet for the purpose of evaluating risk assessments, it is necessary to have an estimate of negligible risk which applies in the aggregate and which can be adjusted to accommodate the risk aversiveness of special subgroups. It is entirely possible that special subgroups or individuals, such as those occupationally exposed, will derive considerable benefit from tolerance of a higher risk level. Clearly, tolerable risk for special population groups needs to be calculated on a case-by-case basis.
>
> Not withstanding the above caveat, environmental risks can be balanced against commonly tolerated risks of equal or lower benefit for the purpose of establishing exposure guidelines. Starr (1969, 1972, 1984) classifies as "negligible" those risks which are lower than the probability of death by natural disaster, a probability of about 10^{-6} per year. This comparison should hold for risks of any benefit level since natural disasters have no concomitant benefits. It therefore follows that environmental exposures resulting in annual mortality risk ratios of 10^{-6} or less can be reasonably considered "safe". Since this level of risk tolerance has been calculated from aggregate populations it should be applied to general population groups or "average" individuals in such a population.
>
> One can develop a sense of how conservative such a guideline is by comparing it with commonly experienced risks. Wilson (1980, 1982) has enumerated the following commonly tolerated risks [see tables in source document]. Wilson's data are consistent with Starr's conclusion about the risk-benefit relationship. Involuntary risks are less tolerable than voluntary risks and risks for activities with little or no benefit are less tolerable than risks with high concomitant benefit. For example, tornadoes hurricanes, and lightning have no benefit, are involuntary, and result in a low annual mortality risk. Auto racing is voluntary, with presumably a high payoff for the participating individual and a high risk level. The high air pollution risk level, while involuntary for the

individual, is associated with the high societal benefits of energy production and is therefore tolerated.

In almost all discussions of quantitative risk evaluation mortality risk is used to estimate tolerable risk. One might question how to proceed if exposure to toxic agents could produce an effect other than death. Mortality was used by Starr and others as a measure of risk because the statistics are easily obtained. Tolerable risk for consequences other than death will surely be higher; therefore, a tolerable annual mortality risk level of 10^{-6} would provide a lower bound for tolerable risk and will introduce a measure of conservatism if used for all general population environmental exposures.

An annual mortality risk of 10^{-6} translates to a lifetime risk of 7 x 10^{-5} assuming 70 years of continuous exposure and simple additivity or risk over the entire period. considering the admitted crudeness of Starr's calculations, the criticisms of the exact quantitative relationship (minor at the low risk end of the curve), the variable nature of tolerable risk for individuals within the general population, and the need to avoid overestimating tolerable risk, it would seem an appropriate value of tolerable lifetime general population mortality risk should be about 10^{-5}.

Recommendation

MDH recommends using of a 10^{-5} lifetime risk level for carcinogens.

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(47)		Hexachloroethane	6.2
(48)		Lead	5.0
(49)		Mercury	0.75
(50)		Methyl ethyl ketone	43
(51)		Methoxychlor	85
(52)		Nickel	38
(53)		Nitrate (as Nitrogen)	2500
(54)		Nitrite (as Nitrogen)	250
(55)	N-	Nitrosodimethylamine	0.0035
(56)	N-	Nitrosodiphenylamine	17.8
(57)		Total carcinogenic polynuclear aromatic hydrocarbons (PAH)	0.007
(58)		Polychlorinated biphenyls (PCB's)	0.02
(59)		Pentachlorophenol	55
(60)		Selenium	11
(61)		Styrene	35
(62)	2,3,7,8-	Tetrachlorodibenzo-p-dioxin (-TCDD)	0.0000005
(63)	1,1,2,2-	Tetrachloroethane	0.44
(64)		Tetrachloroethylene	1.7
(65)		Toluene	500
(66)		Toxaphene	0.075
(67)	1,1,1-	Trichloroethane	50
(68)	1,1,2-	Trichloroethane	1.5
(69)		Trichloroethylene	7.8
(70)	2,4,6-	Trichlorophenol	4.4
(71)	2,4,5-	TP (Silvex)	13
(72)		Vinyl chloride	0.037
(73)		Xylene	110

G. If an intervention limit established under items E, F, and H is exceeded in ground water at any location where the facility's impacts are monitored, the owner or operator must take the following actions:

(1) immediately notify the commissioner in writing;

(2) immediately resample if previous samples at the facility did not exceed the intervention limits;

(3) evaluate the need to resample if previous samples exceeded the intervention limits;

(4) evaluate the significance of the exceedance and the source or cause of the constituents exceeding the intervention limits;

(5) evaluate the need for immediate corrective action to prevent pollutant concentrations from approaching or exceeding standards at the compliance boundary, surface water compliance boundary, or lower compliance boundary;

(6) evaluate the need for changes in water monitoring, including sampling frequencies, constituents analyzed, and installation of additional monitoring points;

(7) within 30 days after obtaining the sample results in which an intervention limit was exceeded, submit a written report to the commissioner describing the evaluations and conclusions under subitems (2) to (6) and the actions taken or planned under subitem (8); and

(8) take other actions described in the facility's contingency action plan and as required in subpart 15 and part 7035.2615.

H. In lieu of the intervention limits and standards under items E and F, the commissioner may establish alternative standards and intervention limits in the facility permit as follows:

(1) If the concentration of any constituent in the background ground

water at a facili...
this subpart, the ...
standard or inter...
to the condition ...
to migration of ...
inadequately de...
ing sampling, ...
monitoring poi...
intervention li...
events occurring ...
tor's control.

(2) ...
establish altern...
filled before the ...
by the agency, or ...
limits must not ex...
or operator mus...
extent and severi...
evaluating the fea...
benefits of the po...
must include co...
dards under ite...
maintain ground ...
under item F. T...
tions that would ...
to which the use ...
and future use o...

(3) ...
migration of lea...
a substance as d...
National Primar...
title 40, part 141, ...
F, the commissione...
standard and alte...

(4) If a ...
substance is know...
commissioner ma...
of health establish ...

(5) If a ...
a facility and is ...
potentially harmful ...
for that substance. Exc...
limits shall be 25 per...

(a) For ...
mental Protection Age...
human carcinogen), ...
Minnesota commissio...

(b) For ...
tal Protection Agenc...
tion corresponding ...
consuming the water ...
mental Protection Agen...
recommended allowab...

(6) If a subs...
under subitems (2) to (5) ...
recommended allowable ...

6.2
5.0
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43
85
38
2500
250
0.0035
17.8

0.007
0.02
55
11
35
0.0000005
0.44
1.7
500
0.075
50
1.5
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13
0.037
110

ns E, F, and H is
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) the commissioner
; (2) to (6) and the

contingency action

under items E and
. intervention limits

background ground

water at a facility is greater than a standard or intervention limit established in this subpart, the background concentration of the constituent must be used as the standard or intervention limit. For purposes of this subitem, background refers to the condition of ground water that has experienced no change in quality due to migration of constituents from the facility. If the background water quality is inadequately defined, the commissioner may require additional evaluation including sampling, statistical analysis of sampling data, and installation of additional monitoring points. The commissioner may alter the alternative standards or intervention limits if background water quality is changing due to actions or events occurring outside the facility property and beyond the owner's or operator's control.

(2) Upon request by the owner or operator, the commissioner may establish alternative limits for some or all substances for portions of a facility filled before the effective date of parts 7035.2525 to 7035.2875. Unless approved by the agency, or by the commissioner as provided in subitem (1), the alternative limits must not exceed four times the concentrations given in item F. The owner or operator must have completed a remedial investigation study evaluating the extent and severity of ground water pollution at the facility and a feasibility study evaluating the feasibility and the environmental and economic costs, risks, and benefits of the possible alternative corrective actions. The alternative approaches must include corrective actions intended to achieve compliance with the standards under items E and F and at least one additional approach intended to maintain ground water concentrations lower than four times the concentrations under item F. The feasibility study also must evaluate the pollutant concentrations that would remain in ground water after corrective action and the extent to which the use of these alternative limits may adversely affect the immediate and future use of ground water downgradient from the facility.

(3) If the quality of a public water supply is potentially affected by migration of leachate from a facility, and if the maximum contaminant level for a substance as defined and established under either chapter 4720 or under the National Primary Drinking Water Regulations, Code of Federal Regulations, title 40, part 141, is a lower concentration than the standard under items E and F, the commissioner may use the maximum contaminant level as the alternative standard and alternative intervention limit for that substance.

(4) If a substance is present in ground water at a facility, and if that substance is known to impart undesirable taste or odor to drinking water, the commissioner may upon the recommendation of the Minnesota commissioner of health establish alternative limits to avoid these taste and odor effects.

(5) If a substance not listed in item F is present in ground water at a facility and is determined by the Minnesota commissioner of health to be potentially harmful to health, the commissioner may establish alternative limits for that substance. Except as provided elsewhere in this subpart, the alternative limits shall be 25 percent of the concentration given in unit (a) or (b):

(a) For a substance not classified by the United States Environmental Protection Agency as Group A (human carcinogen) or Group B (probable human carcinogen), the recommended allowable limit, as determined by the Minnesota commissioner of health; or

(b) For a substance classified by the United States Environmental Protection Agency as a Group A or Group B carcinogen, either the concentration corresponding to a risk of one additional case of cancer per 100,000 adults consuming the water over a lifetime, as estimated by the United States Environmental Protection Agency and the Minnesota commissioner of health, or the recommended allowable limit under unit (a), whichever is lower.

(6) If a substance which has a standard or an alternative standard under subitems (2) to (5) is present in ground water at a facility, and if the recommended allowable limit or the concentration corresponding to the one-in-

100,000 cancer risk under subitem (5) is changed, the commissioner may establish alternative limits for that substance. The alternative limits shall be 25 percent of the concentration given in subitem (5), unit (a) or (b), whichever is applicable.

I. If a substance is not detected in a sample and the limit of detection is higher than the intervention limit or standard for that substance, the intervention limit or standard will not be assumed to have been attained or exceeded.

J. The commissioner, after investigation and evaluation, may require the owner or operator to implement the facility contingency action plan and to take corrective action under the following circumstances, even if a standard or intervention limit established under this subpart is not being exceeded:

(1) in the event of a substantial release of leachate that the commissioner may reasonably expect to result in a violation of water quality standards; or

(2) based on the additive carcinogenicity or toxicity of a combination of pollutants in the ground water, in lieu of the limits for individual substances under items E, F, and H. The additive carcinogenicity or toxicity must be computed using the approach given in "Guidelines for the Health Risk Assessment of Chemical Mixtures," Federal Register, Volume 51, pages 34014-34025, September 24, 1986. Where quantification using this approach is feasible, the commissioner may require response actions if the sum total risk of consuming the water over a lifetime would exceed either 2.5 additional cases of cancer in a population of 1,000,000 persons or for noncarcinogens, 25 percent of the acceptable concentration for long-term consumption.

Subp. 5. **Design requirements.** The design requirements for a mixed municipal solid waste land disposal facility are as follows:

A. The owner or operator must develop an engineering report for the site. The report must include specifications for site preparation. The report shall be submitted with the final permit application required under part 7001.3300. These specifications as they relate to phase development of the facility must be established in the engineering report. Site preparations include clearing and grubbing for disposal areas and building locations, topsoil stripping and storage, cover material excavation, other excavations, berm construction, drainage control structures, leachate collection and treatment system, ground water monitoring system, gas monitoring and collection system, entrance and access roads, screening, fencing, and other special design features.

B. The owner or operator must develop the site in phases. Each phase must contain individual cells that will provide for filling in a manner to achieve final waste elevations as rapidly as possible. The phases must be designed and constructed to minimize moisture infiltration into the fill areas while maintaining stable slopes and appropriate operating conditions. The owner or operator must consider seasonal phases in order to accommodate the differences between wet and dry and warm and cold weather operations. The owner or operator must bring each phase to the final waste contours, as shown on the ultimate site development plan, and close the phase according to the approved facility closure plan.

C. Any new fill area at a land disposal facility must be located at least 200 feet from the nearest property line, unless otherwise approved by the commissioner based on existing filling procedures, existing site structures, the facility design, compliance boundaries, and existing land restrictions.

D. The owner or operator must divert surface water drainage around and away from the site operating area. A drainage control system, including changes in the site topography, ditches, berms, sedimentation ponds, culverts, energy breaks, and erosion control measures, must take into consideration at least the following features:

(1) the expected final contours for the site and the planned drainage pattern;

(2) the drain
effects on and by the regi

(3) the need

(4) the base
minimum two percent slc

(5) the area'

E. The owner or
ageways to prevent erosio
greater than 200 feet long
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tions, proposed design fe
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the need for drainageway
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G. The final cor
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tions.

H. The facility

(1) a cover

(2) a liner

(3) a leach
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(4) a water

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Subp. 6. Intermitte
operator of a mixed mu
maintain a cover syster
the fill areas, preventi
movement, preventing
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A. The owner
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criteria for toxic pollutants in the absence of numerical standards listed in part 7050.0220. The site-specific numerical criteria established by these methods protect Class 1 surface waters for public and private domestic consumption, and Class 2 waters for the propagation and maintenance of fish and aquatic life, the consumption of fish and edible aquatic life by humans, and the consumption of aquatic organisms by wildlife. These criteria also protect the uses assigned to Class 7, limited resource value, waters as described in part 7050.0220.

Subpart 2. Objectives. Protection of the aquatic community from the toxic effects of pollutants means the protection of no less than 95 percent of all the species in any aquatic community. Greater protection may be applied to a community if economically, recreationally, or ecologically important species are very sensitive.

Protection of human consumers of fish, other edible aquatic organisms, and water for drinking from surface waters means that exposure from noncarcinogenic chemicals shall be below levels expected to produce known adverse effects; and the incremental cancer risk from exposure to carcinogenic chemicals, singly or in mixtures, shall not exceed one in 100,000. The combined risk from mixtures of carcinogens will be determined as described in part 7050.0220, subpart 3, item G.

Protection of wildlife that eat aquatic organisms means the protection of the most sensitive wildlife species or populations. Greater protection may be applied if the exposed animals include endangered or threatened wildlife species listed in chapter 6134, or in the Code of Federal Regulations, title 50, part 17, under the Endangered Species Act of 1973, United States Code, title 16, sections 1531 to 1543.

7050.0218 METHODS FOR ~~DETERMINING~~ PROTECTION OF SURFACE WATERS FROM ~~WATER STANDARDS FOR~~ TOXIC ~~SUBSTANCES~~ POLLUTANTS FOR WHICH NUMERICAL STANDARDS NOT PROMULGATED.

~~Subpart 1. Purpose and applicability. The purpose of this part is to establish methods for developing water quality standards for toxic substances. The standards established by these methods protect Class 1 surface waters for public and private domestic consumption; and Class 2 waters for the propagation and maintenance of fish and aquatic life, the consumption of fish and edible aquatic life by humans, and the consumption of aquatic organisms by wildlife. The standards also protect the uses assigned to Class 7, limited resource value, waters as described in Part 7050.0200.~~

~~Subp. 2. Policy. The standards established under this part, together with other provisions in this chapter, shall prevent the discharge of sewage, industrial waste, or other wastes from point or nonpoint sources into the waters of the state in amounts that impair the quality of the waters of the state or the aquatic community, or in any manner render the aquatic community unsuitable or objectionable for fishing, fish culture, or recreational uses.~~

~~Protection of the aquatic community from the toxic effects of substances means the protection of no less than 95 percent of all the species in any aquatic community. Greater protection may be applied to a community if economically, recreationally, or ecologically important species are very sensitive.~~

~~Protection of human consumers of fish, other edible aquatic organisms, and water for drinking from surface waters means that exposure from noncarcinogenic chemicals shall be below levels expected to produce known adverse effects; and the incremental cancer risk from exposure to carcinogenic chemicals, singly or in mixtures, shall not exceed one in 100,000. The combined risk from mixtures of carcinogens will be determined as described in subpart 12, item B.~~

~~Protection of wildlife that eat aquatic organisms means the protection of the most sensitive wildlife species or populations. Greater protection may be applied if the exposed animals include endangered or threatened wildlife species listed in chapter 6134, or in the Code of Federal Regulations, title 50, part 17, under the Endangered Species Act of 1973, United States Code, title 16, sections 1531 to 1543.~~

Subpart 1. Purpose. The numerical water quality standards for toxic pollutants in part 7050.0220 do not address all pollutants which may be discharged to surface waters and cause toxic effects. Therefore, methods are established in this part to address on a site-by-site and case-by-case basis the discharge into surface waters of toxic pollutants not listed in part 7050.0220.

Subp. 3. Promulgation of new standards. The agency may also adopt new standards according to Minnesota Statutes, chapter 14, to replace those listed in part 7050.0220 that are more stringent or less stringent if new scientific evidence shows that a change in the standard is justified.

Subp. 4. Standards for substances not listed in part 7050.0220. Standards for toxic substances not listed in part 7050.0220 shall be derived by the commissioner using the procedures in this part. Numerical standards so derived have the same authority as standards listed in part 7050.0220.

Subpart 2. Site-specific criteria for pollutants not listed in part 7050.0220. Site-specific criteria for toxic pollutants not listed in part 7050.0220 shall be derived by the commissioner using the procedures in this part.

A. A site-specific criterion so derived is specific to the point source being addressed. Any effluent limitation determined to be necessary based on standards derived from a site-specific criterion under this subpart shall only be required after the discharger has been given notice of the specific proposed effluent limitations and an opportunity for public to request a hearing as provided in parts 7000.1000 and 7001.0130. The requirements in chapter 7001 regarding notice of National Pollutant Discharge Elimination System and State Disposal System permits can satisfy the notice and opportunity for hearing requirements in this subpart.

B. A site-specific criterion so derived for remedial action cleanup activities is specific to the affected surface water body.

Subp. ~~5~~. 3. Definitions. For the purposes of parts ~~7050.0218~~ 7050.0217 to 7050.0220, the following terms have the meaning given them:

A. "Acute-chronic ratio" or "ACR" means the ratio of the acute toxicity, expressed as an LC50 or EC50, of a toxicant to its chronic toxicity expressed as the chronic value. The ACR is used as a factor for estimating chronic toxicity on the basis of acute toxicity.

B. "Acute toxicity" means a stimulus severe enough to rapidly induce a response. In toxicity tests, a response is normally observed in 96 hours or less. Acute effects are often measured in terms of mortality or other debilitating effects.

C. "Available scientific data" means information derived from scientific literature including but not limited to: published literature in peer reviewed scientific journals, USEPA ambient water quality criteria documents, and other reports or documents published by the USEPA or other governmental agencies.

~~C.~~ D. "Bioaccumulation factor" or "BAF" means the concentration of a ~~substance~~ pollutant in one or more tissues of an aquatic organism, exposed from any source of the ~~substance~~ pollutant but primarily from the diet and bottom sediments in addition to the water column, divided by the average concentration in the solution in which the organism had been living.

D. E. "Bioconcentration factor" or "BCF" means the concentration of a substance pollutant in one or more tissues of an aquatic organism, exposed only to the water as the source of the substance, pollutant, divided by the average concentration in the solution in which the organism had been living.

E. F. "Cancer potency factor" or "q1*" means a factor indicative of a chemical's human cancer causing potential. The q1* is the upper 95 percent confidence limit (one sided) of the slope from a linear nonthreshold dose-response model used by the USEPA to provide an upper bound estimate of incremental cancer risk. The q1* assumes a lifetime exposure and is expressed in days times kilogram body weight per milligram toxicant per kilogram body weight (d x kg/mg).

F. G. "Chronic toxicity" means a stimulus that lingers or continues for a long period of time, often one-tenth the life span or more. A chronic effect can be mortality, reduced growth, reproduction impairment, harmful changes in behavior, and other nonlethal effects.

G. H. "Chronic criterion" or "CC" means the highest water concentration of a toxicant to which organisms can be exposed indefinitely without causing chronic toxicity.

I. "Chronic standard" or "CS" means the highest water concentration of a toxicant to which organisms can be exposed indefinitely without causing chronic toxicity. Chronic standards are listed in part 7050.0220, subpart 3.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

June 27, 1990

JUL 02 1990
Environmental Health
Radiation Control

TO: ALL NRC LICENSEES

SUBJECT: NRC's POLICY STATEMENT ON BELOW REGULATORY CONCERN

Gentlemen:

Enclosed for your information is the Nuclear Regulatory Commission (NRC) policy statement on "below regulatory concern" (BRC), along with an information booklet on the policy.

The policy will be used by NRC in responding to requests for rulemakings or licensing actions to exempt from some or all regulatory controls certain practices involving very low-level radioactive material. Examples may include: (1) release for unrestricted public use of lands and structures containing residual radioactivity, (2) distribution of consumer products containing small amounts of radioactive material, (3) disposal of very low-level radioactive waste at unlicensed disposal sites, and (4) recycling of slightly contaminated materials.

The policy statement is not a regulation. It does not in itself change current regulations or licenses, and no response or action is required by licensees at this time. The NRC will be holding public information meetings to discuss the policy in August-October 1990, near its regional offices in Philadelphia, Atlanta, Chicago, Dallas, and San Francisco. Separate notices will be issued providing the details for these meetings.

Questions may be directed to the contacts listed in the enclosed statement.

Sincerely,

Hugh L. Thompson, Jr.
Deputy Executive Director for
Nuclear Materials Safety, Safeguards,
and Operations Support

Enclosures:
1. BRC Policy
2. Information Booklet

NUCLEAR REGULATORY COMMISSION

Below Regulatory Concern; Policy Statement

AGENCY: Nuclear Regulatory Commission.

ACTION: Policy statement.

SUMMARY: This policy statement establishes the framework within which the Commission will formulate rules or make licensing decisions to exempt from some or all regulatory controls certain practices involving small quantities of radioactive material. Opportunity for public comment will be provided with each rulemaking and each licensing action where generic exemption provisions have not already been established. The exemptions may involve the release of licensee-controlled radioactive material either to the generally accessible environment or to persons who would be exempt from Commission regulations. Practices for which exemptions may be granted include, but are not limited to, (1) the release for unrestricted public use of lands and structures containing residual radioactivity; (2) the distribution of consumer products containing small amounts of radioactive material; (3) the disposal of very low-level radioactive waste at other than licensed disposal sites; and (4) the recycling of slightly contaminated equipment and materials. As described in this policy statement, NRC intends to continue exempting specific practices from regulatory control if the application or continuation of regulatory controls is not necessary to protect the public health and safety and the environment, and is not cost effective in further reducing risk. The policy statement defines the dose criteria and other considerations that will be used by NRC in making exemption decisions. The policy establishes individual dose criteria (1 and 10 mrem per year [0.01 and 0.1 millisievert per year]) and a collective dose criterion (1000 person-rem per year [10 person-sievert per year]). These criteria, coupled with other considerations enumerated in the policy statement, will be major factors in the Commission's determination on whether exemptions from regulatory controls will be granted.

The policy statement establishes a consistent risk framework for regulatory exemption decisions, ensures an adequate and consistent level of protection of the public in their use of radioactive materials, and focuses the Nation's resources on reducing the most significant radiological risks from practices under NRC's jurisdiction. The average U.S. citizen should benefit from implementation of the BRC policy through (1) enhanced ability of NRC, Agreement States, and licensees to focus resources on more significant risks posed by nuclear materials; (2) timely and consistent decisions on the need for cleanup of contaminated sites; (3) increased assurance that funds available to decommission operating nuclear facilities will be adequate; (4) reduced costs and overall risks to the public from managing certain types of slightly radioactive waste in a manner commensurate with their low radiological risk; and (5) increased assurance of a consistent level of safety for consumer products containing radioactive material under the Commission's jurisdiction.

EFFECTIVE DATE: July 3, 1990

ADDRESSES: Documents referenced in this policy statement are available for inspection in the NRC Public Document Room, 2120 L Street, N. W. (Lower Level), Washington, DC.

FOR FURTHER INFORMATION CONTACT:

The appropriate NRC Regional Office:

Region I – Dr. Malcom Knapp, King of Prussia, Pennsylvania; telephone (215) 337-5000

Region II – Mr. J. Philip Stohr, Atlanta, Georgia; telephone (404) 331-4503

Region III – Mr. Charles E. Norelius, Glen Ellyn, Illinois; telephone (708) 790-5500

Region IV – Mr. Arthur B. Beach, Arlington, Texas; telephone (817) 860-8100

Region V – Mr. Ross A. Scarano, Walnut Creek, California; telephone (415) 943-3700

Federal and State Government Officials may contact: Mr. Frederick Combs, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Office of Governmental and Public Affairs, telephone (301) 492-0325.

Questions may also be directed to the following individuals at the U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Dr. Donald A. Cool, Office of Nuclear Regulatory Research; telephone (301) 492-3785

Mr. John W. N. Hickey, Office of Nuclear Material Safety and Safeguards; telephone (301) 492-3332

Mr. L. J. Cunningham, Office of Nuclear Reactor Regulation; telephone (301) 492-1086

SUPPLEMENTARY INFORMATION:

Statement of Policy

I. Introduction.

Ionizing radiation is a fact of life. From the day we are born until the day we die, our bodies are exposed to low levels of radiation emitted from a variety of natural and man-made sources, including the cosmos, earth, building materials, industrial facilities, clothing, medicine, food, air, and our own bodies. All materials exhibit some degree of radioactivity. The consensus among scientists is that even low levels of radiation typical of the natural environment pose some correspondingly low risk of adverse health effects to humans. Recognition of the risk due to radiation exposure from natural sources provides perspective on the risks associated with human uses of radioactive materials.

Natural and man-made radionuclides are used in today's society in many forms for a variety of purposes, such as medical therapy and diagnosis, materials analysis, and power generation. In general, the existing regulatory framework ensures that radioactive materials are controlled consistent with the degree of risk posed to the public and the environment. Some products such as smoke detectors contain small quantities of radioactive materials that pose such a low risk that they have been widely distributed without continuing regulatory controls. To require that all radioactive materials be controlled in the same strict manner regardless of the risks they pose would not be a sound use of limited National resources. Such strict control could also deprive society of the benefits already derived from appropriate uses of radioactive materials and radiation. In addition, such control would not significantly reduce the risks associated with radiation exposure from controlled sources compared with risks associated with natural background radiation. Therefore, responsible decisions need to be made on how radioactive materials are controlled based on a judgement about the levels of risk they pose and the effectiveness of regulatory control to reduce those risks.

Over the last several years, the Commission has pursued development of a risk threshold to distinguish those radioactive materials that do not require the same stringent level of regulatory control as that imposed on potentially more hazardous materials. The Commission recognized throughout this process that the threshold would need to be low enough to continue to ensure adequate protection of the public. The Commission also recognized that the threshold should be compatible with technological and measurement capabilities so it could be readily used in NRC's regulatory program for nuclear materials. In addition, the Commission identified the need to balance incremental reductions in risk below the safety threshold with the attendant expenditure of private and public resources.

In today's notice, the Commission establishes a policy to guide its decisions on which radioactive materials are "below regulatory concern" (BRC) because the low levels of risk they pose do not warrant regulation to the same degree as other radioactive materials to ensure adequate protection of the public and the environment. This policy translates the Commission's judgement on acceptable risk into explicit and practical criteria on which to base decisions to exempt practices from the full scope of NRC's regulatory program. The BRC criteria are necessary to ensure adequate and consistent decisions on acceptable risks posed by decontaminated and decommissioned nuclear facilities, consumer products containing radioactive materials, and very low activity radioactive wastes. These decisions will be implemented by the Commission through rulemakings and licensing decisions based on careful and thorough analyses of the risks associated with specific practices to ensure that the public is adequately protected.

Under the regulatory approach used by the U.S. Nuclear Regulatory Commission (NRC), the use of radioactive materials is subject to limits and conditions that ensure the protection of the health and safety of both workers and members of the general public, and the environment. For example, radioactive material is controlled by NRC and Agreement State licensees to ensure that dose limits are not exceeded. In addition, sources of radiation are designed, used and disposed of in a manner that ensures that exposures to radiation or radioactive material are as low as is reasonably achievable (ALARA), economic and social factors being taken into account. NRC has endorsed the ALARA provision in regulatory practice for a number of years (10 CFR Part 20). However, NRC has not yet provided criteria that would establish the basis for defining the level of residual risk at which further regulatory control is no longer warranted.

The policy statement in today's notice provides a unifying risk framework for making decisions about which practices can be exempted from the full scope of NRC's comprehensive regulatory controls. Under the criteria and principles of this policy statement, exemptions of radioactive materials from regulatory controls would involve the transfer of very small quantities of the materials from a regulated to an unregulated status. NRC will analyze each proposed exemption to ensure that doses resulting from the proposed transfer will be sufficiently low that the public health and safety and the environment will remain adequately protected. A licensed activity producing an exempt material would continue to be subject to the full range of regulatory oversight, inspection, and enforcement actions up to and including the point of transfer to an exempt status. The Commission also intends to conduct research periodically to evaluate the effectiveness of this policy and to confirm the safety bases that support the exemption decisions.

Through appropriate rulemaking actions or licensing decisions, the Commission will establish constraints, requirements, and conditions applicable to specific exemptions of radioactive materials from NRC's regulations. The NRC will verify that licensees adhere to these exemption constraints and conditions through NRC's liensing, inspection, and enforcement programs. For example, the Commission may promulgate regulations that would require some type of labeling so that consumers could make informed decisions about purchasing a product containing exempted materials. Such labeling is presently required by the Commission for smoke detectors containing radioactive material (see 10 CFR 32.26). The NRC ensures that manufacturers label the detectors in compliance with the labeling requirement through licensing reviews and inspections. Specific source controls and exemption conditions are not discussed further in this policy because they will be more appropriately addressed in developing the exemption requirements for specific exemption proposals.

The concept of regulatory exemptions is not new. The Atomic Energy Act of 1954, as amended, authorizes the Commission to exempt certain classes, quantities, or uses of radioactive material when it finds that such exemptions will not constitute an unreasonable risk to common defense and security and to the health and safety of the public. In the 1960s and 1970s, the Atomic Energy Commission used this authority to promulgate tables of exempt quantities and concentrations for radioactive material. These exemptions allow a person or a licensee, under certain circumstances, to receive, possess, use, transfer, own, or acquire radioactive material without a requirement for a license (30 FR 8185; June 26, 1965 and 35 FR 6425; April 22, 1970). The Commission currently allows distribution of consumer products or devices to the general public and allows releases of radioactive material to the environment consistent with established regulations. For example, regulations currently specify the conditions under which licensees are allowed to dispose of small quantities of radioactive material into sanitary sewer systems (see 10 CFR 20.303). These existing regulations specify requirements, conditions, and constraints that a licensee must meet if radioactive material is to be "transferred" from a regulated to an exempt or unregulated status.

More recently, Section 10 of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985 directed the Commission to develop standards and procedures and act upon petitions "to exempt specific radioactive waste streams from regulation ... due to the presence of radionuclides ... in sufficiently low concentrations or quantities as to be below regulatory concern." The Commission responded to this legislation by issuing a policy statement on August 29, 1986 (51 FR 30839). That policy statement contained criteria that, if satisfactorily addressed in a petition for rulemaking, would allow the Commission to act expeditiously in proposing appropriate relief in its regulations on a "practice-specific" basis consistent with the merits of the petition.

Federal and State agencies have also developed and implemented similar exemptions based on evaluations of their risks to the public and the environment. The Food and Drug Administration (FDA), for example, has applied sensitivity-of-method, risk-based guidelines in connection with the regulation of animal drugs, food contaminants, and trace constituents in some food additives. Similarly, the Environmental Protection Agency (EPA) established exemption or threshold levels based on individual risks in the regulation of pesticides and other toxic and carcinogenic chemicals. For example, EPA employs such a concept in defining hazardous waste through the new Toxicity Characteristic rule in 40 CFR Part 261 [55 FR 11798; March 29, 1990].

The Commission believes that the Below Regulatory Concern policy is needed to establish a consistent, risk-based framework for making exemption decisions. Specifically, this framework is needed to (1) focus the resources of NRC, Agreement States, and licensees on addressing more significant risks posed by nuclear materials; (2) ensure that beyond the adequate protection threshold potential benefits from additional regulation outweigh the associated burdens; (3) establish residual radioactivity criteria and requirements for decommissioning and cleanup of radioactive contamination at licensed and formerly-licensed facilities; (4) ensure that licensee decommissioning funding plans provide adequate funds to cover the costs of cleanup of these facilities to protect people and the environment; (5) ensure that the public is consistently protected against undue risk from consumer products that contain radioactive materials under the Commission's jurisdiction; (6) provide decision criteria for reviewing petitions to exempt very low-level radioactive wastes in accordance with the Low-Level Radioactive Waste Policy Amendments Act of 1985; and (7) ensure that existing exemptions involving radioactive materials are consistent and adequate to protect the public.

The Commission's BRC policy establishes an explicit and uniform risk framework for making regulatory exemption decisions. This policy will also be used by the Commission as a basis for reevaluating existing NRC exemptions to ensure that they are consistent with the criteria defined herein. In lieu of such a policy, the Commission could continue the current practice of evaluating exemptions on a case-specific basis. Such an approach, however, does not ensure consistent evaluation and control of risks associated with exempted practices. For this reason and the reasons discussed above, the Commission has established the BRC Policy Statement. This policy supersedes the Atomic Energy Commission's policy statement on this subject [30 FR 3462; March 16, 1965].

The Commission recognizes that Agreement States will play an important role in the implementation of the Below Regulatory Concern policy, specifically in the areas of developing and enforcing compatible State regulations, regulating cleanup and decommissioning of certain types of contaminated nuclear facilities, and exempting certain low-level radioactive wastes from requirements for disposal in licensed low-level waste disposal facilities. The Atomic Energy Act of 1954, as amended, gives to the Federal government the exclusive authority to regulate source, special nuclear, and byproduct materials to ensure protection of the public health and safety. While Congress subsequently provided for Federal-State agreements under Section 274b of the Atomic Energy Act through which States could assume regulatory responsibilities in lieu of Federal regulation for certain classes of nuclear materials, it required that State radiation protection standards be coordinated and compatible with the Federal standards for radiation protection.

NRC regulations exempting BRC wastes will not affect the authority of State or local agencies to regulate BRC wastes for purposes other than radiation protection in accordance with Section 274b of the Atomic Energy Act. Under the Atomic Energy Act, Congress intended that there be uniformity between the NRC and Agreement States on basic radiation protection standards. Future BRC Rulemakings will establish basic radiation protection standards below which regulatory oversight is not needed. The Commission will address compatibility issues in future rulemakings. In initiating proceedings to implement NRC's BRC policy, the Commission will continue to consult with and seek the advice of the States.

Some States have expressed concerns that economic and institutional impacts of actions resulting from the Commission's BRC policy may undermine their efforts to develop new disposal facilities for low-level radioactive waste in accordance with the Low-Level Radioactive Waste Policy Amendments Act of 1985. These States would prefer to establish their own standards for determining which wastes should be exempted from regulatory control rather than adopting standards that are compatible with uniform Federal standards. The Commission has developed the BRC policy to provide a uniform and consistent health and safety framework for exemption decisions. In so doing, the Commission recognized the concerns expressed by Congress when it enacted the Low-Level Radioactive Waste Policy Amendments Act of 1985 that health, safety, and environmental considerations should take precedence over economic or institutional concerns (see Senate Report 99–199 that accompanied S. 1517, Senate Committee on Energy and Natural Resources, November 22, 1985, 99th Congress, 1st Session at page 9).

The Commission is confident that waste exemption decisions made in accordance with requirements that implement its BRC policy will be adequate to ensure protection of the public health and safety. The Commission is concerned that inconsistent regulation of BRC wastes could result in differing levels of risks to the public and the environment through the application of different residual radioactive criteria in the cleanup of contaminated sites. The Commission is also concerned that inconsistent regulation of BRC waste could in fact undermine State and Federal efforts to manage low-level waste safely. A uniform framework for exemption decisions is needed now to avoid disrupting State and compact development of new disposal facilities close to Congressional milestones in 1993 and 1996. Such a framework may also facilitate the resolution of the mixed waste issues for these BRC wastes.

The policy described in this document is intended to provide the public health and safety protection framework that would apply to a wide spectrum of Commission exemption decisions. As such, it provides individual and collective dose criteria, and discusses other important elements of the exemption decision-making process. Section II provides definitions of key terms and concepts used in the policy statement. Section III presents the basic elements of the policy, while Section IV discusses how the policy will be implemented through rulemakings and licensing actions and describes how the public will have an opportunity to comment on the Commission's exemption decisions. This section also notes NRC plans to review past exemption decisions to ensure consistency with the risk framework described in the BRC policy. Section V describes, in general terms, the information needed to support the exemption decision-making process.

II. Definitions.

"ALARA" (acronym for "as low as is reasonably achievable") means making every reasonable effort to maintain radiation exposures as far below applicable dose limits as is practical, consistent with the purpose for which the licensed activity is undertaken taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations and in relation to utilization of nuclear energy and licensed materials in the public interest.

"Agreement State" means any State with which the Commission has entered into an effective agreement under subsection 274(b) of the Atomic Energy Act of 1954, as amended.

"Byproduct material" means—

(1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material; and

(2) The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction

processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition.

"Collective dose" is the sum of the individual doses (total effective dose equivalents) received in a given period of time by a specified population from exposure to a specified source of radiation (or practice involving the use of radioactive material). Note: The calculated collective dose used to determine compliance with the criterion of this policy need not include individual dose contributions received at a rate of less than 0.1 mrem per year (0.001 mSv/year).

"Committed effective dose equivalent" is the sum of the products of weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to those organs or tissues.

"Deep dose equivalent" is the dose equivalent at a tissue depth of 1 cm.

"Dose" or "radiation dose" in this policy is the total effective dose equivalent.

"Exemption from regulatory control" refers to a decision process that may allow radioactive material to be transferred from a regulated status to an unregulated status, in which the material will no longer be subject to NRC requirements. Decisions to grant exemptions will be based upon findings by reason of quantity or concentration that the radioactive material poses a small risk to public health and safety and the environment and that the small magnitude of the risk does not warrant expenditure of additional resources of regulatory agencies and the regulated community in attempting to further reduce the risk.

"Exposure" means being exposed to ionizing radiation or to radioactive material.

"Licensed material" means source material, special nuclear material, or byproduct material that is received, possessed, used, transferred, or disposed of under a general or specific license issued by the Commission or an Agreement State.

"Licensee" means the holder of an NRC or Agreement State license.

"Linear, no-threshold hypothesis" refers to the theory that there is a proportional relationship between a given dose of radiation and the statistical probability of the occurrence of a health effect (such as latent cancers and genetic effects), and that there is no dose level below which there is no risk from exposure to radiation.

"Natural background dose" means the dose received from naturally occurring cosmic and terrestrial radiation and radioactive material but not from source, byproduct, or special nuclear material.

"Practice" is a defined activity or a set or combination of a number of similar coordinated and continuing activities aimed at a given purpose that involves the potential for radiation exposure. Disposal of specified types of very low-level radioactive waste; the release for unrestricted public use of lands and structures with residual levels of radioactivity; the distribution, use, and disposal of specific consumer products containing small amounts of radioactive material; and the recycle and reuse of specific types of residually contaminated materials and equipment are examples of practices for which this policy will have potential applicability. (See Section III for further discussion of practice).

"Rem" is the special unit of dose equivalent (1 rem = 0.01 sievert).

"Risk," for purposes of this policy, means the annual or lifetime probability of the development of fatal cancer from exposure to ionizing radiation and is taken as the product of the dose received by an exposed individual and a conversion factor based upon the linear, no-threshold hypothesis. The conversion factor for dose to risk is taken to be 5×10^{-4} fatal cancers per rem of radiation dose. The fatal cancer risk is considered, in general, to be more likely than other radiation induced health effects and to be the most severe outcome to an individual. While the Commission recognizes that the risks from exposure to radiation are greater for children than adults and that there are increased risks from exposure to the embryo/fetus, the estimate of fatal cancer risk for all ages and both sexes is considered to be an appropriate measure of risk from practices being considered for exemption in accordance with this policy statement (see Appendix).

"Source material" means —

(1) Uranium or thorium, or any combination of uranium and thorium in any physical or chemical form; or

(2) Ores which contain, by weight, one-twentieth of one percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

"Special nuclear material" means —

(1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of Section 51 of the Act,

determines to be special nuclear material, but does not include source material; or

(2) Any material artificially enriched by any of the foregoing but does not include source material.

"Total effective dose equivalent" means the sum of the deep dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures) expressed in rem or sievert.

III. Policy Elements.

The purpose of this policy statement is to establish the risk framework within which the Commission will initiate the development of appropriate regulations or make licensing decisions to exempt certain practices from some or all regulatory controls. This policy is directed principally toward rulemaking activities but may be applied to license amendments or license applications involving the release of licensed radioactive material either to the environment or to persons who would be exempt from Commission regulations. In either case, opportunity for public comment will be provided with each rulemaking and each licensing action where generic exemptions provisions have not already been established.

It is the Commission's intent to broadly define specific practices so that the effect of an exemption decision on any individual or population will be evaluated in its entirety and not in a piecemeal fashion. At the same time, the practice must be identified and described in terms that will facilitate reasonable impact analyses and allow imposition of appropriate constraints, requirements, and conditions as the radioactive material passes from a regulated to an unregulated status (i.e., the material is no longer required to be under the control of a licensee). Under this policy, the definition of a "practice" in any specific decision (rulemaking or licensing action) is a critical feature. The NRC will ensure that formulation of exemptions from regulatory control will not allow deliberate dilution of material or fractionation of the radiation or radioactive material for the purpose of circumventing controls that would otherwise be applicable. The definition of the practice in any specific exemption decision will also provide the framework for taking into account the potential effects of aggregated exposure from that practice together with other exempted practices, as well as the possible consequences of accidents or misuse or the potential for other nonstochastic radiological impacts associated with the exemption.

The Commission may determine on the basis of risk estimates and associated uncertainties that certain practices should not be considered candidates for exemption, such as the introduction of radioactive materials into products to be consumed or used primarily by children. Such practices should be specifically evaluated to determine if they could result in greater risk levels to exposed members of the public than the levels found acceptable by the Commission in formulating this policy. These decisions clearly fall within the Commission's purview to protect the health and safety of the public.

In formulating this policy statement, the Commission deliberated at length on the need to consider whether practices must be rigorously justified in terms of societal benefit regardless of the level of risk they pose. Justification of practice is recognized by health physics professionals and national and international organizations as one of the three fundamental tenets of radiation protection (justification, dose limits, and ALARA). The Commission has prepared this policy statement in conformance with these basic tenets as appropriate for exemption decisions. Consistent with the position of the International Atomic Energy Agency in its Safety Series Report No. 89, the Commission believes that justification decisions usually derive from considerations that are much broader than radiation protection alone. The Commission believes that justification decisions involving social and cultural value judgments should be made by affected elements of society and not the regulatory agency. Consequently, the Commission will not consider whether a practice is justified in terms of net societal benefit.

A. Principles of Exemption.

The principal consideration in exempting any practice from some or all regulatory controls hinges on the general question of whether the application or continuation of regulatory controls is necessary to protect the public health and safety and the environment. To decide if exemption is appropriate, the Commission must determine if adequate protection is provided and one of the following conditions is met:

1. The application or continuation of regulatory controls on the practice does not result in any significant reduction in dose received by individuals within a critical group (i.e., the group expected to receive the highest exposure) and by the exposed population; or

2. The costs of the controls that could be imposed for further dose reduction are not balanced by the potential commensurate reduction in risk.

At a sufficiently low level of risk, the Commission believes the decision-making process for granting specific exemptions from some or all regulatory controls can be essentially reduced to an evaluation of whether the overall individual and collective risks from each particular practice are sufficiently small. The Commission believes that individual and collective dose criteria should be basic features of its overall policy to define the region where the expenditure of Commission resources to enforce re-

...rements for further dose reductions or licensee resources to comply with such requirements is no longer warranted. These specific criteria include (1) values for the individual annual dose reasonably expected to be received as a result of the practice (e.g., an average dose to individuals in a critical group) and (2) a measure of radiological impact to the exposed population. In combination, these criteria are chosen to ensure that, for the average dose to members of the critical population group from a given exempted practice, individuals will not be exposed to a significant radiological risk and that the population as a whole does not suffer a significant radiological impact.

It is important to emphasize that, in this policy, the Commission does not assert an absence or threshold of risk at low radiation dose levels but rather establishes a baseline level of risk beyond which further government regulation to reduce risks is unwarranted. As described in the Appendix to this policy statement, the technical rationale for the Commission's BRC criteria is explicitly based on the hypothesis that the risk from exposure to radiation is linearly proportional to the dose to an individual. However, the presence of natural background radiation and variations in the levels of this background have been used to provide a perspective from which to judge the relative significance of the radiological risks involved in the exemption decision-making process.

The Commission notes that adoption of the individual and collective dose criteria does not indicate a decision that doses above the criteria would necessarily preclude exemptions. The criteria simply represent a range of risk that the Commission believes is sufficiently small compared to other individual and societal risks that further cost-risk reduction analyses are not required in order to make a decision regarding the acceptability of an exemption. Practices not meeting these criteria may nevertheless be granted exemptions from regulatory control on a case-by-case basis in accordance with the principles embodied within this policy, if (1) the potential doses to individual members of the public are sufficiently small or unlikely; (2) further reductions in the doses are neither readily achievable nor significant in terms of protecting the public health and safety and the environment; and (3) the collective dose from the exempted practice is ALARA.

B. The Individual Dose Criterion.

The Commission has noted that, although there is significant uncertainty in calculations of risks from low-level radiation, in general these risks are better understood than the risks from other hazards such as toxic chemicals. Moreover, radiation from natural background poses involuntary risks (primarily cancers), which must be accepted as a fact of life and are identical to the kinds of risks posed by radiation from nuclear materials under NRC jurisdiction. These facts provide a context in which to compare quantitatively the radiation risks from various practices and make radiation risk especially amenable to the use of the approach described below to define an acceptable BRC level.

The Commission believes that if the risk from doses to individuals from a practice under consideration for exemption is comparable to other voluntary and involuntary risks which are commonly accepted by those same individuals without significant efforts to reduce them, then the level of protection from that practice should be adequate. Furthermore, for risks at or below these levels there would be little merit in expending resources to reduce this risk further. The Commission believes the definition of a BRC dose level can be developed from this perspective.

Variations in natural background radiation apparently play no role in individuals' decisions on common matters such as places to live or work (e.g., the 60–70 mrem differences between average annual doses received in Denver, Colorado versus Washington, DC). In addition, individuals generally do not seem to be concerned about the difference in doses between living in a brick versus a frame house, the 5 mrem dose received during a typical roundtrip coast-to-coast flight, or incremental doses from other activities that fall well within common variations in natural background radiation. These factors lead to the conclusion that differential risks corresponding to doses on the order of 5–10 mrem (0.05–0.1 mSv) are well within the range of doses that are commonly accepted by members of the public, and that this is an appropriate order of magnitude for the Commission's BRC individual dose criterion.

Although the uncertainties in risk estimates at such low doses are large, the risk to an individual as calculated using the linear, no-threshold hypothesis is shown in Table 1 for various defined levels of annual individual dose. The values in the hypothetical lifetime risk column are based on the further assumption that the annual dose is continuously received during each year of a 70-year lifetime. To provide further perspective, a radiation dose of 10 mrem per year (0.1 mSv per year) received continuously over a lifetime corresponds to a risk of about 4 chances in 10,000 (3.5×10^{-4}) or a hypothetical increase of about 0.25% in an individual's lifetime risk of fatal cancer. The Commission prefers to use factors of ten to describe such low individual doses because of the large uncertainties associated with the dose estimates. The Appendix to the policy statement provides a more complete discussion of the risks and uncertainties associated with low doses and dose rates.

Table 1

Incremental Annual Dose*	Hypothetical Incremental Annual Risk**	Hypothetical Lifetime Risk From Continuing Annual Dose**
100 mrem (1.0 mSv)	5×10^{-5}	3.5×10^{-3}
10 mrem (0.1 mSv)	5×10^{-6}	3.5×10^{-4}
1 mrem (0.01 mSv)	5×10^{-7}	3.5×10^{-5}
0.1 mrem (0.001 mSv)	5×10^{-8}	3.5×10^{-6}

* The expression of dose refers to the Total Effective Dose Equivalent. This term is the sum of the deep [whole body] dose equivalent for sources external to the body and the committed effective [whole body] dose equivalent for sources internal to the body.

** Calculated using a conservative risk coefficient of 5×10^{-4} per rem (5×10^{-2} per Sv) for low linear energy transfer radiation based on the results reported in "Sources, Effects and Risks of Ionizing Radiation," United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1988 Report to the General Assembly with Annexes and "Health Effects of Exposures to Low Levels of Ionizing Radiation, BEIR V," 1990, Committee on Biological Effects of Ionizing Radiation, National Research Council (see also NUREG/CR-4214, Rev. 1).

In view of the uncertainties involved in risk assessment at low doses and taking into account the aforementioned risk and dose perspectives, the Commission finds that the average dose to individuals in the critical group should be less than 10 mrem per year (0.1 mSv per year) for each exempted practice. In addition, an interim dose criterion of 1 mrem per year (0.01 mSv per year) average dose to individuals in the critical group will be applied to those practices involving widespread distribution of radioactive material in such items as consumer products or recycled material and equipment, until the Commission gains more experience with the potential for individual exposures from multiple licensed and exempted practices. These criteria provide individual dose thresholds below which continued regulatory controls are unnecessary and unwarranted to require further reductions in individual doses. The Commission considers these criteria to be appropriate given the uncertainties involved in estimating doses and risks, and notes that these criteria should facilitate straightforward implementation of this policy in future rulemakings or licensing decisions.

The Commission believes that, notwithstanding exemption of practices from regulatory control under these criteria, it still has reasonable assurance that exposures to individual members of the public from all licensed activities and exempted practices will not exceed 100 mrem per year (1 mSv per year) given the Commission's intent (1) to define practices broadly; (2) to evaluate potential exposures over the lifetime of the practice; (3) to evaluate the potential for aggregated exposures from multiple exempted practices; (4) to impose both individual and collective dose criteria; (5) to monitor and verify how exemptions are implemented under this policy; (6) to verify dose calculations through licensing reviews and rulemakings with full benefit of public review and comment; and (7) to inspect and enforce licensee adherence to specific constraints and conditions imposed by the Commission on exempted practices.

The Commission intends that only under unusual circumstances would exemptions be considered for practices that could cause continuing radiation exposure to individuals exceeding a small fraction of 100 mrem per year (1 mSv per year). In rare cases, exemptions of such practices may be granted if, after conducting a thorough analysis of the proposed exemption, the Commission determines that doses to members of the public are ALARA and that additional regulatory control is not warranted by further reductions in individual and collective doses.

C. The Collective Dose Criterion.

The Commission believes that the collective dose (i.e., the sum of individual total effective dose equivalents) resulting from exposure to an exempt practice should be ALARA. However, if the collective dose resulting from an exempted practice is less than an expected value of 1000 person-rem per year (10 person-Sv per year), the resources of the Commission and its licensees could be better spent by addressing more significant health and safety issues than by requiring further analysis, reduction, and confirmation of the magnitude of the collective dose. The Commission notes that, at this level of collective dose, the number of hypothetical health effects calculated for an exempted practice on an annual basis would be less than one.

The National Council on Radiation Protection and Measurements recommends in its Report No. 91[1] that collective dose assessments for a particular practice

[1]Recommendations on Limits for Exposure to Ionizing Radiation, NCRP Report No. 91, National Council on Radiation Protection and Measurements, June 1, 1987. Available for purchase from NCRP Publications, 7910 Woodmont Ave., Suite 1016, Bethesda, MD 20814.

should exclude consideration of those individuals whose annual effective dose equivalent is less than or equal to 1 mrem per year (0.01 mSv per year). In the sensitivity-of-measure, risk-based guidelines used by EPA and FDA, a 10^{-6} lifetime risk of cancer has been used as a quantitative criterion of insignificance. Using an annual risk coefficient of 5×10^{-4} health effects per rem (5×10^{-2} per sievert), as discussed in the Appendix, the 10^{-6} lifetime risk value would approximate the calculated risk that an individual would incur from a continuous lifetime dose rate in the range of 0.01 to 0.1 mrem (0.0001 to 0.001 mSv) per year.

As a practical matter, consideration of dose rates in the microrem per year range and large numbers of hypothetical individuals potentially exposed to an exempted practice may unduly complicate the dose calculations that will be used to support demonstrations that proposed exemptions comport with the criteria in this policy. The Commission believes that inclusion of individual doses below 0.1 mrem per year (0.001 mSv per year) introduces unnecessary complexity into collective dose assessments and could impute an unrealistic sense of the significance and certainty of such dose levels. For all of these reasons, the Commission concludes that 0.1 mrem (0.001 mSv) per year is an appropriate truncation value to be applied in the assessment of collective doses for the purposes of this policy.

IV. Implementation.

The Commission's BRC policy will be implemented principally through rulemakings; however, exemption decisions could also be implemented through specific licensing actions.

In the first case, a proposal for exemption, whether initiated by the NRC or requested by outside parties in a petition for rulemaking, must provide a basis upon which the Commission can determine if the basic policy criteria have been satisfied. The Commission intends to initiate a number of rulemakings on its own (e.g., to establish a dose criterion for decommissioning) and may initiate others as a result of NRC's review of existing codified exemptions (e.g., consumer product exemptions in 10 CFR Parts 30 and 40). Rulemakings may also be initiated in response to petitions for rulemaking submitted by outside parties, such as a BRC waste petition submitted in accordance with Section 10 of the Low-Level Radioactive Waste Policy Amendment Act of 1985. In general, rulemaking exemption proposals should assess the potential health and safety impacts that could result if the exemption were to be granted.

The proposal should consider the uses of the radioactive materials, the pathways of exposure, the levels of radioactivity, and the methods and constraints for ensuring that the assumptions used to define a practice remain appropriate as the radioactive materials move from a regulated to an unregulated status. Any such rulemaking action would follow the Administrative Procedure Act, which requires publication of a proposed rule in order to solicit public comment on the rulemaking action under consideration. The rulemaking action would include an appropriate level of environmental review in accordance with the Commission's regulations in 10 CFR Part 51, which implement the National Environmental Policy Act.

If a proposal for exemption results in a Commission regulation containing specific requirements for a particular exemption, a licensee using the exemption would no longer be required to apply the ALARA principle to reduce doses further for the exempted practice provided that it meets the conditions specified in the regulation. The promulgation of the regulation would, under these circumstances, constitute a finding that the practice is exempted in accordance with the provisions of the regulation and that ALARA considerations have been adequately addressed from a regulatory standpoint. The Commission in no way wishes to discourage the voluntary application of additional health physics practices which may, in fact, reduce actual doses significantly below the BRC criteria or the development of new technologies to enhance protection to the public and the environment. This is particularly pertinent in the area of decontamination and decommissioning, where the Commission anticipates that emerging technologies over the next several decades should enhance existing technical capabilities and further reduce doses to workers and the public and where other Federal agencies are in the process of developing standards which may affect those receiving exemptions.

The second means of policy implementation could involve exemptions that would be granted through licensing actions, such as determinations that a specific site has been sufficiently decontaminated to be released for unrestricted public use. The NRC intends to develop guidance regarding the implementation of the BRC criteria to ensure that such site-specific actions adhere to the criteria and principles of this policy statement. New licensing actions that transfer radioactive material to an unregulated status will be noticed in the Federal Register if they differ from previous generic exemption decisions.

One of the principal benefits of the policy is that it provides a framework to evaluate and ensure the consistency of past exemption decisions by the Commission. With the adoption of this BRC policy, the NRC will initiate a systematic assessment of exemptions currently existing in NRC's regulations to ensure that the public is adequately and consistently protected from the risks associated with exempted practices. In addition, the NRC will, on a periodic basis, review the exemptions granted under this policy to ensure that the public health and safety continue to be protected adequately.

V. Information To Support Exemption Decisions.

A. General.

The information required to support an exemption decision in a rulemaking or licensing action should provide the basis for the proposed exemption in accordance with Section III of this policy. In addressing the radiological health and safety impacts, potential individual and collective doses attributed to the practice under consideration should either meet the policy's dose criteria or otherwise be demonstrated to be low enough to ensure protection of the public health and safety and ALARA. In addition to the impacts of routine exposures, realistic impacts resulting from potential misuse or accident scenarios should also be evaluated and demonstrated to be insignificant. The NRC may reject proposals for exemptions if they do not provide a sufficient technical basis to support analysis of the potential exemption.

Practices should be defined with respect to the geographic and demographic areas to which the exemption will apply. In some cases, an exemption will be limited to one particular locality or area. However, many practices will have national applicability and should be characterized accordingly. Information on these issues will be necessary for determinations regarding which individual dose criterion should be applied.

The Commission believes that the implementation guidance provided with its "General Statement of Policy and Procedures Concerning Petitions Pursuant to §2.802 for Disposal of Radioactive Waste Streams Below Regulatory Concern," published August 29, 1986, 51 FR 30839, generally defines the types of information needed to support an exemption decision. However, not all of the information may be applicable to the broader range of practices considered for exemption under this policy. Applicants should examine potentially relevant guidance available at the time the exemption proposal is being prepared and provide the information which is relevant to the particular type of exemption decision being requested.

B. Material Characterization.

1. Radiological properties. The radiological properties of the materials to be exempted should be described, including, as appropriate, the concentration or contamination levels and the half-lives, total quantities, and identities of the radionuclides associated with the exempted practice. The chemical and physical form of the radionuclides should be specified. All radionuclides present or potentially present should be specified. The distribution of the radionuclides should be noted (e.g., surface or volume distribution). Mass- and volume-averaged concentrations should also be presented. The variability of radionuclide concentration, distribution, or type as a function of process variation or variations among licensees should be addressed and bounded, as appropriate.

2. Nonradiological properties. The nonradiological properties of the materials to be exempted should be described to ensure complete characterization of the properties of the material and consideration of any adverse impacts associated with these properties. An NRC exemption, based on radiological impacts, would not relieve licensees from compliance with applicable rules of other agencies which cover nonradiological properties. A description of the materials, including their origin, chemical composition, physical state, volume, and mass should be provided. The variability and potential changes in the materials as a function of process variation should be addressed. The variation among licensees should be described and bounded, as applicable.

C. Practice Characterization

1. Total impact. A regulatory action taken under this policy is likely to be generic and may be nationwide in scale. Therefore, to the extent possible, an estimate of the number of NRC and Agreement State licensees that possess the radioactive material considered for exemption, the annual volumes and masses, and the total quantities of each radionuclide that would be a part of the exempted practice should be given. The estimates should include the current situation and the likely variability over the reasonably foreseeable future. A geographical description would be a helpful tool in characterizing the distribution of radioactive material involved in the exemption decision. Such distribution, submitted as part of the practice characterization, should be used to assess realistic impacts of the practice, in addition to conservative bounding estimates that tend to overestimate human exposures and doses. In any case, the typical quantities produced per practice (e.g., number of units of a particular consumer product) and an estimate of the geographic description of the practice should be described. The potential for short- and long-term recycle or reuse of the product containing the exempted radioactive material should also be addressed. Both the resource value (e.g., salvageable metals) and the functional usefulness (e.g., usable tools) should be examined.

2. Basis for assessment. A description of bases for the materials and practice characterizations should be provided. Monitoring and analytical data and calculations should be specified and provided in support of the characterization. Actual measurements or values that can be related to measurements to confirm calculations are important and should be provided. The description should address the quality-assurance program used in data collection and analysis and supporting information. If any surveys were conducted, they should be described. Market

:fc. ation may be useful in characterizing a practice on national basis.

3. As low as is reasonably achievable (ALARA). An nalysis should be provided that demonstrates that radia-.on exposure and radionuclide releases associated with ıe exempted practice overall will be ALARA consistent ·ith the criteria in this policy. The ALARA principle eferred to in 10 CFR Part 20 applies to efforts by licen-ees to maintain radiation exposures and releases of ra-ioactive materials to unrestricted areas as low as is rea-onably achievable. Appendix I to 10 CFR Part 50 de-cribes ALARA for radioactive material releases from ght water reactors (nuclear power plants). Exemption roposals should describe how ALARA considerations ave been applied in the design, development, and imp-ementation of controls for the proposed practice. Licen-ee compliance with the ALARA principle must remain ı effect up to and including the point at which the materi-ls are transferred to an unregulated status in accordance ·ith an exemption granted under this policy.

). Impact Analyses.

To support and justify a request for exemption, each etitioner or licensee should assess the radiological and onradiological impacts of the proposed exemption. The ın s should be based on the characterizations de-c previously and should cover all aspects of the roposed exempt practice, including possession, use, ransfer, ownership, and disposal of the material. NRC onsideration of the exemption proposal and any environ-nental assessments and regulatory analyses required to mplement the exemption will be based on the impact ınalyses and supporting characterizations.

1. Radiological impacts. The evaluation of radiologi-al impacts should clearly address the policy's individual ınd collective dose criteria or provide a sufficient ALARA evaluation supporting the exemption. In either ase, the following impacts should be assessed:

- Average doses to the critical population group;
- Collective doses to the critical population group and the total exposed population (under conditions defined in Section III); and
- The potential for and magnitude of doses associated with accidents, misuses, and reconcentration of radionuclides.

The collective doses should be estimated and summed in two parts: total dose to the critical population gr and total dose to the exposed population. The group is the relatively homogeneous group of indi-vi s whose exposures are likely to be the greatest and for whom the assessment of doses is likely to be the most accurate. Average doses to this group are the controlling factors limiting individual doses and risk, and should be compared with the individual dose criteria, as appropriate. The critical group should be the segment of the population most highly exposed to radiation or radioactive materials associated with the use of radioactive material under unregulated conditions. The second part of the population exposure is the general population exposure, exclusive of critical group exposure. For this group, the individual exposures should be smaller, and the assessment will often be less precise. The impacts analysis should present an estimate of the distribution of doses within the general population. In situations where truncation of the collective dose calculation is done under the provisions of this policy, the basis for applying the truncation provision should be provided.

The evaluation of radiological impacts should distinguish between expected and potential exposures and events. The analysis of potential exposures in accident or misuse scenarios should include all of the assumptions, data, and results used in the analysis in order to facilitate review. The evaluation should provide sufficient information to allow a reviewer to independently confirm the results. The potential for reasonable interactions between the exempted radioactive material and the public should be assessed.

2. Other impacts. The analysis of other radiological impacts such as those from transportation, handling, processing, and disposal of exempted materials should be evaluated. Nonradiological impacts on humans and the environment should also be evaluated in accordance with NRC requirements in 10 CFR Part 51. The analysis should also consider any adverse impact of the measures taken to provide nonradiological protection on radiation exposure and releases of radioactive material. Any NRC action to exempt a practice from further regulatory control would not relieve persons using, handling, processing, owning, or disposing of the radioactive material from other requirements applicable to the nonradiological properties of the material.

E. Cost-Benefit Considerations (as required).

A cost/benefit analysis is an essential part of both environmental and regulatory impact considerations. The analysis should focus on expected exposures and realistic concentrations or quantities of radionuclides. The cost/benefit analysis should compare the exposures and economic costs associated with the regulated practice and alternatives not subject to regulation. Benefits and costs should be considered in both quantitative and qualitative terms. Costs of surveys and compliance verification discussed under Item V.G. should also be covered. Any legal or regulatory constraints that might affect an exemption decision should be identified. For example, one such constraint might stem from Department of Transportation

(DOT) requirements for labeling, placarding, and manifesting radioactive materials in 49 CFR Part 173.

F. Constraints, Requirements, or Conditions on Exemptions.

In most cases, the characterizations of the material and the assessment of impacts will be based on either explicit or implicit constraints, such as limitations on the amount of radioactive material in a consumer product. In order for an exemption decision to take credit for these constraints, the exemption proposal should specifically identify appropriate constraints, such as quantity limits, concentration limits, and physical form characteristics. The bases on which these constraints are to be ensured should also be discussed. In general, constraints should be verifiable in order to provide the basis for an exemption decision.

G. Quality Assurance and Reporting.

This portion of the exemption proposal should be tailored to either a generic petition for rulemaking or specific proposal for a license amendment. For generic petitions for rulemaking, the proposal should provide and justify generic requirements for Quality Assurance/Quality Control and Reporting. Such proposals should include example requirements and show their effectiveness and feasibility. For site-specific license amendments, the exemption proposal should provide specific requirements for Quality Assurance/Quality Control and Reporting that have been tailored to the licensee's program.

1. Quality assurance/quality control. The program to ensure compliance with specific exemption constraints, requirements, or conditions should be defined. The records of inventory, tests, surveys, and calculations used to demonstrate compliance with the exemption constraints should be maintained for inspection. Such programs are necessary to provide the NRC and the public reasonable assurance of conformance with the constraints and of adequate protection of human health and the environment.

2. Reports. Reports may be required from licensees who, by rule or license, are permitted to release materials exempted from regulatory control. Associated recordkeeping to generate the reports should be defined. Minimum information in the reports could include volume, isotope and curie content. More detailed recordkeeping and reporting requirements may be imposed to address uncertainties in projecting future volumes or amounts of exempted materials and to consider the cumulative impacts of multiple exemptions.

APPENDIX – DOSE AND HEALTH EFFECTS ESTIMATION

I. Dose Estimation

In estimating the dose rates to members of the public that might arise through various practices for which exemptions are being considered, the Commission has decided to apply the concept of the "total effective dose equivalent." This concept, which is based on a comparison of the delayed health effects of ionizing radiation exposures, permits the calculation of the whole body dose equivalent of partial body and organ exposures through use of weighting factors. The concept was proposed by the International Commission on Radiological Protection (ICRP) in its Publication 26 issued in 1977. Since that time, the concept has been reviewed, evaluated, and adopted by radiation protection organizations throughout the world and has gained wide acceptance. The "total effective dose equivalent" concept is incorporated in "Radiation Protection Guidance to Federal Agencies for Occupational Exposure–Recommendations Approved by the President," that was signed by the President and published in the Federal Register on January 27, 1987 (52 FR 2822). The Commission recognizes that, in considering specific exemption proposals, the total effective dose equivalent must be taken into account.

Estimating Health Effects From Radiation Exposure

A. Individual Risks.

In the establishment of its radiation protection policies, the Commission has considered the three major types of stochastic (i.e., random) health effects that can be caused by relatively low doses of radiation: cancer, genetic effects, and developmental anomalies in fetuses. The NRC principally focuses on the risk of fatal cancer development because (1) the mortality risk represents a more severe outcome than the nonfatal cancer risk, and (2) the mortality risk is thought to be higher than the risk associated with genetic effects and developmental effects on fetuses.[2] However, even though radiation has been shown to be carcinogenic, the development of a risk factor applicable to continuing radiation exposures at levels equal to natural background[3] requires a significant extrapolation from the observed effects at much higher doses and dose rates.[4] This results in significant uncertainty in risk estimates as reflected by the views of experts in the field. For example, the Committee on the Biological Effects of Ionizing Radiation (BEIR III) of the National Academy of Science cautioned that the risk values are "...based on incomplete data and involve a large degree of uncertainty, especially in the low dose region." This Committee also stated that it "...does not know whether dose rates of gamma or x-rays (low LET; low linear energy transfer radiation) of about 100 mrads/year (1 mGy/year) are detrimental to man." More recently, the BEIR V Committee of the National Academy of Science/National Research Council stated that it "recognizes that its risk estimates become more uncertain when applied to very low doses. Departures from a linear model at low doses, however, could either increase or decrease the [estimation of] risk per unit dose." The Commission understands that the Committees' statements reflect the uncertainties involved in estimating the risks of radiation exposure and do not imply either the absence or presence of detrimental effects at such low dose levels.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) stated in their 1988 Report to the General Assembly that "...there was a need for a reduction factor to modify the risks (derived at high doses and dose rates)...for low doses and dose rates....[A]n appropriate range (for this factor) to be applied to total risk for low dose and dose rate should be between 2 and 10." This factor would lead to a risk coefficient value between 7×10^{-5} and 3.5×10^{-4} per rad (7×10^{-3} and 3.5×10^{-2} per Gy) based on an UNSCEAR risk coefficient of 7.1×10^{-4} per rad (7.1×10^{-2} per gray) for 100 rad (1 gray) organ absorbed doses at high dose rates. The report also stated, "The product of the risk coefficient appropriate for individual risk and the relevant collective dose will give the expected number of cancer deaths in the exposed population, provided that the collective dose is at least of the order of 100 person-Sv (10,000 person-rem). If the collective dose is only a few person-Sv (a few hundred person-rem), the most likely outcome is zero deaths."

In December 1989, the BEIR V Committee published a report entitled "Health Effects of Exposure to Low Levels of Ionizing Radiation," which contained risk estimates that are, in general, similar to the findings of

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[2] Further discussion of these topics is provided in "Sources, Effects and Risks of Ionizing Radiation," United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1988 Report to the General Assembly with Annexes.

[3] Natural background radiation can vary with time and location. In Washington, D.C., natural background radiation (excluding radon) results in individual doses of about 90 mrem per year (0.9 mSv/yr), while in Denver, Colorado, the value is about 160 mrem per year (1.6 mSv/yr). In both cases, naturally occurring radioactive material in the human body contributes approximately 40 mrem per year. Radiation from inhalation of the daughter products of radon contributes an average additional dose of 200 mrem per year (2 mSv/yr) to members of the U.S. population (NCRP Report No. 93, "Ionizing Radiation Exposure of the Population of the United States").

[4] The health effects clearly attributable to radiation have occurred principally among early radiation workers, survivors of the atomic bomb explosions at Hiroshima and Nagasaki, individuals exposed for medical purposes, and laboratory animals. Natural background radiation causes an annual dose that is at least two orders of magnitude less than the dose received by human populations from which the cancer risks are derived. Experiments at the cellular level, however, provide similar indications of biological effects at low doses.

the 1988 UNSCEAR report. The BEIR V report's estimate of lifetime excess risk of death from cancer following an acute dose of 10 rem (0.1 Sv) of low-LET radiation was 8×10^{-3}. Taking into account a dose rate effectiveness factor for doses occurring over an extended period of time, the risk coefficient is on the order of 5×10^{-4} per rem, consistent with the upper level of risk estimated by UNSCEAR.

In view of this type of information, the NRC, the Environmental Protection Agency, and other national and international radiation protection authorities have established radiation protection standards defining recommended dose limits for radiation workers and individual members of the public. As a matter of regulatory prudence, all these bodies have derived the value presumed to apply at lower doses and dose rates associated with the radiation protection standards by a linear extrapolation from values derived at higher doses and dose rates. This model is frequently referred to as the linear, no-threshold hypothesis, in which the risk factor at low doses reflects the straight-line (linear) dose-effect relationship at much higher doses and dose rates. In this respect, the BEIR V report notes that "in spite of evidence that the molecular lesions which give rise to somatic and genetic damage can be repaired to a considerable degree, the new data do not contradict the hypothesis, at least with respect to cancer induction and hereditary genetic effects, that the frequency of such effects increases with low-level radiation as a linear, non-threshold function of the dose."

The Commission, in the development of the BRC policy, is faced with the issue of how to characterize the individual and population risks associated with low doses and dose rates. Although the uncertainties are large, useful perspective on the bounding risk associated with very low levels of radiation can be provided by the linear, no-threshold hypothesis. Consequently, such risk estimates have been a primary factor in establishing individual and collective dose criteria associated with this policy. The estimations of the low risk from potentially exempted practices can be compared to the relatively higher potential risks associated with other activities or decisions over which the NRC has regulatory responsibility. Through such comparisons, the Commission can ensure that its radiation protection resources and those of its licensees are expended in an optimal manner to accomplish its public health and safety mission.

In this context, the risk to an individual as calculated using the linear, no-threshold hypothesis is shown in Table 1 for various defined levels of annual individual dose. The values in the hypothetical lifetime risk column are based on the further assumption that the annual dose is continuously received during each year of a 70-year lifetime. To provide further perspective, a radiation dose of 10 mrem per year (0.1 mSv per year) received continuously over a lifetime corresponds to a hypothetical increase of about 0.25% in an individual's lifetime risk of cancer death. Ten millirem per year (0.1 mSv per year) is also a dose rate that is a small fraction of naturally occurring background radiation and comparable to the temporal variations in natural background radiation due to fluctuations that occur at any specific location.

The Commission prefers to use factors of ten to describe such low individual doses because of the large uncertainties associated with the dose estimates. Use of values such as 0.7 or 12 imputes a significance and sense of certainty that is not justified considering the levels of uncertainty in the dose and risk estimates at these low levels. Thus, order of magnitude values such as 1 and 10 are preferable to avoid providing analysts and the public with a sense of certainty and significance that is not commensurate with the actual precision and certainty of the estimates.

B. Collective or Population Risk

In the application of the fundamental principles of radiation protection, collective dose provides a useful way to express the radiological impact (i.e., potential detriments) of a practice on the health of the exposed population. Because of the stochastic nature of risk, analysis of exposures of large groups of people to very small doses may result in calculated health effects in the population at large. Collective dose is the sum of the individual total effective dose equivalents resulting from a practice or source of radiation exposure. It is used in comparative cost-benefit and other quantitative analytical techniques and, therefore, is an important factor to consider in balancing benefits and societal detriments in applying the ALARA principle. For purposes of this policy, individual total effective dose equivalents less than 0.1 mrem per year (0.001 mSv per year) do not need to be considered in the estimation of collective doses. The Commission believes consideration of individual doses below 0.1 mrem per year imputes a sense of significance and certainty of their magnitude that is not justified considering the inherent uncertainties in dose and risk estimates associated with potentially exempted practices. The Commission also notes that doses in the range of 0.01 to 0.1 mrem per year correspond approximately to lifetime risks on the order of one in a million. The NRC has used collective dose, including rationales for its truncation, in a number of rulemaking decisions and in resolving a variety of generic safety issues.

Table 1

Incremental Annual Dose*	Hypothetical Incremental Annual Risk**	Hypothetical Lifetime Risk From Continuing Annual Dose**
100 mrem (1.0 mSv)	5×10^{-5}	3.5×10^{-3}
10 mrem (0.1 mSv)	5×10^{-6}	3.5×10^{-4}
1 mrem (0.01 mSv)	5×10^{-7}	3.5×10^{-5}
0.1 mrem (0.001 mSv)	5×10^{-8}	3.5×10^{-6}

* The expression of dose refers to the Total Effective Dose Equivalent. This term is the sum of the deep [whole body] dose equivalent for sources external to the body and the committed effective [whole body] dose equivalent for sources internal to the body.

** Risk coefficient of 5×10^{-4} per rem (5×10^{-2} per Sv) for low linear energy transfer radiation has been conservatively based on the results reported in UNSCEAR 1988 (Footnote 2) and BEIR V (see also NUREG/CR–4214, Rev. 1).

III. Dose and Risk Estimation

The Commission recognizes that it is frequently not possible to measure risk to individuals or populations directly and, in most situations, it is impractical to measure annual doses to individuals at the low levels associated with potential exemption decisions. Typically, radionuclide concentrations or radiation dose rates can only be measured before the radioactive material is released from regulatory control. Estimates of doses to members of the public from the types of practices that the Commission would consider exempting from regulatory control must be based on input of these measurements into exposure pathway models, using assumptions related to the ways in which people might become exposed. These assumptions incorporate sufficient conservatism to account for uncertainties so that any actual doses would be expected to be lower than the calculated doses. The Commission believes that this is an appropriate approach to be taken when determining if an exemption from some or all regulatory controls is warranted.

The additional views of Commissioner Curtiss and Chairman Carr's comments are attached.

Dated at Rockville, Maryland, this 26th day of June, 1990.

For the Nuclear Regulatory Commission.

Samuel J. Chilk
Secretary of the Commission.

Additional Views of Commissioner Curtiss

I strongly endorse going forward with a comprehensive policy that will establish a disciplined and consistent framework within which the Commission can define those practices that, from the standpoint of radiological risk, we consider to be below regulatory concern (BRC). The principal advantage of such a policy, in my view, is that it will bring much-needed discipline and technical coherence to the patchwork of BRC regulatory decisions that have been rendered to date, providing a clearly articulated, risk-based approach for reaching decisions on matters such as—(1) the release for unrestricted public use of lands and structures containing residual radioactivity, (2) the distribution of consumer products containing small amounts of radioactive material, (3) the disposal of very low-level radioactive waste, and (4) the recycling of slightly contaminated equipment and materials. A coherent, risk-based policy is urgently needed to provide the foundation for future regulatory actions in each of these areas. Accordingly, I strongly support this initiative.

There are certain aspects of this policy, however, with which I must reluctantly disagree. My views on these matters follow:

Individual Dose Criteria

I support the individual dose criteria of 10 millirem per year for practices involving potential exposures to limited numbers of the public and 1 millirem per year for widespread practices that involve potential exposures to large numbers of the public. In view of the potential for multiple exposures from widespread practices, however, and in the interest of administrative finality, I believe that the Commission should establish the 1-millirem criterion as a final criterion, rather than an interim value.

Collective Dose Criterion

I do not support the establishment of a collective dose criterion at a level of 1000 person-rem. This level is an order of magnitude higher than the level recommended in IAEA Series No. 89, as well as the level recommended by most other international groups. Furthermore, it is an order of magnitude higher than the 1986 collective dose to members of the public due to effluents from *all* operating reactors, the most recent year for which figures are available.

A collective dose criterion of 1000 person-rem would mean, for example, that if, pursuant to this Policy Statement, the Commission were to exempt on the order of fifteen separate practices with collective doses at or near the exemption level of 1000 person-rem—not an unreasonable expectation, given previous practice—we would project somewhere between 5 and 10 excess health effects annually. I consider this level to be unacceptably high, when viewed in the context of other risks that we regulate and in view of the fact that the purpose of this Policy Statement is to establish a framework for identifying those practices that the Commission considers to be below regulatory concern.

Beyond this, if the collective dose criterion is to be defined as the floor to ALARA (as I would propose below), a more conservative approach to establishing a collective dose criterion is warranted in view of the fact that doses may be truncated in the calculation of collective dose and the collective dose criterion may be applied to single licensing actions.

For these reasons, I do not support a collective dose criterion of 1000 person-rem. Instead, in view of what appears to be the prevailing technical view on this matter, I would endorse a collective dose criterion of 100 person-rem.[1]

ALARA

I would define the individual and collective dose criteria as floors to ALARA.[2] Unfortunately, the Policy Statement is equivocal on this issue, suggesting at one point that the individual and collective dose criteria should be construed as floors to ALARA —

> [A] licensee . . . would no longer be required to apply the ALARA principle to reduce doses further for the exempted practice provided that it meets the conditions specified in the regulation.

but then going on to send what I consider to be a conflicting and confusing message about what the Commission expects —

> The Commission in no way wishes to discourage the voluntary application of additional health physics practices which may, in fact, reduce actual doses *below the BRC criteria* or the development of new technologies to enhance protection to the public and the environment (emphasis added).

If the Commission intends to say, as I believe it does in this Policy Statement, that those practices that fall within

[1] I would point out that the Policy Statement allows higher collective doses if analyses show that the collective dose is ALARA for a given practice. Therefore, adoption of the lower IAEA value of 100 person-rem based on dollar estimates of resources to do detailed ALARA analyses would not eliminate the option to approve practices such as smoke detectors that involve large numbers of potentially exposed members of the public.

[2] By "floor to ALARA," I mean that the petitioner and the staff are relieved from the regulatory obligation to perform further ALARA analyses below these levels if individual doses are 1 millirem/10 millirem *and* the collective dose is 100 person-rem.

t[ind]ividual and collective dose criteria can be designated below regulatory concern, it is unclear why the Commission would then go on to say that it expects additional steps to be taken to keep exposures ALARA. As a general matter, I do not object to the ALARA concept. Indeed, I support the notion that collective dose and ALARA analyses should be performed in a manner that is consistent with basic national and international radiation protection principles. But in the context of a Policy Statement on Below Regulatory Concern, for the Commission to say on the one hand that the individual and collective dose criteria reflect levels below which no regulatory resources should be expended, while at the same time encouraging voluntary ALARA efforts to achieve lower doses, sends a confusing regulatory message.[3] For the sake of regulatory clarity, I would explicitly identify the individual and collective dose criteria as floors to ALARA.

Justification of Practice

On the issue of justification of practice, the Policy Statement is unclear as to when and under what circumstances the justification of practice principle would be applied. At one point, the Policy Statement provides that:

> The Commission believes that justification decisions involving social and cultural value judgments should be made by affected elements of society and not the regulatory agency. Consequently, the Commission will not consider whether a practice is justified in terms of net societal benefit.

At another point, the Policy Statement indicates that:

> The Commission may determine on the basis of risk estimates and associated uncertainties that certain practices should not be considered candidates for exemption, such as the introduction of radioactive materials into products to be consumed or used primarily by children.

This bifurcated approach to justification of practice, which appears to distinguish practices involving children from all other practices, will inevitably lead to confusion. Moreover, this approach poses the very real potential that the Commission could, on the one hand, reject a practice involving children (e.g., baby food, pacifiers, and the like) on the ground that the risk posed by such a practice is too high, yet authorize a practice directed at the general public that could, coincidentally, expose an even greater number of children, even though the practice itself is not specifically directed at children.

In my view, this ambiguity should be resolved in favor of a clear and unequivocal statement endorsing the principle of justification of practice. While I acknowledge that the principle of justification of practice calls upon the Commission to make decisions involving so-called questions of "societal value," that is an insufficient reason, in my view, to step back from this widely accepted health-physics principle. Indeed, the Commission already takes such considerations into account, either explicitly or implicitly, in many of the decisions that it renders.

Accordingly, in view of the central role that the justification of practice principle has played in health physics practice, as well as the complexity and confusion that will invariably result from the approach set forth in the Policy Statement, I would state explicitly in this Policy Statement that the Commission retains the prerogative to determine that specific practices may be unsuitable for exemption, regardless of risk, documenting such determinations on a case-by-case basis.

Agreement State Compatibility

With one exception, I concur in the general approach that this Policy Statement takes on the issue of Agreement State compatibility. The one area where I disagree involves the treatment of matters involving low-level radioactive waste disposal.

As I understand the position of the majority, the approach established in this Policy Statement, and to be implemented in the context of subsequent rulemaking initiatives, will be considered a matter of strict compatibility for Agreement State programs. As a consequence, the approach taken by individual Agreement States on BRC issues must be identical to the approach taken by the Commission. I disagree with this approach for the following reasons:

When Congress enacted the Low Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA), it vested in the States the responsibility for developing new low-level radioactive waste disposal capacity. Indeed, the Congress recognized at the time that the States were uniquely equipped to handle this important responsibility. Accordingly, the States were given a great deal of latitude in deciding how best to proceed with the development, construction, and operation of new low-level waste disposal facilities. To take one example, Congress

[3] I am also concerned that the approach to ALARA set forth in the Policy Statement appears to be motivated, in part, by a concern that the Environmental Protection Agency may at some future point set more stringent criteria for BRC. Of particular note is the statement that—

> This [approach to ALARA] is particularly pertinent in the area of decontamination and decommissioning ... where other federal agencies are in the process of developing standards which may affect those receiving exemptions.

In my view, the ALARA issue should be approached with the objective of formulating a sound and defensible policy, rather than with an eye towards trying to anticipate what policy EPA might establish in the future.

recognized that some States may decide to construct facilities that, from a technical standpoint, go beyond the requirements established in 10 CFR Part 61 for shallow land burial facilities; for this reason, Congress directed the NRC to develop guidance on alternatives to the shallow land burial approach reflected in Part 61 (see Section 8 of P.L. 99-240). Similarly, should a State decide to require radioactive wastes beyond those defined by the NRC as Class A, B, and C wastes to be disposed of in a regional disposal facility, the Act permits the States that option as well (see Section 3(a)(2) of P.L. 99-240).[4] In short, the LLRWPAA grants States a great deal of latitude in deciding what kind of facility to build and what types of waste will be disposed of in that facility, so long as—(1) the facility complies with the requirements of 10 CFR Part 61 and (2) the State provides disposal capacity for Class A, B, and C wastes.

If one interprets the LLRWPAA in this manner, as I do, then in my judgment it is consistent with this general approach to conclude that this Policy Statement (and the subsequent rulemaking initiatives implementing the Policy Statement) should not be considered matters of compatibility. The result of such an approach would be that individual States would be allowed the option of deciding whether low-level wastes designated BRC by the Commission under this Policy Statement should nevertheless be disposed of in a licensed low-level radioactive waste disposal facility.

The argument, as I understand it, that is advanced in support of the approach taken in the Policy Statement—that the Commission's position on BRC should be a matter of compatibility — is that States should be foreclosed from departing in any way from the approach established by the Commission. To take the most visible and controversial example that has arisen to date, this would lead to the result that a State could not require that low-level waste streams designated BRC by the Commission nevertheless be disposed of in a licensed low-level radioactive waste disposal facility.

I am not aware of any public health and safety rationale involving low-level waste disposal that has been advanced as a basis for the NRC to insist that the Commission's position on BRC should be a matter of compatibility for Agreement States. One hears the anecdotal information about reducing exposures to truck drivers by allowing BRC waste streams to be disposed of in local landfills, rather than requiring such waste to be transported across the country to a licensed low-level waste disposal facility. If examples such as this constitute the basis for declaring that a health and safety concern exists such that the Commission should, in turn, prohibit a State from requiring such waste to be disposed of in a licensed low-level waste disposal facility, then a more disciplined and persuasive presentation of the argument is needed. To date, I have yet to see such a case.[5] In the absence of a health and safety concern, it is incongruous, in my judgment, to say that the risk from a particular waste stream can be so insignificant as to be "below [NRC's] regulatory concern," but at the same time insist that we nevertheless have a sufficient interest to dictate how a State might otherwise wish to handle that waste stream.[6]

For the foregoing reasons, I would not treat the Federal policy on below regulatory concern, as set forth in this Policy Statement and subsequent rulemakings, as a matter of compatibility for Agreement States when it comes to issues involving commercial low-level radioactive waste disposal.

[4] Indeed, the Commission did not object when the Rocky Mountain compact proposed to dispose of radium waste in the Rocky Mountain compact site.

[5] This kind of information may well be a part of the waste stream petition that the nuclear utilities are reportedly preparing for submission. If so, I would hold open the option of revisiting this question if and when the petition is filed. But at this point, I have yet to see a health and safety justification that would support a decision on the Commission's part that states should be preempted from the option of requiring waste streams designated BRC under this Policy Statement to be disposed of in licensed low-level radioactive waste disposal facilities.

[6] The argument has been made that permitting states the option of requiring BRC waste streams to be disposed of in licensed low-level waste disposal facilities would use up scarce disposal capacity and otherwise have an adverse impact on the compacting process. Indeed, this appears to have been one of the principal concerns advanced in the Commission's 1986 Policy Statement on BRC, wherein the Commission expressed the view that low-level waste generators would "be competing for space in the existing [LLW disposal] sites and the [BRC] concept should be applicable nationwide" in order to ensure "that the system works on a national basis and that it remains equitable." It was in part for this reason that the Commission declared in the 1986 Policy Statement that future "[r]ulemakings granting petitions [on BRC] will be made a matter of compatibility for Agreement States." (Policy Statement, 51 *Fed.Reg.* 30839, 30840 (August 29, 1986)). Whatever merit that approach might have had at the time, I disagree with it for two reasons: (1) Congress has vested states with the responsibility for developing and managing disposal capacity for low-level waste and, in view of this, decisions about how best to proceed, including decisions about whether States prefer to require BRC waste streams to be disposed of in licensed low-level waste sites rather than sanitary landfills, are best left to the individual States. (2) There is an abundance of disposal capacity under development at the present time and, for this reason, the concern about husbanding limited disposal capacity no longer appears to be relevant. Indeed, the decision to permit the Rocky Mountain compact to dispose of radium waste in its regional disposal facility seems to suggest that the objective of preserving limited disposal capacity for the disposal of low-level radioactive waste is not the driving consideration.

Chairman Carr's Response to Commissioner Curtiss' Views on the BRC Policy Statement

I am proud of the Commission's accomplishment in completing a comprehensive Below Regulatory Concern policy statement. I appreciate Commissioner Curtiss' enthusiasm and strong support for the policy. Commission deliberation of such views has helped to forge a comprehensive risk framework for ensuring that the public is protected at a consistent level of safety from existing and future exemptions and releases of radioactive materials to the general environment. The framework should also be helpful in allowing NRC, States, and the public to focus resources on reducing the more significant risks under NRC's jurisdiction. I offer the following response to Commissioner Curtiss' thoughtful views in the spirit of the constructive process that has culminated in the BRC policy.

As with many of the issues that the Commission deals with, there were very few right and wrong solutions to the issues associated with the BRC policy. The Commission reached its decisions on the policy by selecting preferred solutions from among a spectrum of possible policy options. These decisions were made based on the Commission's technical analysis of the issues associated with regulatory exemptions, legal interpretation of governing legislation, and regulatory experience in approving exemptions since the birth of civilian uses of nuclear materials in the 1950's. I believe Commissioner Curtiss' views on selected issues constitute part of the continuous spectrum of policy options. However, for the reasons articulated below, I affirm the Commission's decision to approve the policy statement in its present form and reject the differing views put forth by Commissioner Curtiss.

Commissioner Curtiss clearly endorses the policy and the concept of establishing a comprehensive framework for making decisions on regulatory exemptions. However, he takes issue with five elements of the policy: (1) the interim nature of the 1-millirem-per-year criterion for practices with widespread distribution, (2) selection of the 1000-person–rem-per-year criterion for collective dose, (3) the manner in which the Commission views the BRC criteria as a "floor" to ALARA, (4) omission of the principle of justification of practice, and (5) making BRC rules an item of compatibility for Agreement State programs. These issues were fully considered by the Commission and the NRC staff in the course of developing the BRC policy. Indeed, Commissioner Curtiss voted in September 1989 to approve the BRC policy, the essence of which is preserved in the final BRC policy in today's notice.

Interim Individual Dose Criterion

On the first issue, Commissioner Curtiss would prefer to establish the 1-millirem-per-year criterion as a final criterion, rather than an interim value.

As stated in the BRC policy, the Commission is establishing the 1-millirem-per-year criterion as an interim value until after it develops more experience with the potential for individual exposures from multiple licensed and exempted practices. The widespread practices to which this criterion applies are primarily consumer products, which could involve very small doses to large numbers of people. The 1-millirem criterion was selected specifically to address the possibility that members of the public may be exposed to several exempted practices.

Simply put, exposure of an individual to a handful of exempted practices could result in annual doses close to 100 millirem if each practice were allotted individual doses up to 10 millirem per year. This is highly improbable given the Commission's plans to closely monitor any overlap of exposed populations from exempted practices as well as the aggregate dose to the public from exemptions. Nevertheless, NRC does not presently know how many exemption requests will be submitted by the public, how many will be approved, and what types of doses will be associated with the exemptions. If few exemptions are requested and granted, the probability of multiple exposures from exempted and licensed practices exceeding a substantial fraction of 100 millirem per year is considerably reduced. Therefore, the 1-millirem-per-year criterion may be too restrictive and the regulatory resources associated with its implementation may be better spent to control more significant risks. Consequently, the 1-millirem-per-year criterion was selected as an interim individual dose criterion to ensure that the sum of all exposures to an individual from exempted practices does not exceed a substantial fraction of 100 millirem per year. This criterion will remain an interim value until after the Commission gains experience with the potential for multiple exposures to exempted and licensed activities.

The initial rulemakings to implement the policy, particularly in the area of consumer product exemptions, should provide valuable insights into the validity and appropriateness of the 1-millirem criterion in terms of its need to protect the public against multiple exposures to nuclear materials. Although I agree with Commissioner Curtiss that a final criterion would be desirable from the standpoint of "administrative finality," it would be premature to establish the 1-millirem criterion as a final criterion until after the Commission gains more experience with exemptions of practices with widespread distribution.

Collective Dose Criterion

Commissioner Curtiss would have preferred to adopt a collective dose criterion of 100 person–rem/year because of his view that this value is more consistent with the prevalent technical view on this matter.

For the reasons discussed below, I believe that a collective dose criterion of 1000 person–rem/year is more consistent with the prevalent technical view on this matter and provides a sounder regulatory basis for making exemption decisions. The Commission considered two fundamental questions associated with the collective dose criterion: (1) is there a need for a collective dose criterion and, if so, (2) what should the value of that criterion be?

The Commission initially questioned the very need for a collective dose criterion for the types of practices that would be considered as potential candidates for exemption. This questioning was based on a number of factors that indicated that the Commission may not need to consider collective dose in making exemption decisions. These factors included:

1. There is considerable uncertainty associated with the validity of risk estimates based on projections of collective doses composed of small to very small doses to large numbers of people.

2. The individual dose criteria of 1 and 10 millirem per year, coupled with the other provisions of the policy (e.g., broad definition of practice), should ensure a consistent and adequate level of protection of members of the public from all exempted and licensed practices.

3. Although collective dose has been considered in evaluating environmental impacts and in assessing the effectiveness of licensee ALARA programs, NRC's regulatory program has not traditionally placed specific constraints on collective doses associated with regulated activities.

4. Based on comments submitted to the Commission on its proposed BRC policy, including comments presented by the Health Physics Society, the prevailing technical view opposed adoption of a collective dose criterion in the BRC policy.

Despite these considerations, the Commission also recognized the benefit of a collective dose criterion in limiting the total population dose associated with exempted practices and in evaluating environmental impacts and the effectiveness of ALARA programs. Consequently, the Commission decided to establish a collective dose criterion as a part of the BRC policy, provided that it was based on valid scientific analysis and that it did not constrain decisions on exemptions without an adequate health and safety or environmental basis.

Based on these provisions, the Commission selected the value of 1000 person–rem/year as a level of collective dose that ensures less than one health effect per practice. In selecting this value, the Commission relied on contemporary recommendations of expert national and international bodies. These included the 1988 conclusions of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) that collective dose calculations only provide reasonable estimates of health risks if the collective dose is at least of the order of 10,000 person–rem. This value is an order of magnitude greater than the value of the collective dose criterion selected by the Commission. UNSCEAR also stated that the most likely outcome of collective doses on the order of a few hundred person–rem is zero deaths.

The Commission also considered the magnitudes of collective doses associated with practices, primarily consumer products, that have already been exempted by the Commission. This was done to provide a benchmark for the value of the collective dose criterion based on historical decisions that the public found acceptable. The Commission found that the magnitudes of the collective doses for these exempted practices fell in the range of the 1000 person–rem/year dose. Specific examples include 1200 person–rem/year from watches whose dials are adorned with paint containing tritium, 800 person–rem/year from smoke detectors containing radioactive materials, and 8600 person–rem/year from gas mantles for lanterns that contain thorium (NCRP Report No. 95).

In addition, the Commission considered the magnitude of collective doses associated with licensed activities, such as discharge of effluents from nuclear power plants. The Commission established ALARA design objectives for effluent treatment systems for power plants in Appendix I to 10 CFR Part 50. The Commission noted that the dose values established in the design objectives are generally consistent with a collective dose criterion with a magnitude of 1000 person–rem/year. However, the Commission also recognized that licensees have performed better than required in accordance with Appendix I by reducing estimated collective doses from reactor plant effluents to 110 person–rem per year in 1986, which is the most recent year for which the data have been completely assessed (see NUREG/CR-2850, Vol. 8).

Finally, the Commission and its staff are only beginning to evaluate specific details of how the BRC policy will be implemented through subsequent rulemakings and licensing decisions. Even at this preliminary stage, the Commission has identified substantive implementation issues pertaining to the application of the collective dose criterion. For example, an issue has been identified regarding how the collective dose criterion would be applied in making decisions about appropriate levels of cleanup for contaminated sites. Specifically, does the collective dose criterion apply generically to the practice of decommissioning or would it be applied on a site-specific basis? Similarly, how should the collective dose criterion be applied in cases where nuclear operations have contaminated groundwater resources that could potentially supply municipal drinking water systems? Resolution of these and other issues could cause the Commission to revise its selection of the magnitude of the collective dose criterion through future rulemakings and development of generic guidance. However, based on the technical information and recommendations currently before the Commission, 1000 person-rem/year appears to be an appropriate magnitude for the collective dose criterion.

For all of these reasons, the Commission established a collective dose criterion of 1000 person-rem/year for each practice.

ALARA

Commissioner Curtiss would prefer to define the individual and collective dose criteria as "floors" to ALARA, that is, that the regulated community and NRC are relieved from the regulatory obligation to perform further ALARA analyses below these levels if individual doses are 1 millirem/10 millirem and the collective dose is 1000 person-rem. Specifically, Commissioner Curtiss believes that the BRC policy sends a confusing message by encouraging voluntary efforts to achieve doses below the BRC criteria.

In responding to Commissioner Curtiss' view on this issue, it is important to begin from the definition of the term ALARA. ALARA is the regulatory concept that radiation exposures and effluents should be reduced as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to the benefits to public health and safety and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest (10 CFR 20.1(c)). The ALARA concept is one of the fundamental tenets of radiation protection and has been a keystone in NRC's regulatory framework. Public comments on the proposed BRC policy statement and on proposed revisions to 10 CFR Part 20 urged the Commission to define "floors" to ALARA or thresholds below which NRC would not require further reductions in doses or effluents.

The Commission responded to these comments in the policy by stating that "... a licensee using the exemption would no longer be required to apply the ALARA principle to reduce doses further for the exempted practice provided that it meets the conditions specified in the regulation" established for a particular exemption. In other words, the BRC criteria and implementing regulations will provide "floors" to ALARA for the exempted practice. In this regard, I agree with Commissioner Curtiss because the truncation of further efforts to reduce doses is one of the principal regulatory motivations for establishing the BRC policy.

However, I disagree with the rest of Commissioner Curtiss' view on this issue. It would be inappropriate to tell the regulated community that they cannot reduce doses below the BRC criteria. In short, although we will not require licensees to reduce doses further, we do not want to discourage their efforts to do so either. This would be tantamount to telling a licensee how to operate his or her business regardless of whether any health or safety issues are involved. Such a direction would be inappropriate because it clearly falls outside of the health and safety focus of the NRC.

In formulating the BRC policy, the Commission recognized that new technologies being developed today promise to reduce doses, and therefore risks, at lower costs than present technologies. Indeed, technological and cost considerations are explicitly recognized in the definition and application of the term "ALARA." Thus, I believe it would be inappropriate to tell licensees that they cannot implement new technologies and health physics practices to further reduce doses if they want to.

Justification of Practice

Commissioner Curtiss would prefer to endorse the principle of justification of practice (i.e., whether the potential impacts of a practice are justified in terms of net societal benefits) and retain the prerogative to reject applications for exemptions regardless of the risk they pose.

I disagree with Commissioner Curtis' view on this matter because it puts the Commission in a position of making decisions in areas outside the normal arena of its expertise, where the agency would be especially vulnerable, perhaps justifiably so, to criticism. Consistent with the mission of the NRC, the Commission should base its judgments on an explicit, objective, and rational consideration of the health, safety, and environmental risks associated with practices, rather than on what many would perceive as personal preferences of the Commissioners. Such an approach fosters long-term stability in regulatory decisionmaking on potential exemptions.

Decisions on justification of practice involve social and cultural considerations that fall outside the Commission's primary focus and expertise for ensuring adequate protection of the public health and safety from the use of nuclear materials. Such decisions should be made by affected elements of society, such as residents near a contaminated site, potential customers, suppliers, and other members of the general public, rather than NRC. I believe that this position is consistent with regulatory practices of other Government agencies that generally do not regulate on the basis of whether a particular practice is justified in terms of net societal benefit. For example, to the best of my knowledge, the Environmental Protection Agency does not question whether the generation of hazardous wastes is justified in terms of net societal benefit, even though the agency promotes the minimization and elimination of such wastes to reduce risks.

I believe that Commissioner Curtiss misinterprets the BRC policy when he claims that it embodies a bifurcated approach on the principle of justification of practice. As clearly indicated in the policy, the Commission may determine that certain practices should not be considered candidates for exemption on the basis of risk estimates or associated uncertainties. Rejection of such an application should be based on the risks posed by the practice, rather than whether the practice is justified in terms of net societal benefit. The types of concerns he raises about risks to children and the general public would be critically evaluated by the Commission in rulemakings to determine whether particular practices should be exempted. Therefore, I believe that the Commission has established an appropriate BRC policy that does not consider whether a proposed practice is justified in terms of societal benefit.

Agreement State Compatibility

Commissioner Curtiss also disagrees with the Commission majority view on the need for uniformity between basic radiation protection standards established by NRC and Agreement States. He indicates that he would not treat the Commission's policy on below regulatory concern as a matter of compatibility for Agreement States with respect to disposal of commercial low-level radioactive waste. He reaches this conclusion in part because he reads the Low-Level Radioactive Waste Policy Amendments Act of 1985 as giving States a great deal of latitude in deciding how to proceed with the development, construction, and operation of new low-level waste disposal facilities. Drawing upon this interpretation, he concludes that individual States should be allowed the option of deciding whether low-level waste designated BRC should be disposed of in a licensed low-level radioactive waste disposal facility.

This policy statement in and of itself does not make any compatibility determinations; as indicated in the statement, compatibility issues will be addressed in the context of individual rulemakings as they occur. But I believe it is important to respond to Commissioner Curtiss on this issue in two respects. First, I do not read the Low-Level Radioactive Waste Policy Amendments Act as giving the States particular latitude let alone specific authority in the area of waste to establish radiation standards different from those of the Commission. Second, I do not believe that the issue of BRC for waste disposal can easily be divorced from BRC in other areas such as decommissioning.

The Low-Level Radioactive Waste Policy Amendments Act did not change the regulatory framework applicable to Atomic Energy Act materials. On the contrary, the Act specifically recognized the importance of that framework by including provisions such as the following:

> Sec. 4(b) . . . (3) EFFECT OF COMPACTS ON FEDERAL LAW.—Nothing contained in this Act or any compact may be construed to confer any new authority on any compact commission or State—
>
> "(A) to regulate the packaging, generation, treatment, storage, disposal, or transportation of low-level radioactive waste in a manner incompatible with the regulations of the Nuclear Regulatory Commission ...;
>
> "(B) to regulate health, safety, or environmental hazards from source material, byproduct material, or special nuclear material;
>
> . . . . .
>
> "(4) FEDERAL AUTHORITY.—Except as expressly provided in this Act nothing contained in this Act or any compact may be construed to limit the applicability of any Federal law or to diminish or otherwise impair the jurisdiction of any Federal agency, ...

Unlike the Uranium Mill Tailings Radiation Control Act of 1978, as amended, the Low-Level Radioactive Waste Policy Act, as amended, does not authorize States to establish more stringent standards. The Act also specifically directed the Commission to establish standards for exempting specific radioactive waste streams from regulation due to the presence of radionuclides in such waste streams in sufficiently low concentrations or quantities as to be below regulatory concern. If, in response to a request to exempt a specific waste stream, the Commission determines that regulation of a radioactive waste stream is not necessary to protect the public health and safety, the Commission is directed to take the necessary steps to exempt the disposal of such radioactive material from regulation by the Commission. Thus, the Act did not, in my view, grant any particular latitude to the States to determine which waste streams were of regulatory concern. Rather, it reaffirmed the existing roles of the NRC and the States in determining regulatory standards for low-level waste and specifically defined the Commission's authority in this regard as including designating waste streams which are below regulatory concern.

The respective roles of the Commission and the States with respect to the licensing and regulation of Atomic Energy Act materials, including the disposal of low-level radioactive waste received from other persons, are governed by the provisions of Section 274 of the

Atomic Energy Act of 1954, as amended. Absent the execution of a Section 274b Agreement with the NRC, a State is preempted by Federal law from exercising regulatory authority over the radiological hazards of these materials. The Commission is authorized to enter into an agreement with a State only upon a finding that the State program is compatible with the Commission's program for regulation of radioactive materials and adequate to protect the public health and safety. Section 274d.(2). The legislative history of Section 274 stresses throughout the importance of and the need for continuing compatibility between Federal and State regulatory programs. In comments on the legislation, the Joint Committee on Atomic Energy (JCAE) stated that

> 5. The Joint Committee believes it important to emphasize that the radiation standards adopted by States under the agreements of this bill should either be identical or compatible with those of the Federal Government. For this reason the committee removed the language 'to the extent feasible' in subsection g. of the original AEC bill considered at hearings from May 19 to 22, 1959. The committee recognizes the importance of the testimony before it by numerous witnesses of the dangers of conflicting, overlapping and inconsistent standards in different jurisdictions, to the hindrance of industry and jeopardy of public safety.

Sen. Rept. No. 870, September 1, 1959, 86th Cong., 1st. Sess.

The potential problems from conflicting standards identified by the JCAE in 1959 are fully apparent in the context of BRC and demonstrate why the scope of compatibility findings to be made by the NRC cannot be drawn to exclude low-level radioactive waste disposal. For instance, the Commission intends to use the risk criteria identified in the policy statement to establish decommissioning criteria, that is, the level at which a formerly licensed site may be released for unrestricted use. If the States are permitted to require that low-level waste streams designated BRC by the Commission be disposed of in a low-level waste facility, it could result in a site in one state being released for unrestricted use, while soil or materials in an adjacent State at that level would be required to be confined in a low-level waste facility. If a patchwork of disposal criteria were to develop, it would be virtually impossible to establish decommissioning funding requirements that would be adequate to assure that all licensed facilities will set aside sufficient funds over the life of a facility to pay for decommissioning. The resulting confusion from these conflicting standards could well result in delays in adequate decommissioning of contaminated sites and certainly in unnecessary concern on the part of the public. I continue to believe that reserving to the NRC the authority to establish basic radiation protection standards, including designating which waste streams are below regulatory concern, is fully justified to ensure an adequate, uniform and consistent level of protection of the public health, safety and the environment.

APPENDIX R

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RADIATION AND HEALTH
(415) [illegible]

March 2nd, 1991

Ms. Laura McCarten
Nuclear Projects Department
Northern States Power Company
1717 Wakonade Drive East
Welch, Minnesota 55089

Re: Prairie Island Independent Spent Fuel Storage Installation

Dear Ms. McCarten,

Northern States Power Company has informed me that the State of Minnesota, through the Department of Health, is applying illustrative tables taken from the National Academy of Sciences-National Research Council's BEIR V Report, as a basis for determining the Prairie Island Independent Spent Fuel Storage Installation (ISFSI) will result in an increased risk of cancer from exspoure to the general public. I should like to comment, in detail, on the complexity of this matter, and that such a basis would lead to spurious conclusions. The use of the BEIR V Report to reach such conclusions would not be appropriate, and would be speculative at best; such use would be invalid and an oversimplification of the system of dose limitation which forms the basis of radiation protection guidance.

1. As you are aware, I have served on the BEIR I, II (Vice-Chairman), III (Chairman of Ad Hoc Committee), IV (Chairman), and V Committees of the National Academy of Sciences-National Research Council. I also serve as a council member of the National Council on Radiation Protection and Measurements(NCRP), and as a committee member (Committee 1) of the International Commission on Radiological Protection (ICRP). The impact of the BEIR reports on the responsibilities and charges of the NCRP and ICRP are relevant to the current situation of the Prairie Island ISFSI.

2. The 1990 BEIR V Report was prepared by the National Academy of Sciences-National Research Council's Committee on the Biological Effects of Ionizing Radiations, and was "the fifth in a series (since 1972) that addresses the health effects of exposure of human populations to low-dose radiation. (BEIR V at 1). "While the BEIR V Committee was asked to summarize radiation risk information in a way that is useful for formulating radiation control decisions, recommendations on standards and guidelines for radiation protection were specifically excluded under the terms of the study." The system of dose limitation for radiological protection is complex, and it integrates much more that the risk estimation process; the BEIR V report was not intended to provide specific regulatory guides.

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3. "On the basis of the available evidence, the population-weighted avaerage lifetime excess risk of death from cancer following an acute dose equivalent to all body organs of 0.1 Sv (0.1 Gy of low LET radiation) (or 10 rem) is estimated to be 0.8%, although the lifetime risk varies considerably with age and time since exposure. For low LET radiation, accumulation of the same dose over weeks or months, however, is expected to reduce the lifetime risk appreciably, possibly by a factor of 2 or more." "The Committee examined in some detail the sources of uncertainty in its risk estimates and concluded that uncertainties due to chance sampling variation in the available epidemiological data are large." The risk estimates are based on an exposure-time-response model for relative risk. The Committee recognized that the variables in the model could be incorrect with considerable uncertainties and technical difficulties inherent in the modle(s). Furthermore, "the Committee recognizes that its risk estimates become more uncertain when applied to very low doses." Throughout the deliberations of each of the five BEIR Committees, it was well understood that the BEIR reports were concerned solely with the risk estimation processes and their uncertainties, and not with risk assessment, risk management or risk regulation. The reports were never intended to provide a primer for radiation protection guidelines, in the form of numerical values, for risk management and decision making.

4. Lifetime risks in the range of 1 in a million or thereabouts are not readily understood, nor quantifiable. For example, a lifetime risk of 10-5 is roughly the equivalent of an annual risk of 10-7, i.e., the effects occurring with a probability of 1 in 10 million. A Study Group Report of The Royal Society of Great Britain (Risk Assessment, 1983, at 180 and 181) considers such levels of imposed risk as "the negligible level of risk to the individual"....(that) "can legitimately be treated as trivial by the decision-maker." "There is a widely held view...that few people would commit their own resources to reduce the annual risk of death that was clearly as low as 10-5, and that even fewer would take action at an annual level of 10-6." "In such circumstances, we could consider 10-7 to be an annual level below which further control was certainly not justified.""On the basis of these figures, it is for annual risks of death to the individual of between 10-3 and 10-6 that risk management should consist of comparing risks, detriments, costs, and benefits, rather than in seeking prohibitions at the upper level, or concluding that no special action is needed at the lower figure." Thus, and annual risk of 10-7, or a lifetime risk of 10-5 is considered the negligible level of risk to the individual in practice, and should not warrant further expenditure of resources to reduce the level of risk.

5. "No human activity can be risk-free (Royal Society at 149). Thus, risk assessment, risk regulation and risk management must involve value judgments. Here, the ICRP and the NCRP become involved in the processes leading to radiological protection recommendations, and regualtory guides. The recommendations of the ICRP (Annals of the ICRP, Publication 60, 1991; and, for review, see 1990 Recommendations of the ICRP, R.H. Clarke, National Radiological Protection Board (NRPB), Great Britain, Suppl., Radiological Protection Bulletin, No.119, 1991) serve as the basis for the system of dose limitation and radiological Protection and in the establishment of the dose limits adopted for occupational exposure and

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and exposure of the general public. All nations in the world have adopted ICRP recommendations for radiological protection guidance. Accordingly, it would be expected that any new technological or industrial application or practice involving radiation would be guided unequivocally by the appropriate and relevant recommendations of the ICRP.

6. "ICRP recognizes three classes of exposure: occupational, medical and public...Dose limits apply to occupational and public exposure."Clarke/NRPB at 1 "The dose limit is set such that continued exposure at a dose just above the limit would be unacceptable on any reasonable basis. Continued exposure just below the dose limit might be tolerated but would not be welcome, so that acceptable doses are those somewhat below the limit. In order to decide where the boundary between unacceptable and tolerable is to be set, ICRP has taken into account a range of quantifiable factors of health detriment." (Clarke/NRPB at 10). This includes the totia of carcinogenic effects, genetic effects, and teratogenic effects, not solely cancer.

7. The ICRP (and the NCRP) have reviewed all the data and their analyses provided by the 1990 BEIR Report and the 1988 UNSCEAR Report on the health effects in human population exposed to low level ionizing radiations. For exposure to members of the public, ICRP caluclated "the consequences of exposure over a lifetime received at 1, 2, 3, or 5 mSv y-1 (or 100, 200, 300, or 500 mrem per year). The time distribution of fatal cancer risk was carefully calculated, and although suggestions of acceptable levels of imposed risk of between 10-5 and 10-4 y-1 have been made, it is clear that judgements have to be made about whether the time at which the risk is received is important. Added risks late in life may be less important than risks added in early years." (Clarke/NRPB at 12). Analyses of that data---the lifetime risk of fatal cancer, the weighted sum of fatal and non-fatal cancers and hereditary effects---characterized the quantitative risk attributes of detriment due to exposure to the whole population. "On the basis of considering these risk levels and the variation in natural background (excluding radon), ICRP has reconfirmed that the dose limit for members of the public should be 1 mSv y-1 (100 mrem per year), or in special circumstances, 1 mSv y-1 averaged over 5 years." (Clarke/NRPB at 12). When analyzed, "the fatality rate (annual risk of death from radiation induced cancer)for 1, 2 3 and 5 mSv y-1 received over an entire lifetime demonstrated an age-dependent interrelationship." "The fatality probability as a function of age, which because of the use of a multiplicative (exposure-time-response) model, tends to follow the probability of death from cancer for a general population. The peak risk-rate rises in the late-70 years age group for all exposure groups." An annual risk of 10-4 y-1 would be exceeded at an age in the mid-50 years age group for someone receiving 5 mSv y-1, in the mid-60 years age group for someone receiving 2 mSv y-1, and in the mid-70 years age group for someone receiving 1 mSv y-1.

8. The BEIR V Report cautions about the use of the risk estimates and the reliability of their numerical values. There is no intention to regard the imprecision of 1 in 10,000, 1 in 100,000, or 1 in 1,000,000 as reliable risk estimates for practical regulatory guidance. To assume this for risk assessment and risk management would lead to biased decision-making by

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those responsible for protecting the public and worker populations. The BEIR V Report cautions the reader on the imprecise and uncertain numerical values calculated from incomplete and often limited data. There is no intention in any BEIR report to assume precision, even in the range of 10-3 or less. This is clearly stated (BEIR V at 3,4) in the BEIR V Report. "As in previous reports, the (BEIR V) Committee on the bBiological Effects of Ionizing Radiations cautions that the risk estimates derived from epidemiological and animal data should not be considered precise. Information on the lifetime cancer experience is not available for any of the human studies. Therefore, the overall risk of cancer can only be estimated by means of models which extrapolate over time. Likewise, estimates on the induction of human genetic disorders are based on limited data from studies with laboratory animals. It is expected that the risk estimates derived by the Committee will be modified as new scientific data and improved methods of analysis become available."

9. There should be no confusion regarding the risk estimation process, and its relation to risk assessment, risk management, and risk regulation. It is inappropriate to use the BEIR V cancer risk estimates or genetic risk estimates directly, as is done so frequently, for purposes of risk management and control. The estimates are derived numerical values based on illustrative examples, and the estimation process is subject to numerous uncertainties and technical difficulties. The process does not consider the other components of risk assessment and risk management---risk limits, intervention, and practical implementation---all of which are based on quantification and involve value judgments for decision making. Thus, the BEIR V Report or the UNSCEAR Report were not designed to determine radiation protection standards for low level exposure. That activity is far more complex, and involves a system of dose limitation which assists in decision making (recommendations) on dose and risk limits for both workers and the public, together with the protection quantities needed to demonstrate compliance. This latter system extends far beyond the narrow scope of and the charge to the BEIR V Committee. Without the development and practical application of the system of dose limitation of the ICRP (and the NCRP), the application of the risk estimates derived by the BEIR and UNSCEAR Committees would be a serious over-simplification, and would necessarily lead to the erroneous conclusions that extremely small doses of radiation from sources that can be controlled, considered trivial from the point of view of regulatory control, would be associated with levels of risk unacceptable to the public or worker populations.

10. In this regard, the ICRP has now established, based on risk levels estimated and taking into account natural background, that the dose limit to members of the public should be 1 mSv y-1 (100 mrem per year). It is this value that should be applied to determine the health risk (cancer and hereditary risks) of the Prairie Island ISFSI. The Safety Analysis Report for the Prairie Island ISFSI provides a value if 3.74 as the maximum annual exposure to the nearest real individual of the public living offsite due to the ISFSI operation. The Report also cites an average dose of about 2 mrem per year. These values are far below the dose limit of 100 mrem per year recommended by the ICRP, and clearly with a safety protection factor of about 30- to 50-fold. Indeed, the ISFSI values approach levels of exposure that the ICRP considers for exemption from regulatory control. (Clarke/NRPB at 15).

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11. "ICRP accepts that some practices need to be exempted from regulation on the basis that the doses are small...The cost of regualtion and assessment is recognized to be a significant component of the optimization process and can be used to judge trivial collective doses for sources that can be controlled...For those sources that can be controlled, ICRP recommends exemption of individual doses that are unlikely to exceed 10 uSv y-1 (1 mrem per year) and the collective dose is not more that 1 man Sv y-1 (100 man rem per year) of practice."(Clarke/NRPB at 15). In this regard, the average annual dose of 2 mrem per year (20 uSv y-1) would only be equivalent of less than 1 % of background radiation exposure levels, and only 1 mrem per year (20 uSv y-1) greater than would be exempted from regulatory control by ICRP. An annual dose of 3.74 mrem (37.4 uSv y-1) to an individual would translate to a collective dose requiring almost 30,000 persons offsite who would have to be exposed each year to this maximum dose due to the ISFSI operation under such circumstances that the ICRP would consider the entire operation expemt from regulatory control. This exemption would be on the basis~~basis~~ that the doses are too small and the collective doses judged trivial from sources that can be controlled.

12. Based on my professional experience, including service on all five BEIR Committees, the ICRP and the NCRP, the following conclusions deserve serious consideration:

(i) The BEIR Reports are not designed or intended to be a direct and simplified approach to risk assessment and risk management for radiation protection guidance and control by providing risk estimates of radiation-associated cancer. To do so would be an over-simplification and would necessarily lead to spurious conclusions, inappropriate decision making for public policy.

(ii) The ICRP (and the NCRP) has the responsibility and expertise in the relevant sciences to develop a system of dose limitation for radiological protection guidance based on the myriad components of the risk estimation-risk assessment-risk management process. The ICRP retains a very conservative position and approach, intentionally over-estimating the risk of low dose, low LET radiation exposure in order to provide prudent recommendations for radiological protection. The dose limits provide the guidance for radiation control; the limits are intentionally set high, so that exceeding them would be considered intolerable and unacceptable. It is on this basis that they provide appropriate and adequate radiation protection to the worker population and the public for radiation practices that are controlled.

(iii)At the present time, the ICRP is publishing its new recommendations for dose limites and radiation protection guidance (ICRP/Annal, 1991). These recommendations are based on the analyses of data by the BEIR V Committee (1990) and the UNSCEAR Committee (1988). Previous dose limits for the public of 500 mrem per year (5 mSv y-1) will be lowered to 100 mrem per year (1 mSv y-1). Levels below 100 mrem per year are considered tolarable, and perhaps somewhat lower, can be considered safe levels, essentially without hazard.

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(iv) The Royal Society (UK) Risk Assessment Study Group (1983) considers a lifetime risk in the range of 10-5 as a negligible level of risk. This would be roughly equivalent to an annual risk of about 10-7. A lifetime risk of 10-5 per rem would be considered at least bordering on a negligible level of risk, whereas a annual level of risk of 10-7 per rem would indeed, be failed to be understood by the public or by the decision makers, and would surely be considered trivial. Based on the new ICRP recommendations, implementing a lifetime risk of 10-5 per rem would require intervention when annual doses above natural backgroup/were in fractions of millirems. Neither the risk estimation process nor any risk assessment process in this realm of dose level would have been considered as appropriate by the BEIR III or BEIR V Committees. In fact, the lowest dose level considered by the BEIR V Committee appropriate for analysis (BEIR V, Table 4-2 at 172) was the lifetime risk of a population of 100,000 to 10 rem (0.1 Sv); otherwise the dose would have been too low or the collective dose would have been too low for analysis. Here, the dose level (10 rems) and the collective dose (10^6 man rem) were considered the lowest that could be analyzed for illustrative example to respond to the charge to the Committee. The data are too sparse and unreliable for doses below 10 rem, that is, a dose 100 times greater than the annual dose limit recommendaed by the ICRP for protection of the public. It follows that if the maximum annual exposure from the Prairie Island ISFSI operation would be about one-thirtieth of the ICRP dose limit of 100 mrems per year, and it appears that they will be, then the levels of exposure from the ISFSI operation to members of the public offsite would be so low that no reliable or useful conclusions can be drawn with respect to the potential cancer risk. Any conclusions would have to be speculative only, and surely would not warrant further consideration in the risk assessment process for management and regulation.

(v) If a policy of radiological protection of the public is set forth for control of the Prairie Island ISFSI operation, and it must, then surely it should be based on the recommendations for dose limitation and radiological protection by the ICRP (and the NCRP) and not on any table in the BEIR V or UNSCEAR reports; any table taken from BEIR V in isolation and not used for the original purposes that required preparation of the table, must necessarily be considered in the entire risk estimation-risk assessment-risk management process. Based on ICRP recommendations, a dose limit of 100 mrem per year (1 mSv y-1) for exposure to the public will provide ample radiological protection to the offsite population exposed to very low level radiation from the Prairie Island ISFSI operation.

I shall be pleased to discuss this matter with you should you request.

Very sincerely yours,

Jacob I. Fabrikant, M.D., Ph.D.

JIF:lb

HEALTH EFFECTS OF EXPOSURE TO LOW LEVELS OF IONIZING RADIATION

BEIR V

Committee on the Biological Effects
of Ionizing Radiations
Board on Radiation Effects Research
Commission on Life Sciences
National Research Council

APPENDIX S

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Therefore, the overall risk of cancer can only be estimated by means of models which extrapolate over time. Likewise, estimates on the induction of human genetic disorders by radiation are based on limited data from studies of human populations and therefore rely largely on studies with laboratory animals. It is expected that the risk estimates derived by the Committee will be modified as new scientific data and improved methods for analysis become available.

SUMMARY AND CONCLUSIONS

Of the various types of biomedical effects that may result from irradiation at low doses and low dose rates, alterations of genes and chromosomes remain the best documented. Recent studies of these alterations in cells of various types, including human lymphocytes, have extended our knowledge of the relevant mechanisms and dose-response relationships. In spite of evidence that the molecular lesions which give rise to somatic and genetic damage can be repaired to a considerable degree, the new data do not contradict the hypothesis, at least with respect to cancer induction and hereditary genetic effects, that the frequency of such effects increases with low-level radiation as a linear, nonthreshold function of the dose.

Heritable Effects

The effects of radiation on the genes and chromosomes of reproductive cells are well characterized in the mouse. By extrapolation from mouse to man, it is estimated that at least 1 Gray (100 rad) of low dose-rate, low LET radiation is required to double the mutation rate in man. Heritable effects of radiation have yet to be clearly demonstrated in man, but the absence of a statistically significant increase in genetically related disease in the children of atomic bomb survivors, the largest group of irradiated humans followed in a systematic way, is not inconsistent with the animal data, given the low mean dose level, < 0.5 gray (Gy), and the limited sample size. The Committee's estimates of total genetic damage are highly uncertain, however, as they include no allowance for diseases of complex genetic origin, which are thought to comprise the largest category of genetically-related diseases. To enable estimates to be made for the latter category, further research on the genetic contribution to such diseases is required.

Carcinogenic Effects

Knowledge of the carcinogenic effects of radiation has been significantly enhanced by further study of such effects in atomic bomb survivors.

Reassessment of A-bomb dosimetry at Hiroshima and Nagasaki has disclosed the average dose equivalent in each city to be smaller than estimated heretofore; furthermore, the neutron component of the dose no longer appears to be of major importance in either city. As a result, lifetime risk of cancer attributable to a given dose of gamma radiation now appears somewhat larger than formerly estimated.

Continued follow-up of the A-bomb survivors also has disclosed that the number of excess cancers per unit dose induced by radiation is increased with attained age, while the risk of radiogenic cancer relative to the spontaneous incidence remains comparatively constant. As a result, the dose-dependent excess of cancers is now more compatible with previous "relative" risk estimates than with previous "absolute" risk estimates; the Committee believes that the constant absolute or additive risk model is no longer tenable.

A-bomb survivors who were irradiated early in life are just now reaching the age at which cancer begins to become prevalent in the general population. It remains to be determined whether cancer rates in this group of survivors will continue to be comparable to the increased cancer risk that has been observed among survivors who were adults at the time of exposure. For this reason, estimation of the ultimate magnitude of the risk for the total population is uncertain and calls for further study.

The quantitative relationship between cancer incidence and dose in A-bomb survivors, as in other irradiated populations, appears to vary, depending on the type of cancer in question. The dose-dependent excess of mortality from all cancer other than leukemia, shows no departure from linearity in the range below 4 sievert (Sv), whereas the mortality data for leukemia are compatible with a linear-quadratic dose response relationship.

In general, the dose-response relationship for carcinogenesis in laboratory animals also appears to vary with the quality (LET) and dose rate of radiation, as well as sex, age at exposure and other variables. The influence of age at exposure and sex on the carcinogenic response to radiation by humans has been characterized to a limited degree, but changes in response due to dose rate and LET have not been quantified.

Carcinogenic effects of radiation on the bone marrow, breast, thyroid gland, lung, stomach, colon, ovary, and other organs reported for A-bomb survivors are similar to findings reported for other irradiated human populations. With few exceptions, however, the effects have been observed only at relatively high doses and high dose rates. Studies of populations chronically exposed to low-level radiation, such as those residing in regions of elevated natural background radiation, have not shown consistent or conclusive evidence of an associated increase in the risk of cancer.

For the purposes of risk assessment, the Committee summarized the epidemiological data for each tissue and organ of interest in the form of an exposure-time-response model for relative risk. These models were fitted to the data on numbers of cases and person-years in relation to dose equivalent, sex, age at exposure, time after exposure, and attained age. Standard lifetable techniques were used to estimate the lifetime risk for each type of cancer based on these fitted models.

On the basis of the available evidence, the population-weighted average lifetime excess risk of death from cancer following an acute dose equivalent to all body organs of 0.1 Sv (0.1 Gy of low-LET radiation) is estimated to be 0.8%, although the lifetime risk varies considerably with age at the time of exposure. For low LET radiation, accumulation of the same dose over weeks or months, however, is expected to reduce the lifetime risk appreciably, possibly by a factor of 2 or more. The Committee's estimated risks for males and females are similar. The risk from exposure during childhood is estimated to be about twice as large as the risk for adults, but such estimates of lifetime risk are still highly uncertain due to the limited follow-up of this age group.

The cancer risk estimates derived with the preferred models used in this report are about 3 times larger for solid cancers (relative risk projection) and about 4 times larger for leukemia than the risk estimates presented in the BEIR III report. These differences result from a number of factors, including new risk models, revised A-bomb dosimetry, and more extended follow-up of A-bomb survivors. The BEIR III Committee's linear-quadratic dose-response model for solid cancers, unlike this Committee's linear model, contained an implicit dose rate factor of nearly 2.5; if this factor is taken into account, the relative risk projections for cancers other than leukemia by the two committees differ only by a factor of about 2.

The Committee examined in some detail the sources of uncertainty in its risk estimates and concluded that uncertainties due to chance sampling variation in the available epidemiological data are large and more important than potential biases such as those due to differences between various exposed ethnic groups. Due to sampling variation alone, the 90% confidence limits for the Committee's preferred risk models, of increased cancer mortality due to an acute whole body dose of 0.1 Sv to 100,000 males of all ages range from about 500 to 1,200 (mean 760); for 100,000 females of all ages, from about 600 to 1,200 (mean 810). This increase in lifetime risk is about 4% of the current baseline risk of death due to cancer in the United States. The Committee also estimated lifetime risks with a number of other plausible linear models which were consistent with the mortality data. The estimated lifetime risks projected by these models were within the range of uncertainty given above. The committee recognizes that its risk estimates become more uncertain when applied to very low doses. Departures from a linear model at low doses, however, could either increase or decrease the risk per unit dose.

Mental Retardation

The frequency of severe mental retardation in Japanese A-bomb survivors exposed at 8-15 weeks of gestational age has been found to increase more steeply with dose than was expected at the time of the BEIR III report. The data now reveal the magnitude of this risk to be approximately a 4% chance of occurrence per 0.1 Sv, but with less risk occurring for exposures at other gestational ages. Although the data do not suffice to define precisely the shape of the dose-effect curve, they imply that there may be little, if any, threshold for the effect when the brain is in its most sensitive stage of development. Pending further information, the risk of this type of injury to the developing embryo must not be overlooked in assessing the health implications of low-level exposure for women of childbearing age.

RECOMMENDATIONS

There are a number of important radiobiological problems that must be addressed if radiation risk estimates are to become more useful in meeting societal needs. Assessment of the carcinogenic risks that may be associated with low doses of radiation entails extrapolation from effects observed at doses larger than 0.1 Gy and is based on assumptions about the relevant dose-effect relationships and the underlying mechanisms of carcinogenesis. To reduce the uncertainty in present risk estimation, better understanding of the mechanisms of carcinogenesis is needed. This can be obtained only through appropriate experimental research with laboratory animals and cultured cells.

While experiments with laboratory animals indicate that the carcinogenic effectiveness per Gy of low-LET radiation is generally reduced at low doses and low dose rates, epidemiological data on the carcinogenic effects of low-LET radiation are restricted largely to the effects of exposures at high dose rates. Continued research is needed, therefore, to quantify the extent to which the carcinogenic effectiveness of low-LET radiation may be reduced by fractionation or protraction of exposure.

The carcinogenic and mutagenic effectiveness per Gy of neutrons and other high-LET radiations remains constant or may even increase with decreasing dose and dose rate. For reasons which remain to be determined, the relative biological effectiveness (RBE) for cancer induction by neutrons and other high-LET radiations has been observed to vary with the type of cancer in question. Since data on the carcinogenicity of neutrons in human populations are lacking, further research is needed before confident estimates can be made of the carcinogenic risks of low-level neutron irradiation for humans. Similarly, the relative mutagenic effectiveness of neutron and other high LET radiation varies with the specific genetic end point. Therefore, additional data are also needed on the mutagenicity of low neutron doses to permit more confident projection of genetic risks from animal data to man.

The extrapolation of animal data to the human is necessary for genetic risk assessment. No population appears to exist, other than the A-bomb survivors, that could provide a substantial basis for genetic epidemiological study. The scientific basis of the extrapolation must therefore rely upon cellular and molecular homologies. Research needs in this area are clear.

As noted previously, the Committee's genetic risk assessment did not attempt to project risk for the category of diseases with complex genetic etiologies. Because genetically related disorders comparable to those in this heterogeneous category of human disorders may have no clearly definable counterparts in laboratory and domestic animals, the required research should be directed towards human diseases whenever feasible.

The dose-dependent increase in the frequency of mental retardation in prenatally irradiated A-bomb survivors implies the possibility of higher risks to the embryo from low-level irradiation than have been suspected heretofore. It is important that appropriate epidemiological and experimental research be conducted to advance our understanding of these effects and their dose-effect relationships.

Finally, further epidemiological studies are needed to measure the cancer excess following low doses as well as large doses of high and low LET radiation. Most of the A-bomb survivors are still alive, and their mortality experience must be followed if reliable estimates of lifetime risk are to be made. This is particularly important for those survivors irradiated as children or in utero who are now entering the years of maximum cancer risk. Studies on populations exposed to internally deposited radionuclides should be continued to assess the risks of nuclear technologies and the effects of radon progeny. Low-dose epidemiological studies may be able to supply information on the extent to which effects observed at high doses and high dose rates can be relied on to estimate the effects due to chronic exposures such as occur in occupational environments. The reported follow-up of A-bomb survivors has been essential to the preparation of this report. Nevertheless, it is only one study with specific characteristics, and other large studies are needed to verify current risk estimates.

1

Background Information and Scientific Principles

PHYSICS AND DOSIMETRY OF IONIZING RADIATION

All living matter is composed of atoms joined into molecules by electron bonds. Ionizing radiation is energetic enough to displace atomic electrons and thus break the bonds that hold a molecule together. As described below, this produces a number of chemical changes that, in the case of living cells, can lead to cell death or other harmful effects. Ionizing radiations fall into two broad groups: 1) particulate radiations, such as high energy electrons, neutrons, and protons which ionize matter by direct atomic collisions, and 2) electromagnetic radiations or photons such as x rays and gamma rays which ionize matter by other types of atomic interactions, as described below.

Absorption and Scattering of Photons

Photons ionize atoms through three important energy transfer processes: the photoelectric process, Compton scattering, and pair production. For photons with low energies (<0.05 megaelectron volt [MeV]) the photoelectric process dominates in tissue. The photoelectric process occurs when an incoming photon interacts with a tightly bound electron from one of the inner shells of the atom, and causes the electron to be ejected with sufficient energy to escape the atom. Characteristic x rays and Auger electrons follow from this process, but the biological effects are due mainly to excitations and ionizations in molecules of tissue caused by the ejected electron. The probability of the photoelectric process occurring is strongly

Elastic scattering is the most important interaction in tissue irradiated with neutrons at energies below 20 MeV. This would include the energy range for fission neutrons (<10 MeV), neutrons produced with 16 MeV deuterons bombarding a beryllium target (<20 MeV), and neutrons produced with 150 keV deuterons on tritium (<20 MeV). The neutron, an uncharged particle, interacts primarily by collisions with nuclei in the absorbing medium. If the total kinetic energy of the neutron and the nucleus remains unchanged by the collision, the collision is termed elastic. During an elastic collision, the maximum energy is transferred from the neutron to the nucleus if the two masses are equal. In soft tissue, the most important neutron interaction is with hydrogen. There are three reasons for this: (1) Nearly two-thirds of the nuclei in tissue are protons, (2) the energy transfer with protons is maximal (about one-half), and (3) the interaction probability (cross-section) for hydrogen is larger than that for any other element. The result is that about 90% of the energy absorbed in tissue from neutrons with energy of less than 20 MeV comes from protons that are recoiling from elastic collisions. The remaining energy is absorbed by other recoiling tissue nuclei in the following decreasing order of importance: oxygen, carbon, and nitrogen.

Inelastic scattering refers to reactions in which the neutron interacts with the nucleus but is promptly reemitted with reduced energy and usually with a changed direction. The scattering nucleus, which is left in an excited state, then emits a nuclear deexcitation gamma ray. For neutrons with kinetic energies of greater than 10 MeV, inelastic scattering contributes to energy loss in tissue; about 30% of the energy deposited in tissue by 14-MeV neutrons, for example, comes from inelastic interactions. The important inelastic interactions of neutrons in soft tissue are not with hydrogen but with carbon, nitrogen, and oxygen.

Nonelastic scattering defines reactions in which the neutron-nucleus interaction results in the emission of particles other than a single neutron such as alpha particles and protons [e.g., $^{16}O(n,\alpha)^{13}C$, $^{14}N(n,p)^{14}C$]. The cross-sections for nonelastic scattering in tissue become significant at energies greater than 5 MeV and increase as the neutron energy approaches 15 MeV. These reactions are usually accompanied by deexcitation gamma rays, but their importance is due to the high LET of the charged particles emitted, especially alpha particles. At neutron energies greater than 20 MeV, even though nonelastic cross-sections do not increase appreciably, nonelastic processes become increasingly important contributors to the total dose because of the increased average energy of the charged particles resulting from the interaction.

The capture of low-energy neutrons in the thermal and near-thermal regions provides a significant contribution to tissue dose. The reactions of importance are $^{14}N(n,p)^{14}C$ and $^{1}H(n,\gamma)^{2}H$. The former reaction produces locally absorbed energy of 0.62 MeV from the proton and the recoil nucleus. The latter reaction yields a 2.2-MeV gamma ray that, in general, deposits energy at a distance from the capture site and that has a reasonable probability of escaping altogether from a mass as large as a rodent. For thermal neutrons the $^{14}N(n,p)^{14}C$ reaction is the major contributor of absorbed energy in tissue samples with a dimension of less than 1 cm because of the short range (<10 μm) of the 0.58-MeV proton. However, for larger masses of tissue (e.g., the human body), the 2.2-MeV gamma rays from the $^{1}H(n,\gamma)^{2}H$ reaction are a significant dose contributor.

In the spallation process the neutron-nucleus interaction results in the fragmentation of the nucleus with the emission of several particles and nuclear fragments. The latter are heavily ionizing, so the local energy deposition can be high. Several neutrons and deexcitation gamma rays also can be emitted, yielding energy carriers that escape local energy deposition. The spallation process does not become significant until neutron energies are much greater than 20 MeV.

In summary, elastic and nonelastic scattering and the capture process are by far the most important reactions in tissue for neutrons in the fission energy range. Inelastic and nonelastic scattering begin at about 2.5 and 5 MeV, respectively, and become important at an energy of about 10 MeV. As the neutron energy goes higher, nonelastic scattering and spallation reactions increase in importance, and elastic scattering becomes of less importance for energies greater than 20 MeV.

POPULATION EXPOSURE TO IONIZING RADIATION IN THE UNITED STATES

A new assessment of the average exposure of the U.S. population to ionizing radiation has recently been made by the National Council on Radiation Protection and Measurements (NCRP87b). Six main radiation sources were considered: natural radiation and radiation from the following five man-made sources: occupational activities (radiation workers), nuclear fuel production (power), consumer products, miscellaneous environmental sources, and medical uses.

For each source category, the collective effective dose equivalent was obtained from the product of the average per capita effective dose equivalent received from that source and the estimated number of people so exposed. The average effective dose equivalent for a member of the U.S. population was then calculated by dividing the collective effective dose equivalent value by the number of the U.S. population (230 million in 1980). As discussed below, the dose equivalent is defined as the product of the absorbed dose, D, and the quality factor Q, which accounts for

TABLE 1-3 Average Annual Effective Dose Equivalent of Ionizing Radiations to a Member of the U.S. Population

	Dose Equivalent[a]		Effective Dose Equivalent	
Source	mSv	mrem	mSv	%
Natural				
Radon[b]	24	2,400	2.0	55
Cosmic	0.27	27	0.27	8.0
Terrestrial	0.28	28	0.28	8.0
Internal	0.39	39	0.39	11
Total natural	—	—	3.0	82
Artificial				
Medical				
x-ray diagnosis	0.39	39	0.39	11
Nuclear medicine	0.14	14	0.14	4.0
Consumer products	0.10	10	0.10	3.0
Other				
Occupational	0.009	0.9	<0.01	<0.3
Nuclear fuel cycle	<0.01	<1.0	<0.01	<0.03
Fallout	<0.01	<1.0	<0.01	<0.03
Miscellaneous[c]	<0.01	<1.0	<0.01	<0.03
Total artificial	—	—	0.63	18
Total natural and artificial	—	—	3.6	100

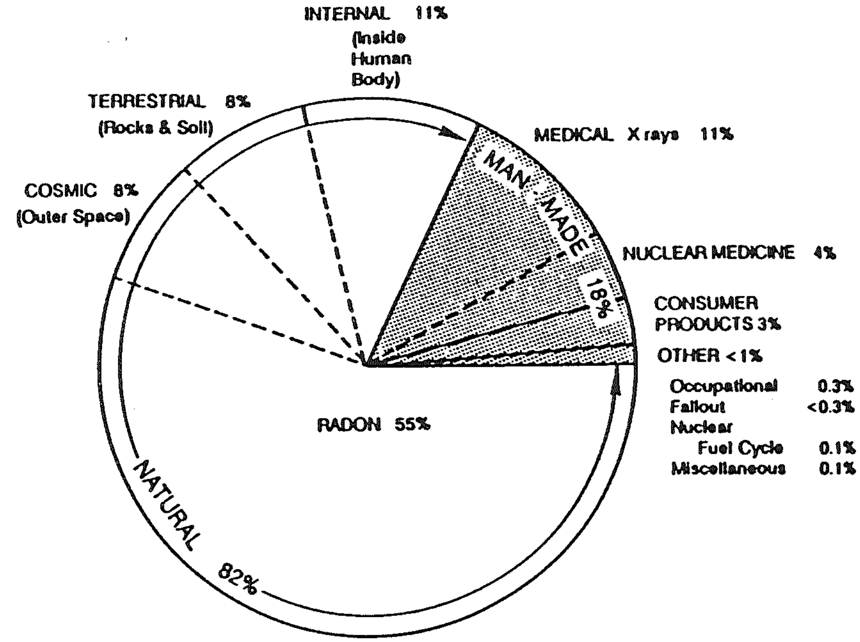
[a] To soft tissues.
[b] Dose equivalent to bronchi from radon daughter products. The assumed weighting factor for the effective dose equivalent relative to whole-body exposure is 0.08.
[c] Department of Energy facilities, smelters, transportation, etc.

SOURCE: National Council on Radiation Protection and Measurements (NCRP87b).

differences in the relative biological effectiveness of different types of radiation. The effective dose equivalent relates the dose-equivalent to risk. For the case of partial body irradiation, the effective dose equivalent is the risk-weighted sum of the dose equivalents to the individually irradiated tissues.

As seen in Table 1-3 and Figure 1-1, three of the six radiation sources, namely radiation from occupational activities, nuclear power production (the fuel cycle), and miscellaneous environmental sources (including nuclear weapons testing fallout), contribute negligibly to the average effective dose equivalent, i.e., less than 0.01 millisievert (mSv)/year (1 [mrem]/year).

A total average annual effective dose equivalent of 3.6 mSv (360 mrem)/year to members of the U.S. population is contributed by the other three sources: naturally occurring radiation, medical uses of radiation, and radiation from consumer products. By far the largest contribution (82%) is made by natural sources, two-thirds of which is caused by radon and its



decay products. Approximately equal contributions to the other one-third come from cosmic radiation, terrestrial radiation, and internally deposited radionuclides. The importance of environmental radon as the largest source of human exposure has only recently been recognized.

The remaining 18% of the average annual effective dose equivalent consists of radiation from medical procedures (x-ray diagnosis, 11% and nuclear medicine, 4%) and from consumer products (3%). The contribution by medical procedures is smaller than previously estimated. For consumer products, the chief contributor is, again, radon in domestic water supplies, although building materials, mining, and agricultural products as well as coal burning also contribute. Smokers are additionally exposed to the natural radionuclide polonium-210 in tobacco, resulting in the irradiation of a small region of the bronchial epithelium to a relatively high dose (up to 0.2 Sv per year) that may cause an increased risk of lung cancer (NCRP84).

Uncertainties exist in the data shown in Table 1-3. Uncertainties for exposures from some consumer products are greater than those for exposures from cosmic and terrestrial radiation sources. The estimates for the most important exposure, that of lung tissue to radon and its decay products, have many associated uncertainties. Current knowledge of the average radon concentration, the distribution of radon indoors in the United States, and alpha-particle dosimetry in lung tissue is limited. In addition, knowledge of the actual effective dose equivalent is poorly quantified. Further uncertainties are caused by difficulties in combining data for exposure from different sources that actually are from different years, mainly from 1980 to 1983.

RADIOBIOLOGICAL CONCEPTS

Experiments on radiation-induced cell killing have given rise to a number of radiobiological principles and concepts. Many of these principles and concepts are inferred to apply to mutagenesis and carcinogenesis, as well as to cell killing, although this is often not known for certain since it is not possible to perform comparable experiments with all of these endpoints. Some of the major concepts are discussed below.

The first concept is that the principal target for radiation-induced cell killing is DNA. Although it is not the exclusive target, it is generally the most consequential. While the evidence for this conclusion is circumstantial, it is also convincing (Le56). As noted above, the consequences of the absorption of radiant energy arise from excitations and ionizations along the tracks of the charged particles that are set in motion when radiant energy is absorbed. Biological damage may be a consequence of a *direct* interaction between the charged particles and the DNA molecule, or the biological effects may be mediated by the production of free radicals (Mi78). In the latter case, which is the *indirect* action of radiation, the absorption of the radiation may occur in, for example, a water molecule, and the consequent free radical produced may diffuse to the DNA, where it gives up its energy to produce a biological lesion. In the case of sparsely ionizing radiations, such as x rays and gamma rays, about two-thirds of the biological effects are produced by this indirect action, and this component of the radiation damage is amenable to modification by a variety of physical and chemical factors. As the quality of the radiation changes from low to high LET, the balance shifts from the indirect action to the direct action.

The second major concept concerns the shape of the dose-response relationship. With cell lethality, R, as the endpoint, the dose-response relationship for low-LET radiations often approximates a linear-quadratic function of the dose, D.

$$R = \alpha D + \beta D^2.$$

The relative importance of the linear and quadratic terms varies widely for different cells and tissues. The ratio α/β, which is the dose at which the linear and quadratic contributions to the biological effect are equal, may vary from about 1 Gray (Gy) to more than 10 Gy. As the LET of the radiation is increased, the ratio α/β also increases for a given cell or tissue, and for very high LET radiations, survival (1-R) approximates an exponential function of dose at doses of interest. For carcinogenesis in laboratory animals, dose-response relationships with a wide variety of shapes have been reported. At higher doses there is the complication of a balance between increased cell transformation and increased cell killing.

The linear-quadratic formulation had its origins in the 1930s, when it was used to fit data for radiation induced chromosome aberrations (Sa40). Many chromosome aberrations appear to be the consequence of the interaction between breaks in two separate chromatids. This applies to aberrations, such as dicentrics, that lead to cell lethality, as well as to aberrations such as translocations that, in some cases, lead to cancer through the activation of an oncogene.

Thus, the interpretation of the linear-quadratic formulation is that the characteristic shape of the dose-response curve reflects a predominance of single-track events, which are proportional to the dose at low doses and low dose rates, and of two-track events which are proportional to the square of the dose and result in the upward bending of the cancer induction curve at high doses received at high dose rates.

This biophysical model has been challenged in recent years, largely on the basis of data with soft x rays, which are highly effective biologically even though the length of the secondary tracks they produce is too short to enable a single track to break two independent chromosomes (Th86). Hence, although the data have been interpreted in terms of the more conventional linear-quadratic formulation (Br88), an alternative model has been proposed in which all biological damage is presumed to result from single track effects, with the additional factor of a repair process that saturates at higher doses. Biological experiments that allow an unequivocal choice to be made between the models have not yet been performed.

The third concept is that the biological consequence of a given dose of radiation varies with the quality of the radiation. With cell killing as the endpoint, the relative biological effectiveness (RBE) of many types of radiation has been studied in detail (Ba63). Although the RBE varies with the LET of the radiation, it also varies with the dose, dose rate, type of cell or tissue used to score the biological effect, and the endpoint in question (Br73, Ba68). The pattern of variation of the RBE with LET appears to be similar for mutagenesis as for cell killing, but it has not been established to be the same for carcinogenesis as an endpoint. The quality factor (Q) rather than RBE is widely used in radiation protection. The International Commission on Radiological Protection (ICRP) has suggested, however, that the quality factor should be based on a microdosimetric quantity such as lineal energy (ICRU86).

TABLE 4-4 Comparison of Lifetime Excess Cancer Risk Estimates from the BEIR III and BEIR V Reports

	Continuous Lifetime Exposure, 1 mGy/y (deaths per 100,000)		Instantaneous Exposure, 0.1 Gy (deaths per 100,000)	
	Males	Females	Males	Females
Leukemia				
BEIR III[a]	15.9	12.1	27.4	18.6
BEIR V	70	60	110	80
Ratio BEIR V/ BEIR III	4.4	5.0	4.0	4.3
Nonleukemia				
BEIR III				
Additive risk model	24.6	42.4	42.1	65.2
Relative risk model	92.9	118.5	192	213
BEIR V	450	540	660	730
Ratio BEIR V/ BEIR III	4.8–18.3	4.6–12.7	3.4–15.7	3.4–11.2

[a] Based on Table V-16, page 203, and Table V-19, page 206 (*LQ-L* model for nonleukemia) (NAS80).

The major differences between the two sets of estimates in Table 4-4 are for the BEIR III Committee's additive risk models. It is the opinion of this committee that the assumption of a constant additive excess risk is no longer tenable in the face of the data now available and that the risk estimates from this model provided in the BEIR III report are therefore too low. The estimates presented in this report are also higher than those based on a simple additive risk model in the latest UNSCEAR report (UN88) but are not quite as high as those based on the simple multiplicative risk model in that report.

UNCERTAINTY IN POINT ESTIMATES OF LIFETIME RISK

The total uncertainty in the Committee's risk models is discussed in Annex 4F. In this section, the discussion is largely limited to the statistical uncertainty in the risk estimates made with the Committee's preferred models. Lifetime risk projections are subject to three types of uncertainty. The first is simply random error owing to sampling variation in the fitted coefficients of the final models; this is thought to be the largest component of uncertainty and is expressed in terms of confidence intervals on the fitted model parameters and the estimated lifetime risks. Second, there is

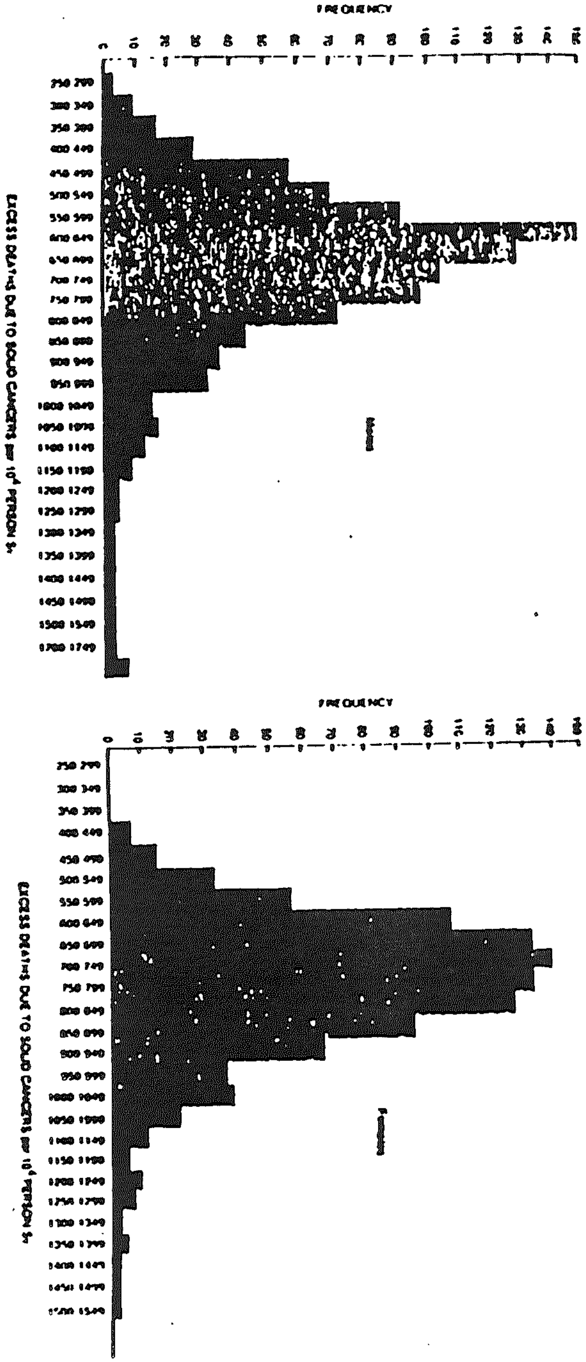


FIGURE 4-1 Excess mortality due to solid cancers per 10^4 person Sv (million person rem). Results of 1,000 Monte Carlo simulations and lifetable analyses of the excess mortality from all solid cancers following an acute total body dose of 0.1 Sv. The populations at risk are 100,000 males and 100,000 females. The Committee's preferred models yield a point estimate for males of 660 excess deaths, for females, 730. In 50% of the trials, the excess mortality for males was between 590 and 820 deaths, for females, between 670 and 860 deaths.

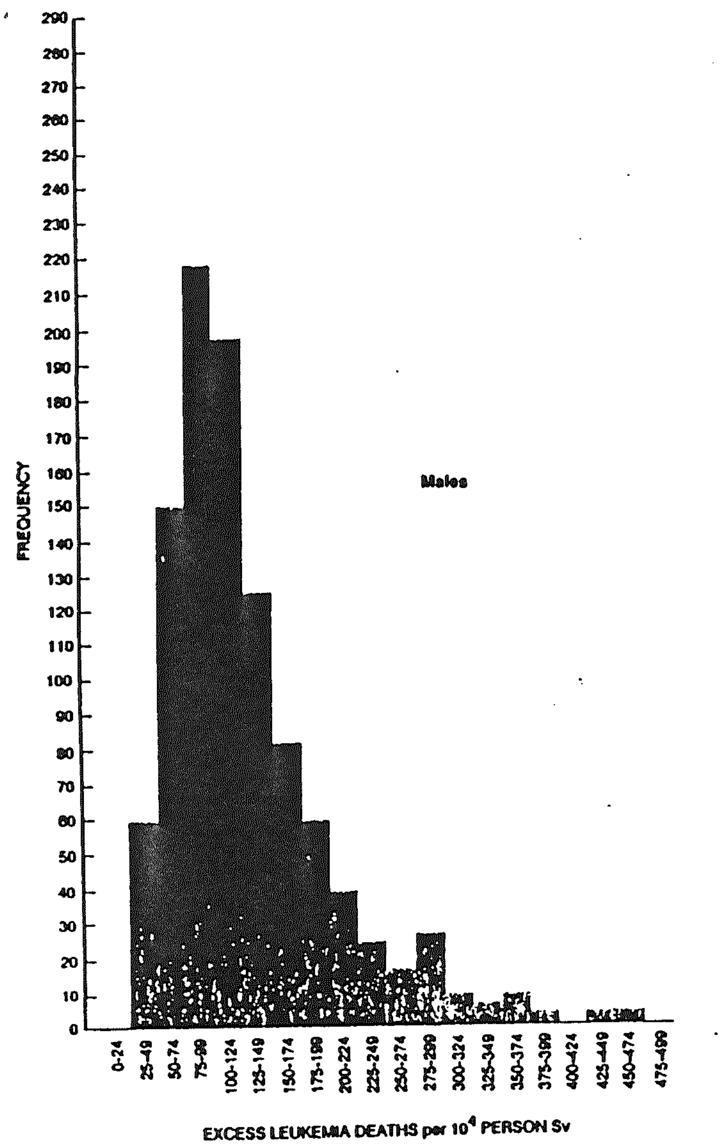
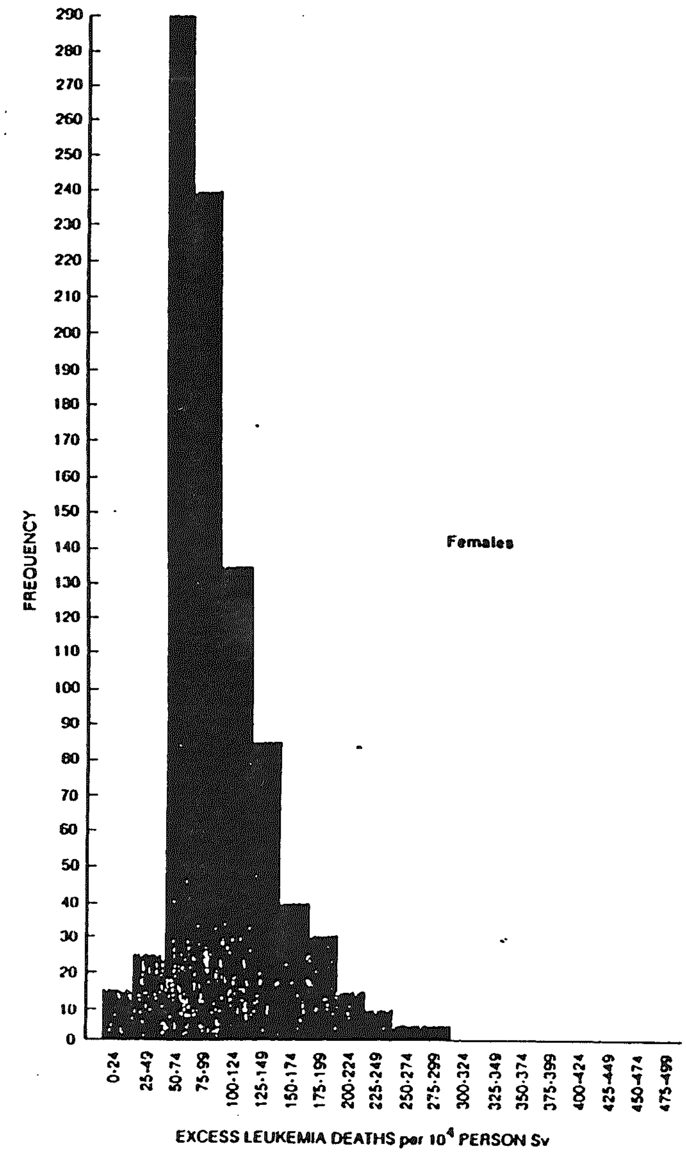


FIGURE 4-2 Excess leukemia fatalities per 10^4 person Sv (million person rem). Results of 1,000 Monte Carlo simulations and lifetable analyses of the excess mortality from leukemia following an acute total body dose of 0.1 Sv. The populations at risk are 100,000 males and 100,000 females. The point estimate for males is 111 excess deaths; for females, 82. In 50 percent of the trials the excess mortality for males was between 60 and 135 deaths; for females, between 55 and 115 deaths.



uncertainty as to the correct form of the exposure-time-response model, since the true model could be misspecified in a number of ways. It is more difficult to assess this component of the uncertainty, but a sense of its importance can be obtained by considering the range of lifetime risks resulting from alternative well-fitting models as discussed in Annex 4D and 4F. In addition, there are various potential biases in the data themselves; while these cannot be quantified precisely, they are discussed in Annex 4F along with the Committee's judgment concerning their magnitude.

Since the lifetime risk is a complex function of the parameters of the fitted models, it is not a simple matter to translate the standard errors in risk coefficients into uncertainties in lifetime risk. This overall uncertainty depends not just on the uncertainty in the coefficient of dose, but also on the uncertainty in the coefficients of the modifying factors and their correlations. Furthermore, the distributions of the estimates of the coefficients are often quite skewed, leading to skewness in the resulting distribution of lifetime risks. For these reasons, the Committee undertook an uncertainty analysis by means of Monte Carlo simulation. In this approach, parameter vectors for each cancer site were randomly sampled from multivariate normal distributions with means and covariant matrices given by their maximum likelihood estimates. Any components that showed marked skewness were adjusted by multiplying the deviations of the sampled value from their means by the ratio of the likelihood-based to asymptotic confidence intervals for the corresponding 90% upper or lower tail. Lifetable calculations of risk were repeated for each randomly selected set of parameters, and in this way a distribution of lifetime risk estimates was produced.

Figure 4-1 presents results for each sex based on 1,000 Monte Carlo simulations and lifetable analyses of the excess mortality risk for all solid cancers following a 0.1 Sv acute total body dose to a stationary population. Figure 4-2 presents the same results for leukemia. These histograms give a good idea of the statistical uncertainty in the Committee's risk models.

Table 4-2 summarizes the resulting 90% confidence limits due to statistical uncertainty on the lifetime risk estimates for each of three exposure patterns. The intervals are wide indicating sparseness of data. For the most part, risk estimates derived from the alternative models described in Annex 4D are within these confidence intervals. Not included in Table 4-2 are several additional sources of uncertainty external to model parameters that are discussed in Annex 4F. The effect of these external sources of uncertainty on the risk estimates is not as well quantified as the uncertainty due to sampling variation shown in Figures 4-1 and 4-2; however, they probably contribute comparable uncertainty. The Committee's analysis in Annex 4F indicates these external factors increase the confidence intervals due to sampling variation in Table 4-2 by about a factor of 1.4.

Finally, it must be recognized that derivation of risk estimates for low doses and dose rates through the use of any type of risk model involves assumptions that remain to be validated. At low doses, a model dependent interpolation is involved between the spontaneous incidence and the incidence at the lowest doses for which data are available. Since the committee's preferred risk models are a linear function of dose, little uncertainty should be introduced on this account, but departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction of either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the millisievert dose range. Thus the possibility that there may be no risks from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero.

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NCHS85 U.S. Decennial Life Tables for 1979-1981, Vol I No. 1, 1985. DHHS publication (PHS) 85-1150-1, Hyattsville, Md.: National Center for Health Statistics.

NRC80 National Research Council. 1980. Committee on the Biological Effects of Ionizing Radiations. The Effects on Populations of Exposure to Low Levels of Ionizing Radiation (BEIR III). Washington, D.C.: National Academy Press. Pp. 524.

APPENDIX T
ATTACHMENTS TO COMMENT LETTERS

Comment Letter #		Attachment
6	1.	ME3 Policy Statement.
	2.	ME3 Membership List.
	3.	Cost-Effective End-Use Efficiency Improvement Potential--RMI
	4.	" " " " " --MDPS
	5.	" " " " " --NSP
	6.	" " " " " --EPRI
	7A.	Draft Presentation, Energy Intensity Model.
	B.	Utility Rates & Earnings.
	C.	Energy Intensity Index.
	D.	Impacts of Conservation.
	E.	Electric Sales Scenarios (with spread sheets).
	F.	Earnings & Bills, NSP Scenario (with spread sheets).
	G.	Earnings & Bills, NAWO Scenario (with spread sheets).
	H.	Energy Intensity Model Equations.
	8A.	Description of Alternative Rate-Making Options.
	B.	Making Conservation Profitable: An Assessment of Alternative Demand Side Management Incentives.
	C.	Financial Incentives For DSM Programs: A Review and Analysis of Three Mechanisms.
	D.	Effect Of The ERAM Mechanism On Utility Incentives.
	E.	Balancing Shareholder and Consumer Interests in Incentive Ratemaking.
	9.	Characteristics of Appropriate Financial Incentive Structuress.
9		Are Radiation-Induced Effects Hormetic On Radiation, Paradigms, and Hormesis Edward Edelson article - no title Academy Panel Raises Radiation Risk Estimate Letters to the Editor, Science, Vol.247
10		Minnesota Energy Agency Director's Decision - Pool Reracking
13	1.	Excerpt from: Minnesota's Energy Options For The 1990's.
	2.	NRC Notice: KR-85 Hazards From Decayed Fuel

Material submitted by Bill Galloway (Greenpeace):

NEES Will Spend $65 Million A Year On Conservation
Examples of Efficiency Programs From Around The Country
The Hood River Conservation Project

MINNESOTANS FOR AN ENERGY EFFICIENT ECONOMY

PROMOTING SUSTAINABLE USE
OF NATURAL RESOURCES

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Attachment 1

POLICY STATEMENT

The manner in which energy is produced and consumed in our society plays a fundamental role in determining our economic well being and the quality of our natural environment. Energy use contributes directly to pollution problems including mercury deposition in Minnesota lakes, acid rain and global warming. In addition, our reliance on foreign sources of energy reduces our overall economic and national security. Promotion of energy efficiency policies and actions can reduce unnecessary energy use and our reliance on environmentally harmful energy production practices, while strengthening the local and national economies. Minnesotans for an Energy Efficient Economy (ME3) supports the following policies which promote the wise stewardship of Minnesota's resources, for ourselves and for future generations:

<u>ME3 Supports Cost-Effective Energy Conservation and Renewable Sources of Energy Supply.</u>

There currently exists in Minnesota and nation-wide a vast untapped source of new energy supply in the form of increased energy efficiency and renewable energy resources. A recent study prepared for the Minnesota Department of Public Service estimates that Minnesotans could reduce their electric consumptions by fifty percent using existing proven efficiency technologies. In addition, large efficiency potential exists with automobiles and non-electrical home and building energy use. Renewable energy resources currently provide five percent of Minnesota's total energy supply and have the potential to be major cost-effective sources in the future.

We believe that energy efficiency can serve as a transition to a renewable energy future.

<u>ME3 Supports the Restructuring of Utility Incentives Through Adoption of an Integrated Resource Planning Process.</u>

Current public utility rate structures in Minnesota penalize utilities for operating effective energy efficiency programs. Minnesota utilities make more money when they sell more electricity or natural gas and lose money when customers conserve. We believe that this financial disincentive to energy conservation must be removed before utilities will aggressively pursue the efficiency options available to Minnesota.

A key ingredient to stimulating efficiency investments in Minnesota is the adoption of an Integrated Resource Planning Process (IRP). Under a properly designed IRP, utilities receive financial incentives for achieving cost-effective conservation within their service territories. IRP then results in the lowest total cost for energy services and the optimal use of utility supply and demand options.

ME3 Supports Energy Pricing Policies Which Recognize and Include the Cost of Environmental Degradation.

Energy use is a major contributor to wide spread environmental degradation. For example, coal power plant emissions represent one of the largest contributors to both acid rain and "greenhouse" pollution. Automobile exhaust has rendered many urban areas as carbon monoxide "hot-spots" and is one of the largest contributors to global warming. Yet when we buy electricity, natural gas or gasoline, the price we pay does not include the cost of the resulting environmental damage.

Unaccounted environmental costs (or externalities) should be included in some form in the price we pay for energy and energy services. Only then can consumers, as well as public policy makers, accurately compare various energy supply and demand options (including renewable energy supplies) and make truly cost-effective choices and policy decisions.

ME3 Encourages Public Participation in Energy Decisions.

Currently, many important state energy and environmental policy decisions are made through a number of relatively unknown and obscure administrative forums. These include utility rate case hearing, utility Conservation Improvement Program filings, building code rule changes and power plant siting hearings to name a few. All of these administrative forums are open to public input, yet few persons or groups are aware of their existence or take the time and effort to participate.

We believe that only through active public participation can public officials receive the information and direction needed to forge consistent and effective state energy and environmental policy. Without such public input, many important issues will not receive the advocacy they deserve.

ME3 Supports the Continuing Education of Public Officials, Building Professionals and the General Public on Issues Relating to Energy and the Environment.

We strongly believe that public officials, building professionals and the general public must be further educated on the critical link between energy use, environmental degradation and economic stability. Our knowledge of the important interactions between these issues has grown substantially since the first "oil crisis" in 1973. Yet, current policies and practices do not show that we have learned the lesson. Realtors, building code inspectors, city council members, state legislators and private citizens must all be constantly reminded of the new options and sound decisions available to us in the real world of the "90's".

MINNESOTANS FOR AN ENERGY EFFICIENT ECONOMY

PROMOTING SUSTAINABLE USE
OF NATURAL RESOURCES

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Attachment 2

MN Building Research Center, University of Minnesota
Dr. David Grimsrud, Director

MN Interfaith Ecology Coalition
John Munter

West Hennepin Human Services Planning Board
Bruce E. Larson, Assistant Director

Lutheran Coalition for Public Policy in MN
James Addington, Director

Institute for Local Self Reliance
David Morris, Co-Director

The Energy Conservatory
Gary Nelson, General Partner

St. Paul Neighborhood Energy Consortium
Anne Hunt, Executive Director

Ramsey Action Programs, Inc.
Paul Vielhaber, Program Manager

Ethical Investments, Inc.
John Schultz, President

Duluth Energy Resource Center
Michael Webb, Coordinator

North American Water Office
George Crocker, Director

Natural Resources Corporation
Michael Noble, President

Energy Resource Center
Tom Griffin, Executive Director

Self Reliance Center
Sue Gunderson, Executive Director

MN Renewable Energy Society
Ralph Jacobsen

Center for Energy and the Urban Environment
Sheldon Strom, Executive Director

Jose Barbosa, MD
Bruce A. Drew
Mary Jane Heinen
James W. Ladner Jr., Esq.
Paul R. Truax
Bruce A. Anderson
Carol Greenwood
Douglas Jensen
Douglas Maddox

Attachment 3

ENERGY, PEOPLE, AND INDUSTRIALIZATION

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5 January 1989

Paper commissioned for the Hoover Institution conference "Human Demography and Natural Resources"

The Hoover Institution, Stanford University, Stanford, California, 1-3 February 1989

Valuable suggestions on content and structure by Prof. Bill Freudenberg and L. Hunter Lovins are gratefully acknowledged.

The round-earth theory poses ultimate limits to population growth and industrialization. Biotic and social carrying capacities, and some resource finitudes, constrain the scope for Los Angelizing the planet. However, even very large expansions in population and industrial activity need not be *energy*-constrained: if we apply what we know, energy can be among the *weakest* of the many reasons for concern about indefinite population and industrial growth. This paper first explains why energy need not limit traditional industrial expansion (at least not until very far beyond most other limits), and then explores why goals other than indiscriminate growth are worthier.

About energy there is good news and bad news.

The good news is that if we simply pursue the narrowest of economic interests, the energy problem has already been solved by new technologies – primarily for more efficient end-use, secondarily for more efficient conversion and sustainable supply. In the United States, for example,

- full practical use, in existing buildings and equipment, of the best electricity-saving technologies already on the market would save about three-fourths of all electricity now used, at an average cost certainly below 1¢/kW-h and probably around 0.6¢/kW-h[1] – much less than the cost of just *running* a coal or nuclear power station, even if building it cost nothing; and

- full practical use of the best demonstrated oil- and gas-saving technologies (many already on the market and the rest ready for production within ~4-5 years) would save about three-fourths of all oil now used, at an average cost well below \$10/bbl and probably nearer ~\$5-6/bbl[2] – less than the typical cost of just *finding* new domestic oil.

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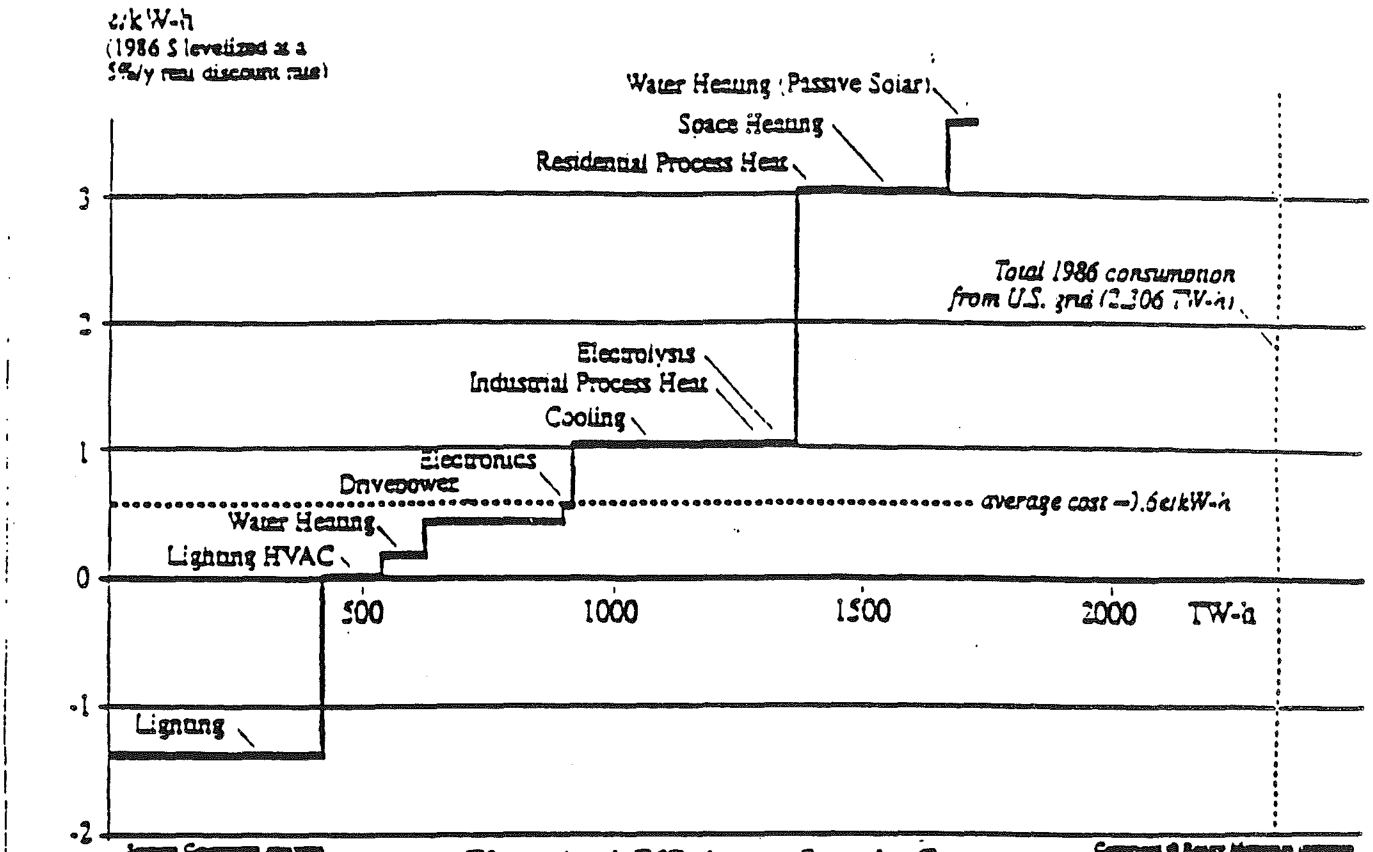
[1] This potential is exhaustively documented by the technical reports of Rocky Mountain Institute's COMPETITEK quarterly update service, currently provided to more than 60 subscribers (chiefly electric utilities and governments) in 14 countries. The application of those technical and economic data to a practical case is illustrated by RMI's June 1988 analysis *Negawatts for Arkansas* (Publication #U88-30, Vol. I, 211 pp.). No interfuel substitution (e.g., of gas for electricity) is assumed here, although it is often worthwhile.

[2] A.B. Lovins, "Drill Rigs and Battleships Are the Answer! (But What Was the Question?)," in P. Fesharaki & R. Reed, eds., *The Petroleum Market in the 1990s*, Westview (Boulder), in press, 1989; preprints available as RMI Publication #88-4, 37 pp. Modest gas-



Electrical Efficiency Supply Curve

An estimate of the full practical potential for retrofit savings of U.S. electricity

Attachment 4

ENERGY
MINNESOTA'S OPTIONS FOR THE 1990s

The State Energy Policy
and Conservation Report to the Legislature

Minnesota Department of Public Service
Energy Division
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St. Paul, Minnesota 55101
612-296-5175

December 1988

Table 5

Conservation Potential by Sector, by End-Use

End-Use	Percent of Use	Conservation Potential (%)	kWh Savings Potential (%)
Residential, Including Farm Residences			
Main Source Space Heat	3.4%	50%	1.7%
Dual-Fuel Space Heat	0.9%	50%	0.5%
Water Heat	6.2%	70%	4.4%
Central AC	1.2%	35%	0.4%
Room AC	0.5%	35%	0.2%
Refrigerators (Total)	5.9%	80%	4.7%
Freezer	1.2%	60%	1.3%
Electric Range	1.9%	40%	0.8%
Clothes Dryer	1.9%	65%	1.2%
Dishwasher	0.3%	85%	0.3%
Waterbed Heater	0.8%	43%	0.3%
Lighting	3.3%	50%	1.7%
Miscellaneous	1.4%		0.0%
TOTAL Residential & Farm	29.7%	58%	17.2%
Commercial			
Space Heat	1.7%	40%	0.7%
Water Heat	0.6%	80%	0.5%
Cooling	3.6%	50%	1.8%
Ventilation	2.9%	50%	1.5%
Refrigeration	3.1%	80%	2.5%
Cooking	0.7%	40%	0.3%
Lighting	14.1%	81%	11.4%
Miscellaneous	3.4%		0.0%
TOTAL Commercial	30.0%	62%	18.5%
Industrial			
Space Heat	0.4%	40%	0.2%
Water Heat	0.1%	80%	0.1%
Cooling	0.9%	50%	0.5%
Ventilation	0.9%	50%	0.5%
Refrigeration	1.1%	70%	0.8%
Process	2.2%		0.0%
Motors	19.8%	30%	5.9%
Lighting	1.9%	85%	1.6%
Miscellaneous	0.4%		0.0%
TOTAL Industrial	27.5%	35%	9.5%
Agricultural Uses	2.5%	48%	1.2%
Other (Government Sales, Seasonal Residential, etc.)	10.2%	50%	5.1%
TOTAL Minnesota[2]	100.0%	52%	51.5%

1. Percentage savings [illegible] for cooling and [illegible] air conditioning include savings from more efficient lighting and other appliances. Less waste heat from several end uses can reduce cooling requirements.

2. Percentages are for the seven largest Minnesota generation and transmission utilities, which supply [illegible] percent of state electric use.

Attachment 5

DEMAND SIDE OPTIONS

Northern States Power Company
May 1989 Officer Planning Conference

EXECUTIVE SUMMARY

Background

Demand-side management (DSM) is the process of modifying electricity use patterns to add value and meet customer energy needs cost-effectively. This scope encompasses all aspects of customers' use of NSP's products and services from conservation and load management to new electric technologies, including the quality of marketing and sales performance.

Whether influenced by NSP or others, DSM significantly affects the production and delivery of energy and related services to customers. These effects are categorized as the following strategies:

* Customer Service
* Conservation
* Peak Reduction
* Load Shifting
* Valley Filling (Off Peak Sales)
* Load Growth

These strategies, except for load growth, are described on pages 4-5 in NSP's 1989 Demand-Side Management Plan, which accompanies this document.

This DSM options paper specifically addresses the conservation and load management aspects of DSM. Discussion of load growth, valley filling and customer service strategies is deferred because NSP's pending decisions regarding DSM center primarily on conservation and load management. In addition, many conservation and load management issues are new or unique to utilities, unlike more familiar load growth and customer service issues. Also, the regulatory climate is keyed on conservation and load management as substitutes for additional supply. Thus, in this document, the term DSM is synonymous with conservation and load management.

Findings

Six inter-related topics are presented to facilitate management discussion, resolve conflicting views and set the direction for NSP's DSM effort over the next few years:

I. Existing NSP DSM effort and forecast impacts of NSP electric marketing;
II. The possible market sources of DSM impacts;
III. The potential for additional DSM on the NSP system beyond the forecast;
IV. The costs and benefits of DSM;
V. Uncertainties and risks of DSM; and
VI. Whether DSM makes sense for NSP in light of regulatory and competitive utility developments.

NSP's existing and currently forecast DSM effort is significant, exceeding 300 MW cumulative system-coincident impact by the end of 1989, and 664 MW cumulative by 1995 (about 8% of what the summer peak would be otherwise).

There is a variety of market sources for this and additional DSM. Lighting, motor, building envelope and cooling efficiency improvements are the largest "end use" markets for

DSM, while offices, service and retail buildings are the largest commercial building segments for DSM. Industry is extremely varied, requiring a more customized orientation.

The 664 MW 1995 achievement is only a portion of the large technical potential for DSM believed to have some level of payback to customers. Defined this way, the total technical potential is estimated to be up to one-half of electricity use. About one-half of this technical potential may be defined as "economic" (i.e, less than five-year payback from the so-called all-ratepayers perspective) and not likely to occur without greater awareness of DSM options. The amount actually achievable and influenced by NSP, excluding that which would occur otherwise through price and other natural market forces, is up to the one-fourth economic potential. The achievable amount is very uncertain because the dynamics of market awareness with vs. without NSP promotions, price influences, etc. are not readily predictable. Additional economic and achievable potentials may be defined provided additional market awareness can be developed and greater incentives used to reduce paybacks. In the end what counts is the ability to actually sell DSM to real customers and demonstrate a real impact.

The existing effort has a benefit/cost ratio of about 3:1, including the profit loss attributable to DSM actions, or a $70 million levelized benefit against current annual marketing costs of about $21 million. Increasing DSM will begin to erode this net benefit, although significantly higher unitary incentives or other program costs would be required to substantially reduce the value.

The associated risks include limited predictability of or control over customer DSM decisions, uncertain baseline and impact measurements, and uncertainty of the effects various market forces would have absent NSP's efforts.

Various regulatory and competitive developments are rapidly bringing DSM forward as a primary utility concern. Several states are developing demand-side bidding as an adjunct to supply bidding. Minnesota government is assessing its potential oversight role and will likely mandate some type of bidding experiment. These developments will affect customer service relations and change the way DSM economics are estimated. In addition, other utilities and related businesses are increasing their DSM efforts, including diversification into efficiency services which could be sold to NSP customers in direct competition with NSP's own services. A large issue looms over the ability to earn an equal or higher rate of return on DSM investments compared to supply investments, as opposed to expensing DSM costs.

Conclusions

Electric Marketing concludes that additional DSM efforts make sense. First, DSM properly done has proven to be cost-effective from even the most conservative economic perspective. Additional DSM could be undertaken without jeopardizing its cost effectiveness or raising long-term rates. Second, customers generally expect and appreciate some level of DSM services from NSP -- a customer satisfaction need. Third, although the impacts of DSM on demand and energy use are difficult to measure, they are measurable, have been accumulating in the last several years at an accelerating pace, and are not expected to saturate most markets for a number of years. Fourth, public sentiment, regulatory policy and competitive utility forces will likely direct NSP's DSM efforts, if the company itself doesn't take the initiative.

On the basis of the above conclusions, Electric Marketing recommends additional resources be committed to DSM in order to achieve the goal of a 1000 MW reduction of the currently projected 1995 base forecast summer peak. This effort would increase the currently projected 1995 system impact of DSM by 50%, or an additional 336 MW of peak reduction system-wide in the summer of 1995.

Additionally, NSP should oppose generic demand-side bidding on the bases of accountability, liability and the resulting abdication of customer relations. Finally, some type of regulatory initiative should be mounted to 1) allow a return on capitalized DSM and 2) institute a rate of return performance incentive on the entire rate base for superior performance, including DSM.

EDITORIAL

Investing in Energy Efficiency

The energy crises of the seventies urged us to use less energy—and we did. In fact, America cut back to the point that demand growth essentially leveled out for the first time in a century. Today the need for prudence in consumption is still with us. But with electricity recognized as a powerful driver of productivity and innovation, simply using less will not be the answer for the competitive nineties. Energy efficiency—making the energy we *do* use go further—is the conservation ethic of the coming decade.

Increasing efficiency at the point of use is the key to the long-term prosperity of utilities, their customers, and the nation. Benefits to the customer are obvious: at the very least, end-use efficiency reduces energy bills. For businesses, both commercial and industrial, energy-efficient electric technologies can also raise productivity, reduce waste, and improve product and service quality—advantages that flow through to the economic benefit of the nation as a whole. And increasing efficiency is the most cost-effective near-term approach to decreasing the impacts of long-term environmental concerns. Electricity, with its unique versatility, flexibility, and efficiency, is the best overall tool for improving our competitiveness and quality of life.

But what about the prosperity of utilities themselves? Selling energy is presently the central concern of the utility business, and one might think that energy efficiency would be seen as a threat to sales. However, more and more utilities are taking a longer view: a utility's fortunes rise and fall, in a very real way, with those of its customers. Energy efficiency can turn an industrial plant's marginal losses into profits, keeping a valuable power customer alive. Helping customers with such problems not only secures and possibly increases sales in the long run, but also improves customer relations.

But we need to go even further with this vision. Pursuing energy-efficient options with customers can provide opportunities to expand a utility's business scope into new areas of energy service—ranging from process engineering to the purchase and installation of equipment and devices. I believe that such a shift of focus—from simply selling electricity to providing expanded energy services—is a central concept for the utility industry's future and will allow utilities to steadily increase the value of electricity to customers. The beginnings of this new vision can be seen and acted on today in promoting energy-efficiency and other consumer outreach programs. I urge all utilities to participate as an investment in the future of their industry.

Clark W. Gellings, Director
Customer Systems Division

By its very nature, electricity is efficient. In the words of Tim Yau of EPRI, "It's like a troop of soldiers marching in step." Electrons, like Yau's soldiers, are organized and directed as they zip through transmission lines and into a multitude of practical and sophisticated applications, from turning motors to powering laser beams. But the inherent efficiency of this refined energy form doesn't guarantee that we will use it efficiently.

Our energy efficiency has improved dramatically since the oil crisis of the 1970s. Overall, our country uses only 7% more energy than it did in 1973, yet the gross national product has increased some 46%. Our better use of electricity alone has already saved the United States at least $21 billion in the cost of new power plants. The advanced electric end-use technologies available today could help the country save even more on its energy bill. Just how much more is difficult to determine. But EPRI recently completed an efficiency study aimed at tracking this answer down. The researchers focused on the following question: How much energy would be saved if consumers were to replace their present end-use equipment with equipment ranked among the top 20% in terms of energy efficiency? The study results show that if today's most efficient electric end-use technologies were applied in every possible case, they would have the potential to save the United States anywhere between 24% and 44% of the electricity it will be using in the year 2000. The low-end estimate alone, which translates into 800 billion kWh, is enough to meet the entire energy needs of the 11 western states in 2000.

The gap between EPRI's high and low estimates is indicative of how difficult it is to determine the efficiency potential of technologies that haven't yet been widely deployed and thoroughly tested in the marketplace: new equipment may perform quite differently under various real-world conditions and use patterns.

THE STORY IN BRIEF

Full use of the most efficient end-use technologies would allow us to significantly reduce electricity consumption, but consumers in all three energy sectors—residential, commercial, and industrial—have been slow to adopt such advanced equipment. While most manufacturers include very efficient models in their product lines, buyers often consider other selling features to be more important. To increase customer interest in energy-saving technologies, many utilities are pushing efficiency through their demand-side management programs. For utilities that are capacity constrained, this makes perfect sense—promoting energy efficiency is simply less expensive than building new capacity. But the benefits are far less clear for utilities that have plenty of power to sell. Regulatory agencies, knowing that efficiency is good for the consumer and for the country as a whole, are now looking at ways to encourage utility investments in promoting efficient electricity-based technologies.

Attachment

7A

DRAFT PRESENTATION

We are at the threshold of a new era in electricity. Modern technology has made it possible to perform the tasks electricity has been doing for many years using only half as much (or less) of the energy they have required in the past. With the new emphasis on avoiding pollution there is no doubt that these new technologies will be implemented more and more. The consequence is that the use of electricity will inevitably decline. This has the potential to cause considerable distress to electric utilities and their investors.

Producers of electricity have a limited number of options. They can try to delay the progress as long as possible by whatever means come to hand. Or they can lead the parade into the new era where energy is used as efficiently as possible, and only for those uses for which it is the most efficient and the least damaging to the environment.

From the public's viewpoint.the second option is the most desirable. Society in general would gain (in Minnesota) by saving about $700,000,000 in the cost of electricity. This would be the least of society's benefits. They would also gain by the reduction in acid rain precursors, in the reduction in other toxic wastes and in the reduction in the carbon dioxide emitted to the atmosphere. Unfortunately, as things stand now, embracing that course would cause the utilities and their investors to bear the brunt of sacrifices which are not really necessary, and to reap none of the benefits. NSP, for example, would see their earnings go from the neighborhood of $165,000,000 annually to a loss of perhaps $500,000,000.

Obviously, we can't allow this to happen. But must we give up our technological progress? Resign ourselves and our children to living in an increasingly polluted world with no prospect but a constantly diminishing quality of life?

Surely there must be a way to share that tremendous financial windfall with the producers of electricity in a fair manner so that all could benefit. Considering the many non-financial benefits of reducing the amount of electrical energy needed to support our current life style, it should be possible to recompense the suppliers of the energy handsomely and still have a considerable savings for society.

Two big questions remain. Is it really possible to save half of the energy without diminishing our current standard of living? What kind of financial incentive system can we use to make it profitable for utilities to pursue conservation wholeheartedly and enthusiastically?

We are prepared to suggest a system to answer the second question. The first question however is subject to considerable controversy. Some estimates of the current amount of waste are as low as 24%, some are as high as 85%. The most authoritative estimates (including one by NSP) seem to cluster around 50%. It seems likely that if the creativity currently expended in finding new ways to use more and more electricity without regard to its efficiency or effectiveness were harnessed to improve end use efficiency we would find ways to conserve more and the 50% figure would become a self fulfilling prophecy.

DRAFT PRESENTATION

As a matter of fact the North American Water Office proposal involves ①tying the utilities' earnings to conservation so that the market would provide the motivation required and ②making it impossible for a utility to increase its earnings by selling more electricity.

Attachment 7B

UTILITY RATES AND EARNINGS

Setting the rates

The utility makes a number of estimates covering the hypothetical operation for a 'test' year. Among many other details, they estimate (a) how much power will be generated and sold; (b) how much capital investment will be used in generating and transmitting this power; (c) what expenses, including income and other taxes, will be incurred in these operations.

A number of technical points are involved in determining the above quantities, such as the treatment of power purchased from other utilities, the amount of power lost in transmission, how to deal with conservation expenditures, the amount and cost of money borrowed by the utility and many others. These estimates can become very complicated.

Some utilities make these estimates by using the actual numbers generated during some past year. This is called a 'historical' test year. Others make an estimate of a future year. This is called a 'forecast' test year.

The next step is to determine the estimated earnings for the test year. The earnings are a percentage of the estimated capital investment, item (b) above. That percentage is determined by the MPUC, usually in an 'order' resulting from a rate case.

Then the earnings and the expenses, item (c) above are added together and divided by the number of kilowatt-hours estimated to be sold, item (a) above, to determine the basic cost per kilowatt-hour of electricity. The rates the utility will be allowed to charge various classes of customers are based on this cost.

Normal operation

During a real year the actual numbers may differ from the estimates on which the rates are based. No adjustments are made for such differences. For example, if the utility actually sells more or less power than they estimated, then their earnings will be more or less than the MPUC contemplated. If the earnings are less, the utility can ask for them to be made up during the next rate case. In fact, this is the usual reason for initiating a rate case.

If there has been conservation, whether due to the utility's efforts or not, that is greater than was estimated then the amount of electricity sold will be less than was estimated. This will cause the utility's revenues and, consequently their earnings, to be less than was estimated.

Amounts spent to promote conservation, to the extent they have been estimated in the test year data, are included in expenses and thus included in the rates charged. If they are more than was estimated the company must try to recover them in the next rate case.

The utilities have complained that money spent on conservation is not the same as money spent on new power plants because the latter is treated as an investment and earns a return. Money spent on conservation is just paid back through the rates and does not earn anything. This is especially galling when the utility has to wait for a subsequent rate case before they get it back.

UTILITY RATES AND EARNINGS

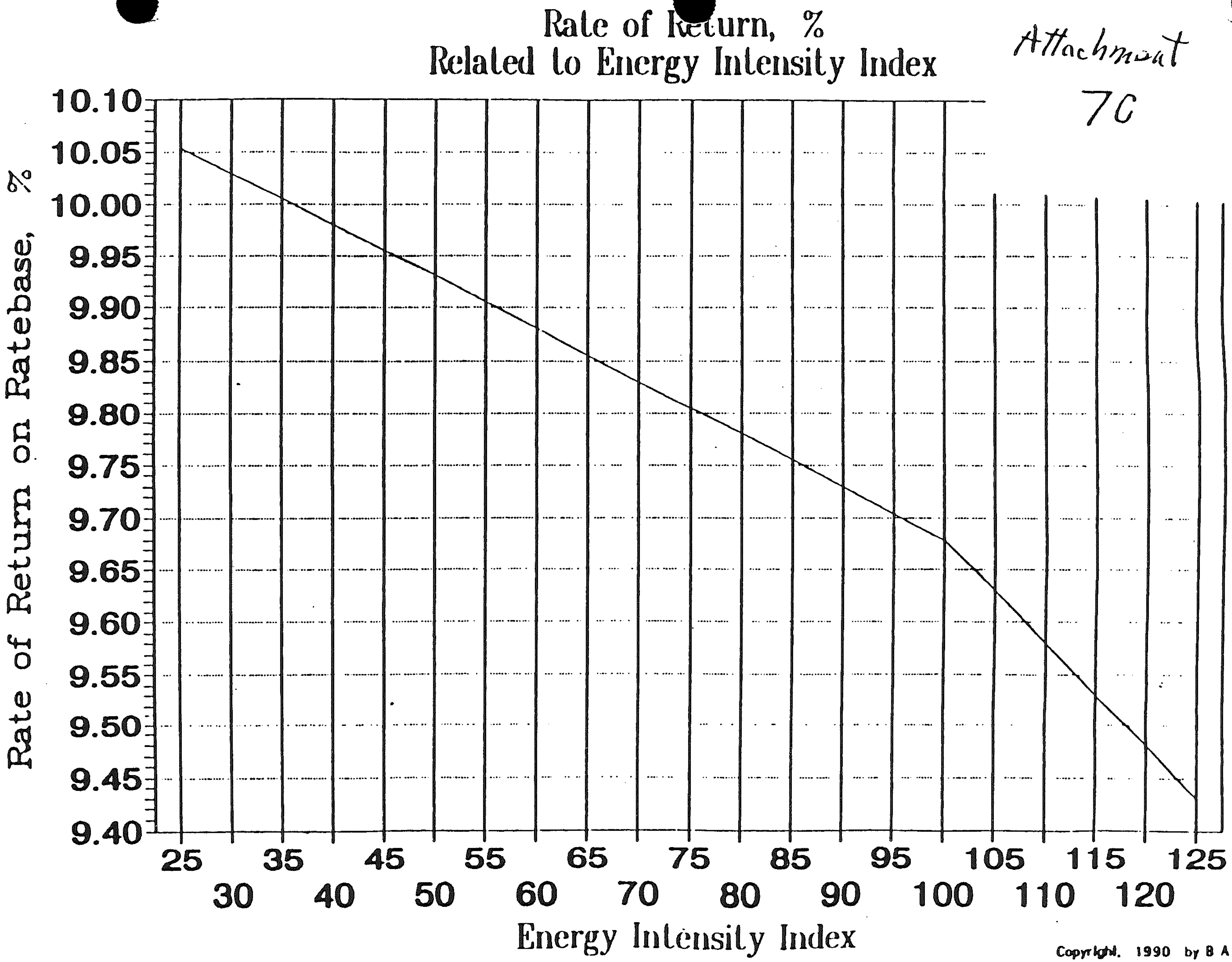
Even though the utility is forced by the law to spend money promoting conservation there is nothing to prevent them from promoting also the use of power for wasteful purposes, since they continue to make additional earnings from the additional energy sold. If they have to add plants to generate the additional power, then they can add the cost of those plants to their ratebase and use this to justify increased earnings in a future rate case.

North American Water Office Proposal

The North American Water Office has proposed that earnings be decoupled from the amount of electricity sold. Instead of setting rates per kilowatt-hour the PUC would set the utility's earnings (profit) as a percentage of its capital investment. The rates would be estimated as before and electricity would be generated and sold as before. However if earnings differed from the amount allowed by the MPUC the difference would be made up in the following year by readjusting the rates or by refunding the excess. This would remove the motivation to generate and sell more power since doing so would not increase the company's earnings.

In addition, in order to encourage the utility to direct their creativity toward socially acceptable ends, the rate of return allowed would be based on the amount of conservation accomplished. As more conservation occurred the rate of return would increase. The specific rates would be tied to conservation in such a way that the savings would be shared between the utility and its ratepayers. The North American Water Office has suggested several measures of performance that might be used.

Attachment 7C



NSPRC004.WKQ

Attachment

7D

03-Dec-90

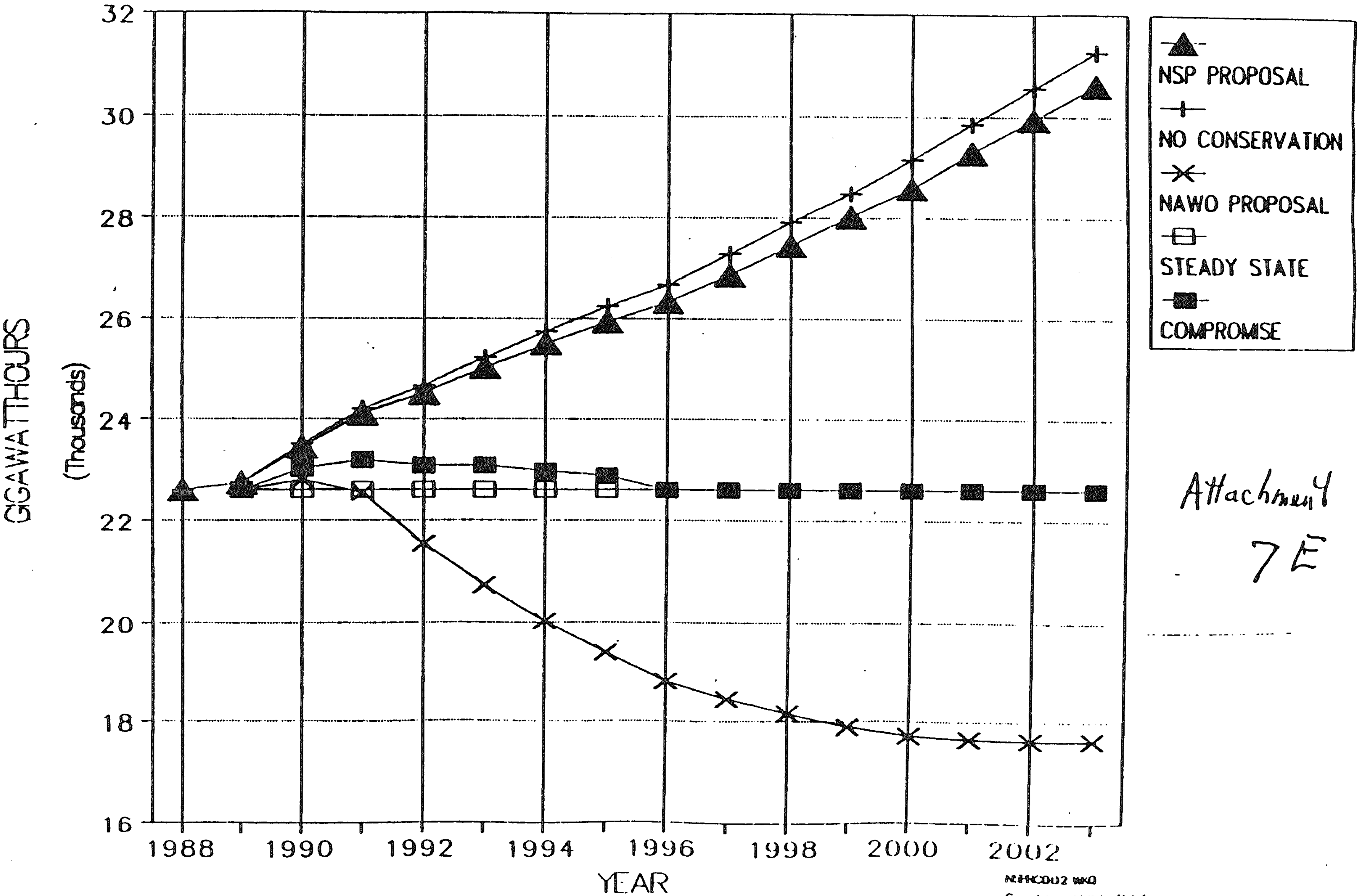
IMPACTS OF CONSERVATION, SUMMARY

			CUSTOMER FUNDED CONSERVATION			NSP FUNDED
			IMMEDIATE	IMMEDIATE	EVENTUAL	EVENTUAL
FINANCIAL ITEM	UNITS	CURRENT	CONST RATES	CONST PROFIT	CONST PROFIT	CONST PROFIT
CONSERVATION LEVEL	%	0	50	50	50	50
TOTAL ENERGY SALES	MWH	23,072,743	11,536,372	11,536,372	11,536,372	11,536,372
TOTAL REVENUE	$(,000)	1,358,824	679,412	1,156,428	788,889	1,035,909
TOTAL COSTS	$(,000)	1,195,603	801,113	993,207	625,668	625,668
PROFIT (EARNINGS)	$(,000)	163,221	(121,701)	163,221	163,221	163,221
REVENUE SAVED	$(,000)	0	679,412	202,396	569,936	322,916
RELATIVE BILL (CURRENT = 100)		100	50	85	58	76

IMPACTS OF CONSERVATION

			CUSTOMER FUNDED CONSERVATION			NSP FUNDED
FINANCIAL ITEM	UNITS	CURRENT	IMMEDIATE CONST RATES	IMMEDIATE CONST PROFIT	EVENTUAL CONST PROFIT	EVENTUAL CONST PROFIT
CONSERVATION LEVEL	%	0	50	50	50	50
RATEBASE	$(,000)	2,372,746	2,372,746	2,372,746	1,186,373	2,372,746
TOTAL ENERGY SALES	MWH	23,072,743	11,536,372	11,536,372	11,536,372	11,536,372
CONSERVED ENERGY	MWH	0	11,536,372	11,536,372	11,536,372	11,536,372
CAPACITY RELATED COSTS	$(,000)	570,400	570,400	570,400	285,200	285,200
DEPRECIATION	$(,000)	164,679	164,679	164,679	82,340	82,340
CONSERVATION (UTILITY AMORTIZATION)	$(,000)	0	0	0	0	247,020
ENERGY RELATED COSTS	$(,000)	404,792	202,396	202,396	202,396	202,396
PRETAX EARNINGS		218,953	(258,063)	218,953	218,953	218,953
INCOME TAXES	$(,000)	55,732	(136,362)	55,732	55,732	55,732
TOTAL COSTS	$(,000)	1,195,603	801,113	993,207	625,668	625,668
PROFIT (EARNINGS)	$(,000)	163,221	(121,701)	163,221	163,221	163,221
TOTAL REVENUE	$(,000)	1,358,824	679,412	1,156,428	788,889	1,035,909
REVENUE SAVED	$(,000)	0	679,412	202,396	569,936	322,916
ENERGY PRICE (CURRENT=100)		100	100	170	116	152
RETURN ON RATEBASE	%	6.88	-5.13	6.88	13.76	6.88
RELATIVE BILL (CURRENT=100)		100	50	85	58	76
CONSERVATION COST	$(,000)/M	0	0.00000	0.00000	0.00000	0.02141

ELECTRIC SALES SCENARIOS
WITH VARIOUS LEVELS OF CONSERVATION



Attachment 7E

NSPRC882.WKQ DEMAND SIDE MANAGEMENT SCENARIOS
BASED ON DATA FROM NSP RATE CASE VOLUME 3 SECTION N APPENDIX B

		1988	1989	1990	1991	1992	1993	1994	1995	1996
(1)	FORECAST FOR NSP-MN, GWh	22626	22742	23460	24085	24480	24993	25500	25945	[illegible]
(2)	PEAK DEMAND (SUMMER) MW	6923	6599	6760	6697	6973	7080	7132	7278	7347
(3)	SUMMER LOAD FACTOR	0.373	0.393	0.396	0.399	0.401	0.403	0.405	0.407	0.409
(4)	PEAK DEMAND (WINTER) MW	5152	5468	5614	5739	5828	5913	6004	6084	[illegible]
(5)	RATIO WINTER/SUMMER PEAKS	0.744	0.829	0.830	0.832	0.836	0.835	0.836	0.837	0.833
(6)	CIP PK REDUCTION MW			152	229	319	404	459	515	585
(7)	SUMMER PK W/O DSM	6923	6599	6912	7126	7292	7484	7641	7795	7948
(8)	NSP PROPOSED DSM GWh			54	108	160	211	261	310	359
(9)	FORECAST W/O DSM, GWh	22626	22742	23514	24193	24640	25204	25761	26255	[illegible]
(10)	NSP PROPOSED DSM, % OF SALES	0.00	0.00	0.23	0.45	0.65	0.84	1.01	1.19	1.34
(11)	NAWO PROPOSED GOAL FOR DSM, %		1	3	7	13	18	22	25	28
(12)	NAWO PROPOSED GWh SAVINGS		116	705	1644	3129	4495	5744	6873	7384
(13)	NAWO PROPOSED FORECAST SALES		22626	22809	22549	21511	20709	20017	19382	[illegible]
(14)	STEADY STATE GOAL FOR GWh SAVINGS		116	388	1567	2014	2578	3135	3629	4054
(16)	STEADY STATE GOAL FOR DSM, %		1	4	6	8	10	12	14	15
(17)	STEADY STATE FORECAST SALES		22626	22626	22626	22626	22626	22626	22626	[illegible]
(18)	COMPROMISE GOAL FOR GWh SAVINGS		116	471	983	1551	2185	2776	3352	4054
(19)	COMPROMISE GOAL FOR DSM, %		1	2	4	6	8	11	13	15
(20)	COMPROMISE FORECAST SALES		22626	23043	23210	23090	23099	22985	22903	[illegible]
(21)	ANNUAL SAVINGS, NSP PROPOSAL			54	54	52	51	50	49	48
(22)	ANNUAL SAVINGS, NAWO PROPOSAL			589	938	1486	1366	1249	1129	1011
(23)	ANNUAL SAVINGS, SEADY STATE			772	679	447	564	557	494	425
(24)	ANNUAL SAVINGS, COMPROMISE			355	512	567	554	671	577	702

NOTES:

(1) From Rate Case Vol 3, Sect N, Appendix B, Page F-61, Column 1. Rounded to nearest GWh.

(2) op cit Page F-62, Column 7.

(3) 1000*(1)/24/365/(2)

(4) op cit Page F-62, Column 8.

(5) (4)/(2)

(6) op cit Page F-7, Figure NSP-D, Schedule F, Column 10.

(7) (2)+(6)

(8) From Rate Case Vol 2 EED-2 Sch 3 Line (3) extrapolated & accumulated. Schedule E Col 16 & Worksheet E-3.

(9) (1)+(8) NSP forecst without conservation.

(10) 100*(8)/(9)

(11) An exponential series designed to approach 52% asymptotically. (11)=52*(1-exp(-0.14(year-1990)))

1997	1998	1999	2000	2001	2002	2003		
26881	27453	28002	28610	29289	29946	30613	(1)	FORECAST FOR NSP-MN, GWh
7465	7590	7707	7847	8005	8160	8316	(2)	PEAK DEMAND (SUMMER) MW
0.411	0.413	0.415	0.416	0.418	0.419	0.420	(3)	SUMMER LOAD FACTOR
6242	6344	6444	6554	6648	6813	6943	(4)	PEAK DEMAND (WINTER) MW
0.836	0.836	0.836	0.835	0.830	0.835	0.835	(5)	RATIO WINTER/SUMMER PEAKS
679	753	827	901	975	1049	1123	(6)	CIP PK REDUCTION
8144	8343	8534	8748	8980	9209	9439	(7)	SUMMER PK W/O DSM
404	450	494	537	579	620	659	(8)	NSP PROPOSED DSM GWh
27295	27903	28496	29147	29868	30566	31272	(9)	FORECAST W/O DSM, GWh
1.48	1.61	1.73	1.84	1.94	2.03	2.11	(10)	NSP PROPOSED DSM, % OF SALES
32	35	37	39	41	42	44	(11)	PROPOSED GOAL FOR DSM, %
8863	9775	10615	11419	12202	12932	13627	(12)	PROPOSED GWh SAVINGS
18422	18128	17881	17728	17666	17634	17645	(13)	NEW FORECAST SALES
4659	5277	5870	6521	7242	7940	8646	(15)	STEADY STATE GOAL FOR GWh SAVINGS
17	19	21	22	24	26	28	(16)	STEADY STATE GOAL FOR DSM, %
22626	22626	22626	22626	22626	22626	22626	(17)	STEADY STATE FORECAST SALES
4659	5277	5870	6521	7242	7940	8646	(18)	COMPROMISE GOAL FOR GWh SAVINGS
17	19	21	22	24	26	28	(19)	COMPROMISE GOAL FOR DSM, %
22626	22626	22626	22626	22626	22626	22626	(20)	COMPROMISE FORECAST SALES
46	46	44	43	42	41	39	(21)	ANNUAL SAVINGS, NSP PROPOSAL
979	912	839	804	783	730	695	(22)	ANNUAL SAVINGS, NAWO PROPOSAL
605	618	593	651	721	698	706	(23)	ANNUAL SAVINGS, SEADY STATE
605	618	593	651	721	698	706	(24)	ANNUAL SAVINGS, COMPROMISE

NOTES:

(12) (9)*(11)/100
(13) (9)-(12)
(14) blank
(15) (9)-22626. Projected GWh savings necessary to keep total sales constant.
(16) 100*(15)/(9)
(17) (9)-(15)
(18) A weighted average of (8) and (15) with the weights starting equal in 1990, gradually shifting toward the steady state till 1996. Same as steady state scenario from 1996 on.
(19) 100*(18)/(9)
(20) (9)-(18)

SCHEDULE A

OPERATING EXPENSES FROM RATE CASE VOL 2,
DCF-1, SCHEDULE 2, PAGE 2/11

DESCRIPTION	AMOUNT $1000
PRODUCTION	599,950
TRANSMISSION	27,501
DISTRIBUTION	74,070
CUSTOMER ACCOUNTS	29,345
SALES	103
CUSTOMER INFORMATION	9,223
ADMINISTRATIVE & GENERAL	100,590
ECONOMIC DEVELOPMENT	453
GRAYSTONE O&M EXPENSE	55
TAXES, R E & PERS PROP	107,409
DEFERRED INCOME TAXES	775
SUBTOTAL	958,300
LESS FUEL EXP (P5)	284,837
LESS PURCH POWER (P5)	67,923
TOTAL FE & PP	352,760
TOTAL OTHER EXPENSES	605,540

RATIO OF FUEL EXP & PURCH POWER TO KWh SALES IN MN

ENERGY ALLOCATED TO MN, DCF-1 SCHEDULE 9 MWh	23,663,233
RATIO (FE & PP)/MWh	0.014900

NOTE THAT THE ENERGY TO BE SUPPLIED TO MN IN 1990 GIVEN IN DCF-1 SCH 9 DIFFERS FROM THAT GIVEN IN RATE CASE VOL 4, SECT N, APPENDIX B, PAGE F-61 COLUMN 1.

SCHEDULE B

INCOME TAX CONSTANTS FOR FORMULA USED IN NSP SUBMISSION TO PUC INCENTIVE INQUIRY DOCKET # E999/CI-89-212

A	73,558
B	1.674201
C	1274378

SCHEDULE C FORECASTS WITHOUT CONSERVATION

YEAR	(1) FORECAST PAGE F-61	(2) CONSERVATION EED-2 SCH 3 EXTRAPOLATED	(3) FORECAST WITHOUT CONSERVATION
1989	22,741,796		22,741,796
1990	23,460,098	54,000	23,514,098
1991	24,084,559	108,000	24,192,559
1992	24,480,141	160,000	24,640,141
1993	24,992,621	211,000	25,203,621
1994	25,499,082	261,000	25,760,082
1995	25,945,319	310,000	26,255,319
1996	26,322,466	358,000	26,680,466
1997	26,891,158	404,000	27,295,158
1998	27,452,793	450,000	27,902,793
1999	28,002,012	494,000	28,496,012
2000	28,609,939	537,000	29,146,939
2001	29,288,648	579,000	29,867,648
2002	29,946,823	620,000	30,566,823
2003	30,613,280	659,000	31,272,280

(1) FROM RATE CASE VOL 2, SECT N, APPENDIX B, PAGE F-61 COLUMN 1

(2) FROM RATE CASE VOL 2, EED-2 SCHEDULE 3 ROW (3) EXTRAPOLATED & ACCUMULATED. SEE SCHEDULE E COL 16 & WORKSHEET E-3

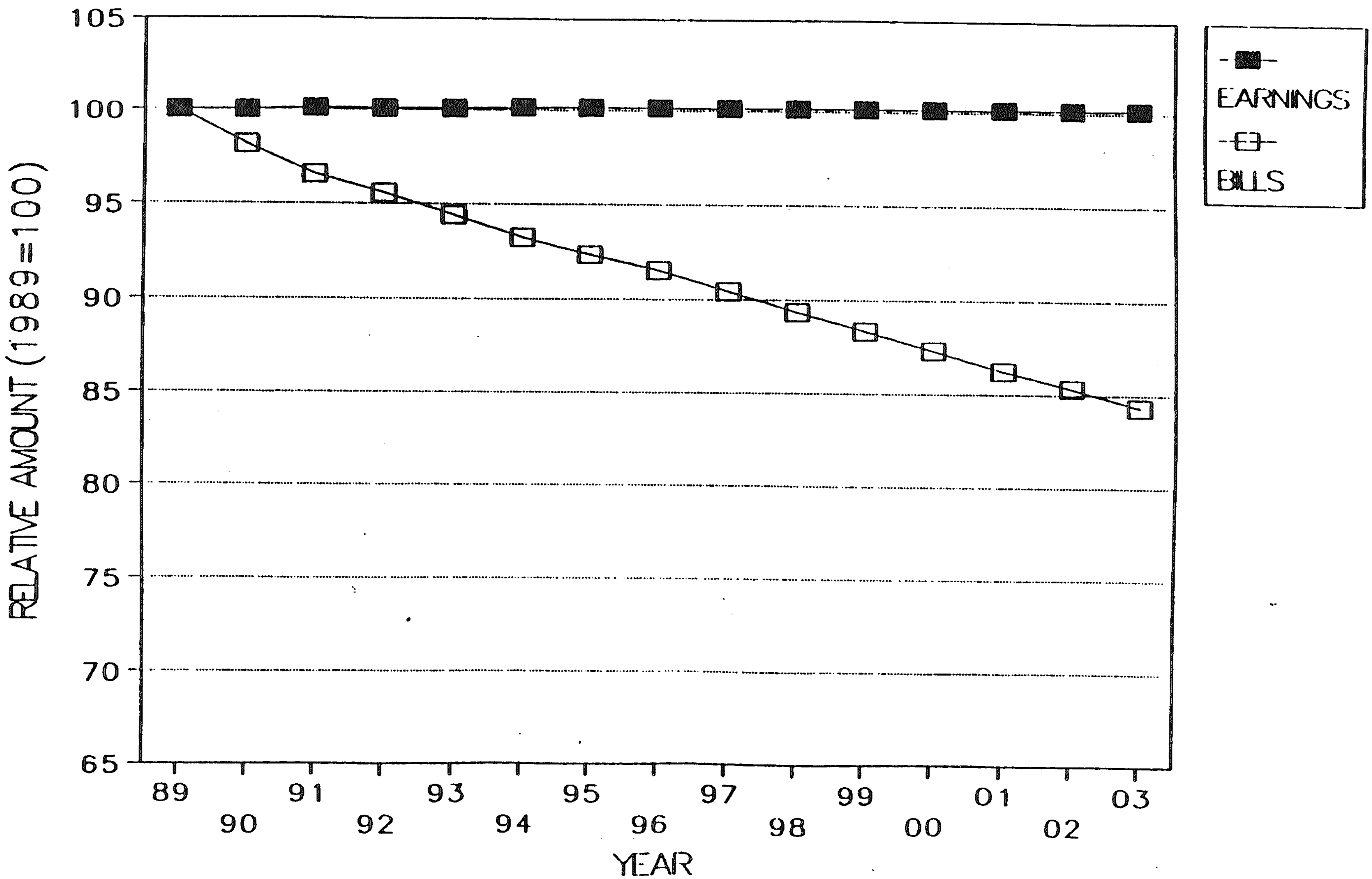
SCHEDULE ? SUMMER PEAK W/O DSM

(1) PEAK F'CAST PAGE F-?2	(2) F'CST DSM IMPCT FIG NSP-D p F-7	(3) F'CST PEAK W/O DSM
6,599		6,599
6,760	312	7,072
6,897	382	7,279
6,973	464	7,437
7,080	542	7,622
7,182	584	7,766
7,270	657	7,927
7,343	734	8,077
7,465	782	8,247
7,590	852	8,442
7,707	914	8,621
7,847	970	8,817
8,005	1,023	9,028
8,160	1,072	9,232
8,316	1,127	9,443

Attached

7F

EARNINGS & BILLS (1989=100)
NSP EXPANDED GOALS WORKSHEET H-23



NCE[illegible]0003.WKQ FINANCIAL IMPLICATIONS OF NSP CONSERVATION EFFORTS 4-[illegible]
ENERGY INTENSITY MODEL, NSP SCENARIO AT ~~[illegible]~~MWh SAVED   10.00
SLOPE OF FORCRS VS EI SET AT 0.001 0.100   0.0010

ROW #	DESCRIPTION	UNITS	1989	1990	1991	1992	1993	1994	1995	1996
(0)	SUMMER PEAK LOAD FACTOR			0.594	0.588	0.591	0.595	0.598	0.601	0.604
(1)	ORDINARY RATEBASE	$1000	2,072,746	2,072,746	2,072,746	2,072,746	2,072,746	2,072,746	2,072,746	2,072,746
(2)	CONSERVATION RATEBASE	$1000	0	1,000	1,944	2,535	3,148	3,639	3,831	4,345
(3)	CONSERVATION INVESTMENT	$1000	1,000	1,000	1,000	1,040	1,020	1,000	980	960
(4)	TOTAL RATEBASE	$1000	2,072,746	2,073,326	2,074,690	2,075,281	2,075,394	2,076,295	2,076,577	[illegible]
(5)	ENERGY SALES FORECAST	MWh	22,741,796	23,514,098	24,192,559	24,640,141	25,203,621	25,760,682	26,255,019	26,500,466
(6)	ENERGY SAVED DUE TO (3)	MWh	54,000	54,000	54,000	52,000	51,000	50,000	49,000	48,000
(7)	CUMULATIVE ENERGY SAVED	MWh	54,000	108,000	162,000	214,000	265,000	315,000	364,000	412,000
(8)	ENERGY SALES	MWh	22,687,796	23,406,098	24,030,559	24,426,141	24,938,621	25,445,382	25,891,019	[illegible]
(9)	FUEL EXP & PUR POWER	$1000	338,220	348,938	358,248	364,145	371,785	379,347	385,998	391,310
(10)	OTHER EXPENSE	$1000	685,540	685,540	685,540	685,540	685,540	685,540	685,540	685,540
(11)	INCOME TAXES	$1000	55,110	62,549	69,082	73,119	78,376	83,555	88,393	[illegible]
(12)	CONS INVESTMT AMORTIZATI	$1000	0	216	389	527	630	709	766	809
(13)	TOTAL EXPENSES	$1000	998,368	1,017,243	1,033,178	1,043,331	1,056,331	1,069,150	1,080,397	1,089,339
(13A)	ENERGY INTENSITY INDEX	%	99.73	99.54	99.33	99.13	98.95	98.78	98.61	98.46
(14)	REQUIRED RATE OF RETURN	%	9.680	9.680	9.681	9.681	9.681	9.681	9.681	9.682
(15)	REQUIRED EARNINGS	$1000	229,687	229,797	229,386	229,958	230,012	230,053	230,086	[illegible]
(16)	REQUIRED REVENUE	$1000	1,228,567	1,247,041	1,263,064	1,273,289	1,286,342	1,299,234	1,310,473	[illegible]
(17)	REQUIRED UNIT PRICE	c/kwh	5.415	5.328	5.256	5.213	5.158	5.106	5.061	5.025
(28)	TYPICAL RESIDENTIAL USE	kWh/yr	6,000	5,986	5,972	5,960	5,948	5,937	5,927	[illegible]
(29)	TYPICAL RESIDENTIAL BILL	$/yr	324.91	318.91	313.92	310.67	306.79	303.12	299.97	[illegible]
(30)	TOTAL REVENUE GENERATED	$1000	1,228,567	1,247,041	1,263,064	1,273,289	1,286,342	1,299,204	1,310,473	[illegible]
(31)	TOTAL EARNINGS	$1000	229,687	229,797	229,986	229,958	230,012	230,053	230,086	[illegible]
(32)	TOTAL RETURN ON RATEBASE	%	9.680	9.680	9.681	9.681	9.681	9.681	9.681	9.682
(33)	PERCENT OF SALES SAVED	%	0.24	0.23	0.22	0.21	0.20	0.19	0.19	[illegible]
(34)	CUM PC OF SALES SAVED	%	0.24	0.47	0.69	0.90	1.10	1.30	1.48	[illegible]
(35)	IMPACT ON EARNINGS	$1000	5	11	16	21	25	29	33	[illegible]

ROW #	DESCRIPTION	UNITS	1997	1998	1999	2000	2001	2002	2003
(0)	SUMMER PEAK LOAD FACTOR		0.607	0.610	0.612	0.615	0.617	0.619	0.621
(1)	ORDINARY RATEBASE	$1000	2,072,746	2,072,746	2,072,746	2,072,746	2,072,746	2,072,746	2,072,746
(2)	CONSERVATION RATEBASE	$1000	4,196	4,277	4,341	4,353	4,342	4,314	4,271
(3)	CONSERVATION INVESTMENT	$1000	920	[illegible]20	390	360	340	320	[illegible]80
(4)	TOTAL RATEBASE	$1000	2,076,942	2,077,023	2,077,087	2,077,099	2,077,088	2,077,060	2,077,017
(5)	ENERGY SALES FORECAST	MWh	27,295,150	27,902,793	28,496,012	29,146,939	29,367,548	30,566,023	31,272,200
(6)	ENERGY SAVED DUE TO (3)	MWh	46,000	46,000	44,000	43,000	42,000	41,000	39,000
(7)	CUMULATIVE ENERGY SAVED	MWh	458,000	504,000	548,000	591,000	633,000	674,000	713,000
(8)	ENERGY SALES	MWh	26,827,150	27,398,793	27,948,012	28,555,939	29,234,548	29,892,023	30,559,200
(9)	FUEL EXP & PUR POWER	$1000	399,939	408,461	416,649	425,712	435,308	445,608	455,577
(10)	OTHER EXPENSE	$1000	605,540	605,540	605,540	605,540	605,540	605,540	605,540
(11)	INCOME TAXES	$1000	97,577	103,041	108,876	114,990	121,011	128,414	135,[illegible]
(12)	CONS INVESTMT AMORTIZATI	$1000	839	855	868	871	868	863	854
(13)	TOTAL EXPENSES	$1000	1,103,895	1,118,198	1,131,933	1,147,113	1,164,050	1,180,447	1,197,083
(13A)	ENERGY INTENSITY INDEX	%	98.32	98.19	98.08	97.97	97.88	97.79	97.72
(14)	REQUIRED RATE OF RETURN	%	9.682	9.682	9.682	9.682	9.682	9.682	9.682
(15)	REQUIRED EARNINGS	$1000	230,129	230,139	230,148	230,151	230,153	230,152	230,149
(16)	REQUIRED REVENUE	$1000	1,334,023	1,348,336	1,362,081	1,377,264	1,394,202	1,410,599	1,427,233
(17)	REQUIRED UNIT PRICE	c/kWh	4.973	4.921	4.874	4.823	4.769	4.719	4.670
(28)	TYPICAL RESIDENTIAL USE	kWh/yr	5,907	5,899	5,892	5,885	5,878	5,873	5,868
(29)	TYPICAL RESIDENTIAL BILL	$/yr	293.75	290.31	287.14	283.82	280.54	277.14	274.04
(30)	TOTAL REVENUE GENERATED	$1000	1,334,023	1,348,336	1,362,081	1,377,264	1,394,202	1,410,599	1,427,233
(31)	TOTAL EARNINGS	$1000	230,128	230,139	230,148	230,151	230,153	230,152	230,149
(32)	TOTAL RETURN ON RATEBASE	%	9.682	9.682	9.682	9.682	9.682	9.682	9.682
(33)	PERCENT OF SALES SAVED	%	0.17	0.16	0.15	0.15	0.14	0.13	0.12
(34)	CUM PC OF SALES SAVED	%	1.83	2.00	2.15	2.30	2.44	2.57	2.70
(35)	IMPACT ON EARNINGS	$1000	40	43	46	48	50	52	54

ITEM	DESCRIPTION	FORMULA
(0)	SUMMER PEAK LOAD FACTOR	ADJUSTABLE
(1)	ORDINARY RATEBASE	CONSTANT
(2)	CONSERVATION RATEBASE	P(2)+P(3)-P(12)
(3)	CONSERVATION INVESTMENT	0.1*(6)
(4)	TOTAL RATEBASE	(1)+(2)
(5)	ENERGY SALES FORECAST	NSP W/O CONS
(6)	ENERGY SAVED DUE TO (3)	ADJUSTABLE
(7)	CUMULATIVE ENERGY SAVED	P(7)+(6)
(8)	ENERGY SALES	(5)-(7)
(9)	FUEL EXP & PUR POWER	0.0149008*(8)
(10)	OTHER EXPENSE	CONSTANT
(11)	INCOME TAXES	A*(1-1/B)*(C-(30))
(12)	CONS INVESTMT AMORTIZATION	(2)/5
(13)	TOTAL EXPENSES	(9)+(10)+(11)+(12)
(13A)	ENERGY INTENSITY INDEX	100*(8)/(5)
(14)	REQUIRED RATE OF RETURN	FROM SCHEDULE B
(15)	REQUIRED EARNINGS	(14)*(4)/100
(16)	REQUIRED REVENUE	(15)+(13)
(17)	REQUIRED UNIT PRICE	100*(16)/(8)
(28)	TYPICAL RESIDENTIAL USE	6000*P(8)/P(5)
(29)	TYPICAL RESIDENTIAL BILL	(17)*(28)/100
(30)	TOTAL REVENUE GENERATED	(17)*(8)/100
(31)	TOTAL EARNINGS	(30)-(13)
(32)	TOTAL RETURN ON RATEBASE	100*(31)/(4)
(33)	PERCENT OF SALES SAVED	100*(6)/(5)
(34)	CUM PC OF SALES SAVED	(33)+P(34)
(35)	IMPACT ON EARNINGS	(31)-.0960*(4)

NOTES:

(0) From 1989 Advance Forecast, Page 62, Column 3.

(1) Assumption: Additions to ratebase are balanced by amortization.

(2) P(N) means Item N of previous year.

(3)

(5) From Schedule C.

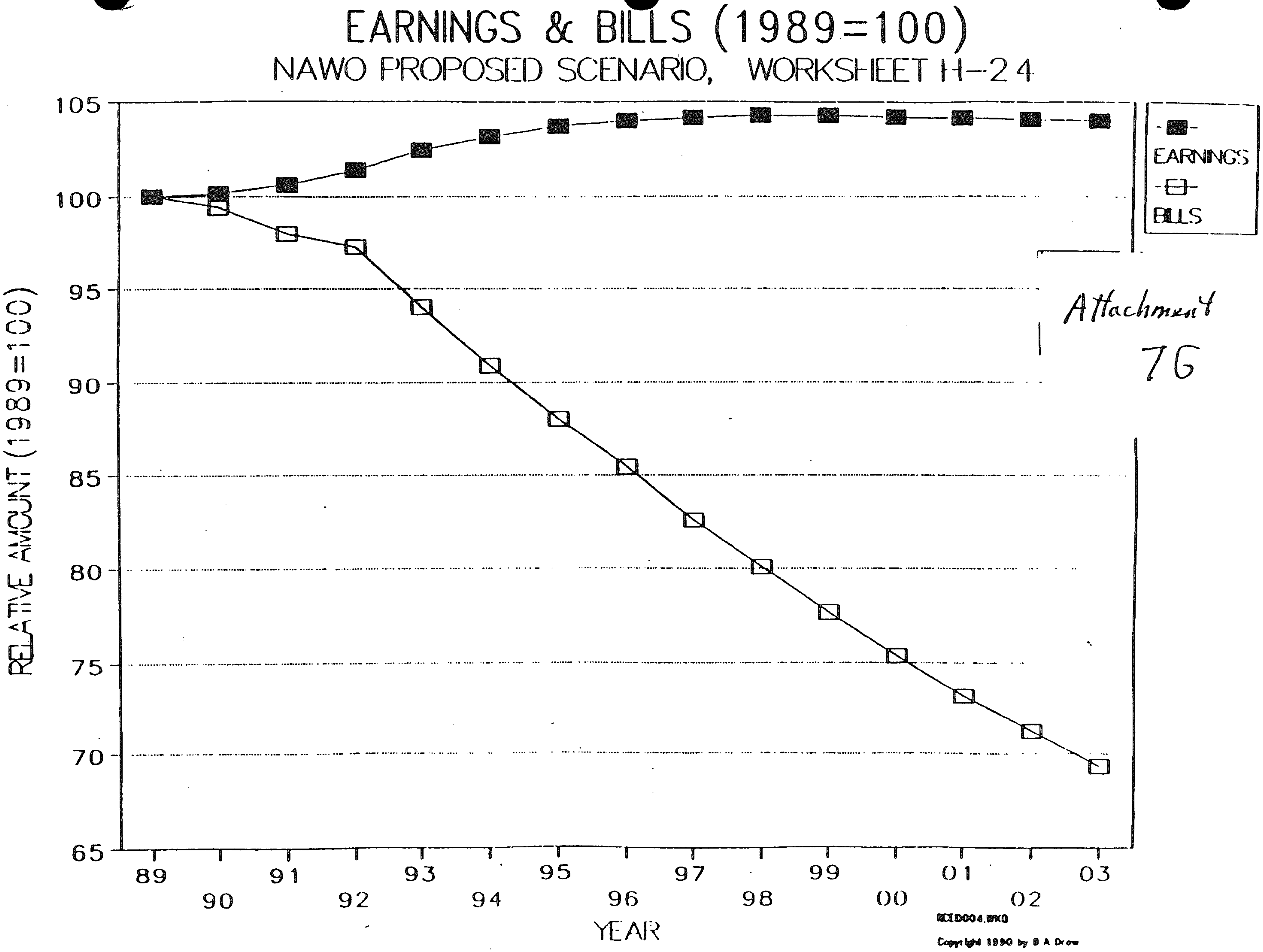
(7)

(9) Ratio from Schedule A.

(10) From Schedule A.

(11) The parameters A, B and C are given in Schedule B.

(28) Assumes consumer shares proportionately in efficiency improvement.



Attachment 7G

F0210004.WK3 FINANCIAL IMPLICATIONS OF NSP CONSERVATION EFFORTS WORKSHEET 4-24
ENERGY INTENSITY MODEL, NAWO PROPOSED SCENARIO AT $20/MWh 20.00
SLOPE OF PCRCRB VS EI SET AT 0.001 0.0010

ROW #	DESCRIPTION	UNITS	1989	1990	1991	1992	1993	1994	1995	1996
(0)	SUMMER PEAK LOAD FACTOR			0.594	0.588	0.591	0.595	0.598	0.601	[illegible]
(1)	ORDINARY RATEBASE	$1000	2,372,746	2,372,746	2,372,746	2,372,746	2,372,746	2,372,746	2,372,746	[illegible]
(2)	CONSERVATION RATEBASE	$1000	0	1,088	12,644	28,375	52,320	69,575	80,641	[illegible]
(3)	CONSERVATION INVESTMENT	$1000	1,088	11,780	19,760	29,720	27,020	24,990	22,590	[illegible]
(4)	TOTAL RATEBASE	$1000	2,372,746	2,373,826	2,385,390	2,401,121	2,425,066	2,442,322	2,453,387	[illegible]
(5)	ENERGY SALES FORECAST	MWh	22,741,796	23,514,098	24,192,559	24,640,141	25,203,621	25,760,382	26,255,019	[illegible]
(6)	ENERGY SAVED DUE TO (3)	MWh	54,000	589,000	903,000	1,486,000	1,366,000	1,249,000	1,129,000	[illegible]
(7)	CUMULATIVE ENERGY SAVED	MWh	54,000	643,000	1,581,000	3,067,000	4,433,000	5,682,000	6,811,000	[illegible]
(8)	ENERGY SALES	MWh	22,687,796	22,871,098	22,611,559	21,573,141	20,770,621	20,078,382	19,444,019	[illegible]
(9)	FUEL EXP & PUR POWER	$1000	338,220	340,962	337,093	321,612	309,648	299,025	299,576	[illegible]
(10)	OTHER EXPENSE	$1000	685,540	685,540	685,540	685,540	685,540	685,540	685,540	[illegible]
(11)	INCOME TAXES	$1000	55,110	57,208	56,975	49,082	46,694	43,170	39,072	[illegible]
(12)	CONS INVESTMT AMORTIZATI	$1000	0	216	2,529	5,775	10,564	13,915	15,123	[illegible]
(13)	TOTAL EXPENSES	$1000	998,350	1,003,927	1,002,137	982,010	972,446	961,961	950,616	[illegible]
(13A)	ENERGY INTENSITY INDEX	%	99.75	97.27	93.46	- 37.55	82.41	77.94	74.06	[illegible]
(14)	REQUIRED RATE OF RETURN	%	9.680	9.683	9.687	9.692	9.698	9.702	9.736	[illegible]
(15)	REQUIRED EARNINGS	$1000	229,687	229,351	231,062	232,776	235,221	236,955	238,124	[illegible]
(16)	REQUIRED REVENUE	$1000	1,228,567	1,233,778	1,233,199	1,215,586	1,207,668	1,198,916	1,188,740	[illegible]
(17)	REQUIRED UNIT PRICE	c/kwh	5.415	5.394	5.454	5.605	5.814	5.971	6.114	[illegible]
(28)	TYPICAL RESIDENTIAL USE	kWh/yr	6,000	5,986	5,306	5,608	5,253	4,945	4,677	[illegible]
(29)	TYPICAL RESIDENTIAL BILL	$/yr	324.91	322.70	318.20	315.99	305.44	295.25	285.91	[illegible]
(30)	TOTAL REVENUE GENERATED	$1000	1,228,567	1,233,778	1,233,199	1,215,586	1,207,668	1,198,916	1,198,740	[illegible]
(31)	TOTAL EARNINGS	$1000	229,687	229,351	231,062	232,776	235,221	236,955	238,124	[illegible]
(32)	TOTAL RETURN ON RATEBASE	%	9.680	9.683	9.687	9.692	9.698	9.702	9.736	[illegible]
(33)	PERCENT OF SALES SAVED	%	0.24	2.58	3.88	6.03	5.42	4.85	4.38	[illegible]
(34)	CUM PC OF SALES SAVED	%	0.24	2.74	6.62	12.65	19.07	22.92	27.22	[illegible]
(35)	IMPACT ON EARNINGS	$1000	6	65	156	299	427	539	636	[illegible]

ROW #	DESCRIPTION	UNITS	1997	1998	1999	2000	2001	2002	2003
(0)	SUMMER PEAK LOAD FACTOR		0.607	0.610	0.612	0.615	0.617	0.619	0.621
(1)	ORDINARY RATEBASE	$1000	2,372,746	2,372,746	2,372,746	2,372,746	2,372,746	2,372,746	2,372,746
(2)	CONSERVATION RATEBASE	$1000	89,394	91,495	91,436	89,929	88,023	86,079	83,463
(3)	CONSERVATION INVESTMENT	$1000	19,590	18,240	16,780	16,300	15,560	14,500	13,900
(4)	TOTAL RATEBASE	$1000	2,462,640	2,464,241	2,464,182	2,462,675	2,460,769	2,459,325	2,456,209
(5)	ENERGY SALES FORECAST	MWh	27,285,150	27,902,793	28,496,812	29,146,939	29,867,548	30,566,823	31,272,230
(6)	ENERGY SAVED DUE TO (3)	MWh	979,000	912,000	839,000	804,000	793,000	770,000	695,000
(7)	CUMULATIVE ENERGY SAVED	MWh	8,801,000	9,713,000	10,552,000	11,356,000	12,139,000	12,869,000	13,564,000
(8)	ENERGY SALES	MWh	18,484,150	18,189,793	17,944,812	17,790,939	17,729,548	17,697,823	17,708,230
(9)	FUEL EXP & PUR POWER	$1000	275,362	271,173	267,509	265,227	264,299	263,827	263,994
(10)	OTHER EXPENSE	$1000	605,540	605,540	605,540	605,540	605,540	605,540	605,540
(11)	INCOME TAXES	$1000	31,379	28,784	26,038	24,530	23,558	22,366	22,476
(12)	CONS INVESTMT AMORTIZATI	$1000	17,979	18,299	18,287	17,986	17,605	17,216	16,693
(13)	TOTAL EXPENSES	$1000	930,459	923,796	917,675	913,283	910,993	909,449	908,702
(13A)	ENERGY INTENSITY INDEX	%	67.74	65.19	62.97	61.04	59.36	57.90	56.63
(14)	REQUIRED RATE OF RETURN	%	9.712	9.715	9.717	9.719	9.721	9.722	9.723
(15)	REQUIRED EARNINGS	$1000	239,178	239,396	239,445	239,346	239,203	239,049	238,826
(16)	REQUIRED REVENUE	$1000	1,169,637	1,163,192	1,157,120	1,152,629	1,150,195	1,148,499	1,147,529
(17)	REQUIRED UNIT PRICE	c/kWh	6.328	6.395	6.449	6.479	6.488	6.490	6.480
(28)	TYPICAL RESIDENTIAL USE	kWh/yr	4,241	4,065	3,911	3,778	3,662	3,561	3,474
(29)	TYPICAL RESIDENTIAL BILL	$/yr	268.36	259.93	252.23	244.78	237.60	231.13	225.11
(30)	TOTAL REVENUE GENERATED	$1000	1,169,637	1,163,192	1,157,120	1,152,629	1,150,196	1,148,499	1,147,529
(31)	TOTAL EARNINGS	$1000	239,178	239,396	239,445	239,346	239,203	239,049	238,826
(32)	TOTAL RETURN ON RATEBASE	%	9.712	9.715	9.717	9.719	9.721	9.722	9.723
(33)	PERCENT OF SALES SAVED	%	3.59	3.27	2.94	2.76	2.62	2.39	2.22
(34)	CUM PC OF SALES SAVED	%	34.60	37.36	40.81	43.57	46.19	48.58	50.30
(35)	IMPACT ON EARNINGS	$1000	794	858	912	959	1,000	1,035	1,065

Col #	DESCRIPTION	FORMULA	NOTES:
(0)	SUMMER PEAK LOAD FACTOR	ADJUSTABLE	(0) From 1989 Advance Forecast, Page F62, Column 9.
(1)	ORDINARY RATEBASE	CONSTANT	(1) Assumption: Additions to ratebase are balanced by amortization.
(2)	CONSERVATION RATEBASE	P(2)+P(3)-P(12)	(2) P(N) means 'Column N of previous year'.
(3)	CONSERVATION INVESTMENT	0.1*(6)	
(4)	TOTAL RATEBASE	(1)+(2)	
(5)	ENERGY SALES FORECAST	NSP W/O CONS	(3)
(6)	ENERGY SAVED DUE TO (3)	ADJUSTABLE	
(7)	CUMULATIVE ENERGY SAVED	P(7)+(6)	
(8)	ENERGY SALES	(5)-(7)	(5) From Schedule C.
(9)	FUEL EXP & PUR POWER	0.014900*(8)	(7)
(10)	OTHER EXPENSE	CONSTANT	
(11)	INCOME TAXES	A-(1-1/B)*(C-(30))	(9) Ratio from Schedule A.
(12)	CONS INVESTMT AMORTIZATION	(2)/5	(10) From Schedule A.
(13)	TOTAL EXPENSES	(9)+(10)+(11)+(12)	(11) The parameters A, B and C are given in Schedule B.
(13A)	ENERGY INTENSITY INDEX	100*(8)/(5)	
(14)	REQUIRED RATE OF RETURN	FROM SCHEDULE B	(28) Assumes consumer shares proportionately in efficiency improvement.
(15)	REQUIRED EARNINGS	(14)*(4)/100	
(16)	REQUIRED REVENUE	(15)+(13)	
(17)	REQUIRED UNIT PRICE	1000*(16)/(8)	
(28)	TYPICAL RESIDENTIAL USE	6000*P(8)/P(5)	
(29)	TYPICAL RESIDENTIAL BILL	(17)*(28)/100	
(30)	TOTAL REVENUE GENERATED	(17)*(8)/100	
(31)	TOTAL EARNINGS	(30)-(13)	
(32)	TOTAL RETURN ON RATEBASE	100*(31)/(4)	
(33)	PERCENT OF SALES SAVED	100*(6)/(5)	
(34)	CUM PC OF SALES SAVED	(33)+P(34)	
(35)	IMPACT ON EARNINGS	(31)-.0968*(4)	

Attachment 7H

Energy Intensity Model

Test year

Estimated Expenses ($,000): E_e

Estimated Fixed Expenses ($,000): F_e

Estimated Variable (Fuel) Expenses ($,000): V_e

$E_e = F_e + V_e + D_e$ $V_e = 0.04S_e$ $D_e = d_e C_e$

Estimated Sales (MWh): S_e

Estimated Ratebase ($,000): B_e

Estimated DSM Expenses ($,000): D_e

Estimated Conservation (MWh): C_e

Estimated Cost of Conservation (($,000)/MWh): d_e

Estimated Energy Intensity Index: $I_e = \left(\frac{S_e}{S_e + C_e}\right)$

Allowed Rate of Return (%): r_{ie} (a function of I_e set by MPUC)

$r_I = 9.68 + 0.3(1 - I)$ for $I < 1.00$

$r_I = 9.68 + (I - 1)$ for $I \geq 1.00$

Price (c/kWh): $P = \frac{\left(E_e + \frac{r_{ie} B_e}{100}\right)}{100\, S_e}$

Note that $r_{ie} = 100\,(100\,PS_e - E_e)/B_e$

Estimated Revenue ($,000): $R_e = 100PS_e = E_e + r_{ie}B_e/100$

Actual year

Actual Expenses ($,000): E

Actual Fixed Expenses ($,000): F

Actual Variable (Fuel) Expenses ($,000): V

$E = F + V + D$ $V = 0.04S$ $D = dC$

Actual Sales (MWh): S

Actual Ratebase ($,000): B

Actual DSM Expenses ($,000): D

Actual Cost of Conservation (($,000)/MWh): d

Actual Conservation (MWh): C

Actual Energy Intensity Index: $I = \left(\frac{S}{S-C}\right)$

Actual Revenue ($,000): $R = 100PS$

Actual Earnings (Profit) ($,000): $\mathcal{E} = 100PS - E$

Effective Rate of Return (%): $r = 100(100PS - E)/B$

Energy Intensity Rate of Return (%): r_I (is a function of I set by order of MPUC)

Energy Intensity Revenue ($,000): $R_I = E + r_I B/100$

NOTE: This is the revenue which is required for the utility to make the earnings (profit) it deserves through having attained the energy intensity index I.

Revenue Deficiency($,000): $\Delta R = R_I - R = (r_I - r)B/100$

NOTE: This is the difference between the guaranteed revenue and the actual revenue. It is the same as the difference between the guaranteed earnings and the actual earnings.

The adjustment to be made is $1.6742006(R_I - R)$. This is to allow for income taxes on the adjustment, that is, Adj(1-0.4027)=ΔR; Adj=$(R_I - R)/0.5973$

Energy Intensity Price (c/kWh): $P_I = \frac{\left(E + \frac{r_I B}{100}\right)}{100S}$

Price Adjustment(c/kWh): $\Delta P = 1.6742006\Delta R/100S_{ee}$ Where S_{ee} is the estimated sales in the following year.

If t=1.6742006, then

$$\Delta P = t(R_I - R)/100S_{ee} = t\left(\frac{E + \frac{r_I B}{100} - 100PS}{100S_{ee}}\right)$$

$$= \frac{t}{100S_{ee}}\left(E + \frac{r_I B}{100} - \frac{100S}{100S_e}\left(E_e + \frac{r_{ie}B_e}{100}\right)\right)$$

$$= \frac{t}{100S_{ee}}\left(E + \frac{r_I B}{100} - \frac{S}{S_e}\left(E_e + \frac{r_{ie}B_e}{100}\right)\right) = \frac{t}{100S_{ee}S_e}\left(S_e\left(E + \frac{r_I B}{100}\right) - S\left(E_e + \frac{r_{ie}B_e}{100}\right)\right)$$

$$= \frac{tS}{S_{ee}}\left(\frac{\left(E + \frac{r_I B}{100}\right)}{100S} - \frac{\left(E_e + \frac{r_{ie}B_e}{100}\right)}{100S_e}\right) = \frac{tS}{S_{ee}}(P_I - P)$$

Attachment 8A

Table 1. Description of alternative rate-making options

Option	Definition
Conventional ROR[a] regulation - Without California-type ERAM[b]	Conventional ROR regulation establishes rates based on the formula: revenue requirements = expenses + rate base x rate of return. Consequently, the more investment a utility has in rate base the higher will be its rates and its profit, except in the unusual circumstance where the company's short run marginal costs exceed its rates. Furthermore, between rate cases the rates don't change. Thus, the more electricity or gas sold the higher will be a utility's profit.
- With ERAM	Same as conventional ROR regulation except that the utility's rates are later adjusted on the difference between predicted and actual sales to ensure that unexpected changes in sales volumes do not affect earnings.
Separate ROR for DSM investment	Rates are maintained as with conventional ROR regulation except that the rate base investment for conservation and load management is accounted for separately and, in a rate case, is calculated to earn a higher rate of return.
ROR adjustment for low bills	Same as conventional ROR regulation except that the rate of return in the revenue requirement formula is adjusted based on the ratio of the average annual utility bill for a set of comparable utility companies to the average annual total bill for the subject utility company.
Performance bonds	Same as conventional ROR regulation except that a third term is added to the revenue requirement formula used in a rate case. As an alternative, the ROR in the revenue requirement formula could be adjusted. In either case, the adjustment is based on the effectiveness of the utility in achieving LCUP goals.
Share DSM savings with utility	Same as conventional ROR regulation except that a third term is added to the revenue requirement used in a rate case. That added term is a predetermined percentage of the calculated savings that the utility can demonstrate from its DSM programs.
Bounty on DSM savings	Same as the previous option except that the adder to revenue requirements is not a percentage of the savings, but a predetermined amount dependent on the achievement of certain goals.

Adjust for sales not earnings

1. Removes Much risk
2. Threat of By pass

[a]ROR is rate of return.

[b]ERAM is electric rate adjustment mechanism, used in California to ensure that the utility recovers lost revenues associated with any overforecast of sales.

Source: National Association of Regulatory Utility Commissioners (1989).

staff to the implementation of its DSM programs. The general requirements for an effective DSM incentive are discussed below in the section on requirements for an effective DSM incentive. And, a particular DSM incentive mechanism recommended the authors which satisfies these requirements is also described.

The NYDPS DSM working group also evaluated the feasibility of integrating DSM incentives within the broader framework of coupling profitability to overall performance in reducing customer electricity service costs and facilitating least cost planning and resource acquisition. The initial results of this effort are discussed under the section on coupling profitability to performance.

ALTERNATIVE RATEMAKING STRATEGIES

Net Lost Revenue Recovery

Six New York utilities have submitted new ratemaking proposals in response to the NYPSC's request. The mechanism initially proposed by each utility for removing lost revenues as the principal DSM disincentive[3] was an automatic annual adjustment in rates to yield additional revenue to offset the following two DSM impacts: (1) recovery of DSM program costs expended in the prior year (in excess of levels forecasted in last rate case) and (2) the estimated net lost revenue (i.e., the projected lost revenues less operating cost savings) which would result from each customer's participation in a DSM program during the previous year.

As illustrated in Column 4 of Table 1, this net lost revenue estimation would conceptually remove the utilities' concern about the adverse impact of DSM on profitability. If the 20 million kWh reduction in sales were caused by the installation of DSM measures, the projected net lost revenue is $1.4 million, i.e., the 10 cents/kWh price less the 3 cents/kWh average marginal cost times 20 million kWh. And, the incremental program cost is assumed to be $0.8 million, i.e., 4 cents per kWh saved times 20 million kWh. Consequently, rates would be increased next year to recover additional revenue of $2.2 million. The net effect would be to yield the same net income as in the Base Case (Column 1).

However, the NYDPS DSM working group was concerned that this Net Lost Revenue Recovery mechanism did not eliminate a potential incentive for the utility to promote increased customer use of electricity as a means of increasing profitability. This situation is illustrated in Column 5 of Table 1. It is assumed that DSM investments reduce consumption by 2% (or 20 million kWh) but that electricity sales increase by 40 million kWh (a 4% increase), resulting in a net 20 million kWh or 2% increase in sales. In this case, Net Income is increased by the combined effect of increased sales and the Net Lost Revenue Recovery mechanism.

The NYDPS DSM working group examined a number of alternative ratemaking mechanisms which would: (1) remove the DSM incentive as well as significantly reduce or eliminate the incentive to market electricity sales as a means for increasing profitability; and (2) provide positive incentives for implementing DSM. This included mechanisms being considered by the NARUC Conservation Committee (Moskovitz 1989) and other promising approaches presented in the utility regulatory and economics literature. Emphasis is given in the subsequent discussion to what the authors consider to be the most promising approaches.

Electric Rate Adjustment Mechanism (ERAM)

In 1981, the California Public Utility Commission (CPUC) adopted ERAM as the basis for the rate making process. (Ziering 1986) ERAM eliminates the lost revenue disincentive for a utility to implement DSM and decouples profitability from the amount of electricity sales. As illustrated in column 6 of Table 1, ERAM adjusts allowable revenue to achieve a "target" Non-Fuel Revenue

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[3] *Because the then prevailing NYPSC accounting practice deferred recovery of DSM program costs (which were not included in base rates) until the next rate case, several New York utilities were concerned the NYPSC's desire to significantly increase DSM expenditures would subject their DSM expenditures to prudency disallowance uncertainty. However, the NYPSC has subsequently revised accounting treatment of DSM program expenditures including amortizing them in a manner similar to supply side investments, including forecasts in base rates, and deferring only variations between forecasted and actual expenditures.*

Requirement, which is equal to $70.8 million in this example. This includes an additional $0.8 million in DSM Costs which were not include in the Base Case projections. The Non-Fuel Revenue obtained from existing rates is the $98 million in total Revenues less the $29.4 million in Fuel Costs, or $68.6 million. (Although we conceptually attribute the reduced sales of 20 million kWh to DSM in this example, this reduction in sales could be due to weather, downturn in the local economy, general consumer conservation, etc.) Rates during the next year would be automatically adjusted under ERAM to collect additional revenue equal to Revenue Adjustment of $2.2 million.

Column 7 of Table 1 illustrates how ERAM removes the incentive for utilities to market electricity to enhance profitability. Because of increased sales of 20 million kWh, Non-Fuel Revenue from existing rates is the $102 million in total Revenues less the $30.6 million in Fuel Costs, or $71.4 million. Rates during the next year would be reduced to give back the $0.6 million balance in the Revenue Adjustment account.

ERAM has the following additional advantages: (1) it protects utilities from adverse impacts on profitability from conditions which are outside of its control (such as lower sales because of weather, increased distribution costs because of greater than anticipated growth in number of customers, etc.); (2) it focuses regulatory agency and utility concern on the costs of providing electricity service and provides incentives for utilities to control costs below projected levels as a means of increasing profits; (3) it lowers next year's rates if additional revenues are collected because of increased sales (due to weather, an economic upturn, and other effects); and (4) as compared with the Net Lost Revenue Recovery mechanism, it eliminates the adverse impacts on the utility or its ratepayers of errors in estimating net lost revenues[4].

[4] *Analysis by the authors has shown that errors in estimating lost revenues from DSM programs can significantly affect the program benefits retained by ratepayers. This is another major reason to prefer a decoupling mechanism to administered lost revenue recoveries. Errors in estimating the shared resource savings DSM discussed in Section 4.6 have a much smaller impact on retained ratepayer benefits.*

Several New York utilities and intervenors expressed opposition to the adoption of ERAM. (NYPSC Opinion and Order 89-29 1989) One of the principal concerns was the increased risk of "buypass". Since ERAM would automatically adjust rates so that it would receive a targeted amount of Non-Fuel Revenue Requirement independent of the level of customer consumption, there was concern that the utility did not have an incentive to inform those customers considering on-site generation about energy efficiency and other alternatives which might be more cost-effective. And, any significant ERAM deficit resulting from bypass decisions would automatically raise rates in the following year and further aggravate this buypass problem.

Another potential disadvantage of ERAM is that it does not provide any positive incentive for utility implementation of cost-effective DSM programs. However, in concept, this could be readily corrected by including a separate profitability incentive for DSM or developing a global performance index which implicitly accomplishes the DSM goals outlined below in the section on effective DSM incentives.

The retention of ERAM by the CPUC was the subject of a proceeding that was initiated in 1986. (Ziering 1986) Following this extensive review (including consideration of concerns similar to those identified by New York utilities and intervenors), the CPUC decided to retain ERAM. However, the CPUC also concluded that ERAM did not include adequate incentives for utilities to implement cost-effective DSM and initiated a collaborative process to identify and implement DSM incentive mechanisms on a pilot basis. (California Collaborative Process 1990)

Following review of the NYDPS DSM working group recommendations and comments received from New York utilities and other interested parties, the NYPSC requested that Orange and Rockland Utilities (O&R) submit a ERAM-type revenue decoupling proposal as part of an upcoming rate case and established a generic proceeding to examine issues of concern to O&R and other New York utilities (NYPSC Opinion and Order 89-29

1989) However, in order to avoid further delays in implementing aggressive DSM programs while this proceeding was conducted, the NYPSC approved the use of the estimated Net Lost Revenue Recovery approach discussed above by O&R and Niagara Mohawk on an interim basis. (The NYPSC has also adopted interim DSM incentive ratemaking mechanisms for 4 other New York electric utilities which include estimated Net Lost Revenue Recovery and a DSM incentive.)

Following review of the Revenue Decoupling Mechanism proposal submitted by O&R, the NYDPS DSM working group recommended that the NYPSC adopt a modified version, including provisions which would couple profitability to O&R's performance in acquiring cost-effective DSM resources and meeting customer service needs as described briefly below. (Brew 1990)

Fuel Revenue Accounting (FRA)

The NYDPS DSM working group sought to identify other potential mechanisms for reducing the coupling between profitability and sales in a manner that would overcome the first disadvantages of ERAM highlighted above. David Moskovitz suggested that the working group consider adaptations of the Fuel Revenue Accounting (FRA) implemented by Central Maine Power (CMP) in 1988. (Dumais 1990)

FRA was developed by CMP to eliminate a potential problem inherent in the design of most time-of-day (TOD) rates which provide utilities with an incentive to encourage customer electricity use during the on-peak period. This incentive results from the higher contribution to Non-Fuel Revenue which is often derived from on-peak consumption as compared to off-peak electricity use. (Moskovitz 1988) With FRA, CMP reduced the Non-Fuel Revenue contribution during the on-peak period and increased the contribution during the off-peak period. The remaining revenue resulting from the difference between the electricity price in each period and the contribution to Non-Fuel Revenue for each customer was allocated to the Fuel Revenue Account. Any positive difference between actual fuel costs and the Fuel Revenue Account is returned to customers and any negative difference is recovered from customers through an automatic adjustment in rates in a manner similar to ERAM.

The following describes a adaptation of the FRA approach developed by the first author, subsequently referred as Modified Fuel Revenue Accounting (MFRA), which allocates revenues to the Non-Fuel Revenue and Fuel Revenue accounts based on the aggregate level of customer consumption during the billing period. This allocation process is designed so that total revenues from electricity sales will be reduced if a customer's electricity use falls below a specified threshold. Any differences between actual fuel costs and the Fuel Revenue Account would be reconciled in a manner similar to the FRA method summarized above. However, any shortfall in total revenues with MFRA might be offset by DSM and other incentive mechanisms such as described in the sections that follow.

This MFRA decoupling mechanism is illustrated in Table 2 for a hypothetical flat-rate example, although the basic approach could be applied to TOD rates in a manner similar to FRA. This example assumes: (1) a rate of 10 cents/kWh is established to recover a projected Non-Fuel Revenue Requirement of $70 million and a projected Fuel Cost of $30 million; (2) the average consumption for a particular billing period is 500 kWh; (3) the MFRA revenue allocation process for this particular month is set up so that a specified percentage, in this case 87.5%, of the revenue associated with the first 400 kWh is allocated to an Allowable Non-Fuel Revenue account; this percentage allocation will ensure that the Allowable Non-Fuel Revenues will yield the $70 million target if all customers consume more than 400 kWh; if consumption falls below 400 kWh for any customer, there will be a shortfall in the Non-Fuel Revenue Account; and (5) the remaining 12.5% of the revenue associated with the first 400 kWh and 100% of the revenue associated with consumption in excess of 400 kWh is allocated to a second account, referred to as the Available Fuel Revenue Account. Table 2 illustrates how revenues are allocated to these various accounts depending on the distribution of consumption by the customer class. For convenience purposes, it is assumed in Table 2 that monthly consumption is the same for each month.

significance. The following two global performance index methods were considered by the NYDPS DSM working group.

Index Based on Average Customer Bills

The following is a summary description of the average customer bill method (Moskovitz 1988). A group of utilities (index group) having characteristics similar to a regulated utility (A) would be selected. In year 1, the average customer bill for the index group would be calculated and compared to the average bill for customers of utility A. In year 2, the index would be recalculated and utility A would be rewarded if the average bill of its customers had declined relative to the average bills of customers served by the index group. Conversely, a relative increase in average bills would be penalized.

Index Based on Total Resources Test

One of the authors (Cummings 1988) has proposed an alternative index based on the total resources test which is intended to provide incentives for implementing least cost planning. An overall performance indicator of the "effective resource cost of electricity" (ERCE) would be established. This indicator would be defined as the sum of: (1) supply side costs; (2) demand side costs; and (3) environmental externality costs; divided by the sum of: (1) kWh actually generated by the utility; and (2) "virtual kWhs" of end use energy services resulting from the utility's DSM programs. Supply side costs would include current fixed and variable revenue requirements as well as estimates of the present value of future capacity additions required by current sales forecasts. Similarly, some demand side costs would be deferred or amortized to reflect the impact of current DSM expenditures on future capacity requirements. "Virtual kilowatts" would be measured using valid and comparable program evaluation methodologies.

As in the case of the Bill Index, the relative change over time in Utility A's performance on the global indicator would be compared to the performance of an index group of utilities. It is possible that the index could be administered as an economically efficient zero-sum game which would require utilities to compete for profits (and losses) awarded by a PUC based on index results (Cummings 1984). Table 3 illustrates and compares the operation of the two indicators. For simplicity of exposition, the index groups have been omitted from the analysis. A single utility's year 2 performance for four different situations is compared with a year 1 base case. In the base case the hypothetical utility sells 1000 MWh at a price of \$.08/kWh. Short run marginal fuel costs of 5 cents/kWh, long-run marginal supply costs of 6 cents/kWh, DSM costs of 3 cents/kWh saved and environmental costs of 1.4 cents per kWh generated are assumed. Customer bills average \$80 and the "effective resource cost of electricity" is \$.094/kWh.

As shown on line M average bills are lowest (\$79), and the utility would be awarded the highest incentive if the utility's sales decline by 20 MWh and the company conducts no DSM programs (Case 1). Average bills are highest (\$81) if sales increased and the utility conducts no DSM program (case 2). But the combination of lower sales and an exceptionally vigorous DSM program (case 4) also results in higher average bills (\$80.20) than the base case. This analysis raises concern that, in some circumstances, an average bill index might reward utilities for declining sales due to weather, economic conditions or utility efforts to restrict supply, but fail to reward the utility for aggressive DSM programs.

Line P shows the operation of the ERCE (effective cost of electricity) index. The resource cost of energy services (9.4 cents per kWh equivalent in the base case) decreases as low cost DSM kWhs replaces high marginal cost supply side kWhs, and reaches a minimum (9.2 cents) in case 4. In case 4, as a result of decreased sales more than outweighed by "virtual kWhs" from DSM efficiency improvements, customers have the maximum amount of energy services available at the minimum average resource cost.

The ERCE is demand and supply side neutral and could reward utilities for increased sales but only if the sum of short and long run marginal and environmental externalities is less than average supply and average demand side costs. Similarly, the ERCE index will reward utilities for demand side investments if short and long run marginal demand side

Table 3. Comparison of Average Bill Index and Effective Resource Cost of Electricity Index

Column Definition:
0 = Base Case: 1000 MWh Sales with no DSM
1 = Case 1: 20 MWh Sales Decrease with no DSM
2 = Case 2: 20 MWh Sales Increase with no DSM
3 = Case 3: 20 MWh Sales Decrease with 20 MWh of DSM
4 = Case 4: 20 MWh Sales Decrease with 40 MWh of DSM

	$/kWh	0	1	2	3	4
A MWh Supply Side		1,000	980	1,020	980	980
B MWh Demand Side		0	0	0	20,000	40,000
C MWh Total Services		1,000	980	1,020	1,000	1,020
D # of Customers		1,000	1,000	1,000	1,000	1,000
Revenue Requirement ($)						
E Base Revenues	0.08	80,000	80,000	80,000	80,000	80,000
F Marginal Cost	0.05	0	-1,000	1,000	-1,000	-1,000
G SupplySide Revenues		80,000	79,000	81,000	79,000	79,000
H Demand Side Costs	0.03	0	0	0	600	1,200
I Total Revenue Req.		80,000	79,000	81,000	79,600	80,200
Other Resource Costs ($)						
J Environmental External.	.014	14,000	13,720	14,280	13,720	13,720
K Long Run Marginal Cost	0.06	0	-1,200	1,200	-1,200	-1,200
L Total Resource Cost		94,000	91,520	96,480	92,120	92,720
Performance Measures						
M Average Bill ($)		80.00	79.00	81.00	79.60	80.20
(Rank)			(1)	(4)	(2)	(3)
N $/kWh (supply only)		0.0800	0.0806	0.0794	0.0812	0.0818
(Rank)			(2)	(1)	(3)	(4)
O ERCE ($/kWh w/o EE)		0.0800	0.0794	0.0806	0.0784	0.0775
(Rank)			(3)	(4)	(2)	(1)
P ERCE ($/kWh w/EE)		0.0940	0.0934	0.0946	0.0927	0.0921
(Rank)			(3)	(4)	(2)	(1)

costs are less than average supply side costs and average demand side costs. Although not illustrated, the ERCE index would also reward utilities for cost effective reductions in emissions from power plants.

The primary short term obstacle to implementing the ERCE index is the difficulty of obtaining consistently measured DSM and environmental data from utilities in an index group. Measurement of "Virtual kilowatt hours", a critical variable in the index, would require that all utilities use comparable "state of the art" program evaluation methodologies for estimating program impacts. NYSERDA and the NYPSC have undertaken studies to develop model DSM Program Evaluation Protocols and methods for quantifying the environmental externalities of power generation and transmission. NARUC is considering undertaking a study to identify DSM data that should be reported in FERC statistical series. These steps should facilitate implementation of an ERCE index in the future.

Table 2. Modified Fuel Revenue Accounting (MFRA) Example

Column Definition:

1 = Monthly Consumption Distribution: Fraction of Customers
2 = Monthly Consumption Distribution: Electricity Consumption in kWh
3 = Average Monthly Sales in kWh
4 = Total Annual Revenue Received in $Million (see Notes 1 and 2)
5 = Allowable Non-Fuel Revenue in $Million (see Notes 2 and 3)
6 = Available Fuel Revenue in $Million (see Note 4)
7 = Fuel Cost in $Million (see Note 5)
8 = MFRA Credit (+) or Deficit (-) in $Million (see Note 6)
9 = Unrecovered Non-Fuel Revenue in $Million (see Note 7)

Case	1	2	3	4	5	6	7	8	9
	.10	450							
1	.80	500	500	100	70	30	30	0	0
	.10	550							
	.10	500							
2	.80	550	550	110	70	40	30.3	9.7	0
	.10	600							
	.10	400							
3	.80	450	450	90	70	20	29.7	-9.7	0
	.10	500							
	.10	350							
4	.80	450	450	90	69.1	20.9	29.7	-8.8	.9
	.10	550							
	.30	350							
5	.40	450	450	90	67.4	22.6	29.7	-7.0	2.6
	.30	550							

Note 1 - It is assumed 166,666 customers consume an average of 500 kWh per month and 600 kWh annually. Total annual consumption is 1000 Million kWh.

Note 2 - Projected Non-Fuel Revenue Requirement is assumed to be $70 Million and Fuel Cost is assumed to be $30 Million. Rate is set to 10 cents/kWh to recover Revenue Requirement of $100 Million. Average cost of fuel is 3 cents/kWh.

Note 3 - 7/8 of monthly revenue received from each customer for first 400 kWh is allocated to Allowable Non-Fuel Revenue Account.

Note 4 - Available Fuel Revenue is Column 4-Column 5.

Note 5 - Marginal cost of fuel is 4 cents/kWh if consumption differs from monthly average of 500 kWh.

Note 6 - MFRA Credit or Deficit is Column 6-Column 7. If positive, MFRA Credit is deferred and next year rate is increased to recover additional revenue. If negative, MFRA Deficit is deferred and next year rate increased to recover additional revenue.

Note 7 - Unrecovered Non-Fuel Revenue is $70 Million Target - Column 5.

In Case 1, the customer consumption distribution assumed in Columns 1 and 2 is such that average monthly consumption is equal to 500 kWh and all customers consume more than the 400 kWh threshold. As a result, the Allowable Non-Fuel Revenue is equal to the targeted value of $70 million and Available Fuel Revenue is equal to the projected Fuel Cost of $30 million. And, in this case, there is no need for any Revenue Adjustment.

Case 2 illustrates the situation where all customers consume greater than 400 kWh threshold but the average consumption of 550 kWh exceeds the projected sales for the billing period. As a consequence, the Allowable Non-Fuel Revenue is equal to the target value of $70 million but the Available Fuel Revenue of $40 million exceeds actual Fuel Costs of $30.3 million by the MFRA Credit of $9.7 million. Column 8 indicates that rates would be reduced in the following year to return this $9.7 million excess revenue to customers.

Case 3 illustrates the situation where all customers consume greater than the 400 kWh threshold but where average consumption of 450 kWh is below the projected 500 kWh average sales level used in setting rates. As a consequence, the Allowable Non-Fuel Revenue is equal to the target level of $70 million but Available Fuel Revenue of $20 million is less than the actual Fuel Costs of $29.7 million. Rates would increased in the next year to collect an additional $9.7 million to cover this MFRA Deficit.

Case 4 illustrates the situation where some customers (10%) consume less than the 400 kWh threshold and where average consumption is below the projected 500 kWh sales level. In this case, the Allowable Non-Fuel Revenue Requirement is below the $70 million target by $0.9 million. And, the Available Fuel Revenue of $20.9 million is less than the actual Fuel Costs of $29.7 million by $8.8 million. Rates would be increased in the next year to collect additional $8.8 million to cover this MFRA Deficit. But, the utility would not be allowed to recover the $0.9 million deficit. However, this MFRA partial decoupling scheme would presumably also include a DSM and other profitability incentives as described previously.

In practice, it would be desirable to implement MFRA so that it exhibits the other desirable properties of ERAM. This would require that the Allowable Non-Fuel Revenue Target to be adjusted in a manner similar to the ERAM Non-Fuel Revenue Requirement to reflect conditions which are outside the utility's control. For example, changes in allowable distribution investment costs based on the actual number of new customers connected and allowable operating expense categories which are based on actual kWhs sold could be included. And, the Allowable Non-Fuel Revenue Target could be varied on a billing period by billing period basis. If this were done, then MFRA would essentially have the attributes of ERAM with the added incentive to be concerned about customer consumption.

COUPLING PROFITABILITY TO PERFORMANCE

The ERAM and MFRA mechanisms can be used to couple profitability to performance by adjusting the Allowable Revenue Requirement to achieve a targeted level of Net Income which would reward the utility for good performance or penalize it for poor performance. ERAM and MFRA inherently include an incentive to reduce operating costs and the three year rate cycle used in California enables the utility to capture the benefits of a cost reduction program. Any additional increases in the allowable return on equity based on performance should be adjusted to be compatible with this implicit cost reduction incentive.

If feasible, it would be desirable to directly link the supply/demand side neutral indicator of utility performance in accomplishing least cost planning and customer service goals. David Moskovitz recommended that the incentives to reduce operating costs inherent in ERAM be supplemented by the following additional components: (1) a global performance index based on analysis of customer bills and/or other available utility data (Moskovitz 1988); (2) an index which would reward utilities for providing reliable service and meeting other customer service needs which could not be readily measured in monetary terms; and (3) other components which also cannot be measured in monetary terms but which for policy or other reasons may have special

Current Status of Performance Indices

An evaluation of the feasibility of Moskovitz's average customer bill-based indices and the Cummings' 'resource cost of electricity services' index is being conducted by Niagara Mohawk at the NYPSC's request. (NYPSC Opinion and Order 89-29 1989)

Because the feasibility of establishing a suitable global performance index has not been demonstrated, the NYDPS DSM working group recommended that the NYPSC augment the existing operating cost reduction incentives inherent in ERAM with a profitability incentive which included a DSM incentive similar to that described below and a Customer Service incentive component. The latter consists of a combination of separate reliability, customer complaint response, billing accuracy and other customer service components. (Brew 1990)

The authors also conclude that it would be desirable to include an improved fuel adjustment clause as part of the package of separate performance incentive measures. This improved FAC should, as a minimum, include an incentive to improve the efficiency of electricity production and distribution.

REQUIREMENTS FOR AN EFFECTIVE DSM INCENTIVE

Promotes Acquisition of Cost Effective DSM Resources

There is an increasing recognition by public utility commissions that customer energy costs can be substantially reduced, fuel consumption and environmental reduced, and the need to construct new electricity supply facilities deferred if utilities would cooperate with customers in implementing DSM measures. The NYPSC has requested that utilities use the total resource test illustrated in Column 1 of Table 4 as the principal criteria for identifying cost-effective DSM resources. Because the avoided cost benefits exceed the costs incurred by the customer and the utility in acquiring it, this DSM resource is a potentially cost-effective option. The decision by a utility to select this DSM measure must be viewed within the broader context of other DSM resources. Given a budget constraint, the utility should select those DSM measures which have the highest benefit to cost ratios.

In this example, avoided environmental impacts from implementing the DSM measure are valued at 1.5 cents/kWh saved (expressed in $1990). This is approximately equal to the 1.4 cents per kWh estimate developed by NYDPS staff in the context of a NYPSC review of O&R's integrated resource bidding plan. (Putta 1989) The NYPSC has requested that utilities internalize environmental impact costs in analyzing the cost-effectiveness of DSM and supply side resources. A major study directed at quantifying environmental impacts is in the planning stages.

Bases DSM Incentives on Actual Impacts

The NYDPS DSM working group agreed that it is important to base any DSM incentives on the best feasible measures of actual program performance. Because methodologies for DSM performance measurement are still being developed and because utility resources to implement rigorous program evaluation differ, the working group recognized that it may be necessary to rely on engineering estimates during a transition period. The NYDPS and the NYPSC have taken steps to improve the quality of DSM program evaluations conducted by New York utilities. These include: (1) establishing a NYDPS evaluation unit; (2) requiring that each utility establish a program evaluation unit; (3) requiring that utilities file program evaluation plans and budgets for each DSM program in a standardized format prescribed by the NYDPS evaluation unit; (4) initiating a cooperative project with NYSERDA to develop and implement a uniform statewide methodology for evaluating commercial and industrial DSM programs; and (5) establishing a statewide Evaluation Task Force to conduct evaluation research of Statewide significance.

The NYDPS DSM working group also examined other alternative approaches for measuring DSM impacts which might be more accurate or less expensive to implement than this indepth program evaluation. One of these alternatives is the "internal

MAKING CONSERVATION PROFITABLE: AN ASSESSMENT OF ALTERNATIVE DEMAND SIDE MANAGEMENT INCENTIVES[1]

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In July of 1988, the New York Public Service Commission (NYPSC) asked utilities to submit innovative ratemaking proposals which would remove current disincentives and provide a positive incentive for effective implementation of demand side management (DSM) programs. The authors participated as members of a New York Department of Public Service (NYDPS) DSM working group which analyzed utility proposals and ratemaking mechanisms, including those being considered by the National Association of Regulatory Utility Commissioners (NARUC). David Moskovitz provided consulting assistance to the working group and participated in many of the working group meetings. The working group recommended interim adoption of incentive ratemaking methods and identified key incentive ratemaking issues which should be examined over the longer term.

This paper discusses the authors' analyses of DSM incentive options with emphasis on the following issues: (1) removing DSM disincentives; (2) assessing utility performance in acquiring cost-effective DSM and supply side resources which reduce customer energy costs; and (3) coupling utility profitability to performance. The status of the NYPSC's efforts to adopt incentive ratemaking mechanisms is also summarized.

The authors conclude that the traditional ratemaking process used by New York utilities provides significant disincentives to implement DSM and significant incentives to market electricity use as a means of enhancing profitability. The Electric Rate Adjustment Mechanism (ERAM) used by the California Public Utilities Commission eliminates both problems and has other desirable properties, including incentives to reduce electricity supply costs. The Fuel Revenue Accounting (MFRA) method used by Central Maine Power can be modified to have most of ERAM's advantages with the added benefit of providing limited coupling of profitability to customers electricity use.

The authors also conclude that a DSM incentive based on a sharing of the net resource savings provides an effective motivational basis for rewarding utilities for their implementation of DSM programs. This DSM incentive should be integrated with a set of complementary incentive mechanisms which reward utilities for performance in reducing the costs of meeting customer end-use energy needs.

[1] *The perspective on DSM incentives and other incentive ratemaking issues described in this paper represents the authors and should not be interpreted as the official position of the NYPSC, the NYDPS DSM working group, NYDPS, and the Energy Research and Development Authority (NYSERDA).*

Attachment 8B

A conceptually appealing alternative to separate performance measures would be to develop global measures of utility performance which inherently capture and give appropriate weight to these separate performance factors, but in a self-consistent manner. The Effective Resource Cost of Electricity (ERCE) index developed by one of the authors appears to have many desirable attributes for assessing utility performance.

BACKGROUND

A study of the DSM potential in New York indicates that electricity consumption could be reduced by 22,000 GWh (22%) annually and peak demand reduced by 6000 MW (29%) (Geller 1989) if utilities would collaborate with their customers in implementing cost-effective energy efficiency and demand management techniques. Significant customer energy cost savings, reductions in power plant emissions and deferral of the need to construct new electricity supply and distribution facilities would be obtained if these DSM resources could be acquired.

The traditional ratemaking process results in the establishment of electric rates to recover both operating costs and the required return on invested capital. Electricity consumption that occurs when marginal revenue exceed marginal fuel and other operating costs directly contributes to utility profits. Since this net revenue can be several cents per kWh, there is a strong economic incentive for utilities to encourage electricity sales during such time periods. The New York utilities were concerned that the lost net revenue from customer adoption of more efficient end-use measures would decrease profitability[2]. Consequently, they expressed a reluctance to implement extensive DSM programs until new rate-making mechanisms were adopted which corrected this lost revenue problem. (NYPSC Opinion and Order 89-29 1989).

The impact of an incremental reduction in electricity sales on profitability is illustrated in Column 2 of the hypothetical utility example in Table 1. A 2% reduction in sales relative to the Base Case in Column 1 of 20 million kWh results in a 3.6% reduction in Net Income. Column 3 illustrates that a 2% increase in sales increases profitability by 3.6%.

In concept, it is possible for utilities to factor customer adoption of energy efficiency into the development of sales forecasts used in establishing rates. However, the traditional ratemaking process described above provides strong incentives for utilities to use conservative estimates of anticipated sales in the rate setting process and to then promote increased customer use of electricity as a means of enhancing profitability. And, these incentives are currently not balanced by a corresponding incentives to promote customer adoption of more efficient end-use equipment.

Two alternative ratemaking mechanisms are described below—ERAM and FRA—which eliminate both the utilities' concern over the effect of lost revenues on profitability and the strong incentive to market electricity as a means for increasing profits.

In addition to eliminating lost revenues as a disincentive, the NYPSC desired to modify the rate making process to include a positive incentive for the utility acquisition of cost-effective DSM resources. If the acquisition of such DSM resources became a significant contributor to increasing profitability, then a utility would have the incentive to allocate its management attention and qualified

2 *Public utility commissions in many states (including New York) allow utilities to use some form of Fuel Adjustment Clause (FAC) to adjust rates in a manner which reconciles major differences between actual fuel costs and projected average fuel costs which are used in the rate making process. Because many DSM measures reduce actual fuel costs on the margin by an amount which is greater than projected average fuel costs, the net effect of the FAC is that utilities have a positive but relatively small incentive to implement DSM (on the order of 0.3-0.4 cents per kWh saved for New York utilities). However, this is significantly less than the net lost revenue disincentive of several cents per kWh saved.*

Table 1. Alternative Ratemaking Strategies

Case 1 - Base Case
Case 2 - Traditional Regulation: 2% Sales Decrease of 20 Million kWh
Case 3 - Traditional Regulation: 2% Sales Increase of 20 Million kWh
Case 4 - Net Lost Rev. Adjust. (NLRA); 20M kWh Sales Decrease due to DSM
Case 5 - NLRA: 20M kWh Net Sales Increase with 20M kWh DSM Program
Case 6 - Electric Rate Adjustment Mechanism (ERAM); 20 Million kWh Decrease from DSM
Case 7 - ERAM: 20M kWh Net Sales Increase with 20 Million kWh DSM Program

		1	2	3	4	5	6	7
A	Sales (Million kWh)	1000	980	1020	980	1020	980	1020
B	Price (¢/kWh) [Note 1]	10	10	10	10	10	10	10
C	Revenues ($M)	100	98	102	98	102	98	102
D	Fuel Cost ($M) [Note 2]	30	29.4	30.6	29.4	30.6	29.4	30.6
E	Rev. Adj. ($M)	0	0	0	2.2	2.2	2.2	-.6
		*****[Note 3]*****			---[Note 4]---		***[Note 5]***	
F	Non-Fuel Rev. ($M) [Note 6]	70	68.6	71.4	70.8	73.6	70.8	70.8
G	Expenses, Interest and Depreciation ($M)	30	30	30	30	30	30	30
H	Incr. DSM Cost ($M) [Note 7]	0	0	0	.8	.8	.8	.8
I	Taxable Income ($M)	40	38.6	41.4	40	42.8	40	40
J	Income Tax @ 37% ($M)	14.8	14.3	15.3	14.8	15.8	7.4	7.4
K	Net Income ($M)	25.2	24.3	26.1	25.2	27.0	25.2	25.2
L	Equity Portion of Rate Base ($M)	200	200	200	200	200	200	200
M	Equity Return (%)	12.6%	12.2%	13.0%	12.6%	13.5%	12.6%	12.6%

Note 1 - Electricity rate is set at 10 cents/kWh so that revenues will be equal to projected costs of $100 Million. All Revenues and Expenses quantities are exposed in $Million ($M).

Note 2 - Fuel Cost is assumed to be equal to average fuel cost of 3 cents per kWh times Sales. The impact of the FAC is reconciling differences between this average Fuel Cost and actual costs is not considered (see Footnote 2).

Note 3 - No Revenue Adjustment Mechanism considered in Cases 1, 2 and 3.

Note 4 - Revenue Adjustment is equal to 7 cents per kWh (i.e. Price less average fuel cost) times Lost Sales plus Cost of implementing DSM Programs (see Note 7). The total is 0.7*20+0.8=$2.2M.

Note 5 - Revenue Adjustment is set equal to the sum of Non-Fuel Revenue Requirement and Fuel Cost less Revenues.

Note 6 - Non-Fuel Revenue is Revenues minus Fuel Cost minus the Revenue Adjustment.

Note 7 - Costs of DSM efficiency measures is assumed to be 4 cents/kWh saved. Total cost is $0.8 Million.

staff to the implementation of its DSM programs. The general requirements for an effective DSM incentive are discussed below in the section on requirements for an effective DSM incentive. And, a particular DSM incentive mechanism recommended the authors which satisfies these requirements is also described.

The NYDPS DSM working group also evaluated the feasibility of integrating DSM incentives within the broader framework of coupling profitability to overall performance in reducing customer electricity service costs and facilitating least cost planning and resource acquisition. The initial results of this effort are discussed under the section on coupling profitability to performance.

ALTERNATIVE RATEMAKING STRATEGIES

Net Lost Revenue Recovery

Six New York utilities have submitted new ratemaking proposals in response to the NYPSC's request. The mechanism initially proposed by each utility for removing lost revenues as the principal DSM disincentive[3] was an automatic annual adjustment in rates to yield additional revenue to offset the following two DSM impacts: (1) recovery of DSM program costs expended in the prior year (in excess of levels forecasted in last rate case) and (2) the estimated net lost revenue (i.e., the projected lost revenues less operating cost savings) which would result from each customer's participation in a DSM program during the previous year.

As illustrated in Column 4 of Table 1, this net lost revenue estimation would conceptually remove the utilities' concern about the adverse impact of DSM on profitability. If the 20 million kWh reduction in sales were caused by the installation of DSM measures, the projected net lost revenue is $1.4 million, i.e., the 10 cents/kWh price less the 3 cents/kWh average marginal cost times 20 million kWh. And, the incremental program cost is assumed to be $0.8 million, i.e., 4 cents per kWh saved times 20 million kWh. Consequently, rates would be increased next year to recover additional revenue of $2.2 million. The net effect would be to yield the same net income as in the Base Case (Column 1).

However, the NYDPS DSM working group was concerned that this Net Lost Revenue Recovery mechanism did not eliminate a potential incentive for the utility to promote increased customer use of electricity as a means of increasing profitability. This situation is illustrated in Column 5 of Table 1. It is assumed that DSM investments reduce consumption by 2% (or 20 million kWh) but that electricity sales increase by 40 million kWh (a 4% increase), resulting in a net 20 million kWh or 2% increase in sales. In this case, Net Income is increased by the combined effect of increased sales and the Net Lost Revenue Recovery mechanism.

The NYDPS DSM working group examined a number of alternative ratemaking mechanisms which would: (1) remove the DSM incentive as well as significantly reduce or eliminate the incentive to market electricity sales as a means for increasing profitability; and (2) provide positive incentives for implementing DSM. This included mechanisms being considered by the NARUC Conservation Committee (Moskovitz 1989) and other promising approaches presented in the utility regulatory and economics literature. Emphasis is given in the subsequent discussion to what the authors consider to be the most promising approaches.

Electric Rate Adjustment Mechanism (ERAM)

In 1981, the California Public Utility Commission (CPUC) adopted ERAM as the basis for the rate making process. (Ziering 1986) ERAM eliminates the lost revenue disincentive for a utility to implement DSM and decouples profitability from the amount of electricity sales. As illustrated in column 6 of Table 1, ERAM adjusts allowable revenue to achieve a "target" Non-Fuel Revenue

3 *Because the then prevailing NYPSC accounting practice deferred recovery of DSM program costs (which were not included in base rates) until the next rate case, several New York utilities were concerned the NYPSC's desire to significantly increase DSM expenditures would subject their DSM expenditures to prudency disallowances uncertainty. However, the NYPSC has subsequently revised accounting treatment of DSM program expenditures including amortizing them in a manner similar to supply side investments, including forecasts in base rates, and deferring only variations between forecasted and actual expenditures.*

Requirement, which is equal to $70.8 million in this example. This includes an additional $0.8 million in DSM Costs which were not include in the Base Case projections. The Non-Fuel Revenue obtained from existing rates is the $98 million in total Revenues less the $29.4 million in Fuel Costs, or $68.6 million. (Although we conceptually attribute the reduced sales of 20 million kWh to DSM in this example, this reduction in sales could be due to weather, downturn in the local economy, general consumer conservation, etc.) Rates during the next year would be automatically adjusted under ERAM to collect additional revenue equal to Revenue Adjustment of $2.2 million.

Column 7 of Table 1 illustrates how ERAM removes the incentive for utilities to market electricity to enhance profitability. Because of increased sales of 20 million kWh, Non-Fuel Revenue from existing rates is the $102 million in total Revenues less the $30.6 million in Fuel Costs, or $71.4 million. Rates during the next year would be reduced to give back the $0.6 million balance in the Revenue Adjustment account.

ERAM has the following additional advantages: (1) it protects utilities from adverse impacts on profitability from conditions which are outside of its control (such as lower sales because of weather, increased distribution costs because of greater than anticipated growth in number of customers, etc.); (2) it focuses regulatory agency and utility concern on the costs of providing electricity service and provides incentives for utilities to control costs below projected levels as a means of increasing profits; (3) it lowers next year's rates if additional revenues are collected because of increased sales (due to weather, an economic upturn, and other effects); and (4) as compared with the Net Lost Revenue Recovery mechanism, it eliminates the adverse impacts on the utility or its ratepayers of errors in estimating net lost revenues[4].

[4] *Analysis by the authors has shown that errors in estimating lost revenues from DSM programs can significantly effect the program benefits retained by ratepayers. This is another major reason to prefer a decoupling mechanism to administered lost revenue recoveries. Errors in estimating the shared resource savings DSM discussed in Section 4.6 have a much smaller impact on retained ratepayer benefits.*

Several New York utilities and intervenors expressed opposition to the adoption of ERAM. (NYPSC Opinion and Order 89-29 1989) One of the principal concerns was the increased risk of "buypass". Since ERAM would automatically adjust rates so that it would receive a targeted amount of Non-Fuel Revenue Requirement independent of the level of customer consumption, there was concern that the utility did not have an incentive to inform those customers considering on-site generation about energy efficiency and other alternatives which might be more cost-effective. And, any significant ERAM deficit resulting from bypass decisions would automatically raise rates in the following year and further aggravate this buypass problem.

Another potential disadvantage of ERAM is that it does not provide any positive incentive for utility implementation of cost-effective DSM programs. However, in concept, this could be readily corrected by including a separate profitability incentive for DSM or developing a global performance index which implicitly accomplishes the DSM goals outlined below in the section on effective DSM incentives.

The retention of ERAM by the CPUC was the subject of a proceeding that was initiated in 1986. (Ziering 1986) Following this extensive review (including consideration of concerns similar to those identified by New York utilities and intervenors), the CPUC decided to retain ERAM. However, the CPUC also concluded that ERAM did not include adequate incentives for utilities to implement cost-effective DSM and initiated a collaborative process to identify and implement DSM incentive mechanisms on a pilot basis. (California Collaborative Process 1990)

Following review of the NYDPS DSM working group recommendations and comments received from New York utilities and other interested parties, the NYPSC requested that Orange and Rockland Utilities (O&R) submit a ERAM-type revenue decoupling proposal as part of an upcoming rate case and established a generic proceeding to examine issues of concern to O&R and other New York utilities (NYPSC Opinion and Order 89-29

1989) However, in order to avoid further delays in implementing aggressive DSM programs while this proceeding was conducted, the NYPSC approved the use of the estimated Net Lost Revenue Recovery approach discussed above by O&R and Niagara Mohawk on an interim basis. (The NYPSC has also adopted interim DSM incentive ratemaking mechanisms for 4 other New York electric utilities which include estimated Net Lost Revenue Recovery and a DSM incentive.)

Following review of the Revenue Decoupling Mechanism proposal submitted by O&R, the NYDPS DSM working group recommended that the NYPSC adopt a modified version, including provisions which would couple profitability to O&R's performance in acquiring cost-effective DSM resources and meeting customer service needs as described briefly below. (Brew 1990)

Fuel Revenue Accounting (FRA)

The NYDPS DSM working group sought to identify other potential mechanisms for reducing the coupling between profitability and sales in a manner that would overcome the first disadvantages of ERAM highlighted above. David Moskovitz suggested that the working group consider adaptations of the Fuel Revenue Accounting (FRA) implemented by Central Maine Power (CMP) in 1988. (Dumais 1990)

FRA was developed by CMP to eliminate a potential problem inherent in the design of most time-of-day (TOD) rates which provide utilities with an incentive to encourage customer electricity use during the on-peak period. This incentive results from the higher contribution to Non-Fuel Revenue which is often derived from on-peak consumption as compared to off-peak electricity use. (Moskovitz 1988) With FRA, CMP reduced the Non-Fuel Revenue contribution during the on-peak period and increased the contribution during the off-peak period. The remaining revenue resulting from the difference between the electricity price in each period and the contribution to Non-Fuel Revenue for each customer was allocated to the Fuel Revenue Account. Any positive difference between actual fuel costs and the Fuel Revenue Account is returned to customers and any negative difference is recovered from customers through an automatic adjustment in rates in a manner similar to ERAM.

The following describes a adaptation of the FRA approach developed by the first author, subsequently referred as Modified Fuel Revenue Accounting (MFRA), which allocates revenues to the Non-Fuel Revenue and Fuel Revenue accounts based on the aggregate level of customer consumption during the billing period. This allocation process is designed so that total revenues from electricity sales will be reduced if a customer's electricity use falls below a specified threshold. Any differences between actual fuel costs and the Fuel Revenue Account would be reconciled in a manner similar to the FRA method summarized above. However, any shortfall in total revenues with MFRA might be offset by DSM and other incentive mechanisms such as described in the sections that follow.

This MFRA decoupling mechanism is illustrated in Table 2 for a hypothetical flat-rate example, although the basic approach could be applied to TOD rates in a manner similar to FRA. This example assumes: (1) a rate of 10 cents/kWh is established to recover a projected Non-Fuel Revenue Requirement of $70 million and a projected Fuel Cost of $30 million; (2) the average consumption for a particular billing period is 500 kWh; (3) the MFRA revenue allocation process for this particular month is set up so that a specified percentage, in this case 87.5%, of the revenue associated with the first 400 kWh is allocated to an Allowable Non-Fuel Revenue account; this percentage allocation will ensure that the Allowable Non-Fuel Revenues will yield the $70 million target if all customers consume more than 400 kWh; if consumption falls below 400 kWh for any customer, there will be a shortfall in the Non-Fuel Revenue Account; and (5) the remaining 12.5% of the revenue associated with the first 400 kWh and 100% of the revenue associated with consumption in excess of 400 kWh is allocated to a second account, referred to as the Available Fuel Revenue Account. Table 2 illustrates how revenues are allocated to these various accounts depending on the distribution of consumption by the customer class. For convenience purposes, it is assumed in Table 2 that monthly consumption is the same for each month.

Table 2. Modified Fuel Revenue Accounting (MFRA) Example

Column Definition:
1 = Monthly Consumption Distribution: Fraction of Customers
2 = Monthly Consumption Distribution: Electricity Consumption in kWh
3 = Average Monthly Sales in kWh
4 = Total Annual Revenue Received in $Million (see Notes 1 and 2)
5 = Allowable Non-Fuel Revenue in $Million (see Notes 2 and 3)
6 = Available Fuel Revenue in $Million (see Note 4)
7 = Fuel Cost in $Million (see Note 5)
8 = MFRA Credit (+) or Deficit (-) in $Million (see Note 6)
9 = Unrecovered Non-Fuel Revenue in $Million (see Note 7)

Case	1	2	3	4	5	6	7	8	9
1	.10 .80 .10	450 500 550	500	100	70	30	30	0	0
2	.10 .80 .10	500 550 600	550	110	70	40	30.3	9.7	0
3	.10 .80 .10	400 450 500	450	90	70	20	29.7	-9.7	0
4	.10 .80 .10	350 450 550	450	90	69.1	20.9	29.7	-8.8	.9
5	.30 .40 .30	350 450 550	450	90	67.4	22.6	29.7	-7.0	2.6

Note 1 - It is assumed 166,666 customers consume an average of 500 kWh per month and 600 kWh annually. Total annual consumption is 1000 Million kWh.

Note 2 - Projected Non-Fuel Revenue Requirement is assumed to be $70 Million and Fuel Cost is assumed to be $30 Million. Rate is set to 10 cents/kWh to recover Revenue Requirement of $100 Million. Average cost of fuel is 3 cents/kWh.

Note 3 - 7/8 of monthly revenue received from each customer for first 400 kWh is allocated to Allowable Non-Fuel Revenue Account.

Note 4 - Available Fuel Revenue is Column 4-Column 5.

Note 5 - Marginal cost of fuel is 4 cents/kWh if consumption differs from monthly average of 500 kWh.

Note 6 - MFRA Credit or Deficit is Column 6-Column 7. If positive, MFRA Credit is deferred and next year rate is increased to recover additional revenue. If negative, MFRA Deficit is deferred and next year rate increased to recover additional revenue.

Note 7 - Unrecovered Non-Fuel Revenue is $70 Million Target - Column 5.

In Case 1, the customer consumption distribution assumed in Columns 1 and 2 is such that average monthly consumption is equal to 500 kWh and all customers consume more than the 400 kWh threshold. As a result, the Allowable Non-Fuel Revenue is equal to the targeted value of $70 million and Available Fuel Revenue is equal to the projected Fuel Cost of $30 million. And, in this case, there is no need for any Revenue Adjustment.

Case 2 illustrates the situation where all customers consume greater than 400 kWh threshold but the average consumption of 550 kWh exceeds the projected sales for the billing period. As a consequence, the Allowable Non-Fuel Revenue is equal to the target value of $70 million but the Available Fuel Revenue of $40 million exceeds actual Fuel Costs of $30.3 million by the MFRA Credit of $9.7 million. Column 8 indicates that rates would be reduced in the following year to return this $9.7 million excess revenue to customers.

Case 3 illustrates the situation where all customers consume greater than the 400 kWh threshold but where average consumption of 450 kWh is below the projected 500 kWh average sales level used in setting rates. As a consequence, the Allowable Non-Fuel Revenue is equal to the target level of $70 million but Available Fuel Revenue of $20 million is less than the actual Fuel Costs of $29.7 million. Rates would increased in the next year to collect an additional $9.7 million to cover this MFRA Deficit.

Case 4 illustrates the situation where some customers (10%) consume less than the 400 kWh threshold and where average consumption is below the projected 500 kWh sales level. In this case, the Allowable Non-Fuel Revenue Requirement is below the $70 million target by $0.9 million. And, the Available Fuel Revenue of $20.9 million is less than the actual Fuel Costs of $29.7 million by $8.8 million. Rates would be increased in the next year to collect additional $8.8 million to cover this MFRA Deficit. But, the utility would not be allowed to recover the $0.9 million deficit. However, this MFRA partial decoupling scheme would presumably also include a DSM and other profitability incentives as described previously.

In practice, it would be desirable to implement MFRA so that it exhibits the other desirable properties of ERAM. This would require that the Allowable Non-Fuel Revenue Target to be adjusted in a manner similar to the ERAM Non-Fuel Revenue Requirement to reflect conditions which are outside the utility's control. For example, changes in allowable distribution investment costs based on the actual number of new customers connected and allowable operating expense categories which are based on actual kWhs sold could be included. And, the Allowable Non-Fuel Revenue Target could be varied on a billing period by billing period basis. If this were done, then MFRA would essentially have the attributes of ERAM with the added incentive to be concerned about customer consumption.

COUPLING PROFITABILITY TO PERFORMANCE

The ERAM and MFRA mechanisms can be used to couple profitability to performance by adjusting the Allowable Revenue Requirement to achieve a targeted level of Net Income which would reward the utility for good performance or penalize it for poor performance. ERAM and MFRA inherently include an incentive to reduce operating costs and the three year rate cycle used in California enables the utility to capture the benefits of a cost reduction program. Any additional increases in the allowable return on equity based on performance should be adjusted to be compatible with this implicit cost reduction incentive.

If feasible, it would be desirable to directly link the supply/demand side neutral indicator of utility performance in accomplishing least cost planning and customer service goals. David Moskovitz recommended that the incentives to reduce operating costs inherent in ERAM be supplemented by the following additional components: (1) a global performance index based on analysis of customer bills and/or other available utility data (Moskovitz 1988); (2) an index which would reward utilities for providing reliable service and meeting other customer service needs which could not be readily measured in monetary terms; and (3) other components which also cannot be measured in monetary terms but which for policy or other reasons may have special significance. The following two global performance index methods were considered by the NYDPS DSM working group.

Index Based on Average Customer Bills

The following is a summary description of the average customer bill method (Moskovitz 1988). A group of utilities (index group) having characteristics similar to a regulated utility (A) would be selected. In year 1, the average customer bill for the index group would be calculated and compared to the average bill for customers of utility A. In year 2, the index would be recalculated and utility A would be rewarded if the average bill of its customers had declined relative to the average bills of customers served by the index group. Conversely, a relative increase in average bills would be penalized.

Index Based on Total Resources Test

One of the authors (Cummings 1988) has proposed an alternative index based on the total resources test which is intended to provide incentives for implementing least cost planning. An overall performance indicator of the "effective resource cost of electricity" (ERCE) would be established. This indicator would be defined as the sum of: (1) supply side costs; (2) demand side costs; and (3) environmental externality costs; divided by the sum of: (1) kWh actually generated by the utility; and (2) "virtual kWhs" of end use energy services resulting from the utility's DSM programs. Supply side costs would include current fixed and variable revenue requirements as well as estimates of the present value of future capacity additions required by current sales forecasts. Similarly, some demand side costs would be deferred or amortized to reflect the impact of current DSM expenditures on future capacity requirements. "Virtual kilowatts" would be measured using valid and comparable program evaluation methodologies.

As in the case of the Bill Index, the relative change over time in Utility A's performance on the global indicator would be compared to the performance of an index group of utilities. It is possible that the index could be administered as an economically efficient zero-sum game which would require utilities to compete for profits (and losses) awarded by a PUC based on index results (Cummings 1984). Table 3 illustrates and compares the operation of the two indicators. For simplicity of exposition, the index groups have been omitted from the analysis. A single utility's year 2 performance for four different situations is compared with a year 1 base case. In the base case the hypothetical utility sells 1000 MWh at a price of $.08/kWh. Short run marginal fuel costs of 5 cents/kWh, long-run marginal supply costs of 6 cents/kWh, DSM costs of 3 cents/kWh saved and environmental costs of 1.4 cents per kWh generated are assumed. Customer bills average $80 and the "effective resource cost of electricity" is $.094/kWh.

As shown on line M average bills are lowest ($79), and the utility would be awarded the highest incentive if the utility's sales decline by 20 MWh and the company conducts no DSM programs (Case 1). Average bills are highest ($81) if sales increased and the utility conducts no DSM program (case 2). But the combination of lower sales and an exceptionally vigorous DSM program (case 4) also results in higher average bills ($80.20) than the base case. This analysis raises concern that, in some circumstances, an average bill index might reward utilities for declining sales due to weather, economic conditions or utility efforts to restrict supply, but fail to reward the utility for aggressive DSM programs.

Line P shows the operation of the ERCE (effective cost of electricity) index. The resource cost of energy services (9.4 cents per kWh equivalent in the base case) decreases as low cost DSM kWhs replaces high marginal cost supply side kWhs, and reaches a minimum (9.2 cents) in case 4. In case 4, as a result of decreased sales more than outweighed by "virtual kWhs" from DSM efficiency improvements, customers have the maximum amount of energy services available at the minimum average resource cost.

The ERCE is demand and supply side neutral and could reward utilities for increased sales but only if the sum of short and long run marginal and environmental externalities is less than average supply and average demand side costs. Similarly, the ERCE index will reward utilities for demand side investments if short and long run marginal demand side

Table 3. Comparison of Average Bill Index and Effective Resource Cost of Electricity Index

Column Definition:
0 = Base Case: 1000 MWh Sales with no DSM
1 = Case 1: 20 MWh Sales Decrease with no DSM
2 = Case 2: 20 MWh Sales Increase with no DSM
3 = Case 3: 20 MWh Sales Decrease with 20 MWh of DSM
4 = Case 4: 20 MWh Sales Decrease with 40 MWh of DSM

	$/kWh	0	1	2	3	4
A MWh Supply Side		1,000	980	1,020	980	980
B MWh Demand Side		0	0	0	20,000	40,000
C MWh Total Services		1,000	980	1,020	1,000	1,020
D # of Customers		1,000	1,000	1,000	1,000	1,000
Revenue Requirement ($)						
E Base Revenues	0.08	80,000	80,000	80,000	80,000	80,000
F Marginal Cost	0.05	0	-1,000	1,000	-1,000	-1,000
G SupplySide Revenues		80,000	79,000	81,000	79,000	79,000
H Demand Side Costs	0.03	0	0	0	600	1,200
I Total Revenue Req.		80,000	79,000	81,000	79,600	80,200
Other Resource Costs ($)						
J Environmental External.	.014	14,000	13,720	14,280	13,720	13,720
K Long Run Marginal Cost	0.06	0	-1,200	1,200	-1,200	-1,200
L Total Resource Cost		94,000	91,520	96,480	92,120	92,720
Performance Measures						
M Average Bill ($)		80.00	79.00	81.00	79.60	80.20
(Rank)			(1)	(4)	(2)	(3)
N $/kWh (supply only)		0.0800	0.0806	0.0794	0.0812	0.0818
(Rank)			(2)	(1)	(3)	(4)
O ERCE ($/kWh w/o EE)		0.0800	0.0794	0.0806	0.0784	0.0775
(Rank)			(3)	(4)	(2)	(1)
P ERCE ($/kWh w/EE)		0.0940	0.0934	0.0946	0.0927	0.0921
(Rank)			(3)	(4)	(2)	(1)

costs are less than average supply side costs and average demand side costs. Although not illustrated, the ERCE index would also reward utilities for cost effective reductions in emissions from power plants.

The primary short term obstacle to implementing the ERCE index is the difficulty of obtaining consistently measured DSM and environmental data from utilities in an index group. Measurement of "Virtual kilowatt hours", a critical variable in the index, would require that all utilities use comparable "state of the art" program evaluation methodologies for estimating program impacts. NYSERDA and the NYPSC have undertaken studies to develop model DSM Program Evaluation Protocols and methods for quantifying the environmental externalities of power generation and transmission. NARUC is considering undertaking a study to identify DSM data that should be reported in FERC statistical series. These steps should facilitate implementation of an ERCE index in the future.

Current Status of Performance Indices

An evaluation of the feasibility of Moskovitz's average customer bill-based indices and the Cummings' "resource cost of electricity services" index is being conducted by Niagara Mohawk at the NYPSC's request. (NYPSC Opinion and Order 89-29 1989)

Because the feasibility of establishing a suitable global performance index has not been demonstrated, the NYDPS DSM working group recommended that the NYPSC augment the existing operating cost reduction incentives inherent in ERAM with a profitability incentive which included a DSM incentive similar to that described below and a Customer Service incentive component. The latter consists of a combination of separate reliability, customer complaint response, billing accuracy and other customer service components. (Brew 1990)

The authors also conclude that it would be desirable to include an improved fuel adjustment clause as part of the package of separate performance incentive measures. This improved FAC should, as a minimum, include an incentive to improve the efficiency of electricity production and distribution.

REQUIREMENTS FOR AN EFFECTIVE DSM INCENTIVE

Promotes Acquisition of Cost Effective DSM Resources

There is an increasing recognition by public utility commissions that customer energy costs can be substantially reduced, fuel consumption and environmental reduced, and the need to construct new electricity supply facilities deferred if utilities would cooperate with customers in implementing DSM measures. The NYPSC has requested that utilities use the total resource test illustrated in Column 1 of Table 4 as the principal criteria for identifying cost-effective DSM resources. Because the avoided cost benefits exceed the costs incurred by the customer and the utility in acquiring it, this DSM resource is a potentially cost-effective option. The decision by a utility to select this DSM measure must be viewed within the broader context of other DSM resources. Given a budget constraint, the utility should select those DSM measures which have the highest benefit to cost ratios.

In this example, avoided environmental impacts from implementing the DSM measure are valued at 1.5 cents/kWh saved (expressed in $1990). This is approximately equal to the 1.4 cents per kWh estimate developed by NYDPS staff in the context of a NYPSC review of O&R's integrated resource bidding plan. (Putta 1989) The NYPSC has requested that utilities internalize environmental impact costs in analyzing the cost-effectiveness of DSM and supply side resources. A major study directed at quantifying environmental impacts is in the planning stages.

Bases DSM Incentives on Actual Impacts

The NYDPS DSM working group agreed that it is important to base any DSM incentives on the best feasible measures of actual program performance. Because methodologies for DSM performance measurement are still being developed and because utility resources to implement rigorous program evaluation differ, the working group recognized that it may be necessary to rely on engineering estimates during a transition period. The NYDPS and the NYPSC have taken steps to improve the quality of DSM program evaluations conducted by New York utilities. These include: (1) establishing a NYDPS evaluation unit; (2) requiring that each utility establish a program evaluation unit; (3) requiring that utilities file program evaluation plans and budgets for each DSM program in a standardized format prescribed by the NYDPS evaluation unit; (4) initiating a cooperative project with NYSERDA to develop and implement a uniform statewide methodology for evaluating commercial and industrial DSM programs; and (5) establishing a statewide Evaluation Task Force to conduct evaluation research of Statewide significance.

The NYDPS DSM working group also examined other alternative approaches for measuring DSM impacts which might be more accurate or less expensive to implement than this indepth program evaluation. One of these alternatives is the "internal

Table 4. Illustration of DSM Incentive Requirements

Column Definition:
1 = Resource Test
2 = Recommended Strategy: Rate Impact Test
3 = Recommended Strategy: Participant Test
4 = Recommended Strategy: Consumer Economics (see Note 4)
5 = Utility Acquisition: Rate Impact Test
6 = Utility Acquisition: Consumer Economics (see Note 4)

	1	2	3	4	5	6
Benefit Components						
Avoided Capacity [Note 1]	1400	1400	N/A	N/A	1400	N/A
Avoided Energy	1450	1450	N/A	N/A	1450	N/A
Avoided Environmental Impacts @1.5 C/kWh in $1990	410	410	N/A	N/A	410	N/A
Utility Bill Savings	N/A	N/A	1785	1125	N/A	1125
Incentives Received	N/A	N/A	390	260	N/A	0
Equipment Depreciation	N/A	N/A	N/A	180	N/A	0
Total Benefits	3260	3260	2175	1565	3260	1125
Cost Components						
Installed Cost	1250	0	1250	1250	1250	0
Acquisition Costs [Note 2]	250		250	250	250	
Equip. O&M Costs [Note 3]	152	0	152	65	0	65
Program Marketing & Admin. [Note 3]	125	125	N/A	N/A	125	N/A
Program Evaluation	63	63	N/A	N/A	63	N/A
Incentives Paid	N/A	390	N/A	N/A	0	N/A
Lost Revenues	N/A	1785	N/A	N/A	1785	N/A
Total Costs	1839	2363	1652	1565	3473	65
Net Benefit	1421	898	523	0	-213	1060

Note 1 - The DSM measure is assumed to reduce end-use electricity demand by 1 kW and electricity use by 2300 kWh per year over a [illegible] year period. Avoided cost and marginal C&I customer revenue impacts were obtained from Con Edison's Demand Side Management filed in September of 1989. The assumed inflation rate is 4.5% and the utility discount rate is 10%.

Note 2 - Annual incremental O&M costs are assumed to be 2% of installed cost.

Note 3 - Program marketing and administration costs are assumed to be 10% of installed cost. Program evaluation costs are assumed to have a present value of 5% of installed cost.

Note 4 - Customer is assumed to have an after-tax discount rate of 25% and a marginal income tax rate of 34%. Because of income tax effects, the Customer effectively receives only 2/3 of the benefits and experiences only 2/3 of the operating cost.

bill index" concept recommended by David Moskovitz. This concept is based on comparing the average bills of a customer class, including those who participated in DSM programs, to the average bills of a representative control group of customers who had not participated in DSM programs. Control group members who chose to participate in DSM programs would be dropped from the control group. The control group would be dissolved and reconstituted every year or two. In concept, the difference in average bills would be a measure of the bill savings resulting from participation in DSM programs. However, if customers who drop out of the control group to participate in DSM programs have different pre-participation energy consumption than the customers who remain in the control group, self selection bias may obscure the actual impacts of DSM programs. Periodic selection of a new control group may make result in underestimation of savings from DSM measures with long useful lives. The NYPSC requested that Niagara Mohawk evaluate the feasibility of this concept. (NYPSC Opinion and Order 89-29 1989)

Evaluates Consumer Requirements for Participation in DSM Programs

In order to encourage a customer to adopt a DSM measure, the utility must inform the customer about its potential benefits and make a convincing argument that sufficient value can be derived from adopting the DSM measure to offset the DSM measure acquisition, equipment and installation costs, incremental O&M and other costs. As illustrated in Column 4 of Table 4, the principal value to a customer from adopting the technology are the Utility Bill Savings, any Financial Incentive paid by the utility, and, if the case of a Commercial and Industrial (C&I) customer, a modest Equipment Depreciation deduction from income taxes. In determining the present value of the benefits and costs in Column 4 of Table 4, it is assumed that this C&I customer has a 25% nominal and 19.5% real after-tax discount rate and a marginal income tax rate of 34%. Because of these tax considerations, a C&I customer receives only about 2/3 of the utility cost saving and incentive benefits (and 2/3 of the incremental operating costs) from adopting the DSM measure. In this example, the customer is assumed to require an upfront $390/kW incentive from the utility to adopt the DSM measure. Because of tax effects, this is equivalent to the $260/kW after-tax incentive illustrated in Column 4.

It is important to note that the required Financial Incentive is significantly different from what would be anticipated if the *idealized* Participant Test were used. The Net Benefit of $523 in the Column 3 Participant Test would lead one to conclude that the customer does not require any incentive to adopt the DSM measure. From an overall perspective, the DSM incentive should be structured so that the utility is motivated to determine what level of financial and other incentives to offer to meet real customer needs and not be limited by the Participant Test or other unrealistic criteria, which may not accurately reflect the consumer's discount rate and technical performance and risk perspective. And, if the utility is able to package the DSM program in a manner which is more acceptable to the customer (e.g., perhaps through some combination of financial incentive, equipment cost sharing, equipment performance guarantees and/or equipment leasing arrangements), then it should have the flexibility to implement such arrangements.

The DSM incentive mechanism that is adopted should encourage the utility to evaluate whether customers are interested in participating in a DSM program, how they perceive the risks of participating, and what are their financial and other requirements for participation. The data collected by a utility in the process of conducting in-depth program evaluation as described above can help in this assessment process.

Minimizing the Costs of Acquiring DSM Resources

Columns 6 and 5 of Table 4 illustrate the impact on the hypothetical C&I Customer and other Ratepayers (i.e., the Rate Impact Test), respectively, if the utility offers to install the DSM measure at no cost to the customer. A "Just say yes" DSM acquisition strategy may be appropriate for residential and small commercial customers because lack of awareness, inability to evaluate benefits and costs, uncertainty about cost saving impacts, lack of access to capital for cost sharing and other barriers may be particularly severe. However, high DSM acquisition costs may have an adverse impact of future rates. Essentially, non-participants in the same and other customer classes are subsidizing the benefits received by participants. And, this acquisition strategy ignores the significant benefits received by participants. Consequently, the utilities should be encouraged to implement DSM programs which achieve significant customer participation but also acquire the DSM resources at the lowest cost. For example, the acquisition approach illustrated in Columns 3 and 4 would be much more desirable if it could be achieved. Other ratepayers receive a net long-term benefit of approximately $900/kW and the C&I customer receives the required 25% discount rate from the transaction.

General Requirements for a DSM Incentive

Based on the above discussion, the authors conclude that a DSM incentive should have the following properties: (1) promotes utility acquisition of DSM resources which achieve the greatest resource cost savings; (2) encourages utilities to inform customers about the cost saving and other benefits of implementing the DSM measure; (3) stimulates the utility to provide adequate incentives and other financial and technical assistance in implementing the DSM measure; (4) rewards the utility if it can lower the program marketing, financial incentive and administrative costs required to induce the customers to acquire the DSM measure; and (5) encourages the utility to continuously monitor that the DSM measure is achieving avoided cost benefits for the utility and the customer.

A Recommended DSM Incentive Mechanism

The authors recommend that a desirable DSM incentive is to increase the utility's net income by a share of the long-term net benefits that accrue to all ratepayers from acquiring the DSM resources. Specifically, it is recommended that the net income incentive be a percentage (say 10%) of the difference between: (1) the present value of the avoided cost and other benefits received by ratepayers (including avoided environmental impacts) obtained from deploying and operating the DSM measure over its service life in cooperation with the customer; and (2) the present value of the program costs (marketing, financial incentives, administration, and evaluation) required by the utility to maintain the DSM Measure over its service life. Program evaluation and other statistical field performance verification techniques can be used for verifying that the avoided cost and other benefits are being received over its service life. This DSM incentive encourages the utility to maximize the avoided cost benefits and to minimize program costs, including the amount of the financial incentives that are offered.

The overall DSM incentive for the utility could be structured in several ways: (1) either as a percentage of the aggregate avoided cost benefits less the aggregate program cost; (2) or on a disaggregated program by program basis. If this latter case applies, a utility which acquires the DSM measure illustrated in Columns 1, 2 and 4 of Table 4 would receive an incentive of 10% times [$3260 -($125+$63+$390)] or $268.20/kW on each measure.

Because this DSM incentive does not internalize customer costs, it must be coupled with a least cost planning process which selects eligible DSM measures based on a total resource test, including customer costs. And, the program evaluation process should include a review of customer satisfaction with a random sample of DSM transactions.

An alternative and, in the authors view, a slightly less desirable approach is to base the DSM incentive on the percentage of the net resource cost savings which internalize the customer costs. This approach does provide the utility with an incentive to maximize avoided cost and other benefits and to minimize total costs, including program marketing, administration, and evaluation. However, this approach does not reward the utility for creativity in designing programs which minimize the magnitude of financial and other incentives that are offered to customers to adopt DSM measures. Reducing program costs can minimize rate increases and adverse impacts on non-participating customers.

Following discussions with the authors about benefits and potential problems with implementing it, O&R decided to base its DSM incentive proposal approved by the NYPSC on the first approach. And, Niagara Mohawk decided to base its DSM incentive on a percentage of the net resource savings. Both are implemented on an aggregate program basis. (NYPSC Opinion and Order 89-29 1989)

CONCLUSIONS

The traditional ratemaking process used by New York utilities provides significant disincentives to implement DSM and significant incentives to market electricity use as a means of enhancing profitability. The latter is fundamentally inconsistent with the goals of least cost planning and the acquisition of cost-effective DSM resources which can help customers reduce energy costs and reduce adverse environmental impacts.

The Electric Rate Adjustment Mechanism (ERAM) used by the California Public Utilities Commission eliminates both the DSM disincentive and power marketing incentive problems and has other desirable properties, including incentives to reduce electricity supply costs.

The Fuel Revenue Accounting (MFRA) method used by Central Maine Power can be modified to have most of ERAM's advantages with the added benefit of providing limited coupling of profitability to customers electricity consumption characteristics.

A DSM incentive based on a sharing of the net resource savings determined through in-depth program evaluation provides an effective motivational basis for rewarding utilities for their implementation of DSM programs. This DSM incentive should be integrated with a set of complementary incentive mechanisms which reward utilities for performance in reducing the costs of meeting customer end-use energy needs.

A conceptually appealing alternative to separate performance measures would be to develop global measures of utility performance which inherently capture and give appropriate weight to these separate performance factors, but in a self-consistent manner. The Effective Resource Cost of Electricity (ERCE) developed by one of the authors appears to have many desirable attributes for assessing utility performance. However, more analysis of utility cost and customer billing data is needed to determine whether the ERCE index or the customer bill-based performance index approach recommended by David Moskovitz can provide a practical basis for coupling profitability to performance.

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Attachment 8C

FINANCIAL INCENTIVES FOR DSM PROGRAMS: A REVIEW AND ANALYSIS OF THREE MECHANISMS

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Throughout the United States, the attention of electric utilities, regulators, and industry analysts has been drawn to the financial implications of electric utility demand-side management (DSM) programs. A consensus has emerged that traditional regulatory mechanisms do not reward electric utilities for pursuing "least-cost" options; moreover, implementation of DSM programs may be counter to utilities' financial interest. It is now widely believed that DSM will be unable to fulfill its potential in the absence of mechanisms to correct this imbalance.

Recently several utilities have developed proposals to create financial incentives for DSM. These proposals, some of which have been implemented after review and modification by regulatory authorities, are aimed at both offsetting the financial penalties of DSM programs and providing a "positive incentive" or reward for successful DSM implementation. While their intents are similar, specific approaches differ considerably.

This paper reviews recent efforts to provide incentives for utilities to undertake DSM. We first present our views of the need for, and appropriateness of, financial incentives. We then analyze specific incentive schemes that have been proposed (and, in two cases, adopted) for three different utilities in the Northeast. The mechanisms are analyzed for their ability to meet three objectives:

- Provide for full and timely recovery of all DSM program costs.
- Adjust for DSM-induced revenue losses.
- Counterbalance risk and loss of financial opportunity by providing a bonus, or "pure incentive," above cost.

INTRODUCTION

Throughout the United States, utilities, regulatory commissions, and intervenors are discussing the use of financial incentives to encourage balanced consideration of resource options and alignment of the profit motive with the goals of least-cost utility planning. To date, discussions on incentives have focused largely on mechanisms that would foster greater development of DSM resources. While a guiding principle of least-cost planning is that *all* resources should be given balanced consideration, the incentives debate has been concentrated on DSM because of:

- The depth of *unexploited DSM resources* that are cost-effective compared to supply-side utility resources.
- The significant *disincentives*—financial and otherwise—that surround utilities' efforts to invest in DSM.

This paper reviews recent efforts to provide incentives for utilities to undertake DSM. We first present our views of the need for, and appropriateness of, incentives. We then analyze specific incentive schemes that have been proposed (and, in two cases, adopted) for three different utilities in the Northeast.

WHY ARE DSM INCENTIVES SOUGHT?

An oft-repeated reaction to the concept of DSM incentives is, "Why give utilities an incentive to do something they should be doing anyway?" Implicit in this question is the assumption that DSM incentives represent a reward, or bonus, above and beyond the costs of doing DSM. While there is a reward component to most incentive proposals, we believe the major need for incentives is to overcome the *disincentives* inherent in traditional regulation that affect utilities' interest in, and motivation for, DSM programs. To a large degree, the disincentives are financial; that is, pursuit of DSM operates at cross purposes with utilities' financial interest, and thus imposes costs that must be compensated for. Disincentives also arise due to perceptions that DSM will increase utilities' exposure to risk. The principal disincentives are discussed below.

Failure to Recover All Program Costs

In many instances utilities' expenditures on DSM have not been recaptured in rates. This is most prevalent in states that base their ratemaking on historic test years. While growth in DSM outlays is sought by both regulators and intervenors, cost recovery in historic test year states is limited to the amount expended in a prior year. Even in states that use future test years, the problem can occur if program expenditures are greater than anticipated (for example, if participation exceeds forecasted levels).

The timing of cost recovery can create a more subtle disincentive for DSM. In many instances recovery of DSM expenditures is deferred significantly until after their incurrence, but no adjustment is made for the loss of interest (carrying charges) in the intervening period. While often not seen as a "real cost," the loss of carrying charges must be considered a cost from the standpoint of financial motivation.

Loss of Revenues

In the absence of special adjustment procedures, such as California's ERAM (Electric Revenue Adjustment Mechanism), DSM programs that reduce kilowatt-hour sales work at cross purposes with utilities' financial interests. This phenomenon is often referred to as the "lost revenues" problem. The practical effect, in many instances, is that the utility under-recovers its allowed fixed costs—costs that were authorized for collection by the regulatory commission in the prior rate case.

This problem may be mitigated somewhat by use of a forward-looking test year (which adjusts test year sales for anticipated DSM impacts) and by more frequent rate cases (which bring actual and test year sales into closer alignment). Even with such policies, however, utilities' motivation may be in the direction of less DSM (and greater sales), because every kWh not sold due to DSM reduces the contribution to fixed costs and earnings. Even if unanticipated sales growth puts the utility above its test year sales amount, every conserved kWh cuts into earnings.

Loss of Financial Opportunity

The third financial disincentive to DSM is the potential loss of opportunity for the utility to grow. Financial theory dictates that growth in a utility's size *per se* is not of intrinsic value: what matters is the rate of return on capital. But this theoretical view is not necessarily shared by utility executives and shareholders: growth in sales, rate base, earnings, and other statistics are often viewed as indicators of financial strength.

DSM works counter to a utility's growth interest in two ways. First, unless DSM expenditures are included in rate base (as is allowed in some states), choosing DSM resources over supply-side options substitutes an expense item for a capital item. In a worst-case scenario, the possible result is what might be called "the incredible shrinking utility": the utility's rate base declines due to amortization of old supply-side investments, which are not replaced (in rate base) by demand-side investments. Second, sales that are lost as the result of DSM are *permanently* lost (assuming persistence of DSM benefits). The result is that future fixed costs will be spread over a smaller sales volume, possibly leading to higher rates and possibly adverse impacts on the utility's competitive position.

Proponents of ERAM-type adjustment mechanisms claim they eliminate the incentive for utilities to increase sales. We believe this to be true only in the short-run—i.e., between rate cases. ERAM recaptures for ratepayers any over-recovery of fixed costs resulting from sales above the test-year amount. Nonetheless, a utility that increases sales will enter its next rate case with a greater sales base over which to spread fixed costs (assuming the increases are not transient). This may be desirable for competitive reasons, since it may allow lower average rates; it is doubly desirable if shareholders and managers value growth in areas other than profits (sales, rate base, number of employees, etc.) for its own sake. Therefore, even under ERAM utilities may view long-run sales growth as in their financial interest, and DSM as at odds with that interest.

Risks of DSM

In addition to the direct financial impacts described above, there are a variety of considerations that affect utilities' perceptions of the risk of DSM and therefore set up additional disincentives that must be overcome. Conservation advocates have often asserted that conservation programs are *less risky* than supply-side options for a variety of reasons: modularity (the ability to obtain DSM in small units), short lead time, lack of environmental risks, and so forth. The fact remains, however, that utilities seldom *perceive* DSM as a low-risk proposition. Several risks enter into utilities' views toward DSM:

Regulatory risk. A retrospective review of today's DSM programs may conclude they were done imprudently or were not "used and useful" and should therefore not be accorded full cost recovery. (Alternatively, regulators could extract a penalty in some other way, such as a reduction in the allowed return on equity.) This risk is heightened by the knowledge that turnover among regulators is high, and that decisions by today's regulators concerning DSM programs will not be binding on their successors.

Impact risk. Underlying the incorporation of DSM into a utility's integrated resource plan are assumptions concerning the expected energy and demand impacts, generally developed on a per-participant basis. The quality of the data used to generate impact assumptions varies greatly depending on the technologies employed and the quality of end-use data available. Further complicating impact estimation is the need to account for coincidence with system peak demand and the extent of free-ridership (the prevalence of customers whose DSM-related actions cannot be attributed to the program). The quality of information available for estimating impacts is steadily increasing, thanks to growth in DSM evaluation activities. Nonetheless, there is still some risk that actual impacts will be less than expected, which implies two further risks: (1) possible need to spend additional dollars on supply- or demand-side measures to make up the shortfall; (2) greater likelihood of adverse actions by regulators, as described above ("regulatory risk").

Market acceptance risk. Even where the technologies used in DSM programs and the expected impacts per customer are well-understood, there often remains substantial uncertainty about DSM program acceptance. Customer response to even the most prevalent types of programs (such as high-efficiency appliance rebates) cannot be predicted by today's models with adequate confidence. As with impact risk, possible outcomes of low market acceptance include the need for additional outlays to make up the difference, and greater exposure to regulatory risk.

Competitive risk. Increasingly, states are adopting the Total Resource Cost (TRC) test as the principal benefit-cost criterion for DSM program selection. A consequence of this decision rule is that utilities are being directed to implement programs that pass TRC but fail the Rate Impact Measure (RIM) test (also known as the non-participants or no-losers test). Such programs increase average rates. Therefore, even if all the direct financial risks identified above are 'cured' through incentive adjustments, utilities may still be concerned that DSM-related rate increases will be harmful in competitive markets, possibly driving away incremental customers or sales, with consequent loss of contributions to margin. This problem may be exacerbated by 'pure incentives' or bonuses, which exert additional upward pressure on rates.

Balance sheet risk. Unless DSM expenditures are given immediate recovery, they result in the creation of 'regulatory assets' or 'IOUs' that are probably less secure (from shareholders' and bondholders' perspectives) than traditional supply-side assets. Further, such assets are not bondable property, i.e., they cannot be pledged as collateral to support a debt issue. If DSM programs become sufficiently large, there is risk of an increase in the cost of capital.

ELEMENTS OF A DESIRABLE INCENTIVES APPROACH

It follows from the preceding discussion that incentive mechanisms should address each of the major areas of disincentive. Specifically, they should:

- Provide for full and timely recovery of all program costs.
- Adjust for DSM-induced revenue losses.
- Counterbalance risk and loss of financial opportunity by providing a bonus, or 'pure incentive,' *above* cost.

It is unlikely that any single regulatory change can serve all of these objectives. Thus, the challenge becomes one of crafting packages of mechanisms that are comprehensive in scope.

Given the complexities of test year definitions, fuel and purchased power adjustment clauses, statutory restrictions on the components of rate base, and so forth, it is unlikely that any one mechanism or package of mechanisms will be applicable without modifications across different states. Superior incentive proposals will be developed with state-specific regulatory practices in mind. It is also important, we believe, to tailor the approach at the utility-specific level. Different utilities may respond in different ways to the same incentive due to differences in structure, rate level, extent of competition, balance sheet characteristics, and management's perceptions.

INCENTIVE PROPOSALS: THREE VARIANTS

Orange and Rockland Utilities (O&R)

An incentive mechanism was established for O&R by the New York Public Service Commission (NY PSC) in an opinion and order issued in September 1989 (New York Public Service Commission 1989). The selected mechanism was based, in part, on an O&R proposal filed in early 1989 (Orange and Rockland 1989a). The description presented here is based on the PSC's order and O&R's compliance filing that followed the order (Orange and Rockland 1989b).

Cost Recovery. O&R will submit annually to the PSC a one-year projection of month-by-month program costs for its DSM programs. It will recover these costs through its fuel adjustment clause. All DSM costs not already accounted for in O&R's base rates, whether capital- or expense-type items, would be recovered in this manner. Monthly variances (positive or negative) in actual versus projected amounts will be tracked and will accrue interest. The cumulative variances will be added to or subtracted from the projected DSM costs for the next year.

Lost Revenues. With its projections of program costs, O&R will include an estimate of its fixed costs that will not be recovered due to DSM. The lost revenue per kWh is estimated by service class as the average rate net of fuel costs, minus an adjustment for variable operations and maintenance expenses. The projected amount will be recovered through the fuel clause. Following the 12-month period of program operation, O&R will estimate actual lost revenues based on program evaluation, and will reconcile under- or over-collections of lost revenues through the fuel clause over the next 12-month period.

Bonus. O&R originally proposed that it be given a bonus based on the level of supply-side investment that would be needed to provide the capacity needs met through DSM. O&R would estimate the cost of constructing a power plant with capacity equal to that provided by the DSM programs (using PSC-approved estimates of avoided cost). It would then estimate the return that it would have earned on such a plant, assuming it were depreciated over a ten-year period (comparable to the life assumed for DSM measures). O&R further requested that the allowed return on this "pseudo-investment" be set at 200 basis points higher than the company's ordinary return on equity. The bonus would be limited to a 1% increase in the company's overall ROE, plus 50% of any excess over that amount.

The actual bonus adopted by the PSC differs significantly from O&R's proposal. The major weakness of O&R's proposal, from the PSC's standpoint, was that the costs of the DSM programs would not figure in the incentive; thus, O&R would not have a direct incentive to control costs. For this reason, the PSC substituted a "shared savings" approach, under which O&R will be granted 20% of the "net resource savings" attributable in each year to DSM. Net resource savings for any one year are calculated as (1) the value of the energy and capacity savings attributable to DSM; plus (2) an adjustment of 1.4 cents per kWh for avoided environmental impacts; minus (3) the company's DSM program costs. For purposes of this calculation only, DSM program costs will be amortized over a ten-year period, i.e., one-tenth of the original expenditure will be subtracted from the energy, capacity, and environmental savings each year. Not included in the calculation of net savings are DSM costs borne directly by customers who participate in the programs.

The bonus will only be collected *after* actual results are available from the company's evaluation activities. Collection will occur over a one-year period through the fuel adjustment clause. The incentive will be capped at an amount equal to an additional 0.75% return on equity.

In its compliance filing, O&R projected that its 1990 DSM expenditures would total $4.3 million and yield first-year avoided-cost benefits of $658,000. Allocating one-tenth of the program costs to the first year, the net benefits would be approximately $225,000, of which O&R would capture 20%, or $45,000. Additional bonus amounts attributable to the first-year program would be collected in each of the nine succeeding years. Presumably, there would be a "cascading" effect in later years, as additional bonuses (from additional expenditures made in 1991, 1992, etc.) take effect.

Massachusetts Electric Company (Mass. Electric)

Mass. Electric, a retail subsidiary of the New England Electric System (NEES), filed an incentive proposal for its 1990 DSM programs in September 1989 (Sergel 1989). In March 1990 the Massachusetts Department of Public Utilities (DPU) adopted an incentive plan for Mass. Electric that differs significantly from the company's proposal in the way the bonus component is computed (Massachusetts Department of Public Utilities 1990). The proposal and the plan as adopted are described below.

Cost Recovery. Mass. Electric proposed to recover DSM program costs as they occur. A separate fund would be created on the company's books to track DSM costs. Revenues for the fund would be collected through an allowance in base rates. Actual DSM expenditures would be charged against the fund monthly. Any difference between the amounts collected and expended would be reconciled, with interest, at the end of the year. If actual costs differed significantly from the projected amounts, the utility could petition for interim adjustments.

The DPU's decision did not alter Mass. Electric's cost recovery scheme. The DPU noted, however, its goal of eventually requiring that cost recovery be linked to actual performance. This would be consistent with the DPU's "preapproved contract" approach for supply-side resources, which envisions that cost recovery of supply-side resources will be governed by a predetermined price per unit of capacity and/or energy output. To this end, the DPU directed Mass. Electric to include a performance-based cost-recovery mechanism when it files for approval of its 1992 DSM programs.

Lost Revenues. Mass. Electric did not request an explicit adjustment for lost revenues due to DSM. Because Mass. Electric purchases all of its power at a wholesale rate from an affiliated company, fixed costs comprise a smaller portion of its cost of service than is typical for stand-alone utilities, so lost revenue is not seen as a major problem. Mass. Electric did suggest, however, that its "maximizing incentive" (described below) would provide "a concrete reimbursement of lost revenues to the extent they exist" (Sergel 1989). The DPU's decision did not address the lost revenues issue.

Bonus. Mass. Electric proposed a two-part bonus scheme tied to estimated avoided costs. It is most readily understood by referring to the 1990 values cited in the company's filing. What Mass. Electric called the "maximizing incentive" would be set at 5% of the present value of the DSM programs (as measured by avoided costs), net of participants' costs. For its 1990 DSM programs Mass. Electric estimated a present value benefit of $97.6 million (net of customer costs), yielding the "maximizing" bonus of $4.9 million. The second part of the bonus, the "efficiency incentive," would be calculated on a shared savings basis. The projected 1990 program costs of $37.0 million would be subtracted from $92.7 million (the program value less the maximizing incentive), and the utility would be allowed to capture 10% of the result, or $5.6 million. Mass. Electric calculated that the combined bonus amount of $10.5 million (efficiency incentive plus maximizing incentive) would yield an increase of about 2% in return on equity if the DSM programs met 100% of goals.[1]

Mass. Electric proposed to collect the maximizing incentive during the program year as measures are installed, based upon predetermined estimates of per-measure impacts, lifetimes, and free-ridership that were included in its proposal. For example, Mass. Electric estimated that each compact fluorescent lamp installed in the small commercial/industrial customer segment would provide 0.045 kW demand reduction and 143 annual kWh energy reduction; 5% of the participants would be free-riders; and that the benefits would last for three years. Based on these values and its avoided costs, Mass. Electric would calculate the present value of each unit installed. As customers enter the program and compact fluorescent lamps are installed, Mass. Electric would be able to claim credit for the value of the lamps and collect 5% of this amount from the fund as the maximizing incentive.

The efficiency incentive would be collected only after the close of the program year, at which point actual program costs would be known. Mass. Electric would collect the efficiency incentive in installments over the following year.

The DPU's decision made several major alterations to Mass. Electric's bonus mechanism. The bonus amounts will be based on actual program results, rather than on predetermined per-unit impacts. The proposed total bonus level was cut in half, so that if Mass. Electric achieves 100% of its program goals, the bonus would amount to $5.25 million, or a 1% increase in the utility's ROE. A threshold of 50% of program goals was established, so that Mass. Electric must meet half of its kW and kWh goals before any bonus is earned. Once the threshold is passed, Mass. Electric will earn the bonus on a specified per-kW and per-kWh basis: $8.32 per kW-year and $.00308 per kWh. If Mass. Electric surpasses 100% of goals, it will still earn the bonus on all kW and kWh above the goals. The bonus will be collected only after the utility has submitted its report on the first program year showing actual per-unit savings, as determined by program evaluation activities. The specific mechanism for the collection of the bonus was not specified by the DPU.

Philadelphia Electric Company (PECO)

In early 1990 PECO submitted a broad outline of an incentive mechanism to the Pennsylvania Public Utility Commission in response to a Commission staff paper and questionnaire on incentives (Philadelphia Electric Company 1990). Unlike the O&R and Mass. Electric plans described above, PECO's incentive approach has not been developed to the level of a formal filing.

Cost Recovery. PECO proposes a split cost recovery approach for DSM expenditures. Expense-type items would be recovered as incurred through the fuel

[1] *Due to the structure of the holding company of which it is a part, the ROE for Mass. Electric alone may be a misleading figure. If the same incentive mechanism were adopted for all the retail companies under its parent, the system-wide increase in ROE would be 0.6%.*

adjustment clause. Actual expenditures would be reconciled with recovered amounts annually. Capital-type items would receive deferred accounting treatment, with an accrual of interest, until the next rate case, at which point they would be folded into rate base and recovered, with a return, over a specified amortization period.

Lost Revenues. PECO would seek preapproval of the expected reduction in fixed costs per program participant. It would collect these amounts through the fuel adjustment clause based upon a projected schedule of participants. At year-end, reconciliation would occur based on the actual number of participants. No retrospective changes would be made in the preapproved values of lost fixed costs per participant.

Bonus. PECO would receive a "shared savings" bonus based on the difference between the present value of the DSM programs (as measured by avoided costs) and the actual program costs. The percentage of savings to be retained by PECO was not specified. The present value of the avoided costs per participant would be preapproved by the commission. The bonus would be collected through the fuel adjustment clause during the program year. At year-end, reconciliation would occur based on the actual number of participants and actual program costs; the preapproved avoided costs would not be adjusted retrospectively.

HOW WELL DO THE PROPOSALS MEET THE OBJECTIVES?

In this section we consider how well each of the three incentive mechanisms meet the objectives outlined previously.

Full and Timely Recovery of All Program Costs

In general, each of the incentive mechanisms will address the partial cost recovery problem. Both O&R and Mass. Electric will recover program costs as they are incurred; unexpected cost increases will be recoverable in the next year through a reconciliation procedure.

PECO proposes to follow a similar treatment for some of its expenditures but to ratebase those that go toward capital items.[2] Its proposal to accrue a return on these capital items before they enter rate base would address another potential area of under-recovery. On the other hand, ratebasing could expose the company to additional risks, including possible denial of full cost recovery at some future date and "balance sheet risk" as described earlier. There might be offsetting advantages to ratebasing DSM, however, such as mitigation of short-term upward pressure on rates.

Adjustment for DSM-Induced Revenue Losses

Both the O&R and PECO mechanisms would provide dollar-for-dollar compensation for DSM-induced shortfalls in fixed cost coverage. Because its purchase of all power at wholesale rates reduces the significance of lost revenues, Mass. Electric neither requested nor received an explicit adjustment, stating instead that the bonus would provide sufficient offset to cover lost revenues. To the extent that revenue loss due to DSM does occur, the Mass. Electric mechanism provide a less straightforward response to the problem.

Bonus to Counterbalance Risk and Loss of Financial Opportunity

All three mechanisms provide for a bonus, or true incentive, above program costs and lost revenues. While computed in different ways, each strives to offset some of the risk and loss of financial opportunity associated with major DSM programs.

How well each mechanism serves this purpose depends on the uncertainty surrounding the actual bonus that will eventually be earned. Uncertainty is a function of both the timing of the bonus and uncertainty about its magnitude. Of the three proposals, only O&R stretches the bonus out over an extended period (ten years). This consideration, we believe, increases the regulatory risk that the bonus will not be earned in full—and therefore diminishes its value.

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2 *PECO has not indicated whether it will seek to capitalize incentive payments that support customers' purchases of long-lived equipment, or whether capitalization would be limited to direct equipment expenditures by PECO.*

In all cases the magnitude of the bonus is uncertain because it depends, in part, on the success of the programs in recruiting participants. The O&R and Mass. Electric bonuses additionally depend on post-installation measurements of actual program impact. In contrast, the PECO plan, as well as Mass. Electric's original proposal, would remove this element of uncertainty by relying on predetermined per-customer or per-measure impacts to compute the bonus.

All of the mechanisms give the utilities an incentive to "do a good job" with their DSM programs in terms of signing up customers. The issue becomes, How important is it to tie bonuses to actual measured results? Surely the notion of paying for *actual*, rather than predicted, performance, has strong intuitive appeal. Further, one might argue that under the PECO approach the company would have no incentive to ensure that the measures are installed well—or (to carry the argument to the extreme) that the company would benefit by intentionally doing a *poor* job.

We believe the importance of using measured results is overrated, particularly in situations where the DSM programs are being approved for a limited time frame and ongoing evaluation efforts are planned. Under the PECO plan, for example, the company would come before the commission *annually* to seek approval of next year's programs and their assumed per-customer impacts. The commission would look to the most recent evaluation results to help it gauge the credibility of the company's impact estimates. Any short-term "gaming" of the system by failing to implement measures well would likely be revealed by evaluation, and would carry a severe risk of loss of credibility with the commission.[3]

Reliance solely on measured results poses two disadvantages. One is that it delays receipt of the bonus until the results are in. The second, and more serious, disadvantage is that it makes the bonus less certain. Other things being equal, we would expect that this reduction in certainty increases the size of the bonus needed to overcome utilities' hesitancy to pursue DSM.

While reliance on preapproved impacts brings the risk that ratepayers will pay bonuses for savings that were not achieved, we believe the potential cost is small, given frequent opportunities to revisit the assumed impacts.

Basis for the Bonus. O&R's original proposal would have based the bonus on avoided costs (specifically, on the size of the investment displaced by DSM). The O&R mechanism as approved by the PSC substitutes a shared savings incentive, which relies on both the avoided costs and DSM program costs. The NY PSC rejected this formulation in favor of a shared savings approach, which relies on both the avoided costs and DSM program costs:

> Under the company's proposal, DSM program costs would simply be recovered, and would not affect the calculation of the incentive itself. The company could conceivably find it profitable to pursue demand reductions without regard to costs. Under [a shared savings] proposal, in contrast, the amount of the incentive payment would be directly tied to the cost-effectiveness of the DSM measures chosen. For this reason, a percentage of savings mechanism is superior (New York Public Service Commission 1989).

The PECO proposal also adopted the shared savings approach. Mass. Electric's original proposal used a combination of avoided costs alone (for the maximizing incentive) and shared savings (for the efficiency incentive). This approach was altered by the Massachusetts DPU, however, due to the DPU's reluctance to institutionalize avoided costs:

> The Department cannot at this time support using avoided energy and capacity costs to calculate value. ...[A]voided energy and capacity costs may not accurately represent value. Instead, such costs are a complex mixture of marginal and embedded costs, which at best represent only the next best alternative. As the Department has made clear its intent to eliminate the need to use

3 *An approach similar to PECO's (preapproval of impacts, coupled with an evaluation plan) was recently endorsed by a coalition of utilities, regulators, and intervenors in California (California Collaborative Process 1990).*

administratively-determined avoided cost for the resource selection and resource pricing process...the Department is interested in minimizing the reliance on such calculations (Massachusetts Department of Public Utilities 1990).

The Massachusetts DPU substituted a bonus method based on kW and kWh achieved. It designed this method to produce the same *result* as Mass. Electric's proposal, namely, achievement of a target increase in ROE if the programs are fully successful. (The DPU, however, set the target at 1% additional ROE rather than the 2% sought by Mass. Electric.)

Notwithstanding Massachusetts' concerns about avoided costs, we believe the shared savings approach is sound and has intuitive appeal to both utilities and regulators. It represents a reward for value received, and it gives the utility a continuing incentive to control costs. Further, it is readily understood by persons outside the utility/regulatory community and is thus likely to pass the "front page test." For these reasons, we expect that other states will likely make shared savings the basis for the bonus component.

In the final analysis, however, the mechanism for computing the bonus is less important than its size and the level of uncertainty surrounding its receipt. While we see advantages to the shared savings mechanism, we suspect that utility managers will view any mechanism primarily in terms of its potential contribution to ROE.

Dollar Value of the Bonus. Perhaps the key question is one that cannot be answered definitively at this point: How large must the bonus be to serve its purpose? An executive with a major investment banking firm has suggested that an increase of .15-.25% in total ROE arising from an incentive would be meaningful to utility investors (personal communication with Caren Byrd, Morgan Stanley & Company, September 1989). If its programs are fully successful, Mass. Electric's incentive plan will yield its parent the equivalent of an additional 0.3% ROE.[4] Another way to view the Mass. Electric plan is that it will provide a bonus of $5.25 million on outlays of $37.0 million, or roughly 14% above actual expenditures.

Whether these amounts ultimately prove adequate, inadequate, or excessive will not be evident for some time. One possible gauge is the effect that one utility's bonus arrangement has on other utilities' DSM plans. For instance, if the precedent established for one utility leads other utilities to approach the commission with proposals for bonuses of similar magnitude, and those companies are showing significantly expanded commitments to DSM, we might infer that the bonus is sufficiently attractive.

CONCLUSIONS

Each of the three incentive mechanisms reviewed here basically meets the goal of overcoming the disincentives that surround utility DSM programs. The most significant differences across the mechanisms are found in the bonus component, which serves to offset the perceived risks of DSM and provide a "pure incentive" above actual costs. Mechanisms that reduce the utility's uncertainty about the receipt of the bonus by providing it in a lump sum will likely prove more powerful motivators than those that spread the bonus out over a period of years. Use of preapproved per-unit or per-customer impact measurements reduces uncertainty and thus increases the apparent value of the bonus. Annual review of program plans and assumed impacts, supported by continuing evaluation activities, minimizes the risk that utilities will "game" the incentive system or receive excessive rewards.

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4 *This estimate assumes an equivalent incentive is put in place for all the NEES retail companies. For Mass. Electric alone, the ROE increase is 1%.*

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EFFECT OF THE ERAM MECHANISM ON UTILITY INCENTIVES

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The Electric Rate Adjustment Mechanism (ERAM), adopted in 1982 by the California Public Utilities Commission (CPUC) for the major investor-owned electric utilities it regulates, represents a major departure from traditional ratemaking. ERAM removes a prior anti-conservation bias by ensuring that the utility will fully collect its authorized revenue requirement irrespective of its sales. Over or undercollections of revenues accrue to a balancing account and are amortized into future rates. This mechanism protects the utility from the risk of sales deviating from expectations for any reason. Shielding the utility in this way can confound other policy actions that assume the utility faces incentives other than those created by ERAM. In this paper, it is assumed that encouraging energy conservation and discouraging bypass are both established CPUC policies. A study of special sales contracts permitted between California utilities and their large industrial customers shows ERAM establishes utility incentives that render these two policies incompatible under normal regulatory practice. This conflict arises because ERAM guarantees that any revenue shortfall arising from a contract will be made up on sales to other customers: that is, the utilities are not hurt by signing contracts favorable to their industrial customers.

INTRODUCTION

Revenue Decoupling. Since the adoption of the Electric Revenue Adjustment Mechanism (ERAM) by California, the introduction of ERAM-like mechanisms has been contemplated by other jurisdictions (Jones 1989; Moskovitz 1989; and Weil 1989). ERAM removes an anti-conservation bias of traditional rate-of-return (ROR) regulation by guaranteeing that a utility will collect its authorized revenue requirement, irrespective of unforeseen fluctuations in sales. Decoupling of utility earnings from sales was only one of the motives for the initial implementation of ERAM. Notably, ERAM was intended to bolster the financial health of the utilities. However, the decoupling motive is emphasized here because it concerns most jurisdictions currently considering ERAM.

Anti-Conservation Bias. ERAM tends to eliminate a recognized anti-conservation bias in prior California regulation. The bias results from the phenomenon that, under pre-1982 California regulation, utilities gain when actual sales exceed those forecast, and vice-versa. This creates an anti-conservation incentive because conservation programs that prove more effective than anticipated hurt utility earnings, while ones that fail benefit the company. ERAM eliminates this incentive by automatically ensuring that utilities collect their exact authorized base revenue requirement over time, irrespective of the volume of sales. Consequently, ERAM reduces company risk and tends to keep profits more stable yet maintains the incentive to cut costs and improve productivity.

Status of ERAM. ERAM enjoys wide support in the industry in California being particularly enthusiastically endorsed by conservationists (Cavanagh 1988). The California utilities have opposed the removal of ERAM, and the National Association of Regulatory Utility Commissioners Energy Conservation Committee stands on record as supporting ERAM-like ratemaking reforms (*NARUC Bulletin* 1988). However, some members of the California

Attachment 8D

Public Utility Commission (CPUC) staff have recommended the elimination of ERAM and a few policy analysts outside the State have also expressed reservations (Ziering 1986; Sissine 1989).

Paper Goal. In this paper, it is assumed that encouraging energy conservation and allowing special utility contracts to prevent bypass are both established CPUC policies, and the cases for and against these policies will not be argued. The goal here is twofold: first, to describe the mechanics of ERAM; and second, to examine the effect of ERAM's existence on the success of the CPUC's special contracts policy.

CALIFORNIA CONTEXT

GRC's. Most ROR ratemaking uses a test year approach, but California is among the minority of states that use a future test year. All test year parameters used in regulatory proceedings are based on forecasts. However, whether or not ratemaking uses a forecast test year, ERAM is applicable because it corrects for inaccuracies in forecasts of actual sales. California regulation also deviates from the norm in that general rate cases (GRC's) are conducted at regular three-year intervals, the two intervening years being called the *attrition years*. In the GRC, the revenue requirements of the utility for the test year are forecast, and they are, essentially, divided by forecast sales to find the rate necessary to recover the approved utility costs, which includes the approved ROR. Electric utilities collect all *non-fuel* costs through this basic process. In California regulation, *non-fuel* costs cover all utility costs other than direct fuel and purchase power expenses.

ECAC and ARA. Since fuel costs are considered more volatile, regulators separately calculate a fuel component to rates in annual Energy Cost Adjustment Clause (ECAC) proceedings. A third California mechanism, the Attrition Revenue Adjustment (ARA, or simply, *attrition*) also prevents a wedge from developing between a utility's costs and its authorized revenue requirement between general GRC's. Attrition takes account of several specific sources of such a wedge, notably, inflation, changes in plant costs, and fluctuations in the cost of capital. ARA and ERAM work together; ARA adjusts the revenue requirement and ERAM guarantees its collection.

History of ERAM. Beginning in 1982, a troubled time for California's electric utilities, the CPUC introduced ERAM for the major companies, Pacific Gas and Electric (PG&E), Pacific Power and Light (PP&L), San Diego Gas and Electric (SDG&E), Sierra Pacific Power (SPP), and Southern California Edison (Edison). During the mid-1980's California utilities achieved comfortable reserve margins as the San Onofre and Diablo Canyon nuclear stations came on-line, non-utility generation appeared in unexpectedly large amounts, and fuel prices fell precipitously. These factors considerably weakened the conservation imperative (Calwell and Cavanagh 1989; Messenger 1989; and CEC/CPUC 1988). Further, some troublesome aspects of ERAM surfaced and, as part of an extensive review of California electric ratemaking, the elimination of ERAM was recommended by the CPUC staff. California utilities and various lobbyists, however, vigorously opposed ERAM's elimination, and the Commission elected to retain it.

ARGUMENTS FOR ERAM

The complexity of the California regulatory process has led to rather convoluted arguments for and against ERAM that are not easily unwound into a neat list, however, following are seven of the key pro ERAM claims.

1. *ERAM eliminates the disincentive to conservation.* The conservation argument holds that without ERAM, California utilities would face two perverse incentives with adverse implications for achieving conservation policy goals. First, once the costs of a conservation program have been added to base rates, the utility's best interests are served by making the program fail to deliver the conservation promised. In this way, the utility recovers the costs of the program yet avoids the revenue loss its success implies. Second, between GRC's, the utility further faces an incentive to sell as much power as possible, virtually irrespective of the costs of generating it. In both cases,

the revenue gained from selling a kWH above the forecast level represents an almost direct contribution to the company bottom line. Conversely, however, ERAM does not reward successful conservation programs. It simply tends to make the utility indifferent to conservation.

2. *ERAM retains the efficiency incentive.* Under ERAM, utilities can still exceed their authorized ROR by cost cutting. Thus, their incentive to be efficient remains.

3. *ERAM removes the incentive to game in forecasting.* The incentive to under forecast sales before a GRC and promote sales after it particularly concerned regulators during the late 1970's and early 1980's. By guaranteeing that the utility will recover its revenue requirement, the incentive to game with sales forecasts disappears.

4. *ERAM encourages the financial health of the utilities.* The guaranteeing of revenue collections contributes to the financial health of the utilities by reducing the variability of earnings. ERAM not only eliminates the potentially adverse effects of losses of sales from conservation, it also automatically adjusts for many other sources of sales perturbations, including weather and the business cycle.

5. *ERAM permits innovative ratemaking.* One potential source of revenue variability merits special mention, namely, the consequences of imperfect or experimental ratemaking. Notice that if the base rate set in the GRC is incorrect, the subsequent miscollection of revenues will accrue in the ERAM balancing account together with any other miscollections. That is, the utility is not hurt by ratemaking inaccuracy. As a result, the CPUC has more latitude with ratemaking innovations that it did prior to ERAM.

6. *ERAM contributes to regulatory efficiency.* With regard to both the elimination of the incentive to game with forecasts, and the elimination of fear of inaccurate ratemaking, it merits repeating that the presence of ERAM reduces the contentiousness of regulatory proceedings, resulting in some savings of administrative effort.

7. *ERAM comes cheap.* ERAM is a bureaucratic mechanism. While being far from free to administer, this approach costs considerably less than alternative methods of monitoring utility behavior.

ERAM MECHANICS

Basic Principle

ERAM periodically adjusts the non-fuel part of rates, base rates, to ensure that the utility actually collects its full authorized revenue requirement. ERAM achieves this parity by maintaining a balancing account in which miscollections of revenues accrue. This accounting procedure mimics the conduct of the California Energy Cost Adjustment Clause (ECAC), the fuel cost adjustment proceeding. Both ERAM and ECAC balancing account mechanisms address the problem of actual revenues straying from authorized levels between GRC's: ECAC adjustments attempt to account for unanticipated fluctuations in fuel costs, while ERAM accounts for unanticipated fluctuations in sales volume. The existence of these mechanisms together considerably reduces utility risk exposure.

Numerical Example

Introduction. The following description leads the reader through a simple ERAM spreadsheet model. The example shows how effective base rates might evolve over time and how ERAM controls a utility's ROR. The starting point loosely represents applicable numbers for the Southern California Edison company, but, beyond the first year, the example is totally fictitious.

Model Assumptions. In this simplified example, the ratemaking for year t takes place precisely at the end of year $t-1$, and all actual data for year $t-1$ are known. In addition, the following important assumptions are made:

1. The ERAM rate is adjusted just once a year and is effective for the entire following year, as are the GRC and attrition adjustments to base rates.

2. All customers on the system are on a tariff whose base rate and ERAM balance rate are identical.

3. Base operating costs are insensitive to sales. That is, an increase in sales does not imply an increase in base operating costs. This is equivalent to assuming that the only incremental cost of generating another kWh is the fuel burned.

4. The model is concerned only with base rates.

Results. The full example appears in the two parts of Table 1. The upper part demonstrates the rate-making done at the end of year *t-1*, and the lower part reflects the events that actually occurred in year *t*. In other words, what appears in the upper area reflects what is known or forecast at the end of year *t-1*, and what appears below reflects what is known at the end of year *t*.

Space does not permit a full description of the model here, but the salient features of ERAM are easily identified. The easiest way to understand Table 1 is to work backwards. Focus first on the company's bottom line. In each of the three years shown, the authorized ROR on rate base is 12.5% (line 5). Line 36 shows that without ERAM this utility would have actually reported the authorized rate in only one of the three years, 1990. Everything works out as planned in 1990 because both sales (lines 2 and 21) and costs (lines 7 and 27) were exactly as forecast. If all years turned out so perfectly, clearly, ERAM would not be necessary.

Look now at the same lines for 1989. In this year, sales exceed forecasts. Exactly as ERAM proponents claim, a significant benefit accrues to the company as the return on rate base is more than two points above authorized (lines 5 and 36). This represents a dramatic effect on the company's performance, given that sales were only 2.9% (line 23) above the forecast. ERAM is designed to eliminate exactly this powerful effect, and line 38 shows how well ERAM works. The reported ROR with ERAM in place in 1989 is precisely the 12.5% authorized. Further, ERAM operates symmetrically. If sales fall below forecast, reported ROR would still be exactly as authorized in this year.

Finally, consider the results in 1991. In this year, the company suffers badly. First, sales are lower than forecast, and second, operating costs exceed those forecasts. Without ERAM, the company ROR falls a devastating 5 points below authorized (line 36). In this case, the ROR is not fully restored by ERAM (line 38). The discrepancy results from the failure of ERAM to make the company whole for the excess operating costs (lines 7 and 27). While the ROR on rate base is not affected by the sales shortfall, it remains sensitive to deviations in operating costs. Hence the claim that ERAM removes the disincentive to conservation while allowing the company to be punished for inefficiency.

ERAM Operation. To understand how ERAM achieves these results, consider the activity in the ERAM balancing account (lines 30 34). Collections above or below authorized accrue in this account. After proper allowance for interest on the balance, an adjustment to future rates, called here the ERAM balance rate (line 18) is calculated and added to the base rate to form an *effective base rate* (line 19), which is the tariff the customer actually sees. The intent is to zero out the account in the upcoming period, although this goal is never actually achieved because of the ongoing inaccuracy of forecasts.

SPECIAL CONTRACTS

Introduction

ERAM was, in part, intended to protect utilities from the between-GRC revenue loss resulting from successful conservation programs, yet in practice it protects utilities from sales deviations resulting from any cause. The all-encompassing nature of ERAM protection portends potential conflicts with CPUC policy in some areas, where the CPUC would prefer to see the utilities bear sales risk. The emergence of special customer contracts, which are used in California to discourage bypass, provides an illuminating example.

Regulatory changes, improvements in cogeneration technology, low prices of natural gas and other light fuels, and cross-subsidies by the industrial rate class of the residential class all tend to make bypass an attractive option to large California customers. However, bypass, it is argued, adversely affects the capacity utilization and fuel mix of utilities, increases the State's dependence on imported fossil fuels, wastefully duplicates the State's generating capacity, confounds industry planning, and has

Table 1. Base Case

line #	year (t)	-> 1988	1989	1990	1991
			(M$ unless noted)		
	RATEMAKING FOR YEAR t AT THE END OF YEAR t-1				
	BASE RATE				
1	forecast sales change		4.0%	3.0%	2.0%
2	forecast sales for year t : (GWh)		68640	70699	72113
3	authorized interest rate		8.0%	8.0%	8.0%
4	rate base		6000	6304	6430
5	authorized rate of return		12.5%	12.5%	12.5%
6	target earnings : (4 x 5)		750	788	804
7	forecast base operating costs including attrition adjustments		3500	3623	3749
8	authorized revenue requirement : (6 + 7)		4250	4411	4553
9	base rate in t-1 : (¢/kWh)		6.170	6.192	6.238
10	forecast revenues at current rates : (2 x 9)/100		4235	4378	4499
11	forecast revenue shortfall: (8 - 10)		15	33	54
12	base rate in t : ((8/2) x 100): (¢/kWh)	6.170	6.192	6.238	6.314
13	change in base rate over year t-1		0.4%	0.8%	1.2%
	ERAM BALANCE RATE				
14	ERAM balance end of t - 1		-178	-131	-5
15	ERAM balance rate in t-1 : (¢/kWh)		-0.304	-0.259	-0.185
16	forecast ERAM revenues at current billing factor : (15 x 2)/100		-209	-183	-133
17	forecast ERAM revenue shortfall : (14 - 16)		31	53	128
18	ERAM balance rate in t : ((14/2) x 100) : (¢/kWh)	-0.304	-0.259	-0.185	-0.007
	EFFECTIVE BASE RATES				
19	effective base rate : (12 + 18)	5.866	5.932	6.054	6.307
20	change in effective base rate over year t-1		1.1%	2.0%	4.2%
	ACTUAL EVENTS IN YEAR t				
	GENERAL RESULTS				
21	actual sales in t : (GWh)	68000	70640	70699	70113
22	actual sales relative to forecast		higher	equal	lower
23	error in sales forecast		2.9%	0.0%	-2.8%
24	actual base rate revenues in t : ((12 x 21)/100)		4374	4411	4427
25	actual ERAM revenues in t : ((18 x 21)/100)		-183	-131	-5
26	total revenues in t : (24 + 25)		4191	4280	4422
27	actual base operating costs		3500	3623	3937
28	actual base operating costs relative to forecast		equal	equal	higher
29	error in operating cost forecast		0.0%	0.0%	5.0%
	EFFECT ON ERAM ACCOUNT				
30	initial ERAM balance at beginning of t		-178	-131	-5
31	miscollection in t : (8 - 26)		59	131	131
32	ending balance at end of t : (30 + 31)		-119	0	125
33	interest accrued during t : (avg(30, 32) x 3)		-12	-5	5
34	closing ERAM Balance at end of t : (32 + 33)	-178	-131	-5	131
	EFFECT OF ERAM ON EARNINGS				
	without ERAM				
35	actual earnings : (24 - 27)		874	788	490
36	actual rate of return : ((35/4) x 100)		14.6%	12.5%	7.5%
	with ERAM				
37	actual earnings : (26 + 31 - 27)		750	788	[illegible]
38	actual rate of return : ((37/4) x 100)		12.5%	12.5%	9.5%

negative environmental consequences. The most strident argument against bypass, however, is that the tariffs of customers remaining on the system rise because the burden of fixed cost recovery falls more heavily on a reduced customer base (MacAvoy, Spulber, and Stangle 1989).

CPUC policy regarding bypass in the mid-1980's was, in general, to disfavor it. The CPUC allowed utilities to write special contracts with customers that threaten to bypass as long as the revenue gained from the contract exceeds the variable cost of serving the customer. In other words, as long as keeping the customer by means of a contract could result in a positive contribution to base revenue requirements, the bypass was considered *uneconomic* and the contract approved.

This question to be addressed in the test case is the following. Since the California electric utilities are allowed, or even encouraged, to make individual contracts with large customers that threaten bypass, how does the existence of ERAM change the effectiveness of the contracts policy.

Test Example

In this example, special contracts are signed that result in lost sales of 500 GWh/y. It is assumed that the contracts ensure that ECAC costs are covered, and, further, that no rate effects result from the ECAC side. In other words, the full impact of the contracts appears in the base rate calculations. The contracts are assumed to provide 2.0 ¢/kWh of revenue, instead of the full effective base rates.

Bypass Case. First consider Table 2. In this table, the rate consequences of allowing the bypass to proceed are presented. Notice that no change in revenue requirement has been made (line 8), in keeping with assumption 3. Note that the forecast does take the contract into account (line 2). Clearly, under these simple assumptions, the remaining customers must be worse off because a fixed burden of the revenue requirement is spread more thickly across the reduced sales. Comparing the effective base rates in Tables 1 and 2, the rates in the bypass case are higher in 1990 in 1991.

Contract Case. Now consider the contract case presented in Table 3. In this case, contracts are successfully negotiated with the bypassers and they agree to remain on the system, but at a preferential rate. Comparing line 19 of Tables 2 and 3 shows customer rates are lower if the bypassers are kept on the system. This comparison demonstrates the key argument in favor of permitting contracts. By keeping the bypassers on the system, even at a favorable rate, the other customers benefit *vis-a-vis* the situation that would result from bypass.

CONCLUSIONS

ERAM works as expected and does indeed shelter the utility from sales fluctuations, thereby removing the anti-conservation bias of pre-1982 California regulation. However this result is achieved in a rather heavy handed manner that achieves the conservation policy goal while potentially confounding the attainment of others.

Ironically, ERAM appears to have come full circle with regard to special contracts. The utility's best strategy, it seems, is to mount a costly effort to negotiate sales contracts and ensure that these costs are safely embedded in rate base. The costs embedded in revenue requirement will be collected by the utility whatever sales ultimately prove to be. After the GRC establishing revenue requirement, the utility should dramatically cut its negotiating effort. Whether or not contracts are actually signed, and at what rates, appears irrelevant. The utility should just make the minimum effort that will prevent a later prudence disallowance of the contracts sales effort. This is exactly the utility behavior towards conservation programs that ERAM was intended to avoid.

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Table 2. Bypass Case

line #	year (t) ->	1989	1990	1991
	RATEMAKING FOR YEAR t AT THE END OF YEAR t-1			
	BASE RATE			
1	forecast sales change	4.0%	2.3%	2.0%
2	forecast sales for year t	68640	70199	71613
3	authorized interest rate	8.0%	8.0%	8.0%
4	rate base	6000	6304	6430
5	authorized rate of return	12.5%	12.5%	12.5%
6	target earnings : (4 x 5)	750	788	804
7	forecast base operating costs including attrition adjustments	3500	3623	3749
8	authorized revenue requirement: (6 + 7)	4250	4411	4553
9	base rate in t-1	6.170	6.192	6.283
10	forecast revenues at current rates : (2 x 9)/100	4235	4347	4499
11	forecast revenue shortfall: (8 - 10)	15	64	54
12	base rate in t : ((8/2) x 100)	6.192	6.283	6.358
13	change in base rate over year t-1	0.4%	1.5%	1.2%
	ERAM BALANCE RATE			
14	ERAM balance end of t - 1	-178	-131	26
15	ERAM balance rate in t-1	-0.304	-0.259	-0.186
16	forecast ERAM revenues at current billing factor : (15 x 2)/100	-209	-182	-133
17	forecast ERAM revenue shortfall : (14 - 16)	31	52	160
18	ERAM balance rate in t : ((14/2) x 100) : (24/2)	-0.259	-0.186	0.037
	EFFECTIVE BASE RATES			
19	effective base rate : (12 + 18)	5.932	6.097	6.395
20	change in effective base rate over year t-1		2.8%	4.9%
	ACTUAL EVENTS IN YEAR t			
	GENERAL RESULTS			
20.a	base case sales in t	70640	70199	69613
20.b	sales loss due to bypass	0	500	500
21	actual sales in t	70640	69699	69113
22	actual sales relative to forecast	higher	lower	lower
23	error in sales forecast	2.9%	-0.7%	-3.5%
24	actual base rate revenues in t : ((12 x 21)/100)	4374	4379	4394
25	actual ERAM revenues in t : ((18 x 21)/100)	-183	-130	26
26	total revenues in t : (24 + 25)	4191	4250	4420
27	actual base operating costs	3500	3623	3937
28	actual base operating costs relative to forecast	equal	equal	higher
29	error in operating cost forecast	0.0%	0.0%	5.0%
	EFFECT ON ERAM ACCOUNT			
30	initial ERAM balance at beginning of t	-178	-131	26
31	miscollection in t : (8 - 26)	59	161	133
32	ending balance at end of t : (30 + 31)	-119	30	160
33	interest accrued during t : (avg(30, 32) x 3)	-12	-4	7
34	closing ERAM Balance at end of t : (32 + 33)	-131	26	167
	EFFECT OF ERAM ON EARNINGS			
	without ERAM			
35	actual earnings : (24 - 27)	874	757	457
36	actual rate of return : ((35/4) x 100)	14.6%	12.0%	7.1%
	with ERAM			
37	actual earnings : (26 + 31 - 27)	750	788	616
38	actual rate of return : ((37/4) x 100)	12.5%	12.5%	9.6%

Table 3. Contracts Case

line #	year (t) ->	1989	1990	'99
	RATEMAKING FOR YEAR t AT THE END OF YEAR t-1			
	BASE RATE			
1	forecast sales change	4.0%	3.0%	2.0%
2	forecast sales for year t	68640	70699	72113
3	authorized interest rate	8.0%	8.0%	8.0%
4	rate base	6000	6304	5430
5	authorized rate of return	12.5%	12.5%	12.5%
6	target earnings : (4 x 5)	750	788	304
7	forecast base operating costs including attrition adjustments	3500	3623	3749
8	authorized revenue requirement : (6 + 7)	4250	4411	4553
9	base rate in t-1	6.170	6.192	6.238
10	forecast revenues at current rates : (2 x 9)/100	4235	4378	4499
11	forecast revenue shortfall: (8 - 10)	15	33	54
12	base rate in t : ((8/2) x 100)	6.192	6.238	6.314
13	change in base rate over year t-1	0.4%	0.8%	1.2%
	ERAM BALANCE RATE			
14	ERAM balance end of t - 1	-178	-131	16
15	ERAM balance rate in t-1	-0.304	-0.259	-0.185
16	forecast ERAM revenues at current billing factor : (15 x 2)/100	-209	-183	-133
17	forecast ERAM revenue shortfall : (14 - 16)	31	53	149
18	ERAM billing factor in t : ((14/2) x 100) : (24/2)	-0.259	-0.185	0.022
	EFFECTIVE BASE RATES			
19	effective base rate : (12 + 18)	5.932	6.054	6.336
20	change in effective base rate over year t-1		2.0%	4.7%
	ACTUAL EVENTS IN YEAR t			
	GENERAL RESULTS			
21	actual sales in t	70640	70699	70113
22	actual sales relative to forecast	higher	equal	lower
23	error in sales forecast	2.9%	0.0%	-2.8%
23.a	sales at the contract rate	0	500	500
23.b	contract base rate		2.000	2.000
23.c	contract revenues : ((23.a x 23.b)/100)	0	10	10
23.d	sales at the full effective base rate : (21 - 23.a)	70640	70199	69613
24	actual base rate revenues in t : ((12 x 23.d)/100)	4374	4379	4395
25	actual ERAM revenues in t : ((18 x 23.d)/100)	-183	-130	15
26	total revenues in t : (23.c + 24 + 25)	4191	4260	4421
27	actual base operating costs	3500	3623	3937
28	actual base operating costs relative to forecast	equal	equal	higher
29	error in operating cost forecast	0.0%	0.0%	5.0%
	EFFECT ON ERAM ACCOUNT			
30	initial ERAM balance at beginning of t	-178	-131	16
31	miscollection in t : (8 - 26)	59	151	133
32	ending balance at end of t : (30 + 31)	-119	20	148
33	interest accrued during t : (avg(30, 32) x 3)	-12	-4	7
34	closing ERAM Balance at end of t : (32 + 33)	-131	16	155
	EFFECT OF ERAM ON EARNINGS			
	without ERAM			
35	actual earnings : (24 - 27 + 23.c)	874	767	468
36	actual rate of return : ((35/4) x 100)	14.6%	12.2%	7.3%
	with ERAM			
37	actual earnings : (26 + 31 - 27)	750	788	616
38	actual rate of return : ((37/4) x 100)	12.5%	12.5%	9.8%

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Attachment 8E

Balancing Shareholder and Customer Interests in Incentive Ratemaking

This system of rewards for utility efficiency investments includes elements of customer equity, "lost revenue" recovery, and an exponential incentive return for shareholders.

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I. The Case For Efficiency Incentives

It is widely believed within the regulatory community that there is far more economic potential for demand-side management and efficiency improvements than is currently envisioned and being pursued by utilities.[1] For example, New York investor-owned utilities, in their most recent long-range DSM plans projected approximately 1,250 MW of peak reduction and 1,800 GWh of energy reduction by 2000, while the recently released New York State Energy Plan[2] encourages utilities to implement DSM programs which could achieve statewide annual peak reductions of 2,900 MW and energy reductions of 15,500 GWh by the year 2000. The Energy Plan targets reduction potential of 8 to 10 percent of projected loads in the year 2000 based in part on a draft study of technical energy efficiency and DSM potential in New York by the American Council for an Energy Efficient Economy.[3]

Other recent studies estimate peak reduction potential of more than 15 percent and energy reductions of 30 percent from full-scale implementation of promising DSM programs.[4] Planned utility investments in energy efficiency and DSM are insufficient to tap this potential.

There remain, in fact, powerful financial disincentives to greater utility investment in DSM.[5] Among them are the potential for greater than expected reductions in sales and lost profit potential on sales not made as a result of DSM. If utilities operated under competitive market conditions, they would behave like any other competitive enterprise and seek out investments which had the greatest potential to maximize earnings.[6] However, since most utility services are monopolistic and are therefore regulated, utilities will seek to maximize earnings subject to the constraints of that regulation.

But the system of existing regulation actually encourages increased sales as a means of achieving higher earnings and discourages investment in lower cost efficiency improvements and DSM options which reduce sales. The less than economically efficient level of investment in DSM resources to date may also be linked to difficulty in providing proper pricing and value signals to utility consumers.[7]

At the same time, however, competitive forces in the energy marketplace are creating new economic imperatives to lower costs and improve customer relations.

To encourage greater utility investment in energy efficiency and DSM, there may well need to be an opportunity for utility investors to profit from efficiency investments—to make the profit on a kilowatt-hour saved equal to or greater than the profit on a kilowatt-hour consumed.[8]

Fortunately, it appears the objective of lowering customer costs, while improving shareholder earnings, may be accomplished by realigning regulation to encourage capital investment in lower cost resource options.

Recognizing that electricity service can be satisfied through either new supply or demand reductions, policymakers are coming to believe that both types of utility investments should be afforded comparable opportunity to provide earnings. This implies that the role of regulation should be to provide proper incentives for utilities to invest in the most economically efficient alternatives.[9]

To encourage greater utility investment in energy efficiency, we may need to make the profit on a kilowatt-hour saved equal to or greater than the profit on a kilowatt-hour consumed.

II. A Proposal for Reform

The remainder of this article focuses on a three-part proposal the author devised to encourage utilities to channel capital into lower cost efficiency investments. This proposal was submitted before the New York State Public Service Commission in proceedings involving Orange and Rockland Utilities, Inc. and Niagara Mohawk Power Corporation, which examined ratemaking and incentive mechanisms to promote least-cost planning and demand-side management.[10]

The proposal was not adopted by the Commission in that proceeding, the Commission having opted for now to adopt similar proposals offered by the utility parties. However, the Commission spoke favorably of the proposal and may yet decide to adopt such an approach in subsequent proceedings. In any case, I commend it to the attention of the many jurisdictions which are considering regulatory reforms to better encourage least-cost, environmentally benign energy planning.

A. DSM Cost Recovery

The first part of the proposal requires that DSM-related costs be classified and allocated by demand and energy charges across all customers in a manner consistent with current rate design practices for supply investments. As with all utility capital costs or expenses, the appropriate accounting and rate treatment requires that cost outlays match the receipt of benefits. Efficiency-related costs should be recovered over the life expectancy of the benefits. Capacity reductions, like capacity additions, benefit all customers by ensuring the availability of adequate supplies to meet customer service needs. Moreover, societal benefits of reduced fossil fuel dependency, reduced air and water emissions, and improved economies of service may be viewed as accruing to all customers in proportion to their service needs.

Consistent with fundamental principles of rate design, investments in rebates or financial incentives for efficient appliances, efficient lighting and efficient HVAC should be allocated on the basis of coincident demand requirements and energy use of each customer class.

Costs associated with reduced capacity needs should be afforded rate base treatment similar to costs associated with capacity supply, with commensurate return for prudent investments.

Noting the validity of the various intervenor and utility arguments in favor of amortizing or expensing DSM related costs, the Commission has deemed it desirable to gain experience with various approaches to DSM cost recovery before any one is adopted as standard practice in New York.[11]

In its order relating to Niagara Mohawk and Orange and Rockland, the Commission provided these utilities latitude to recover program costs in the different manner each had proposed. The Commission's order notes, however, that Orange and Rockland has since stated it would accept amortization of program costs over the period of years coincident with receipt of program savings, while Niagara Mohawk would expense and recover DSM costs from affected customer classes in proportion to its savings.

B. "Lost Revenue" Recovery

The second component of the proposal requires that utilities be allowed to recover lost revenues associated with greater than expected reductions in sales resulting from efficiency investments. Lost revenues should not be considered a "cost" in an economic sense but more a temporary underrecovery of embedded costs.

Utilities should be allowed to recover lost revenues associated with greater than expected reductions in sales resulting from efficiency investments.

Recovery of such costs should be permitted nonetheless as a means to overcome perceived disincentive to efficiency investments.

To this end, the proposal recommends that revenue "losses" be recovered in a manner that best approximates the method under which those revenues would be recovered under traditional ratemaking. For lack of a better interim distribution, they should be recovered from demand and energy charges across all customer classes.[12]

There also remains some confusion regarding lost revenue recovery. In the minds of some utility executives, "lost revenues" is taken to mean lost earnings opportunity, in the sense that sales once lost will be lost forever. I define lost revenues more conventionally to refer to the underrecovery of fixed costs between rate cases. There is no guarantee that sales once lost are lost forever, and in any event DSM investments free up energy and capacity which can be resold to other retail or wholesale customers. They may also wish to do so to avoid excess reserve margin penalties.

Orange and Rockland and Niagara Mohawk, having defined lost revenues in the conventional sense, were allowed by the Commission to use their own preferred methods of recovery on an interim 12-month basis, pending review of other New York utility proposals and an evaluation of the effects of their own recovery schemes. Orange and Rockland had proposed to recover lost revenues through an energy charge across all customers, while Niagara Mohawk had proposed to recover lost revenues only from participating customer classes.

C. Incentive Proposal

The third component of this proposal requires that an incentive rate of return be applied to rate based efficiency and DSM investments. The incentive mechanism is designed to reward utilities for efficiency investment and to satisfy several fundamental objectives. These include: (1) relating incentive returns to measured resource savings; (2) encouraging investment in the most cost-effective resources first; (3) tying reward to reduction targets;

(4) penalizing utilities for poor performance; (5) encouraging long-term efficient allocation of resources; (6) satisfying customer and shareholder interests; and (7) being easily understood and implemented.

The recovery of an incentive rate of return should be provided on investments actually made and based on measured resource savings, triggered by actual results in meeting reduction targets.[13] This return would be tied to the savings realized per kW and kWh as measured by a total resource cost test.[14] The incentive return would be calculated by multiplying the percentage savings associated with investing in DSM as compared with the avoided supply alternative, times the base return on equity.

For example, if an efficiency investment is one-half as costly as the avoided supply alternative (representing a 50 percent resource savings) and the utilities base equity return is 10 percent, the incentive portion of the return would be 5 percent, or 500 basis points. The incentive return would be applied to the rate based DSM investment cost.

The company would be permitted 100% of the incentive return *only* if it meets its expected reduction targets. The incentive would be reduced exponentially for any shortfalls in meeting reduction targets.

If only 50 percent of targeted DSM reductions were achieved, meaning that for an equivalent MW block cost savings fall to 25 percent, the proposal would reduce the available incentive to 6.3 percent of the equity return (from 50 percent of the base equity return) representing 25 percent of the 25 percent resource savings percentage.

To address the problems inherent in measuring DSM savings and evaluating DSM reliability to ensure that targets are met, Orange and Rockland proposed detailed measurement and evaluation criteria for each of its DSM programs. The Commission has allowed Niagara Mohawk and Orange and Rockland each to define net resource savings differently for the calculation of the incentive. One includes environmental externalities as a cost and one does not. Moreover, one excludes customer costs as an economic cost of bringing the efficiency improvement to market, while the other includes this cost.[15]

III. The Incentive Proposal in Practice

Table 1 presents background figures for the incentive rate of return calculation. Tables 2 and 3 illustrate how the incentive rate of return would be applied. The incentive is based on a calculation of the difference between the cost per kW or kWh of avoided supply and the cost of DSM, including both utility and customer costs. The size of the available incentive is limited by DSM savings calculated as a percentage of avoided cost as illustrated in Table 1. The greater the savings, the greater the incentive return

TABLE 1: Incentive Return Proposal
Avoided Cost and DSM Assumptions
(Thousand 1989 Dollars)

Projected Load Reduction	50 MW
Avoided Capacity Cost	$346 per MW
Avoided Production Costs[1]	$1867 per MW
Total Avoided Cost	$110,650
DSM Resource Cost	$325 per MW
Total Cost	$16,250
Net Resource Savings	$94,400
% Savings	85.3%

[1] Net present value of avoided generation, transmission and distribution costs for 30 years, which assumes a 30-year operating and depreciable life of the supply facilities. DSM investment is assumed to have a 10-year operating and depreciable life and, after initial installment, is replaced twice for equal present value cost.

both in absolute dollars and as a percentage of net resource savings.

The effect of this incentive mechanism should be to channel investment dollars into the most cost-effective DSM opportunities available, by providing greater incremental investment returns on the most cost-effective DSM options. The incentive return would decrease as the marginal cost-effectiveness of DSM decreases to the point where marginal DSM cost is to equal to the marginal savings.

Prudent DSM investments, representing a good faith effort to achieve results would be recovered regardless of performance but with a significantly reduced incentive if target levels were not achieved. The basis for determining the level of incentive would be avoided cost estimates for new supply additions and investment in DSM programs.[16]

The incentive return increases the return on the equity portion of capital investment. To calculate the rate of return on *total* investment, the incentive return is weighted by the equity portion of the rate base. For this analysis we assume the return payable *without* the incentive would be 12.5 percent for equity and 10 percent overall.

The numbers appearing at line 1 of Table 2 represent the levelized return on DSM investment in rate base (the $16,250,000 figure from Table 1) over an assumed 30-year investment life. As can be seen on line 1, the otherwise allowable equity return of $3.189 million (calculated *without* an incentive rate of return) could potentially increase by as much as $2.7 million, or 1070 basis points, with the incentive. This translates into a 484 basis point increase in the otherwise allowable total rate of return (debt and equity) of 10 percent.

In all, the DSM investment might be provided a maximum equity return of 23.2 percent and a maximum overall return of 14.8 percent. These are stunningly high levels of profitability. Note that, although the company may be eligible for the maximum incentive on DSM investments, it need not take it all, particularly if it faces competitive pressures to keep rates low.

If the company does not reach its expected reduction targets, however, the incentive rate of return is decreased exponentially as illustrated in Table 3. Table 4 assumes that actual reductions are 50 percent of the figure projected. The maximum equity incentive return would then drop 800 basis points (from 1070 to 270, or 75 percent) for this assumed 50 percent reduction in energy savings. If 50 percent of the reduction potential is achieved, only 50 percent of the percentage resource savings would be allowed as an incentive: thus the overall return on rate base would drop from 14.8 percent to 11.2 percent and the equity return would drop from 23.2 percent to 15.2 percent. Likewise, if actual savings exceed targeted savings, the maximum incentive could increase.

In fact, if actual reductions exceed target and net resources savings for the larger MW block reduction exceed 100 percent, the incentive return could exceed 100 percent, so that the equity return on DSM investment could more than double.

Even if investments produce no energy savings, utilities would be granted recovery of their prudent DSM investments. However, if investments in energy efficiency are not made where the Commission has identified cost-effective opportunities, utilities could face stiff

TABLE 2: Incentive Return Proposal
100% of Target Reductions Achieved
($ 000)

	Total Rate Base	Equity
Return on DSM Investment (w/o Incentive)[1]	$5,619	$3,189
Maximum Incentive Return	$2,721	$2,721
Maximum Allowable Return	$8,340	$5,910
Percentage Base Return	10	12.5
Basis Point Incentive	484	1,070
Return on DSM Investment	14.8%	23.2%

[1] Assumes a 45.4 % equity capitalization rate, a 12.5% equity cost and a 10% overall return on rate base.

reprimands or financial penalties.

IV. Advantages of the Proposal

This approach to providing increased earnings opportunity to utilities would encourage aggressive deployment of resources that result in actual savings, as opposed to simply providing an incentive to spend money. It would also encourage installation of the most efficient equipment first: the lower the cost of the efficiency improvement, the greater the percentage dollar and sharing of net resource savings as an incentive. Since the method employs a total resource cost test, it produces an incentive return proportional to the extent the investment is economic from a societal perspective.

This approach has several distinguishing characteristics:

—With the size of the incentive tied to the amount of actual measured resource savings, utilities are encouraged to meet or exceed reduction targets and overcome customer and other market barriers to investments in efficiency. Targets could be adjusted annually or established initially.

—The incentive return increases as the percentage energy savings increase, both in absolute dollars and as a percentage of net resource savings in the context of shared savings.

—Good performance is rewarded and poor performance penalized, but once determined prudent, there is a floor under downside risk with recovery of the efficiency investment at least, and the possibility for a return above the normal return on investment.

—Investment in the most effective resource options is encouraged up to the point where the marginal benefit equals the marginal cost of additional investment.

—The utility has the flexibility to balance customer and shareholder concerns when incorporating the incentive rate of return into rates, which could particularly benefit utilities confronting competitive threats.

—The method is easily understood and could be relatively easily implemented.

In its Opinion 89-29, the New York Commission characterized this particular incentive proposal as being "by far, the most well-developed" of the alternative DSM incen-

TABLE 4: Incentive Return Proposal
50% of Target Reductions Achieved[1]
($ 000)

	Total Rate Base	Equity
Return on DSM Investment (w/o Incentive)	$5,619	$3,189
Incentive Return	$679	$679
Allowable Return	$6,298	$3,868
Percentage Base Return	10	12.5
Basis Point Incentive	123	270
Return on DSM Investment	11.2%	15.2%

[1] Assumes that resource savings also falls by 50%. DSM cost make-up energy and capacity costs are assumed to be $63,450 implying a net resource savings of $47,200 or 42.7%. Incentive return equals 50% of resource savings or 21.3% of base equity rate.

TABLE 3: Sliding Scale Incentive for Efficiency Investment

% of Target Achieved	Premium % of Maximum
100%	100.0%
75%	56.3%
50%	25.0%
25%	6.3%

tive proposals submitted. It further noted that Orange and Rockland had stated that it would not oppose the proposal were its own incentive proposal not adopted.

The Commission went on to acknowledge that this proposal:

> provides for (1) a return on DSM investment (defined as total resource costs) equal to a utility's overall authorized return; and (2) a common equity return premium based on the extent to which program results (demand or energy savings) meet program targets established in annual filings submitted to and approved by us. The maximum premium would be earned when achieved savings equal or exceed 100 percent of target savings. The premium would tail off exponentially as achieved results fell below the target. . . .

In an attempt not to micro-manage the utilities, the Commission has been reluctant to adopt any one particular incentive scheme for all of the utilities. Instead, incentive proposals of Consolidated Edison, Central Hudson Gas and Electric, and New York State Electric and Gas will be reviewed and commented upon by the Commission by the end of October and perhaps decided by year-end.

At some point after initial operating data under the different schemes is in, the Commission could decide to standardize its approach to incentive regulation, as well as DSM cost recovery and lost revenue recovery.

V. Conclusion

Electric utilities are finding it increasingly difficult to maintain exclusive domain over customer end-use product selection, due to diminishing production economies, competition from self-generation, and increased competitiveness of alternative fuels. To regain the competitive edge in a

changing energy marketplace, utilities must strive to lower costs of service and diversify product mix. This requires that they reduce total costs to improve competitiveness, change product mix to satisfy differing customer service needs, and redirect investment to the most economically efficient resource options having the greatest earnings potential.

To foster this move, several changes to existing ratemaking policies are warranted. Taken as a reform package, the three-point plan outlined here would satisfy these objectives with little or no adverse impact on customers or shareholders and create instead a win-win situation for both customers and shareholders.

Moreover, since the incentive is tied to measured savings and capped at a maximum level, utilities would be encouraged to seek out investments which reduce total cost of service with the greatest opportunity for future earnings, just as they would in a competitive marketplace.

The time has come to move forward with regulatory reform by implementing logical and consistent changes to existing ratemaking practices so as to encourage optimal levels of utility investment in low cost efficiency. The three-point plan presented here could provide a major impetus to utility investments in cost-effective efficiency by providing greater earnings opportunities in a changing energy marketplace. ■

Footnotes:

1. In an effort to spur utility attention to efficiency in integrated resource planning, New York's Public Service Commission last year directed the state's utilities to focus on the role of conservation and DSM in developing their long-range integrated resource plans. Annual DSM plans which detail planned expenditures, energy and capacity contributions, and timing of program implementation necessary to achieve reduction targets are required to be filed with the Commission as well.

2. Executive Order No. 113, issued by Governor Cuomo on December 23, 1988, established an energy planning process for the purpose of developing a statewide integrated energy resource plan (the Energy Plan). The Executive Order directed that this plan be developed jointly by the State Energy Of-

nce, the Department of Public Service and the Department of Environmental Conservation, with input from other private and public entities. The Plan was issued in October 1989.

3. American Council for an Energy Efficient Economy, The Potential for Electricity Conservation in New York State (unpublished draft report for the Niagara Mohawk Power Corporation and the New York State Energy Research and Development Authority), February 1989.

4. ALLIANCE TO SAVE ENERGY, DESIGNING AND EVALUATING DSM REBATE PROGRAMS: ANALYTICAL TOOLS AND CASE STUDY APPLICATION (1988); AMERICAN COUNCIL FOR AN ENERGY EFFICIENT ECONOMY, ACID RAIN AND ELECTRICITY CONSERVATION (1987).

5. *See, e.g.*, S. Weil, *Making Electric Efficiency Profitable*, PUB. UTIL. FORT., July 6, 1989.

6. In competitive markets, investments provide an opportunity for profit either by lowering production costs or increasing sales. Investments promising lower production costs make a firm more competitive for a given level of sales. Investments promising the greatest percentage return or contribution to earnings would always be selected first.

7. *See, e.g.*, R. Cavanagh, *Responsible Power Marketing in an Increasingly Competitive Era*, 5 YALE J. ON REG. 331 (1988).

8. An incentive return approach which depends on indexing of utility performance, such as that advocated by former Maine PUC commissioner David Moskovitz, is one of many schemes now emerging to reward utilities for improving efficiency and lowering costs of service. *See*, D. MOSKOVITZ, PROGRESS AND PROFITS THROUGH LEAST-COST PLANNING (NARUC) (1989).

9. To the extent that all costs can be internalized, including environmental costs, an optimal investment portfolio would be relatively easy to achieve when the objective and constraints can be agreed upon.

10. See cases 89-E-041 and 89-E-176, involving Orange and Rockland and Niagara Mohawk. The proposal has been resubmitted in similar proceedings relating to Consolidated Edison, New York State Electric and Gas, and Central Hudson Gas and Electric which are now before the Commission.

11. See, e.g., Commission Opinion and Order 89-29, Approving Demand-Side Management Rate Incentives and Establishing Further Proceeding, Issued and Effective September 12, 1989.

12. If revenues are recovered from only one customer class or only participating customers, the potential exists for economically inefficient investment decisions. This could occur when lost revenues plus a participant's own costs exceed marginal revenue (bill savings) or reduce customer payback, rendering otherwise cost-effective DSM uneconomic to participants.

13. Such an incentive can easily be applied to any operating efficiency investment decision, though the discussion here is limited to efficiency and DSM investments only.

14. Kilowatt-hour reductions may be more valuable than kilowatt reductions, due to associated reduction in environmental externalities.

15. The New York Commission has stated that no generic action is warranted at this time, favoring examination of issues of measurement and reliability of DSM savings on a case-by-case basis.

16. A utility could also substitute the average cost of winning bids for new supply-side capacity from its last capacity auction, or use the avoided cost estimate of a new supply addition.

17. *Id.*, note 11, Opinion and Order No. 89-29 at 69.

Utility executives are beginning to discover that there may be increased profits, as well as virtue, in focusing on the demand-side.

North American Water Office

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Legislative Proposal for Electric Utility Financial Incentive and Rate Design Restructuring

No electric utility serving more than 50 meters in the State of Minnesota shall be allowed to apply for a rate increase, construction permit, certificate of site compatibility, installation permit, or facility permit modification unless the applicant utility operates with a rate design containing financial incentives that reward efficient, rather than increasing consumption of electricity.

To qualify for the above applications, the following financial incentive characteristics must be contained in the applicant utility's rate design:

1. Utility earnings are tied to conservation, rather than energy sales.

2. The utility will not increase earnings by selling more electricity.

3. Utility earnings must improve, rather than decrease, as the cost-effectiveness of the utility conservation investment improves.

4. The performance, rather than the amount, of conservation expenditures is rewarded.

5. Market forces and entrepeneurial initiative, rather than program-by-program regulation, drive the utility's conservation effort.

Attachment 9

Are Radiation-Induced Effects Hormetic?

SHELDON WOLFF

The original definition of the once obsolete word hormesis came to us from pharmacology, and meant a stimulation brought about by a low-level exposure to a substance that was toxic at high levels. In recent times, however, the word has been resurrected and the definition has been modified to refer not only to a stimulatory effect but also to a beneficial effect. In other words, hormesis now connotes a value judgment whereby a low dose of a noxious substance is supposedly good.

Although one cannot deny that hormetic effects can occur with pharmacological agents, the situation is much less clear with ionizing radiations, which produce random lesions within cells. The amount of energy deposited by low doses of radiation is just too small to bring about the physiological effects that could lead to stimulation. The reason for this, of course, is that Avogadro's number is so large that, even though the molar concentration of, say, an enzyme in a cell is small, the cell still will have a very large number of identical molecules necessary to carry out its proper metabolic function, which thus will not be affected by the destruction of a small percentage of the molecules. Consequently, to account for the effects of low-level radiation, it has been necessary to look for a system within the cell that not only is sensitive to radiation, but also is capable of magnifying an individual lesion so that it can have a physiological effect. The genetic apparatus, the genes and chromosomes in the nucleus, represents just such a target for radiation. Radiation can induce mutations, occasionally by inducing some random base changes, but mainly by breaking chromosomes, which then can result in the broken pieces being deleted or rearranged, and these effects can have a profound influence on the cell.

The usual experiment on the genetic effects of ionizing radiations, however, has shown that the effects induced, rather than being hormetic with a beneficial effect, are deleterious (*1*). This has been shown in innumerable experiments in mutation in which it has been found that radiation-induced mutations themselves, unlike spontaneous ones, are, indeed, usually deleterious. That this should be so is not surprising, in that all living organisms are the result of eons of evolution in which they have been selected to fit their proper ecological niches. Any random mutational change then would be expected to change this fine balance and decrease fitness. With ionizing radiation, in which most of the induced mutations are deletions, this is even more likely.

The question of hormesis after somatic irradiation is even more problematical, in that the deleterious effects of radiation would be different in each cell and, somehow, in the absence of strong selection (these are low doses after all) the effects would have to be translated into a *repeatable* beneficial effect for the whole organism.

The field of hormesis is replete with sporadic reports of unrepeatable beneficial effects being brought about by irradiation. Perhaps the greatest profusion of these reports came out of the Soviet Union in the late 1940s to early 1950s, in the era of Lysenko, during which there was a severe repression of modern Mendelian genetics. For reasons of political ideology whereby the state could change the environment and thus ameliorate man's (and other organisms') condition, the whole basis of modern genetics was suppressed. During that time, numerous reports appeared in which plants changed morphology, matured faster, grew bigger, and so on, if they had been irradiated. Unfortunately, when these experiments were repeated with proper scientific controls outside of the Lysenkoist sphere, the results were not found to be reproducible in any systematic way (*2*).

Although these theoretical and observational reasons speak against any hormetic effects of low-level radiation, recent experiments raise some questions regarding the possibility that, under some conditions at least, repeatable effects might be found. Among these is the observation that under *strong* selective pressure, bacteria appear to respond to a change in their environment with the production of new mutations related to the change (*3*). This observation, which on the surface smacks of Lamarckism, might have a more conventional interpretation that involves a general error-prone DNA repair with a concomitant selection of only those mutants that are capable of coping with the selective environment (*4*).

The other experiments consist of the repeatable adaptation of human lymphocytes (*5–10*) and V79 Chinese hamster cells (*11*) to low-level radiations from tritiated thymidine or x-rays, which then makes the cells less susceptible to the induction of chromosomal damage by subsequent high doses of x-rays. This phenomenon lasts for up to three cell cycles after the cells have been preexposed to doses of as little as one-half rad (0.5 cGy). The response is induced by radiation and other agents, such as alkylating agents, bleomycin, or oxidative radicals, that produce breaks in DNA, and is negated by the inhibition of poly(ADP-ribosyl)ation, which itself is induced by DNA breaks. This adaptive response has been attributed to the induction of a hitherto unknown chromosomal break repair mechanism that, if in place when the cells are subsequently exposed to high doses of radiation, can repair much of the initial damage and leave the cells with only approximately one-half as much cytogenetic damage as expected. The response has also been found to take 4 to 6 hours after the preexposure to become fully operational, and it can be inhibited by the protein synthesis inhibitor, cycloheximide, if it is present for this 4- to 6-hour period. Presumably, the enzymes necessary for the repair are being synthesized at this time and, indeed, two-dimensional gel analysis of protein extracts from lym-

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On Radiation, Paradigms, and Hormesis

LEONARD A. SAGAN

Three lines of inquiry have recently raised the surprising possibility that very low doses of ionizing radiation may not be harmful after all or may even have net benefits, a phenomenon known as hormesis. Many studies (but not all) show that laboratory animals exposed to low doses of radiation outlive unexposed animals (*1*). How could this happen? DNA damage occurs commonly as a result of normal metabolic processes as well as from exposure to environmental mutagens. Whether the outcome is harmful depends on the dynamic balance between damage and repair processes. A net benefit can result when protective responses to low-grade exposure more than compensate for the harmful effects of the radiation. For example, a major cause of radiation injury at high doses is thought to result from the production of free radicals. Feinendegen *et al.* have shown that free radical scavengers increase after low-dose radiation, possibly to a greater extent than that necessary to neutralize the radicals produced by the radiation (*2*). This increased production of scavengers might increase cell defenses against free radicals that result from exposure to other environmental mutagens or those produced by normal oxidative metabolism.

In other work, Wolff and colleagues have found evidence that DNA repair may be enhanced by low doses of radiation (*3*). This suggests another means of protection, namely, that radiation-exposed DNA may be more readily repaired after subsequent exposures to mutagens. One study demonstrates that enhanced DNA repair exists in workers occupationally exposed to radiation (*4*).

Third, radiation-induced cell death stimulates cell reproduction as a homeostatic mechanism that maintains cell compartment size. Accordingly, Kondo has suggested another possible response to low-level stimulation, namely, that immune cell production may be enhanced by low-dose radiation (*5*). Evidence for increased numbers of lymphocytes in laboratory animals after exposure to low-dose radiation has been presented by several investigators (*6–8*). Whether this immune enhancement results from direct effects on lymphatic tissues or through stimulation of central neuroendocrine regulatory mechanisms deserves investigation.

Epidemiological studies of human populations exposed to relatively low doses of ionizing radiation have not shown the existence or absence of low-dose effects. For example, the studies of populations living in areas of high natural background radiation have not shown any increase in adverse health effects (*9*). In the absence of observable effects, it has nevertheless been assumed that low-level exposures produce the same harmful effects as those seen at high levels of exposure, but with lower frequency. This assumption has become the accepted radiation paradigm, justified on the basis of prudence, and on certain laboratory observations of mutagenic effects of ionizing radiation at relatively low doses. Beginning in the 1950s, fear of genetic effects, together with the associated "target theory" of radiation injury, have continued to dominate radiation protection thinking. As a result, substantial efforts are made to reduce or avoid small exposures, even exceedingly small exposures, to workers and members of the public.

In more recent years, accumulated experience has tended to reduce fears of the mutagenic effects of low-dose ionizing radiation. Direct observations of mutagenesis in human populations have shown humans to be one-fourth as sensitive as expected from previous indirect estimates based on rodent studies. Furthermore, although some findings are suggestive, genetic studies of survivors of the atomic bombings have failed to produce statistically significant findings (*10*). Finally, while radiation damage to DNA was once thought to be irreparable, and radiation uniquely dangerous, we now know such damage from a great variety of agents to be common. We also now recognize the remarkable efficacy of DNA repair mechanisms (*11*). Because of these protective mechanisms, DNA appears not to be fragile, but highly resilient.

An alternative model in which low-level radiation is not harmful, but could under certain circumstances produce net benefits, is plausible. The stimulatory effect of low doses of a wide variety of chemical agents on the growth of organisms had been noted by Hugo Arndt and Rudolph Schultz, German biologists, in the 19th century. They considered the phenomenon to be universal. More recently, these earlier observations have been extended to include increased longevity of animals exposed to low doses of agents toxic at high doses (*12*). In 1940, the term "hormesis" was coined to describe this stimulatory effect. In 1979, Luckey collected some 1200 references supporting the existence of hormetic effects from exposure to low doses of radiation (*13*). Much of this literature was reviewed at a conference held in Oakland, California, in August of 1985 (*14*). The proceedings of a second recent conference on low-dose radiation and the immune system are also available (*15*). At neither of these meetings was a consensus reached regarding the existence of hormetic effects; however, there does appear to be a movement away from an attitude of general skepticism to one of a new willingness to consider the evidence.

Although it may be premature to revise public health policy on the basis of the newer observations cited above, it would seem prudent that the scientific community reexamine the paradigm. Failure to examine a stimulatory response to low-dose radiation could result in neglect of important biological and possibly clinically important information regarding immune function.

Finally, further research to resolve uncertainty about the health effects of low-dose radiation would provide improved guidance for public health policy on very low-dose radiation. This is especially important when, for example, literally tens of billions of dollars are

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being sought by one federal program alone for the purpose of reducing exposure to low levels of radiation and chemical wastes on the basis of largely hypothetical health risks (*16*).

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phocytes exposed to 1 cGy of x-rays shows that certain proteins are absent in all control cultures, but are reproducibly present in all irradiated cultures. These proteins represent excellent candidates for being the induced enzymes needed for the repair of the cytogenetic damage.

Nevertheless, the fact that a protein (enzyme) involved in repair can be induced by very low doses of radiation does not necessarily mean that these doses are in and of themselves "good" or hormetic. Several new proteins were found to have been induced, which indicates that the metabolism of the cells had been changed. Some of these proteins might have a metabolic effect of their own, and could possibly lead to a cascade effect whereby subsequent metabolic steps unrelated to the induced repair would be altered. To call this beneficial would be premature, indeed.

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Twenty years ago, maverick biochemist Bruce Ames warned against the health hazards of man-made chemicals in our foods and in the environment. Now he says most of the effort to control those cancer-causing substances is a waste of time and money, and that such "natural" foods as oranges and peanut butter are just as—or more—dangerous. What's up, doc?

By EDWARD EDELSON

Bruce Ames is eating an orange, methodically chewing the slices in the hope it will help fight his cold. He looks at it and says reflectively, "D-limonene. That's the main ingredient in citrus oil; it gets into all the orange juice. It's a carcinogen." He eats another slice. "People don't want to come to grips with a world that is full of carcinogens. I'm going to rub their noses in it."

The scene is Ames's home in Berkeley, a few blocks from the University of California campus where he is chairman of the biochemistry department. It's as placid a California as anyone could want on a sunny spring day.

But from Bruce Ames's point of view, it's a scene of unremitting chemical warfare, no less violent because it's nature's own. From the orange in his hand to the plants in his garden to the produce in the health store a few blocks away, Ames sees a plethora of cancer-causing chemicals so dangerous that almost anything humans add to the witches' brew is trivial by comparison.

Ames has been preaching this gospel for several years in scientific journals and public forums, arguing from chemical principles that most of the billions being spent to control industrial pollution and keep pesticides out of the diet are wasted as far as cancer prevention is concerned. Ames makes a few exceptions, notably cigarette smoking and some kinds of occupational exposure. But otherwise he thinks pollution prevention money is being misspent because regulators and environmental zealots are ignoring the realities of nature's chemistry. And he thinks that the animal tests used to predict a chemical's carcinogenic potential in humans are just about worthless.

It's a controversial position—all the more controversial because not much more than a decade ago Ames was preaching just the opposite in equally fervent terms. Renowned as the inventor of the Ames test, a quick and cheap way to identify industrial carcinogens, Ames began as a crusader against the dangers of food additives and other man-made chemicals. When I interviewed him on the Berkeley campus in the 1970s, a can of diet soda was tacked to the wall in his office to display its long list of ingredients. Now the man who questioned such chemicals as cyclamates looks askance at oranges and celery. In scientific terms, his conversion is as radical as the evolution of a young Communist to a middle-aged reactionary.

A load of nonsense?

His critics say Ames now is talking "just a load of nonsense, for a variety of reasons" in the words of Samuel Epstein, a University of Illinois researcher who delights in contrasting what Ames says now with what he said in the 1970s. "If you talk to most of the really good people in carcinogenesis, they're very wary of what he's saying," says Marvin Legator of the University of Texas at Galveston. "I don't think you'd find anyone who'd agree with him."

But Robert M. Hollingworth, who heads the pesticide Research Center at Michigan State University, says, "To someone with an open mind, Bruce Ames's arguments have support." And Clark Heath, an epidemiologist at the American Cancer Society, says, "My general feeling is rather like his."

Before he got involved with the chemistry of cancer, Ames's career followed the conventional route of many a bright New Yorker: the Bronx High School of Science, Cornell University, California Institute of Technology, the National Institutes of Health, the University of California at Berkeley. "And then," he says wryly, "at some point I began reading too many labels on packets of potato chips."

Like everyone else, Ames knew the chemical industry was spewing out a vast variety of new compounds, most of which, because of time and money, had not been tested for carcinogenicity. To do such a test, you used laboratory animals—a hundred or so rats or mice, who were fed the maximum amount of a chemical that they could tolerate without getting very sick or dying. After a year or more of feeding, carcinogenicity was assessed by determining how many of the animals had developed cancers.

Aside from the hellish expense, animal tests aren't always easy to evaluate. There's always a certain natural rate of tumor occurrence, and picking a cancer-causing signal out of the biological noise isn't always easy. A recent case offers a vivid illustration. The big dither last year about Alar, a chemical growers sprayed on apples to retard ripening, occurred because the EPA's expert panel of scientists couldn't make sense out of the animal studies that indicate Alar was carcinogenic. So the EPA delayed a decision. Alar now is effectively off the market.

And cyclamates, the artificial sweeteners banned two decades ago, might be back on the shelves soon because the FDA thinks the original animal tests didn't prove what they were supposed to.

The better test Bruce Ames decided to invent is based on a belief that cancer can be explained in straightforward chemical terms—the biochemistry of changes in DNA, the molecule that carries genetic information.

Human DNA is a long string of a molecule that contains the code for 50,000 to 100,000 genes, each of which governs production of an essential protein. Ames's starting point was the logical supposition that cancer occurs

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when one of those genes is changed by a chemical mutation, so that it starts turning out an abnormal protein. Putting it formally, a carcinogen would also be a mutagen.

Mutated bacteria

"In the lab we were mutating bacteria all the time, changing genes," Ames recalls. "So I thought maybe as a hobby I'd start using our bacterial system to detect mutagens."

Ames used a bacterium that was deliberately mutated so it needed an amino acid called histidine to survive. (Normal bacteria can make their own histidine; Ames's mutated version couldn't.) The Ames test is brilliantly simple in concept: Grow mutated bacteria in a dish, feeding them just enough histidine for survival. Add a suspected chemical to the dish. If it's a mutagen, some of the bacteria that mutate will regain the ability to make histidine because the abnormal gene gets changed back to normal. Those bacteria will grow like crazy, creating large colonies on the dish. Just count the colonies, and you can measure whether the chemical is a mutagen, and hence a carcinogen.

Ames started working on the test in the 1960s. It took him about a decade to develop it to the stage that a laboratory technician could do it in a matter of days. The chemical industry grabbed at the Ames test, delighted that it could assess a chemical in a few days rather than spending a year and a million dollars. Ames didn't make any money from his invention because he didn't patent it—biochemists weren't as money-minded a few years ago as they are now—but he did pick up a shelf of awards and a major reputation. Ames and others published lots of scientific papers showing that a high percentage of industrial chemicals were mutagens, sign of a dangerous man-made world.

Then came a disturbing discovery. Takashi Sugamura, head of Japan's National Cancer Institute, was watching his wife cook fish on a charcoal broiler one day when he decided to test the compounds formed as the fish turned brown. The stuff he scraped off the surface of the fish was magnificently mutagenic in the Ames test. Sugamura put some scientists to work isolating more compounds from cooked fish. They were mutagenic too.

"So that meant whenever you cook your food you make mutagens," says Ames. "In retrospect, that makes sense because you get a mixture of thousands and thousands of compounds when you cook food. Think of all the black material in a cup of coffee; it's full of mutagens. Sugamura showed there are a couple of mutagens in coffee that are also carcinogens. Other people showed that the outside of your nice French bread, all that brown color, is full of mutagens. People testing plant products were finding all kinds of mutagens. So my thinking started to change a bit because we were getting a different picture of the world."

"Change a bit," is an understated way of describing what became a revolution. After all, this was the Bruce Ames who had once proposed that there was no safety threshold for industrial chemicals.

"We are doing an eighty-billion-dollar pollution experiment with no controls"

In 1971 Ames wrote a scientific paper saying "one molecule of a mutagen is enough to cause a mutation." In 1972 he tested tris, a chemical being used to make children's pajamas flame-resistant, found it to be mutagenic, and started a hulabaloo that had tris banned. Around the same time he ran some hair dyes through the Ames test. They flunked, and manufacturers reformulated their products to take out the guilty dyes. As late as 1977, Ames was writing that ethylene dibromide (EDB), used to fumigate fruit, should be banned because of its chemical resemblance to tris.

But in 1983, Ames published the first of what's turned into a long series of scientific papers emphasizing the dangers of natural carcinogens and absolving industrial chemicals from blame for increased cancer rates. Indeed, he wrote in one journal, "there is no good evidence that there is any increase in cancer due to the modern industrial world."

Behind this drastic turnabout is a beautifully interlocking theory that Ames says he was led to by the hard biochemical facts of the real world.

First, there's a lot of nasty stuff in nature. "There's a war between plants and animals," says Ames. "Plant people knew that plants were full of toxins to kill off insects. A plant doesn't have teeth, it doesn't have claws, it can't run away, it doesn't have an immune system. So all plant evolution is chemical warfare. Plants are much better chemists than Dow or Monsanto. They've been at it a long time, so every plant has thirty or forty of these chemicals that tend to be present in parts per thousand or parts per million."

Second, the resulting DNA mutation rates in the animals that eat the plants are enormous. Why, then, aren't we all loaded with tumors?

The answer, Ames says, is that animal cells have developed their own defenses. One is to repair DNA like mad. Another is to get rid of damaged cells as fast as possible. "The whole lining of your digestive system is thrown away every day," says Ames. "The surface of your mouth, the surface of your esophagus, the surface of your stomach, colon, intestine. You have these stem cells down there, they're dividing, and the surface cells get sloughed off."

How tough is Bruce Ames's world? Well, for starters, he sees no difference between getting a dose of radiation and breathing. "I've been thinking of oxygen as the critical thing because oxygen is the electron receptor that generates energy. To generate energy in the cell you have to add four electrons to oxygen to make water. You're pulling electrons out of sugars, and you have to put them somewhere, so you put them in oxygen.

Dangerous breathing

"That's a tricky process. If you add electrons one at a time, you're in trouble because you make superoxide, hydrogen peroxide, and hydroxyl radicals. They're all mutagens. They're dangerous. Radiation is a mutagen because it splits water and produces these same things. So in fact, living is the same as getting radiated."

That conclusion leads sequentially to Ames's opinion about animal cancer tests, which is low—again, he says, because of the basic chemical principles. One of his criticisms is that the MTD, maximum tolerated dose, is used in those tests. "The MTD has bothered toxicologists for years," he says. "All their training is that everything is a poison. Every chemical is toxic at some dose. A certain amount of aspirin will kill you, and a certain amount is all right."

But his major criticism is that animal tests are done almost exclusively for synthetic chemicals, not the natural stuff found in nature. About half the synthetic chemicals tested in animals have been found to be carcinogens. Ames's major effort of the 1980s has been to show that these results aren't as alarming as they seem because nature is just as malevolent.

One thing he did was set up a computerized data base of animal cancer tests, with government financing. He and Lois Gold, one of his colleagues, have about 4,000 tests in the data base. They can use it not only to tell whether a chemical tested positive for carcinogenicity but also to measure its virulence.

Calculating danger

And from that value comes Ames's "daily Human Exposure dose/Rodent Potency dose," abbreviated HERP. It's his way of computing chemical dangers. He takes the estimated daily dose of a chemical that will cause cancer in one-half of a group of test animals. He compares that with the estimated daily dose that humans get of a given chemical. The result is a percentage that gives the carcinogenic danger of the chemical.

Some of the HERP numbers are startling. So is the way in which Ames uses them. For example, there's his reasoning about trichloroethylene, the solvent that's caused major alarms because it's been found in wells in California's Silicon Valley and Woburn, Mass. Wells have been closed; suits have been filed.

"Woburn—that water was safer than ordinary tap water," says Ames. "Most tap water in the United States is eighty-three parts per billion in chloroform, that comes from chlorination. Trichloroethylene is ten times weaker as a carcinogen. Trichloroethylene replaced flammable solvents. We can't go back to cleaning our clothes in flammable solvents.

"What you pay for a modern technological society is you get a little trichloroethylene in your water. You can get out that last part per billion at enormous cost, but it wouldn't be worth it."

Or, as he wrote in a scientific paper: "Water from the most polluted well... has a HERP value orders of magnitude less than for carcinogens in an equal volume of cola, beer, or wine. Its HERP value is also much lower than ...the average peanut butter sandwich."

Follow his reasoning on Alar. Ames calculates a lifetime HERP of 0.0017 percent from Alar for anyone who drinks six ounces of apple juice every day. "This possible hazard is less than from the natural carcinogenic hydrazines consumed in one daily mushroom [HERP=0.1 percent] or that from aflatoxin in a daily peanut butter sandwich [HERP=0.03 percent]," says Ames. In addition, apples that aren't treated with Alar are more susceptible to mold formation, he says. "I'd rather take my chances with Alar than all the mold carcinogens."

Natural poisons

Ames has a few favorite stories about nature's natural poisons. One concerns the rash (literally) of complaints about dermatitis from supermarket workers who were handling a new variety of insect-resistant celery introduced to reduce the use of pesticides. Tests showed the celery fought off insects because it had 9,000 parts per billion of psoralens, natural pesticides that are also carcinogens. In Ames's book, that's a net increase in human exposure to carcinogens in the name of environmental purity.

Ames can (and does) go on and on about carcinogens in pure food. Shrimp contain formaldehyde. Basil contains estragole. Apple juice contains 125 volatile compounds. Five of them have been tested, and three are carcinogens. The chemical that makes mustard pungent is a carcinogen.

Abandon hope? No, there's plenty of reason for hope, if we choose the right targets, Ames says. An example is his approach to ethylene dibromide. He testified in California that its industrial use should be banned because workers were getting excess exposure. "The workers breathe in 20,000 liters of air a day but you only drink one liter of water a day," he explains. "If there's one part per million in the water and one part per million in the air, that's a 20,000-fold difference. EDB workers were allowed to get half the same dose that was giving half the mice and rats cancer. I testified it was outrageous, and California lowered the exposure limit a hundredfold after my testimony.

"But the EPA outlawed EDB because of its residues in grain, and that was 0.001 percent on our HERP scale. I thought *that* was outrageous."

From there, Ames moves on to a sweeping attack against what he sees as misplaced priorities: "We're doing an eighty-billion-dollar experiment with no controls. Eighty billion is what we spend a year on pollution control. But the total amount of basic research in the United States is only 8.6 billion dollars. The eighty-billion-dollar experiment hurts our competitiveness, it's done inefficiently, it's mainly sold on a health basis, and I don't think any of that is going to be right."

Ames's numerous critics point out that much pollution control spending —on acid rain, for example—has nothing to do with cancer prevention. And they give him a vigorous argument on his cancer calculations.

"Some recent studies indicate that our extrapolations made from animal tests are not conservative, but, if anything, are not stringent enough," says Marvin Legator of the University of Texas. "And if you take into account that most of our chemicals have not been evaluated, what's happened in the past five or six years when we've found a number of potent carcinogens is incredible. Ames's present position, it just doesn't make sense."

But Clark Heath of the American Cancer Society buys a lot of the Ames argument. "If you compare animal assay results on man-made chemicals, you can't help but feel that man-made things are on the minor side compared with things in the diet in terms of concentration and amount," he says. "The concern that arises time and again about the hazards of man-made chemicals does seem out of proportion to the actual hazards as judged by animal experiments."

"A lot of toxicologists would agree in broad, general terms that we disproportionately spend our time looking at a small percentage of the chemicals in the food supply," says Michigan State University's Robert Hollingworth.

Next: aging

And for someone who sees a carcinogen under every leaf, Ames is amazingly hopeful about reducing cancer rates. We've got to concentrate on natural things because the studies that compare cancer rates in different countries indicate that simple changes in diet and living habits—consuming more fiber, for example—can have major effects, he says.

When he gets cancer out of the way, Ames would like to tackle the biochemistry of aging. A lot of what happens when cells grow old has to do with the kind of oxidants that cause cancer, he believes.

"Before my neurons go out, I'd like to crack aging," says Ames. And ate another slice of orange. ■

Academy Panel Raises Radiation Risk Estimate

What was once an extreme view becomes mainstream as statisticians recalculate the effects of the Japanese atomic blasts

THE MILLS OF the National Academy of Sciences may be slow, but they sometimes grind exceedingly fine. In December they produced a 421-page report* that pulverizes an argument made by a group of experts 10 years ago that the dangers of low-level radiation were being exaggerated.

The new study concludes that the risks have been underestimated until now. Not only that, but it says that the likelihood of getting cancer after being exposed to a low dose of radiation is three to four times higher than that given in the earlier Academy report, which itself was denounced by some old hands at the time as alarmist. Thus, an evolving scientific understanding of health effects has made the alarmist viewpoint of the 1970s appear moderate today and it has given some former alarmists a chance to say "I told you so" about their predictions.

The person responsible for bringing this risk assessment to a soft landing—unlike the last one in 1979 which shattered on impact—is Arthur C. Upton, the unflappable chairman of the Academy's fifth committee on the Biological Effects of Ionizing Radiation (or BEIR V). Upton, who heads the Institute of Environmental Medicine at New York University, is scrupulously balanced in his presentation of these issues. This helps to explain why his group was able to reach a consensus while the last one, BEIR III of 1979–1980, broke into factions.

BEIR V deals with low levels of penetrating radiation that impinge on humans from outside the body, essentially x-rays, neutrons, and gamma rays, which make up the bulk of the public threat that has concerned health officials in the past. A special study issued last year, BEIR IV, deals with a different problem that gets increasing attention these days—internal short-range "alpha" radiation primarily from radon gas. Thus, while BEIR IV has implications for clearing the air in homes and uranium mines, BEIR V has implications for policing man-made sources such as medical diagnostic machines and the nuclear industry.

Although BEIR V was not officially asked to comment on public safety, Upton said at a press conference that he expected there would be "some response" from regulatory authorities in the form of tighter standards. At least one activist group, the Nuclear Information and Resource Service of Washington, D.C., is already citing the new BEIR V data as it seeks to prevent federal deregulation of very low-level radioactive waste streams (emitting less than 10 millirem per year). Warren Sinclair, president of the National Council on Radiation Protection and Measurements, an industry advisory body, says that given the "pressure" of BEIR V, his council "might very well feel that now is the time" to reduce the maximum occupational exposure limit from 5 rem per year to something less.

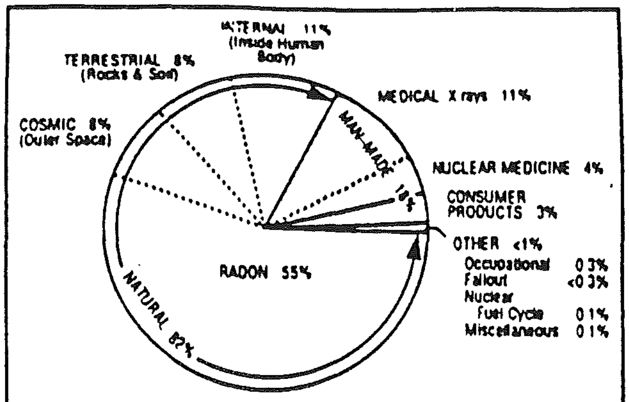
Even so, perhaps in the interests of preserving calm, Upton takes a low-key approach to the implications of his report. "There has been no revolution in the assessment of risk, no frightening increase [in the perceived health effects]," Upton told an audience at the Academy on 19 December. But he said it is possible to be much more specific about the degree of risk now because there has been a tremendous improvement in three areas of analysis. The most

Unflappable chairman. *Arthur Upton's steady direction helped achieve a consensus.*

*"Health Effects of Exposure to Low Levels of Ionizing Radiation" (National Academy Press, Washington, D.C., 1990).

important is that researchers have been able to accumulate another decade of mortality data from Japan, where survivors of the Hiroshima and Nagasaki atom bomb attacks are watched closely for the aftereffects of the radiation they received in 1945. The other two changes are an improved calculation of the radiation released by the two bombs and a more sophisticated computer model of risk designed specifically for this report.

The shift began with the most tangible of all data: the body count. According to a committee member who helped write both reports, Jacob I. Fabrikant of the University of California at Berkeley, "More cancers are appearing than we predicted" in BEIR III.



U.S. Sources of Ionizing Radiation
(Source: National Council on Radiation Protection and Measurements)

Where the risk begins. *Most of the radiation hazard, as far as public health is concerned, comes from natural sources such as radon.*

Meanwhile, physicists were making huge changes in the estimates of the amount of radiation released in Hiroshima and Nagasaki. In the early 1980s, researchers at the Lawrence Livermore National Laboratory uncovered problems with calculations made in the 1960s of the amount of gamma rays and neutrons released when the bombs detonated. The more they looked, the more inaccuracies they found. In the end, the governments of Japan and the United States decided to pour several million dollars into a complete revision of the dose estimates.

The leaders of the dosimetry revision at the Radiation Effects Research Foundation of Japan went to "incredible and unbelievable" lengths to ensure accuracy this time, Fabrikant says. For example, roof tiles from buildings at various distances from the epicenter of the blast were subjected to a new "thermal luminescence" examination to determine exactly how many gamma rays hit them on 6 and 9 August 1945. The results were double-checked by laboratories in several countries. The shielding provided by air, humidity, windows, walls, and roofs was recalculated. The doses received by the 95,000 survivors were individually reconstructed, taking into account whether the person was facing or turned away from the blast, and, if sideways, which side of the body was exposed. Today, researchers are intent on recalculating the radiation doses to the survivors' individual organs.

Although the new Japanese dosimetry reshuffled all the cards in the deck, it made two changes of broad significance. It eliminated neutrons from the picture almost entirely, meaning that gamma rays alone were responsible for most of the health effects. This greatly simplified and strengthened the association between low-level gamma radiation and cancer. In addition, it lowered the overall level of gamma rays in one of the bombed cities by about a factor of 2, meaning that the gamma radiation must have been more potent than realized before.

When it came time to link these dose estimates together with the cancer data in a model that could be used to project effects at low doses, the BEIR V committee found that it could not fit the new information to old mathematical constructs. Even the models used as recently as 1988 by the United Nations Committee on the Effects of Atomic Radiation were unworkable. Instead, the committee turned to a new model developed by statisticians Dale Preston and Donald Pierce with a program they wrote.

David G. Hoel of the National Institute of Environmental Health Sciences, the committee member who led this mathematical subgroup, says, "We pretty much started de novo," tossing out all the equations that had been used before. The BEIR III committee, he says, used "lots of different models," including a linear-quadratic formula that assumes the effects are negligible at low doses and climb steeply at higher doses. Looking back on that effort, Hoel says, "The data didn't really fit the model." One can see at a glance that the solid tumors "are all clearly linear," fitting on a straight-line pattern of decreasing effect with decreasing dose. Hoel says: "There wasn't any suggestion that we should have a threshold value" for doses below which one would expect to see no detrimental effects. The leukemia effects, however, are best described by a linear-quadratic curve.

For individuals, BEIR V calculates risk in terms of many variables, including sex, age at exposure, time since exposure, dose rate, and so on. But for purposes of whole population exposures as might occur in a nuclear accident or during war, it provides a general lifetime risk factor for all types of cancer of 0.8% for a single exposure of 0.1 Sievert (10 rem). This means that in a population of 100,000 people exposed to 10 rem of radiation, roughly 21,000 would die of cancer, and probably 800 of those cancers could be blamed on radiation.

The BEIR V results seem to vindicate the chairman of the previous BEIR panel, Edward P. Radford, who fought bitterly with what he calls a "rump group" of his committee and ended up in a quarrelsome press conference at the Academy on 2 May 1979. He had wanted to use a simple linear model to express risks, extrapolating straight down from the highest dose-response patterns (which are well established) to the lowest dose effects. He also held out for the use of a "relative risk" model, which would have multiplied (rather than added) a risk factor with the normal cancer rate to express the effects of radiation.

But a group of six dissidents in the committee led by Harald Rossi of Columbia University argued that these measures would exaggerate the risks. They argued that the cancer effects at low doses are unknown and probably do not follow a straight line projected down from the high-dose effects. Rossi argued that the committee should not try to set a single risk factor under the threshold of 10 rad, below which he considered the risks negligible.

The factions carried their quarrel into the auditorium at the Academy and from there to the pages of scholarly journals. They never reached agreement. Behind the scenes, Fabrikant was asked to serve as chairman of a subgroup to clean up the mess. In 14 months he put together a final report—BEIR III—which included dissenting statements from Radford and Rossi.

Although Radford believes his position has been justified retroactively by BEIR V's decision to use a linear, no-threshold, relative risk model for solid tumors, Fabrikant disagrees. "That's Mickey Mouse," he says, "or more like Donald Duck. Radford quacks a lot. Don't pay attention to it." Radford has "a very singular concept that if you draw a straight line, all the dots fit on the line. He has no understanding of the complex aspects" of risk estimation, Fabrikant says. Furthermore, he argues that the data available to BEIR III in 1979 simply did not justify this approach. According to Fabrikant, it's like saying, "in the absence of data, I was clairvoyant. . . . We have done things in BEIR V that we couldn't conceivably have done before." ■ ELIOT MARSHALL

Low-Dose Radiation Exposure

We wish to clarify what may have been a widespread misunderstanding about severe mental retardation as an effect of low-dose ionizing radiation. The National Research Council issued a press release and held a press conference at the time it published the report of its Committee on the Biological Effects of Ionizing Radiation (BEIR V). On the basis of the press release, newspapers and telecasts informed the public that low-dose radiation exposure at 8 to 15 weeks of gestational age can cause mental retardation. Actually, the committee's statistical analysis of a linear model pertaining to severe mental retardation suggested "that a threshold may exist at 0.2–0.4 Gy [gray] (20–40 rad)" (*1*). The accompanying graph in the report showed little, if any, increase in retardation among persons who received less than 0.50 to 0.99 Gy (50 to 99 rad) as compared with controls.

The press release, under the heading "Mental retardation effects" was concerned, not with mental retardation as it is usually understood, but with reduction of IQ test scores and with the school performance of children in the first grade who had been exposed in utero to the atomic bomb in Japan. The estimated IQ loss was 21 to 29 points per gray, or 0.2 to 0.3 IQ points per rad. Rarely does a fetus receive more than 1 rad from diagnostic examination of the mothers abdomen during pregnancy (*2*).

The news reports contributed to an unjustified fear of essential radiological studies during pregnancy. No measurable impairment of brain function is to be expected from prenatal exposure to doses as low as those received from diagnostic x-rays.

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2. *Exposure of the U.S. Population from Diagnostic Medical Radiation*, (National Council on Radiation Protection and Measurements, Bethesda, MD, 1989), report 100, fig. 3.1; J. G. Kereiakes and M. Rosenstein, *Handbook of Radiation Doses in Nuclear Medicine and Diagnostic X-Ray*, (CRC Press, Boca Raton, FL, 1980), table 102.

Eliot Marshall's article "Academy panel raises radiation risk estimates" (News & Comment, 5 Jan. p. 22) contains misstatements about me and about BEIR III. Since I take the view that radiation risks at doses of less than 0.1 gray (10 rads) are unknown, I have never declared or considered them to be "negligible." The number of dissidents in the BEIR III committee was larger than six, although it was never clear how many there were. I do not remember who first proposed a lower dose limit for risk estimates, but it was not I. I do remember that the committee was unanimous on that matter.

My position remains as valid now as it was then. Lowered dose estimates, a higher sensitivity of the young, and the (apparently appropriate) adoption of the relative risk model increase the estimates of radiation cancer risk in Hiroshima and Nagasaki. It is nevertheless unlikely that we will ever be able to evaluate the effects of low doses of ionizing radiation on the basis of epidemiology. The most persuasive aspect of extrapolations is that statistical limitations as well as other uncertainties make it impossible to discern the effects of doses that are less than about 0.1 Gy. In animals exposed to moderate radiation doses, cancer incidences that are both higher and lower than those in the control population have been demonstrated with high probability. The latter phenomenon, sometimes termed "hormesis," has caused an increasing number of people to speculate that low radiation doses may pose a risk that is less than negligible. At present this position is neither more nor less unreliable than the claim of a proportional relation for doses below 0.1 Gy.

The postulate that this relation applies to cancers in humans (except for leukemia, where incidence is high and statistical uncertainty therefore lower) is merely an article of faith. In the absence of tangible information it may be adopted in stipulating "risks" in connection with radiation protection (*1*), but any claim that these risks are actual rather than nominal cannot be supported by science but only by "political science."

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1. H. H. Rossi, "Limitation and assessment in radiation protection" (Lauriston S. Taylor Lecture No. 8, National Council on Radiation Protection and Measurements, Bethesda, MD, 1984).

BEIR V: Implications for the Nuclear Workforce

The National Academy of Sciences fifth report on the biological effects of ionizing radiation (BEIR V) (*1*) (News & Comment, 5 Jan., p. 22) indicates a need for "tighter" control of nuclear worker exposure. But BEIR V's "increased risk" needs modification when applied to male adults in the nuclear workforce for the following reasons.

1) The BEIR V risk assessment is based on statistical analysis of cancer mortality among atomic bomb survivors in Hiroshima and Nagasaki. The latest Radiation Effects Research Foundation (RERF) report (*2*) shows a computed excess of 252 cancer deaths among 5734 nonleukemic cancer deaths. Some 74 of 2007 observed stomach cancer deaths are attributed to radiation. Had Americans (whose incidence of stomach cancer is much lower than that of the Japanese) been exposed at Hiroshima and Nagasaki, the number 74 would have been less than 10.

2) Tables 2-5 through 2-33 in (*2*) tabulate risk for 27 types of cancer—an average of less than 10 excess cancer deaths per cancer type observed from 1950 through 1985. The number of male cancer deaths is much smaller because 3 of every 5 survivors are female and 56 excess deaths are specific to female organs. This leaves an insubstantial statistical basis for assessing male radiation risk.

3) The bulk of the collective exposure (72%) in Hiroshima and Nagasaki was about 50 rem—the mean dose was 132 rem per survivor. The average dose for half a million U.S. nuclear power workers (1969–1988) was 1.2 rem accumulated over the work career. BEIR V statisticians constructed five different models to bridge the gap between these two types of exposure.

4) The atomic bombs produced an instantaneous flash of radiation, whereas U.S. workers accumulate their exposure gradually over several years. BEIR V concedes that this distributed dose could be two to ten times less biologically effective than a single exposure, but it does not incorporate a correction factor in its models. BEIR III (*3*) introduced a 2.25-fold dose effect correction in its model.

5) BEIR V increases risk assessment in part because of greater than expected cancer deaths among those who were under age 20 at the time of bombing. Such an effect would not apply to nuclear workers, who are exposed at an average of less than 30 years of age.

If one takes these factors into account, the BEIR V risk assessment increase of about 350% dwindles to about 70% when applied to the nuclear workforce exposure. Nothing has really happened that would lead to a tightening of radiation controls for a U.S. workforce whose lifetime radiation exposure averages 5% above that to which all Americans are exposed. BEIR V concludes its risk assessment with this final sentence: "At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero" (*1*, p. 181). The risk is speculative and may be zero.

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2. Radiation Effects Research Foundation *Life Span Study Report 11 Part 1* (National Academy Press, Washington, DC, 1989)
3. Committee on the Biological Effects of Ionizing Radiations, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation* (National Academy Press, Washington, DC, 1980).

91. The health and safety issue of the increased severity of a loss-of-pool-water accident if such an accident occurred with increased amounts of spent fuel stored in the pool was discussed by experts of NSP, PIP, and MEA Staff.

92. Two conditions are necessary for an accident to occur in which the spent fuel in the SFP would pose a danger: (1) loss of SFP cooling water; and (2) failure of all backup water supply systems, including lack of access to the pool.

93. PIP witnesses Thompson and Webb alleged that as a result of either a major external event, such as an earthquake, or because of a Prairie Island reactor accident, a loss of water accident could occur in the spent fuel pools. Dr. Thompson is a consultant engineer active in the area of energy and environmental studies; he is a member of the Political Ecology Research Group, Ltd. (a non-profit company) of Oxford, England. He has participated in two public investigations of the hazards of spent fuel storage,

the Windscale Public Inquiry in England and the Gorleben International Review. Dr. Webb has a Ph.D. in nuclear engineering and was previously on the staff of Admiral Rickover in the Division of Naval Reactors of the Atomic Energy Commission. He has written extensively on the accident hazards of nuclear power plants and has served as technical consultant for the township of Lower Allaways Creek in Salem County, New Jersey, which intervened in the Nuclear Regulatory Commission's licensing hearing on the proposal of the Salem Utility to increase spent fuel storage at Salem.

94. PIP witnesses Webb and Thompson also postulated (1) a major accident in one of the Prairie Island reactors, causing (2) the spent fuel pool to become inaccessible, causing (3) the loss of the capability to add makeup water to the pool, followed by (4) the breakdown of the spent fuel pool cooling system from the accident or from an independent cause, resulting in (5) gradual pool boiloff. Dr. Webb also contended that a zirconium fire, and various kinds of explosions, could occur in the pool once most or all of the water had evaporated.

95. PIP presented no evidence as to the likelihood of the initiating events postulated by their witnesses. Dr. Thompson stated that he had not considered probability. PIP witness Webb stated that he does not assign probabilities to mechanisms and that he cannot determine the likelihood of an event without multiple full-scale experiments (which no one has ever conducted).

96. NSP presented substantial and uncontroverted evidence by two panels of witnesses that the types of events postulated by the PIP witnesses are so improbable and remote that they pose a miniscule risk.

97. The testimony of NSP witnesses Drs. Kaplan and Garrick, using probability analysis techniques, estimated that the likelihood that the Prairie Island spent fuel pools would become inaccessible as a result of a serious reactor accident is once in every 200,000 years with a 90% confidence that it would be between once in 10,000 years and once in 4 million years. Moreover, the likelihood that this inaccessibility would cause significant radiation releases from the spent fuel pool was estimated to be once every 400 million years, with 95% confidence that the frequency of inaccessibility is no bigger than once in 17 million years. Dr. Garrick, who has a Ph.D. in nuclear engineering, is an expert in risk assessment, reliability, and nuclear safety analysis, particularly with respect to the application of probabilistic methods. Dr. Kaplan is a mathematician and engineer specializing in risk analysis, decision theory and applied probability in general. The analysis of Drs. Garrick and Kaplan was based upon a review of the particular systems existing at the Prairie Island reactors.

98. MEA Staff witness, Dr. Stratton, a nuclear physicist employed by the Los Alamos Scientific Laboratory, also testified that the probability of a reactor accident causing pool inaccessibility, with loss of coolant and makeup to the pools, is less than once in every 10 million years.

99. The Director notes, however, that certain remote events such as sabotage, war, and social disturbance, could lead to a loss of water in the spent fuel pool. The likelihood of such events have not been, and probably cannot be, quantified.

100. NSP also presented a panel of four witnesses, ("the Gilcrest panel") whose testimony reviewed in a qualitative fashion the risk associated with the accident scenarios postulated by the PIP witnesses. After describing the proposed expansion, the witnesses described and analyzed the Prairie Island fuel storage structure; the spent fuel pool structure's ability to withstand natural phenomena; the spent fuel pool cooling system, including redundant or backup systems available in the event regular cooling should fail; the electrical and backup electrical systems upon which many of the cooling systems rely; the instrumentation which monitors water level and water temperature, and radioactivity condition in the pools; the pool leak detection system; the pool ventilation system; and effects on the pool structure and cooling system from the proposed expansion. All of these safety features of the plant, the pool, and associated systems and structures make the loss-of-water accident hypothesis remote.

101. The Gilcrest panel also evaluated the time available to prevent pool water boiling and evaporation, assuming pool coolant system breakdown. On the basis of these calculations, it is clear that ample time would be available to pump water into the pools, whether through one of the plant cooling systems or by hooking up a water hose to a diesel fire pump or to the Mississippi River, to prevent loss of pool water.

102. A variety of backup water supply systems is available

to replace any loss of water in the pool. Each of these systems is capable of providing water at flowrates in excess of the maximum boil-off rate. These sources include: (1) chemical and volume control system; (2) chemical and volume control system hold-up tanks; (3) refueling water storage tank; (4) reactor makeup water storage tank; (5) demineralized water; and (6) fire protection water.

103. The Gilcrest panel described in detail the kinds of reactor accidents against which the plant and its protective systems are designed to protect. None of these accidents, including the type of accident which occurred at Three Mile Island, would cause pool inaccessibility for a time sufficient to permit pool boiling. Based upon the multiple safety systems incorporated into the plant, including the plant and fuel design, the protective devices and systems provided, and the emergency systems which only respond if the first two defense levels fail, the Gilcrest panel concluded that the pool loss-of-coolant accident hypothesis is so improbable as to be incredible.

104. With regard to the testimony concerning the ability of the Prairie Island spent fuel pool and supporting plant systems and structures to withstand the effects of natural phenomena and accidents affecting the reactor and/or spent fuel pools, the record shows that the proposed expansion of the fuel storage capacity has little or no effect on this ability.

105. Although there was disagreement as to the consequences of a loss-of-water accident, should it occur, the remoteness of the accident makes resolution of the dispute less important. Nevertheless, the Director finds that the testimony of NSP's witness Dr. Dhir

appears to be reasonable. Dr. Dhir has a Ph.D. in mechanical engineering and is currently associate professor in the School of Engineering and Applied Science at UCLA. He has been working in the nuclear mechanical and engineering department at UCLA since 1974.

106. Dr. Dhir's analysis, based on his own extensive calculations, was reviewed by Drs. Kaplan and Garrick and independently verified by another expert in the field. Dr. Thompson, who described his own work as judgmental rather than quantitative in nature, stated that he agreed with Dr. Dhir's approach, although he could not evaluate Dr. Dhir's results without replicating the analysis. Dr. Thompson claimed that Dr. Dhir failed to consider the partial loss of water as the most serious accident case. Dr. Thompson's claim appears to be confirmed by preliminary calculations done by Benjamin et al. in their report to the NRC entitled "Spent Fuel Heatup Following Loss of Water During Storage," (NUREG/CR-0649, March 1979). However, Dr. Dhir's evaluation included the case of a partially filled pool, demonstrating that in that case the pool would eventually boil dry. As to Dr. Webb, his methods and findings have not been substantiated by other scientists. To the contrary, MEA Policy Analysis Staff witness Stratton and several of Dr. Stratton's colleagues, reviewed one of Dr. Webb's submittals on reactor safety and concluded that it should be ignored because it failed to describe a mechanistic series of precursor events, failed to analyze reactor safety, and ignored probabilities.

107. Finally, several other accident hypotheses were briefly raised by various witnesses. MEA Staff witness Dr. Stratton pointed

out the need to ensure sufficient heat removal from the spent fuel pools, as expanded, and to design the storage racks so as to avoid a critical system. The nuclear characteristics of the proposed spent fuel pool expansion are described in the testimony of the Gilcrest panel. In addition, NSP Exhibit 6, which consists of NSP's request to the NRC for a license amendment to expand the spent fuel pool, addressed this question in detail, by describing how the proposed racks would be conservatively designed to prevent criticality. On the basis of the analysis presented by NSP, which will be subject to NRC staff review, the Director believes that the issue of criticality has been satisfactorily considered by NSP.

108. Dr. Webb alleged that a hypothetical reactor power excursion accident had not been given sufficient consideration. The evidence does not support Dr. Webb's opinion given the fact that power excursion accidents are evaluated in the Prairie Island Final Safety Analysis Report (FSAR) and that, to reach the Webb scenario either the reactors would have to violate their operating limits or one would have to assume that boron present in the primary system is absent. The report on which Webb relied states that the "safety implications of the design philosophy of existing and proposed reactors are not in question."

109. Finally, Dr. Webb was concerned about the possibility of the formulation of a fast-neutron reactor and explosion from gross plutonium segregation in the event of a fuel meltdown in the spent fuel pools. Both the Gilcrest panel and Dr. Stratton rejected Webb's gross plutonium segregation hypothesis. Both theoretical and experimental work show that this postulated event could not occur.

110. In conclusion, due consideration has been given by the Director to testimony presented by NSP, PIP, and the MEA Policy Analysis Staff regarding the impact of various accident scenarios, including so-called Class 9 accidents, on the spent fuel pool in light of the proposed expansion. On the basis of the record developed during the proceeding, the Director has determined that the spent fuel pool modification, as proposed, will not materially increase the risk of severe accident and resulting severe radioactive releases occurring in the pools.

APPENDIX 1

added insulation, improved compressor efficiency and controls, and other improvements described in the residential, commercial, and industrial sections. Dairy refrigeration use can also be reduced by precooling fresh warm milk in a heat exchanger or heat pump. The captured heat can then be used to heat or preheat some of the large supply of hot water required in dairying. Further cooling can also be accomplished with a well water heat exchange or with seasonal ice storage.

OTHER SECTORS

Governmental and seasonal residential electric use are included in the "other" sector. Some of the governmental electric uses are similar to commercial uses for offices, hospitals, prisons, and schools. Other governmental uses are more similar to those in industry, such as sewage treatment systems or water supply systems. Seasonal residential electric consumption goes for uses similar to those of regular customers. The reduced occupancy, however, may decrease the cost-effectiveness of some conservation measures.

The conservation potential for the "other" sector is estimated at between 34 to 61 percent, representing the range of conservation potential in the residential, commercial, industrial, and agricultural sectors.

Table 5 summarizes the technical savings potential for all the sectors. The end uses by sector are in the first column. The current percentage of use by end use is in the second column. The third column lists the percentage of conservation potential for each end use and the achievable kWh savings are found in the fourth column. The total savings estimate of 52 percent includes a wide array of specific efficiency improvements for each sector and end use of electricity.

from:

<u>Minnesota's Energy Options For the 1990s</u>

Minnesota Department of Public Service

December, 1988

Table 5

Conservation Potential by Sector, by End-Use[1]

End-Use	Percent of Use	Conservation Potential (%)	kWh Savings Potential (%)
Residential, Including Farm Residences			
Main Source Space Heat	3.4%	50%	1.7%
Dual-Fuel Space Heat	0.9%	50%	0.5%
Water Heat	6.2%	70%	4.4%
Central AC	1.2%	35%	0.4%
Room AC	0.5%	35%	0.2%
Refrigerators (Total)	5.9%	80%	4.7%
Freezer	1.2%	60%	1.3%
Electric Range	1.9%	40%	0.8%
Clothes Dryer	1.9%	65%	1.2%
Dishwasher	0.3%	85%	0.3%
Waterbed Heater	0.8%	43%	0.3%
Lighting	3.3%	50%	1.7%
Miscellaneous	1.4%		0.0%
TOTAL Residential & Farm	29.7%	58%	17.2%
Commercial			
Space Heat	1.7%	40%	0.7%
Water Heat	0.6%	80%	0.5%
Cooling	3.6%	50%	1.8%
Ventilation	2.9%	50%	1.5%
Refrigeration	3.1%	80%	2.5%
Cooking	0.7%	40%	0.3%
Lighting	14.1%	81%	11.4%
Miscellaneous	3.4%		0.0%
TOTAL Commercial	30.0%	62%	18.5%
Industrial			
Space Heat	0.4%	40%	0.2%
Water Heat	0.1%	80%	0.1%
Cooling	0.9%	50%	0.5%
Ventilation	0.9%	50%	0.5%
Refrigeration	1.1%	70%	0.8%
Process	2.2%		0.0%
Motors	19.8%	30%	5.9%
Lighting	1.9%	85%	1.6%
Miscellaneous	0.4%		0.0%
TOTAL Industrial	27.5%	35%	9.5%
Agricultural Uses	2.5%	48%	1.2%
Other (Government Sales, Seasonal Residential, etc.)	10.2%	50%	5.1%
TOTAL Minnesota[2]	100.0%	52%	51.5%

1. Percentage savings estimates for cooling and residential air conditioning include savings from more efficient lighting and other appliances. Less waste heat from several end uses can reduce cooling requirements.

2. Percentages are for the seven largest Minnesota generation and transmission utilities, which supply 94 percent of state electric use.

APPENDIX 2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

February 1, 1990

NRC INFORMATION NOTICE NO. 90-08: KR-85 HAZARDS FROM DECAYED FUEL

Addressees:

All holders of operating licenses or construction permits for nuclear power reactors and holders of licenses for permanently shutdown facilities with fuel on site.

Purpose:

This information notice alerts addressees to potential problems resulting from the accidental release of Kr-85 from decayed fuel. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

During the licensing reviews for the Oconee independent spent fuel storage installation, and in the decommissioning of the La Crosse and Dresden Unit 1 power reactors, the NRC staff analyzed the radiological hazards associated with the gases in decayed spent fuel. The age of the nuclear power industry and the lack of a permanent repository for spent fuel have resulted in the accumulation of decayed spent fuel. Decayed spent fuel is manipulated after long shutdowns of operating reactors, during spent fuel pool re-racking, during movement to alternate reactor sites or independent spent fuel storage installations, and during decommissioning. Analysis of hypothetical accidents involving decayed spent fuel has focused attention on potential difficulties that could be associated with the exposure of onsite personnel to an accidental release of Kr-85. Kr-85 is a noble gas fission product that is present in the gaps between the fuel pellets and the cladding. It has a 10.76-year half-life, and, as a result of the considerably shorter half-lives of virtually all other gaseous fission products (I-129 being the exception, but in low abundance), Kr-85 becomes increasingly the dominant nuclide in the accident source term for gap releases as decay times increase. After 2 weeks of decay, Kr-85 is a significant nuclide in the source term, and after 190 days of decay, it is the predominant gaseous nuclide for a gap release. The unusual decay characteristics of Kr-85 give cause for focusing attention on the onsite consequences of a gap release from decayed fuel.

Discussion:

Kr-85 emits beta radiation with a maximum energy of 0.67 MeV for 99.6 percent of the decays and 0.51 MeV gamma radiation for 0.4 percent of the decays. Consequently, direct exposure to this gas would result in a dose to the skin approximately 100 times the whole-body dose. Analysis of the relative consequences (in terms of radiological doses) of a cask-drop accident as a function of decay time of the fuel is illustrated in Figure 1. In the event of a serious accident involving decayed spent fuel, protective actions would be needed for personnel on site, while offsite doses (assuming an exclusion area radius of 1 mile from the plant site) would be well below the Environmental Protection Agency's Protective Action Guides. Accordingly, it is important to be able to properly survey and monitor for Kr-85, and to assess the skin dose to workers who could be exposed to Kr-85 in the event of an accident with decayed spent fuel.

Licensees may wish to reevaluate whether Emergency Action Levels specified in the emergency plan and procedures governing decayed fuel-handling activities appropriately focus on concern for onsite workers and Kr-85 releases in areas where decayed spent fuel accidents could occur, for example, the spent fuel pool working floor. Furthermore, licensees may wish to determine if emergency plans and corresponding implementing procedures address the means for limiting radiological exposures of onsite personnel who are in other areas of the plant. Among other things, moving onsite personnel away from the plume and shutting off building air intakes downwind from the source may be appropriate.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate NRR project manager.

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Charles S. Hinson, NRR
(301) 492-3142

Robert A. Meck, RES
(301) 492-3737

Attachments:
1. Figure 1, Dose Consequences of a Spent Fuel Drop Accident
2. List of Recently Issued NRC Information Notices

DOSE CONSEQUENCES OF A SPENT FUEL DROP ACCIDENT

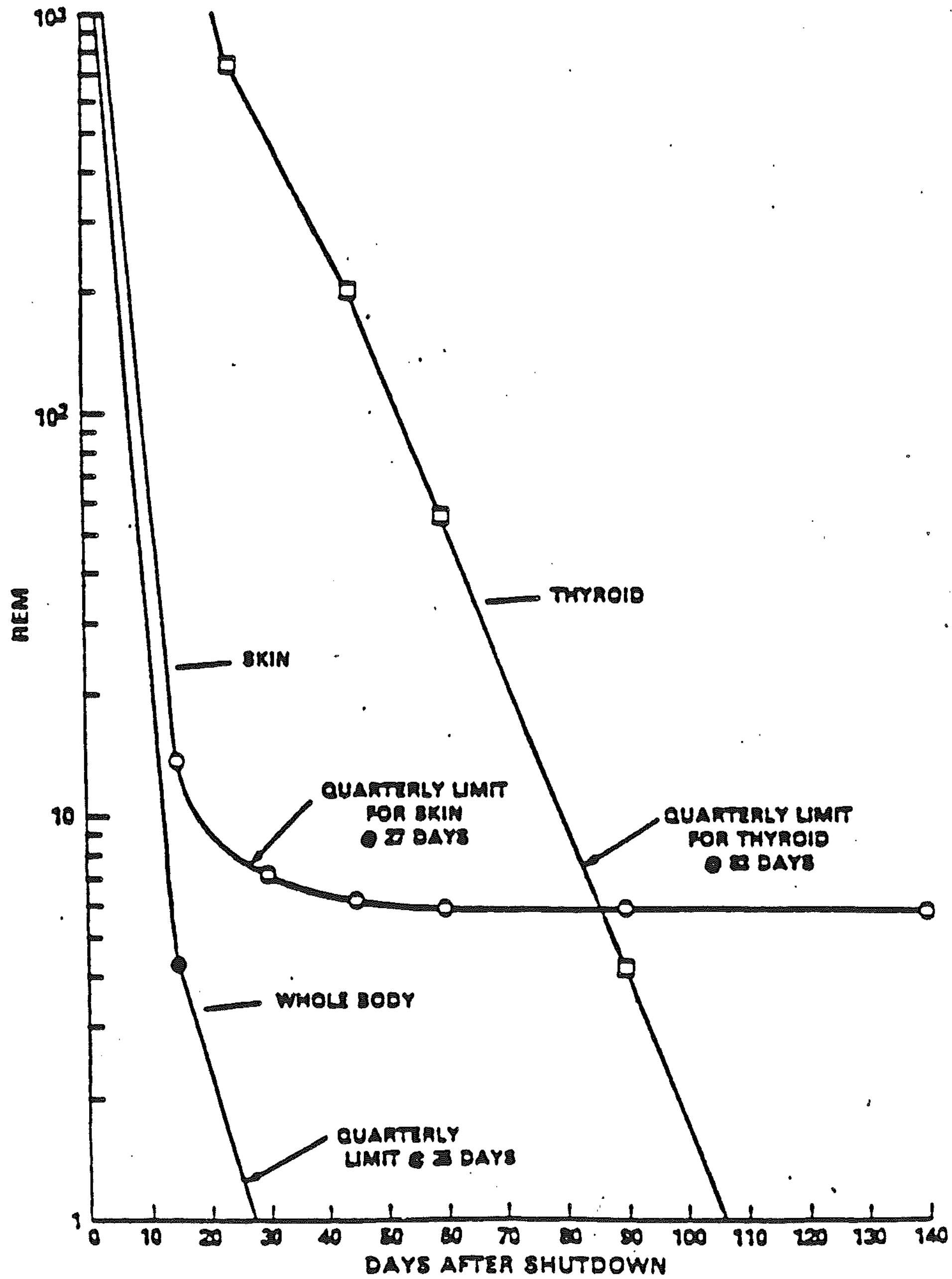

Figure 1

NEES Will Spend $65 Million A Year On Conservation

BY SUSAN LINCOLN

New England Electric System, the second largest utility in the six-state region, is embarking on a $65 million per year search for a new source of energy. Oil has not been discovered in Boston harbor, nor coal in Vermont, but NEES hopes to find megawatts in New England's homes, businesses, and factories.

NEES will be investing its millions in energy-efficient light bulbs, air conditioning, electric motors and building design, according to the Westborough, Massachusetts-based utility. Another $500 million will be spent in New England for energy efficiency measures over the next three years.

A twist in the venture is a partnership with the Conservation Law Foundation, an environmental group traditionally at loggerheads with energy utilities. CLF and NEES are collaborating in the new program called "Power by Design," which aims to ease the region's increasingly tight electricity supply and avoid building new power plants by tapping into energy efficiency.

While CLF portrays the program as "a stroke of genius" and takes much of the credit for spurring the utility to action, energy efficiency has been a company priority "well before CLF entered the picture" said a NEES spokesman. NEESPLAN, the utility's overall strategic plan has included reducing electricity use through conservation and efficiency since 1979, according to NEES president John Rowe.

Douglas Foy, executive director of CLF, dubbed the project the "third generation" of energy conservation. The first was the hardship model, turning down thermostats, foregoing electric blankets and wearing sweaters, Foy said. The second generation was efforts to get consumers to buy energy efficient appliances by offering rebates, performing energy audits and similar incentive programs.

Yet these programs never seemed to take off. The missing piece was a clear profit motive for the electricity supplier, the utility. Without the ability for the utility to earn a return on the investment, Foy explained, conservation measures were doomed to remain good public relations, without serious impact on utilities' projections of future energy needs and their plans for new facilities.

Enter CLF. The group co-authored a report in 1987 titled *Power to Spare*. The report concluded that New England could meet between 35 percent and 57 percent of its total electricity needs for the next twenty years through currently available efficiency improvements, while maintaining or increasing the region's current rate of economic growth. The energy supplied through efficiency would cost between one-quarter and one-half the price of kilowatts supplied from new power plants.

Lack of utility action or investment was identified as a key obstacle to consideration of conservation. *Power to Spare* concluded that energy efficiency is a resource that should be purchased like any other resource, not left to customers to finance.

The crucial difference, Foy says, is to switch the utilities from a goal of selling kilowatt hours to selling energy services. It's a return to the ideas of Thomas Edison, Foy pointed out. The inventor's original company sold light, not kilowatt hours. If those services can be provided to the consumer for less kilowatts, no one loses—neither the consumer nor the utility—and the environment gains in avoiding the need for new plants. Utilities also avoid the risky and resource-consuming task of trying to build new capacity.

So in 1988 CLF took their case to four of the utilities commissions in the New England region and won converts. With "various degrees of coercion" state regulatory commissions in the area ordered the utilities to put conservation on a "level playing field" with new power generation, said CLF staff attorney Stephen Burrington.

First to get off the ground was NEES. The Massachusetts Department of Public Utilities ordered the utility company to work with former adversary CLF to design and implement state-of-the-art energy efficiency programs. Since such large scale direct investment in energy efficiency by utilities is unprecedented, the jointly-designed program was to include rigorous monitoring and evaluation provisions, open to revamping as experience grows.

Now the "Power by Design" plan is set to launch, and has already begun by retrofitting low-income houses in Worcester, Massachusetts. The first year of the plan sets a goal of 60,000 homes and 15 million square feet of office space to retrofit and redesign. NEES will spend over $65 million this year alone.

The program blazes some new ground in utility-sponsored energy efficiency programs, according to CLF's Burrington. First is the scale of the project, and the direct utility involvement, rather than indirect consumer incentives programs. "It represents the first attempt by a utility to really go after energy efficiency," said Burrington.

NEES will pay for the additional expense of designing an energy-efficient heating and cooling system for new buildings. For existing buildings, the utility will replace regular light bulbs with energy-efficient bulbs which use one quarter of the electricity and last ten times as long as incandescent bulbs—all at no cost to the homeowner or business.

Second is a more complex, but crucial bookkeeping change. Previously, utilities wrote off investments in energy conservation as expenses. The cost of conservation investments were applied for that year only, providing a lower rate of return than investments in new generation that were ratebased, or subject to long-term amortization.

NEES has worked out a cost-recovery deal with the utility commissions where conservation investments can be included in the ratebase, earning interest on the investment equal to capital sunk in new generating capacity. As an additional carrot, the ratesetters are allowing an extra return to be earned by the utility.

Although ratebasing efficiency measures has been tried before, for example in Wisconsin, the New England case is different because the cost-recovery plan is tailored to encourage cost-effective energy efficiency measures, according to Burrington. In addition, the utility commission has agreed to let the price per kilowatt to rise, making up for the potential overall decrease in demand.

Susan Lincoln is a reporter for **Environment Week**, *a sister publication to* **The Energy Daily**.

EXAMPLES OF EFFICIENCY PROGRAMS FROM AROUND THE COUNTRY

A few highlights of Seattle City Light Company's conservation effort:

Large Ad Campaign -In Seattle, the power company advertises its programs extensively through bill inserts as well as bus posters.

Free Home Energy Check -The company offers a free home energy check. Inspectors are sent to individual residences, supplying detailed recommendations on how the homeowner can save through specific efficiency measures.

Free High Tech Bulb and Shower Nozzle -At the time of their visit, power company inspectors provide, free of charge, a slow-flow shower nozzle and an efficient fluorescent bulb to demonstrate advanced lighting technologies. An accompanying brochure explains in layman's terms how the new technologies work, the long-term cost savings and where more bulbs can be purchased.

Fluorescent Technology Break Throughs -Recent technological developments allow fluorescent bulbs to be twisted into small compact shapes. These are fitted at the bottom with electronic "ballasts," which regulate power flow precisely. The entire unit screws into existing home sockets. Gas vapor inside a 15 watt fluorescent bulb generates the same level of illumination as the 60 watt metal filament of a conventional incandescent model. New formulations of the bulb's inside phosphor coating allow a more pleasant, yellow tinted light than was previously possible with fluorescents.

Contractor Info -Once an energy audit has been performed, the power company assists homeowners in finding independent contractors that will install storm windows and put insulation in ceilings, floors and walls. It is very common in Seattle to have liquid foam insulation blown into walls through small holes that are readily refilled. All work will be inspected and warranted by the power company. The standard pay-back period for insulation is five years, after which the homeowner should show a yearly net profit from his investment.

Zero Interest Loan -The power company provides a substantial financing incentive to go ahead with an insulation plan. It agrees to finance the project with an interest free five year loan, or an immediate 50% cash rebate.

A few highlights from the Massachusetts Electric Company's conservation effort:

Appliance labels -The power company in 1990 will be placing bright blue labels on efficient appliances in retail show rooms to aid consumers in their purchases.

Free Bulbs for Low income Homes

-The power company also plans to install 70,000 efficient bulbs at no charge by going door to door in low income neighborhoods. This program will service almost a quarter of qualifying homes in the company's service area.

A few highlights of Indiana/Michigan Power's energy conservation effort:

Leasing Efficient Appliances

-The Indiana/Michigan power company will install and maintain an energy efficient water heater at no cost, charging only a monthly rent. A timer in the unit insures that heating occurs only during non-peak hours when electricity is cheaper.

Geo-Thermal Climate Control

-Indiana/Michigan power also encourages businesses to utilize geo-thermal climate control techniques. Pipes filled with water and sugar (to prevent freezing) are laid in the ground. The water is drawn up inside the building where it's nearly constant 55 degree temperature supplies a base level for either heating or cooling.

A highlight of Wisconsin Electric's conservation effort:

Bonds for Old Appliances

-The electric company gives savings bonds to customers when they turn in out-dated power gulping appliances. An new efficient, refrigerator, for example, uses about ten times less electricity than a conventional model. The upfront costs are higher, but over time they prove far more economical to operate.

A highlight of Florida Power Corporation's conservation effort:

Long Lasting Security Lights

-The power company sold inexpensive outdoor security lighting. Security lights receive constant use and thus are prime candidates for energy saving. Properly engineered bulbs not only draw less power but can last up to ten times as long as conventional models.

A few highlights of Southern California Edison's conservation effort:

Energy Hotline Line

-For many years Southern California Edison has sponsored a toll free "Action Line" which offers customers a wide range of information on energy conservation. The line handled nearly 140,000 inquiries in 1989.

Celebrity Plugs

-Southern California Edison spent more than $3 million in 1989 airing radio and TV spots featuring Betty White and George Burns. They described the range of conservation programs available to utility customers.

Rebates for Advanced Climate Control

-Southern California Edison also offers cash to customers who invest in new climate control methods. For example, it will provide up to $100 in reimbursement for an evaporator cooler or a heat pump.

Bonuses for Peak-period Conservation

-Southern California Edison provides incentives to businesses with the flexibility to reduce power usage during times of greatest demand. Electric power consumption varies considerably, depending on time of day and year. During hot summer afternoons when there is intense business activity coupled with high air conditioner use, electric systems face enormous burdens. Spreading power usage more evenly can eliminate the need for reserve generating capacity used only to meet high peak demand. That means fewer power plants.

Better New Buildings

-Southern California Edison offers substantial incentives to architects for incorporating key conservation features in their plans. For example, by adopting "daylighting" standards, designers maximize the amount of solar illumination available to a building, even in interior spaces. This is just one of a host of conservation concepts best applied when a structure is first built. The biggest and least costly energy savings are achieved in this fashion. Energy specialists frequently decry the "lost opportunities" inherent in traditional construction methods.

Upgrading Old Structures: Motion Sensors, High Tech Windows And New Fixtures

-There are a large number of steps that can be taken to "retrofit" older commercial and industrial buildings such as installing low emissivity windows. These windows are adjustable, allowing visible light to pass through while blocking heat. During the winter they can be reset to allow entry of more heat. Motion sensors can turn off lights after a room remains unoccupied for a short period. A central climate control computer can sharply reduce inefficiencies such as simultaneous heating and cooling in two parts of the same building. (Our own Sear's tower has relied heavily on air conditioning even during the middle of winter). Installing specially arrayed silver coated light reflectors enhances bulb brightness without the need for additional power.

THE HOOD RIVER CONSERVATION PROJECT

COOPERATION AND COMMUNITY CONSERVATION

June 1987

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prepared for

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Portland, Oregon 97204
and
Bonneville Power Administration
Portland, Oregon 97208

Summary

The Hood River Conservation Project (HRCP) was intended to test the reasonable upper limits of a residential weatherization program. It was proposed by the Natural Resources Defense Council, funded by the Bonneville Power Administration, and operated by Pacific Power & Light Company in Hood River, Oregon. This five-year, $20 million research and demonstration project installed as many cost-justified energy-conservation measures in as many electrically heated homes in Hood River as possible. The measures were aimed at the building shell to reduce electricity use for space heating and at water-heating efficiency; no heating or water heating equipment was replaced.

The Project had two parts. One was the weatherization of Hood River homes. Energy audits were performed and measures were installed between fall 1983 and the end of 1985. The other was the research and supporting data collection, which began a year before field activity started and continued for more than a year after measures were installed. This research was critical to the Project's success because HRCP was designed to provide information on the appropriate role of Pacific Northwest utilities in securing "conservation resources."

This report summarizes both elements. Topics discussed include the background and objectives of HRCP, the Project's design and data resources, implementation and marketing efforts, household participation in the Project, weatherization measures installed, levels and changes in electricity use, Project cost-effectiveness, and several supplemental studies that used HRCP data to address issues beyond the scope of the original Project.

PROJECT DESIGN

HRCP was envisioned as a major research and demonstration project to provide information on residential weatherization programs. Therefore, before field activities began, substantial effort was devoted to planning the data collection and analysis needed to address the critical issues facing the region's utilities about such programs. The five key Project objectives were to determine:

- The effects of weatherization measures on annual electricity use and on peak demands
- The maximum penetration of the program and of the recommended measures
- The effectiveness of different marketing approaches
- The social dynamics related to the Project within the community
- The costs of the Project

A detailed evaluation plan was prepared in late 1982 to address these five objectives. The plan called for collection of extensive and detailed data on the operation and effects of HRCP. Data collection began several months before the Project officially started, with a community assessment and baseline survey being conducted in early 1983.

A Regional Advisory Group, composed of regional energy experts representing dive interests, was established to guide the Project and to help maintain its research integri A Community Advisory Committee, made up of residents from different groups with Hood River, helped educate residents about HRCP and provided valuable feedback abc community concerns with the Project. Both groups were established before the ener audits began.

PROJECT IMPLEMENTATION

Establishment and operation of the Project's field office, delivery of energy audi installation of measures, and inspection of contractor work can be divided into thr phases: startup, expansion, and production. The startup phase, which lasted from Octob 1983 through May 1984, included development of operating procedures and promotion the Project throughout the community. Procedures were refined. and the Project's sta was increased during the seven-month expansion phase. More than three-fourths of th weatherization jobs were completed in the final year (1985).

Participants in special projects were recruited during the summer of 1983 Thes households played a crucial role in marketing the Project by letting their friends an neighbors know about this new activity. This unanticipated word-of-mouth publicit resulted in many requests for participation, more than the Project staff were initiall prepared to handle.

Pacific Power & Light Company's (as well as Bonneville Power Administration's) cor porate commitment to achieving 100% participation was a key element in the Project' success. This commitment led to substantial autonomy, informality, and flexibility for th Pacific Power & Light Company staff in Hood River. As a consequence, the staf developed a strong "can do" spirit of teamwork. In addition, the Regional Advisory Grouf provided strong consensus support for the Project throughout its lifetime.

PARTICIPATION

To achieve 100% participation among electrically heated homes, HRCP offered an extensive package of weatherization measures, generally installed at no cost to the household. The Project also offered "one-stop" convenience to participants; one phone call began the entire process.

HRCP was a remarkably popular program. About 91% of the eligible households received at least an energy audit; 85% of the homes had major measures installed by the Project. During the first three months of operation, more than one-fourth of the eligible households signed up to participate (Fig. S.1). This dramatic response is in stark contrast to the participation rates normally obtained in residential weatherization programs. For example, about 9%/year of the eligible households participated in the Bonneville Power Administration's regionwide Residential Weatherization Program during its first two years. The offer of free weatherization and effective marketing explain much of the difference between response rates to HRCP and to other programs.

More than half the participants first learned about the Project from a friend, neighbor, relative, or community leader. Thus, word-of-mouth was the primary information source about the Project, much more important than newspaper articles, radio, TV, or billboards. The local weekly newspaper, cited by 28% of the participants, was the second most important information source. HRCP's use of community involvement and one-on-one communication, coupled with full-cost reimbursement, can be replicated by other utilities to achieve comparable participation rates in other conservation programs.

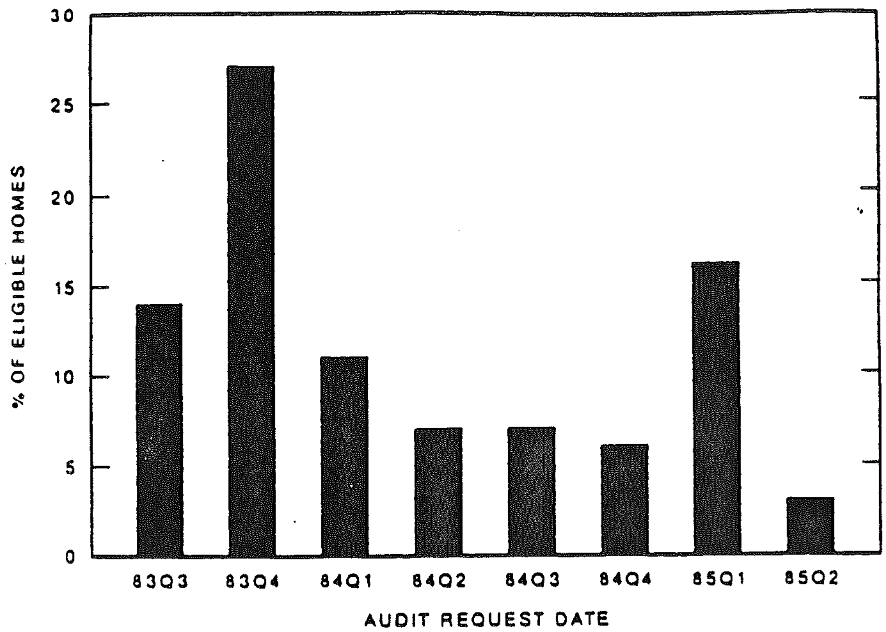

Fig. S.1. Household signups for HRCP from mid-1983 through mid-1985. By the end of 1983, about 40% of the eligible households had asked for energy audits.

The few households that were eligible but did not participate (about 250 of the 3500 eligible homes) differed somewhat from those that participated. Nonparticipants were more likely to live in single-family homes and to own their homes. Nonparticipants also had higher incomes and newer homes than did participants. Thus, in contrast to most other conservation programs, HRCP attracted larger fractions of low-income households, occupants of multifamily units, and renters.

The key factors leading to the Project's enormous success in achieving high participation levels include:

- The offer of free weatherization
- Determination on the part of HRCP staff to enlist every eligible household
- The use of community-based marketing approaches
- The reliance on extensive word-of-mouth communication among Hood River residents (begun by the Project's solicitation of households to participate in the special studies a few months before HRCP officially began)
- The early 1985 personal solicitations to the remaining nonparticipants by HRCP staff

INSTALLATION OF MEASURES

The Project paid for installation of measures up to an allowable limit based on the avoided cost of a new coal plant, roughly four times the limit in other Northwest residential weatherization programs.

Eighty-three percent of the measures recommended in the energy audits were installed. These installed measures were expected to save 6140 kWh/year (93% of the saving expected if all the recommended measures had been installed; Fig. S.2).

Ceiling insulation, storm windows, caulking, door weatherstripping, and outlet gaskets were installed in more than two-thirds of the homes. On the other hand, duct insulation and thermal doors were recommended and installed in less than 15% of the homes.

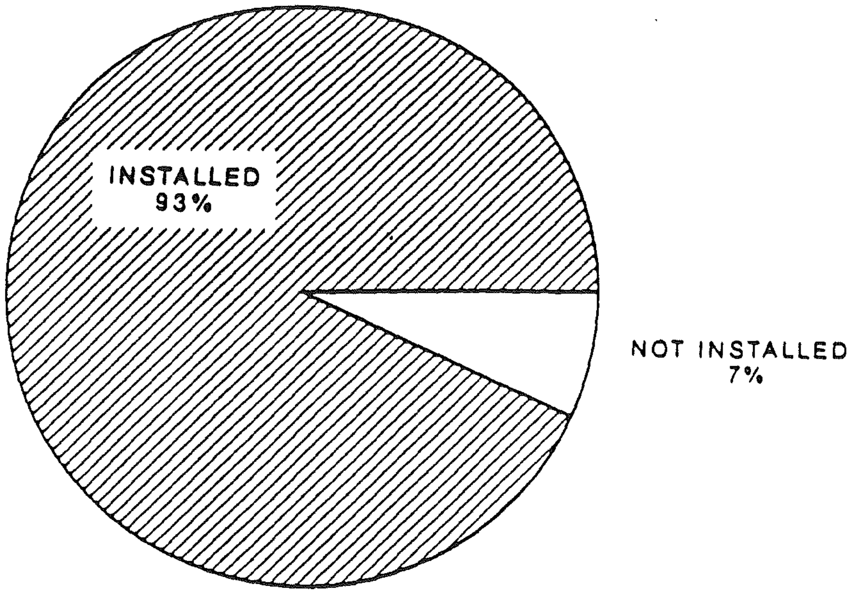

Fig. S.2. Electricity savings estimated by the energy audits for recommended measures, installed and not installed.

Overall, 46% of the 15 measures theoretically available in the HRCP packag installed, 45% of the measures were neither recommended nor installed, and only 9° recommended but not installed (Fig. S.3). Almost half (45%) of the barriers that pre installation arose because the measure was already partially or fully in place, whic dered further installation cost-ineffective. Physical barriers accounted for 31% · noninstallations, noncompatible conditions for 19%, customer concerns for 4%, and barriers for the remaining 2%.

ELECTRICITY USE AND SAVINGS

HRCP performance was assessed in two ways with respect to electricity use (Fig One computed the actual electricity savings caused by the Project's measures. The s approach examined post-HRCP levels of electricity use.

Postweatherization electricity use (1985/86) among participants was remarkabl, averaging 16,000 kWh/year, of which space heating accounted for less than 5000 Even in single-family homes that used electricity as their primary heating fuel (i.e., little wood), total and space-heating electricity uses averaged only 20,000 and 7000 l respectively. This space-heating use is equivalent to 4.2 kWh/ft^2 (2.6 Btu/ft^2 heating-degree day), which is less than the 5.6 kWh/ft^2 observed in recently constr electrically heated single-family homes in the same climate zone. The low levels of HRCP electricity use were caused by a combination of low levels of pre-HRCP electr use and the HRCP measures. After weatherization, the HRCP homes used less electr for space heating than did the participants in other weatherization programs in the on a climate-adjusted basis.

Electricity use among HRCP participants before the Project began (1982/83) was than 19,000 kWh/year, below levels expected in Hood River and below typical le observed throughout the Pacific Northwest at that time. For example, single-family hc used about 20,000 kWh/year in Hood River, compared with almost 25,000 k

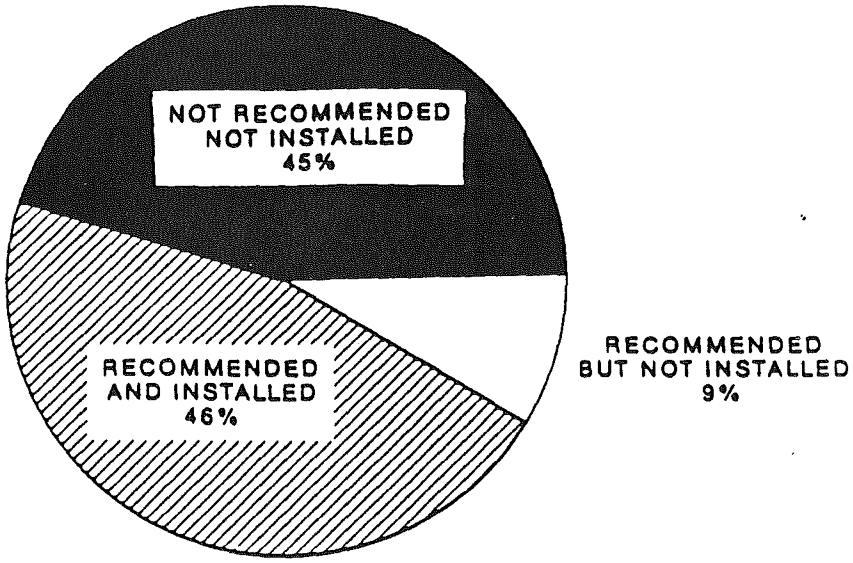

Fig. S.3. Percentages of HRCP measures recommended and installed. Slightly less than half the measures theoretically available in the Project's "package" were installed; on the other hand, 83% of the measures recommended during energy audits were installed.

throughout the region. Similarly, Hood River homes used less than 8,000 kWh/year for space heating, far below the almost 13,000 kWh observed throughout the region.

These low levels of electricity use were associated with convenient access to and use of wood, high unemployment, and dramatic increases in electricity prices; during the two years preceding HRCP, real (corrected for inflation) electricity prices rose by 40% in Hood River. Almost two-thirds of the participants used wood as their primary or supplemental heating fuel, probably because of increases in electricity prices and unemployment. Use of wood reduced annual space-heating electricity use by as much as 6000 kWh per wood-burning home. In addition, participation in prior conservation programs and growing public knowledge of how to save energy contributed to lower electricity use. Some of the lower usage reflects behavioral changes that, unlike the HRCP measures, are reversible. If electricity prices remain stable, households may relax their conservation behaviors, which will effectively increase the HRCP-induced savings.

The reduction in electricity use (pre-HRCP minus post-HRCP; 1982/83 minus 1985/86) in weatherized homes averaged 2600 kWh/year (15% of preweatherization use), almost entirely because of reductions in space heating. Multifamily homes, mobile homes, and single-family homes that used electricity as their secondary heating fuel saved less than the average (Table S.1). On the other hand, single-family homes that had not participated in earlier weatherization programs saved 3050 kWh, much more than that saved by the 1985 participants in the Bonneville Power Administration's regionwide weatherization program (2000 kWh). However, HRCP spent an average of $5400/house on measures and program administration, compared with $2300 for the Bonneville Power Administration program.

The actual savings averaged only 43% of those predicted during energy audits of these homes. Differences between actual and predicted savings can be attributed to typical discrepancies between actual savings and audit estimates, to pre-HRCP reductions in electricity use, and to post-HRCP changes in energy-related behaviors (e.g., higher indoor temperatures and less use of wood).

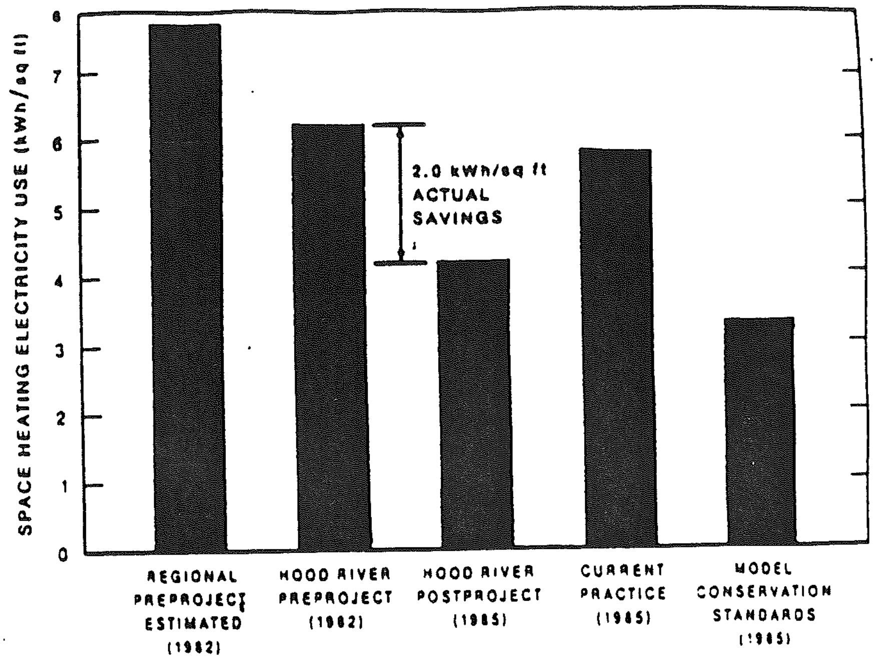

Fig. S.4. Comparison of annual electricity use for space heating in single-family homes.

The most important reason for HRCP's small savings was probably the low pre-HRCP electricity use. Had electricity use averaged 25,000 kWh in 1982/8: than 19,000 kWh, the savings would have been about 4,000 kWh. Other factors a tributed to the modest electricity savings. Households took the efficiency imprc provided by HRCP measures in terms of both reduced electricity bills and incr comfort and convenience. For example, reductions in wood use (pre- v weatherization) increased electricity use, thereby cutting electricity savings by rou kWh. This 300 kWh reduction in wood use is attributable to behavioral changes : addition to a roughly 1500 kWh reduction associated with proportional savings and electricity uses for space heating. Also, indoor temperatures increased slightl average of 0.6°F after weatherization, which cut electricity savings by an additi kWh/year.

LOAD REDUCTIONS

HRCP measures affected peak demands (kW) as well as annual electricity use Reductions in demand at the time of system peak can reduce capital costs associa the construction of power plants intended to meet peaks, transmission lines, and tion systems. The reduction in demand at the time of Pacific Power & Light Cc system peak averaged 0.5 kW/house (about 10%). Load reductions increase as temperatures drop. The reduction for all-electric single-family homes was abou the average reduction.

COSTS

The HRCP budget was $20 million, split between implementation and Implementation costs totaled $14 million, of which almost 80% was spent on in of weatherization measures. Energy audits cost $171,000, air-to-air heat exchan

Table S.1. Electricity savings for homes weatherized by HRCP

House type	Electricity savings (kWh/year)	Percentage of weatherized homes
Single-family	2900	65
Primary electric	(4000)	(15)
Other	(2600)	(50)
Multifamily	1600	17
Mobile home	2500	18
Average	2600	
Total		100

other air-quality activities cost $1.3 million, and administration (including marketing and computer costs) totaled $1.6 million. Thus, administrative costs amounted to about 14% of the costs of weatherization materials and installation.

The average cost of HRCP-installed measures, including administrative expenses, was $4400/house (exclusive of the air-to-air heat exchangers), of which the Project paid 99%. Only 10% of the households paid anything for measures; their average payment was $430.

Weatherization costs increased with house age because improvements in construction practices, stimulated by higher fuel prices and new construction standards, reduced the need for and cost of measures in newer homes. For example, the costs were roughly three times higher for homes constructed before 1945 than for homes built after 1979.

The research and evaluation costs amounted to almost $5 million. The largest cost (almost $2 million) was for equipment to collect end-use load data from 320 Hood River homes.

PROJECT ECONOMICS

Assessments of the costs to achieve HRCP savings (i.e., comparison of benefits and costs) must be approached with caution because of the Project's research focus. These research goals led to tests of the maximum number and extent of measures that were possible candidates for inclusion in future regional conservation programs. As expected, some measures and program-design features were more costly than others, so the total cost represents a meld of measures and design characteristics that include both "winners" and "losers." The data base established by the Project allows energy planners to estimate the cost of saved energy for a range of alternative program designs.

HRCP economics can be considered from two perspectives. One is retrospective, focuses on the measured electricity savings, and probably underestimates the Project's economic benefits in this instance. Averaged over all weatherized homes, the annual savings were 2600 kWh/house. The average cost to achieve these savings was $4400/house, equivalent to $1.70/annual kWh actual saving, substantially higher than the cost-effectiveness limit ($1.15/kWh). Annualizing the $4400 cost (at a 3% real discount rate and a 44-year lifetime) yields a cost of conservation of 7.1¢/kWh, higher than the 5.0¢ used by the Northwest Power Planning Council as the cost limit for conservation programs. These calculations give no credit to HRCP for increases in comfort and convenience associated with less use of wood and warmer homes. Nor do the calculations account for possible savings in transmission and distribution costs because of reductions in load at the time of system peak. Finally, environmental benefits associated with reduced electricity generation are not computed.

The second perspective, which probably overestimates HRCP benefits in this case, is that of a utility planner deciding among alternative strategies to meet long-term power needs. When HRCP was being designed, utility estimates of space-heating electricity use averaged 13,000 kWh/year for single-family homes in the Pacific Northwest; final Hood River figures for single-family homes with little or no wood heat were 6000 kWh lower. Utilities did not predict the decline in electricity use that occurred in Hood River (and other communities) during the early 1980s, and given the reversibility of much of the savings, there will be understandable reluctance to assume that such patterns can be sustained indefinitely without utility intervention. When predicting long-term system needs, utilities cannot count on independent customer actions that result collectively in large reductions in electricity use; this is one reason why utilities invest directly in customer conservation measures.

The ability to plan confidently for post-weatherization loads that are 6000 kWh below forecast estimates would allow a utility to avoid an equivalent commitment to new generating capacity. These planning savings were obtained in Hood River at an average cost of $5600 per single-family house heated primarily with electricity, or 3.7¢/kWh.

SUPPLEMENTAL STUDIES

HRCP's focus on providing high-quality information to support decisions about residential weatherization programs led to development of an extensive data base. These data turned out to be valuable for purposes that went beyond the original HRCP objectives. In fact, several additional studies were conducted that relied on these data:

- A random sample of 75 Hood River participants received the "House Doctor" treatment to reduce infiltration in addition to the usual HRCP measures.
- Results obtained with an engineering model that calculates electricity use for space heating were compared with end-use load data from Hood River homes.
- The data collected from several surveys, both in Hood River and in the Pacific Northwest, were used to assess the extent to which Hood River results could be generalized to the region as a whole. (The primary conclusion is that the lessons learned from HRCP can be applied to regional energy planning.)
- Results obtained with a widely used method to adjust monthly electricity billing data for differences in winter severity were compared with the end-use load data.
- The end-use load data were used to examine electricity use and savings for water heating, changes in indoor temperatures after weatherization, and use of wood for space heating.
- Because these data are so valuable, end-use load data will be collected for at least two more years. Monthly billing and survey data will also be collected to assess the durability of electricity savings produced by HRCP measures.

In summary, HRCP demonstrated the feasibility of gaining nearly 100% participation from eligible households in an aggressive weatherization program. Probably because of the substantial financial incentives and the commitment to achieve high penetration rates, 85% of the electrically heated homes installed most of the recommended measures. The measured reductions in electricity use were substantially below initial expectations, pri-

HRCP Facts, Figures, and Findings

A five-year demonstration (1983-1987), funded by Bonneville Power Administration and run by Pacific Power & Light Company, focused on information needed for regional energy planning about residential weatherization potentials.

Aimed at weatherizing 100% of electric-heat homes in Hood River with an extensive set of measures installed at no cost to the households.

Cooperation was key element of Project, included participation from Bonneville Power Administration, Pacific Power & Light Company, Natural Resources Defense Council, Northwest Power Planning Council, Northwest Public Power Association, Pacific Northwest Utilities Conference Committee, and others.

Achieved almost complete participation:

91% of homes received energy audits,

85% of homes had major measures installed, and

participation even greater from renters and other hard-to-reach groups than from single-family homeowners.

Most (83%) of the recommended measures were installed, accounting for 93% of estimated electricity savings.

Electricity savings (2600 kWh/year, 15% of pre-Project levels) were less than expected, primarily because pre-HRCP electricity use was very low.

Post-HRCP electricity use among primary-electric single-family homes was very low, better than either typical new-home construction or postweatherization levels achieved in other programs.

Project cost $20 million (75% fieldwork and 25% data and analysis); weatherization costs averaged $4400 per house.

marily because pre-HRCP levels of electricity use were already quite low. On the other hand, the combination of HRCP savings and low prior levels of usage led to very low levels of electricity use after HRCP, lower than those in typical new homes constructed during the early 1980s and far below levels obtained in other weatherization programs throughout the U.S.

In addition, HRCP showed that groups that are normally adversaries can design and implement an important project and see it through to completion. The Regional Advisory Group, which included a diversity of interests within the region, met monthly from 1982 to the present. This group guided the project through its difficulties and was largely responsible for the Project's delivery of high-quality information on residential weatherization programs.

HRCP results have already proven useful, to both the Bonneville Power Administration (in their review of residential conservation programs) and the Regional Council (in development of their regional plan). The value of HRCP results stems from the high-quality data collected by the Project and the ongoing attention to process and results from the Regional Advisory Group.

Table 3. HRCP conservation measures

Measure	Target level
Home energy audit	All electrically heated homes[a]
Ceiling insulation and appropriate ventilation	R-49
Floor insulation[b]	R-38
Wall insulation	R-11 to R-19
Cold and hot water pipe insulation to water heater[c]	R-3
Dehumidifiers and air-to-air heat exchangers[d]	As required
Clock thermostats	Where applicable
Duct insulation	Crawl space R-11, attic R-30, where applicable
Storm windows and thermal replacement sash and glazing	Triple-glazing
Thermal doors and double-glazed sliding doors	Where applicable
Caulking and weatherstripping	Where applicable
Outlet and switchplate gaskets[c]	Where applicable
Heat pump conversion of existing furnace system[d]	Where appropriate conventional measures cannot be installed
Electric water heater wraps[c]	R-11
Low-flow showerheads and other hot water flow regulators[c]	As required

Source: Peach et al. (1984).

[a]Audits were provided to homes heated with nonelectric fuels, primarily to maintain good relations with the community.

[b]Includes insulation of hot and cold water pipes, if under the floor.

[c]These four low-cost measures were installed by the auditor at the time of the energy audit or soon thereafter.

[d]These measures were installed only in special circumstances.

APPENDIX U

PRAIRIE ISLAND 1989 ANNUAL RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

NSP

Northern States Power Company

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Minneapolis, Minnesota 55401-1927
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April 27, 1990

Prairie Island Technical
Specification TS 6.7.C.1

U S Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D C 20555

Prairie Island Nuclear Generating Plant
Docket No. 50-282 License No. DPR-42
Docket No. 50-306 License No. DPR-60

1989 Annual Radiological Environmental Monitoring Report

In accordance with the Prairie Island Technical Specifications, Appendix A to Operating License DPR-42 and DPR-60, we are submitting one copy of the Annual Radiological Environmental Monitoring Report, covering the period January 1 through December 31 of 1989.

Respectfully submitted,

F . L. Fey, Jr., Manager
Nuclear Radiological Services

Attachment

4.0 RESULTS AND DISCUSSION

All of the scheduled collections and analyses were made except those listed in Table 5.3.

All results are summarized in Table 5.4 in a format recommended by the Nuclear Regulatory Commission in Regulatory Guide 4.8. For each type of analysis of each sampled medium, this table lists the mean and range for all indicator locations and for all control locations. The locations with the highest mean and range are also shown.

4.1 Atmospheric Nuclear Detonations and Nuclear Accidents

There were no reported atmospheric nuclear tests in 1989. The last reported test was conducted on October 16, 1980 by the People's Republic of China. The reported yield was in the 200 kiloton to 1 megaton range.

There were no reported accidents at nuclear reactor facilities in 1989.

4.2 Program Findings

Results obtained show background levels of radioactivity in the environmental samples collected in the vicinity of the Prairie Island Nuclear Generating Plant in 1989, with the exception of some of the additional special ground water samples and well water samples.

Ambient Radiation (TLDs)

Ambient radiation was measured in the general area of site boundary, at outer ring 4 - 5 mi distant from the Plant, at special interest areas, and at one control location. The means ranged from 15.7 mR/91 days at inner ring locations to 17.0 mR/91 days at outer ring locations. The mean at special locations was 15.2 mR/91 days and 16.7 mR/91 days at the control location. The differences are not statistically significant. The dose rates measured at all indicator and control locations were similar to those observed in 1978 (12.1 and 15.1 mR/91 days, respectively); in 1979 (12.6 and 15.3 mR/91 days, respectively); in 1980 (11.2 and 13.5 mR/91 days, respectively),; in 1981 (13.0 and 14.5 mR/91 days, respectively); in 1982 (12.0 and 13.0 mR/91 days, respectively),; in

1983 (13.0 and 14.9 mR/91 days, respectively); in 1984 (13.9 and 15.3 mR/91 days, respectively); in 1985 (13.9 and 15.3 mR/91 days, respectively); in 1986 (16.6 and 17.0 mR/91 days, respectively), in 1987 (15.4 and 16.0 mR/91 days, respectively) and in 1988 (16.2 and 16.7 mR/91 days, respectively). No plant effect on ambient gamma radiation was indicated.

Airborne Particulates

The average annual gross beta concentration in airborne particulates was nearly identical at both indicator and control locations (0.028 and 0.027 pCi/m^3), respectively.and was slightly higher than the levels observed in 1982 (0.026 pCi/m^3), 1983 (0.023 pCi/m^3), 1984 (0.024 pCi/m^3), 1985 (0.025 pCi/m^3), 1986 (0.025 pCi/m^3), and 1987 (0.024 pCi/m^3). It was slightly lower than in 1988 (0.030 pCi/m^3 at both indicator and control locations). The average of 0.025 pCi/m^3 for 1986 does not include the results from May 19 to June 9, 1986, which were influenced by the accident at Chernobyl.

A spring peak in beta activity had been observed almost annually for many years (Wilson <u>et al</u>., 1969). It had been attributed to fallout of nuclides from the stratosphere (Gold <u>et al</u>., 1964). It was pronounced in 1981, occurred to a lesser degree in 1982, and did not occur in 1983, 1984, 1985, 1987 or 1988. In 1986, the spring peak could not be identified because it was overshadowed by the releases of radioactivity from Chernobyl. The highest averages for gross beta were for the month of January and the first quarter. The increase of beta activity during winter months were also observed in 1983, 1984, 1985, 1986 (exclusive of the period between May 19, 1986 and June 9, 1986), 1987 and 1988.

Two pieces of evidence indicate conclusively that the elevated activity observed during the fourth quarter was not attributable to the Plant operation. In the first place, elevated activity of similar size occurred simultaneously at both indicator and control locations. Secondly, an identical pattern was observed at the Monticello Nuclear Generating Plant, about 100 miles distant from the Prairie Island Nuclear Generating Plant (Northern States Power Company, 1989).

Gamma spectroscopic analysis of quarterly composites of air particulate filters yielded similar results for indicator and control locations. Beryllium-7, which is produced continously in the upper atmosphere by cosmic radiation (Arnold and Al-Salih, 1955), was detected in all samples. All other gamma-emitting isotopes were below their respective LLD limits.

Airborne Iodine

Weekly levels of airborne iodine-131 were below the lower limit of detection (LLD) of 0.07 pCi/m^3 in all samples.

Milk

Iodine-131 results were below the detection limit of 1.0 pCi/l in all samples.

Cs-137 results were below the LLD level of 15 pCi/l in all samples. No other gamma-emitting isotopes, except potassium-40, were detected in any milk samples. This is consistent with the finding of the National Center for Radiological Health that most radiocontaminants in feed do not find their way into milk due to the selective metabolism of the cow. The common exceptions are radioisotopes of potassium, cesium, strontium, barium, and iodine (National Center for Radiological Health, 1968).

In summary, the milk data for the 1989 show no radiological effects of the plant operation.

Drinking Water

In drinking water from the City of Red Wing well, tritium activity was below the LLD level of 330 pCi/l in all samples. Iodine-131 activity was also below the LLD level at 1.0 pCi/l in all samples. As with the other well water samples, all analyses for gamma-emitting isotopes yielded results below detection limits. Gross beta averaged 7.5 pCi/l and was similar to the levels observed in 1979 (10.5 pCi/l), 1980 (11.8 pCi/l), 1981 (10.7 pCi/l), 1982 (8.9 pCi/l), 1983 (8.0 pCi/l), 1984 (7.9 pCi/l), 1985 (7.1 pCi/l), 1986 (6.8 pCi/l), 1987 (7.9 pCi/l) and 1988 (8.0 pCi/l).

River Water

At the upstream and downstream collection sites, quarterly composite tritium levels were below the LLD level of 330 pCi/l in all samples.

River water was also analyzed for gamma-emitting isotopes. All gamma-emitting isotopes were below their respective detection limits. There was no indication of a plant effect.

Well Water

At the control well P-25, Kinneman Farm and three indicator wells (P-8, Community Center; P-10, Lock and Dam No. 3; and P-9, Plant Well No. 2) no tritium was detected above LLD level of 330 pCi/l in all samples.

Gamma-emitting isotopes were below the detection limits in all samples.

Special Well Water, Ground Water and Surface Water

At four additional wells (P-27, Nauer Residence; P-28, Perkins Residence; P-29, Childs Residence; and P-6, Lock and Dam No. 3 Well, no tritium was detected above LLD level of 190 pCi/l. At the well P-24d, Suter's Deep Well, the level detected was 1430 pCi/l; at the well P-24s, Suter's Shallow Well, the level detected was 1070 pCi/l; at the well P-26, Prairie Island Training Center, the level detected was 300 pCi/l.

At three surface water sites near the plant (P-33, Pickerel Slough; P-34, Duck Pond; and P-35, Refuge Pond) no tritium was detected above LLD level of 190 pCi/l.

At two ground water seepage points the results were: for P-31, Birch Lake Seepage No. 1, the level was 820 pCi/l; and for P-32, Birch Lake Seepage No. 2, the level was 540 pCi/l.

Gamma-emitting isotopes were below the detection limits in all samples.

The Special Well, Ground, and Surface Water results are contained in Table 5.5.

Crops

Two samples of cabbage were collected in September and analyzed for I-131. The I-131 level was below 0.047 pCi/g wet weight in both samples. There was no indication of a plant effect.

The field sampling personnel conducted a survey and found that there was no river water taken for irrigation into fields within 5 miles down stream form Prairie Island Plant. Therefore, it was not necessary to collect and analyze corn samples.

Fish

Fish samples were collected in May and September, 1989. The only isotope detected was naturally-occuring potassium-40 and there was no significant difference between upstream and downstream results. There was no indication of a plant effect.

Aquatic Insects or Periphyton

Aquatic insects (invertebrates) or periphyton were collected in May and September, 1989. The samples were analyzed for gamma-emitting isotopes. All gamma-emitting isotopes were below their respective LLDs. No plant effect was indicated.

Bottom and Shoreline Sediments

Sediment collections were made in May and September, 1989. The samples were analyzed for gamma-emitting isotopes.

Cs-137 was detected in one bottom sediment upstream sample (0.077 pCi/g dry weight) and one shoreline sediment sample (0.028 pCi/dry weight).

All other gamma-emitting isotopes, except naturally-occurring potassium-40, were below their respective LLDs. No plant effect was indicated.

5.0 TABLES

Table 5.1 Sample collection and analysis program, 1989.

Medium	Locations No.	Locations Codes (and Type)[a]	Collection Type and Frequency[b]	Analysis Type and Frequency[c]
Ambient radiation (TLDs)	32	P-01A - P-10A P-01B - P-15B P-01S - P-06S P-01C	C/Q	Ambient gamma
Airborne particulates	5	P-1(C), P-2, P-3, P-4, P-6	C/W	GB, GS (QC of each location)
Airborne iodine	5	P-1(C), P-2, P-3 P-4, P-6	C/W	I-131
Milk	5	P-16 to P-18, P-25(C), P-14	G/M[d]	I-131, GS
River water	2	P-5(C), P-6	G/W	GS(MC), H-3(QC)
Drinking water	1	P-11	G/W	GB(MC), I-131(MC) GS(MC), H-3(QC)
Well water	4	P-25(C), P-6, P-8, P-9	G/Q	H-3, GS
Edible cultivated crops - leafy green vegetables	2	P-25(C), P-24	G/A	I-131
Special Well Water	3	P-27, P-28, P-29	G/Q	H-3, GS
Special Ground Water	3 2	P-24d, P-24s, P-26 P-31, P-32	G/M G/M	H-3, GS H-3, GS
Special Surface Water	3	P-33, P-34, P-35	G	H-3, GS

Table 5.1. Sample collection and analysis program, 1989 (continued) Prairie Island

Medium	Locations No.	Locations Codes (and Type)[a]	Collection Type and Frequency[b]	Analysis Type and Frequency[c]
Edible cultivated crops - corn	2	P-25(C), P-20	G/A	GS
Fish (one species edible portion)	2	P-5(C), P-6	G/SA	GS
Periphyton or invertebrates	2	P-5(C), P-6	G/SA	GS
Bottom sediment	2	P-5(C), P-6	G/SA	GS
Shoreline sediment	1	P-12	G/SA	GS

[a] Location codes are defined in Table 5.2. Control stations are indicated by (C). All other stations are indicators.

[b] Collection type is coded as follows: C/ = continuous, G/ = grab. Collection frequency is coded as follows: W = weekly, M = monthly, Q = quarterly, SA = semi-annually, A = annually.

[c] Analysis type is coded as follows: GB = gross beta, GS = gamma spectroscopy, H-3 = tritium, I-131 = iodine 131. Analysis frequency is coded as follows: MC = monthly composite, QC = quarterly composite.

[d] Milk is collected biweekly during the grazing season (May - November) if milch animals are on pasture.

Table 5.2. Sampling locations. Prairie Island

Code	Type[a]	Name	Location
P-1	C	Air Station P-1	11.8 mi @ 316°/NW
P-2		Air Station P-2	0.5 mi @ 294°/WNW
P-3		Air Station P-3	0.8 mi @ 313°/NW
P-4		Air Station P-4	0.4 mi @ 359°/N
P-5	C	Upstream of Plant	1.8 mi @ 11°/N
P-6		Lock & Dam #3 & Air Station P-6	1.6 mi @ 129°/SE
P-8		Community Center	1.0 mi @ 321°/WNW
P-9		Plant Well #2	0.3 mi @ 306°/NW
P-11		City of Red Wing	3.3 mi @ 158°/SSE
P-12		Recreational Area	3.0 mi @ 116°/ESE
P-14		Gustafson Farm	2.2 mi @ 173°/SSE
P-16		Johnson Farm	2.6 mi @ 60°/ENE
P-17		Place Farm	3.5 mi @ 25°/NNE
P-18		Christensen Farm	3.7 mi @ 88°/E
P-20		River Irrigated Corn Field*	
P-24		Highest D/Q Garden**	
P-24d		Suter's Deep Well	0.6 mi @ 158°/SSE
P-24s		Suter's Shallow Well	0.6 mi @ 158°/SSE
P-25	C	Kinneman Farm	11.1 mi @ 331°/NNW
P-26		PINGP Training Center	0.4 mi @ 258°/WSW
P-27		Nauer Residence	0.9 mi @ 154°/SSE
P-28		Perkins Residence	1.0 mi @ 152°/SSE
P-29		Childs Residence	1.2 mi @ 149°/SSE
P-31		Birch Lake Seepage No. 1	0.8 mi @ 169°/SSE
P-32		Birch Lake Seepage No. 2	0.7 mi @ 179°/S
P-33		Pickerel Slough No. 1	1.4 mi @ 140°/SE
P-34		Duck Pond No. 1	0.4 mi @ 169°/SSE
P-35		Refuge Slough	1.2 mi @ 140°/SE
P-01A		Property Line	0.4 mi @ 359°/N
P-02A		Property Line	0.3 mi @ 10°/N
P-03A		Property Line	0.5 mi @ 183°/S
P-04A		Property Line	0.4 mi @ 204°/SSW
P-05A		Property Line	0.4 mi @ 225°/SW
P-06A		Property Line	0.4 mi @ 249°/WSW
P-07A		Property Line	0.4 mi @ 268°/W
P-08A		Property Line	0.4 mi @ 291°/NNW
P-09A		Property Line	0.7 mi @ 317°/NW
P-10A		Property Line	0.5 mi @ 333°/NNW
P-01B		Thomas Killian Residence	4.7 mi @ 355°/N
P-02B		Roy Kinneman Farm	4.8 mi @ 17°/NNE

[a] "C' denotes control location. All other locations are indicators.

* Collected only if river water is used to irrigate the cornfields (Technical Specification Revision No. 80, effective 11-14-86).

** This location is not predetermined

Table 5.2. Sampling locations.

Code	Type[a]	Name	Location
P-03B		Wayne Anderson Farm	4.9 mi @ 46°/NE
P-04B		Nelson Drive (Road)	4.2 mi @ 61°/ENE
P-05B		County Road E and Coulee	4.1 mi @ 102°/ESE
P-06B		William Houschildt Residence	4.4 mi @ 112°/ESE
P-07B		Red Wing Service Center	4.7 mi @ 140°/SE
P-08B		David Wnuk Residence	4.1 mi @ 165°/SSE
P-09B		Highway 19 South	4.2 mi @ 187°/S
P-10B		Cannondale Farm	4.9 mi @ 200°/SSW
P-11B		Wallace Weberg Farm	4.5 mi @ 221°/SW
P-12B		Roy Gergen Farm	4.5 mi @ 247°/WSW
P-13B		Thomas O'Rourke Farm	4.4 mi @ 270°/W
P-14B		David J. Anderson Farm	4.9 mi @ 306°/NW
P-15B		Holst Farms	4.2 mi @ 347°/NNW
P-01S		Federal Lock & Dam #3	1.6 mi @ 129°/SE
P-02S		Charles Suter Residence	0.6 mi @ 158°/SSE
P-03S		Carl Gustafson Farm	2.2 mi @ 173°/S
P-04S		Richard Burt Residence	2.0 mi @ 202°/SSW
P-05S		Kenney Store	2.0 mi @ 270°/W
P-06S		Earl Flynn Farm	2.5 mi @ 299°/WNW
P-01C		Robert Kinneman Farm	11.1 mi @ 331°/NNW

[a] "C" denotes control location. All other locations are indicators.

Table 5.3. Missed collections and analyses, 1989. Prairie Island Nuclear Generating Plant. All required samples were collected and analyzed as scheduled except the following.

Sample	Analysis	Location	Collection Date or Period	Comments
Thermoluminescent Dosimeters (TLDs)	Ambient Radiation	P-13B	2nd Qtr. 1989	Lost in the field.
Milk	I-131, Gamma	P-17	07-05-89	Samples not available.
Air Particulates and Charcoal	Gr. beta I-131	P-3	07-24-89	Improper mounting.
Air Particulates and Charcoal	Gr. beta I-131	P-2	08-22-89	Pump failure.
Air Particulates and Charcoal	Gr. beta I-131	P-6	09-25-89	Lost in the Field.

Table 5.4. Environmental Radiological Monitoring Program Summary.

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota Reporting Period January - December 1989
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F) Range	Number of Non-routine Results[e]
				Location[d]	Mean (F) Range		
TLD (mR/91 days) (Inner Ring, General Area at Site Boundary)	Gamma 40	3.0	15.7 (40/40) (12.0-19.4)	P-03A Property Line 0.5 mi @ 183°/S	17.4 (4/4) (13.6-19.1)	(See control below)	0
TLD (mR/91 days) (Outer Ring,	Gamma 59	3.0	17.0 (59/59) (11.7-22.7)	P-02B R. Kinneman Farm, 4.8 mi @ 17°/NNE	19.0 (4/4) (14.5-21.0)		0
				P-03B W. Anderson Farm, 4.9 mi @ 46°/NE	19.0 (4/4) (15.3-21.8)	(See control below)	0
4-5 miles distant)				P-04B, Nelson Drive 4.2 mi @ 61°/ENE	19.0 (4/4) (15.6-20.8)		
TLD (mR/91 days) (Special Interest Areas)	Gamma 23	3.0	15.2 (24/24) (11.0-20.6)	P-03S, C. Gustafson Farm, 2.2 mi @ 168°/SSE	17.4 (4/4) (12.4-20.6)	(See control below)	0
TLD (mR/91 days) (control)	Gamma 4	3.0	None	P-01C, R. Kinneman Farm, 11.1 mi @ 331°/NNW	16.7 (4/4) (15.4-18.5)	16.7 (4/4) (15.4-18.5)	0
Airborne Particulates (pCi/m³)	GB 252	0.002	0.028 (201/201) (0.006-0.092)	P-2, Station P-2 0.5 mi @ 294°/WNW	0.029 (50/50) (0.006-0.075)	0.027 (51/51) (0.011-0.062)	0
	GS 20						
	Be-7	0.022	0.067 (16/16) (0.046-0.099)	P-2, Station P-2 0.5 mi @ 294°/WNW	0.073 (4/4) (0.056-0.092)	0.064 (4/4) (0.053-0.077)	0
	Mn-54	0.0017	<LLD	-	-	<LLD	0
	Co-58	0.0019	<LLD	-	-	<LLD	0
	Co-60	0.0014	<LLD	-	-	<LLD	0
	Zn-65	0.0034	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.0034	<LLD	-	-	<LLD	0
	Ru-103	0.0017	<LLD	-	-	<LLD	0
	Ru-106	0.014	<LLD	-	-	<LLD	0
	Cs-134	0.0014	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota Reporting Period January - December 1989
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F) Range	Control Locations Mean (F) Range	Number of Non-routine Results[e]
Airborne Particulates (pCi/m^3) (continued)	Cs-137	0.0017	<LLD	-	-	<LLD	0
	Ba-La-140	0.0099	<LLD	-	-	<LLD	0
	Ce-141	0.0029	<LLD	-	-	<LLD	0
	Ce-144	0.0095	<LLD	-	-	<LLD	0
Airborne Iodine (pCi/m^3)	I-131 252	0.07	<LLD	-	-	<LLD	0
Milk (pCi/l)	I-131 76	1.0	<LLD	-	-	<LLD	0
	GS 76						
	K-40	100	1340 (60/60) (1180-1720)	P-14, Gustafson Farm 2.2 mi @ 168°/SSE	1360 (16/16) (1200-1610)	1300 (16/16) (1170-1530)	0
	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	15	<LLD	-	-	<LLD	0
	Ba-La-140	15	<LLD	-	-	<LLD	0
Drinking Water (pCi/l)	GB 12	1.0	7.5 (12/12) (5.0-9.4)	P-11, City of Red Wing, 7.1 mi @ 135°/SE	7.5 (12/12) (5.0-9.4)	None	0
	I-131 12	1.0	<LLD	-	-	None	0
	H-3 4	330	<LLD	-	-	None	0
	GS 12						
	Mn-54	15	<LLD	-	-	None	0
	Fe-59	30	<LLD	-	-	None	0
	Co-58	15	<LLD	-	-	None	0
	Co-60	15	<LLD	-	-	None	0
	Zn-65	30	<LLD	-	-	None	0
	Zr-Nb-95	15	<LLD	-	-	None	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota Reporting Period January - December 1989

(County, State)

Sample Type (Units)	Type and Number of Analyses[a]		LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F) Range	Number of Non-routine Results[e]
					Location[d]	Mean (F) Range		
Drinking Water (pCi/l) (continued)	Cs-134		10	<LLD	-	-	None	0
	Cs-137		10	<LLD	-	-	None	0
	Ba-La-140		15	<LLD	-	-	None	0
	Ce-144		64	<LLD	-	-	None	0
River Water (pCi/l)	H-3	8	330	<LLD	-	-	<LLD	0
	GS	24						
	Mn-54		15	<LLD	-	-	<LLD	0
	Fe-59		30	<LLD	-	-	<LLD	0
	Co-58		15	<LLD	-	-	<LLD	0
	Co-60		15	<LLD	-	-	<LLD	0
	Zn-65		30	<LLD	-	-	<LLD	0
	Cs-134		15	<LLD	-	-	<LLD	0
	Cs-137		18	<LLD	-	-	<LLD	0
	Ba-La-140		15	<LLD	-	-	<LLD	0
	Ce-144		67	<LLD	-	-	<LLD	0
Well Water (pCi/l)	H-3	16	330	<LLD	-	-	<LLD	0
	GS	16						
	Mn-54		15	<LLD	-	-	<LLD	0
	Fe-59		30	<LLD	-	-	<LLD	0
	Co-58		15	<LLD	-	-	<LLD	0
	Co-60		15	<LLD	-	-	<LLD	0
	Zn-65		30	<LLD	-	-	<LLD	0
	Zr-Nb-95		15	<LLD	-	-	<LLD	0
	Cs-134		10	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota Reporting Period January - December 1989
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F) Range	Number of Non-routine Results[e]
				Location[d]	Mean (F) Range		
Well Water (pCi/l) (continued)	Co-60	15	<LLD	-	-	<LLD	0
	Zn-65	30	<LLD	-	-	<LLD	0
	Zr-Nb-95	15	<LLD	-	-	<LLD	0
	Cs-134	10	<LLD	-	-	<LLD	0
	Cs-137	10	<LLD	-	-	<LLD	0
	Ba-La-140	15	<LLD	-	-	<LLD	0
	Ce-144	71	<LLD	-	-	<LLD	0
Crops-Cabbage (pCi/g wet)	I-131 2	0.047	<LLD	-	-	<LLD	0
Fish - Flesh (pCi/g wet)	GS 4						
	K-40	0.1	3.58 (2/2) (3.27-3.88)	P-6, Lock and Dam No. 3, 1.6 mi @ 129°/SE	3.58 (2/2) (3.27-3.88)	3.11 (2/2) (2.37-3.85)	0
	Mn-54	0.046	<LLD	-	-	<LLD	0
	Fe-59	0.15	<LLD	-	-	<LLD	0
	Co-58	0.042	<LLD	-	-	<LLD	0
	Co-60	0.031	<LLD	-	-	<LLD	0
	Zn-65	0.089	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.065	<LLD	-	-	<LLD	0
	Cs-134	0.030	<LLD	-	-	<LLD	0
	Cs-137	0.035	<LLD	-	-	<LLD	0
	Ba-La-140	0.21	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1989

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F) Range	Control Locations Mean (F) Range	Number of Non-routine Results[e]
Invertebrates (pCi/g wet)	GS 4						
	Be-7	4.34	<LLD	-	-	<LLD	0
	K-40	0.5	2.66 (2/2) (0.66-4.66)	P-6, Lock and Dam No. 3 1.6 mi @ 129°/SE	2.66 (2/2) (0.66-4.66)	0.85 (2/2) (0.79-0.91)	0
	Mn-54	0.16	<LLD	-	-	<LLD	0
	Co-58	0.49	<LLD	-	-	<LLD	0
	Co-60	0.095	<LLD	-	-	<LLD	0
	Zn-65	0.33	<LLD	-	-	<LLD	0
	Zr-Nb-95	1.03	<LLD	-	-	<LLD	0
	Ru-103	1.09	<LLD	-	-	<LLD	0
	Ru-106	1.09	<LLD	-	-	<LLD	0
	Cs-134	0.10	<LLD	-	-	<LLD	0
	Cs-137	0.11	<LLD	-	-	<LLD	0
	Ba-La-140	0.36	<LLD	-	-	<LLD	0
	Ce-141	2.65	<LLD	-	-	<LLD	0
	Ce-144	0.69	<LLD	-	-	<LLD	0
Bottom and Shoreline Sediments (pCi/g dry)	GS 6						
	Be-7	0.38	<LLD	-	-	<LLD	0
	K-40	1.0	8.66 (4/4) (7.83-9.56)	P-12, Recreational Area 3.4 mi @ 116°/ESE	9.47 (2/2) (9.39-9.56)	8.75 (2/2) (8.37-9.14)	0
	Mn-54	29	<LLD	-	-	<LLD	0
	Co-58	30	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1989

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F) Range	Control Locations Mean (F) Range	Number of Non-routine Results[e]
Special Well Water (pCi/l)	H-3 6	190	993 (3/7) (300-1430)	P-24d Suter's Deep Well 0.6 mi 158°	1430 (1/1)	<LLD	3
	GS 6	-	<LLD	-	-	<LLD	0
Special Ground Water (pCi/l)	H-3 2	190	680 (2/2) (540-820)	P-31 Birch Lake Seepage 1 0.7 mi 179°	820 (1/1)	<LLD	2
	GS 2	-	<LLD	-	-	<LLD	0
Special Surface Water (pCi/l)	H-3 3	190	<LLD	-	-	<LLD	0
	GS 3	-	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1989

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F) Range	Control Locations Mean (F) Range	Number of Non-routine Results[e]
Bottom and Shoreline Sediments (pCi/g dry) (continued)	Co-60	0.039	<LLD	-	-	<LLD	0
	Zn-65	0.070	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.061	<LLD	-	-	<LLD	0
	Ru-103	0.038	<LLD	-	-	<LLD	0
	Ru-106	0.25	<LLD	-	-	<LLD	0
	Cs-134	0.023	<LLD	-	-	<LLD	0
	Cs-137	0.027	0.028 (1/4)	P-5(C), Upstream of Plant, 0.6 mi @ 60°/ENE	0.077 (1/2) -	0.077 (1/2) -	0
	Ba-La-140	0.12	<LLD	-	-	<LLD	0
	Ce-141	0.064	<LLD	-	-	<LLD	0
	Ce-144	0.17	<LLD	-	-	<LLD	0

[a] GB = Gross beta; GS = gamma scan.

[b] LLD = Nominal lower limit of detection based on 4.66 sigma error for background sample.

[c] Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified location is indicated in parentheses (F).

[d] Locations are specified (1) by name and code (Table 2) and (2) distance, direction, and sector relative to reactor site.

[e] Non-routine results are those which exceed ten times the control station value. If no control station value is available, the result is considered non-routine if it exceeds ten times the preoperational value for the location.

Table 5.5 Special Well, Ground, and Surface Water Analysis.

Sample Description and Concentration (pCi/l)						
Location	P-24d Sutter's Deep Well	P-24s Sutter's Shallow Well	P-26 Training Center	P-27 Res. No. 1 Nauer Well	P-28 Res. No. 2 Perkins Well	P-29 Res. No. 3 Childs Well
Date Collected	11-21-89	11-21-89	12-07-89	12-07-89	12-11-89	12-07-89
Lab Code	SPW-7691	SPW-7692	SPW-7820	SPW-7815	SPW-7816	SPW-7817
H-3	1430±140	1070±130	300±100	<190	<190	<190
Mn-54	<1.9	<2.8	<4.8	<5.6	<2.6	<4.0
Fe-59	<4.5	<5.6	<10.2	<11.5	<6.0	<7.8
Co-58	<2.0	<2.8	<4.4	<5.4	<2.5	<4.5
Co-60	<2.2	<2.5	<4.7	<5.3	<2.8	<3.7
Zn-65	<4.9	<6.6	<14.6	<12.7	<5.2	<9.5
Zr-Nb-95	<2.1	<2.8	<5.3	<5.8	<3.0	<5.0
Cs-134	<2.1	<3.2	<6.5	<7.0	<2.2	<5.2
Cs-137	<2.1	<2.8	<5.2	<5.7	<3.0	<4.4
Ba-La-140	<3.2	<3.1	<10.1	<9.9	<3.5	<7.5
Ce-144	<13.6	<26.9	<41.3	<43.5	<19.9	<30.9

Table 5.5 Special Well, Ground, and Surface Water Analysis (continued)

Sample Description and Concentration (pCi/l)					
Location	P-31 Birch Lake Seepage No. 1	P-32 Birch Lake Seepage No. 2	P-33 Pickerel Slough No. 1	P-34 Duck Pond No. 1	P-35 Refuge Slough
Date Collected	12-07-89	12-07-89	12-07-89	12-07-89	12-07-89
Lab Code	SPW-7813	SPW-7814	SPW-7818	SPW-7821	SPW-7822
H-3	820±120	540±110	<190	<190	<190
Mn-54	<7.8	<4.9	<8.0	<5.5	<3.4
Fe-59	<13.9	<11.5	<15.9	<12.1	<7.5
Co-58	<7.0	<4.8	<7.6	<6.0	<3.5
Co-60	<7.0	<5.7	<7.2	<5.7	<3.0
Zn-65	<16.6	<13.9	<18.0	<11.1	<6.1
Zr-Nb-95	<7.8	<5.5	<8.4	<6.0	<3.9
Cs-134	<8.1	<7.1	<9.1	<5.8	<3.0
Cs-137	<7.7	<5.0	<8.4	<5.4	<3.5
Ba-La-140	<9.5	<10.6	<10.1	<6.1	<3.2
Ce-144	<59.1	<38.9	<65.1	<40.7	<29.4

APPENDIX V

NSP

Northern States Power Company

414 Nicollet Mall
Minneapolis, Minnesota 55401-1927
Telephone (612) 330-5500

April 1, 1991

VIA TELEFAX 627-5075

Mary J. O'Brien
Deputy Commissioner
Minnesota Department of Public Health
717 S.E. Delaware Street
P.O. Box 9441
Minneapolis, Minnesota 55440

Re: Prairie Island Independent Spent Fuel Storage Installation (ISFSI)

Dear Ms. O'Brien:

Pursuant to discussions with representatives of the Minnesota Department of Health, Environmental Quality Board and Department of Public Service, and the Agreement of Northern States Power Company (NSP), the Minnesota Agencies and the Mdwekanton Sioux Indian Community (Community), dated March 8, 1991, NSP submits the following information regarding best estimate analyses of radiological impacts from the ISFSI.

1. <u>Bounding Analysis In the Draft Environmental Impact Statement and Safety Analysis Report:</u>

In the Safety Analysis Report (SAR) submitted to the Nuclear Regulatory Commission, NSP conservatively calculated the maximum annual dose to the nearest permanent resident from the ISFSI to be 4.27x10-4 millirem (mrem) per hour, which is equivalent to 3.74 mrem per year (Safety Analysis Report, August, 1990 at 7.5-1). The nearest permanent resident for this bounding analysis was the nearest resident to the south of the Prairie Island Nuclear Generating Plant. For comparison purposes the maximum annual dose to the nearest resident in the Community is 0.07 mrem per year under the bounding analysis. This conservative calculation was also incorporated in the draft environmental impact statement (EIS) prepared by the Environmental Quality Board (Draft Environmental Impact Statement, November 30, 1990 at 4.9).

In reviewing the draft EIS the Department of Health raised the issue of potential radiological health effects from the ISFSI. NSP has conferred with the Department of Health and other Minnesota Agencies regarding the issue and in the discussions NSP has emphasized the bounding analysis contained in the SAR and draft EIS presents the outside bounds of potential radiological impacts and incorporates significant conservatisms.

NSP, in conjunction with the manufacturer of the casks which will be placed in the ISFSI, Transnuclear, Inc., has calculated the annual dose rate based on the expected conditions at the ISFSI. This calculation provides a best estimate of radiological impacts from the ISFSI.

The Department of Health previously acknowledged the average annual dose to the nearest permanent resident, rather than the maximum annual dose, should be considered as the basis for an evaluation of potential radiological health effects. The average annual dose calculation incorporates the incremental placement of casks in the ISFSI. This is important as all forty-eight (48) casks will not be placed in the ISFSI in one year; rather, the casks will be placed at a rate of one to three casks a year. Incorporating the incremental placement of the casks and assuming a seventy (70) year exposure period for the nearest permanent resident yields an average annual dose to the nearest permanent resident of 1.8 mrem per year.

2. Best Estimate of Radiological Impacts from the ISFSI:

NSP's best estimate of radiological impacts from the ISFSI provides a maximum annual dose rate to the nearest permanent resident of 0.42 mrem per year. The nearest permanent resident for the best estimate analyses is a resident to the north, rather than to the south as in the bounding analysis. This change is due to the consideration in the best estimate analyses of the shielding effect of the Prairie Island Nuclear Generating Plant and the atmosphere, which significantly reduce the annual dose to the nearest permanent resident to the south. The results of the best estimate analyses are contained in the attached table and graph.

The average annual dose to the nearest permanent resident to the north is 0.34 mrem per year. As stated above, the annual dose to residents further from the ISFSI, including the Community, is significantly lower.

3. Differences between the Bounding and Best Estimate Analyses:

Pursuant to the Agreement between the NSP, the Minnesota Agencies and the Community, NSP agreed to provide best estimate analyses showing calculations of radiological effects based on expected conditions at the ISFSI site, including radioactivity levels in the spent fuel assuming average burn-up and cooling time. This is the first difference between the bounding and best estimate analyses. New source terms were generated for the fuel with 40,000 MWD/MTU burn up, which more closely resembles actual burn up at the Prairie Island Nuclear Generating Plant, as compared to 45,000 MWD/MTU in the bounding analysis. NSP's installation schedule was also followed, which assumes the casks when first placed in the ISFSI will contain 15-year, rather than 10-year, cooled fuel.

The second difference is the assumptions regarding cask shape and the presence of a cover. In the bounding analysis a spherical cask model was used for convenience in modeling. In the best estimate analyses a cylindrical cask model was used, which permits a more accurate characterization of the radiation source. In addition, the shielding effect of the steel weather cover, which will be attached to casks in the ISFSI, was incorporated in the best estimate analyses.

The third difference is incorporation of shielding from trees and housing materials which will further reduce the dose to the nearest permanent resident. Representatives of the Department of Health acknowledged that consideration of such shielding effects is reasonable. The best estimate analyses incorporate an assumption of four inches (4") of wood to represent the shielding of wood, concrete, shingles etc., which could reasonably be expected to surround the nearest permanent resident during occupancy.

The Department of Health has suggested continuous seventy (70) year occupancy of the person in the nearest permanent residence should be the basis for a best estimate analysis. While NSP does not agree with this assumption, for the purposes of this submission continuous occupancy has been assumed.

4. <u>The Best Estimate Analyses in Context of Sources of Natural and Artificial Radiation:</u>

NSP has determined the average annual dose to the nearest permanent resident from the ISFSI is 0.34 mrem per year. It is important to compare the average annual dose from the ISFSI to sources of natural radiation and other sources of artificial radiation. The Committee on the Biological Effects of Ionizing Radiations in, "Health Effects of Exposure to Low Levels of Ionizing Radiation (BEIR V)," provides a table of the average annual dose equivalents from ionizing radiation. From the table and discussion in BEIR V, which is attached, it is significant to note that natural sources of radiation, such as radon, and artificial sources, such as medical x-ray diagnosis, provide much higher doses than those anticipated from the ISFSI. Of even greater significance is the comparison to "voluntary" exposure from everyday activities. It is estimated smoking one and one-half of packs of cigarettes a day results in an average annual dose of 8,000 mrem. Occupancy in a masonry building results in an average annual dose of 7 mrem. Exposure from road construction materials while driving results in an average annual dose of 4 mrem. (Gollnick, "Basic Radiation Protection Technology," 2d.Ed 1988) While NSP does not intend to trivialize concern over potential radiological effects from the ISFSI, it is important to place any risk from the ISFSI in the context of other exposures or risks which are undertaken routinely or voluntarily.

5. <u>Standards Governing Radiological Impacts:</u>

In addition to placing the 0.34 mrem per year average annual dose from the ISFSI in context with other sources of radiation, it is important to emphasize the average annual dose is well within all applicable standards for radiological exposure. The Nuclear Regulatory Commission has recently adopted a standard of 100 mrem per year as a limit for exposure to members of the general public. This standard applies to all radiation, except for natural sources of radiation and medical applications. The standard of 100 mrem per year is also supported by the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurement.

The Environmental Protection Agency has adopted a standard of 25 mrem per year as a limit for exposure for members of the general public to uranium fuel cycle facilities. The difference between the standards is the 100 mrem standard applies to almost all potential artificial sources of radiation. The 25 mrem standard is limited exclusively to uranium fuel cycle facilities, including nuclear generating plants and spent nuclear fuel storage installations.

The average annual dose of 0.34 mrem per year and the maximum annual dose of 0.42 mrem per year are well within the applicable standards.

6. <u>Effect of Additional Berming and Alternative Locations on Potential Radiological Impacts:</u>

Pursuant to the Agreement between NSP, the Minnesota Agencies and the Community, NSP agreed to provide best estimate analyses showing calculations of radiological effects based on additional berming and alternative locations of the ISFSI. As NSP has discussed with the Department of Health and the other Minnesota Agencies, the ISFSI as currently designed includes a sixteen-foot (16') berm on the north and west sides. The 0.34 average annual dose already incorporates the shielding effects of this berm. According to calculations performed by Transnuclear, Inc., if the berm height is raised an additional four feet (4'), from sixteen (16') to twenty feet (20'), the average annual dose is reduced ten percent (10%).

With regard to the effect of alternative locations, the attached table and graph show dose rates at various distances (30 to 800 meters) from the ISFSI. For distances greater than 800 meters, the dose rate decreases inversely with the square of the distance.

NSP would like to confer when you have had an opportunity to review the best estimate analyses. In the interim, if you have any questions, please call me.

Sincerely,

Laura McCarten

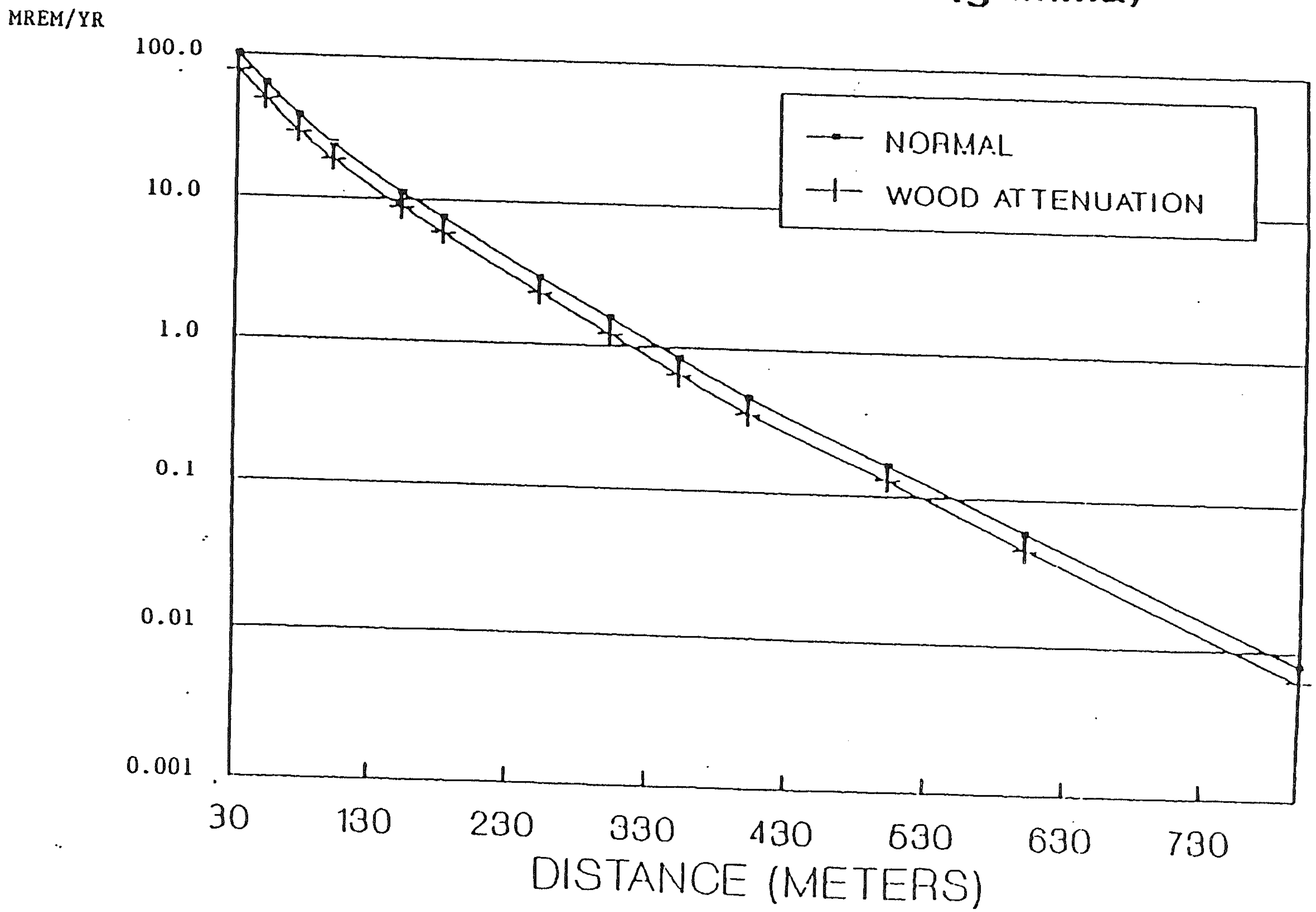
Laura McCarten

cc: Dr. Ray Thron-Minnesota Department of Health
Michael McCarthy-Department of Public Service
William Grant-Department of Public Service
Mary Jo Murray, Esq.-Office of Attorney General
Robert Cupid-Environmental Quality Board
Gretchen Sabel-Environmental Quality Board
Richard Duncan, Esq.-Attorney for the Community
William Hardacker, Esq.-Attorney for the Community

PRAIRIE ISLAND ISFSI
BEST ESTIMATE DOSE RATES
MAXIMUM DOSE VS. DISTANCE

Distance meters)	Annual Dose (millirem/yr) with wood attenuation	without wood attenuation
30	77.5	99.7
50	48.5	62.4
75	29.6	38.1
100	19.1	24.6
150	8.79	11.3
180	5.81	7.48
250	2.27	2.92
300	1.21	1.55
350	0.657	0.845
400	0.364	0.468
500	0.128	0.165
600	0.0443	0.0570
800	0.00601	0.00774

PRAIRIE ISLAND ISFSI DOSE RATE
SKYSHINE DOSE MREM/YR (gamma)



HEALTH EFFECTS OF EXPOSURE TO LOW LEVELS OF IONIZING RADIATION

BEIR V

Committee on the Biological Effects of Ionizing Radiations
Board on Radiation Effects Research
Commission on Life Sciences
National Research Council

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

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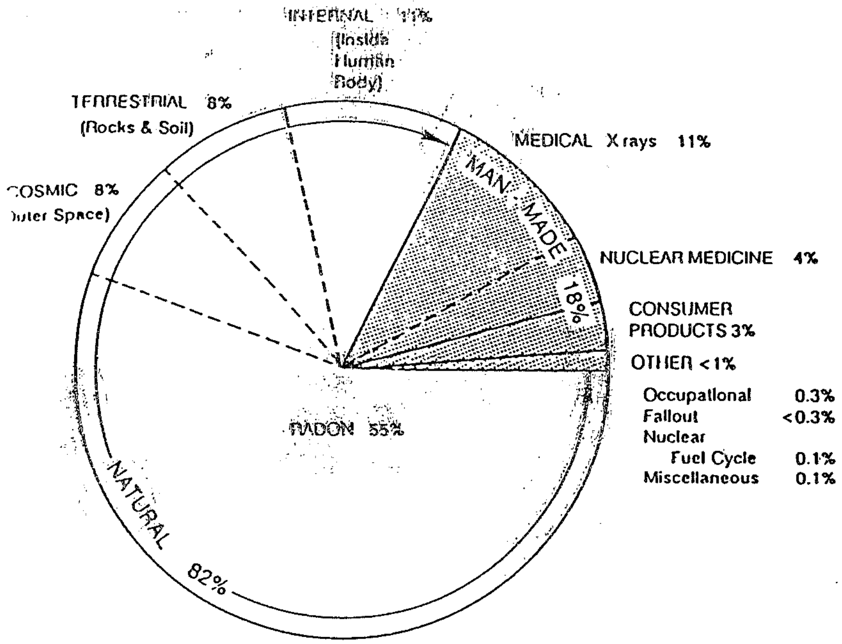

lecay products. Approximately equal contributions to the other one-third ·ome from cosmic radiation, terrestrial radiation, and internally deposited adionuclides. The importance of environmental radon as the largest source of human exposure has only recently been recognized.

The remaining 18% of the average annual effective dose equivalent onsists of radiation from medical procedures (x-ray diagnosis, 11% and nuclear medicine, 4%) and from consumer products (3%). The contribution by medical procedures is smaller than previously estimated. For consumer products, the chief contributor is, again, radon in domestic water supplies, although building materials, mining, and agricultural products as well as coal burning also contribute. Smokers are additionally exposed to the natural radionuclide polonium-210 in tobacco, resulting in the irradiation of a small region of the bronchial epithelium to a relatively high dose (up to 0.2 Sv per year) that may cause an increased risk of lung cancer (NCRP84).

Uncertainties exist in the data shown in Table 1-3. Uncertainties for exposures from some consumer products are greater than those for exposures from cosmic and terrestrial radiation sources. The estimates for the most important exposure, that of lung tissue to radon and its decay products, have many associated uncertainties. Current knowledge

of the average radon concentration, the distribution of radon indoors in the United States, and alpha-particle dosimetry in lung tissue is limited. In addition, knowledge of the actual effective dose equivalent is poorly quantified. Further uncertainties are caused by difficulties in combining data for exposure from different sources that actually are from different years, mainly from 1980 to 1983.

locally absorbed energy of 0.62 MeV from the proton and the recoil nucleus. The latter reaction yields a 2.2-MeV gamma ray that, in general, deposits energy at a distance from the capture site and that has a reasonable probability of escaping altogether from a mass as large as a rodent. For thermal neutrons the $^{14}N(n,p)^{14}C$ reaction is the major contributor of absorbed energy in tissue samples with a dimension of less than 1 cm because of the short range (<10 μm) of the 0.58-MeV proton. However, for larger masses of tissue (e.g., the human body), the 2.2-MeV gamma rays from the $^1H(n,\gamma)^2H$ reaction are a significant dose contributor.

In the spallation process the neutron-nucleus interaction results in the fragmentation of the nucleus with the emission of several particles and nuclear fragments. The latter are heavily ionizing, so the local energy deposition can be high. Several neutrons and deexcitation gamma rays also can be emitted, yielding energy carriers that escape local energy deposition. The spallation process does not become significant until neutron energies are much greater than 20 MeV.

In summary, elastic and nonelastic scattering and the capture process are by far the most important reactions in tissue for neutrons in the fission energy range. Inelastic and nonelastic scattering begin at about 2.5 and 5 MeV, respectively, and become important at an energy of about 10 MeV. As the neutron energy goes higher, nonelastic scattering and spallation reactions increase in importance, and elastic scattering becomes of less importance for energies greater than 20 MeV.

POPULATION EXPOSURE TO IONIZING RADIATION IN THE UNITED STATES

A new assessment of the average exposure of the U.S. population to ionizing radiation has recently been made by the National Council on Radiation Protection and Measurements (NCRP87b). Six main radiation sources were considered: natural radiation and radiation from the following five man-made sources: occupational activities (radiation workers), nuclear fuel production (power), consumer products, miscellaneous environmental sources, and medical uses.

For each source category, the collective effective dose equivalent was obtained from the product of the average per capita effective dose equivalent received from that source and the estimated number of people so exposed. The average effective dose equivalent for a member of the U.S. population was then calculated by dividing the collective effective dose equivalent value by the number of the U.S. population (230 million in 1980). As discussed below, the dose equivalent is defined as the product of the absorbed dose, D, and the quality factor Q, which accounts for

TABLE 1-3 Average Annual Effective Dose Equivalent of Ionizing Radiations to a Member of the U.S. Population

Source	Dose Equivalent[a]		Effective Dose Equivalent	
	mSv	mrem	mSv	%
Natural				
Radon[b]	24	2,400	2.0	55
Cosmic	0.27	27	0.27	8.0
Terrestrial	0.28	28	0.28	8.0
Internal	0.39	39	0.39	11
Total natural	—	—	3.0	82
Artificial				
Medical				
x-ray diagnosis	0.39	39	0.39	11
Nuclear medicine	0.14	14	0.14	4.0
Consumer products	0.10	10	0.10	3.0
Other				
Occupational	0.009	0.9	<0.01	<0.3
Nuclear fuel cycle	<0.01	<1.0	<0.01	<0.03
Fallout	<0.01	<1.0	<0.01	<0.03
Miscellaneous[c]	<0.01	<1.0	<0.01	<0.03
Total artificial	—	—	0.63	18
Total natural and artificial	—	—	3.6	100

[a] To soft tissues.
[b] Dose equivalent to bronchi from radon daughter products. The assumed weighting factor for the effective dose equivalent relative to whole-body exposure is 0.08.
[c] Department of Energy facilities, smelters, transportation, etc.

SOURCE: National Council on Radiation Protection and Measurements (NCRP87b).

differences in the relative biological effectiveness of different types of radiation. The effective dose equivalent relates the dose-equivalent to risk. For the case of partial body irradiation, the effective dose equivalent is the risk-weighted sum of the dose equivalents to the individually irradiated tissues.

As seen in Table 1-3 and Figure 1-1, three of the six radiation sources, namely radiation from occupational activities, nuclear power production (the fuel cycle), and miscellaneous environmental sources (including nuclear weapons testing fallout), contribute negligibly to the average effective dose equivalent, i.e., less than 0.01 millisievert (mSv)/year (1 [mrem]/year).

A total average annual effective dose equivalent of 3.6 mSv (360 mrem)/year to members of the U.S. population is contributed by the other three sources: naturally occurring radiation, medical uses of radiation, and radiation from consumer products. By far the largest contribution (82%) is made by natural sources, two-thirds of which is caused by radon and its

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Environmental and Occupational Health
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(612) 626-0900

May 1, 1991

Robert Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, MN 55155

Dear Mr. Cupit:

It has come to my attention that Minnesotans are again flapping around about trivial levels of radiation exposure. Three bits of information may help maintain a reasonable perspective on risks associated with a little bit of radiation.

1. In the United States the average radiation dose each of us receives from background (naturally occurring) radiation is 300 mrem. If we live to age 70, our total lifetime dose would be 21,000 mrem from naturally occurring radiation alone.

2. Men (on average) have more muscle tissue than women, and muscle contains most of the naturally radioactive potassium in our bodies. Each year men receive several mrem more than women because of this difference in body composition alone.

3. Variations in naturally occurring radiation doses in houses of different construction and location are more than a few mrem per year even when variations attributable to radon are ignored.

The trouble with numerical risk assessment is the aura of respectability given to calculations and the numbers they produce without understanding the assumptions and caveates inherent in them. To argue that a few mrem above or below bureaucratic limits makes any difference in the health of the population is rhetorical. Think about it!

Sincerely,

Donald E. Barber, Ph.D., CHP
Professor

May 6th, 1991
Mr. and Mrs. Richard Ahern
RR 2, Box 21454
Welch, MN 55089

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Str.
St. Paul, MN 55155

Dear Mr. Cupit:

This letter is sent in response to the Final Environmental Impact Statement, "Prairie Island Independent Spent Fuel Storage Installation," by the Minnesota Environmental Quality Board, dated April 12, 1991.

We feel that this statement is dangerously inadequate in its analysis of the long-term potential risks to health and environment resulting from the dry cask spent fuel storage system. We strongly feel that this system of storage has not been sufficiently tested to insure the continued quality of life, health and environment of the area surrounding the proposed site. We feel that the dry cask proposal, or any other type of additional spent fuel storage at this location, will only be a catalyst for further expansion and escalation of a potentially dangerous and deadly intruder to our neighborhood.

Mr. Cupit, we also feel that not enough effort has been made to notify the residents of this area. (We live within 5 miles of the site of the proposed addition of dry cask storage facilities. We, like many of our neighbors, only recently learned of the proposal to add additional storage facilities. (We do not subscribe to any local newspaper because we work in the metropolitan area) We were never notified by mail or phone that public hearings were being held and only recently received the yearly newsletter from NSP, which made brief mention of the proposal.

We ask that more effort be made to inform the public and nearby residents of the proposal. We also feel that an extensive and exhaustive effort be made to explore and research alternatives to additional storage facilities, i.e. conservation, alternative energy sources etc.

Please let us find a better solution to this danger rather than hoping our children will find one for us.

Sincerely,

[signature]

Justina L. Ahern

United States Department of the Interior
BUREAU OF INDIAN AFFAIRS
MINNEAPOLIS AREA OFFICE
331 2ND AVENUE SOUTH
MINNEAPOLIS, MINNESOTA 55401

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
Hydrology

MAY 3 1991

Mr. Robert Cupit
Minnesota Environmental Quality Board
658 Cedar Street
St. Paul, Minnesota 55155

Dear Sir:

The final Environmental Impact Statement (EIS) for the Prairie Island Independent Spent Fuel Storage Installation (ISFSI) is deficient in several respects. Most obviously, the EIS is poorly organized so that it is difficult to locate all the information needed to evaluate any one alternative against the proposed ISFSI.

Despite the addition of references to the Prairie Island Indian Community in the final EIS, key sections of the EIS still fail to note the proximity of the ISFSI to the Prairie Island Indian Community. The General Site Description (Chapter 3, Section B, page 3.2) describes the location of the plant with respect to the City of Red Wing (six miles from downtown) and the number of people estimated to live within certain distances of the plant. The closest residence is described as being "about six-tenths of a mile south-south-east of the reactor buildings." This section, however, fails to mention that the Prairie Island Indian Community is contiguous with the Prairie Island Nuclear Power Generating Plant on the north and west sides and that the Prairie Island Indian Community is only about one-half mile from the proposed location of the ISFSI.

Maps provided in the EIS do not clearly illustrate the proximity of the proposed ISFSI to the Prairie Island Indian Community. The maps provided in this section do not clearly illustrate the proximity of the proposed ISFSI to the Prairie Island Indian Community. Figure 3-2, Regional Topography, is so poorly reproduced that neither topography nor the boundary of the Prairie Island Indian Community are discernable. The Prairie Island Indian Community is the nearest organized population concentration to the Prairie Island Nuclear Power Generating Plant; the reservation boundary and the primary residential area should be shown and labeled on a map of this scale.

It is impossible to compare alternatives in a meaningful way unless complete information is available on each alternative. The descriptions of alternatives do not provide the information necessary to compare the alternatives to each other, to the proposed ISFSI, or to the no action alternative as required by the Council on Environmental Quality regulations governing the National Environmental Policy Act process.

The following minimum information is crucial to the evaluation of alternatives to the ISFSI:

1) the cost of all phases (construction, licensing, operation, decommissioning) of each alternative,

2) the amount of additional storage provided by each alternative,

3) duration and level of plant operation gained over the no action alternative,

4) the additional radiation dose to residents of the Prairie Island Indian Community from each alternative,

5) the additional radiation dose to any nearby resident from each alternative, and

6) any other pivotal factors, such as lead time for licensing and construction.

This information is not presented for all alternatives. For example, the discussion of increased pool capacity (pages 5.20-5.29) does not include an estimate of the increased radiation dose to off-site residents that would occur if Pool 1 were expanded, or if another pool (Pool 3) were constructed. The discussion states only that there would be an incremental increase in radiation exposure. We believe that this increase would be much smaller than from the proposed ISFSI. There is no mention of the number of fuel assemblies that could be stored in Pool 3; the discussion states only that capacity would be fixed at the time of construction.

We suggest that a table be added to the EIS to compare all alternatives to the proposed ISFSI. Table 5-1, Comparison of Dry Storage Systems, could be used as a model with the addition of the minimum information listed above.

The discussion of the combination of alternatives does not consider the possibility of combining reracking, consolidation, or two-tier storage with construction of a new pool. It appears (page 5.25) that the options of expanding Pool 1 or building Pool 3 were rejected simply because existing storage would be exhausted before either project could be completed. Any of the foregoing alternatives appear, on the basis of the limited discussion provided in the EIS, to be capable of providing sufficient additional storage to permit full operation of the Prairie Island Nuclear Power Generating Plant until Pool 3 could be constructed or Pool 1 expanded.

We believe that a comprehensive presentation of all alternatives to the proposed ISFSI will show that there are economically attractive alternatives to the proposed ISFSI that are more protective of public health and the health and safety of the Prairie Island Indian Community.

If you have any questions concerning our comments, please contact Q. Brown, Area Hydrologist, at Area Code: (612) 373-1143.

Sincerely,

Earl J. Barlow
Area Director

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES

Celebrate MINNESOTA 1990

DNR INFORMATION
(612) 296-6157

500 LAFAYETTE ROAD • ST. PAUL, MINNESOTA • 55155-4010

May 1, 1991

Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, MN 55155

RE: Prairie Island Independent Spent Fuel Storage Installation
Final Environmental Impact Statement (EIS)

Dear Mr. Cupit:

The Department of Natural Resources has reviewed the above-referenced document. The Final EIS has adequately addressed the comments we submitted on the Draft EIS.

Thank you for the opportunity to review this document. If you have any questions regarding our comments, please contact Rebecca Wooden of my staff at (612)297-3355.

Sincerely,

Thomas W. Balcom

Thomas W. Balcom, Supervisor
Natural Resources Planning & Review Services
Office of Planning

c: Rod Sando, Commissioner
Bill Johnson, Region V
Steve Colvin, Ecological Services
Tom Lutgen, Waters
Joe Day, Region I
Steve Johnson, Mississippi River Team
Gregg Downing, EQB
Robert Welford, USFWS
Gary Anderson, NSP

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Minnesota Pollution Control Agency
520 Lafayette Road, Saint Paul, Minnesota 55155-3898
Telephone (612) 296-6300

Celebrate MINNESOTA 1990

May 6, 1991

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

Dear Mr. Cupit:

RE: Final Environmental Impact Statement, Prairie Island Independent Spent Fuel Storage Installation

The Minnesota Pollution Control Agency (MPCA) staff has reviewed the above referenced document. Relative to those areas for which the MPCA has jurisdiction, the staff has determined that the Final Environmental Impact Statement is adequate. This decision was based upon the conditions outlined in the Environmental Quality Board Rules, Minn. Rules pt. 4410.2800 subp. 4.

It is our understanding that review and validation of the exposure modeling, used in the health risk assessment, will occur during the Nuclear Regulatory Commission (NRC) Licensing Process. If the exposure modeling results are significantly different due to the NRC review and validation process, the MPCA staff recommends that a Supplemental Environmental Impact Statement be conducted to address possible changes in risk associated with the project.

Thank you for the opportunity to review this document. If you have any questions or concerns, please contact Meri K. Nielsen of my staff at 612/297-1766.

Sincerely,

Charles W. Williams
Commissioner

CWW:bh

MPIRG

Minnesota Public Interest Research Group
2512 Delaware Street Southeast
Minneapolis, Minnesota 55414
(612) 627-4035

May 5, 1991

TO: Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

FROM: The Minnesota Public Interest Research Group (MPIRG)
Heather Cusick, Executive Director
Michael E. Lee, Research Director
Tom Flood, Legislative Intern
Mark Schmitz, Legal Intern
Dave Anderson, Chair, Board of Directors

RE: Final Environmental Impact Statement
Prairie Island ISFSI

Our comments on the draft of the Final Environmental Impact Statement are attached. These comments and questions cover three areas: (1) the risk assessment, (2) efficiency/conservation alternatives, and (3) technical assistance. We have also provided three documents as attachments.

We appreciate the hard work that has gone into this document by you and your staff. We hope these comments help make it an even better document.

HEALTH RISK ASSESSMENT

The conclusion of the Final Environmental Impact Statement (FEIS) concerning health risks of the proposed ISFSI at Prairie Island are stated in Chapter 6 of the FEIS:

"MDH estimates that the cancer risk to nearby residents from the proposed facility may be as much as 6 per 100,000. Moving the facility two hundred yards or more to an alternative site to the south would enable the ISFSI to be built and still achieve the Minnesota criterion for acceptable risk for involuntary exposure to environmental pollutants." (6.1)

A memo from the MN Department of Health to Mary Jo Murray, Special Assistant Attorney General and Bill Grant, Department of Public service, February 23, 1991 regarding the ISFSI (attachment number 1) makes clear the Minnesota standard:

"The threshold of acceptable/unacceptable risk (one in 100,000 lifetime cancer risk) is based on cancer occurrence (not mortality)"

The memo goes on to apply the standard with data supplied by NSP and the cask manufacturer. When this is done the memo concludes:

"This cancer risk is converted to actual risk for the ISFSI by multiplying the risk by the ratio of NSP proposed dose to the 0.1 rem reported in Table 4-2. This ratio is 1.79:100 (0.0179) and the RESULTING ACTUAL RISK IS ABOUT 23 PER 100,000." (emphasis added)

Thus, between the date of the memo (February 23, 1991) and the publication of the Final EIS (April 12, 1991), the cancer risk assessment was lowered at least 2300%. This extreme change was not the result of any major study but rather from new data supplied by NSP and the recalculation of existing data.

The basic question remains - does the ISFSI meet MN DOH standards or not?

THE MN DOT STANDARD FOR ACCEPTABLE CANCER RISK

The FEIS (6.2) states: "[Thus], Minnesota policy is not extreme. Furthermore, it is consistent with what is known and documented about willingness to accept involuntary risks with little or no benefit, or about acceptance of risk where benefits and risks do not accrue to the some set of individuals."

Minnesota has chosen to use the "benefit-risk" model which is conservative (i.e. errs on the side of caution) for the following well established reasons:

1. Some other methods, like those employed by the Nuclear Regulatory Commission, tend to confuse voluntary and involuntary risk. For example, NRC policy which tries to compare radiation risk from a facility to "background levels" (See appendix P of FEIS)

The MN DOH notes in "Tolerable Risk", (Appendix L, FEIS) that, "The problem with all of this is that the background exposure, especially to radiation (see table on page 16, Commonplace Risks of Daily Life), is not acceptable not because the resulting risk is considered by society to be negligible, but rather because there is no alternative to its acceptance."

Appendix L also states that the public considers involuntary risk 1,000 times less acceptable than voluntary risk.

2. A second reason for taking a cautious and conservative attitude in risk assessment is that often the measured effect (cancer or cancer death) is only the worst of a variety of possible outcomes. It is well known that low levels of radiation also can cause genetic damage, birth defects, and mental retardation.

Thus, setting a strict standard for the one worst outcome makes up for not counting the others at all. This is stated in NRC policy (Appendix P) and in Appendix L from the Health Department.

Appendix L states: "Mortality was used by Starr and others as a measure of risk because the statistics are easily obtained. Tolerable risk for consequences other than death will surely be higher; therefore, a tolerable annual mortality risk level of (one in 1,000,000) would provide a lower bound for tolerable risk and will introduce a measure of conservatism if used for all general population environmental exposures."

The unscientific nature of setting the standard is illustrated by changes in current NRC policy statements. In a 1986 policy statement on BRC (Below Regulatory Concern) levels of radiation the NRC policy stated:

"Studies of comparative risks experienced by the population in various activities appear to indicate that annual probability of death of the order of (one in 1,000,000) per year or less is not taken into account by individuals in their decisions as to actions that would influence their risk." (51 Fed. Reg. 30839, 30845, Aug. 29, 1986).

Just two years later, with no new evidence, NRC policy states:

"The (Nuclear Regulatory) Commission believes that annual fatality risks below approximately (one in 100,000) are of little concern to most members of society" (53 Fed. Reg. 49886, 49888, Dec. 12, 1988).

In 1988 the Environmental Protection Agency considered an acceptable risk of cancer to be at a level of one in one million, lifetime risk. This translates into substantially less than one mrem per year. (Ch. 2, The Health Risks of 'Low-Level Radioactive Wastes, MPIRG report. - Attachment number 2).

3. Finally, The MN Health Department report on Tolerable Risk (Appendix L) states:

"The term 'risk acceptability' conveys the impression that society purposely accepts risks as the reasonable price for some beneficial technology or activity." (p. 2)

Thus, if nuclear power were the only way to deliver electric services a lower standard of safety could be used. But given the fact that the Final EIS outlines alternative methods to achieve the same result, the safety standard should not be lowered. In fact, it would be more appropriate to maintain the high standard and apply it to all of the proposed alternatives.

MPIRG QUESTIONS ABOUT THE FINAL EIS (RISK ASSESSMENT)

Chapter 6 of the PI-ISFSI EIS begins by stating:

As presently designed, NSP's proposed Independent Spent Fuel Storage Installation (ISFSI) will deliver a dose of gamma radiation to offsite residents resulting in a cancer risk above the acceptable or tolerable risk limit established by the Minnesota Department of Health."

But that same chapter concludes:

"Moving the facility two hundred yards or more to an alternative site to the south would enable the ISFSI to be built and still achieve the Minnesota criterion for acceptable risk for involuntary exposure to environmental pollutants."

In the light of the ways the Department of Health apparently prefers to deal with uncertainty (documented above), a number of questions arise concerning the methods used to achieve the greatly reduced risk assessment.

QUESTIONS REGARDING RECALCULATIONS

According to the FEIS (6.9) several "unrealistic assumptions" were made by NSP which caused the dose to be calculated too high. To correct this the average dose was recalculated downward to reflect new calculations regarding: (a) the gradual increase in the number of casks (b) characteristics of the fuel (c) the shape of the cask (d) the shielding of the cover (f) shielding effects of trees and housing materials (g) the height of the earth berm (h) the effect of different locations.

* Since Minnesota bases risk on cancer incidence and not on mortality, why were conversion factors taken exclusively from BEIR-V and a recent MN DOH study finding 50% of cancers fatal ignored.

* Since it is the policy of the MN Health Department to use the upper limit of confidence levels to err on the side of safety and to account for non-cancer effects, why is the calculation nearly cut in half with a reference to a table in BEIR-V where the risk is multiplied by 0.645? (6.13)

* If indeed the Health Department has decided it is "imprudent" to use a DREF to estimate the repair potential of cells - why does the FEIS decide that it is prudent, thus calculating the risk much lower?

* The overall thrust of the recent BEIR-V report is that low-level radiation is more dangerous than previously thought. Why are only specific tables in BEIR-V used that tend to make the risk of the ISFSI seem lower, while other sections are ignored.

* Why is BEIR-V used at all since Appendix R, a letter from Dr. Fabrikant, a member of many BEIR committees states: "The system of dose limitation for radiological protection is complex, and it integrates much more than the risk estimation process; the BEIR-V report was not intended to provide specific regulatory guides"?

COMMENTS ON RISK ASSESSMENT

Risk assessments can be conducted in a variety of ways and the Minnesota Department of Health has published guidelines indicating a prudent approach given uncertainties. The DOH approach was documented above.

Given the guidelines of the DOH the final conclusions of the FEIS seem to treat uncertainty in only one way - to turn it into assessments of lower risk. The calculations in Chapter 6 are not objective and rely on selective reading of BEIR-V. There is not enough information given to agree that the risk has indeed been justly recalculated from 23 cancers per 100,000 to just 6.

But most inadequate of all is the final "calculation" that the unacceptable 6 cancers per 100,000 is now just one or below. There is NO good evidence for this at all.

If this Final EIS is to be used to document that the acceptable cancer risk of one in 100,000 has been met - evidence for this must be provided. This will require a supplemental EIS documenting the calculations and logic by which 6 cancers per 100.000 becomes one cancer per 100,000!

EFFICIENCY/CONSERVATION ALTERNATIVES

The Final EIS finds that there are alternatives to the dry cask method of storing high-level nuclear waste at Prairie Island which involve a reduced operation of the facility to conserve existing pool storage. This method is desirable because of the uncertainty surrounding the completion of a Federal Repository to finally take possession of the waste.

The EIS notes (5.12) that NSP could replace the electricity generated at Prairie Island by spending approximately $150 million to reduce energy demand without curtailing electric services.

This option is dismissed (5.7) by stating that it "appears infeasible to offset the capacity of Prairie Island with conservation by 1994".

What is needed is a more specific cost/benefit analysis of gradually implementing efficiency and conservation while gradually reducing the operations at Prairie Island. This option does not cause any immediate "shutdown" and is especially attractive in the light of the Federal Repository uncertainties.

Scenarios should be developed for several possibilities. One possibility is that the delay of the Federal Repository will continue but a MRS (Monitored Retrievable Storage) facility will be sited somewhere in the United States. The cost of nuclear generated electricity then involves temporary storage on site, temporary storage at the MRS and final storage at the Repository with all the transportation costs between each stage.

Another possible scenario that should be costed is the distinct possibility that high-level waste will remain on-site at Prairie for several hundred years ("mothballed").

These calculations should include not only the dollar cost but the internalized environmental costs. Demand-side options that reduce the amount generated should be given credit for the lack of negative environmental impacts.

Also, given the time radioactive waste remains dangerous (10,000 years) some consideration should be given to the costs passed on to future generations along with the risk. Here again, demand-side options fair very well and should be given credit for not requiring 10,000 year concerns and costs.

In other words, the scale down scenario should be compared with the ISFSI method internalizing as many costs as possible over as long a time period as possible. Clearly the potential of efficiency and conservation are even greater than stated in the FEIS since the PLC report done for the Department of Public Service notes that the calculation of 50% demand reductions with no loss of service is "conservative".

One argument coming from NSP states that if generation of electricity is to be accomplished we should start by scaling down the burning of coal. But coal fired plants are not at a critical phase as Prairie Island now is with the necessity of storage of waste.

Even so, the Final EIS should detail a cost/benefit analysis for three options. (1) Building the proposed ISFSI (2) Gradually scaling down Prairie Island production while increasing efficiency and conservation, and (3) Building the ISFSI and scaling down coal burning plants.

There is enough information available now about demand-side options, existing efficient appliances and end uses, conservation, renewables, waste storage and transportation costs, and the costs of the all scenarios, to make reasonable comparisons between the alternatives. These options are mentioned in the Final EIS, but they should be made as specific as possible in any "decision making document" at this critical time.

LACK OF TECHNICAL KNOWLEDGE

We are concerned about the amount of technical input into the EIS by NSP. The ability to generate technical information seems one sided when the utility can afford to obscure the issue with sheer volumes of information and then possibly recover these costs in the rate base. Commentators and citizens are at a disadvantage in spite of the best efforts of the Environmental Quality Board.

Although Minnesota Statute and rules do not provide for such technical expertise for all commentators, Minnesota Statute does provide for such assistance to be provided for "an Indian tribal council that has jurisdiction over part of a potentially impacted area".

> MN 116C.71 [Definitions]; reads:
> "Subd. 18. Potentially Impacted area.
> "Potentially impacted area" means the area designated or described in a draft or final area recommendation report of area characterization plan for study or consideration."

The EQB initially believed that the Prairie Island Sioux community did not fall within the legal definition of "potentially impacted area". MPIRG believes however, that the tribe does fall within this definition.

The enclosed letter to Mike Sullivan (dated April 17, 1991) from Rep. Karen Clark, the author of this stature, (Attachment number 3) clears up the dispute by stating that "the legislative intent was clearly meant to cover just such an instance as the one the (Prairie Island) Sioux community finds itself in."

Therefore, the EQB realizing that the legislative intent of this statute was to provide such technical expertise to the tribal council, and understanding that the legal basis for their decision is based on legal interpretation, should now make this help available if it is requested.

Since this help should have been available throughout the EIS process, the results should be incorporated into the final EIS even if more time must be allowed.

Attachment #7

Karen Clark
State Representative

District 60A
Hennepin County

Minnesota House of Representatives

Robert Vanasek, Speaker

COMMITTEES: HOUSING, CHAIR; APPROPRIATIONS--HUMAN RESOURCES DIVISION; ECONOMIC DEVELOPMENT--INTERNATIONAL TRADE AND TECHNOLOGY DIVISION; FINANCIAL INSTITUTIONS AND INSURANCE

April 17, 1991

Mike Sullivan, Executive Director
Environmental Quality Board
State Planning Agency
3rd Floor, Centennial Office Building
658 Cedar Street
St. Paul, MN 55155

Dear Mr. Sullivan:

It has come to my attention that the Prairie Island Sioux community has been denied technical assistance that they requested under MN 116C.722.

As the author of the legislation that created the statute in 1984, I want to make it clear that the legislative intent was clearly meant to cover just such an instance such as the one the Sioux community now finds itself in, and for which it is requesting technical assistance.

Please contact me immediately regarding your interpretation of this statute if the facts regarding the Prairie Island Sioux community are as I have been informed.

Sincerely,

Karen Clark

Karen Clark
State Representative

cc: R. Cupit
T. Flood, MPIRG

ATTACHMENT # 1

DEPARTMENT : Health

STATE OF MINNESOTA

Office Memorandum

DATE : February 23, 1991

TO : Mary Jo Murray, Special Assistant Attorney General
Bill Grant, Department of Public Service

FROM : Through Raymond W. Thron, Ph.D., P.E., Director, Env. Hlth
David G. Gray, Chief, Section of Health Risk Assessment
Alice Dolezal Hennigan, Chief, Section of Radiation Control

PHONE : 627-5059
627-5071

SUBJECT : Proposed Prairie Island Spent Fuel Storage Installation.

After reviewing Northern States Power Company's plan for proposed construction of an on-site dry cask storage facility for spent fuel rod assemblies at the Prairie Island Plant, the Minnesota Department of Health is concerned about the level of radiation exposure for residents living in close proximity to the proposed facility. The expected annual maximum radiation dose for these residents calculated by NSP in its Safety Analysis Report is 3.74 millirem per year. NSP staff has indicated that the average dose rate over a 70 year lifetime would be about 1.79 millirem per year. As presently designed, this facility will deliver a dose of gamma radiation to offsite residents which will result in an incremental lifetime cancer risk well above the Minnesota Department of Health tolerable incremental lifetime carcinogenic risk from any single source of environmental pollution. The acceptable level established by the Department of Health is a lifetime risk level of one in one hundred thousand, or 10^{-5}.

Radiological impacts from the proposed dry cask storage facility will meet exposure standards established by the Nuclear Regulatory Commission for the annual dose at the facility fence line. This standard is 25 millirem annually. Clearly, the radiation dose to the residents in close proximity to the proposed facility would not exceed this standard. However, the excess lifetime cancer risk from this facility would be twenty-three times 10^{-5}, assuming that the annual average offsite dose to the nearest residents is 1.79 millirem. The basis for this conclusion is contained in the enclosed document entitled Estimated Risk of Lifetime Excess Public Cancer Occurrence from Proposed Northern States Power Company Independent Spent Fuel Storage Installation.

For over a decade the Minnesota Department of Health (MDH), in concert with other state agencies, most notably the Minnesota Pollution Control Agency (MPCA), has implemented a policy such that carcinogenic risk from any single source of environmental pollution must be insignficant. Based on studies of "tolerable" or "acceptable" risk, which are described in two enclosed documents written by the MDH Section of Health Risk Assessment, Tolerable Risk (1985) and Carcinogen Lifetime Risk (1991), MDH uses a lifetime risk level of 10^{-5}. This means that the upper 95% confidence limit for the estimated incremental incidence of cancer risk caused by pollutants from any one source or project should not exceed one per one hundred thousand over a 70 year lifetime.

This policy is in general agreement with the policies of the United States Environmental Protection Agency (USEPA) and with the policies of other states. There is no one risk value used by the USEPA or by the states. However, regulatory levels used by federal and state governments are almost always set between 10^{-4} and 10^{-6} for lifetime cancer risk. Thus, Minnesota policy is not extreme. Furthermore, it is consistent with what is known and documented about acceptance of involuntary risks with little or no benefit, or about acceptance of risk where benefits and risks do not accrue to the same set of individuals. These points are discussed in greater detail in the above-referenced documents.

The Minnesota policy is non-controversial. For instance, the advisory committee which is assisting MDH in writing rules for Health Risk Limits for Drinking Water, pursuant to the Minnesota Groundwater Protection Act of 1989 accepted this lifetime cancer risk level with no debate. The advisory committee includes representatives from the regulated community, from environmental groups and from government agencies. Thus, this lifetime cancer risk level will be used for rulemaking setting health risk limits for ground water. A lifetime cancer risk level of 10^{-5} is already in use for calculation of Recommended Allowable Limits for Drinking Water Contaminants (enclosed).

MDH is also represented on the Air Toxics Advisory Committee which is assisting MPCA in writing an Air Toxics Rule. Again, it is assumed by the committee, which represents the regulated community, environmental groups and state agencies, that Acceptable Ambient Limits for toxic air pollutants will be calculated using the criterion for acceptable lifetime cancer risk of 10^{-5}.

These are only the latest uses of the 10^{-5} level for acceptable risk in Minnesota rules. This risk number occurs in the Solid Waste Rule. A copy of the relevant portion of this rule (7035.2815, Subpart 4G) is enclosed. The 10^{-5} level for acceptable risk also occurs in the draft chapter 7050 of the Minnesota Rules, Standards for the Protection of the Quality and Purity of the Waters of the State. As of November 12, 1990, this chapter is now a final Minnesota rule. A copy of the relevant portion of the draft rule as proposed April 10, 1990 (7050.0127, Subpart 2 and 7050.0128 Subpart 2) is enclosed. This draft rule specifically mentions that risk shall be calculated from a linear non-threshold dose-response model used by the USEPA to provide the upper 95% confidence limit of the acceptable cancer risk.

The 10^{-5} level of acceptable incremental lifetime cancer risk is also used for environmental review of proposals for new facilities. Most specifically, it is used in review of Environmental Impact Statements and Environmental Assessment Work

Sheets and for permitting in Minnesota. All projects involving municipal and medical waste incineration in Minnesota are very controversial. Examples of such projects are the proposed Dakota County Incinerator and the Mayo Foundation Medical Waste Incinerator. However, controversial issues surrounding these two projects have most to do with whether or not they are needed, and with the process used to site them. All of the parties agree that the maximum incremental lifetime cancer risk from incinerator emissions, including all routes of exposure (for example inhalation of gases and particulates, dermal contact with soil contaminated with particulate emissions, food chain exposure via contamination of soil used for crops and livestock, and exposure to contaminated drinking water) should be less than 10^{-5}.

Northern States Power (NSP) has proposed several facilities in recent years, submitting health risk assessments for review, with the specific aim of showing that these projects have been designed such that the incremental lifetime cancer risk is less than 10^{-5}. These projects include:

1. NSP Minnesota Valley PCB/Oil Incineration Project, in Granite Falls Minnesota.

2. NSP Wilmarth Refuse Derived Fuel Municipal Waste Combustor in Mankato, Minnesota.

3. NSP Ash Storage Facility near Becker, Minnesota.

Many of the carcinogenic agents associated with various facilities and sites and evaluated by MDH have not been established as carcinogenic in humans. In contrast, there is abundant epidemiological evidence that gamma radiation is a human carcinogen. Thus, the cancer risk to humans from gamma radiation is a more certain risk than the cancer risk from many other environmental carcinogens.

It is our recommendation that this spent fuel dry storage facility should not be built unless the design is modified so that the offsite dose of gamma radiation is sufficiently small such that it is consistent with the Minnesota policy that the incremental lifetime cancer risk is no higher than 10^{-5}.

Enclosures

cc (with enclosures): Paul Zerby

ESTIMATED RISK OF LIFETIME EXCESS PUBLIC CANCER OCCURRENCE FROM PROPOSED NORTHERN STATES POWER COMPANY INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Radiation levels experienced by nearby residents to the ISFSI are taken from the NSP Safety Analysis Report. Cancer mortality risks are taken from BIER-V.

Page 7.5-1 of the SAR indicates that the expected maximum annual dose rate to the nearest resident is 4.27 E-4 mrem per hour (this dose contains both a gamma and neutron component). Assuming 8760 hours per year yields an annual rate of 3.74 mrem. Discussion with NSP staff on February 22, 1991 indicate that the average dose rate over a 70 year lifetime is about 1.79 mrem per year. (While the licensed period is only 20 years, there is no assurance that the facility may not operate indefinitely).

Referring to Table 4-2 of the BIER-V report, excess cancer mortalities can be obtained based on annual lifetime doses of 0.1 rem per year. As can be seen from the table, the upper 90% confidence interval is 980 excess cancers in the most sensitive population of 100,000 (males) and the mean rate of excess cancers is 520.

A 95% confidence limit can be estimated by the method shown on page 221 of BIER-V. The natural log of the quotient of the upper 90% confidence interval and the mean divided by 1.645 (z for the 90th percentile of the normal distribution) is the geometric standard deviation. In this case it is 0.385. The upper 95% confidence interval is e raised to the power [1.96 (z for the 95th percentile of the normal distribution) times 0.385] times the mean, or 1106.

The threshold of acceptable/unacceptable risk (one in 100,000 lifetime cancer risk) is based on cancer occurrence (not mortality). ~~BIER-V estimates are based on cancer mortalities, so an adjustment is made.~~ Current Minnesota lifetime cancer incidence for males is about 50% and cancer mortality is about 25% Therefore, the risk for cancer occurrence is about 2 times larger than the risk for dying of cancer. The risk of 1106 lifetime cancer mortalities per 100,000 males thus becomes 2212.

Because NSP proposed dose rate is lower than the pattern of exposure used in Table 4-2, a dose rate effectiveness factor is appropriate. A DREF is further indicated because the radiation is mostly low-LET gamma (the less than 1% high-LET neutron radiation, which may not have a DREF associated with it, can be ignored). Page 23 of BIER-V suggests a DREF of 2 for hard tumors (a DREF of 2.1 is used for leukemia).

According to BIER-V, for males there are 450 non-leukemia for every 520 cancers, on the average. This proportion is about 87% Therefore, excess cancer occurrences will be divided by 87% of the DREF of 2, or 1.73. The estimated cancer occurrences are now

2212 divided by 1.73 (accounts for DREF for solid cancers, DREF is implicit for leukemia), or 1270.

This cancer risk is converted to actual risk for the ISFSI by multiplying the risk by the ratio of NSP proposed dose to the 0.1 rem reported in Table 4-2. This ratio is 1.79:100 (0.0179) and the resulting actual risk is about 23 per 100,000.

ATTACHMENT II 2

IMMINENT DANGER:

Radioactive Waste Dumping in Minnesota

by
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December 1989

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PART II

THE HEALTH RISKS OF "LOW-LEVEL" RADIOACTIVE WASTE

There are three major types of long-term health impacts from exposure to radiation: cancer, hereditary effects, and developmental effects on fetuses such as mental retardation.[1]

Human exposure to radiation is measured in "rads" and "rems". "Rad" stands for "Radiation Absorbed Dose" and is a measure of radiation energy absorbed by matter (such as the human body). "Rem" stands for "Roentgen Equivalent Man" which takes into account the biological damage caused by various types of ionizing radiation. Thus the rem and millirem (one-thousandth of a rem, abbreviated "mrem") are the most useful measures for evaluating the health effects of "low-level" radiation.

BACKGROUND RADIATION

Everyone is exposed to some radiation, both natural and artificial, from a variety of sources. (see Table II-1). Far from being harmless, all natural and artificial sources combined result in a calculated maximum lifetime risk of fatal cancer of approximately one in 100 according to the Environmental Protection Agency (EPA).[2] A one in 100 risk to an individual would translate into about 2.5 million fatal cancers over 70 years.

Background levels are neither safe nor unalterable. When the risks are known, individuals can lower their exposure by various means such as the mitigation of radon in homes, asking doctors to use the minimum number of X-rays, and avoiding consumer products such as watches with luminous dials and smoke detectors with radioactive elements (photo-electric smoke detectors are available).

TABLE II-1. Average Annual Radiation Dose in the U.S., 1980-82.

Source	millirem/person/year*
NATURAL	
Radon	200
Other (mostly cosmic rays from space and radiation from radioactive minerals on the earth)	100
ARTIFICIAL	
Occupational	0.90 (230)+
Consumer Products (Building materials, combustible fuels, smoke detectors, luminous watches, etc.)	5 - 13
Nuclear Fuel Cycle (includes radiation from nuclear fuel processing, nuclear power generation, and waste management)	0.05 (0.1 - 260)**
Radioactive Fallout from atmospheric testing of nuclear weapons	less than 1
Medical Diagnosis & Therapy	53
ROUNDED TOTAL	360 - 368

*1 millirem is equal to one one-thousandth of a rem.

+Occupational doses only apply to radiation workers, and thus the 0.90 millirem figure (an average over the entire U.S. population) is entirely artificial. According to the NCRP, the average annual exposure of radiation workers is 230 millirems.

**Like the occupational dose, the dose listed from the nuclear fuel cycle (0.05 millirem) is an artificial number that does not represent the dose actually received by those exposed. For example, according to the NCRP, the most exposed persons living near a nuclear fuel milling facility may receive annual doses as high as 260 millirems. On the other end of the spectrum, the most exposed person living near a model Boiling Water Reactor is estimated to receive an annual dose of 0.1 millirem.[33]

SOURCE: National Council on Radiation Protection and measurements

NO "SAFE LEVEL" - THE DOSE RESPONSE CURVE

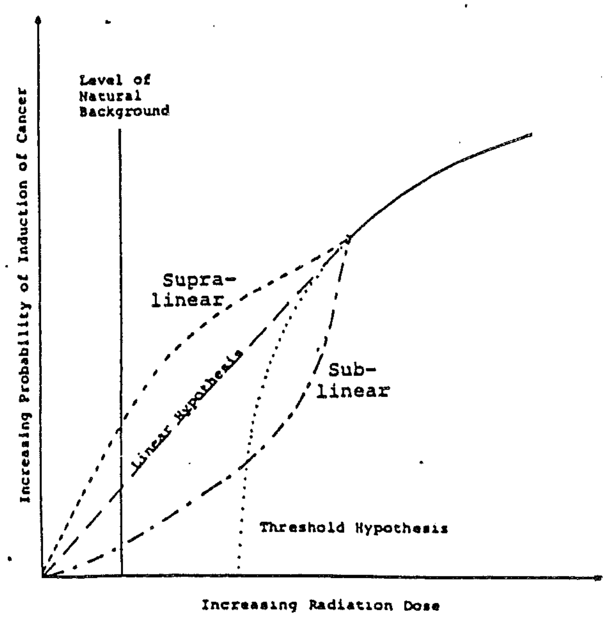
In the past, when setting radiation safety standards, it was assumed that there existed a "threshold dose" below which there would be no carcinogenic effects. This notion of a "safe" level was abandoned between 1960 and 1970 by the Atomic Energy Commission (AEC), the Biological Effects of Ionizing Radiation Committee (BEIR), the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection (NCRP), and the EPA.[3]

The old "threshold" model was replaced with a linear non-threshold model which assumes that the risk of radiation-induced effects (principally cancer) is proportional to the dose, no matter how small the dose may be. That is to say, there is no longer any "safe" level.[4]

Ramifications of the linear radiation health risks model are profound. The earlier threshold model implied that small amounts of radioactive material could be spread out in the environment with no ill effects. The linear model implies that any distribution would be the worst possible course of action and would tend to maximize the harm, no matter how little radioactive material was involved.

As Dr. John Gofman, the physicist who discovered Uranium-233, has said of exposures to "low-level" radiation: "[E]ven if the risk is small to an individual, it will lead to a sizable number of deaths in a population if many individuals are put at risk. The aggregate effect of many, widespread, small risks -- each considered trivial on a personal basis -- can be huge."[5]

TABLE II-2. The Dose-Response Curve.



The solid line indicates the high-dose region in which the response to a given radiation dose has been empirically drawn from observation. The threshold hypothesis curve assumes that no health responseoccurs below a certain threshold dose. The linear hypothesis assumes a linear (straight line) dose response down to zero dose. The upper supra-linear curve assumes a greater-than-linear response; the lower sub-linear curve, a less-than-linear response.

(SOURCE: Public Citizen, Nuclear Legacy)

EFFECTIVE DOSE EQUIVALENT: A SHIFT FROM SAFETY STANDARDS TO "ACCEPTABLE RISK"

Both the NRC and the EPA agree that there is no "safe" level of exposure to radioactivity, and that any additional exposure increases the risk. Therefore, regulatory cutoffs like those required for a BRC policy are being based on "acceptable risk" and not on safety.

The Nuclear Regulatory Commission (NRC) uses the concept of "effective dose equivalent" to determine risk. This calculation, developed by the ICRP, has been in use since 1977. The additional risk of fatal cancer is calculated using weighting factors that involve several estimates. The calculated risk for exposure to an additional 100 mrem per year is usually expressed as two in every 100,000, instead of 2,500 people every year, which it would be if all of us were exposed equally. The very fact that everyone will not be exposed equally brings up the issue of those living near garbage incinerators and landfills who might be exposed at much higher levels.

The following table of risks is derived from an NRC policy statement of Dec. 12, 1988.[6]

TABLE II-3 RISK OF FATAL CANCER AT VARIOUS EXPOSURES

Incremental Annual Doses	Incremental Annual Risk	Lifetime Risk
100 mrem	2 in 100,000	1 in 1000
10 mrem	2 in 1,000,000	1 in 10,000
1 mrem	2 in 10,000,000	1 in 100,000

According to these official estimates, if the population of the United States were uniformly exposed to an additional 10 mrem, one out of every 10,000 people would die from cancer caused by this exposure during a lifetime. This would be approximately 25,000 people. If the lifetime exposure were 100 additional mrem 250,000 people would die from cancer during this time.

In 1986, the NRC based its "acceptable risk" policy on ICRP Publication 46 which reads:

> Studies of comparative risks experienced by the population in various activities appear to indicate that annual probability of death of the order of (1 in 1,000,000) per year or less is not taken into account by individuals in their decisions as to actions that could influence their risk.[7]

The subjectivity of "acceptable risk" concepts is demonstrated by the fact that just two years later NRC's expanded BRC policy proposal recalculated the public's "concern" about risk:

"The (Nuclear Regulatory) Commission believes that annual fatality risks below approximately (1 in 100,000) are of little concern to most members of society."[8]

THE EPA AND "ACCEPTABLE RISK"

The NRC "acceptable risk" levels present a problem for the EPA, the federal agency charged with "protecting human health and the environment" and setting standards for hazards. At an NRC-sponsored conference held at the Pan American Health Organization in October 1988, Richard J. Guimond, from the EPA's Office of Radiation Programs, spoke concerning a regulatory cutoff for BRC radioactive waste. Guimond stated:

> A universal cutoff considering these approaches would probably be set at a lifetime cancer risk level of about one in one million or less, which would translate to an effective dose equivalent of substantially less than one mrem per year.[9]

Guimond's views had little impact on the NRC, however. Just one month later, a new NRC policy proposed BRC cutoffs allowing the possibility that, "some individuals may receive doses near the 100 mrem per year limit."[10]

In addition, the ability of the EPA to adequately address all risks is called into question by a 1988 General Accounting Office (GAO) report which states:

> EPA is faced with gaps in the information it needs to make risk decisions. For example noncancer health effects data -- such as developmental, immunological, kidney, liver, neurotoxic, and reproductive effects -- are poor or nonexistent. In addition, no generally accepted methods exist on how to count and access noncancer health or ecological effects. Much of EPA's efforts focused on cancer-related health concerns.[11]

EVERYTHING INVOLVES SOME RISK, SO WHY NOT ALLOW BRC DUMPING?

It is true that many things involve some risk. That risk is usually balanced against a benefit gained, however. In the case of the proposed BRC policy the only positive result is that generators of nuclear waste will save money by treating some radioactive material as if it were harmless.

Since industry savings are the only real benefits of this policy, attempts at a cost/benefit analysis such as that provided by the Electric Power Research Institute (EPRI) are hard-pressed to come up with "benefits". The $1,000-a-copy EPRI study reports environmental benefits such as the 2,500 tons of steel that will not be needed for drums to safely store radioactive waste and the 200,000 gallons of diesel fuel saved by hauling waste to local landfills instead of licensed facilities.[12]

In spite of the difficulties posed by calculating an "acceptable risk" there are some instances when risk can be almost completely eliminated. NRC policy itself states that:

> Criteria can be set sufficiently restrictive such that there is absolute assurance that health and safety will always be protected, no matter what events might transpire. However, in doing so, the regulator may then place undue and unnecessary restrictions on practices which should be permitted because of otherwise reasonable social, economic, or industrial considerations. There is always the danger of over-regulation...[13]

Current regulations which require all "low-level" radioactive waste to be sent to licensed and monitored facilities are apparently viewed by the NRC as a form of "over-regulation." This after three of the six licensed facilities in the United States have been closed because of leaks. It is a strange policy indeed to advocate leaking <u>all</u> BRC waste into the environment to avoid the problem of leaks at currently regulated storage facilities.

Hazardous materials regulation is based on the premise that costs are a major factor to be considered when the materials have to be collected from the environment (such as a program to collect all discarded smoke detectors to avoid the radioactive materials being disposed of in landfills or garbage burners). BRC dumping is the reverse of this -- radioactive materials that are already in a "collected" state at specific locations are to be distributed into the environment in such a way as to preclude monitoring.

The trade-off of financial benefits against public health risks is in no way balanced.

HIROSHIMA AND NAGASAKI A-BOMB DATA AND WHAT WE DON'T KNOW

Further questions on the real risks involved in the BRC policy are posed by the latest analysis of data from the Radiation Effects Research Foundation's "Life Span Study" of Hiroshima and Nagasaki survivors. These <u>real life</u> cases indicate that "low-level" radiation may be 10 or even 20 times more dangerous than previously thought.[14]

Interpretations of the latest A-bomb data are currently being debated in journals such as <u>Health Physics</u> and it is clear that there is no consensus concerning this new information. In addition to this uncertainty, other unknowns can be listed which call into question the wisdom of proceeding with a BRC dumping policy. These include:

1. The EPA has not evaluated health effects other than fatal cancers. Other known health effects such as risks to fetuses, retardation in children, genetic defects, and non-fatal cancers have not been quantified for long term "low-level" radiation exposures.

2. Proposed BRC materials would be "recycled" as well as disposed of in the waste stream creating untold opportunities for multiple exposures.

3. No reliable model exists for guaranteeing that some individuals will not be exposed to many sources without their knowledge. BRC status implies that no one will be monitoring.

4. Only one provision has been made to protect high-risk groups such as children and pregnant women who are more susceptible to radiation. The NRC's token action on this issue, prohibiting the use of radioactive materials in toys and materials meant for application to the skin or ingestion, is not enough.

5. The only obvious benefit of incinerating BRC waste is volume reduction to achieve cost savings. The new technology of supercompaction has not been fully explored.

6. Proposals to incinerate radioactive waste fail to take into account the simple fact that no radiation is destroyed by fire. The result will be radioactive materials contaminating the air as well as the ash in ways which could well be expensive and hazardous for municipal garbage incinerators.

PART II ENDNOTES

1. 54 Fed. Reg. 9612, 9613 (March 7, 1989).

2. Ibid. 9612, 9614.

3. Charles Sutcliffe, The Dangers of Low Level Radiation Avebury, Brookfield, U.S.A. (1987).

4. 53 Fed. Reg. 49886, 49888 (December 12, 1988).

5. John Gofman, quoted in Radioactive Waste Campaign Deadly Defense p. 126 (1988) 625 Broadway, New York, N.Y. 10012.

6. 53 Fed. Reg. 49886, 49888 (December 12, 1988).

7. 51 Fed. Reg. 30839, 30845 (August 29, 1986).

8. Ibid. 49886, 49889.

9. Ibid. 49886, 49890.

10. U.S. Nuclear Regulatory Commission, Proceedings of the Workshop on Rules for Exemption from Regulatory Control, October 17-19, 1988 p.47. EPA's Views on Regulatory Cutoffs for Radiation Exposure. (Paper presented by Richard J. Guimond, Office of Radiation Standards, EPA).

11. U.S. General Accounting Office, Environmental Protection Agency: Protecting Human Health and the Environment Through Improved Management, GAO/RCED-88-101. (August, 1988).

12. Electric Power Research Institute, Below Regulatory Concern Owners Group: Cost-Benefit Analysis of BRC Waste Disposal. EPRI NP-5681 Final Report (March, 1987).

13. 53 Fed. Reg. 49886, 49888 (December 12, 1988).

14. Rudi H. Nussbaum, 'New Data Inconsistent with "Scientific Consensus" on Low Level Radiation Cancer Risks', Health Physics Vol.56, No.6, June, 1989. pp.961-962.

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May 6, 1991

Mr. Robert Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155

Re: Prairie Island Independent Spent Fuel Storage Installation

Dear Mr. Cupit:

Attached are the comments of Northern States Power Company regarding the Final Environmental Impact Statment prepared by the Minnesota Environmental Quality Board. These comments address Chapter 5 "Alternatives," specifically the discussion of the alternative of conservation, and Chapter 6 "Health Risk Assessment."

Thank you for your consideration.

C. Gary Anderson
Manager, Regulatory Services
Environmental & Regulatory Affairs

COMMENTS ON CHAPTER 5 "ALTERNATIVES":

NSP disagrees with the conclusions of the Environmental Impact Statement regarding potential conservation. In both text and charts the Environmental Impact Statement states the output of the Prairie Island Nuclear Generating Plant could be entirely displaced with conservation, which could be accomplished by spending only $150 million. (EIS at 5.12). This estimate is based on the conclusions of a June, 1988, study by PLC, Inc. under contract to the Minnesota Department of Public Service. The PLC study concluded that 52% of Minnesota's kilowatt (kwh) use could be displaced cost-effectively by conservation. The Environmental Impact Statement takes this estimate one step further by concluding that the output specifically of Prairie Island could be displaced by conservation.

- The 52% reduction in kwh usage claimed by the PLC report is theoretically achievable only to the extent all appliances currently used are assumed to be of low efficiency and can instantly be replaced; however, they are not all inefficient and replacement takes many years to accomplish. The PLC study nonetheless implies that the entire existing equipment stock is of relatively low efficiency and that it can be replaced virtually overnight.

- The PLC study assumes all efficiency measures can always and in all applications be combined for maximum technical effect. This assumption is unrealistic. Customers instead typically take a piecemeal approach in replacing equipment. This fact is not incorporated in the PLC study.

- The PLC study assumes the ready availability of a number of technologies not yet available in the market. This serious flaw is not qualified in the study.

- The study is largely based on the "South Texas Project" analysis conducted by the Rocky Mountain Institute. The PLC study assumes that the performance characteristics of baseline energy use and the impact of efficiency measures is the same in Minnesota as in Texas. This assumption may be inappropriate given differences in weather, lifestyle, business mix and resulting energy use patterns between Texas and Minnesota.

- The PLC study bases its economic analysis on a flawed avoided-cost estimation method that fails to recognize the hourly, daily and seasonal time dependencies of electric production costs and related capacity needs. The resulting estimates of avoided costs thus are overstated, implying more conservation is cost-effective than is achievable.

- The PLC study fails entirely to account for the cost of marketing the efficiency effort. This cost can be substantially greater than the incremental cost of the efficiency measures themselves because of the effort needed to convince individuals to embrace the more efficient technologies or behaviors. These added costs not accounted for in the study, along with the estimated incremental cost of the measures themselves, could run well over $1 billion.

CONCLUSION

The PLC study is seriously flawed in its estimates of the efficiency potential logistically available in the 1990's, the power supply costs avoided, and the conservation costs incurred in the process. In addition, the EIS inappropriately assumes the application of the flawed PLC estimates to displacing PI output to the exclusion of displacing other, more costly generation resources. Continued aggressive, yet prudent, growth in conservation efforts, with continued operation of PI through reasonable expansion of the plant's spent fuel capacity, is the best overall resource solution to meeting customers' energy needs.

COMMENTS ON CHAPTER 6 "HEALTH RISK ASSESSMENT":

NSP disagrees with the method and conclusions of the Health Risk Assessment prepared by the Minnesota Department of Health (MDH) for the proposed Dry Cask Storage Facility, also referred to as an Independent Spent Fuel Storage Installation ("ISFSI").

SUMMARY

MDH claims the proposed Facility presents an increased cancer risk to the offsite residents closest to the Facility above the "tolerable" risk limit asserted by MDH. The Health Risk Assessment needlessly alarms the public, and specifically the Prairie Island community, about doses and dose rates of radiation which are so low as to be unmeasurable and have never been shown to cause adverse health effects. MDH's Health Risk Assessment is seriously flawed, is not based on sound scientific or medical evidence and its conclusion is invalid because:

° MDH relies almost exclusively on a report that was never intended for risk assessment or standards or guidelines for radiation protection.

° MDH ignores well-established scientific evidence in order to overstate the risk from the Facility.

° MDH ignores the conclusions and reasoning of international and national authorities and consensus scientific judgment, and in contradiction of its own policy, ignores existing national and state standards.

First, MDH relies almost exclusively on the BEIR V report, which was never intended for risk assessment. This is expressly stated in the BEIR V report. In addition, one of the Committee members who authored the BEIR V report, Dr. Jacob Fabrikant, stated this expressly in correspondence to MDH prior to the preparation of the Health Risk Assessment.

Second, there is no evidence the low doses and dose rates of radiation from the Facility will cause increased cancer or adverse health effects. The radiation dose from the Facility will be a very small fraction of the average dose of natural background radiation. The radiation dose from the Facility is one thousand times less than the dose known to result in adverse health effects.

Third, MDH ignores the conclusions and reasoning of international and national authorities and consensus scientific judgment. MDH is proposing a limit of 0.054

millirem per year to the maximum exposed individual. All international and national authorities agree this low radiation dose at low dose rates does not present a significant risk and should not be regulated. MDH also ignores its own policy, which states that their "tolerable" risk limit will not be imposed where there are existing federal or state standards. Federal and state radiation protection standards do exist and are enforced.

DISCUSSION

No direct scientific or medical evidence supports the conclusion that the low doses and dose rates of radiation from the Facility will cause cancer or any other adverse health effects.

There is no epidemiological evidence of increased cancer or any adverse health effects from the levels of radiation which will be emitted by the Facility. NSP estimates an average annual radiation dose of 0.34 millirem and a maximum annual dose of 0.42 millirem to the nearest offsite resident from the Facility. Scientific and medical evidence from a substantial number of credible and reliable epidemiological studies and reports shows detectable health effects do not occur from instantaneous radiation doses of about 20,000 to 50,000 millirems to an organ or about 5,000 to 10,000 millirems to the whole body. At these dose levels the total adverse health effects from stochastic effects, primarily cancer, are estimated to be less than a fraction of 1%. Direct observation of an increased cancer risk has occurred in human populations down to about 20,000 to 50,000 millirems in the survivors of the atomic bombings of Hiroshima and Nagasaki and in selected instances down to about 10,000 millirems in observations of patients exposed to radiation during medical x-ray treatment. The radiation dose from the Facility is dramatically below the doses and dose rates of radiation at which adverse health effects have been detected.

The report of the Committee on the Biological Effects of Ionizing Radiation, "Health Effects of Exposure to Low Levels of Ionizing Radiation, " NAS/NRC, 1990, referred to as "BEIR V" is the basis for MDH's Health Risk Assessment. While the BEIR V report is highly-reputed, MDH has used its findings inappropriately and in a piecemeal fashion. The BEIR V committee reviewed well over fifty epidemiological studies and surveys, including studies of survivors of the atomic bombings and exposure due to diagnostic or medical radiography and radiotherapy, fallout from nuclear weapons testing, low-dose occupational exposure, and natural background. The BEIR V report has devoted considerable study to these epidemiological studies and surveys, and it expressly states that risks for doses less than 10,000 millirem "are too small to be detectable by direct observation in epidemiological studies." (BEIR V, 1990 at 46).

There is no evidence populations living in counties near nuclear power plants in the United States have higher cancer rates as a result of increased radiation exposure. (Jablon et al., 1990; Jablon et al., 1991). The absence of evidence of higher cancer rates extends to Goodhue County, in which Prairie Island Nuclear Generating Plant is located. (Jablon et al., 1990; Jablon et al., 1991). As the Journal of the American Medical Association stated recently in an editorial:

> It is somewhat ironic that public concern over the potential hazards of normally operating facilities receives much greater attention than the far greater risks imposed by such voluntary life-style factors as smoking, drinking, and diet. Nevertheless, the public has a valid concern about potentially hazardous exposures over which they have no direct control, and which are subject to regulatory authority, such as those involved in the operation of nuclear facilities. The type of study undertaken by Jablon et al. should help provide the public with the reassurance to which it is entitled--that the normal operation of nuclear facilities does not pose undue public health risks.

(JAMA, 1991 at 1439).

MDH's conclusion that the Dry Cask Storage Facility will produce a lifetime excess risk of cancer to the most exposed resident of 6 per 100,000 is seriously flawed.

In the absence of any direct or epidemiological evidence of adverse health effects from such low doses of radiation delivered at very low dose rates, MDH relies on extrapolation from known health effects from high doses delivered at high dose rates to predict health effects from very low doses delivered at very low dose rates. The primary sources for epidemiological studies are survivors of the atomic bombings of Hiroshima and Nagasaki discussed in the BEIR V report. While these studies are critical in estimating excess cancer risks from radiation, the studies contain inherent limitations and uncertainties which must be considered and quantified. These risk estimates and uncertainties due to the many factors that modify the estimates of risk values are numerous. (Fabrikant, 1990). In addition, they are explicitly acknowledged in the BEIR V report; however, MDH's Health Risk Assessment fails to consider these inherent limitations, technical difficulties and uncertainties. As a result, the Health Risk Assessment implies precision, significance and certainty where in reality none exist.

The BEIR V report repeatedly cautions about the uncertainties inherent in its mathematical models and calculations in the estimation process. The BEIR V committee examined in detail the basis for its conclusions and stated that uncertainties in the data and chance sampling variation, as well as other factors, are large. (BEIR V, 1990 at 217-

218). The BEIR V committee further recognized that its risk estimates become more uncertain when applied to very low doses, i.e. less than 100 millirems, at low dose rates. (BEIR V, 1990 at 181). On the range of low dose radiation to be emitted by the Facility the BEIR V committee concluded:

> Since the committee's preferred risk models are a linear function of dose, little uncertainty should be introduced on this account, but departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction of either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the millisievert [100 millirems] dose range. Thus the possibility that there may be no risks from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates is zero.

(BEIR V, 1990 at 181; BEIR III, 1980 at 139-140). This means that at doses below 100 millirems the risk of adverse health effects may be zero. This important qualification due to the risk estimation process and uncertainty is not acknowledged by MDH. External natural background radiation, excluding radon, is approximately 100 millirems or almost 300 times the radiation exposures from the Facility. External natural background radiation including radon is approximately 300 millirems. The BEIR V report concludes that at low doses of radiation, i.e. less than 100 millirems, it cannot exclude the possibility of no health effects. (BEIR III, 1990 at 139-140). Health effects at this level are lost in the natural or spontaneous incidence and can never be detected.

That the BEIR V report was never intended for use as a risk assessment tool for purposes of radiological protection at such low levels of radiation is confirmed by Dr. Jacob I. Fabrikant, one of the committee members who authored the BEIR V report and an internationally-recognized expert on radiology and radiological sciences:

> There should be no confusion regarding the risk estimation process, and its relation to risk assessment, risk management and risk regulation. It is inappropriate to use the BEIR V cancer risk estimates or genetic risk estimates, as is done so frequently, for purposes of risk management or control. The estimates are derived numerical values based on illustrative examples, and the estimation process is subject to numerous uncertainties and technical difficulties.

(EIS, Appendix R at 4; See also BEIR III, 1980 at 1-3; BEIR IV, 1988 at 4; BEIR V at vi, 3-4, 6). More directly, Dr. Fabrikant states:

> The BEIR Reports are not designed or intended to be a direct and simplified approach to risk assessment and risk management for radiation protection guidance and control by providing risk estimates of radiation-associated cancer. To do so would be an over-simplification and would necessarily lead to spurious conclusions, [and] inappropriate decision making for public policy.

(EIS, Appendix R at 5).

MDH's failure to acknowledge the limitations and uncertainty involved in its imposition of a risk limit on the Facility is most prominent in two areas: failure to quantify the uncertainty in its risk assessment and failure to consider the inherent bias in its risk assessment. In a number of instances, MDH states it is adopting the "conservative" assumptions or analysis for its exposure assessment procedure. While individually each of these assumptions may appear a prudent response to uncertainty because no human data exist on the low doses of radiation, in combination the approach results in distortion equal to the product of the individual conservative assumptions. To illustrate, suppose there are ten independent steps in a risk assessment and prudence dictates conservative assumptions each of which result in estimates of two times the expected value. In aggregate such an assessment would result in an estimate of total risk more than 1,000 times, i.e. three orders of magnitude, higher than the most probable risk estimate. (1991 Office of Management and Budget ("OMB"), "Regulatory Programs of the United States Government," 1991). The OMB in evaluating risk assessments based on conservative biases, concluded risk estimates could exceed the most likely value by a factor of one million or more.

The failure to quantify uncertainty and consider the inherent bias in the risk assessment is most evident in three areas. First, the extrapolation of BEIR V risk factors from an instantaneous dose of 10,000 millirems to 0.35 millirem per year delivered at a very low rate substantially increases the uncertainty in the estimation of cancer risk. (BEIR V, 1990 at 6 and 172). As the BEIR V report indicates, the risk estimation process has serious limitations when it is used to predict health effects at very low doses and very low dose rates of radiation. The BEIR V report states that the uncertainty extends the risk estimate to zero health effects. MDH's Health Risk Assessment does not discuss this uncertainty.

Second, MDH does not explain uncertainties external to the BEIR V exposure time response models that influence risks. For example, extrapolating from the Japanese population to the population of the United States creates uncertainties. MDH concedes the uncertainty exists, but concludes there is no reason to adjust the extrapolation which forms the basis for the Health Risk Assessment. The BEIR V report, however, calls the population effect among the most important factors not accounted for in the model and states:

> Since baseline (naturally occurring) cancer rates are different in the U.S. from those in Japan for many kinds of cancer, it is not clear whether cancer risks derived from one population are applicable to the other, and if so, whether relative or absolute risks should be used. The answer to this question may be that neither absolute nor relative risks can be extrapolated with assurance.

(BEIR V, 1990 at 218). The report concludes the population extrapolation effect alone corresponds to an uncertainty of factor of 1.2. (BEIR V, 1990 at 223). The report lists a number of other uncertainties and the magnitude of their contributions. (BEIR V, 1990 at 224). MDH's Health Risk Assessment does not quantify these uncertainties nor does it take into account the extent to which they modify the cancer risk estimates.

Third, extrapolation from the 90% confidence limit used in the BEIR V report to the 95% confidence limit used by MDH increases uncertainty. MDH's risk assessment does not quantify this uncertainty. Use of the 95% confidence limit introduces an additional upward bias. MDH does not quantify the extent to which the use of the 95% confidence limit may overstate the risk. MDH also does not explain its use of a 95% confidence interval, other than to refer to state groundwater rules, Minn. Rule pt. 7050.0218, subpt. F. As described below there is no reason to adopt the confidence interval used for chemical carcinogens.

The National Academy of Scientists and Office of Science and Technology Policy explicitly call for the quantification of uncertainty, particularly for the selection of dose-response models and exposure assumptions. (National Academy of Sciences-National Research Council ("NAS/NRC"), 1983; Office of Science and Technology Policy ("OSTP"), 1985). MDH's only attempt to quantify the uncertainty inherent in its risk assessment is the statement, "Further, because of uncertainties in risk assessment, MDH uses conservative risk estimates; the true risk from the proposed ISFSI is most likely smaller than 6 in 100,000." (EIS at 6.1). MDH's Health Risk Assessment seeks to create the impression of precision and certainty in its estimation of a tolerable risk level. This precision and certainty is an illusion. MDH asserts that the tolerable risk limit is a single number, when it is clear from the numerous uncertainties incorporated and those not incorporated in the BEIR V report that the risk is in a range with wide uncertainties. (BEIR V, 1990 at 3-4, 6, 217-239).

<u>MDH ignores relevant and well-established scientific evidence to in order to overstate the risk of low dose radiation.</u>

MDH's failure to quantify the uncertainty and the inherent bias in its risk assessment is compounded by MDH's unwillingness to accept relevant and well-established scientific evidence. This unwillingness, best exemplified in MDH's rejection of a "dose rate effectiveness factor" (DREF), adds to MDH's overstatement of the risk of low dose radiation.

A dose rate effectiveness factor accounts for the effect caused by a specific dose of radiation changes at low dose rates as compared to high dose rates. As the amount of time the dose received is extended, the effect of the dose is reduced. The BEIR V report expressly acknowledges and endorses the use of a DREF for low dose, low-linear energy transfer (LET) radiation, which includes the radiation emitted by the Facility. (BEIR V, 1990 at 23). In its conclusion the report states:

> For low LET radiation, accumulation of the same dose over weeks or months, however, is expected to reduce the lifetime risk appreciably, possibly by a factor of 2 or more.

(BEIR V, 1990 at 6).

MDH's rejection of a DREF is curious given its stated overall reliance on BEIR V as the basis for its risk assessment. First, MDH contends that human data suggests a DREF may not be appropriate for two types of solid cancers based on a 1989 United States Environmental Protection Agency Environmental Impact Statement. It is unclear why the MDH condemns and rejects other studies or reports issued prior to the BEIR V report, for example the expert scientific reports of the NCRP and ICRP, but is willing to accept wholesale the conclusions of the 1989 EPA EIS, which has never been reviewed by the NCRP, ICRP or National Academy of Sciences BEIR committees. MDH also fails to acknowledge recent studies on the same two types of solid cancers supporting a DREF. Specifically, recent data on low dose irradiation of the thyroid suggests a dose rate effectiveness factor at least equal to 4 and possibly greater. (Holm et al. 1988). The most recent comprehensive study on female breast cancer and low dose radiation suggests a DREF of 2 and possibly 3. (Miller et al. 1989). Second, MDH contends that a DREF may not be appropriate for leukemia based on a study of occupational exposure by Wing et al., which recently appeared in the Journal of the American Medical Association. (Wing et al., 1991). The study by Wing et al. has not been subject to extensive scientific review and is not supported by the leading authorities in radiological sciences. The MDH accepts the conclusions of one unsupported study as justification for rejecting conclusions of the BEIR V report and indirectly rejecting the vast body of scientific evidence in NCRP, ICRP and UNSCEAR reports.

(In its discussion of uncertainty in the estimate of cancer incidence risk, MDH revisits use of a DREF and states, "Thus, overall, a DREF of 2 (0.5 x 4) appears at present to provide the best estimate of cancer incidence of low dose, prolonged radiation exposure." (EIS at 6.13). No authority is cited for the statement that a DREF should be applied to half of the expected cancers. (EIS at 6.13). The single best estimate in the BEIR V report is 4, not 2. (BEIR V, 1990 at 23). Despite its endorsement, MDH does not use a DREF in its calculation of the tolerable risk limit.)

It is troubling that MDH does not acknowledge the support for a DREF at low doses by international and national authorities, including the BEIR V committee, which represents the most reliable consensus scientific reports extant on the subject. The 1988 UNSCEAR report suggests a DREF of 2.5 for use in cancer risk assessment for human leukemia and solid cancers at low doses, and estimates the ranges as being from 2 to 10. MDH does not refer to the 1989 Report of the French Academie des Sciences which endorses the DREF as being from 2 to 10 and the 1980 NCRP which reported the DREF as being from 2 to 10 based on scientific evidence. The willingness of MDH to reject a DREF and ignore the international and national authorities supporting application of a DREF to low dose radiation suggests MDH is more concerned with conjuring a low risk limit, rather than objectively evaluating and assessing the risk from the Facility.

<u>MDH's adoption of a tolerable risk limit of 10^{-5} for radiation ignores the differences between radiation and chemical carcinogens or other environmental pollutants.</u>

Use of a lifetime tolerable risk level of 10^{-5} for chemical carcinogens does not <u>a priori</u> justify imposition of the same risk level for radiation for purposes of radiological protection. MDH's Health Risk Assessment refers to a number of instances in which a lifetime tolerable risk level of 10^{-5} is applied to chemical carcinogens. (EIS at 6.1-6.3). MDH does not refer to any other instance in which the tolerable risk level of 10^{-5} has been applied to radiation in Minnesota. This risk level has never been imposed on NSP for radiation protection. Rather, MDH applies the lifetime tolerable risk limit of 10^{-5} to radiation from the Dry Cask Storage Facility, based on the argument that cancer risk from gamma radiation is a more certain risk to humans than the cancer risk from chemical and other environmental carcinogens. (EIS at 6.3). This argument, instead of supporting the use of the same risk level as chemical carcinogens, contradicts MDH's analysis of the risk from radiation.

MDH correctly states that the health effects from chemical carcinogens are less understood than those from radiation. Risk levels for chemical carcinogens are based almost exclusively on animal bioassay data and multistage mathematical models.

Because of the lack of human data for most chemical carcinogens and technical difficulties with extrapolating the results of animal tests to humans, risk levels for chemical carcinogens are arbitrarily and intentionally set at high levels. It must be recognized, however, that this is a political or regulatory value judgment, rather than scientific, decision, and one that is essentially arbitrary. As MDH states, there is no one correct risk level and other states and the federal government use other risk levels. (EIS at 6.1-6.2). MDH recognizes that federal agencies do not use the same lifetime risk level for all carcinogens and that risk levels are based on economic, technological and feasibility factors. (EIS, Appendix M at 2).

There is no reason to adopt the same arbitrary risk level applied to chemical carcinogens for purposes of dose limitation and radiation protection. Radiation is a known carcinogen at high doses. ("Low" and "high" doses of low-LET radiation, such as gamma radiation, are characterized by the NCRP as 0 to 20,000 millirems and 150,000 to 350,000 millirems, respectively.) For low doses of radiation, cancer and other adverse health effects, primarily hereditary disorders, are the principal stochastic effects. Stochastic effects are assumed to have no threshold, but the frequency, not the severity, is dependent on the dose. Stochastic effects are assumed to be induced with a frequency which is proportional to dose in the low dose region. The low dose region considered in the most studies and reports is on average 30,000 times the average annual dose from the Facility (10,000 millirems versus 0.34 millirem).

An additional distinction between risk assessments for chemical carcinogens as compared to radiation is the significance of natural background radiation. There is no evidence or experience with background concentrations of chemical carcinogens and the levels are vanishingly small or undetectable. There is no basis for determining whether 1 part per million or 1 part per billion of a chemical carcinogen is a risk other than through extrapolation from very high doses in animal tests and the use of mathematical models. (MDH is required to set standards and intervention limits for groundwater at background concentration for pollutants listed in Minn. Rules pt. 7035.2815, subpt. 4(H)(1)). In comparison, the presence and significance of natural background radiation is undeniable. While the public is seldom exposed to low levels of carcinogenic chemicals, the public is always exposed to low levels of radiation. The BEIR V report, relying on an assessment prepared by NCRP, calculated that members of the population in the United States receive an annual effective radiation dose equivalent of 360 millirems. Naturally-occurring radiation accounts for 82% of the dose equivalent received. (BEIR V, 1990 at 18-19 and EIS, Appendix G at 13-14). Nuclear power production accounts for less than 1 millirem or 0.1 % of the dose equivalent. (BEIR V, 1990 at 18-19). The average annual dose equivalent from the Facility is about 0.11%, or about 1/10,000th of the annual dose equivalent of natural background radiation. Despite the continual presence of widely varying levels of natural background radiation, no increase in cancer has been documented in populations residing in areas of high natural background radiation, which in some geographical regions measures three to ten times the natural background radiation in Minnesota. MDH's Health Risk Assessment, without any authority or evidence, makes the bald and scientifically unsubstantiated assertion that "[it is] the relatively high ambient levels of natural radiation, which most likely contributes significantly to background cancer rates." (EIS at 6.6). The BEIR V report reaches the opposite conclusion. (BEIR V, 1990 at 385).

Radiation protection standards promulgated by international and national authorities, and the State of Minnesota, regulate at risk levels where health effects from radiation are potentially detectable. These standards, which are described in more detail below, are all 100 millirems per year for the general population. These recommendations are designed to limit the exposure of the public to reasonable levels of risk comparable with risks from other mortality risks. Natural background radiation has been considered and incorporated into all radiation protection standards promulgated by international and national authorities.

No international or national authority has adopted radiation risk limits for radiation protection of the magnitude of the Minnesota Department of Health.

MDH is imposing a dose limit of 0.054 millirem per year to the maximum imposed individual. No international or national authority has recommended radiological protection guidelines based on a system of dose limitation for regulation of this low dose and low dose rate of radiation. The State of Minnesota, specifically the Minnesota Department of Health, has not attempted to regulate at this low dose and low dose rates of radiation nor has it proposed to regulate this low dose and low dose rates of radiation in its draft rules.

The magnitude of risk from low doses of radiation is evaluated at regular intervals by international and national committees, such as the United Nations Scientific Committee on the Effects of Atomic Radiation ("UNSCEAR") and the National Academy of Sciences ("NAS"). Recommendations concerning public health, worker safety and radiological protection are the responsibility of different scientific councils and committees, such as the International Commission on Radiological Protection ("ICRP") and National Council on Radiation Protection and Measurements ("NCRP"). UNSCEAR, NAS, ICRP and NCRP have found no compelling evidence of excess cancer occurring at radiation levels a few times greater than natural background radiation levels, including radon. ICRP and NCRP both recommend the average annual dose to an individual not exceed 100 millirems per year. This exposure is above natural background radiation. The NCRP recommendations are the basis for federal radiation protection standards and radiation protection standards proposed by MDH.

MDH rejects the ICRP and NCRP limits and argues they are outmoded because they do not consider the results of the BEIR V report. (EIS at 6.5). This is incorrect for three reasons. First, ICRP has extensively reviewed the BIER V report, took the information into account and still advocates a limit of 100 millirems per year. (ICRP, 1991). Second, NCRP has also extensively reviewed the results of the BEIR V report, took the information into account and still advocates a limit of 100 millirems per year. (NCRP, 1991). Contrary to the MDH's assertion, the dose limits were not adjusted by a factor of 5 in response to the BEIR V report. (EIS at 6.5). Instead, ICRP and NCRP recognize the uncertainty inherent in the extrapolation to low doses of radiation, i.e. less than 100 millirems per year, the scientific evidence, the comparative risks and the importance of natural background radiation in setting radiation protection standards. Third, NCRP in its 1987 recommendations states:

> Because the coupling between risks and dose limits is still quite loose, the use of these particular estimates [BEIR III] at this time does not critically affect the choice of effective dose equivalent levels for limits or guidance. Radiation protection systems and recommendations, in addition to being based as much as possible on quantitative data on irradiation and the resulting risk to health, also require some value judgments in which experience plays an important role. In addition, human experience with hazards in other aspects of society must be taken into account. ... Similarly, in the radiation protection of the general public, risk should be limited to levels comparable with those experienced in other circumstances to which the public is normally exposed.

(NCRP, 1987 at 2).

The 1987 NCRP recommendations have direct relevance to MDH's Health Risk Assessment in the definition of "negligible individual risk level (NIRL)." (NCRP, 1987 at 43-45). "The NIRL is regarded as *trivial* compared to the risk of fatality associated with ordinary, normal societal activities and can, therefore, *be dismissed from consideration.*" (emphasis in original)(NCRP, 1987 at 43). NCRP distinguishes the negligible individual risk level from an acceptable risk level, as the former is considered so low as to be inappropriate in relation to reasonable priorities for expenditure of resources. (NCRP, 1987 at 44). The NIRL is given an annual value of 10^{-7}, the annual risk that corresponds to an annual effective dose of about 1 millirem. (NCRP, 1987 at 45). The maximum and average radiation dose from the Dry Cask Storage Facility are well below the NIRL.

The recommendations of international and national authorities on radiation protection are relevant and important. Moreover, these international and national authorities have considered and analyzed the BEIR V report, which is the basis for MDH's Health Risk Assessment. Based on their review of BEIR V and the available evidence concerning adverse health effects from low doses of radiation, these authorities have recommended responsible and reliable standards to protect the public based on scientific evidence, comparative risks and value judgments.

MDH fails to follow its own policy in adopting a risk limit for radiation.

MDH's policy for adopting tolerable risk limits for environmental pollutants states that risks are considered for the general populations and that the tolerable risk limit of 1 in 100,000 has been applied when there are no existing state or federal standards. MDH fails to follow its own policy in adopting a tolerable risk limit for radiation based on exposure to the maximum exposed individual.

First, MDH's Health Risk Assessment is based on exposure to the maximum exposed individual, rather than a general or average population. The MDH's 1985 "Tolerable Risk" policy states:

> It therefore follows that environmental exposures resulting in annual mortality risk ratios of 10^{-6} or less can reasonably [be] considered "safe". Since this level of risk tolerance has been calculated from aggregate populations it should be applied to general population groups or "average" individuals in such a population.

(EIS, Appendix L at 16). In conclusion the 1985 policy states, "[i]t would seem an appropriate value of tolerable lifetime general population mortality risk should be about 10^{-5}." (EIS, Appendix L at 19). This conclusion is repeated in the 1991 policy of the Health Risk Limits Unit. (EIS, Appendix M at 4). Despite these statements of policy, MDH's Health Risk Assessment is based on the exposure of the maximum exposed individual. The Health Risk Assessment specifically rejects consideration of population exposure. (EIS at 6.6).

The population or collective dose from the Facility reconfirms that the radiation dose from the Facility is well below the level which poses a risk to the general public. The collective dose is calculated by adding individual doses received in a given population from exposure to the Facility. In this instance the given population includes residents within one mile of the Facility. Approximately 174 people live within one mile of the Prairie Island Nuclear Generating Plant, which includes the site of the proposed Facility

Approximately 10 people live within a radius from the proposed Facility which results in an annual average dose of greater than the "tolerable" risk limit of 0.054 millrem per year. All 10 are assumed to receive 0.34 millrem per year, the average dose from the proposed Facility. The remaining 164 people are assumed to receive an average annualdose of 0.02 millirem per year. (Persons visiting Lock and Dam No. 3 or the Prairie Island Mdewakanton Sioux Indian Community, specifically the Treasure Island Casino, are not included in the calculation of the collective dose because the dose a person would receive is below .005 millirem per year, one-tenth of the MDH "tolerable" risk limit and the exposure time is minimal.) The collective dose for the Facility is approximately 7 person-millirems per year or .007 person-rem per year. As described in more detail below, the current NRC collective dose criterion for ALARA is 1000 person-rem per year.

Second, MDH's Health Risk Assessment ignores existing state and federal standards for exposure to radiation for protection of the public. According to MDH policy, "Since this time [1981], whenever risk assessments have been conducted on various nonthreshold agents and there are no existing state or federal standards for these agents, the Department of Health has made recommendations for action based on this [lifetime tolerable risk level of 10^{-5}] level of risk." (EIS, Appendix L at 3 and 4). In applying the lifetime tolerable risk level of 10^{-5} to the Facility, MDH failed to follow its own policy; state and federal standards for exposure radiation exist and international and national recommendations of the ICRP and NCRP have been in existence for over sixty years. Unlike the risk limit the MDH imposes on the Facility, these standards have been promulgated and adopted pursuant to state and federal administrative procedures for rules and regulations.

The United States Nuclear Regulatory Commission (NRC) has existing standards limiting exposure to radiation to the public and from the Facility. (EIS, Appendix G at 18). New NRC regulations limit exposure to any member of the public from all sources of radiation to 100 millirems per year. 10 C.F.R. 20. This is a limit for the radiation dose a member of the general public may receive in one year from all sources. The NRC also has a standard for emissions from nuclear fuel cycle facilities, which is one-fourth of the total dose allowed. The NRC standard states annual exposure to any person outside of the plant must not exceed 25 millirems to the whole body as a result of direct radiation from the Facility. 10 C.F.R. 72.104. The United States Environmental Protection Agency (EPA) also has an existing standard limiting exposure to radiation from the Facility. (EIS, Appendix G at 17). The EPA standard limits exposure to the same levels as the NRC. 40 C.F.R. 191.03. The average annual radiation dose equivalent to the whole body from the Facility is estimated to be about 1.5% of the existing federal standards of 25 millirems. MDH's Health Risk Assessment concedes the existence of the federal NRC standard and that the radiation dose persons in close proximity to the Facility will receive is far below the standard. (EIS at 6.3); however, MDH still chooses to use a lifetime tolerable risk limit 10^{-5}, despite its own policy.

MDH has its own rules limiting exposure of members of the general public to radiation. MDH limits the maximum annual dose of radiation a person in "public environs" may receive to 500 millirems. Minn. Rule pt. 4730.3300. Radiation exposure to members of the public from the Facility is estimated to be 0.07 % of the existing state standard. MDH has proposed in rulemaking to repeal this rule and lower the level of permissible public exposure from radiation. In rules proposed February 2, 1991, MDH proposes an annual limit of 100 millirems per year for an individual continually present and 500 millirems for an individual periodically present in an "unrestricted area," which would include areas outside boundary limit of the Facility. Proposed Minn. Rule pt. 4730.0380. MDH's Health Risk Assessment does not mention the existing or proposed state standards for dose limits to members of the public. In the Statement of Need and Reasonableness for the proposed rules, MDH states, "The purpose of state regulation of sources of ionizing radiation is to reduce unnecessary radiation exposure when and where possible, by whatever means practical." (Statement of Need and Reasonableness ("SONAR") at 1). The Health Risk Assessment does not explain the apparent inconsistency of MDH proposing a standard of 100 millirems, which is intended to reduce unnecessary radiation exposure, and simultaneously advocating a risk limit of 0.054 millirem per year in the EIS. The Health Risk Assessment does not explain the apparent inconsistency of MDH proposing a standard 1800 times less restrictive than what it considers a "tolerable" or "acceptable" risk in the EIS. The Health Risk Assessment does not explain the use of 1987 NCRP recommendations as the basis for its proposed rule (SONAR at 36-37), which MDH condemns as "outmoded." (EIS at 6.5).

Moreover, the proposed rules for radiation protection conflict with MDH's use of a tolerable risk level of 10^{-5} as a definition of insignificant risk. The basis of the proposed rules on radiation protection to the general public is the 1987 NCRP report. (SONAR at 36-37). The 1987 NCRP report recommendation of a 100 millirems limit corresponds to a risk of mortality of about 10^{-5} annually or about 10^{-3} lifetime. (NCRP, 1987 at 37). MDH does not explain why in its Health Risk Assessment a lifetime risk of mortality of less than 10^{-5} is tolerable for the Facility, while at the same time it is proposing rules for the general public with a lifetime risk of mortality of 10^{-3}.

In addition to existing state and federal radiation protection standards, federal regulatory policies also conflict with the risk limit imposed by the MDH on the Dry Cask Storage Facility. MDH refers to the NRC's policy on Below Regulatory Concern ("BRC") for support for its risk limit. NRC has proposed a policy to exempt practices involving small quantities of radioactive material from regulatory control, based on the determination the risk they pose to individuals and society is "below regulatory concern." (EIS, Appendix P at 1). NRC's BRC policy is not directly relevant to the operation of the Facility; however, MDH analogizes the BRC policy because it presents NRC's judgement on "acceptable risk." (EIS, Appendix P at 2). NRC's BRC policy concludes the average dose to individuals in the critical group, i.e. the group expected to receive the highest exposure, should be less than 10 millirems per year for each exempted practice. NRC also finds the average dose to individuals in the critical group for practices involving widespread distribution of radioactive material in items such as consumer products or recycled material should be less than 1 millirem per year. (EIS, Appendix P at 8). The radiation dose from the Facility is geographically limited, does not result in exposure to the general public and does not result from widespread distribution of radioactive material. As a result, the 10 millirems dose limitation criterion is most applicable to the Facility. The average annual radiation dose to the nearest offsite resident from the Facility of 0.34 millirem per year is well below NRC's individual dose criterion and based on the NRC's BRC policy, the Facility should be considered an acceptable risk.

NRC's BRC policy also provides a collective dose equivalent criterion. The policy states that if a collective dose equivalent resulting from an exempted practice is less than 1000 person-rem per year, "the resources of the Commission [NRC] and its licensees could be better spent by addressing more significant health and safety issues than by requiring further analysis, reduction and confirmation of the magnitude of the collective dose." (EIS, Appendix P at 8). The collective dose is the sum of individual doses received in a period of time by a specified population from exposure to a source of radiation. (EIS, Appendix P at 5). The criterion is not to be considered as a dose limit for radiological protection, but rather a policy that takes into account societal and economic considerations. The cut-off of 1000 person-rem per year is currently the floor for ALARA, an acronym for "as low as reasonably achievable," which represents the level above which resources are committed to reduce the collective dose fromradiation. NRC's BRC policy finds individual doses below 0.1 millirem should not be considered in calculating a collective dose. MDH misconstrues this as a cut-off level and thus as an endorsement of their risk limit. ("It might be inferred that NRC considers this [0.1 millirem per year] to be a negligible dose. Again this is in reasonable agreement with the MDH calculation of the negligible dose of 0.054 millirem per year." (EIS at 6.4)). MDH's inference is incorrect. First, NRC's BRC policy clearly states the annual individual dose criterion for the critical group is 10 millirems. This is the most applicable risk limit to the Facility. The average estimated dose from the Facility is 0.3 % of the individual annual dose limit criterion. Second, MDH ignores the basis for the cut-off level of 0.1 millirem in calculating a collective dose.

> The Commission [NRC] believes consideration of individual doses below 0.1 mrem per year (0.001 mSv per year) do not need to be considered in the estimation of collective doses. The Commission believes consideration of individual doses below 0.1 mrem per year imputes a sense of significance and certainty of their magnitude that is not justified considering the inherent uncertainties in dose and risk estimates associated with exempted practices.

(EIS, Appendix P at 14). The NRC's BRC policy does not support MDH's Health Risk Assessment; it expressly challenges MDH's attempt to attach significance and certainty to extremely low doses of radiation, which in practice is considered to be a negligible individual risk level.

CONCLUSION

The proposed Dry Cask Storage Facility does not pose a risk to public health. MDH's Health Risk Assessment and its conclusion that the Facility presents an increased risk of excess cancer to the nearest offsite resident is seriously flawed. MDH relies almost exclusively on a report never intended for risk assessment or standards or guidelines for radiation protection. Moreover, MDH ignores well-established scientific evidence and as a result the Health Risk Assessment overstates the risk from the Facility. MDH ignores the conclusions and reasoning of international and national authorities and consensus scientific judgment, and in contradiction of its own policy, ignores existing national and state standards. These national and state standards were lawfully adopted and are based on consensus scientific judgment.

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North American Water Office

P.O. Box 174, Lake Elmo, MN 55042 (612) 770-3861

May 6, 1991

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar St.
St. Paul, MN 55155

RE: Adequacy of the Final Environmental Impact Statement For Northern States Power Company's Proposed High-Level Radioactive Waste Dump At Prairie Island (ISFSI)

Dear Mr. Cupit:

These comments are submitted on behalf of Minnesotans For An Energy Efficient Economy (ME3) and the North American Water Office (NAWO).

ME3 and NAWO support the comments submitted by Richard A. Duncan and William Hardacker on behalf of the Prairie Island Mdewakanton Sioux Indian Community.

In particular, the health risk assessment contained in the Environmental Impact Statement (EIS) presents enough cause for concern to warrant a full-scale analysis of the risk presented by the proposed dump. It is not adequate for the EIS to dismiss the risk assessment findings, that exposure to this single source would cause cancer risks that are 6 to 23 times greater than the acceptable level of risk in Minnesota, by suggesting that the dump be moved 200 yards south, and then postulating that such a move will reduce cancer risks to acceptable levels. To be adequate, considering the findings of the health risk assessment, the EIS must contain a full-scale Health Risk Analysis.

ME3 and NAWO support the EIS treatment of the conservation alternative, as far as it goes. This treatment significantly increases the ability of decision-makers to base energy management decisions on real-world costs and benefits of various supply and demand-side options.

While the conservation alternative in and of itself is adequately presented in the EIS, the EIS does not adequately discuss the various options in the broader context of what is the safest, most clean, most reliable, and most cost-effective mix of options for delivering electric utility services. The various options are analyzed in a piecemeal, isolated fashion that fails to serve the public's environmental and economic interests.

The need to place this decision in the broader context of how to best provide utility services has been recognized and codified as Minnesota Rules Chapter 7843, "Public Utilities Commission Resource

Planning Process." Considering the importance Minnesota's Energy Policy places on conservation, renewable energy, and cogeneration (see Minn. Stat. 216B.164, 216B.241 and 216C.05, for starters) and the ability of the proposed radioactive waste dump to effectively preclude these cost-effective, preferred options, the EIS is not adequate until it contains an analysis that places the proposed dump in the broader context. This context should be broad enough to include not only the resource mix required by NSP, but also the resource mix of other utility systems in the region that have the potential to impact NSP system requirements.

Thank you for your consideration.

Sincerely,

George Crocker
North American Water Office
Minnesotans For An Energy Efficient Economy

MINNESOTANS FOR AN ENERGY EFFICIENT ECONOMY

PROMOTING SUSTAINABLE USE OF NATURAL RESOURCES

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May 6, 1991

Bob Cupit
Minnesota Environmental Quality
Board
300 Centennial Building
658 Cedar Street
St. Paul, MN 55155

HAND DELIVERED

Re: Final Environmental Impact Statement, Prairie Island ISFSI Proposal

Dear Bob:

Enclosed for filing please find a bound original and an unbound copy of the Comments of the Prairie Island Sioux Indian Community to the Final EIS.

Very truly yours,

Richard A. Duncan

RAD:slw/0278P
Enclosure
cc: Members, Enironmental Quality Board (w/encl.)

COMMENTS OF THE
PRAIRIE ISLAND MDEWAKANTON
SIOUX INDIAN COMMUNITY
ON THE FINAL ENVIRONMENTAL
IMPACT STATEMENT
PRAIRIE ISLAND INDEPENDENT
SPENT FUEL STORAGE INSTALLATION

In making any decision, consider the effects of your action on the next seven generations.

Traditional Indian
Land Use Guide

I take it the intent of science is to ease human existence. If you [scientists] give way to coercion, science can be crippled, and your new machines may simply suggest new drudgeries. Should you then, in time, discover all there is to be discovered, your progress must then become a progress away from the bulk of humanity. The gulf might even grow so wide that the sound of your cheering at some new achievement would be echoed by a universal howl of horror.

Bertolt Brecht,
Galileo Scene 13

Everyone must be able to form an opinion about a matter that vitally affects our lives and our health, as well as the health of our offspring. Everyone must be entitled to take part in the adoption of decisions that will determine the future of our country and of the world.

Should nuclear power be developed? If so, should the construction of nuclear power stations . . . be permitted aboveground? Or should they be built underground? These issues are so crucial that they cannot be left to technical experts, and still less to bureaucrats, whose approach is too narrowly technical, too tendentious and sometimes prejudiced, as it is paralyzed by a network of mutual solidarity.

Andrei Sakharov,
forward to The Truth About Chernobyl,
by Grigori Medvedev

The Prairie Island Mdewakanton Sioux Indian Community ("Community") submits these comments on the Final Environmental Impact Statement ("FEIS") on the proposed Prairie Island Independent Spent Fuel Storage Installation ("ISFSI"). Overall, the FEIS represents a significant improvement over the Draft EIS issued last fall. Particularly in the area of identifying conservation alternatives to Northern States Power Company's ("NSP") proposed storage facility, the FEIS gives state and federal decision makers important new information. While the Community recommends that the Environmental Quality Board ("EQB") not approve the FEIS in its current form, but rather remand it to the staff for additional work, the FEIS's shortcomings are discrete, and can be remedied. The FEIS is well on its way to being a legally proper, useful decision making aid for the agencies that have to make the ultimate decision on whether to proceed with the ISFSI, particularly the Minnesota Public Utilities Commission ("PUC").

The Minnesota Environmental Policy Act ("MEPA"), Minn. Stat. § 116D.04 subd. 2a, requires that an EIS analyze the significant environmental impacts of a proposed project. The FEIS does not yet meet this standard. The FEIS has two major shortcomings which require that it be remanded for additional work:

1) **Lack of a health study.**

   Cursory "health risk assessments" have identified radiation levels from the ISFSI ranging from 6 to 23 times acceptable state standards. It is time for the EQB to order a comprehensive study of the health effects and costs of the ISFSI.

2) **Failure to identify a preferred alternative.**

The FEIS studies the proposed ISFSI and numerous feasible alternatives. FEIS at second page. To be a proper decision aiding document, the FEIS should identify a preferred alternative, as other EISs do.

Additionally there are several other smaller flaws in the FEIS which are enumerated herein, which are relatively simple to fix, and which should be corrected as part of the remand.

I. CONSERVATION IS A FEASIBLE AND PRUDENT ALTERNATIVE TO THE ISFSI

The most significant new finding in the FEIS is that conservation is a feasible and prudent alternative to the ISFSI.[1] FEIS at 5.7 - 5.12.

The FEIS concludes:

> A 1988 study of the electric conservation potential in Minnesota, performed by PLC Incorporated for the Department of Public Service, found that a substantial percentage of the electricity currently consumed could be saved without any reduction in convenience or standard of living. The potential savings amounts to over half of the electric energy used in Minnesota. The total energy savings could not be achieved overnight and would require some investment. However, the

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[1] "Feasible and prudent" is a term of art in environmental and public construction statutes. An alternative is "feasible" if it is technically possible; an alternative is "prudent" if it can be implemented without creating community disruptions of extraordinary magnitudes. <u>See</u> <u>County of Freeborn v. Bryson</u>, 243 N.W.2d 316, 320 (Minn. 1979) (interpreting Minnesota Environmental Rights Act, Minn. Stat. Ch. 116B, and adopting federal law definition contained in <u>Citizens to Preserve Overton Park v. Volpe</u>, 401 U.S. 402, 411 (1971)).

> investment would be paid off with lower energy bills.
>
> In evaluating the cost-effectiveness of a conservation measure, the impact of not saving electricity must be considered. In the absence of energy conservation, electricity consumption will increase, thereby causing greater environmental impact and economic costs. The cost of electricity, therefore, must include not only the direct costs of generating electricity (fuel, operation, and maintenance) but also the costs of future capacity additions and the indirect environmental costs.
>
> The PLC report estimates a cost that includes the direct costs and the costs of future capacity additions to determine which conservation measures should be incorporated in the total savings estimates. The estimate does not include environmental costs. The types of conservation that were very cost effective include residential refrigeration, lighting, and air conditioning, commercial lighting and refrigeration, and industrial cooling, lighting heating and refrigeration. . . .
>
> NSP would need to spend approximately $150 million to reduce energy demand [by an amount] equal to that generated by the PI plant in 1989 (8,279 gigawatt-hours).

FEIS at 5.11 - 5.12. Conservation is a feasible alternative ("a substantial percentage of the electricity currently consumed could be saved," i.e. technically possible). Conservation is a prudent alternative (savings made, "without any reduction in convenience or standard of living," i.e. no disruptions of extraordinary magnitude).

Independent experts corroborate the finding in the FEIS that conservation is a feasible and prudent alternative to the proposed ISFSI. Paul Hansen is the person in Minnesota who combines in one individual the greatest combined expertise on the environmental status of the Upper Mississippi River (from St. Paul to St. Louis including the stretch of the river in which Prairie Island lies) and energy conservation through demand side management programs (the types of programs examined in the Department of Public Service study).

Mr. Hansen reviewed the FEIS and its conclusions on conservation and found them compatible in terms of technical potential (feasibility) and impact on lifestyles (prudence) with demand side management programs already underway at other utilities. Affidavit of Paul Hansen at ¶¶ 4-6, attached at Tab 1. Specifically, he found that the technical potential for energy savings identified in the Department of Public Service ("DPS") study was consistent with the technical potential nationally found in studies by the Lawrence Berkeley Laboratories, the Oak Ridge National Laboratory, the Rocky Mountain Institute, and even the captive research arm of the utility industry, the Electric Power Research Institute ("EPRI"). Like the DPS study, all of these studies concluded that the identified savings would be achieved without extraordinary disruption in consumers' lives.

Mr. Hansen identifies in his affidavit numerous examples of utility conservation programs already in place which will save from 600 to 2,500 megawatts ("MW") each -- ample evidence that replacing through conservation any amount of output from NSP's Prairie Island nuclear generating station up to its full 1000 MW capacity is feasible. Hansen affidavit at ¶ 6. Specifically, Pacific Gas and Electric will save 2,475 MW of capacity over the next 10 years; Sacramento Municipal Utility District will save 600 MW; Bonneville Power Administration will save 1,350 MW; New England Electric will save 1,162 MW; Con Ed of New York will save 2,509 MW. Id.

Identifying and quantifying conservation as a feasible and prudent alternative to the ISFSI is the major improvement of the FEIS over the Draft EIS. The State's decision makers now have the option to avoid semipermanent storage of high level waste above ground, the program chosen by NSP as the solution to our energy needs.

II. THE EQB SHOULD ORDER A COMPREHENSIVE HEALTH EFFECTS STUDY

The FEIS's treatment of the health effects of the proposal ISFSI is terribly inadequate, especially in comparison to the significant improvement made in the conservation portions of the document. It is time to stop skirting the health issues with "risk assessments." The EQB should order a comprehensive study of the health effects of the proposed ISFSI and should not approve the FEIS until it includes such a study. The EQB should also order that if the ISFSI is constructed, an ongoing health monitoring program be put in place to monitor the effects of the installation on residents' health.

As noted above, MEPA requires that significant impacts be evaluated. The EQB's rules also require that, if necessary, expert studies be undertaken or commissioned as part of an EIS. An interdisciplinary approach to EISs is required, including the use of the expertise within State agencies and retained consultants if necessary. See Minn. R. 4410.2100 subp. 10 (selection of consultants); Minn. R. 4410.2200 (interdisciplinary study required). Radiation from the proposed ISFSI is a form of environmental pollution with known significant adverse human health effects. FEIS at 6.7.[2] The EQB has a duty to fully study those health effects, and quantify their cost.

The Minnesota Department of Health ("MDH") Risk Assessment, FEIS at 6.1, concludes that the ISFSI:

> will deliver a dose of gamma radiation to offsite residents resulting in a cancer risk above the acceptable or tolerable risk limit established by the Minnesota Department of Health (MDH). The acceptable level for incremental lifetime carcinogenic risk from any single source of environmental pollution is a lifetime risk level of one in 100,000 or 10^{-5}. MDH estimates that the cancer risk to nearby residents from the proposed facility may be as much as 6 in 100,000.

The FEIS shrugs off a risk six times the level accepted by the state as "small risk well within the range of risks that people voluntarily accept." FEIS at 6.1.[3] The state regulates

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[2] See also Wing, et al., "Mortality Among Workers at Oak Ridge Nat'l Laboratory," 265 J.A.M.A. 1397, 1399-1401 (1991), copy attached to Comments of Community to Draft EIS (Mar. 21, 1991), attached at Tab 2.

\ [3] The MDH and other Minnesota state agencies have implemented a policy of accepting a lifetime cancer risk level of 1 per 100,000 for over a decade. FEIS at 6.1. The level of acceptable cancer risk for airborne carcinogens in the Clean Air Act Amendments of 1990 is 1 per 1,000,000, reflecting new evidence of the harmful effects of carcinogenic substances. Clean Air Act § 112(c)(9)(B), 42 U.S.C. § 7412(c)(9)(b). The MPCA will be required to revise its level of acceptable risk in carcinogens and potential; radiation is a proven carcinogen. FEIS at 6.7. The same standards are applied to potential human carcinogens, such as dioxin. The FEIS, in downplaying the state's own health standards, implies that for the known human carcinogen radiation, we should be less concerned about exposure levels than we are for other pollutants which are only potential human carcinogens. The state would never downplay the risks of dumping a potential human carcinogen like dioxin into the Mississippi River in the same way that the FEIS downplays the excessive health risk from the known human carcinogen radiation. Just because radiation is silent and invisible does not mean we

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promulgating clean air regulations. The MDH should also reconsider the level of carcinogenic risk from any single source in light of the new studies of the effects of low-level radiation on the survivors of the atomic bombs. See BEIR V; Nussbaum at Tab 5. Moving to an acceptable risk level of 1 per 1,000,000 cases of cancer from any single source would bring MDH's standards into conformity with new clean air standards used by MPCA.

Moreover, it is no longer necessary to use downward extrapolation from actual measurements of cancer at high doses to estimate cancer risk from low levels of radiation, as is erroneously reported in FEIS at 6.1. R.H. Nussbaum, R.E. Belesy and W.Kohnlein, "Recent Mortality Statistics for Distally Exposed A-Bomb Survivors: The Lifetime Cancer Risk for Exposure Under 500cGy (rad)", Med. Nucl. 2 (1990), H.2 (Verlag Gesundheit Gmbh Berlin) 163, 172, attached at Tab 5 (hereinafter "Nussbaum")

> At a minimum, these findings of exposure to low doses of radiation suggest the need to reconsider current radiation safety guidelines and to update projections estimating the future public health impact of low-dose radiation exposure . . . .

Nussbaum at 172, Tab 5.

should give special allowance to projects which pollute through radiation rather than more tangible pollutants.

The FEIS determined that the cancer risk from the ISFSI would be 6 out of 100,000 based on estimated offsite dose rates supplied by NSP. NSP initially estimated that the highest dose to nearby residents would be 3.74 mrem per year. Based on this dose, the MDH concluded that the increased lifetime cancer risk from the ISFSI would be 23 in 100,000. The MDH recommended that the facility not be built. Id.

Faced with this recommendation, NSP recalculated the offsite dose rate to incorporate the shielding effects of trees and housing materials, the spherical shape of the casks and the casks' weather cover. The original estimate was also based on the dose which would occur when all 48 casks were in place and this was reduced to reflect the gradual placement of casks at the site.[4]

The recalculation resulted in an estimated average annual dose to the nearest resident of .34 mrem per year. The FEIS provides no explanation of the method used to calculate offsite dose rate. Accurate calculation of dose rates by an independent third party would be a key improvement of the health effects study.

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[4] A more accurate calculation would include the likelihood of no federal acceptance of spent fuel and the resulting placement of 90, instead of 48, casks at the ISFSI. See infra at Part IV.1; Scenario D, FEIS at 3.25.

NSP's revised estimate incorrectly assumed that area residents spend 100% of their time indoors. FEIS at 6.9. The MDH made an upward adjustment to account for a small percentage of time spent outdoors. The MDH's calculations of lifetime cancer risk are based on an average dose of .35 mrem per year. FEIS at 6.9. This dose rate is artificially low.

The MDH then estimated the lifetime cancer risk for continuing gamma radiation to the nearby population. The determination that an offsite dose of .35 mrem per year would create a risk of 6 out of 100,000 was based primarily on Table 4-20 of the BEIR V Report. FEIS at 6.10.[5] This risk is clearly unacceptable, as it is six times higher than the state's acceptable risk of one per 100,000. Furthermore, prior to last-minute "recalculations" of doses by NSP, MDH had estimated a cancer risk 23 times that specified in state standards. These earlier findings raise significant doubt with regard to the FEIS's rather Polyanna-like conclusion that the ISFSI will "only" cause six times as many cancer deaths as the state regularly permits from a single source of pollution, and that the risk is acceptable. It is not acceptable to the Prairie Island Indian Community. The Community has a right to the true facts, and the

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5 Other studies conclude that the lifetime risk of cancer from low dose exposure is higher than that indicated in the BEIR V report. See Comments by Radioative Waste Management Associates at 5, attached at Tab 4 (hereinafter "RWMA Comments"); Nussbaum at 169, Tab 5; J.S. Gofman, Radiation-Induced Cancer from Low-Dose Exposure (CNR 1990) at Table 16-B, 16-4, 16-5 and 25-7 (". . . radiation committees are underestimating cancer-risk by up to 30-fold.").

EQB has a duty to complete a proper, comprehensive health study as part of this EIS.[6]

The Community also submits the specific comments of Dr. Rosalie Bertell. Dr. Rosalie Bertell, Ph.D., GNSH, has devoted twenty years to the study of populations exposed to low doses of radiation. Dr. Bertell reviewed the FEIS, particularly, the risk assessment in Chapter 6.1, and pointed out several risks which are not addressed by the FEIS:

1. The complete lack of attention to risks to the unborn child or to the reproductive capacity of exposed persons. These concerns may present a special problem to Native Americans because of limited gene pool due to intermarriage. Affidavit of Dr. Rosalie Bertell at ¶ 3, attached at Tab 6.

2. The FEIS fails to allow for higher radiation exposure for local hunting or fishing, as people use the open fields and walk nearer to the storage area. Bertell affidavit at ¶ 4.

3. All possible exposures occurring during the transportation of the spent fuel rods to the storage facility may not have been considered. Bertell affidavit at ¶ 5.

Dr. Bertell questioned the MDH's reduction of cancer risk due to low dose prolonged radiation exposure by one-third.

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[6] The conflict between the MDH's earlier conclusion that the risk from the ISFSI would be 23 per 100,000 and its present conclusion that the risk would be 6 per 100,000 alone is enough to require a remand of the FEIS for the performance of a comprehensive health effects study.

Bertell affidavit at ¶ 2. This reduction may not be warranted and further data and analysis should be supported.

Dr. Bertell emphasized the importance of conducting a health study now, before the first cask is put in place, to establish base line health data for persons at risk from the storage facility. Data should be collected on blood and urine samples, liver function and reproductive experience for the surrounding population. Gathering base line data would facilitate the monitoring of the population for changes and early identification of changes. A baseline study coupled with ongoing monitoring of the population would make preventive measures possible before there are serious cancers, congenital diseases or infectious diseases. Bertell affidavit at Page 2.

III. THE FEIS CONTAINS OTHER FLAWS WHICH SHOULD BE REMEDIED

While the lack of a health effects study is the primary shortcoming in the FEIS, there are several other areas in which the FEIS devotes insufficient study to a problem, or is simply incorrect in its conclusions. What follows is a discussion of some of the other areas of inadequacy in the FEIS, which should be remedied during a remand. This listing is not meant to be exhaustive, but only to highlight important flaws:

A. How will the irradiated fuel be removed from Prairie Island and the installation decommissioned?

It is not clear from the EIS how the irradiated fuel will eventually be removed from Prairie Island and the installation decommissioned. Though the TN-40 cask could conceivably employ an overpack for transportation, the total weight of cask, overpack, fuel and carriage may exceed the safe carrying weight of local bridges. Transportation issues have not been explored in the FEIS. RWMA Comments at page 1, Tab 4.

A final repository is not expected till the year 2010, probably later. Because the potential removal of irradiated fuel from Prairie Island has been advanced so far into the future, the State should require a performance bond, if available, or have NSP contribute to a stand-alone decommissioning fund which can be used by NSP for dismantling the ISFSI, or by the State, if the fuel is not removed from the site by date certain. This is to ensure that the ISFSI does not become a state liability. If a final repository never operates the State should protect itself. RWMA Comments at page 2, Tab 4.

B. What would be the impact of a major flood or airplance crash?

Safety problems are understated in the FEIS. Though rushing water from a major flood, by itself, may not dislodge a TN-40 cask, piled debris, forming a dam, may build up sufficient force to turn over casks. The FEIS states that the water velocity at maximum flood, is only 6.2'/sec and the draft force is only 20% of that needed to cause the cask to tip or slide. The FEIS does not specifically discuss how NSP will recover from this accident. RWMA Comments at page 6, Tab 4.

Another accident involves the direct impact of an airplane engine into the cask. Though the probability of such an accident is small, a jet engine crashing into a cask is likely to do considerable damage to a cask. In Germany this potential accident is scale-model tested by requiring the CASTOR cask to withstand the force of a one-ton missle striking the cask at the speed of sound. It is unlikely that the TN-40 could survive such a test. The FEIS analysis on this point is nonexistent.

If the TN-40 casks were sheltered in a concrete building, this accident would not be possible. In addition, a concrete building would have other beneficial effects: gamma radiation would be shielded, and the casks would also be protected from the elements, including the freese/thaw cycle. RWMA Comments at page 6, Tab 4.

C. Would the TN40 cask withstand anti-tank weapons or explosive devices which may be used by terrorists or during war?

Security problems are also understated. The FEIS refers to NRC reports which were outdated when written in 1979. Irradiated fuel casks, while extremely sturdy, can be compromised by anti-tank weapons or explosive devices commonly available, for example, at oil fields in the MidEast. Such explosive devices could easily penetrate 14 inchies of steel. Of course, other terrorist targets are available, but the risk should not be discounted by dismissing or minimizing the threat. RWMA Comments at page 7, Tab 4.

D. The FEIS Improperly Concludes That Minn. Stat. § 116C.722 Does Not Apply To This Proceeding

Section 116C.722 of the Minnesota Statues provides that in conjunction with a proposed nuclear waste storage facility,

> If an Indian tribal council that has jurisdiction over part of a potentially impacted area within the state requests legal or technical assistance, the [Environmental Quality] board shall provide assistance.

It is undisputed that radiation spilling off the dry casks of the ISFSI would impact tribal land and members of the Community if the project goes forward.

The Community applied for legal and technical assistance pursuant to Minn. Stat § 116C.722, and was turned down. See correspondence contained at Tab 7. On this issue, the FEIS states:

> Comment 15A refers to "technical and legal assistance", which, upon request, can be provided by the EQB to Indian tribes pursuant to Minnesota Statutes, section 116D.722 [sic]. However, that statute was designed to provide assistance in the event that a high level radioactive waste repository was being sited in Minnesota. The statute specifically excludes the on-site storage of spent fuel from consideration. While it may be argued that some issues relevant to the proposed ISFSI are not dissimilar from a repository, the intent of the state is clear.

FEIS at 4.10. The FEIS is incorrect. The legislator who drafted the statute wrote to the EQB on April 17, 1991:

> The legislative intent was clearly meant to cover just such an instance such as the one the Sioux community now finds itself in, and for which it is requesting technical assistance.

Tab 8. Indeed, the argument that the ISFSI is not a "high level radioactive waste repository" is rather nonsensical. The FEIS should be amended to reflect that Minn. Stat. § 116C.722 applies to this proceeding.

IV. THE FEIS SHOULD IDENTIFY A PREFERRED ALTERNATIVE

The FEIS is not a proper decision-aiding document because it does not take advantage of the combined environmental expertise represented by the EQB and identify either the ISFSI or one of the alternatives as the preferred alternative. The governor has described the EQB as the "environmental cabinet." The Board should take this opportunity to lead the State on energy policy and nuclear waste storage policy. The Board should identify a preferred alternative.[7]

The proposed ISFSI should not be the preferred alternative. It is a known health-risk. It is a temporary solution which may develop into a permanent problem. It will be economically and environmentally costly to a degree far greater than NSP acknowledges.

Conservation should be the preferred alternative. It is feasible and prudent. It is clean. It will be a bargain economically in the long run. Indeed, under the substantive

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[7] It matters not that the EQB itself will not make a final permitting decision on the ISFSI. In the context of an EIS it is appropriate and necessary for the EQB to offer its expertise to the ultimate permitting authorities, the Minnesota PUC and the NRC, through the selection of a preferred alternative. Cf. Natural Resources Defense Council, Inc. v. Morton, 458 F.2d 827, 834-35 (D.C. Cir. 1972) (agency has duty in EIS to study alternatives outside its regulatory permitting authority; decided under National Environmental Policy Act, 42 U.S.C. § 4332).

standards contained in MEPA, Minn. Stat. § 116D.04 subd. 6, and the Minnesota Environmental Rights Act, Minn. Stat. 116B.09 subd. 2, conservation is the legally mandated preferred alternative.

A. The ISFSI Will Cost Much More Than Estimated by NSP

According to the FEIS,

> NSP has estimated the cost of the proposed ISFSI project to be between $35 and $40 million. This estimate includes costs of design, licensing and review, facility construction, 36 casks, cask handling equipment, and personnel through 2015.

FEIS at 4.27 (emphasis added). This cost estimate, however, excludes numerous areas of cost, such as cost of making the casks transport ready for eventual shipment to a permanent repository, and to costs such as increased health care costs for local residents which have yet to be quantified. Simply taking cost information presented in other portions of the FEIS, it is clear that NSP is underestimating the true cost of the ISFSI project by at least a factor of three. When one includes costs which have yet to be quantified, including health care and health monitoring costs, and a multiplier to reflect the historic failure of nuclear power facilities to come in anywhere near estimated cost, it is obvious that NSP's $40 million cost estimate is only a small down payment on the ISFSI.

Before delving into the details of cost projections, one important overall point must be established:

> **The cost of the ISFSI includes not just costs which NSP plans to bear directly, but also all direct and indirect costs which NSP wants to slough off onto third parties, whether costs**

> of transport (to be borne by the federal Department of Energy, FEIS at 4.20, 4.27 - 4.28), health care costs (to be borne by local residents including the members of the Community), or other costs.

To analyze properly the ISFSI and alternatives to it, overall societal costs and benefits must be compared, not simply present day accounting costs to NSP.

What follows is an analysis of the likely actual costs of the proposed ISFSI. For purposes of illustration, let's begin with NSP's upper end estimate of $40 million for 36 casks.

Base Cost Estimate For ISFSI: $40 Million

1. NSP Will Need Many More Than 36 Casks

The cost of the casks is the primary direct cost of the ISFSI. "The overall cost of the installation will be determined largely by the number of casks required." FEIS at 3.25.

First, let's simply adjust the base cost estimate to reflect the number of casks for which NSP is presently seeking permits -- 48, <u>not</u> 36. FEIS at 1.1 - 1.2. Basing cost estimates on a 36 cask facility is deceptive when authorization is being obtained for a 48 cask facility. 48 casks is 1.333 times 36 casks, so the cost of the project has now increased 1.333 times, or ($40 million) (1.333) = $53.333 million.

Cost Of ISFSI With Permitted Number Of Casks: $53.333 million

But how likely is it that the ISFSI will not need to be larger than 48 casks at full operation, given NSP's desire to operate its Prairie Island plant at full capacity through an extended license period, and the Department of Energy's ("DOE") inability to begin accepting waste for permanent storage? The FEIS indicates not likely at all. FEIS at 3.24 - 3.25, 4.20, 4.24 - 4.26.

The FEIS outlines five scenarios with respect to the quantity of dry cask storage required. FEIS at 3.24 - 3.25. All indications are that NSP plans to seek an extension of its Nuclear Regulatory Commission ("NRC") operating license for Prairie Island, and that federal acceptance of waste for permanent disposal is uncertain and distant. The conclusion on federal waste storage is unsurprising; one need only recall the political furor in this State when the federal government suggested siting a permanent repository here. Scenario D is the appropriate scenario for likely cost estimates:

> Assumptions: No federal acceptance of spent fuel before the plant is to be decommissioned, 50 year plant life [assumes a 10 year plant life extension granted by the NRC].
>
> Results: Storage for 3546 spent fuel assemblies needed, and would require a total of about <u>90 casks</u>. This number cannot be specifically projected, due to the presence of non-standard (either previously consolidated or damaged) fuel currently in pool storage. Storage would be needed until all fuel is accepted by the DOE.

FEIS at 3.25 (emphasis added). 90 casks is 1.875 times 48 casks. If the cost of a 48 cask ISFSI is $53.333 million, the cost of the more likely 90 cask ISFSI is ($53.333 million) (1.875) = $100 million.[8]

Cost Of ISFSI With Likely Eventual Number Of Casks: $100 Million

2. The Casks Have To Be Made Transport Ready Eventually

The casks which NSP proposes to use in the ISFSI are not designed for long distance transport. FEIS at 3.29, 5.14 - 5.16. The reason why is that transport-worthy casks cost 50% to 100% more than casks designed for storage alone. FEIS at 5.16. Yet, the casks <u>must</u> at some point be retrofitted for transport, or replaced with transport-worthy casks. Otherwise, a fraud will have been committed on the public, as NSP's "temporary" storage facility become a permanent above ground waste dump. Prior reaction in Minnesota to such proposal has shown that, in the

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[8] It is proper to use the FEIS's Scenario D in calculating the likely eventual number of casks in the ISFSI. NSP has had a history of systematically underestimating the scope of the nuclear waste problem at its Prairie Island plant, then returning to regulatory authorities for larger and larger bites at the apple. For instance the initial "environmental review" documents for the construction and operation of the Prairie Island plant blandly assumed that, "there was no expectation that there would ever be a problem with storage space." Tab 9. Of course, there was a problem. Fifteen years later, in the early 1980s, NSP sought and obtained permission to "re-rack" the spent fuel rods in its storage pool, a quick-fix which was allegedly going to solve Prairie Island's fuel storage problems. Of course, it didn't. Now NSP would have everyone believe that a 48 cask ISFSI will solve the problem. It won't. Use of the 90 cask Scenario D for purposes of calculating the true likely cost of the ISFSI is appropriate. Every time the nuclear waste problem at Prairie Island is revisited, it just gets worse. Worst case analysis is clearly appropriate here. <u>See also</u> Minn. R. 4410.2500 regarding need for worst case analysis.

full light of disclosure, such a proposal could never succeed. Therefore, the cost of making the casks transport ready must be factored into the costs of the ISFSI.[9] For the sake of estimation, let's use the midpoint in the range of cost to make the casks transportable: 75% more expensive than the present storage-only proposal. Likely cost of the project then becomes ($100 million storage-only ISFSI cost)(1.75) = $175 million.

Cost Of ISFSI With Transport Worthy Casks: $175 Million

3. Cost of Decommissioning Must Be Included

Costs of decommissioning the ISFSI are not included in NSP's cost estimate. FEIS at 4.27. The FEIS identifies these costs to be $3.1 million. It is unclear why these costs -- certainly a cost of the project which must be included in any analysis -- are not included in the cost estimate. They should be, and they add at least $3 million to the cost of the project.

Cost of ISFSI With Decommissioning: $178 Million

4. Cost Overruns Will Plague The ISFSI

Perhaps more than any other private industry, the nuclear power industry has historically been plagued by cost overruns. Typical cost overruns are in the billions of dollars on a generating station. These cost overruns have become so mammoth and so routine in the industry that it is unrealistic to assume that the ISFSI will come in anywhere near budget. The likely

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[9] Again, it matters not whether transport costs are ultimately borne by NSP or DOE. Transport is a cost of the project; whether citizens of Minnesota bear that burden as rate payers or as taxpayers doesn't change that fact.

cost of the ISFSI without accounting for cost overruns is $178 million as per the calculations above. The investment banking firm of Donaldson, Lufkin & Jenrette ("DLJ") used to publish nuclear industry investment reports tracking, among other things, the increasing costs which have plagued nuclear projects. That firm's 1985 report, portions of which are attached at Tab 10, surveyed many of the commercial reactors in the country. That survey showed that, on average, the estimated cost of nuclear plants during or after construction was 5.5 times[10] the initial estimate of costs. The foreseeable total cost of the ISFSI including cost overrun is ($178 million)(5.5) = $890 million.

Cost Of ISFSI After Foreseeable Cost Overruns: $890 Million

5. The FEIS Does Not Calculate Indirect Health Costs Of The ISFSI

The FEIS fails to quantify the increased health care and health monitoring costs associated with ISFSI. There costs exist. The fact that they have not yet been quantified merely hides them; it does not make them go away. The FEIS must be remanded for a full study of the nature of these costs, and their quantity. These costs must be considered a part of the project.

Cost Of ISFSI Including Health Effects: $890 Million + ?

6. The FEIS Identifies But Does Not Quantify Worst-Case Scenario Operating Costs

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10 This figure was derived by comparing the initial "Total Cost" estimate given in the DLJ report with the most recent (1984 or 1985) cost figure given for each of the reactors surveyed. The two highest and the two lowest figures were then discarded. An unweighted average cost overrun was then calculated.

If a federal repository is not set up until well after the Prairie Island plant is shut down and decommissioned, the FEIS identifies escalating costs for longer-term storage. FEIS at 4.25. Furthermore, a cost bond should be posted by NSP to cover decommissioning costs. However, the FEIS does not attempt to quantify these costs. Nonetheless, decision makers need to be aware of such costs.

Cost Of ISFSI Under Worst-Case Operating Scenario: $890 Million + ? + ?

7. The FEIS Does Not Quantify The Costs Of An Accident

The longer spent fuel is stored in above ground casks, the greater the chances of a catastrophic accident. There is no putting the genie back in the bottle. Once those casks are sitting outdoors on their pad, they will stay there until a federal repository is opened. If no federal repository opens, they may stay there essentially forever -- certainly longer than the 500 year flood which the ISFSI is designed to withstand. FEIS at 4.14.

The FEIS makes no attempt to quantify the costs of a catastrophic accident. They are obviously immense. Even if discounted to reflect likelihood of occurrence, if we knew them exactly, the costs of an accident could swamp all other costs of the ISFSI combined. Those costs should be factored into decisions on the ISFSI.

Cost Of ISFSI Including Accident Costs: $890 Million + ? + ? + ?

In summary, the State and the rate payers are not getting a bargain with the ISFSI. They are buying a pig in a poke, with direct costs certain to mount to many times NSP's estimates, and with numerous large but as yet unquantified costs skulking about out there.

B. CONSERVATION SHOULD BE THE PREFERRED ALTERNATIVE

Of the proposed ISFSI and all the alternatives identified in the FEIS, the conservation alternative is clearly the best option. The EQB should identify it in the EIS as the preferred alternative.

The conservation alternative is feasible and prudent. See supra at Part I. By reducing output at Prairie Island over the next several years, and replacing that output with more efficient use of energy, NSP will be able to continue to operate the plant without a dry cask storage system, through the plant's presently licensed operating period if need be. FEIS at 5.47.

The conservation alternative is clean. As the FEIS notes at 5.11 - 5.12, there are environmental costs associated with power production. We know there are significant health costs associated with the proposed ISFSI. The conservation alternative avoids these costs.

The conservation alternative is forward looking. There is substantial doubt, reflected in the FEIS, that there will ever be a permanent nuclear waste repository in the United States, or a permanently safe method of waste disposal. While we cannot go back in time to the days when, "there was no expectation that there would ever be a problem with storage space," and stop the entire accumulation of high level radioactive waste, we can avoid generating more waste then is absolutely necessary. The conservation alternative allows for such action.

The conservation alternative makes economic sense. The FEIS identifies the cost to conserve the amount of energy equivalent to the amount generated by the Prairie Island plant to be $150 million. When all costs of the ISFSI are fairly measured and incurred, the cost of conservation will seem cheap. In addition, as the FEIS notes, "the investment [in conservation] would be paid off with lower energy bills." FEIS at 5.11.

The conservation alternative is legally mandated. The Minnesota Environmental Rights Act ("MERA"), Minn. Stat. § 116B.09 subd. 2 provides:

> In any [ ] administrative, licensing, or other similar proceedings, the agency shall consider the alleged impairment, pollution, or destruction of the air, water, land, or other natural resources located within the state and no conduct shall be authorized or approved which does, or is likely to have such effect so long as there is a feasible and prudent alternative consistent with the reasonable requirements of the public health, safety, and welfare and the state's paramount concern for the protection of its air, water, land and other natural resources from pollution, impairment, or destruction. Economic considerations alone shall not justify such conduct.

(Emphasis added.) MEPA provides in Minn. Stat. § 116D.04 subd. 6 a virtually identical substantive standard for decision making. State Health Department "risk assessments" have identified a cancer risk from the proposed ISFSI ranging from 6 to 23 times acceptable state standards. The carcinogenic radiation coming off those casks is a pollutant. It will pollute the environment every bit as much as if the Prairie Island plant were pouring dioxin straight into the Mississippi River. There is a feasible and prudent alternative--the conservation alternative--to this environmental degradation. The law requires the EQB to endorse that alternative.

When Bertolt Brecht, an intelligent layman, made the observation quoted at the beginning of these comments, the nuclear age had barely dawned. To him, the idea that nuclear energy was too dangerous to be left in the hands of scientists was immediately apparent. By contrast, it took physicist Andrei Sakharov an entire career working in the nuclear field to come to the same conclusion; but arrive at it he did. The EIS process is one in which citizens and the collected knowledge of the State's environmental agencies can affect decision making on the proposed ISFSI. The EQB can and should take a leadership role on the nuclear waste storage issue and endorse the conservation alternative as the preferred alternative.

CONCLUSION

For all of the reasons given, the EQB should pass a motion which remands the FEIS for the following action:

1) Performance of a comprehensive study of the effects of the ISFSI on human health, including a quantification of the health care and health care monitoring costs which will be incurred as a result of the ISFSI if built;

2) Correction of the other flaws in the FEIS identified in Part III of these comments;

3) Identification of a preferred alternative.

The evidence demonstrates, and MERA and MEPA require, that conservation be the preferred alternative.

Dated: May 6, 1991

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ATTACHMENT # 1

AFFIDAVIT OF PAUL W. HANSEN

State of Minnesota)
) ss.
County of Hennepin)

Paul W. Hansen, being duly sworn, states based on his knowledge, information and belief:

1. By virtue of my background, training, and experience, I have gained expertise in issues related to the conservation of energy and the conservation of the natural resources of the Upper Mississippi River. In preparation for giving this affidavit, I have reviewed the Final Environmental Impact Statement ("FEIS") dated April 12, 1991, prepared by the Minnesota Environmental Quality Board on the proposed Prairie Island Independent Spent Fuel Storage Installation ("ISFSI"), specifically the section on conservation alternatives to the ISFSI, FEIS at 5.7 - 5.12, as well as the conservation programs implemented or scheduled to be implemented by other electric utilities nationwide, and studies by the Oak Ridge National Laboratory, the Lawrence Berkeley Laboratories, the United States Congress's Office of Technology Assessment, the United States Department of Energy, the Rocky Mountain Institute, the Electric Power Research Institute, the Northwest Power Planning Council, and others. A list of the titles of these studies is appended to this affidavit.

2. I am Director of the Midwest Office of the Izaak Walton League of America, an organization with 53,000 members

nationwide who are dedicated to the wise use and protection of the environment and America's outdoor heritage. Since 1984, I have directed programs aimed particularly at clean air, energy policy, and the wise use of the Upper Mississippi River system, which Congress has recognized as a nationally significant ecosystem. Since 1989, I have concentrated an increasingly large portion of my professional activity on issues related to energy conservation and efficiency. For almost a decade, I have also served as a consultant to the Canadian government, providing monthly or quarterly reports on energy and environmental issues of bilateral concern. From 1981 to 1990, this activity focused predominately on acid rain and clean air issues, with some discussion of energy, Great Lakes and Arctic issues. It now focuses primarily on reportage of environmental initiatives and other developments in the environment and energy area that might be of interest to Canadians. I hold a bachelor's degree in biology from Antioch University, and a master's degree in natural resources administration from Goddard University. This affidavit is presented independent of my professional affiliations.

3. I am very familiar with the energy policy issues implicated by the ISFSI and the technical potential of increased energy efficiency to save electric power. In 1979, my master's thesis, "Energy Resource Development and the Public

Lands," focused on the environmental benefits of energy efficiency. I read regularly numerous journals and publications on energy efficiency issues, and in the past year I have been asked to write and speak on energy issues before many business, legislative and utility groups. In April 1991, for instance, I spoke before a group convened by the Minneapolis Chamber of Commerce and Minnesota Attorney General's office. I have had editorials on energy efficiency published in the Minneapolis Star Tribune. Extensive reference to my work is featured in an article in the current issue of Audubon Magazine. In the past year I have attended professional meetings at the invitation of the Rocky Mountain Institute, the General Electric Lighting Institute, the United States Department of Energy, Wisconsin's utilities' Energy Expo, Niagara Power, the National Association of Independent Lighting Distributors, the Independent Lighting Distributors Association and others. On March 1, 1991, I was one of ten national experts invited to participate in a training and strategy session on utility regulatory reform and efficiency at the Conservation Law Foundation in Boston.

4. I have conducted my review of the FEIS toward the goal of answering the following question:

Is energy conservation a feasible and prudent alternative to the proposed ISFSI?

By this I mean is it technically possible in Minnesota to replace up to the entire capacity of Northern States Power Company's ("NSP") Prairie Island nuclear power station without creating "community disruptions . . . reaching extraordinary magnitudes." County of Freeborn v. Bryson, 243 N.W.2d 316, 320 (Minn. 1976). My conclusions are that energy conservation is a feasible and prudent alternative to the proposed ISFSI:

a. There is no doubt that the technical potential exists within Minnesota and within NSP's service area to reduce energy demand by the 8,279 gigawatt-hours ("GWh") produced by the Prairie Island nuclear power station (1989) (FEIS at 5.12), thereby providing a feasible, prudent and completely safe alternative to 20 or more years of "temporary" storage of highly radioactive waste. The 1988 Department of Public Service ("DPS") study Energy: Minnesota Options for the 1990's concluded that Minnesotans could save 52% of electric energy, which represents 3511 megawatts ("MW") of NSP's 1990 capacity (6752 MW) or 16,798 GWh of NSP's total 1990 power output (32,304.9 GWh). This potential savings represents more than twice the power output (1988) of the Prairie Island station. See FEIS at 5.11 - 5.12.

b. The Minnesota DPS study's conclusions on the technical potential for energy savings are quite consistent with a number of studies from other highly regarded sources such as the Lawrence Berkeley Laboratories and the Oak Ridge National Laboratory. Studies from the Rocky Mountain Institute find that it is technically possible to save up to 75% of the energy currently used through conservation methods. Studies of the Electric Power Research Institute ("EPRI") -- the utility industry's research arm -- more conservatively identify the technical potential to save 24% to 44% of current energy use through conservation technology. As a percent of NSP's 1990 total power output of 32,304.9 million GWh, even EPRI's lowest range estimate would provide 7,753 GWh of savings, an amount approaching the entire output of the Prairie Island station.

c. The DPS study, and the studies from Lawrence Berkeley Laboratories, Oak Ridge National Laboratory, Rocky Mountain Institute, and EPRI all conclude that the technically possible savings identified can be achieved without disruptions of extraordinary magnitudes in the lives of energy consumers. In fact, these studies all specifically note that these savings can be accomplished at no loss, and often an improvement, in service as compared to existing products and technologies. The technically possible savings identified are therefore prudent in nature.

5. Programs underway at a number of utilities have shown that these potential savings can be realized through demand-side management ("DSM") programs:

a. The basic principles of demand-side management (alternately referred to as least cost planning or integrated resource management) call for utilities to invest in rebates, financing, technical assistance and other partnership programs with business and residential customers to improve the end use efficiency of electrical use in their service area. Most programs offer advice and incentives to make sure that no opportunities will be missed in the construction of new buildings, where marginal investments for more efficient systems are particularly cost effective. Programs to share the cost of improvements in commercial lighting equipment, refrigeration and air conditioning, and replacement of inefficient industrial motors with more efficient ones, are a common part of DSM programs. Residential programs to provide rebates for energy efficient lighting, weatherization, low-flow shower heads and water heater wraps are also common to DSM programs in other regions, but do not exist in Minnesota. Some programs in California and New England are now providing one-stop service to every customer in their service area -- leasing the upgraded efficient equipment to the customer at a rate that lowers the customer's energy costs, but is cheaper than providing the power by other means.

b. During the 1980s several programs undertaken by the Bonneville Power Administration for just a few electrical use areas -- residential heating, commercial outdoor lighting, and limited industrial modernization -- have yielded a measured savings of 241 MW and estimated savings of another 50 MW. Improved building codes and standards have saved an additional 100-400 MW. The New England Electric System expects to have saved 356 MW and 572 GWh by the end of this year after only a few years of experimental programs. The tiny Osage, Iowa (pop. 3600) municipal utility, only a few miles south of the Minnesota border, saved an estimated $1.2 million in 1988 or more than $1,000 per household, through their DSM efforts. In the coming year, Wisconsin utilities will spend about $138 million on DSM programs and Iowa utilities will spend over $40 million. Minnesota utilities will spend only about $20 million -- much of it not on the most cost-effective programs.

6. Many of the nation's utilities believe that demand-side management programs designed to capture the energy savings made possible by advances in end use efficiency provide a feasible and prudent means of reducing energy demand, as evidenced by the major investments that they are making to capture these savings. The nation's largest investor-owned utility, Pacific Gas and Electric, recently announced plans to save through conservation technology 2,475 MW of capacity over the next ten years, including over 102 MW of peak capacity in the next year alone. The Sacramento Municipal Utility District

is currently "building" 600 MW of conservation power through a comprehensive program of customer service and financing of efficiency improvements in their service area. The Bonneville Power Administration power plan calls for 1,350 megawatts of "conservation power" over the next ten years. New England Electric System is going ahead with plans to save 1,162 MW and Consolidated Edison of New York has plans to save 2,509 MW.

7. Based upon my knowledge and expertise in the field, my review of the FEIS, the DPS 1988 study, and my review of other studies on energy conservation through demand side management, and DSM programs already underway at other utilities, I conclude that conservation is a feasible and prudent alternative to the proposed ISFSI at Prairie Island.

Dated: May 3, 1991

Paul W. Hansen

State of Minnesota)
) ss.
County of Hennepin)

On this 3rd day of May, 1991, before me, a Notary Public within and for said County, personally appeared Paul W. Hansen, to me known to be the person described in and who executed the foregoing instrument and acknowledged that he executed the same as his free act and deed.

Notary Public

77500

SHEILA L HOWELL
NOTARY PUBLIC - MINNESOTA
HENNEPIN COUNTY
My Commission Expires June 4, 1996

THE DOCUMENTS REVIEWED IN PREPARATION OF THIS AFFIDAVIT INCLUDED:

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THE IZAAK WALTON

LEAGUE OF AMERICA

PAUL HANSEN
DIRECTOR, MIDWEST REGIONAL OFFICE
THE IZAAK WALTON LEAGUE OF AMERICA

Paul Hansen was born on February 22, 1952, in Bridgeport, Connecticut. He received his B.A. in biology from Antioch University in 1975, and completed his M.A. in natural resources administration in 1979. His thesis focused on the environmental benefits of the efficient use of energy.

Paul Hansen came to the Izaak Walton League of America (IWLA) in January of 1982 as Acid Rain Project Coordinator and moved to Minneapolis in September of 1984 to open the IWLA Midwest Regional Office. He was promoted to director of that office in January of 1989. This office focuses on Upper Mississippi River wildlife habitat, navigation issues, water resources and development, hydropower, soil erosion, sustainable agriculture, energy issues, air quality, and other issues.

Since 1981, Hansen has also served as a consultant on Acid Rain and other environmental issues of bilateral concern for the Canadian government's Department of the Environment and Department of External Affairs.

He has written hundreds of articles on conservation issues and is the author of the IWLA reports Acid Rain and Waterfowl: The Case for Concern in North America, Air Pollution: The Invisible Thief of American Agriculture and Planned Obsolescence in Lighting: The Cost to the Environment and Economy. Paul Hansen is also Conservation and Natural Resources Editor of Fishing Facts magazine and is presently Chair of the National Affairs and Environment Committee of the Outdoor Writers Association of America.

Over the past few years, he has made presentations on environmental and energy issues to groups in the U.S. and Canada, including appearances on "Good Morning America" in the U.S. and "The Journal" in Canada. He has testified before committees in both the U.S. House of Representatives and Canada's House of Commons. In 1987, Canada's Speaker of the House of Commons, John Fraser, personally recognized Hansen on the floor of the Parliament as an "American Friend of Canada," for his work on the acid rain issue - a privilege usually reserved for visiting heads of state and other dignitaries. After almost a decade of involvement in the effort to reauthorize the Clean Air Act with strong acid rain controls, on November 15, 1990 he was invited to the White House signing ceremony for this historic legislation.

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HEADLINE: Efficient use of electricity

BYLINE: Fickett, Arnold P.; Gellings, Clark W.; Lovins, Amory B.

BODY:

Efficient Use of Electricity

Electricity is fundamental to the quality of modern life. It is a uniquely valuable, versatile and controllable form of energy, which can perform many tasks efficiently. In little over 100 years electricity has transformed the ways Americans and most peoples of the world live. Lighting, refrigeration, electric motors, medical technologies, computers and mass communications are but a few of the improvements it provides to an expanding share of the world's growing population.

Many analysts believe that regional electricity shortages could occur in the U.S. within the next 10 years, perhaps as early as 1993. Given the importance of electricity to all sectors of the economy, such shortages would have severe consequences. Yet financing large-scale power plant construction could push America's $ 170-billion-a-year electricity costs higher: a large (one billion watts) power plant costs more than $ 1 billion and may entail lengthy regulatory and environmental approvals. Thus there is growing pressure for utilities to provide needed generating capacity or to reduce electricity demand, or both.

A kilowatt-hour of electricity can light a 100-watt lamp for 10 hours or lift a ton 1,000 feet into the air or smelt enough aluminum for a six-pack of soda cans or heat enough water for a few minutes' shower. To save money and ease environmental pressures, can more mechanical work or light, more aluminum or a longer shower be wrung from that same kilowatt-hour?

The answer is clearly yes. Yet estimates as to how much more range from 30 to 75 percent. Also at issue is how fast efficiency can be improved, and at what cost.

Since the oil embargo of 1973, energy intensity--the amount of energy required to produce a dollar of U.S. gross national product--has fallen by 28 percent. Plugged steam leaks, caulk guns, duct tape, insulation and cars whose efficiency has increased by seven miles per gallon have helped to extract more work from each unit of fuel. Applications of electricity, too, have made important contributions to productivity and to a more information-based economy. Electricity accounts for a growing fraction of energy demand, and its relation to the gross national product has held relatively steady in recent years. It is not clear, however, that electricity and economic growth must continue to march in lockstep. Technologies and implementation techniques now exist for using electricity more efficiently while actually improving services. Harnessing this potential could get society off the present treadmill of ever higher financial and environmental risks and could make affordable the electric services that are vital to global development [see illustration on next page].

Historical patterns are already starting to change. California reduced its electric intensity by 18 percent from 1977 to 1986 and expects the trend to continue. Nevertheless, in such major industries as cars, steel and paper, Japan's electric use per ton is falling while the U.S.'s is rising--chiefly because American companies are still adopting new fuel-saving "electrotechnologies" already common in Japan. But companies there are improving their efficiency at a faster rate. The resultant widening efficiency gap contributes to Japanese competitiveness.

Other industrialized nations are also setting higher standards for efficiency. Sweden has outlined ways to double its electricity efficiency. Denmark has vowed to cut its carbon dioxide output to half the 1988 level by 2030 and West Germany to 75 percent of the 1987 level by 2005; both nations emphasize efficiency.

These encouraging developments reflect rapid progress on four separate but related fronts: advanced technologies for using electricity more productively; new ways to finance and deliver those technologies to customers; expanded and reformulated roles for electric utilities; and innovative regulation that rewards efficiency.

The technological revolution is most dramatic. The 1980's created a flood of more powerful yet cost-effective electricity-saving devices. If anything, progress seems to be accelerating as developments in materials, electronics, computer design and manufacturing converge. Rocky Mountain Institute estimates that in the past five years the potential to save electricity has about doubled, whereas the average cost of saving a kilowatt-hour has fallen by about two thirds. The institute has also found that most of the best efficient technologies are less than a year old.

Of course, while some innovations are saving electricity, others will use electricity in new ways in those areas where electricity has an advantage over other forms of energy. For example, electricity can be environmentally beneficial and cost-effective in ultraviolet curing of finishes, microwave heating and drying, induction heating and several other industrial uses. Such electrotechnologies save money and fuel and reduce pollution overall. The Electric Power Research Institute (EPRI) estimates that by 2000 these new technologies will save as much as half a quadrillion British thermal units (Btu's) of fuel per year yet will increase electricity use in the U.S. only slightly.

How much electricity could be saved if we did everything, did it right and fully applied the best technologies for efficiency? Agreement is growing that an astonishing amount of electricity--far more than the 5 to 15 percent cited a few years ago--could be saved in the U.S. According to a 1990 report by EPRI, it is technically feasible to save from 24 to 44 percent of U.S. electricity by 2000--some of it rather expensively--in addition to the 9 percent already included in utility forecasts. Thus, theoretically, aggressive efficiency efforts might capture as much as three to five times the savings that EPRI forecasts to happen spontaneously, about four to seven times as much as current utility programs plan to capture (80 billion watts before 2000). Rocky Mountain Institute estimates a long-term potential to save about 75 percent of electricity at an average cost of .6 cent per kilowatt-hour--several times lower than just the cost of fuel for a coal or nuclear plant. Even more could be saved at higher costs. The differences between these estimates are less important than their agreement that substantial amounts of electricity can be saved in a cost-effective manner.

How do potential electricity savings in the U.S. compare with analyses for other countries? Potential savings vary, mainly because of differences in climate, in use of appliances and in price and economic structure. Western Europeans and the Japanese have already captured more of the potential electricity savings, and, as these nations continue to progress, they will pay more for less electricity savings than Americans, but the differences are probably not substantial. Studies have found potential savings of 50 percent in Sweden at an average cost of 1.3 cents per kilowatt-hour, 75 percent in Danish buildings at 1.3 cents per kilowatt-hour and 80 percent in West German households at a cost repaid in 2.6 years [see illustration on page 68].

Strong anecdotal evidence suggests that in most developing and socialist countries, many electric devices are several times less efficient than in the U.S. Improved devices are often costly there today because they require electronics or special materials that are not readily available. But as global markets for these devices expand, lowering their international prices, it is reasonable to expect that the potential electricity savings will be even greater in the countries that are the least efficient today. The U.S. potential may therefore prove to be not a bad surrogate for the global average.

To understand the pitfalls involved and the effort required to move toward a more efficient economy, consumers and suppliers of electricity must understand how major savings can be achieved. Electricity, like other forms of energy, can be saved by demanding fewer or inferior services--warmer beer, colder showers, dimmer lights. No such options are considered here. If technology is applied intelligently, electricity can be saved without sacrificing the quality of services. In fact, many new devices actually function better than the equipment they replace: they provide more pleasing light, more reliable production and higher standards of comfort and control.

The biggest savings in electricity can be attained in a few areas: lights, motor systems and the refrigeration of food and rooms. In the U.S. lighting consumes about a quarter of electricity--about 20 percent directly, plus another 5 percent in cooling equipment to compensate for the unwanted heat that lights emit. In a typical existing commercial building, lighting uses about two fifths of all electricity directly or more than half including the cooling load. Converting to today's best hardware could save some 80 to 90 percent of the electricity used for lighting, according to Lawrence Berkeley Laboratory. EPRI suggests that as much as 55 percent could be saved through cost-effective means.

Compact fluorescent lamps, for instance, consume 75 to 85 percent less electricity than do incandescent ones. They cyclists are either mixed with motorized traffic or assigned to lanes that lack protective barriers. In suburban areas, pedestrians must often do without sidewalks and even crosswalks.

The Netherlands, one of the most densely populated OECD countries, has worked hard to create incentives for the use of bicycles. The government has set aside paths and parking spaces for bicycles, established rent-a-bike facilities at railroad stations and allowed train passengers to bring their bicycles on board. As a result, bicycles carry fully 9 percent of the country's commuters. In some cities, they account for more than 40 percent of all passenger trips.

Although a large majority of the vehicles on the road today are in the OECD countries, most of the increase in the world's fleet over the next 50 years is likely to occur in Eastern Europe and the developing countries. There are many reasons to keep the concomitant increase in oil consumption as low as possible. Countries that lack oil will have to spend scarce foreign exchange to import it; countries that now export oil will have to divert some of it to their expanding domestic markets. In either case, the supply of investment capital for development will dwindle, and the external debt could well grow. At the same time, regional air quality will undoubtedly deteriorate, as it already has in many traffic-congested cities in the developing world.

Developing nations do have one crucial advantage over developed ones: they can head off many problems of unplanned industrialization before they become intractable. Because developing countries have not yet institutionalized the private car to the degree seen in the OECD nations, they are still in a position to create mass-transit systems that people will want to use.

Curitiba, capital of the state of Parana, in southeastern Brazil is a famous model of how planning can avert the disadvantages of wasteful fuel consumption and gridlock. The city's transportation system revolves around five radial express lines reserved exclusively for buses. These arteries are connected by interdistrict lines, and the whole system is linked to neighborhoods by feeder lines. Land-use ordinances have encouraged the establishment of residences and businesses near bus stops. As a result, Curitiba enjoys one of the highest rates of motor vehicle ownership per capita and one of the lowest rates of fuel consumption per vehicle in Brazil. A comparatively large number of people have cars, but most of them prefer mass transit for routine urban travel.

Of course, even with the aggressive pursuit of mass transit, the demand for cars in Eastern Europe and the developing countries is likely to increase--but not as fast as it did in regions that industrialized earlier. It is therefore crucial that the cars they import be as efficient as possible. Furthermore, as developing nations establish domestic automotive industries of their own, it is of critical importance that they make efficient products.

Because of the increasing consumption of energy by the transportation systems of Eastern Europe and the developing countries, air quality and the balance of payments are deteriorating hand in hand. Many of these countries might consider developing indigenous alternative fuels, just as Brazil did in the late 1970's, when skyrocketing oil prices and plummeting sugar prices devoured that country's supply of foreign exchange.

Even though most developing countries are not as well endowed with biomass feedstock as Brazil and may not be able to produce enough fuel to run all their vehicles, biomass can still replace a significant fraction of the imports. Moreover, quite a few of these countries possess unexploited reserves of natural gas. Thailand, Indonesia and Argentina, for example, are already testing cars that run on domestic natural gas. Before any alternative-fuel programs are launched, however, all the risks and benefits must be assessed comprehensively.

But the effort to rethink transportation systems must begin in the OECD countries, which created the problems of waste and pollution. This effort must first concentrate on light vehicles, which predominate in overall transportation energy use. Progress in addressing this sector can be made only with the cooperative leadership of national governments. The OECD members can perhaps best begin their task by signing a protocol on the lowering of carbon dioxide emissions from road vehicles. That step could serve as the model for other countries whose transportation sectors are only now beginning to expand.

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from the ground, one must determine how much electricity can be profitably saved employing existing technology and how to convert that reserve to actual production.

Efficient technologies are often underused because of the lack of customer demand (market pull) or the lack of a sufficient distribution channel (market push), or both. If electricity consumers want efficient appliances and ask retailers to provide them, retailers will then ask wholesalers to supply them, and wholesalers in turn will seek manufacturers to produce those products. If consumers fail to act, then the whole string of potential benefits unravels.

To create market pull, energy planners must understand how consumers make energy choices. Most planners are puzzled to find that customers sometimes shun efficiency even when it is accompanied by attractive economic incentives. In the past, manufacturers and retailers have not considered efficiency to be an important feature in new products, because they have found that consumers rarely decide to make a purchase based on efficiency. The factors that most consistently affect their choices are appearance; safety; comfort, convenience and control; economy and reliability; high-technology features; the need to have the latest equipment; the desire to avoid hassles; and resistance to having utilities control energy use. Because human nature is diverse, the weighing of these factors varies enormously, and retailers must adjust their marketing strategies accordingly. Businesses have analogous concerns, including product quality, production reliability, fuel flexibility, environmental cleanliness, a clean workplace and low risk.

If efficient technologies are to be widely deployed, a third party, such as the electric utility or government, may need to assume responsibility for both market push and market pull. As we shall see, utilities have a special interest in influencing customers' demand--treating it not as fate but as choice--in order to provide better service at lower cost while increasing their own profits and reducing their business risks. Utilities can choose from a wide range of market push and pull methods designed to influence consumer adoption and reduce barriers. These include rebates or other financing options, direct contact with their customers, special tariffs, advertising, education, and cooperative ventures with architects, engineers and suppliers of efficient technology. Collectively, such efforts are part of demand-side management, which seeks to change the demand for electricity while still meeting customers' needs.

More than 60 utilities serving almost half of all Americans now offer rebate programs to promote the buying or selling of efficient devices. The over-whelming majority (92 percent) pay rebates to purchasers to create market pull; about 24 percent pay appliance dealers to create market push.

Utility rebate programs can rapidly stimulate market development. Efficient lighting equipment was unavailable in Las Vegas, for instance, until Nevada Power Company started offering rebates, whereupon within six months, 20 wholesale and retail outlets were competing in the price and breadth of efficient lighting systems.

Many utilities have begun to pay consumers for each kilowatt-hour saved, no matter how it is done. They have also tried to reward "trade allies" who remove old, inefficient equipment or who sell, specify or install electricity-saving devices. Utilities sometimes offer rebates to consumers who beat a government performance standard, thus eliciting better technologies so the standard can be raised until cost-effectiveness limits are reached.

Other financial incentives complement rebates: low- or no-interest loans, gifts and leases. Southern California Edison Company, for example, has given away more than 800,000 compact fluorescent lamps. The Taunton Municipal Lighting Plant in Massachusetts leases such lamps for 20 cents each per month and replaces them for free. Thus, customers can pay for efficiency over time, just as they would otherwise pay for power plants. The makers of compact fluorescent lamps have relied on both their own and utilities' marketing strategies to achieve annual U.S. sales of about 20 million units. Those sales are doubling or tripling each year, and such lamps already dominate the West German market.

These well-established methods are so effective that when Southern California Edison Company had a peak load of 15 billion watts, in 1983-1984, it was able to reduce its forecast of peak demand by more than 500 million watts in a single year. At the same time, California's appliance and building standards increased electricity savings even more. Annual savings represented 8.6 percent of the utility's peak demand at the time and cost the utility only about 1 percent as much as building and running a new power station. If all Americans saved electricity as fast as those 10 million did, the U.S. economy could grow by several percent every year while total electricity use decreased.

Such success stories are now spreading in the U.S. and abroad. In some instances, skillful and imaginative marketing has captured 70 to 90 percent of specific efficiency markets, such as housing insulation, in just a year or two. Some utilities, such as the Bonneville Power Administration, are saving businesses money through commercial efficiency programs whose cost is about .5 cent per kilowatt-hour.

Utilities such as North Carolina's Duke Power Company offer lower rates to efficient customers. Others require minimum efficiency levels as a condition of service; Atlantic Electric in New Jersey, for example, has such an air conditioner standard. Several states are now trying or considering a sliding-scale hookup fee: when a utility connects a new building to the power grid, it charges a fee that is tied to the building's efficiency. Consideration is also being given to using such fees to pay rebates ("feebates") for the most efficient buildings.

Still further savings may be achieved by methods that seek not merely to market "negawatts" (saved electricity) but to make markets in negawatts: saved electricity can be treated as a commodity just like copper or sowbellies. This strategy can maximize competition among means of savings and among providers of savings and so drive down the cost. For example, some utilities run competitive bidding processes in which all ways to make or save electricity compete.

Saved electricity can be converted to money and traded between utilities or between customers. Some utilities may even want to become "negawatt brokers" and make spot, futures and options markets in saved electricity. Others are considering buying contracts from their customers to stabilize or reduce demand. The contracts could be resold in secondary markets, just as some brokers already buy and sell air pollution rights.

Some aggressive utilities competing in the emerging negawatt market even sell efficiency in the territories of other utilities. Puget Sound Power and Light Company sells electricity in one state, but its subsidiary sells efficiency in nine states.

Even though some utilities and consumers have taken the lead in electricity efficiency, most of the potential savings remain untapped. Customers use very different financial criteria to assess ways to save electricity than utilities use to assess new power plants. On the one hand, if customers invest money to save electricity in their home or business, they will probably want to recoup their investment within about two years--perhaps as long as five years for a few farsighted industries and less than one year for low-income renters. On the other hand, if utilities build plants to increase capacity, their technical and financial strength lets them recover costs over a 20-year period.

The gap between the payback horizon of consumers and utilities tends to make society buy too little efficiency and too much supply. The result in the U.S. alone is the $ 60 billion per year now spent in expanding electricity supplies that could be partly displaced by investments in efficiency. The payback gap also dilutes price signals. If customers can avoid a tariff of six cents per kilowatt-hour by saving electricity, then without other incentives they will buy efficiency costing up to .6 cent per kilowatt-hour--about a tenth of the tariff, because the tariff is calculated at the utility's payback horizon of 20 years, but the customer invests on the basis of a two-year horizon. Just getting the prices right will therefore not necessarily induce people to buy as much efficiency as would benefit society at large. However, correct pricing is important: only prices that tell the truth can inform customers about how much is enough. Prices should be adjusted to the time and season of use--perhaps ultimately with sophisticated new kinds of electronic meters--and reflect real-time spot prices in order to provide the most accurate signals.

Utilities around the world are reexamining their purpose. Is their mission the production and sale of electricity, or is it the profitable production of customer satisfaction? Utilities that take the latter view believe that if [illegible] with high-performance shower heads and superefficient refrigerators. The only relevant question, then, is who will sell efficiency? If efficiency is cheaper than electricity, customers will buy less electricity and more efficiency. It is generally a sound business strategy to satisfy customer needs before someone else does.

Utilities are the logical organizations to expedite the use of energy -efficient products: they have technical skill, permanence, credibility, close ties to customers, a relatively low cost of capital and a fairly steady cash flow. At present, however, they have little motive to expedite energy efficiency. The conflict is obvious: Why spend money to reduce sales?

In principle, utilities can profit in several ways from making their customers more efficient. They can avoid operating costs in the short run, construction costs of new power plants in the medium run and replacement costs of old power plants in the long run. They can also earn a spread on financing efficiency, just as a bank would. Legislation such as the amended U.S. Clean Air Act may allow utilities to use efficiency to generate pollution rights, which they can resell. And finally, under new regulations now being adopted in some states in the U.S., utilities may be able to receive exemplary financial rewards for money-saving investments.

A major breakthrough occurred in 1989 when new regulations were accepted in principle nationwide for consideration by state regulators. The proposed rules would uncouple utilities' profits from their sales, removing a utility's disincentive to invest in efficiency. In effect, the utilities will be compensated for the revenue they would otherwise lose by selling less electricity--and will get to keep part of the savings.

Such rules have already proved effective in a few cases. Pacific Gas & Electric Comapny in California and a group of environmentalists, government administrators and consumers recently agreed that the utility should keep 15 percent of any money saved by certain new efficiency programs. Customers will benefit by getting 85 percent rather than all of nothing.

In New York Niagara Mohawk Power Corporation has proposed another way to profit from efficiency services. Under the plan, the utility's 12 efficiency programs, which cost $ 30 million to implement in 1990, will be allowed to recover costs and clear a $ 1-million profit if the utility's 12 programs achieve the state's goal of saving 133 million kilowatt-hours, which is worth about $ 10 million a year in reduced energy cost for participating customers. By 1992 the programs should save 240 million kilowatt-hours per year. When does the money come from? Prices per kilowatt-hour will rise by as much as 1.4 percent, yet participating customers will still pay lower bills because they will consume less.

Niagara's residential low-cost measures program, for example, provides each participating household with a low-flow shower head, a compact fluorescent light bulb and insulation to wrap their electric water heaters and pipes. The equipment should save 960 kilowatt-hours per participating household per year. For each household, the utility loses about $ 72 in annual energy sales but saves about $ 40 on fuel and capacity costs. The difference ($ 32 a year) is charged to the residential customers each year for eight years and includes a $ 5 profit for the utility. For the equipment, each participating household pays $ 6 a year for eight years. Therefore, each household will save $ 272 over eight years.

As efficient technologies and implementation techniques spread, how will they change the economics of our businesses, the services we receive and the health of our environment? Consider first the effect of efficiency on local business. In Osage, Iowa (population 4,000), a utility manager launched a nine-year program to weatherize homes and control electricity loads at peak periods. These initiatives saved the utility enough money to prepay all its debt, accumulate a cash surplus and cut inflation-corrected rates by a third (thereby attracting two factories to town). Furthermore, each household received more than $ 1,000 of savings a year, boosting the local economy and making shops noticeably more prosperous than in comparable towns nearby. If other communities in the U.S. followed the lead of Osage, they could create economic vitality that would reverberate from Main Street to Wall Street.

Electric efficiency can also enhance industrial competitiveness. When the rod, wire and cable business fell on hard times around 1980, for example, the biggest independent U.S. firm, Southwire, responded by saving, over eight years, about 60 percent of its gas and 40 percent of its electricity per ton of product. the savings yielded virtually all the company's profits during a tough period. The efforts of two engineers may have saved 4,000 jobs at 10 Southwire plants in six states.

Electric efficiency could also break a major logjam in global development. In developing nations, electricity generation already consumes a fourth of global development capital, and in the next few decades the utilities of those nations are projected to need about eight times more capital than is expected to be available--a prescription for power shortages. But efficiency can be the key to saving the capital desperately needed for other development tasks.

Electric efficiency can also ease environmental pressures. If a consumer prelaces a single 75-watt bulb with repplces an 18-watt compact fluorescent lamp that lasts 10,000 hours, the consumer can save the electricity that a typical U.S. power plant would make from 770 pounds of coal. As a result, about 1,6000 pounds of carbon dioxide and 18 pounds of sulfur dioxide would not be released into the atmosphere, reducing the contribution of these gases to global warming and acid rain. Alternatively, an oil-fired electric plant would save 62 gallons of oil--enough to fuel and American car for a 1,500-mile journey. Yet far from costing extra, the lamp generates net wealth and saves as much as $ 100 of the cost of generating electricity. Since saving the fuel is cheaper than burning it, environmental problems can be abated at a profit. (Power plants that run on fossil fuel use three units of fuel to make one unit of electricity, whereas in socialist and developing countries they often use five to six units to do the same.)

No matter how electric efficiency is used to reduce emissions, consumers and suppliers of electricity will achieve the biggest reduction at the lowest cost in the shortest time only if they choose the best buys first. Suppose a government wants to reduce carbon dioxide emissions by reducing the amount of electricity generated by coal-fired power plants. To replace that electricity, the government should invest in low-cost efficiency options such as lighting or motor retrofits before considering alternative high-cost technologies such as solar or nuclear power. Otherwise each dollar spent will replace less coal burning than it could have. As we compete for limited resources, the order of environmental priority should be the order of economic priority.

The determined either by "least-cost utility planning" or "integrated resource planning"--a formal procedure now required by utility regulators in most of the U.S.--by an equivalent market process in which all ways to make or save electricity compete fairly for markginal investment.

Electric efficiency, wisely bought today, can go far to stretch the electricity supply. It can also provide time to perfect and deploy renewable energy resources such as solar power, an area where recent progress has been so encouraging. If efficiency decreases the demand for electricity, then renewable resources can be deployed more area where recent progress has been so encouraging. If efficiency decreases the demand for electricity, then renewable resources can be easily and provide more electricity to more people. Buth in the broad sense and in detailed design, electric efficiency and renewable resources are natural partners.

The electric utility is only one of many organizations that should be encouraging energy efficiency. State and local agencies can be particularly helpful in educating customers. Federal support for such programs, which were largely abandoned over the past decade, should be restored.

America's largest landlord--the U.S. government--can take the lead by starting a massive, modern retrofit program in federally owned buildings. The government could be the key to developing market push in certain technologies. It could provide funds to help underwrite the high initial manufacturing costs that penalize new technologies. In addition, state and federal authorities could encourage manufacturers to make more efficient products and broaden performance labeling [see illustration above].

Governments could also do more to assist in the research and development of efficient technology. Investments in efficiency are far out of line with potential benefits. Not only do consumers and suppliers of electricity need more and better hardware choices, but they also need better ways to help designers choose from the bewilderingly large array of technologies that are already available.

A formidable challenge to electric utilities and governments, then, as well as to customers, design professionals and many other stakeholders, is to integrate the technical, economic, cultural, marketing and policy innovations into coherent efforts to capture the efficiency potential. It is encouraging that many are rising to this challenge. The seriousness of some U.S. utilities' effort, such as that of the New England Electric System, is indicated by their commitment to allocate as much as 4 percent of their gross revenues to improving customers' end-use efficiency. In recent weeks, five U.S. utilities have added nearly $ 1 billion to their efficiency budgets. Some utilities in Western Europe and Japan, too, have undertaken similarly impessive programs. With such efforts, electric and economic growth need to use electricity lockstep--if in a way that saves money and the environment.

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FURTHER READING

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GRAPHIC: photograph; Graph; Chart; Caption: Relation between U.S. electricity consumption and the economy. graph; Variations in the habits of many developed nations suggest flexibility. graph; Retrofit can raise efficiency of typical motor-pump system 31 to 72%. chart; Efficient technologies may reduce long-term U.S. electricity consumption. graph; Gov't standards influenced production of more efficient refrigerators. graph

SUBJECT:
Energy conservation, innovations; Electric power, supply and demand; Electric lighting, energy consumption; Electric utilities, energy conservation

COMPANY:
SIC: 4911

LOAD-DATE-MDC: December 06, 1990

ATTACHMENT # 2

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March 21, 1991

Minnesota Environmental
Quality Board
c/o Michael Sullivan,
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300 Centennial Building
658 Cedar Street
St Paul, Minnesota 55155

<u>HAND DELIVERED</u>
<u>AND BY U.S. MAIL</u>

Re: Prairie Island Independent Spent Fuel Storage Installation. Agreement Between State and NSP on Cask Decontamination and Pad Monitoring; and Letter Agreement on Radiological Health Effects Study

Dear Board Members:

On behalf of the Prairie Island Mdewakanton Sioux Indian Community ("Community"), we present for the Board's consideration these comments regarding two recent agreements entered into between agencies of the State of Minnesota and Northern States Power Co. ("NSP") relating to the proposed Prairie Island Independent Spent Fuel Storage Installation ("ISFSI"). Those agreements are specifically:

1) The Agreement dated March 8, 1991, between NSP and two Minnesota agencies, Minnesota Department of Public Service and the MEQB, on cask decontamination and pad monitoring; and

2) The further letter agreement of March 8, 1991, on radiological health effects documents to be included in the Environmental Impact Statement being prepared on the ISFSI.

(The Community itself is a party to the third agreement being considered today by the Board -- the agreement with Nuclear Regulatory Commission staff and NSP regarding sharing of information.)

Approximately 150 members of the Community live on the Prairie Island Reservation, immediately adjacent to (literally across the street from) the site of the proposed ISFSI. An additional 150 members of the Community live outside the reservation. A fuller description of the Community and its concerns with the proposed ISFSI is contained in the Community's comments on the Draft EIS, submitted earlier to the Board.

The Community has the following specific objection to the cask decontamination/pad monitoring agreement:

> **In both the areas of cask decontamination and pad monitoring, the agreement allows for unilateral changes of procedure by NSP, see paragraphs 1.a.iv., 1.b.iv.**

The cask decontamination/pad monitoring agreement should not be approved unless and until NSP agrees that the procedures identified in the agreement will only be altered to become more stringent. No procedural changes which reduce the level and certainty of cask decontamination or which reduce the frequency or extent of pad monitoring should occur. In the event of a dispute between the Minnesota agencies and NSP over whether a proposed change in procedure will result in more stringent control, the opinion of the State agencies should govern. An appropriate vehicle through which to resolve this concern would be a letter agreement between NSP and the State agencies confirming these points.

With regard to the letter agreement on documentation to be included in the EIS on radiological health effects, the Community does not object to the specific terms of the agreement. We do note that NSP has asked that only certain portions of the BEIR V study results be contained in the EIS. We reserve the right to ask that additional portions of the BEIR V studies be included in the EIS to ensure that the BEIR V study results are fairly presented, and the right to submit other studies for inclusion in the record. We submit herewith the very recent study of Wing, et al., Mortality Among Workers at Oak Ridge National Laboratory, 265 J.A.M.A. 1397 (1991), discussed in more detail below.

The Community does have the following concerns with regard to the need to conduct comprehensive studies of the radiological health effects of the proposed ISFSI:

1. To date no one has performed a comprehensive study of the radiological health effects of the proposed ISFSI on the members of the Community living adjacent to it, and other nearby residents;

2. To date no one has analyzed the relative health effects of alternatives to the proposed ISFSI, particularly to investing the $40 million-plus cost of the project in conservation or non-polluting energy alternatives to reduce demand for generating capacity from the Prairie Island plant;

3. To date no one has developed or funded a health monitoring and health care program for residents of the immediate vicinity of the proposed ISFSI to detect and treat the cancers which are a foreseeable result of the proposed ISFSI.

The studies referenced in the letter agreement -- BEIR V -- and studies to date in the possession of the Minnesota Department of Health on the health effects of the Prairie Island nuclear generating plant on residents of Goodhue County, are not adequate standing alone to meet the MEQB's responsibility to study the health effects of the proposed ISFSI.

The National Cancer Institute has done a nationwide study on the radiological effects of nuclear generating facilities. This study is presently in the possession of the Minnesota Department of Health. The study compared cancer rates in the county where each nuclear plant was located to cancer rates in similar counties where there were no nuclear plants. Statisticians believe that in most instances this methodological technique is flawed, as evidence of increased health risks to persons -- such as members of the Community -- living in the immediate vicinity of a plant could be buried in statistical information gathered from a large county population. However, this study did show that the number of leukemia cases in Goodhue County (where the Prairie Island plant is located) was significantly higher than in the control group.

There is also the BEIR V report, parts of which will be included at NSP's request in the final EIS. This is a 1990 report of the effects of low level radiation, based largely on the experience of survivors of atomic bombs. It is unclear how one would extrapolate the results of this study to the situation of low level radiation from a spent fuel storage facility.

A recently published long-term medical study on workers at Oak Ridge National Laboratories (copy attached) indicates that exposure to low-level radiation well within federal "safety" limits leads to a dramatically increased rate of leukemia. As reported yesterday in the Star Tribune, the study concluded:

> Workers at the Oak Ridge National Laboratory in Tennessee who were exposed to very low levels of nuclear radiation for many years had a leukemia death rate 63 percent higher than the general population, according to a new study.
>
> The study appears to be the first to indicate that long-term exposure to radiation levels well below permissible levels--and below the average exposure for workers at commercial nuclear-power plants--could result in an elevated risk of leukemia.
>
> It also suggests that the longer a group of workers is monitored, the higher the leukemia rate that will be found because the disease takes years to develop.
>
> Epidemiologist Steve Wing of the University of North Carolina and his colleagues examined the records of 8,318 white men who worked at Oak Ridge from 1943 to 1972.

> Because they came from a generally well-educated and prosperous segment of the population, the researchers said, the workers had lower-than-expected death rates from all causes, including cancers other than leukemia.
>
> But of the 1,524 who are known to have died, 28 died of leukemia and two others had leukemia among other illnesses, the researchers found, a rate "63 percent higher than expected."
>
> An earlier report on these workers found no such elevated rate. "A primary difference between previous analyses and the current one is the addition of seven years of follow-up," according to the study, indicating that the risk increases with time, Wing said.
>
> I think it's disturbing," Wing said of the study, which appears in today's issue of the Journal of the American Medical Association.

The conclusion to the study itself states:

> The all-cancer dose-response estimates reported in this study are an order of magnitude higher than those reported from analyses of the mortality experience of the survivors of the atomic bombings of Hiroshima and Nagasaki, Japan.

265 J.A.M.A. at 1402. In other words, the BEIR V study may be wholly inapplicable to the situation encountered at the proposed ISFSI -- years-long low-dose exposure.

This new study is disturbing because members of the Community living adjacent to the proposed ISFSI are situated much more similarly to the plant workers who suffered these high health risks than to the residents in older county-wide studies which indicated lower health risks. (Though it is noteworthy that if the new Oak Ridge study is correct, the elevated leukemia rates identified in Goodhue County by the National Cancer Institute will become more pronounced as the years pass.)

In order to comply with its duty to analyze all environmental impacts of the proposed ISFSI and alternatives thereto, the Board should:

1. **Commission a comprehensive study of the radiological health effects of the proposed ISFSI on neighboring residents from the Minnesota Department of Health.**

   While information-sharing with NSP can be very helpful to this study, the study should be conducted independently by the State.

2. **Commission the study and development of a health monitoring program and health care program for local residents to facilitate early detection and treatment of the cancers which the proposed ISFSI will cause.**

   The costs of necessary health monitoring and health care created by the proposed ISFSI should be quantified and included as part of the costs of the project. They are every bit as much a cost of the project as cement and steel.

3. **The relative health effects of alternatives to the proposed ISFSI should be studied.**

   In particular, the presently inadequate consideration of investing the cost of the project in conservation technology and alternative energy technology to reduce requirements for power generation from the Prairie Island reactor should be expanded, and should include study of the comparative health effects of such alternatives.

It is important that the Board bear these health-related questions in mind when reviewing the agreements between the State and NSP. Now is the time for the Board to focus on the presently inadequate state of the record on the health effects of the proposed ISFSI and to begin the studies necessary to document the human health cost of the project, to quantify the medical monetary cost of the project, to determine who is to bear those costs, and to examine what less-costly alternatives exist and should be considered.

Thank you for your consideration of these comments and concerns of the Prairie Island Mdewakanton Sioux Indian Community.

/s/

Richard A. Duncan
FAEGRE & BENSON

and

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Attorneys for the Community

slw/6948P

Original Contributions

Mortality Among Workers at Oak Ridge National Laboratory

Evidence of Radiation Effects in Follow-up Through 1984

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White men hired at the Oak Ridge (Tenn) National Laboratory between 1943 and 1972 were followed up for vital status through 1984 (N=8318, 1524 deaths). Relatively low mortality compared with that in US white men was observed for most causes of death, but leukemia mortality was elevated in the total cohort (63% higher, 28 deaths) and in workers who had at some time been monitored for internal radionuclide contamination (123% higher, 16 deaths). Median cumulative dose of external penetrating radiation was 1.4 mSv; 638 workers had cumulative doses above 50 mSv (5 rem). After accounting for age, birth cohort, a measure of socioeconomic status, and active worker status, external radiation with a 20-year exposure lag was related to all causes of death (2.68% increase per 10 mSv) primarily due to an association with cancer mortality (4.94% per 10 mSv). Studies of this population through 1977 did not find radiation-cancer mortality associations, and identical analyses using the shorter follow-up showed that associations with radiation did not appear until after 1977. The radiation-cancer dose response is 10 times higher than estimates from the follow-up of survivors of the bombings of Hiroshima and Nagasaki, Japan, but similar to one previous occupational study. Dose-response estimates are subject to uncertainties due to potential problems, including measurement of radiation doses and cancer outcomes. Longer-term follow-up of this and other populations with good measurement of protracted low-level exposures will be critical to evaluating the generalizability of the results reported herein.

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THE OAK RIDGE National Laboratory (ORNL) is a US Department of Energy (DOE) research and development facility that began operation in Oak Ridge, Tenn, in 1943. It is one of many facilities included in a large follow-up

For editorial comment see pp 1437 and 1438.

study of the health and mortality of workers at DOE facilities.[1] Mortality follow-up of white men hired prior to 1973 and followed up for vital status through 1977 has been reported previously for this population alone[2] as well as in combination with other DOE populations.[3,4] This report considers follow-up

Two types of analyses are presented. First, cause-specific mortality in the study population is compared with mortality of US white men. Second, the relationship between protracted exposure to low levels of external penetrating ionizing radiation and mortality within the study population is examined. Most epidemiologic data on radiation and cancer have been obtained from populations exposed to higher doses over short periods, whereas exposures in the present study occurred at low levels over long periods.

MATERIALS AND METHODS

Between 1943 and 1972, 17 517 workers were known to have been employed at ORNL. Workers with unknown sex, race, date of birth, or employment dates and those employed for less than 30 days were excluded (Table 1). Women and nonwhite men were excluded from analysis of the association of radiation with mortality because they had fewer deaths and lower radiation exposures. A comparison of mortality for all workers, including women and nonwhite men, to the general population is available from the National Auxiliary Publication Service (NAPS; see acknowledgments). White men who were known to have worked at another DOE facility were excluded because their occupational exposures to ionizing radiation could not be determined from records at ORNL. Vital status was ascertained primarily through employment records and the Social Security Administration for 91.8% of the cohort (96.5% of potential person-years of follow-up), and 1524 deaths were identified by the end of 1984. Workers lost to follow-up tended to have short employment duration, and one third were lost after 1982. Death certificates were obtained from state vital records departments for 1490 of the deaths. Underlying causes of death and nonunderlying cancer causes were coded to the *International Classification of Diseases, Adapted, Eighth Revision* (*ICDA-8*). The number of workers in this study differs slightly from the previous report[1] due to corrected demographic data that excluded 57 workers from the cohort.

Radiation Exposure

Individual exposures to external penetrating radiation, primarily gamma rays, were measured using pocket ionization chambers from 1943 until June 1944, film badges from then until 1975, and thermoluminescent dosimeters since 1975. Pocket ionization chambers were read on a daily basis, and film badges were evaluated weekly from June 1944 until July 1956, when quarterly monitoring was initiated. Although weekly reading facilitates prompt action in cases of undue exposure, it could promote cumulative dose underestimation if badges were not sufficiently exposed to reach a minimum detectable dose. Dosimeters were incorporated into security badges necessary to enter the facility for most of the period. Doses were estimated for the 4.9% of work years for which data were

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Table 1.—Cohort Definition and Vital Status as of December 31, 1984

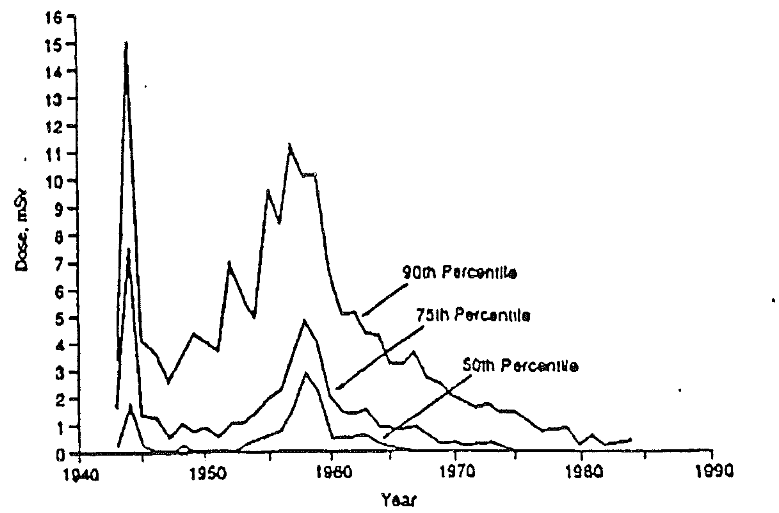
Total workers*			17 517
Exclusions			
Unknown demographic or employment information			428
Women			3792
Nonwhite			805
Employment in other plants†			3707
White male study cohort			8318
Vital status, (%) No.			
Alive	(73.4)	6108	
Dead	(18.3)	1524	
Unknown	(8.2)	686	

*From January 29, 1943, to December 31, 1972.
†Other US Department of Energy or predecessor organization facilities.

Table 2.—Distribution of Workers in Categories of Cumulative External Radiation Dose

Cumulative Dose, mSv*	Workers No.	Workers (%)
D=0	2129	(25.6)
0<D<10	3913	(47.0)
10≤D<50	1636	(19.7)
50≤D<100	317	(3.8)
100≤D<500	302	(3.6)
500≤D<1145	19	(0.2)

*Median=1.4 mSv; mean=17.3 mSv; and total=144 mSv. D indicates dose.



Percentiles of the annual external radiation dose distributions.

not available, primarily from the individual worker's own data within 2 years of the missing value. Averages for the worker's department in the missing data year were used when no individual data were available, and plant averages (by year) were used in the 0.9% of work years for which the dose in a given year for a worker's department was not known.

The distribution of workers by cumulative external radiation dose is shown in Table 2. The low recorded exposures of the population are evident. One quarter of the workers had no detectable external radiation doses during their employment, and almost three quarters had cumulative external doses of less than 10 mSv (1 rem). Only 638 workers received cumulative doses of greater than 50 mSv and 19 received doses of over 500 mSv; the highest value was 1144.4 mSv and the second highest was 1031.1 mSv. Both workers with cumulative external radiation doses over 1000 mSv were alive at the end of follow-up. The 50th, 75th, and 90th percentiles of the distributions of annual doses are shown in the Figure. Two modes are evident: a spike in 1944 and a rise from the late 1940s to the late 1950s that gradually declined until the end of the study. Median annual doses were less than 1 mSv in all years except 1944, 1957, 1958, and 1959.

Beginning in 1951, some workers were monitored for internal radionuclide contamination, primarily on the basis of the potential for contamination in the work area. Other reasons included incidents and follow-up. Quantitative dose estimates to specific organs were not available, but the majority of internal monitoring results of this cohort suggested negligible internal doses. However, workers who had at some time been monitored for internal contamination (N=3763) generally had higher external doses; 50% of those ever monitored but only 8% of those never monitored for internal contamination had cumulative external doses of greater than 10 mSv.

Statistical Methods

Cause-specific mortality in ORNL workers was compared with vital statistics for the United States, adjusted for age and calendar year by the indirect method,[5] to form standardized mortality ratios (SMRs) of observed to expected deaths. The SMRs were calculated for the entire cohort and separately for workers who had been monitored for internal contamination.

Analyses of the relationship of cumulative external penetrating radiation doses to mortality with internal comparisons were conducted using Poisson regression.[6] The death rates are modeled on a logarithmic scale as a function of the covariates of interest and cumulative external radiation dose.[7] The model can be expressed as $\ln \lambda(Z,x) = Z\alpha + \beta x$, where λ indicates the death rate; Z, the vector of covariates; x, the cumulative external radiation dose; α, the vector of covariate parameters; and β, the change in the log of the relative risk per unit dose (10 mSv). The radiation dose parameter estimates have been multiplied by 100 to yield the logical percentage change in mortality per 10-mSv cumulative dose.[4] At the low values of dose found in this study, the logical percentage change is approximately equal to the percentage change and is referred to as such.

Four causes of death were analyzed in detail: all causes (1524 deaths), all cancers (330 deaths), lung cancer (104 deaths), and leukemia (30 deaths). Noncancer mortality was also analyzed. The number of deaths for cancer analyses with internal comparisons was slightly larger due to the inclusion of deaths where cancers were contributory causes. This inclusion increases the sensitivity and specificity of the cancer and noncancer classifications. Leukemia analyses were also performed excluding seven deaths from chronic lymphocytic leukemia (*ICDA-8* 204.1), which is not in some lists of radiation-related leukemias.[8]

Cause-specific risk in the white male cohort was first described by modeling sociodemographic factors. The effects of external radiation doses were then assessed while controlling for sociodemographic factors. Data on smoking, chemical exposures, medical exposures to ionizing radiation, and cancer morbidity were not available. Age, birth year, pay code (monthly or nonmonthly), and active worker status were considered in the regression analyses. Pay code was used as an indicator of socioeconomic status. Active worker status was considered because workers who continued employment, and consequently exposure, tend to be healthier.[10-12] Cumulative external dose was stratified into eight 20-mSv width groups ranging from 0 to 120 mSv and above and modeled using a linear term. The midpoint of lower groups and the median value of the person-years in the highest category, 194 mSv, was used. The sensitivity of the β coefficients to the median value was tested by substituting the 25th and 75th percentiles of the distribution of dose in the highest category. The improvement in the fit of the model resulting from addition of terms to the model was assessed by a likelihood ratio test based on the change in deviance, distributed approximately as a χ^2 statistic, with degrees of freedom equal to the number of terms added to the model. A detailed description of the statistical methods is available from the National Auxilliary Publication Service (NAPS; see acknowledgments).

RESULTS

Worker Mortality Compared With US White Men

Table 8 lists the number of deaths and SMRs for all workers and for those monitored for internal radionuclide contamination. All-cause mortality was 26% lower than expected in the total cohort. The SMRs are low for all cancers, circulatory system diseases, nonmalignant respiratory diseases, and external causes. Values near unity are seen for prostate cancer, lymphosarcoma and reticulosarcoma, Hodgkin's disease, and pancreatic and brain cancer; leukemia mortality was 63% higher than expected (28 cases observed). Twenty-six of the 28 leukemia deaths occurred after 1965 in men hired before 1960, for whom the SMR in 1965 through 1984 was 2.23. Leukemia SMRs by decade of calendar year and decade of hire are available from NAPS. Given a previous observation of an association of external radiation with multiple myeloma (*ICDA-8* 203) at the Hanford facility,[1] it is of interest that there was only one death with multiple myeloma as the underlying cause. Mortality due to other lymphatic tissue malignant neoplasms as a group (*ICDA-8* 202 and 203) was 59% lower than expected (five deaths).

Workers who were ever monitored for internal contamination showed lower relative mortality than the whole cohort for all causes, circulatory system diseases, and external causes, suggesting higher levels of overall fitness among those workers. The leukemia SMR in workers monitored for internal contamination (2.23, 16 deaths) was higher than for the total cohort.

The SMRs were elevated for ill-defined causes in the total cohort (2.34) and in workers monitored for internal radionuclide contamination (2.89), reflecting the preponderance of deaths certified by medical examiners in eastern Tennessee. This would bias cause-specific SMRs downward. If distributed proportionately among specific causes, excess ill-defined deaths and deaths without a certificate would result in only minor changes in SMRs for more common causes; however, for rarer causes, the addition of even a few deaths could result in large increases.

The SMRs were also calculated for the 16 622 workers of all race-sex groups hired before 1972 and employed at ORNL for more than 30 days. The SMRs were 0.73, 0.75, 0.66, and 1.33 for all causes, all cancers, lung cancer, and leukemia, respectively. Detailed results are available from NAPS.

Mortality Within the Worker Population

Mortality from all causes, all cancers, lung cancer, and leukemia was studied

Table 3.—Cause of Specific Numbers of Observed Deaths and Standardized Mortality Ratios for All Workers and Workers Monitored for Internal Radionuclide Contamination*

Cause of Death (ICDA-8)	All Workers			Workers Monitored for Internal Contamination		
	Obs	SMR	95% CI	Obs	SMR	95% CI
All causes	1524	0.74	0.71-0.78	528	0.63	0.58-0.69
All cancers (140-209)	346	0.79	0.71-0.88	149	0.82	0.69-0.96
Esophagus (150)	8	0.53	0.21-1.27	4	0.93	0.25-2.39
Stomach (151)	17	0.66	0.50-1.38	6	0.79	0.29-1.72
Large intestine (153)	34	0.89	0.62-1.24	12	0.78	0.40-1.35
Rectum (154)	5	0.42	0.14-0.99	2	0.43	0.05-1.57
Pancreas (157)	25	1.09	0.71-1.61	9	0.95	0.44-1.81
Lung (162-163)	96	0.55	0.52-0.79	48	0.72	0.53-0.97
Prostate (185)	28	1.05	0.68-1.53	10	1.12	0.53-2.05
Brain/CNS (191-192)	16	1.04	0.58-1.72	5	0.78	0.25-1.81
Lymphosarcoma and/or reticulosarcoma (200)	9	1.05	0.48-1.99	6	1.65	0.60-3.59
Hodgkin's disease (201)	5	0.91	0.29-2.13	2	0.83	0.09-2.99
Other lymphatic (202-203)	5	0.41	0.13-0.95	1	0.19	0.00-1.08
Leukemia (204-207)	28	1.63	1.08-2.35	16	2.23	1.27-3.62
All circulatory system (390-458)	738	0.74	0.69-0.80	231	0.59	0.52-0.67
Nonmalignant respiratory (460-519)	73	0.61	0.48-0.77	28	0.60	0.40-0.87
Ill defined (780-799)	65	2.34	1.76-3.05	29	2.89	1.93-4.14
External causes (E800-E999)	172	0.75	0.64-0.87	53	0.61	0.33-0.87

*ICDA-8 indicates *International Classification of Diseases, Adapted, Eighth Revision*; Obs, observed; SMR, standardized mortality ratios; CI, confidence interval; and CNS, central nervous system.

Table 4.—Estimated Percent Increase in Cause Specific Mortality per 10 mSv Increase in External Penetrating Radiation Dose With Various Lag Assumptions

Cancer and Lag, y	Increase, %	SE	χ^2 (1 df)	P value
All Causes*				
0	1.33	.69	3.5	.06
10	1.71	.74	5.0	.03
20	2.68	.90	7.8	.005
All Cancer†				
0	2.53	1.18	4.2	.04
10	3.27	1.22	6.3	.01
20	4.94	1.39	10.2	.001
Lung Cancer‡				
Total workers				
0	5.23	1.84	6.5	.01
10	5.33	1.97	5.8	.02
20	5.21	2.54	3.0	.08
Lung Cancer‡				
Nonmonthly workers				
0	3.55	1.94	2.9	.09
10	3.44	2.10	2.3	.13
20	3.59	2.61	1.8	.21
Leukemia‡				
0	6.38	10.71	0.0	1.0
10	6.88	10.93	0.0	1.0
20	9.15	11.07	0.6	.44

*Adjusted for age, cohort, pay code, active work, pay code by cohort, age by active work, active work by cohort, and active work by pay code.
†Adjusted for age, cohort, pay code, active work, pay code by cohort, and age by active work.
‡Adjusted for age, cohort, and age by cohort.

Table 5. —Cause Specific Numbers of Observed and Expected Deaths* in Categories of External Penetrating Radiation Dose

Cause (Lag in y)	Dose Category, mSv							
	0	0-19	20-39	40-59	60-79	80-99	100-119	≥120
All Causes (20)								
Observed	737	619	75	33	20	2	6	32
Expected	755.8	613.8	74.4	29.8	14.0	5.6	4.0	19.3
All Cancer (20)								
Observed	154	169	20	14	5	0	5	13
Expected	170.9	164.1	21.1	8.8	3.9	1.9	1.3	6.3
Lung Cancer (0) Total Workers								
Observed	15	59	10	7	1	1	2	9
Expected	22.4	58.4	9.6	4.5	2.2	1.4	0.8	3.8
Lung Cancer (0) Nonmonthly								
Observed	13	42	8	7	1	1	2	9
Expected	13.7	45.3	8.2	4.9	2.3	1.7	1.0	4.9
Leukemia (10)								
Observed	7	15	6	0	0	0	0	2
Expected	8.9	16.8	2.5	1.0	0.5	0.3	0.2	0.9

*Expected deaths derived from Poisson regression models. Expected lung cancer deaths among monthly workers cannot be computed by subtracting expected nonmonthly from total expected deaths because age, cohort, and age by cohort terms were independently estimated.

within the white male cohort in relation to sociodemographic factors as well as cumulative external penetrating radiation dose. A number of sociodemographic relationships conformed to expectations from the literature, including an increasing age trajectory of lung cancer mortality in younger cohorts[13] and an increase in mortality for workers who were paid nonmonthly compared with workers paid monthly in younger birth cohorts.[14] Parameter estimates showing sociodemographic factor-mortality associations are available from NAPS.

The estimated percentage increases in mortality per 10-mSv increase in cumulative external penetrating radiation dose for all causes, all cancers, lung cancer, and leukemia mortality under various exposure lag assumptions and adjusted for sociodemographic factors are shown in Table 4. In all-cause and all-cancer mortality, the estimates increased when mortality was related to doses received more than one and two decades in the past. With a 20-year exposure lag, all-cause mortality increased 2.68% per 10 mSv, and all-cancer mortality increased 4.94% per 10 mSv. The improvement in the fit of the models to the data, as indicated by the χ^2 statistics, clearly increased with the length of the lag. When the all-cancer analysis (20-year lag) was repeated using the 25th and 75th percentile values for the highest dose category (12 mSv and above) instead of the median, the parameter estimates varied from about 3% to 6%. Dose coefficients for all cancers showed little variation whether there was control for active work, pay code, or cohort, or whether age was treated as a continuous or categorically stratified factor.

Two analyses are shown for lung cancer, one including monthly and nonmonthly workers and one restricted to nonmonthly workers. Nonmonthly workers had higher lung cancer mortality and external radiation doses. However, no lung cancer deaths were observed for monthly workers at doses above 40 mSv, whereas deaths among nonmonthly workers were distributed throughout the range of doses. It was therefore not possible to examine the effects of external radiation doses in monthly workers alone, and analyses were performed for all workers without controlling for pay code and for nonmonthly workers alone. Analyses for the total cohort showed estimated increases in lung cancer mortality of about 6% per 10 mSv at all lag assumptions. Estimates were smaller and SEs larger for nonmonthly workers. Unlike all-cause and all-cancer results, the χ^2 statistics indicate that the improvement in the fit of the model is greatest at zero lag and declines with increasing lag.

Results for leukemia are shown in the bottom panel of Table 4. Estimated percentage increases per 10 mSv rose from 6.38% at an exposure lag of 0 years to 9.15% with a 10-year lag. The SEs were larger than the parameter estimates and the χ^2 values indicate that the linear term for radiation dose did not contribute to the goodness of fit of the model. Analyses repeated with chronic lymphocytic leukemia deaths that were excluded from the leukemia category showed similar results.

The parameter estimates in Table 4 were estimated from data stratified into eight dose groups, and Table 5 shows observed and expected deaths in each dose group for the best-fitting lag assumption for each cause of death. The expected deaths were calculated from the full model for each cause but without the dose term and thus represent the number of deaths expected in each dose group given its sociodemographic distribution of person-years. Fewer than expected deaths were observed in the zero dose group for each cause, and the pattern of increases in observed over expected deaths at higher doses is evident. For leukemia, while an increasing trend of observed over expected deaths occurred in the first three dose groups, there were no observed and only 2.0 expected deaths between 40 and 119 mSv.

COMMENT

Mortality in this largely professional work force is low compared with the general population. This is expected based on the levels of health necessary to work and on the selection of a work force from the core economic sector and also in the primary labor market.[14] Exposures to external penetrating radiation were generally low. Only 135 of the close to 88 000 annual external dose estimates were above the current permissible annual occupational exposure limit of 50 mSv. Despite the overall healthiness of the population and its low levels of exposure to ionizing radiation, leukemia SMRs were elevated, and measures of exposure to external penetrating radiation were related to death from all cancers and all causes to a greater degree than would be expected from the radiation epidemiology literature.[16-19] However, less is known about the effects on humans of protracted low doses of ionizing radiation than about the effects of acute high doses. Furthermore, despite the widespread acceptance of dose-response estimates from the few studies of humans exposed to high doses, uncertainties about dose estimates for individuals in those studies are great.

The earlier report[2] on this population showed no suggestion of a trend of higher mortality from all cancers in higher cumulative radiation dose categories, and reanalyses employing regression techniques to estimate continuous dose-response relationships also failed to detect an effect.[4] A primary difference between previous analyses and the current one is the addition of 7 years of follow-up. There are also other differences in cohort construction, use of cancer contributory causes of death, dose estimation, and inclusion of covariates in regression analyses.

All-cancer models, as shown in Table 4, were fit to the follow-up data through 1977, excluding subsequent radiation exposures and counting as alive those who died after 1977 in order to determine what part of the difference between the present and past results could be attributed to the additional follow-up per se. Using identical models, the data through 1977 showed a small negative dose effect on all cancers at a 10-year exposure lag, similar to that reported by Gilbert et al,[4] and a small positive effect at a 20-year lag. The closeness of these results to previous reports shows that differences between present and past findings are not attributable to cohort construction, exposure classification, statistical models, or the specification of covariates. This suggests that the all-cancer dose-response effects were due to the added recent follow-up experience, which occurred more than 20 years after the higher exposures at ORNL during the late 1950s (Figure).

These findings are surprising because low doses and measurement problems should limit the ability to detect a radiation effect. The median cumulative dose over the entire work experience (1.4 mSv) is hardly greater than the estimated average annual background external dose of 1 mSv in the general population.[11] Accurate classification of doses over the working lifetime was facilitated by the individual film badge data, but nondifferential misclassification is expected due to badge-reading uncertainties and technical problems inherent in the task of matching hundreds of thousands of film badge records accumulated over decades of employment to individual workers. Lack of cancer incidence data and reliance on death certificate diagnoses in a geographical area with relatively high rates of certification to ill-defined causes should also reduce the ability to detect radiation-cancer associations.

While nondifferential misclassification of exposure and disease would reduce the ability to detect a dose effect,[20,21] other factors could result in overestimates. The practice of reading external dosimeters on a daily or weekly basis prior to July 1956 could have led to an underestimate of cumulative doses if badges did not receive sufficient exposure in the shorter periods to reach detectable levels. Upward bias in dose-response estimates would result if underestimation were more of a problem at higher than at lower cumulative doses, although downward bias would result if underestimation were primarily a problem at lower doses. In either case, the annual dose distribution does not show a striking change in 1956 (Figure), suggesting that the switch from weekly to quarterly reading in that year did not grossly affect dose estimates. The potential for greater internal radiation exposure of workers with higher external doses would also lead to underestimation of radiation doses at higher levels of external dose. However, if the dose most relevant to the outcome is the amount accrued in a particular time window rather than the total cumulative dose, sufficient doses would be overestimated. Another situation that could have led to an overestimate of dose response would occur if workers who were exposed to radiation were more likely to be exposed to chemical carcinogens such as benzene, asbestos, and a variety of solvents used at ORNL. The consistent increases in all-cancer dose response with increasing lag assumptions, however, suggest that if chemical exposures explain much of the radiation effect observed, they must have occurred in the same temporal pattern. Such temporal coincidence is more likely for occupational exposures than for the other potential confounders, which must also exhibit temporal coincidence if they are to explain the lag effects and the lack of a dose-response relationship in follow-up before 1978.

Some temporal relationships in the present findings are consistent with expectations from the radiation epidemiology literature. The interval between radiation exposure and leukemia death has been estimated to be considerably shorter than that for solid tumors.[1] Leukemia SMRs showed the greatest elevation during the 1960s, the decade following the higher exposure levels of the late 1950s, while all-cancer dose-response relationships did not emerge until after 1977. All-cancer mortality combined showed increasing effects of dose up to a 20-year lag. Although the dose-response estimates for leukemia are based on small numbers, they are larger than the estimates for all cancers, as would be expected from the literature.[1] The lung cancer results do not fit this pattern. Dose-response estimates for lung cancer showed little relationship to the lag of dose. To the extent that these data do suggest a radiation effect, the lag analyses suggest a late-stage carcinogenic effect for lung cancer.

The all-cause mortality results are important for a number of reasons. Because classification of cause of death is not an issue, the all-cause findings can be viewed as supporting an effect of external penetrating radiation dose in the absence of assumptions about the use of death certificate data as a proxy for cancer incidence, the underlying phenomenon of interest. However, application of the all-cause, 20-year lag model to noncancer deaths yields a dose coefficient of 1.59% with an SE of 1.15 and a χ^2 of 1.7, which suggests that the association of external radiation dose and mortality is specific to cancer mortality. The low association of radiation dose with noncancer mortality, the majority of which is smoking-related cardiovascular and nonmalignant respiratory disease (Table 3), suggests that smoking is an unlikely explanation of radiation-mortality associations. In any case, large smoking differences between dose groups would be necessary to produce substantial bias in the dose-response estimates.[22]

A number of factors could contribute to differences between the present findings and the largely negative results of previous studies of US workers exposed to low doses of external penetrating radiation. The average follow-up of the workers at Rocky Flats, Hanford, and ORNL in past reports was 14, 21, and 21 years, respectively.[4] Average follow-up of ORNL workers in this study was 26 years. Comprehensiveness and quality of the dose measurements may also differ. Data were available for 95% of working years in the present study and were estimated for years in which data were unavailable. The completeness of data from other facilities has not been fully described.[4] The present radiation-cancer mortality associations are consistent with the report of Beral et al[23] from the mortality follow-up of employees of the Atomic Weapons Establishment of the United Kingdom.[3] Dose-response estimates for all-cancer mortality assuming a 10-year exposure lag were 7.9% per 10 mSv for the multiplicative and 8.1% for the excess relative risk models in that study, values that are close to the 4.9% reported herein for the multiplicative model with a 20-year lag (Table 4).

Agreement of dose-response findings from different populations should depend not only on data quality and length of follow-up but also on differences in the effect of radiation in populations with different susceptibilities and coexistent exposures. This suggests that epidemiologic studies should not be seeking universal laws of dose response but rather effects that pertain to historically specific populations. Furthermore, not only the magnitude but the shape of the dose response may vary. The current dose-response estimates, as well as those of Beral et al,[8] are too large to be consistent with extrapolation to high doses, but there is no reason to assume that dose response conforms to any simple parametric form (linear, log linear, or quadratic) over a large range of doses.

The low-dose carcinogenic impact of ionizing radiation is a topic of great public concern due to fears about cancer and about an invisible exposure that emanates, in part, from secretive industries associated with production of weapons with high destructive potential. However, the issue of low-dose health effects of ionizing radiation exposures should be placed in the context in which it occurs. Other factors studied, such as birth cohort and pay code, showed much stronger relationships to mortality than does radiation, and only a few percentage points of these effects can be statistically attributed to external penetrating radiation.

Conversely, while factors other than radiation clearly predominate the statistical analysis of mortality in this population, the public health impact of these radiation exposures and the industry that produces them extend far beyond the low-dose occupational exposures themselves, which are estimated to constitute only 0.3% of the population dose of ionizing radiation in the United States.[16] The exposure of workers in this setting, and any attending health effects, depends on the historical development of an industry linked to a concentration of resources in military spending, which itself has gross health effects.[24] By providing an alternative to fossil fuels for electric power generation, the industry encourages ever-increasing energy consumption, a factor in potential health effects of global climatic and environmental change.[25] Additional effects of ionizing radiation from the industry may occur in surrounding communities,[26,27] in offspring of workers,[28] and in areas where waste products must be isolated from the environment for generations. Use of radioisotopes in medical research, diagnosis, and therapy also affects public health. Further consideration of potential harmful effects of low-dose ionizing radiation is essential in setting occupational and environmental exposure standards. However, focus on these effects should not distract attention from the public health impact of the context in which the exposures occur.

CONCLUSIONS

The all-cancer dose-response estimates reported in this study are an order of magnitude higher than those reported from analyses of the mortality experience of the survivors of the atomic bombings of Hiroshima and Nagasaki, Japan.[16] This difference is difficult to explain in terms of current knowledge of radiation epidemiology[16-19] or in terms of potential biases in the collection and analyses of data. The exact magnitude of the dose-response estimates reported herein is subject to many potential uncertainties. However, because power calculations have shown that studies of this type have little chance of detecting an effect of radiation if the effect is as small as has been assumed in the past,[29] the findings of consistent positive associations are important regardless of their exact magnitude. Because the observed effects have clearly emerged from the most recent period of follow-up and because of long delays of the apparent radiation effects, it is essential that mortality follow-up continue in this population and in other populations with protracted exposures to chronic low doses of external penetrating ionizing radiation for which high-quality exposure and disease follow-up data are available.

This report concerns work undertaken as part of the Health and Mortality Study of Department of Energy workers being conducted by Oak Ridge (Tenn) Associated Universities with the collaboration of the School of Public Health, University of North Carolina at Chapel Hill, under contract DE-AC05-76OR00033 between the Department of Energy, Office of Energy Research, and Oak Ridge Associated Universities.

We wish to thank James E. Watson, Jr, and Douglas Crawford-Brown for their assistance with dosimetry, Jo E. Heiss for help in data preparation and analysis, Janice Watkins for suggestions on the analyses, and Ethel Gilbert for critical comments and analyses. Shirley A. Fry contributed to planning and execution of the study as well as to preparation of the manuscript.

We acknowledge the vital statistics offices of the individual states as the sources of death record data and appreciate the offices' technical support of this research. We are solely responsible for the data analyses and interpretation of the results.

See NAPS document 04849 for 19 pages of supplementary material. Order from NAPS c/o Microfiche Publications, PO Box 3513, Grand Central Station, New York, NY 10163-3513. Remit with your order, not under separate cover, in US funds only $7.75 for photocopies or $4 for microfiche. Outside the United States or Canada, add postage of $4.50 for the first 20 pages and $1 for each 10 pages of material thereafter. The postage charge for any microfiche order is $1.50. Institutions and organizations may order by purchase order. However, there is a billing and handling charge for this service of $15, plus any applicable postage.

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ATTACHMENT # 3

DEPARTMENT : Health

STATE OF MINNESOTA

Office Memorandum

DATE : February 23, 1991

TO : Mary Jo Murray, Special Assistant Attorney General
Bill Grant, Department of Public Service

FROM : Through Raymond W. Thron, Ph.D., P.E., Director, Env. Hlth
David G. Gray, Chief, Section of Health Risk Assessment
Alice Dolezal Hennigan, Chief, Section of Radiation Control

PHONE : 627-5059
627-5071

SUBJECT : Proposed Prairie Island Spent Fuel Storage Installation.

After reviewing Northern States Power Company's plan for proposed construction of an on-site dry cask storage facility for spent fuel rod assemblies at the Prairie Island Plant, the Minnesota Department of Health is concerned about the level of radiation exposure for residents living in close proximity to the proposed facility. The expected annual maximum radiation dose for these residents calculated by NSP in its Safety Analysis Report is 3.74 millirem per year. NSP staff has indicated that the average dose rate over a 70 year lifetime would be about 1.79 millirem per year. As presently designed, this facility will deliver a dose of gamma radiation to offsite residents which will result in an incremental lifetime cancer risk well above the Minnesota Department of Health tolerable incremental lifetime carcinogenic risk from any single source of environmental pollution. The acceptable level established by the Department of Health is a lifetime risk level of one in one hundred thousand, or 10^{-5}.

Radiological impacts from the proposed dry cask storage facility will meet exposure standards established by the Nuclear Regulatory Commission for the annual dose at the facility fence line. This standard is 25 millirem annually. Clearly, the radiation dose to the residents in close proximity to the proposed facility would not exceed this standard. However, the excess lifetime cancer risk from this facility would be twenty-three times 10^{-5}, assuming that the annual average offsite dose to the nearest residents is 1.79 millirem. The basis for this conclusion is contained in the enclosed document entitled Estimated Risk of Lifetime Excess Public Cancer Occurrence from Proposed Northern States Power Company Independent Spent Fuel Storage Installation.

For over a decade the Minnesota Department of Health (MDH), in concert with other state agencies, most notably the Minnesota Pollution Control Agency (MPCA), has implemented a policy such that carcinogenic risk from any single source of environmental pollution must be insignficant. Based on studies of "tolerable" or "acceptable" risk, which are described in two enclosed documents written by the MDH Section of Health Risk Assessment, Tolerable Risk (1985) and Carcinogen Lifetime Risk (1991), MDH uses a lifetime risk level of 10^{-5}. This means that the upper 95% confidence limit for the estimated incremental incidence of cancer risk caused by pollutants from any one source or project should not exceed one per one hundred thousand over a 70 year lifetime.

This policy is in general agreement with the policies of the United States Environmental Protection Agency (USEPA) and with the policies of other states. There is no one risk value used by the USEPA or by the states. However, regulatory levels used by federal and state governments are almost always set between 10^{-4} and 10^{-6} for lifetime cancer risk. Thus, Minnesota policy is not extreme. Furthermore, it is consistent with what is known and documented about acceptance of involuntary risks with little or no benefit, or about acceptance of risk where benefits and risks do not accrue to the same set of individuals. These points are discussed in greater detail in the above referenced documents.

The Minnesota policy is non-controversial. For instance, the advisory committee which is assisting MDH in writing rules for Health Risk Limits for Drinking Water, pursuant to the Minnesota Groundwater Protection Act of 1989 accepted this lifetime cancer risk level with no debate. The advisory committee includes representatives from the regulated community, from environmental groups and from government agencies. Thus, this lifetime cancer risk level will be used for rulemaking setting health risk limits for groundwater. A lifetime cancer risk level of 10^{-5} is already in use for calculation of Recommended Allowable Limits for Drinking Water Contaminants (enclosed).

MDH is also represented on the Air Toxics Advisory Committee which is assisting MPCA in writing an Air Toxics Rule. Again, it is assumed by the committee, which represents the regulated community, environmental groups and state agencies, that Acceptable Ambient Limits for toxic air pollutants will be calculated using the criterion for acceptable lifetime cancer risk of 10^{-5}.

These are only the latest uses of the 10^{-5} level for acceptable risk in Minnesota rules. This risk number occurs in the Solid Waste Rule. A copy of the relevant portion of this rule (7035.2815, Subpart 4G) is enclosed. The 10^{-5} level for acceptable risk also occurs in the draft chapter 7050 of the Minnesota Rules, Standards for the Protection of the Quality and Purity of the Waters of the State. As of November 12, 1990, this chapter is now a final Minnesota rule. A copy of the relevant portion of the draft rule as proposed April 10, 1990 (7050.0127, Subpart 2 and 7050.0128 Subpart 2) is enclosed. This draft rule specifically mentions that risk shall be calculated from a linear non-threshold dose-response model used by the USEPA to provide the upper 95% confidence limit of the acceptable cancer risk.

The 10^{-5} level of acceptable incremental lifetime cancer risk is also used for environmental review of proposals for new facilities. Most specifically, it is used in review of Environmental Impact Statements and Environmental Assessment Work

Sheets and for permitting in Minnesota. All projects involving municipal and medical waste incineration in Minnesota are very controversial. Examples of such projects are the proposed Dakota County Incinerator and the Mayo Foundation Medical Waste Incinerator. However, controversial issues surrounding these two projects have most to do with whether or not they are needed, and with the process used to site them. All of the parties agree that the maximum incremental lifetime cancer risk from incinerator emissions, including all routes of exposure (for example inhalation of gases and particulates, dermal contact with soil contaminated with particulate emissions, food chain exposure via contamination of soil used for crops and livestock, and exposure to contaminated drinking water) should be less than 10^{-5}.

Northern States Power (NSP) has proposed several facilities in recent years, submitting health risk assessments for review, with the specific aim of showing that these projects have been designed such that the incremental lifetime cancer risk is less than 10^{-5}. These projects include:

1. NSP Minnesota Valley PCB/Oil Incineration Project, in Granite Falls Minnesota.

2. NSP Wilmarth Refuse Derived Fuel Municipal Waste Combustor in Mankato, Minnesota.

3. NSP Ash Storage Facility near Becker, Minnesota.

Many of the carcinogenic agents associated with various facilities and sites and evaluated by MDH have not been established as carcinogenic in humans. In contrast, there is abundant epidemiological evidence that gamma radiation is a human carcinogen. Thus, the cancer risk to humans from gamma radiation is a more certain risk than the cancer risk from many other environmental carcinogens.

It is our recommendation that this spent fuel dry storage facility should not be built unless the design is modified so that the offsite dose of gamma radiation is sufficiently small such that it is consistent with the Minnesota policy that the incremental lifetime cancer risk is no higher than 10^{-5}.

Enclosures

cc (with enclosures): Paul Zerby

ESTIMATED RISK OF LIFETIME EXCESS PUBLIC CANCER OCCURRENCE FROM PROPOSED NORTHERN STATES POWER COMPANY INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Radiation levels experienced by nearby residents to the ISFSI are taken from the NSP Safety Analysis Report. Cancer mortality risks are taken from BIER-V.

Page 7.5-1 of the SAR indicates that the expected maximum annual dose rate to the nearest resident is 4.27 E-4 mrem per hour (this dose contains both a gamma and neutron component). Assuming 8760 hours per year yields an annual rate of 3.74 mrem. Discussion with NSP staff on February 22, 1991 indicate that the average dose rate over a 70 year lifetime is about 1.79 mrem per year. (While the licensed period is only 20 years, there is no assurance that the facility may not operate indefinitely).

Referring to Table 4-2 of the BIER-V report, excess cancer mortalities can be obtained based on annual lifetime doses of 0.1 rem per year. As can be seen from the table, the upper 90% confidence interval is 980 excess cancers in the most sensitive population of 100,000 (males) and the mean rate of excess cancers is 520.

A 95% confidence limit can be estimated by the method shown on page 221 of BIER-V. The natural log of the quotient of the upper 90% confidence interval and the mean divided by 1.645 (z for the 90th percentile of the normal distribution) is the geometric standard deviation. In this case it is 0.385. The upper 95% confidence interval is e raised to the power [1.96 (z for the 95th percentile of the normal distribution) times 0.385] times the mean, or 1106.

The threshold of acceptable/unacceptable risk (one in 100,000 lifetime cancer risk) is based on cancer occurrence (not mortality). ~~BIER-V estimates are based on cancer mortalities, so an adjustment is made.~~ Current Minnesota lifetime cancer incidence for males is about 50% and cancer mortality is about 25% Therefore, the risk for cancer occurrence is about 2 times larger than the risk for dying of cancer. The risk of 1106 lifetime cancer mortalities per 100,000 males thus becomes 2212.

Because NSP proposed dose rate is lower than the pattern of exposure used in Table 4-2, a dose rate effectiveness factor is appropriate. A DREF is further indicated because the radiation is mostly low-LET gamma (the less than 1% high-LET neutron radiation, which may not have a DREF associated with it, can be ignored). Page 23 of BIER-V suggests a DREF of 2 for hard tumors (a DREF of 2.1 is used for leukemia).

According to BIER-V, for males there are 450 non-leukemia for every 520 cancers, on the average. This proportion is about 87% Therefore, excess cancer occurrences will be divided by 87% of the DREF of 2, or 1.73. The estimated cancer occurrences are now

2212 divided by 1.73 (accounts for DREF for solid cancers, DREF is implicit for leukemia), or 1270.

This cancer risk is converted to actual risk for the ISFSI by multiplying the risk by the ratio of NSP proposed dose to the 0.1 rem reported in Table 4-2. This ratio is 1.79:100 (0.0179) and the resulting actual risk is about 23 per 100,000.

ATTACHMENT # 4

Comments on Final Environmental Impact Statement
Prairie Island Independent Spent Fuel Storage Installation
by
Radioactive Waste Management Associates
May 6, 1991

Northern States Power has proposed storing its irradiated fuel from the Prairie Island reactors in an independent spent fuel storage installation, essentially, metal casks on a concrete storage pad near the reactor. Radioactive Waste Management Associates, a public interest consulting firm, has reviewed the adequacy of this FEIS and submits the following comments.

Northern States Power finds itself in the same predicament as almost all nuclear utilities in the United States and other countries. Since no permanent repository for final disposal of irradiated fuel is available, this highly radioactive material must be stored indefinitely. Since there is no centralized storage facility, and the fuel pool is nearly full, short of closing down the reactor, the company is opting to store fuel in storage-only metal casks. Rather than choosing a cask licensed for transportation and storage, NSP is choosing the riskier choice of a cask which is not even certified for transportation.

In employing an uncertified storage-only cask, it is not clear how the irradiated fuel will eventually be removed from Prairie Island and the installation decommissioned. Though the TN-40 cask could conceivably employ an overpack for transportation, the total weight of cask, overpack, fuel and carriage may exceed the safe carrying weight of local bridges. This is an issue which has not been explored in the FEIS. On the other hand, if NSP chose to reload the irradiated fuel into certified transport casks, the deleterious effect of temperature and time on fuel cladding integrity must be resolved. The potential maximum temperatures proposed by NSP are too high and may lead to cladding degradation. We strongly advise against using the TN-40 casks until these problems are resolved. Rather than reloading irradiated fuel up to three times, at the reactor for transport, and at a centralized storage for storage and then final disposal, with attendant radiation dose to nuclear workers at each handling, it is far preferable to load irradiated fuel once in a universal cask which can be directly accepted for disposal at the permanent repository. These issues are discussed further below and must be considered in the FEIS.

A final repository is not expected till the year 2010, probably later. Because the potential removal of irradiated fuel from Prairie Island has been advanced so far into the future, the State should require a performance bond, if available, or have NSP contribute to a stand-alone decommissioning fund which can be used by NSP for dismantling the ISFSI, or by the State, if the fuel is not removed from the site by date certain. This is to ensure that the ISFSI does not become a state liability. If a final repository never operates the State should protect itself.

The FEIS understates the health risk. A major component of the radiation dose from large casks, greater than 50% is due to neutron, not gamma radiation. This is not considered in the FEIS. The berms will not effectively shield neutrons. In addition, sky and ground scatter of gamma radiation must also be considered. The effective dose to off-site residents and nuclear workers is expected to be higher than estimated by NSP. In addition, the dose-effect relationship, and therefore the risk of the ISFSI, should be increased by a factor of 8.

Safety problems are understated in the FEIS. Though rushing water from a major flood, by itself, may not dislodge a TN-40 cask, piled debris, forming a dam, may build up sufficient force to turn over casks. The FEIS does not specifically discuss how NSP will recover from this accident. Another accident involves the direct impact of an airplane engine into the cask. Though the probability of such an accident is small, a jet engine crashing into a cask is likely to do considerable damage to a cask. In Germany this potential accident is modeled by requiring the CASTOR cask to withstand the force of a one-ton missile striking the cask at the speed of sound. It is unlikely that the TN-40 could survive such a test. The FEIS analysis on this point is nonexistent.

Security problems are also understated. The FEIS refers to NRC reports which were outdated when written in 1980. Irradiated fuel casks, while extremely sturdy, can be compromised by anti-tank weapons of commonly available explosive devices. Of course, other terrorist targets are available, but the risk should not be discounted by dismissing or minimizing the threat.

The full environmental impact and safety problems associated with the proposed storage method have not been captured by the impact statement which understates the risk and leaves many issues unresolved. We recommend that this inadequate EIS be rewritten.

Along with specific comments on sections of the FEIS, the above issues are discussed in more detail below.

FEIS Must Address Fuel Removal Issues
<u>Performance Bond Needed</u>

Since no final repository will be available in the foreseeable future and the Prairie Island fuel pools are nearing capacity, NSP has chosen the path of other U.S. utilities in a similar predicament, modular storage using dry storage containers. The method is simple enough. Fuel is loaded into casks and the casks are placed on a concrete pad or in a concrete structure.

Three dry casks methods have been proposed (See Table 1):

(a) single purpose casks, designed for at-reactor storage. Two concepts are in use: storage in thin-walled metal casks which are placed inside a concrete storage module (NUHOMS), or thick walled metal storage casks, such as the TN-40.

(b) dual purpose casks designed for storage and transportation, such as the CASTOR cask, that would be unloaded at the repository or MRS for packaging into a disposal cask. Dual purpose casks are typically heavier than storage-only casks.

(c) universal casks, to serve as a transport, storage and disposal container. The Department of Energy originally funded research by Westinghouse into this concept, which minimizes radiation doses to nuclear workers, but eliminated funding since the concept competed with their proposed centralized storage or MRS facility.

Though the TN-40 cask could conceivably employ an overpack for transportation, the total weight of cask, overpack, fuel and carriage may exceed the safe carrying weight of local bridges. The location of all bridges near Prairie Island that could be used in transporting nuclear fuel should be specified, along with the safe carrying capacity and the weight of the TN-40 laden train. This is an issue which has not been explored in the FEIS.

It is important to note that contracts between DOE and the utilities require fuel to have cooled at least five years before acceptance. The Department's acceptance priority is based on older fuel being shipped first. Damaged fuel has a lower acceptance priority. Thus, casks holding older fuel would ship first, and newer fuel within the fuel pool would be packaged and shipped later.

In addition, the Nuclear Regulatory Commission, 10 CFR Part 71, may require inspecting irradiated fuel and canning damaged fuel before it is shipped.

Two problems may arise as a result of long-term storage - fuel cladding degradation and corrosion of cask bolts and seals. The latter problem affects whether the TN-40 cask can be easily opened to allow the irradiated fuel to be removed for repacking into a transport or disposal cask. NSP intends to use epoxy paints and to maintain the casks during storage, but this needs to be incorporated into the company's license for the IFSFI.

Fuel cladding integrity is a problem that has seriously concerned investigators.[1,2] Fuel cladding is the Zircaloy tubing that contains the stacked irradiated fuel pellets. Nuclear Regulatory Commission regulations, 10 CFR Part 72.72(h), require that fuel cladding "shall be protected against degradation and gross rupture" throughout the life of the spent fuel storage installation. This also means that cladding should maintain integrity during handling after storage period. However, "the dry storage demonstration studies conducted to date are inadequate for extrapolating Zircaloy behavior under long-term storage conditions."[1] "The demonstration studies . . . consisted of too few assemblies and was observed for too short at time to permit confident predictions of long-term behavior." The degradation mechanisms considered are stress, corrosion and temperature. Stress is caused by internal gas pressure-helium.

For fuel which has remained in the fuel pool for ten years, the maximum allowable initial temperature within the cask[2] is 320°C. If the internal temperatures exceed this value, the fuel cladding may degrade, making it difficult to repackage and move at a later date. However, the maximum temperature of fuel cladding in the TN-40 may approach 340°C, exceeding the recommended limits. Considering the lack of long-term testing and the uncertainty of the predicted maximum temperature, we strongly advise against use of the TN-40 cask until these uncertainties have been resolved.

A final waste repository is not expected till the year 2010, probably later and possibly never. Because the potential

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[1] Spend Fuel Cladding Integrity During Dry Storage, by MW Schwartz and MC Witte, Lawrence Livermore National Laboratory, September 1987.

[2] Workshop on Spent Fuel/Cladding Reaction During Dry Storage, Nuclear Regulatory Commission, NUREG/CP-0049, August 1983.

removal of irradiated fuel from Prairie Island has been pushed so far into the future, the State should require a performance bond, if available, or have NSP contribute to a stand-alone decommissioning fund which can be used by NSP for dismantling the ISFSI, or by the sate if the fuel is not removed from the site by a dated certain. This fund should be similar, but in addition to and separate from, the fund established to decommission the Prairie island reactors. The purpose of the fund is to ensure that the ISFSI does not become a state liability. Since it is possible that a waste repository may never operate, the state should protect itself.

Health Risk Understated

The FEIS understates the health risk. A major component of the radiation dose from large casks, greater than 50%, is due to neutron, not gamma, radiation. The berms will not effectively shield neutrons. Neutron radiation dose is not considered in the FEIS.

To illustrate this point, the dose rates from an IF 300 railroad shipping cask, holding 7 PWR assemblies, are shown in Table 2. For an IF 300, neutron shielding is accomplished with a water jacket around the cask. In Table 2, "wet" shielding indicates that the water tanks are intact. For a TN-40 cask, neutron absorbing material is embedded in a way resin surrounded by another carbon steel shell. The resin is always present except in the case of an accident involving a high temperature fire. The resin would not withstand a high temperature fire, but the EIS is silent on this point. Without the resin, the external neutron dose would rise dramatically, as is seen in Table 2, when the neutron shield is dry. At five years after discharge, the neutron dose without neutron shielding, is 255 millirem/hour. Since the TN-40 holds so much more irradiated fuel than the IF-300, the dose would be much higher without neutron absorbing material.

It is not clear if sky and ground scatter of gamma radiation have been included in off-site dose estimates in the FEIS. Scatter of gamma radiation is expected to increase the estimated dose.

An important issue in calculating radiation risk is the relation between radiation dose and latent cancer fatalities and genetic effects. Recent results of a study of Japanese survivors of the atomic bombings, and independent studies, show the health effects of radiation to be greater than previously thought. Federal agencies previously expected 120 health effects as a result of a total population radiation dose of one million person-rems. The results from a study jointly conducted by the

Department of Energy and Japanese Ministry of Health of atomic bomb survivors show radiation health effects to occur at a rate approximately 16 times greater for individual doses less than 1 rem.

A crucially important issue is the slope of the dose-response curve, that is, the relationship between the dose received by a population and the number of cancers expected. The standard assumption is to assume that if the total dose to two population groups is equal, the total number of cancers will be equal. That is, if 10,000 persons receive a dose of 1 rem each, or 100,000 persons receive a dose of 0.1 rem each, since the total persons-rems is the same, the number of health effects should be equal. Recent Japanese data do not support this hypothesis.[3] The data indicate that if a large number of persons receive a small dose, the consequences are greater than if a small number of persons receive a large dose. According to Shimizu, "...since the curvature is invariably downwards when a curvilinear model gives an acceptable fit, this would imply a higher risk at low doses than that which obtains under a linear model."

For low doses, one expects not 743 latent cancer fatalities per million person-rems, as stated in the FEIS at 6.14, but 3700.[4] Thus, contrary to the EPA-expected dose-effect relationship, one expects a latent cancer fatality rate approximately five times greater. One also expects an equal number of non-fatal cancers and genetic effects.

Safety Problems Understated

Safety problems are understated in the FEIS. Though rushing water from a major flood, by itself, may not dislodge a TN-40 cask, piled debris, forming a dam, may build up sufficient force to turn over casks. The FEIS states that the water velocity at maximum flood, is only 6.2'/sec and the drag force is only 20% of that needed to cause the cask to tip or slide. The FEIS does not specifically discuss how NSP will recover from this accident.

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3 Shimizu, Y, et al, "Life Span Study Report 11, Par I. Comparison of Risk Coefficients for Site-Specific Cancer Mortality Based on the DS86 and T65DR Shielded Kerma and Organ Doses," RERF Technical Report TR-12-87.

4 JS Gofman, Radiation-Induced Cancer from Low-Dose Exposure, CNR, San Francisco, 1990.

Another accident involves the direct impact of an airplane engine into the cask. Though the probability of such an accident is small, a jet engine crashing into a cask is likely to do considerable damage to a cask. In Germany this potential accident is scale-model tested by requiring the CASTOR cask to withstand the force of a one-ton missile striking the cask at the speed of sound. It is unlikely that the TN-40 could survive such a test. The FEIS analysis on this point is nonexistent.

If the TN-40 casks were sheltered in a concrete building, this accident would not be possible. In addition, a concrete building would have other beneficial effects: gamma radiation would be shielded, and the casks would also be protected from the elements, including the freeze/thaw cycle.

Security Problems Are Understated

Security problems are also understated. The FEIS refers to NRC reports[5] which were outdated when written in 1979. Irradiated fuel casks, while extremely sturdy, can be compromised by anti-tank weapons or explosive devices commonly available, for example, at oil fields in the MidEast. Such explosive devices could easily penetrate 14 inches of steel. Of course, other terrorist targets are available, but the risk should not be discounted by dismissing or minimizing the threat.

Conclusions

As stated above, the full environmental impact and safety problems associated with the proposed storage method have not been captured by the impact statement which understates the risk and leaves many issues unresolved. If fuel is stored at too high a temperature for a long duration, the cladding is expected to degrade, complicating final removal of the fuel from Prairie Island. The recommendations above are intended to increase the safety of the storage facility, and the likelihood the fuel will be recovered from the site and ensure that the storage facility will not become a liability to the state. We recommend that this inadequate EIS be rewritten.

MGG01E87.WP5

5 Nuclear Regulatory Commission, "Generic Adversary Characteristics -- Summary Report," NUREG-0459, March 1979.

Table 1. NRC Approved Topical Reports

Cask	Manufacturer	Capacity	Comments
CASTOR-1C	General Nucl Systems	16 BWR	Nodular cast iron 81 tons, T/S
CASTOR-V/21	General Nucl Systems	21 PWR	Nodular cast iron 117 tons; T/S In use at Surry
NUHOMS-7	NUTECH	7 PWR	Concrete/SS storage In use at HB Robinson
MC-10	Westinghouse	24 PWR	Cast ferretic steel 120 tons; T/S
Modular Vault Dry Store	FW Energy Applictns	5 x 83 PWR 5 x 150 BWR	concrete modules
NAC-S/T	Nucl Assurance Corp	26 PWR	Lead and SS 100 tons; up to 31 PWR w/NRC burnup credit; 56 PWR consolidated
TN-24	Transnuclear	24 PWR	Ferretic steel cask, 100 tons; cask used at INEL demo; designed as S/T

NRC Topical Reports Under Review

Cask	Manufacturer	Capacity	Comments
CASTOR-X	General Nucl Services	28 PWR	Nodular cast iron, for 10 yr old fuel; Up to 33 PWR w/ burnup credit
CP-9	Nuclear Packaging	9 PWR	Concrete cask, 88 tons
Dry Cap	Combustion Engineering	24 PWR	Ferretic steel cask, 112 tons
NUHOMS-24P	NUTECH	24 PWR	Concrete storage module; transfer cask to move fuel to storage module; design selected by Duke Power, Carolina P&L, Baltimore G&E

Table 2.

Dose Rates for the IF 300 Rail Cask with Variation in Fuel Cooling Times*

Decay Time	Fuel Cavity	Neutro Shield	Dose Type	Dose Rate (mr/hr) Surface	1 Meter	2 Meter	3 Meter
5 yr	Dry	Wet	Neutron	8.273	2.623	1.414	0.8329
			Gamma	9.065	2.769	1.439	0.8502
			Total	17.338	5.392	2.853	1.6831
10 yr	Dry	Wet	Neutron	6.896	2.187	1.179	0.6944
			Gamma	5.726	1.633	0.8078	0.4646
			Total	12.622	3.82	1.9868	1.159
15 yr	Dry	Wet	Neutron	5.766	1.829	0.9854	0.5806
			Gamma	4.48	1.254	0.6109	0.3483
			Total	10.246	3.083	1.5963	0.9289
20 yr	Dry	Wet	Neutron	4.827	1.531	0.8249	0.4861
			Gamma	3.615	1.001	0.4834	0.2742
			Total	8.442	2.532	1.3083	0.7603
25 yr	Dry	Wet	Neutron	4.057	1.267	0.6934	0.4085
			Gamma	2.968	0.8158	0.3917	0.2214
			Total	7.025	2.0828	1.0851	0.6299
5 yr	Dry	Dry	Neutron	255.1	79.61	40.23	23.28
			Gamma	5.586	2.085	1.199	0.7674
			Total	260.686	81.695	41.429	24.0474
10 yr	Dry	Dry	Neutron	212.6	66.34	33.52	19.4
			Gamma	1.843	0.6689	0.3785	0.2397
			Total	214.443	67.0089	33.8985	19.6397
15 yr	Dry	Dry	Neutron	177.7	55.44	28.02	16.21
			Gamma	1.055	0.3767	0.2109	0.1326
			Total	178.755	55.8167	28.2309	16.3426
20 yr	Dry	Dry	Neutron	148.8	46.44	23.47	13.58
			Gamma	0.6722	0.236	0.1307	0.08149
			Total	149.4722	46.676	23.6007	13.66149
25 yr	Dry	Dry	Neutron	125	39	19.71	11.41
			Gamma	0.4564	0.1575	0.08626	0.05334
			Total	125.4564	39.1575	19.79626	11.46334

* Data from CV Parks, et al, "Parametric Study of Radiation Dose Rates from Rail and Truck Spent Fuel Transport Casks," Oak Ridge National Laboratory, ORNL/CSD/TM-227, August 1985.

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Recent mortality statistics for distally exposed A-bomb survivors: The lifetime cancer risk for exposure under 50 cGy (rad)

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Abstract

An analysis of mortality statistics from the most recent Life Span Study reports of Hiroshima and Nagasaki survivors (covering both the 1950–1982 and the 1950–1985 follow-up periods) indicates a significant difference ($p < 0.001$) in cancer mortality rates between two distally exposed groups of survivors with organ-absorbed radiation doses under 40 cSv. This implies a mean incremental lifetime cancer risk (exclusive of leukemias) of about 25 excess fatal cancers per 10,000 persons exposed to one additional cSv (rem) of ionizing radiation for persons who had been exposed to doses in the range 1–40 cSv above background levels. This risk value is independent of whether the original (T65DR) dosimetry assignments (choosing a value of 10 for the relative biologic effectiveness of neutrons) or the new dosimetry estimates (DS86) are used.
The present estimate of A-bomb survivor radiogenic cancer risk associated with low dose exposure was obtained directly from the observed cancer deaths in the low-dose exposure groups without reliance on model-dependent extrapolation from high dose data. This low-dose risk estimate is about ten times larger than the risk estimates adopted previously by national and international radiation commissions as a basis for current radiation safety guidelines for workers and the general public.

Key words: Biological effects of radiation, radiation epidemiology, low-dose cancer risks, radiation protection standards

Introduction

The aftermath of the explosion of atomic bombs over Hiroshima and Nagasaki in August 1945 coincided with the beginning of radiation epidemiology, the medical-statistical study of human health effects as a consequence of exposure to ionizing radiation. Systematic follow-up of about 120,000 A-bomb survivors for the duration of their lifetimes was begun in 1950. This group of survivors, of whom about 91,000 had been exposed to various levels of radiation from the bombs' explosion, have been designated the Life Span Study cohort (LSS). A team of scientists of the Joint U.S.-Japan Radiation Effects Research Foundation (RERF) in Hiroshima is responsible for the LSS follow-up studies of health and mortality statistics. Technical reports and journal summaries have been published by RERF with increasing frequency in recent years.
Estimation of the dose-response relation in the low dose exposure range is of particular importance for establishing radiation protection standards for nuclear industry workers and for the general public. The purpose of the present analysis of recent A-bomb survivor mortality statistics is to develop an updated estimate of the radiogenic cancer risk for low dose radiation exposure. The analysis is limited to the cancer mortality statistics of a group of distally exposed survivors with kerma exposures below 50 cGy (rad) (more than 1,600 m from ground zero in Hiroshima, greater than 2,000 m in Nagasaki). The

straightforward method used to determine the radiogenic cancer risk for this group of survivors provides an estimate of the average slope of the dose-effect relationship for a dose range below 20 cSv (rem) and it does not require familiarity with sophisticated epidemiological techniques.

The A-Bomb survivor study

For the 91,000 A-bomb survivors from the original LSS cohort, dose estimates were reconstructed in the 1960's on the basis of the then available information about their whereabouts at the time of the explosions and the physical properties of the explosion (T65DR dosimetry). This population of survivors was originally subdivided into eight dose groups with external dose estimates ranging from a presumed zero dose to 400+ cGy (rad). During the first 25–30 years after the dropping of the bombs – and before the long latency periods, preceding symptomatic presentation were fully appreciated – excess cancer mortalities, significantly exceeding the expected levels of spontaneous cancer deaths, were found only among the medium to high-dose groups of survivors. The cancer death rates in the low-dose groups were, for many years, lower than or equal to those observed for the general population (Table 1). These early observations led radiation experts to assume that low levels of radiation exposure

Table 1
The change in cancer rate [all cancer deaths, excluding leukemia]/[total deaths by all causes] for Two Low-Dose Groups (T65DR) of the LSS Cohort for Successive Follow-Up Periods (SE in parentheses)

Time period	"1–9 rad"	"10–49 rad"
1950–54	0.126 (11)	0.156 (17)
1955–58	0.143 (11)	0.144 (15)
1959–62	0.182 (12)	0.212 (19)
1963–66	0.179 (12)	0.203 (17)
1967–70	0.187 (12)	0.220 (18)
1971–74	0.213 (14)	0.225 (19)
1975–78	0.226 (14)	0.223 (18)
1979–82	0.229 (14)	0.239 (19)

National average for Japan (refs. [15, 16]): 0.213

are probably harmless to human health. By the early 1980's it was generally surmised that if any harmful effects would result from low-dose exposure, they would be so insignificant that their existence could never be statistically validated [1]. This view became formalized in the recommendations of the International Commission on Radiological Protection (ICRP), repeated and supported by other official commissions in their reports from the late 1970's or early 1980's [2–4]. Accordingly, a worker's maximum allowable exposure of 5 cSv (rem)/year was promulgated to assure an exceedingly high standard of occupational safety in the nuclear industry. One tenth of that value (0.5 cSv/year) has been set as a standard of radiation protection for the general public. These standards have not been substantially changed in the U.S. for more than 30 years [5].

Revision of the Hiroshima-Nagasaki dosimetry estimates

By 1978, serious shortcomings in the original dose assignments were recognized and revised dose estimates for the LSS cohort were deemed necessary. Recent publications of mortality statistics refer to a truncated LSS subcohort of survivors to whom revised dose estimates could be assigned according to an updated dosimetry system.

The nearly dosimetry model included the assumption that radiation exposure associated with the bomb on Hiroshima (uranium) contained a considerably higher neutron component than that from the sec bomb on Nagasaki (plutonium). It was thought that exposure to neutron radiation was biologically much more effective and thus caused higher cancer mortalities among the Hiroshima survivors compared to cancer mortality in Nagasaki. Comparison of mortality statistics for the LSS subcohorts from the two cities was, thus, thought to provide a reliable basis for determining the RBE of neutrons to be at least 10. By 1980, on the basis of extensive experimental and modeling research on nuclear weapons, scientists concluded that previous analysis of the A-bomb survivor LSS cohort had used a dosimetry model (T65DR) that overestimated the intensity of the neutron contribution to radiation exposures in Hiroshima by a factor of about 10 and the intensity of gamma radiation exposure in both cities by a varying factor of up to 3.5, depending on the city and the distance from ground zero [6, 7]. The 1986 dosimetry system (DS86) now recognizes that the overall contribution of neutrons to absorbed doses was minor for the entire LSS cohort and that it was negligible for the distally exposed survivors making up the low dose groups. Differences in neutron flux for the two cities, therefore, no longer provides a reliable basis for estimating an RBE value for neutrons [8–10].

For a truncated LSS subcohort of aobut 76,000 survivors (the DS86 subcohort), the available information about their whereabouts at the instant of the explosion was considered sufficiently detailed to assign them revised dose estimates according to the DS86 dosimetry system. The changes resulting from the new absorbed organ dose assignments for this subcohort removed most of the previous differences in the dose-dependent cancer statistics between the two cities. Thus, for the purpose of radiogenic cancer studies, survivors from Hiroshima and Nagasaki can now be treated with improved statistical power as a single, roughly similar population [8–12].

Alphabetical glossary of terms

Doubling dose is that dose of radiation which (assuming a proportional relationship between risk and dose) would double the cancer mortality , compared to the spontaneous (unexposed) rate.

DS 86, a new, considerably more complex dosimetry model of 1986 which replaces the previous dosimetry system (T65DR). It takes into account many more variables, including greatly improved knowledge about the point of explosion, the energy output of the two different type bombs used on Hiroshima and Nagasaki, revised estimates of energy and radiation intensities at various distances from the hypocenter in the two cities, detailed modeling of the shielding properties of the atmosphere, the type of building the survivor was occupying at the time of the blast, and of various parts of the human body, including corrections for the specific position of the individual and his distance to the location of the hypocenter.

Gray (Gy), a unit of absorbed dose of radiation which quantifies the deposition of a specified amount of energy per gram of exposed tissue. The Gy replaces the older unit rad (One rad = 0.01 Gy = 1 cGy).

Kerma dose is the "tissue dose free-in-air" (at the body's surface), before the radiation may have been modified by intervening physical structures and before it is further modified by absorption inside the body due to skin, surface tissue, bones, etc.

Organ-absorbed dose is the biologically effective dose to the internal organs of the body. The effective dose to the colon is generally used for cancers other than leukemia, while the bone marrow dose is used for leukemia. The organ dose can be determined by applying suitable transmission factors to the kerma dose. It is the appropriate dose to be used to develop radiogenic cancer risk estimates from statistical data such as those from the LSS cohort.

RBE is a correction factor which takes into account the presumed greater relative biological effectiveness (RBE) of neutrons (or alpha particles) relative to gamma (X-radiation) or beta particles (electrons). A mean of low-energy neutrons which deposits the same amount of energy per gram of tissue as a beam of gamma rays or electrons has been assumed to have at least a tenfold higher carcinogenic effect than gamma rays. On that assumption, 1 cGy of neutron dose in air (kerma) outside tissue represents an absorbed tissue dose of 10 cSv (RBE=10).

Relative Risk in contrast to absolute risk (e.g. excess mortality per unit dose), expresses increased cancer risk due to a specified dose of any carcinogen (in this paper limited to radiogenic risk) as a multiple of the spontaneous cancer risk at zero dose. A relative risk of 1.00 is assigned to the spontaneous cancer mortality, and a doubling dose of radiation would increase the relative risk to 2.00

Sievert (Sv) is a unit of biologically effective tissue dose, taking into account that certain types radiation such as neutrons or alpha particles are biologically more effective for the same amount deposited energy per gram of tissue than X- or gamma radiation. The Sv replaces the older unit rem (1 rem = 0.01 Sv = .1 cSv).

T65DR is a physical-mathematical model, first formulated in 1965 and slightly modified in 1982, used to estimate radiation dose exposure of individual A-bomb survivors up to 1982. The assigned dose depended on several factors, including an assumed spectrum of A-bomb radiation and the survivor's location relative to the hypocenter of the Hiroshima or Nagasaki A-bomb explosions.

Methods

The designation of dose groups as defined in most RERF reports, using the "rad" as the unit of kerma dose, is continued in this report. It is now generally recognized that the appropriate dose to be considered when studying the health effects of radiation is the "organ absorbed" dose, measured in cSv (rem). Mean kerma doses can be transformed into effective organ absorbed doses by appropriate conversion factors (Table 2). The calculated lifetime radiogenic cancer risk estimates in this report are based on the estimated organ absorbed radiation dose.

Table 2
Calculations to Estimate the Radiogenic Cancer Mortality Risk of Low-Dose Radiation Exposure [Hiroshima-Nagasaki Survivors, <20 cSv (rem)]*

Follow-up period Dosimetry system	1950–1982 T65DR		1950–1985 DS86	
Dose group	"1–9 rad"	"10–49 rad"	"1–9 rad"	"10–49 rad"
1 Persons in group	28,855	14,943	23,321	11,730
2 Mean kerma dose (cGy)	3.0	21.9	2.9	23.5
3 Mean organ dose [cSv]				
neutron RBE-1	1.4	10.3	2.1	17.4
neutron RBE-10a	2.4	16.6	–	–
4 Cancer deaths (except leukemia)	1,779	1,055	1,653	953
5 Cancer mortality/10^4 for follow-up	6.17×10^2	7.06×10^2	7.10×10^2	8.12×10^2
6 Follow-up correction (see Table 2 and text)	3.40	3.40	2.90	2.90
7 Expected lifetime cancer mortality/10^4	2.096×10^3	2.400×10^3	2.059×10^3	2.355×10^3
8 Lifetime radiogenic cancer deaths if 10^4 people are exposed to one additional cSv				
RBE-1	34 (1.4–10.3 cSv)		19.3 (2.1–17.4 cSv)	
RBE-10	21 (2.4–16.6 cSv)		–	
9 With adjustment for 23% under-reporting of cancer deaths among A-bomb survivors and (95% confidence limits) (see text)				
RBE-10	26 (12; 40)		RBE-1 24 (10; 38)	

* neutrons do not contribute to the DS86 dose for these dose groups

Calculations (key to table 2)

Data reference sources and calculations required to develop the radiogenic cancer risk estimates shown in Table 2:

	1950–1982 LSS Report	1950–1985 LSS Report
Line 1.	Number of persons in group: (Ref. 12, Table 1)*	(Ref. 10, Table 2 and Appendix Table 2)
Line 2.	Mean kerma dose: (Same as line 1)	(Same as line 1)
Line 3.	Correction factors used to calculate effective mean organ doses from line 2: (Ref. 18; calculation of the effective neutron dose required combining values from Ref. 19, Table 2 with Ref. 12, Table 1, mean doses)**	(Ref. 10, Table 3, TR 12-87)
Line 4.	Number of cancer deaths: (Ref. 12, Table A3–7 in TR 1-86)	(Ref. 10, Table 2)
Line 5.	Cancer mortality rate: Divide Line 4 by Line 1	
Line 6.	Correction to determine lifetime cancer mortality (see Table 3 and text for derivation and sources): 3.4	2.9
Line 7.	Excepted lifetime cancer mortality: Multiply line 5 with line 6	
Line 8.	Lifetime radiogenic cancer deaths per 10,000 people, per cSv dose above the mean dose of "1–9 rad" group: Divide the difference between entries on Line 7 for the "10–49 rad" and "1–9 rad" groups by the difference in mean dose values for the same groups from entries on Line 3, yielding the increment in radiogenic cancer deaths per unit dose.	
Line 9.	Lifetime radiogenic cancer deaths per 10,000 people, per cSv dose after adjustment for 23% under-reported cancer deaths (ref. 3, 8, 9, 11) with 95% confidence ranges in parentheses (see text).	

* Corrected for the number of Hiroshima survivors in the ("1–9 rad") group to read 15,931 instead of 15,391.

** Consistent with most current radiation protection guidelines, RBE = 10 should be used for the risk estimate based on the T65DR dosimetry. However, for the purpose of demonstrating the significant influence this value has on T65DR organ doses, we include the calculation for RBE = 1 for the 1950–1982 follow-up data. In contrast, the value for neutron RBE is irrelevant for the low doses in the new (DS86) dosimetry, for which we followed RERF reports in using RBE = 1 [10, 11].

Our analysis is limited to the distally exposed survivors who constitute the dose groups below 50 cGy (rad). These dose groups comprise 89% of the 91,231 persons in the original LSS cohort (T65DR) if the "0 rad" group is included and 48% of this cohort if only survivors exposed to more than 1 cGy (rad) are considered. For the 75,991 survivors in the smaller DS86 LSS subcohort, the corresponding fractions are 79% and 46%, respectively.

Following the estimation of lifetime risk of mortality from radiogenic cancers in recent RERF reports [8, 9, 11], we do not stratify low-dose radiogenic risks according to various categories of cancers but, rather, distinguish only two major categories of malignancies: leukemia and all cancers except leukemia. Our radiogenic cancer risk estimates deal only with the second category, representing an average for all cancers found among the low-dose LSS subcohorts, excluding leukemia. Furthermore, the determined risk is for a mixed population (in terms of age and sex) that corresponds to the make-up of the distally exposed survivor group. An incremental radiogenic cancer risk estimate is presented which is equivalent to the average slope of the dose response relation in the "1–49 rad" kerma dose range. For some cancers the slope may be greater and for others smaller. Those differences are, however, likely to fall within the 95% confidence limits of our radiogenic cancer risk estimation.

Reference group

A reference group of survivors who were located 2,500–10,000 m from the hypocenters of the A-bombs has been used in all previous analyses of LSS data as a presumably unexposed "0 rad" control group. Only recently, it was recognized that a fraction of the control subcohort was in fact exposed to varying levels of residual radioactivity from fallout and soil activation. Organ-absorbed doses due to fallout among members of this group who were present at certain locations about 3,000 m from ground zero in both cities were estimated to range from 12–24 cGy in Nagasaki and from 0.2–2 cGy in Hiroshima [13]. Additional exposure from soil activation affected persons in the control group. A comparison of the "zero dose" group with the "1–9 rad" subcohort, exposed to a mean dose of about 2 cSv, reveals identical cancer mortality rates, consistent with uncertain but similar radiation exposure of the control group. The Panel on Reassessment of A-Bomb dosimetry (1987) recommended that persons exposed to residual radioactivity be removed from epidemiological studies [14]. As far as we can ascertain, this correction has not yet been implemented in the most recent RERF tabulations available to us. We chose, therefore, to evaluate the incremental cancer risk in our analysis by a direct comparison of mortality figures in the "1–9 rad" with those in the "10–49 rad" groups, circumventing the need for a truly unexposed control group.

Method of analysis

An estimate of the average excess lifetime radiogenic cancer mortality per unit organ-absorbed dose in the range 1–40 cSv was obtained from the statistically significant differences ($p < 0.001$) between the cancer mortalities for the "1–9 rad" group and the "10–49 rad" group, using both dosimetry assignments (Table 2). The calculations are based on the commonly accepted hypothesis that any statistically significant increase in cancer mortality among the survivor subcohort with the higher mean dose, compared to that of the group with lower mean dose, may be ascribed to the effects of increased mean exposure. A direct comparison is admissible provided the age and sex composition of the two subcohorts is similar enough to have a minor effect on the final risk factor, considering its relatively wide range of confidence (corrections for significant differences in mean age at exposure between the two lowest dose groups considered which are not available to us could lower the calculated risk estimates by at most 50%). This method yields an estimate of the mean incremental radiogenic cancer risk per additional unit of dose (i.e., the mean slope of the dose response curve) for a mixed population consisting of persons exposed to an average dose between about 2–17 cSv (rem) above background (Table 2).

Lifetime risk

The incremental lifetime cancer risk is an accepted way of estimating the risk of exposure to low doses of ionizing radiation. Given the long latency time before cancer development is clinically apparent and since more than 60% of the individuals in the two low-dose A-bomb survivor subcohorts considered were still alive at the end of 1982, it is necessary to establish the eventual lifetime cancer risk by extrapolating from the limited follow-up data to the expected lifetime cancer mortality after all members of the subcohorts will have died. This requires evaluation of a correction factor that relates

Table 3
The "1–9 rad" reference group 1950–1982 follow-up (T65DR)

Total persons in group:	28,855
Total deaths (all causes) (1950–1982):	9,563
Total cancer deaths (1950–1982):	1,779
Still alive at end of 1982:	19,293
Additional cancer deaths expected:	0.228 × 19,293 = 4,399 (see text)
Total lifetime cancers expected:	1,779 + 4,399 = 6,178 (from line 4, Table 2)

$$\text{Follow-up correction: } \frac{\text{[Lifetime cancers]}}{\text{[Cancers through 1982]}} = 3.47 \text{ (line 6, Table 2)}$$

Table 4
Radiation-Related Lifetime Cancer Risks (excluding leukemia) [number of life-time excess fatal cancers per 10,000 persons, per cSv exposure, corrected for 23% under reporting][a]

Data Source	Neutron RBE assumed	Dose range used (cSv)	Lifetime excess cancers/10^4 per cSv (95% conf. range)	doubling dose[b] (cSv)	Ref.
			T65DR (1950–1982)		
this work	10	2.4–16.6	26 (12; 40)	77 (50; 167)	–
Gofman	1	1–400	41	49	17,20
near 10 cSv	10	1–400	26	77	17,20
			DS86 (1950–1985)		
this work	1	2.4–16.6	24 (10; 38)	83 (53; 200)	–
Preston	1	0–400	17	118	8
(linear fit)	1	0–400	11	182	9
Shimizu	1	0–200 (400)	10–12	167–200	11
Gofman	1	at 2.4	35	57	17,20
(curvilinear fit)		at 16.6	17	118	17,20
Hanford workers		1–50	26 (2; 49)	79 (41;983)	22,24
OSCC (fetal risk, including leukemia)					
		<1	20 (5; 29)	1	26,27
UNSCEAR ('77, '86)		0–400+	0.75–1.75	1,100–2,700	4
ICRP ('77)		0–400+	1.25	1,600	2
BEIR III ('80)[c]		0–400+	2–5	400–1,000	3

[a] If radiation-effects are not proportional to dose, the same level of population exposure in person-cSv does not lead to the same health effects, except at for equal doses. Person-cSv is the number of persons times their average dose in cSv, e.g. an exposure of 3×10^3 person-cSv corresponds 1,000 people exposed to an average dose of 3 cSv, or 3,000 people exposed to 1 cSv.

[b] derived quantity, assuming an average normal adult lifetime cancer rate of 20% (does not apply to fetal risk). For the Hanford worker data, the doubling dose is the primary finding and the lifetime excess cancer rate per 10^4 person-cSv is derived.

[c] Tables V–4, V–19, V–20.

future expected cancer deaths to the cancer deaths already recorded through the end of the follow-up periods in 1982 and 1985, repectively. Cancer mortality statistics from earlier RERF compilations showed that the observed proportion of cancer deaths to total deaths from all causes for the low-dose "1–9 rad" group (T65DR dosimetry) rose rather rapidly from below the Japanese national average in the early 1950's to the national average in the early 1970's (Table 1). It continued to rise slowly during the period 1975–1982, from 0.226 to 0.229 with a mean value only slightly higher than the mean value 0.213 for the Japanese population as a whole for the same time period [15, 16]. We have adopted the 1975–1982 mean value of 0.228 (standard error SE 0.010) and assume that, in the low dose range, it will remain constant for the purpose of estimating total future cancer deaths (assumption of constant relative risk [11]). This assumption is likely to provide a conservative estimate of future cancer mortality, given the observed continuing slow increase of this ratio over recent follow-up periods (Table 1). The total lifetime cancer deaths expected in the "1–9 rad" (T65DR) subcohort can now be estimated by adding the number of expected future cancer deaths among the survivors still alive in 1982 (i.e., the number of survivors alive in 1982 multiplied by the adopted cancer mortality rate 0.228) to the number of already observed cancer deaths to 1982 in that subcohort. A sample derivation of the latency correction factor (determined to be 3.47 for the 1950–1982 follow-up data) is shown in Table 3. A similar analysis for the statistically somewhat weaker data for the "10–49 rad" group yields, within statistical limits, the same correction factor. For the same dose group and the same LSS reports *Gofman*

[17] developed a latency correction factor of 3.35 following similar arguments. A value of 3.4 (SE 0.1) has been chosen as an estimate of the latency correction factor in our calculation of the expected lifetime cancer mortality for the 1950–1982 follow-up data.

It is reasonable to assume (as borne out by the data of previous follow-up periods, within their statistical limits) that the latency factor, i.e., the proportion of total lifetime cancer deaths to cancer deaths recorded through the end of each future follow-up period, will be the same for the "10–49 rad" groups as for the "1–9 rad" groups. This assumption does imply a comparable distribution of ages and sex and a constant relative cancer risk for the two subcohorts. Minor deviations from these assumptions will not significantly affect our final conclusions, given their statistical uncertainties. We, therefore, use the same latency correction factor to estimate the total lifetime cancers from the cancer deaths already registered for the "10–49 rad" groups as for the "1–9 rad" groups for each of the two follow-up periods considered here.

Since additional persons died between 1982–1985 in each of the two dose groups considered, an analysis equivalent to that shown in Table 3 yields a lower latency correction factor of 2.90 for the lifetime cancer deaths expected for the "1–9 rad" and "10–49 rad" groups in the 1950–1985 (DS86) follow-up statistics [8, 10, 11, 17]. (Note that this correction factor must eventually approach 1.00 for extended future follow-up periods.)

To correct for a previously estimated under-reporting of cancer mortality on A-bomb survivors' death certificates, a 23 % adjustment was made to the derived radiogenic cancer risks (lines 8 and 9, Table 2). This correction was applied consistent with evaluations of lifetime radiogenic cancer risks presented in earlier BEIR and RERF reports [3, 8, 9, 11] (shown for reference and comparison in Table 4).

Statistical confidence limits for the risk estimates

The statistical significance ($p < 0.001$) of the differences in the cancer mortality rates for the two groups exposed in the low dose range for the follow-up periods 1950–1982 and 1950–1985 were tested using the Student's t test.

To establish confidence limits for the estimates of lifetime excess radiogenic cancers per ten thousand persons exposed to an additional dose of one cSv (the mean slope of the dose response relation) in the low dose range, the variances of the proportions m, the life-time cancer mortality rates (line 7, Table 2) are calculated from $m(1 - m)/N$, while N is the number of persons at risk (line 1, Table 2). Neglecting errors in the mean doses, the variance for the radiogenic cancer risk (line 9, Table 2) is the sum of the variances of the cancer mortality rates m for the two dose groups which are compared for both follow-up periods. The 95 % confidence limits for the low-dose radiogenic cancer risk estimates (line 9, Table 2) are then determined by a range of 1.96 times the standard error (SE – the square root of the summed variances) to either side of the central value.

Although the resulting 95 % confidence ranges are rather wide, this straightforward estimation of low-dose cancer risks has the advantage that it can be duplicated, step by step, by readers without epidemiological training and that these estimates can easily be re-evaluated when updated mortality statistics become available in future LSS reports.

Results

Lifetime radiogenic cancer risk estimates:

1. The most recent LSS reports covering the follow-up periods 1950–1982 (T65DR dosimetry) and 1950–1985 (DS86 dosimetry) show a statistically significant difference in cancer mortalities between the two lowest dose groups exposed to mean doses of about 2 cSv and 17 cSv respectively ($p < 0.001$, Table 2). Estimates of radiogenic cancer effects for this low dose exposure range (for a one-time exposure) can now be obtained directly from the Hiroshima-Nagasaki A-bomb survivor LSS mortality data, eliminating the need to estimate risks by model-dependent extrapolations from medium and high-dose mortality statistics.

2. The mean lifetime radiogenic cancer risk for low dose exposures using the revised DS86 dosimetry (1950–1985 follow-up reports) is independent of the presently uncertain neutron RBE value. However, it agrees well with the low dose exposure risk derived from the T65DR dosimetry (1950–1982 follow-up reports) provided an RBE value of 10 is used (Table 2).
3. The mean lifetime radiogenic cancer risks in the organ-absorbed dose range 1–40 cSv (Table 4) are 26 (12; 40 = 98 % confidence limits) for the 1950–1982 follow-up (T65DR dosimetry) and 24 (10; 38) for the 1950–1985 follow-up (DS86 dosimetry) excess cancers per 10,000 persons exposed to one additional cSv (rem), respectively.
4. Estimates of the lifetime radiogenic cancer mortality doubling dose (with their 95 % confidence limits) of 77 (50; 167) cSv (rem) (T65DR) and 83 (53; 200) cSv (rem) (DS86) can be obtained by assuming an average spontaneous cancer rate of 20 % (Table 4).
5. The excess lifetime radiogenic cancer risk based on the cancer mortality statistics of the low-dose LSS subcohorts of the A-bomb survivor population is at least ten times larger than the current officially adepted risk values (Table 4) which were calculated by downward extrapolation from the mortality rates of the high-dose exposed LSS subcohorts.

Risk estimates from other studies are shown in table 4 for comparison, including:

- analyses based on model fits to the recent A-bomb survivor data by RERF scientists,
- an independent analysis of the same data covering all dose categories up to 400+ cGy (rad) kerma dose, and using both a linear and a curvilinear fit to the two sets of data,
- results from two earlier epidemiological studies of populations exclusively exposed to low doses of ionizing radiation and
- radiation risk values currently adopted by official national and international radiation commissions, based on earlier follow-up data.

Discussion

The radiogenic cancer risk values reported in this communication were derived directly from analyses of the cancer mortality statistics of the distally exposed low-dose A-bomb LSS survivor groups without the use of modeldependent extrapolations. These radiogenic cancer risk estimates are at least ten times higher per unit dose in the low-dose range than some of the currently used risk values which were based on earlier data and various hypothetical dose response models (Table 4).
Scientific debate about the health risks of exposure to low doses of ionizing radiation has long suffered from intense controversy among scientists because of gross discrepancies between findings derived from follow-up studies of the A-bomb survivors and epidemiologic studies of other human populations. Studies the relationship between pre-natal x-ray exposure and childhood cancer [25–27] and some cancer risk studies of nuclear workers [23–24] suggested much higher radiogenic cancer risks from low-dose radiation exposure.
The widely used radiation risk values published by the ICRP [2], the UNSCEAR [4], or the BEIR III reports [3] (Table 4) presumed to be conservative estimates for low-dose exposures. They are based on model-dependent extrapolations from the observed high-dose mortality rates toward the low dose range. Such extrapolations were necessary since excess cancer deaths remained statistically insignificant in the earlier 1950–1974 A-bomb survivor LSS follow-up data on which the conclusions of these commissions have been based. These analyses still serve as the basis for all current radiation protection guidelines and officially adopted risk estimates.
A recent evaluation of the 1950–1985 follow-up statistics (DS86) by RERF scientists [8] estimated 17 excess radiogenic cancer deaths per 10,000 person-cSv (Table 4). This analysis was obtained by fitting the cancer mortality data from all DS86 dose groups, including the contaminated "zero" dose group (about 30 % of the DS86 subcohort), up to doses above 100 cGy to a linear dose response relation. In a subsequently published version the authors reduced their risk value from 17 to 11 by applying a speculative correction function (Table 4) [9]. The value of 17 cancer deaths per 10,000 person-cSv is lower than out midpoint value of 24, but well within the 95 % confidence range of 10–38 excess cancer deaths per 10,000 person-cSv obtained from the same data, but limited to survivors exposed to less than

50 cGy (Table 4). An even more recent RERF analysis [11], using both a linear and a linear-quadratic dose response model, as well as the zero dose group, uncorrected for fallout exposure, found life-time excess cancer deaths (at 10 cSv exposure) between 10 and 12 per 10^4 person-cSv.
One independent analysis of the 1950–1985 data over the entire dose range found an improved fit particularly with exposure to low doses of radiation, by using a curvilinear regression analysis. This, in turn, resulted in higher radiogenic cancer risk estimates per unit dose (the slope of the dose relation) at lower exposures compared to those at higher ones [17, 20]. We attempted to test the linearity of the DS86 dose response curve for radiogenic cancer risk in the lower dose range. Present numbers of cancer deaths in the more finely divided low-dose exposure groups, as listed in recent RERF reports [10, 11], are too small to evaluate the detailed shape of the dose response curve in the low dose range with sufficient accuracy. However, comparing the cancer mortalities for the combined "50–199 rad" medium dose group (mean dose 93 cSv) with that of the "1–9 rad" group (mean dose 2 cSv) results in a mean slope of the lifetime radiogenic cancer risk dose response curve for the 2–93 cSv dose interval of 10.9 (7.6; 14.3, 95 % confidence range) lifetime excess cancers/10^4 person-cSv. This value agrees well with recent RERF estimates (Table 4) covering the entire dose range. We find a substantially lower slope of the dose response relationship over the much larger dose range than the value of 24 for the 2–17 cSv low dose range (Table 4). This surprising indication of a strong non-linearity, in an opposite direction from that assumed by the BEIR III report [3] will require further study as additional follow-up data becomes available allowing appropriate corrections to be made for differences in mean ages at the time of exposure.
Our estimates of radiogenic cancer risk from low-dose radiation exposure of A-bomb survivors, although not strictly comparable due to substantial differences in methods of analysis, appear to be consistent with earlier findings from two epidemiologic studies that dealt, exclusively, with low-dose radiation exposure: one being a study of Hanford workers [21–24], the other the British Oxford Survey of Childhood Cancers [25–27] (Table 4). The most recent findings of the British childhood cancer survey (OSCC), associating cancer rates with terrestrial background radiation, as well as with pre-natal x-ray exposures [32, 33], reopens questions about what fraction of spontaneous cancer mortality may, in fact, be related to be unavoidable exposure to background radiation and, thus, how much present and future controllable sources of radiation might contribute incrementally to this fraction in the future [34]. Upward revision of estimated lifetime radiogenic cancer risk for low dose exposure levels would also imply that the added cancer burden from the radioactive fallout over many areas of Europe, as a result of the explosion at the Chernobyl (USSR) nuclear plant, may eventually greatly exceed various estimates [28–31], based on currently adopted risk values.

Conclusion

After many years of controversy about whether the health risk of exposure to low levels of ionizing radiation is measureable or negligible, statistically significant numbers of excess cancers have now been found in subcohorts of A-bomb survivors exposed to low doses of radiation. It is, therefore, no longer necessary nor justified to rely primarily on extrapolations from high-dose LSS data, using hypothetical models to estimate low-dose radiogenic cancer risk or to generalize from data other than those from human populations. Analysis of the cancer deaths in the low-dose groups reported in the most recent A-bomb survivor LSS studies suggests that officially adopted estimates of low-dose radiogenic cancer risk may be as much as an order of magnitude too low. On the other hand, given the inherently wide statistical confidence ranges of such calculations it now appears that the increased low-dose exposure risk estimates from the A-bomb survivor study are compatible with risk estimates obtained from earlier epidemiological studies of other human populations exposed exclusively to low doses of ionizing radiation.
At a minimum, these findings of increased radiogenic risk after exposure to low doses of radiation suggest the need to reconsider current radiation safety guidelines and to update projections estimating the future public health impact of low-dose radiation exposure, particularly with regard to various options for clean-up and permanent disposal of radioactive waste products.

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ATTACHMENT # 6

PROVINCE OF ONTARIO)
) ss.
CITY OF TORONTO)

AFFIDAVIT OF ROSALIE BERTELL

Rosalie Bertell being duly sworn, deposes and says:

By virtue of my background, training and experience, I have gained expertise in the field of radiation health. Having received and read the EIS on the Prairie Island Independent Spent Fuel Storage Installation (ISFSI) Draft, and the Risk Assessment in the Final EIS (Chapter 6), I would offer the following comments:

1. In part G: "Uncertainty in the Estimate of Offsite Cancer Incidence Risk", the 8th paragraph, I fail to understand the reduction of risk by a factor of 3. This may not be warranted and I would appreciate further reasons for this reduction.

2. There is no mention of risks to the unborn child (teratogenic effects) or to the reproductive capacity of the exposed persons (genetic effects). These are of equal concern to cancers in the minds of most people. It may provide a special problem in Native Americans because of limited gene pool due to intermarriage.

3. No allowance for higher radiation exposure for local hunting or fishing appears to have been incorporated into the calculations. Persons tend to use open fields, walk nearer to the storage area, etc.

4. It was not apparent to me that all possible exposures in the transportation of spent fuel rods from the reactor to emplacement in the storage facility were included. I would like to spend more time in reviewing this section.

In my twenty years of study of populations exposed to chronic low doses of radiation, I have found measurable changes in blood counts for large proportions of the population. This is clinically manifested as monocytopenia, eosinophilia, and eventually lymphopenia and neutropenia. This depletion of white blood cells leaves the person at higher than normal risk of bacterial or viral infections and tumours (malignant and benign).

It would be important to establish base line data on several blood and urine tests, liver function tests and reproductive experience for the persons at risk from this storage facility prior to its operations. In this way, the at-risk population could be easily monitored for changes. If the changes are identified early on -- before there are serious infectious diseases, congential problems or cancers -- there is a high likelihood of being able to take preventive actions.

FURTHER AFFIANT SAYETH NOT.

Rosalie Bertell

Rosalie Bertell, Ph.D.

Subscribed and sworn to before me
this 6th day of May, 1991.

Louis Taube

Notary Public

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EDUCATION	DEGREE	DATE	FIELD
D'Youville College, Buffalo	B.A.	1951	Mathematics
Catholic University of America, Washington	M.A.	1959	Mathematics
Catholic University of America, Washington	Ph.D.	1966	Mathematics
Mount St. Vincent University, Halifax	D.Hum.L.	1985	Honoris Causa
D'Youville College, Buffalo	D.Sc.	1988	Honoris Causa
Laurentian University, Sudbury	Doctor of Laws	1988	Honoris Causa
Ryerson Polytechnical Inst. Toronto	Ryerson Fellowship	1988	"Recognition for substantive work in environmental and occupational health"
University of Windsor	D.Sc	1988	Honoris Causa
The Ontario Institute for Studies in Education, Toronto	Distinguished Educator of the Ontario Institute for Studies in Education	1990	

POSITIONS HELD

President:	International Institute of Concern for Public Health	9/87 - present
Founding Member:	International Commission of Health Professionals	1/85 - present
Editor in Chief:	International Perspectives in Public Health	1/84 - present
Director of Research President Board:	International Institute of Concern for Public Health	6/84 - 9/87

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Ass't Research Professor, Graduate School:	State University of NY, Buffalo	1974 - 1978
Senior Cancer Research Scientist:	Roswell Park Memorial Institute, Buffalo	1970 - 6/78
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Coordinator of Inst. Research:	D'Youville College, Buffalo	1/71 - 1972
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CONSULTANCIES

British Columbia Medical Association, Environmental Health Committee, Canada
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National Council of Churches, Energy Task Force, U.S.A.
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Nuclear Regulatory Commission, Standards Development Office, U.S.A.
President's Commission on the accident at Three Mile Island, Citizen's Advisory Committee, U.S.A.
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Mercy Health Services, International, U.S.A.
Rongelap People's Council, Rongelap, Republic of the Marshall Islands
Ontario Hydro Employee's Union, Canada

ACADEMIC AND PROFESSIONAL HONORS, SCHOLARSHIPS, TRAINEESHIPS

Scholarship (4 years D'Youville), graduated Magna Cum Laude
Kappa Gamma Pi, Sigma Xi, Graduate Assistantship (Catholic University) for M.A.
National Institute of Health Grant (3 years at Catholic University) for Ph.D.
New York State Dept. of Health, Post Doctorate Summer Research
Grey Nuns' Legislative Chapter, Elected Delegate 1971, 1974, 1975
National Assembly of Women Religious: House of Delegates 1973 to 1976
National Executive Board 1977 to 1980
Outstanding Civic Leader of America Award 1970
Reader for Advanced Placement Calculus Examination, Educational Testing, Princeton 1971, 1972
Outstanding Educators of America, Elected 1973
Award Spring 1981 from National Organization of Women WNY Chapter
Award 1981 from New York Public Interest Research Group
Honorary Member of Aerztebund fuer Umwelt und Lebensschutz (Federation of Physicians for the Protection of Energy and Life) 1983
Hans Adalbert Schweigart Medal, Awarded by the World League for the Protection of Lif Vienna, Austria 1983
Fellow of the Indian Society of Naturalists, Baroda, India 1985
The Right Livelihood Award, December, 1986
Distinguished Alumnae Award, Mount St. Joseph Academy, 1987
Women of Distinction Award, YWCA - Toronto, 1987
World Peace Award, World Federalists of Canada 1988

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Institute of Society, Ethics and Life Sciences
International Biometric Society
International League of Women for Peace and Freedom
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Sigma Xi: Scientific Research Honor Society
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Advisory Board Member, Musicians United for Safe Energy
Plenary Member of Health Physics Society
Board of Advisors, Nuclear Reform Project
Board of Advisors, Colorado Atomic and Agent Orange Veterans

Advisory Board, Ecumenical Task Force on the Love Canal, USA
Advisory Board, Lawyers for Social Responsibility, Canada
Board of Directors, Peacework Alternatives, U.S.A.
Food and Water, Inc., Board of Directors, Denville, New Jersey
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BIOGRAPHICAL PUBLICATIONS

American Catholic Who's Who 1977, 1978, 1979, 1980, 1981
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American Registry Series 1980 (Selected)
Anglo-American Who's Who 1981
Community Leaders and Noteworthy Americans 1977, 1978, 1979, 1980
Community Leaders of America 1982
Dictionary of International Biography 1977-78, 1978-79, 1979-80, 1980-81
Directories of Distinguished Americans 1981
International Book of Honor, Second World Edition 1986
International Who's Who in Community Service 1978, 1979
International Who's Who of Intellectuals, Vol. II, 1978
International Register of Profiles 1979
International Register of Biographies, 1986
International Who's Who in Contemporary Achievement, 1985
Men and Women of Distinction 1979
Notable American 1976-77, 1978-79
Notable Americans of Bicentennial Era 1976
Personalities of the Americas, First Commemorative Edition 1987
Who's Who in American Scientists 1973-77
Who's Who in American Women 1975, 1976, 1977, 1978, 1979-80
Who's Who in Health Care 1977
Who's Who in the East 1977-78, 1979-80
World Who's Who of Women 1976, 1977, 1981
Foremost Women of the Twentieth Century, 1986

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2. Introduction to Creative Mathematics, (Book) Edwards and Sons, 1971.

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ATTACHMENT # 7

BLUEDOG LAW OFFICE

SOUTHGATE OFFICE PLAZA, SUITE 555
5001 WEST 80TH STREET
BLOOMINGTON, MN 55437
(612) 893-1813
FAX (612) 893-0650

January 17, 1991

Mr. Bob Cupit
Minnesota Environmental Quality Board
300 Centennial Building
658 Cedar Street
St. Paul, MN 55155

RE: NSP ISFSI proposal; Prairie Island Indian Community request for technical and legal assistance

Dear Mr. Cupit:

I have been instructed by the Prairie Island Indian Community Tribal Council to make a formal request to the MEQB for technical and/or legal assistance pursuant to Minn. Stat. 116C.722, which states:

> If an Indian tribal council that has jusrisdiction over part of a potentially impacted area within the state request legal or technical assistance, the board shall provide assistance.

Presently, I understand that this particular state law provision has never been utilized, so there may be some uncertainty as to what type of technical and legal assistance is required of the board. I understand that there is also the possibility of disagreement as to whether the law applies in this situation. Therefore, in order to avoid any misunderstanding and complication, I suggest that you make a formal determination of whether the state law applies to the Prairie Island situation and then whether the board will provide technical and/or legal assistance. After that initial determination is made, we can then discuss, if necessary, the type of technical and legal assistance the Tribe may desire from the board.

I envision at least a couple of sessions with your legal counsel to discuss our legal options during the licensing procedures; and then, regarding technical assistance, I can see the Tribe wanting to have seminars on potential health impacts and then, on the proposal itself. The Tribe may be interested to get an "objective" explanation of the proposal and its potential impacts.

If you feel this letter does not suffice as a formal request of the Prairie Island Tribal Council, please inform me as soon as possible. The Tribal Council is willing to pass a formal resolution making the request. Let me assure you though, the Council directed me to make the request herein. I am beginning to understand that we are under a rapidly moving time schedule and your immediate attention to this matter will be greatly appreciated. If you could please respond in writing to this letter by January 25, the Tribal Council will be very grateful.

Thank-you for your time and consideration.

Sincerely,

William J. Hardacker
General Counsel
Prairie Island Indian
Community

cc: Don Murdoch, BIA Field Rep
Q Brown, Dept. of Interior
Jean Sutton, Field Solicitor's Office

MINNESOTA ENVIRONMENTAL QUALITY BOARD
300 Centennial Building • 658 Cedar Street • St. Paul, Minnesota 55155
612-296-2603

RECEIVED
1991

January 31, 1991

William Hardacker
Bluedog Law Office
Southgate Office Plaza
Suite 555
5001 West 80th Street
Bloomington, Minnesota 55437

Dear Mr. Hardacker:

Your letter of January 17, 1991, requested technical and/or legal assistance from the Minnesota Environmental Quality Board pursuant to Minnesota Statutes, Section 116D.722, in regard to the NSP ISFSI proposal at Prairie Island. We have consulted the Board's legal counsel, and based upon that consultation, have determined that your request for assistance is not covered by the cited statute.

The basis for this opinion is the statute itself, which has no apparent relevance to the NSP project currently under environmental review by the Board. "Potentially impacted area" is defined in Minnesota Statutes 1989, Section 116C.71, Subdivision 18, as an "area designated or described in a draft or final area recommendation report or area characterization plan for study or consideration". By definition in Minnesota Statutes 1989, Section 116C.71, Subdivisions 10 and 11, the Prairie Island Reservation's proximity to NSP's ISFSI project does not permit it to be recognized as a potentially impacted area.

Further, the Radioactive Waste Management section of M.S. 116C excludes regulation of the on-site storage of spent nuclear fuel at existing generating plants. Specifically, Minnesota Statutes, Section 116C.71, Subdivision 16, defines disposal as "the permanent or temporary placement of high level waste at a site within the state other than a point of generation".

The only section of the statute which appears to apply to NSP's proposed ISFSI is Minnesota Statutes, Section 116C.731. This section relates to transportation of high level radioactive waste. When the spent fuel is ultimately transported out of the state, that section provides for notification to the Department of Public Safety and transport route determination.

You may wish to inquire about intervenor funding in the Public Utilities Commission's Certificate of Need process. That review process should begin in the next few weeks. If you have questions about the Certificate of Need process you should contact Mr. David Jacobson, of the Public Utilities Commission staff, at 297-4562.

We regret that we cannot formally provide you with the assistance requested. However, we will certainly continue to work with you and the Tribal Council through the EIS preparation process and in our intervention in the U.S. NRC's license review process. If you have further questions or have additional facts or legal considerations which you'd like to bring to our attention, please call Mr. Eldon Kaul at 296-7341 or Mr. Bob Cupit at 296-2096.

Sincerely,

Michael Sullivan

Michael Sullivan
Executive Director

cc: Bob Cupit
Eldon Kaul

ATTACHMENT # 8

Karen Clark
State Representative

District 60A
Hennepin County

Minnesota
House of
Representatives
Robert Vanasek, Speaker

COMMITTEES: HOUSING, CHAIR; APPROPRIATIONS–HUMAN RESOURCES DIVISION; ECONOMIC DEVELOPMENT–INTERNATIONAL TRADE AND TECHNOLOGY DIVISION; FINANCIAL INSTITUTIONS AND INSURANCE

April 17, 1991

Mike Sullivan, Executive Director
Environmental Quality Board
State Planning Agency
3rd Floor, Centennial Office Building
658 Cedar Street
St. Paul, MN 55155

Dear Mr. Sullivan:

It has come to my attention that the Prairie Island Sioux community has been denied technical assistance that they requested under MN 116C.722.

As the author of the legislation that created the statute in 1984, I want to make it clear that the legislative intent was clearly meant to cover just such an instance such as the one the Sioux community now finds itself in, and for which it is requesting technical assistance.

Please contact me immediately regarding your interpretation of this statute if the facts regarding the Prairie Island Sioux community are as I have been informed.

Sincerely,

Karen Clark

Karen Clark
State Representative

cc: R. Cupit
T. Flood, MPIRG'

2633 18th Avenue South, Minneapolis, Minnesota 55407 (612) 722-7728
State Office Building, St. Paul, Minnesota 55155 (612) 296-0294
House Fax (612) 296-1563

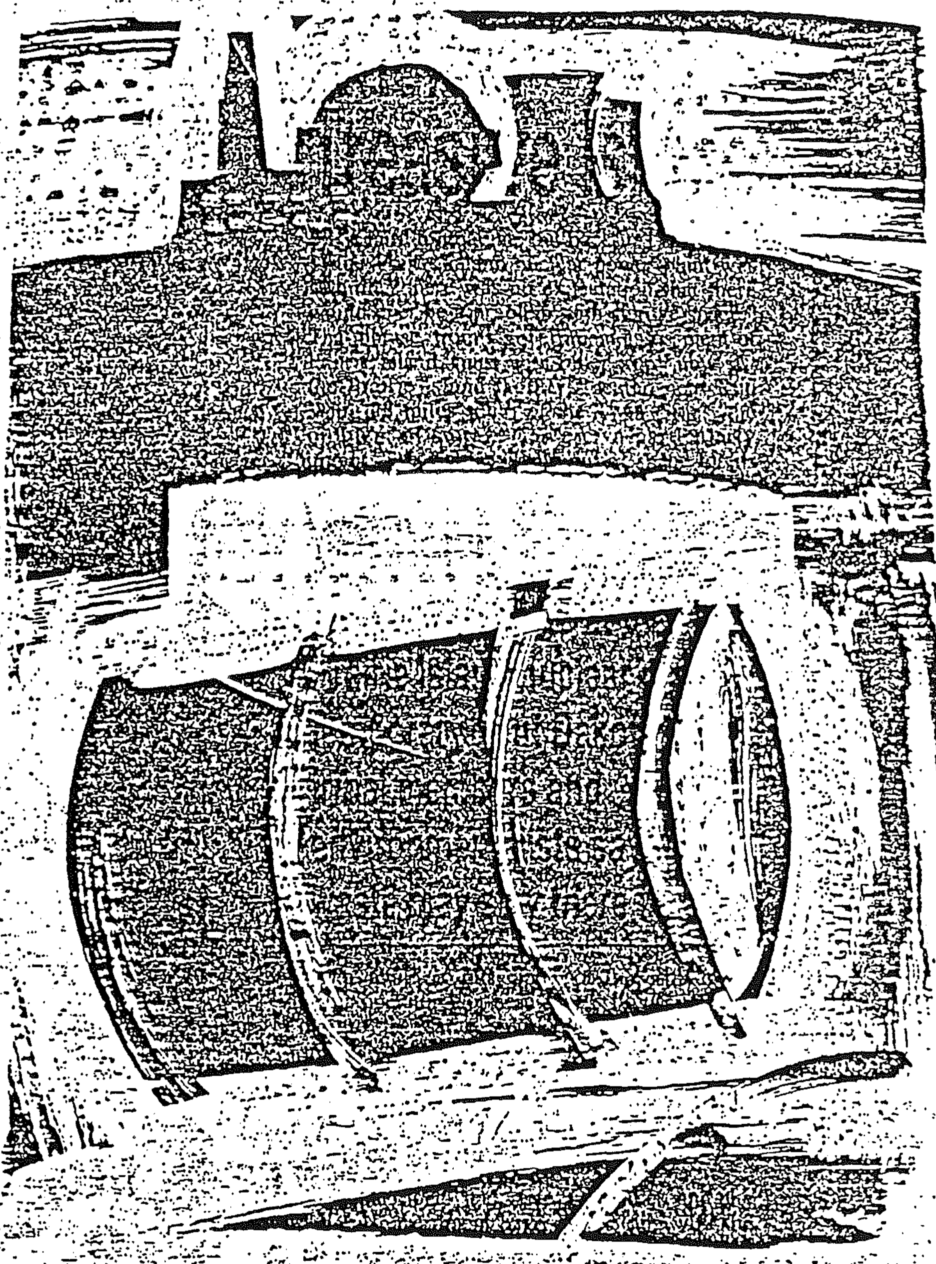
ATTACHMENT # 9

News

Nuclear Treasure Island

It's hard to imagine, but back in 1968, when the Prairie Island nuclear power plant was built, "there was no expectation that there would ever be a problem with storage space." That phrase, from a government assessment of Prairie Island, rings with bitter irony now. At the Prairie Island facility, located near Red Wing 28 miles south of the Twin Cities, the problem of storage has grown particularly urgent. The plant will run out of space for its spent fuel rods—now stored in water pools inside the plant—by 1994.

NSP says its plan to store radioactive waste at the Prairie Island nuclear plant is temporary. But Dakota tribal members and environmentalists say the waste may stay there forever.



JULIE DELTON

To avoid a glut and possible shutdown, plant operator Northern States Power is turning to the same solution as a homeowner might with an overflowing garage: Pile the stuff up in the yard. The company wants to erect 48 specially built metal casks on its property to store more than 700 tons of highly radioactive waste, including some plutonium.

So far, local and state authorities and the federal government have gone along with the proposal, which environmentalists say could set a dangerous precedent. But one group is still resisting NSP's plans: the tiny Dakota tribe that lives just outside the plant doors. The community's decision to take on the nuclear industry could start a precedent-setting battle in the ongoing fight over nuclear waste storage.

The fuel rods NSP wants to store are the most highly radioactive waste generated in a nuclear plant. Even after 10 years in a water pool, the waste is still so hot it will melt the snow on the surface of the metal casks in minus-20-degree weather, according to documents NSP filed with the federal Nuclear Regulatory Commission. The casks—which aren't yet licensed by the federal government—are built to catch the radiation from the uranium and plutonium inside; they're also supposed to withstand floods, fires, and tornadoes. "It's a matter of physics and mathematics," says NSP spokesman Tom Bushee. "When you know the age of the fuel and the thickness of the steel and you design the casks appropriately, it's absolutely safe."

State health officials, however, aren't entirely convinced. Using information supplied by NSP itself, they've run calculations indicating that the storage facility could create a health risk greater than what the state considers "acceptable": For the closest residents, they figured a cancer risk of 1:10,000. A water well with that level of risk would be judged unsafe to drink from. The study is

Nuclear *to page 8*

Nuclear *from page 6*

preliminary, and NSP says it finds the methodology questionable.

Still, the scenario worries the Prairie Island tribe. Tribal members live closer to the plant than anyone else—some houses are just across the street from the plant gates—yet they haven't been asked for permission to build the plant, much less to store the waste. Tribal council lawyer Willie Hardecker says the consultations between NSP and the tribe were "little more than PR. The tribe has not got enough information to make an educated decision about this."

The uneasy relationship between the tribe and NSP is not new. Back in 1967, before construction began at Prairie Island, an archeological evaluation found an ancient native village and burial mounds, some as old as 2,000 years; tribal elders camped at the site for months to prevent construction, to no avail. Today, NSP pays $17 million each year in property tax to the county, the local school district, and the city of Red Wing, eight miles away. The tribe, less than one mile away, has received a few streetlights and jobs for eight of its members.

Back in 1967, the site by the reservation may have been an attractive place to put a nuclear plant; little opposition was expected from a community lacking political clout and in need of jobs. Now, the decision to build there may come back to haunt NSP. Tribes are considered "quasi-sovereign entities"; their [illegible] status gives them a direct relationship with the federal government. Thus, the Prairie Island tribe can make its presence felt in the permit process for the storage plan in a way no environmental group or citizens' organization can: as a government.

For example, tribal lawyers recently unearthed a document showing that NSP bought the right-of-way for the only access road to the plant for $178 in 1967. That sum was assessed by the Bureau of Indian Affairs based entirely on calculations supplied by NSP; now, the tribe may reclaim the road and challenge NSP's right to transport nuclear materials over it. With its sovereign status, the tribe could also challenge NSP in the regulatory process, claiming that the utility must consider tribal needs and regulations. Tribal lawyers are hoping to enlist help from local and national environmental groups, which would provide funding and expertise in return for a good case against the nuclear industry.

"It really could turn into a battleground for a larger war," says Michael Lee, research director for the Minnesota Public Interest Research Group (MPIRG). "The industry needs this kind of storage to keep nuclear power viable, and that's why we want to stop it."

For the past 10 years, the federal government has been trying to establish a permanent nuclear-waste storage site somewhere in the U.S. Nevada's Yucca Mountain was finally selected as the site, but today the plan is all but dead in the water because of stiff local opposition and the state of Nevada's refusal to issue permits. Federal regulators are back to the drawing board to design a new facility, but the odds of whether they'll find a site are questionable. If local opposition couldn't be overcome in the Nevada desert, where can it be?

"The realistic thing to say is, this stuff isn't going anywhere," says Lee. "We might as well face up to it now, instead of putting up these casks and extending the life of the plant and generating more waste."

And there's another thing that worries Lee and other environmentalists: that NSP's temporary casks may be a Trojan horse for permanent storage. "They're saying it's just for a few years," says George Crocker of the Lake Elmo-based North American Water Office. "But once they've got the permit, who's to say they won't apply for an extension?" (The draft environmental impact statement already considers the possibility that up to 90 casks might eventually sit on Prairie Island.) "And then, by about 2010, when they have to decommission the plant and they already have permission to store radioactive waste on the site, they can just mothball the whole thing and let it sit there."

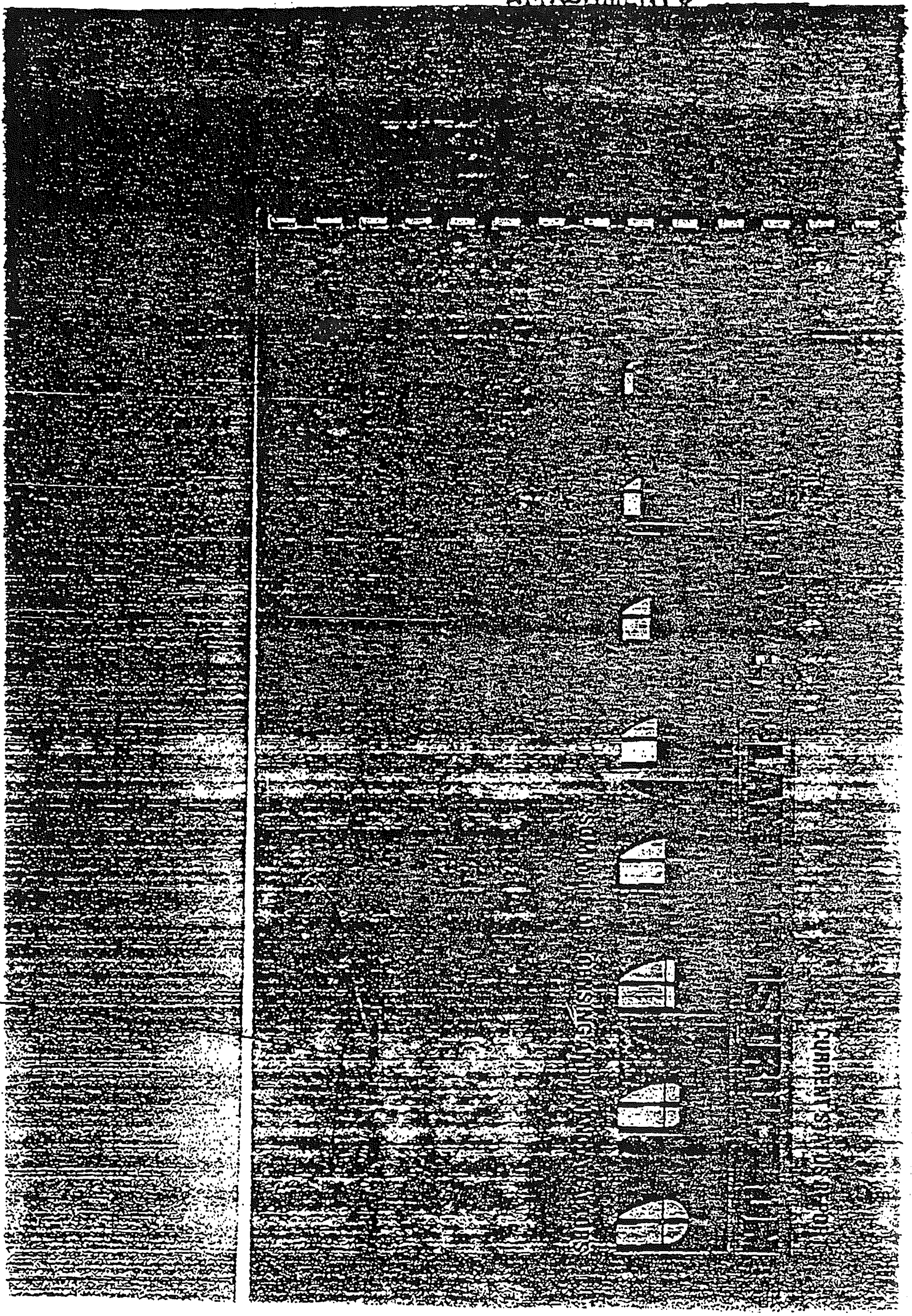
NSP's Bushee acknowledges that the storage facility may very well stay on the island longer and become larger than is predicted now. "We're not very optimistic that [the U.S. Department of Energy] is going to have a repository anytime soon. That's part of why we're building this facility." And other plants are likely to follow suit: NSP's other nuclear plant, Monticello, is expected to run out of space for its spent fuel by 2005. Bushee says, however, that NSP does not plan to store highly radioactive waste at Prairie Island permanently: "That is the responsibility of the federal government. It's not a question of if they're going to do it, but when."

Because the federal government holds exclusive authority over radiation and nuclear waste (regulatory power was taken away from states in 1954), opponents don't have many options to stop the NSP plan. During the 1980s, Congress rewrote nuclear-industry regulations to allow fewer objections to waste transportation and storage plans; as a result, neither the tribe nor the state of Minnesota saw much of a chance to press their objections in the federal permitting process. Both the tribe and the state have now signed a deal that will keep them out of the NRC deliberations, allowing them to see the information provided but not to call their own witnesses.

There is, however, another hurdle NSP has to overcome, and that's where opponents hope to mount their battle. The utility must ask the state Public Utilities Commission for a "certificate of need." NSP plans to apply for the certificate next week; that means it will have to demonstrate in public hearings that it can't do without the storage casks, and that there are no feasible alternatives. Storage opponents will argue that NSP doesn't really need to dump its spent fuel on-site, and that it could instead slow down its production and institute conservation measures to make up for the loss. "That would be the best scenario, from our perspective," says MPIRG's Lee.

—Monika Bauerlein

ATTACHMENT # 10



Donaldson, Lufkin & Jenrette

ANT NAME **Beaver Valley 2**

Licensee: Duquesne Light

Major Owners	% Share	Mws	% 1984 Peak
-Ohio Edison	42	357	9
-Cleveland Electric Illum.	24	208	6
-Toledo Edison	20	170	13
-Duquesne Light	14	117	5

Location

-Site: Shippingport, PA (5 mi. E. of E. Liverpool, Ohio)
-NRC Region: 1

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Stone & Webster
-Principal Contractor: Stone & Webster
-Megawatt Rating: 852

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
11/72	1978	NA	NA	NA
1980	1986	2,000	NA	2,347
4/11/84	10/86-12/86	3,466	NA	4,068
12/31/84	12/86	3,590	NA	4,214
10/18/85	12/87	4,250	1,600	4,988

% currently completed: 90

Status of NRC Licensing Process (a 10/3(

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards rev
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision

Est. Licensing Action	6/84 Licensee
-Construction Completion:	12/85
-Hot Functional Test Complete:	9/85
-Fuel Load/Low Power License:	6/86
-First Criticality:	8/86
-Full Power License:	9/86
-Commercial Operation:	10-12/86

Capital Concentration ($mil. -- w/AFUDC --- as (

Major Owners	Current Investment
-Ohio Edison	
(*$millions*)	1,105
(*Inv. as % of*)	100
-Cleveland Elec. Illum.	
(*$millions*)	647
(*Inv. as % of*)	100
-Toledo Edison	
(*$millions*)	586
(*Inv. as % of*)	100
-Duquesne Light	
(*$millions*)	376
(*Inv. as % of*)	100

PLANT NAME Braidwood 1

Licensee: Commonwealth Edison

Major Owners	% Share	Mws	% 1984 Peak
-Commonwealth Edison	100	1,120	8

Location

-Site: Braidwood, Illinois (24 mi. SSW of Joliet, Ill.)
-NRC Region: III

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Sargent & Lundy
-Principal Contractor: Commonwealth Edison
-Megawatt Rating: 1,120

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	11/81	644	NA	516
1980	11/85	1,506	NA	1,196
4/01/84	5/86	2,145	NA	1,596
12/31/84	9/86 11/86	2,466	NA	2,200
11/30/85	5/31/87	3,028	910	2,704

% currently completed: 90

Status of NRC Licensing Process (as

-Construction Permit application dockete
-Construction Permit issuance:
-Operating License application docketed.
-Final Environmental Statement complet
-Final Safety Analysis Report completior
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Is
-Advisory Committee on Reactor Safegu
-FEMA review of offsite emergency plan
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial

Est. Licensing Action

-Construction Completion:
-Hot Functional Test Complete:
-Fuel Load/Low Power License:
-First Criticality:
-Full Power License:
-Commercial Operation:

Capital Concentration ($mil. -- w/AFU

Major Owners	Cu Inves
-Commonwealth Edison ($millions)	2
(Inv. as % of)	

PLANT NAME **Braidwood 2**

Licensee: Commonwealth Edison

Major Owners	% Share	Mws	% 1984 Peak
-Commonwealth Edison	100	1,120	8

Location

-Site: Braidwood, Illinois (24 mi. SSW of Joliet, Ill.)
-NRC Region: III

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Sargent & Lundy
-Principal Contractor: Commonwealth Edison
-Megawatt Rating: 1,120

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	11/82	430	NA	516
1980	11/86	1,044	NA	1,196
4/01/84	5/87	1,430	NA	1,596
12/31/84	IVQ87	1,644	NA	1,468
11/30/85	9/30/88	2,016	620	1,800

% currently completed: 60

Status of NRC Licensing Process (as of 9/:

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards r
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decis

Est. Licensing Action	6/8 Licen:
-Construction Completion:	11/
-Hot Functional Test Complete:	4/
-Fuel Load/Low Power License:	11/
-First Criticality:	11/
-Full Power License:	5/
-Commercial Operation:	5/

Capital Concentration ($mil. -- w/AFUDC --

Major Owners	Current Investment
-Commonwealth Edison ($millions)	1,099
(Inv. as % of)	100

PLANT NAME **Byron 1**

Licensee: Commonwealth Edison

Major Owners	% Share	Mws	% 1984 Peak
-Commonwealth Edison	100	1,120	8

Location

-Site: Byron, Ill. (17 mi. SW of Rockford, Ill.)
-NRC Region: III

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Sargent & Lundy
-Principal Contractor: Commonwealth Edison
-Megawatt Rating: 1,120

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	11/80	625	NA	479
1980	11/83	1,452	NA	1,104
4/01/84	2/85	2,261	NA	11,082
12/31/84	IIIQ85	2,508	NA	2,240
6/30/85	4/22/85*	2,500	768	2,240

% currently completed: 100

* This is what CwE calls the "in service" date, it does not represent initial full power operation which occurred in 9/85.

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Issues:
-Advisory Committee on Reactor Safeguards review co
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee	I
-Construction Completion:	7/84	
-Hot Functional Test Complete:	C	
-Fuel Load/Low Power License:	9/84	I
-First Criticality:	8/84	
-Full Power License:	2/85	
-Commercial Operation:	2/85	

* See "Miscellaneous Comments."

Capital Concentration ($mil. -- w/AFUDC -- as of: 6

Major Owners	Current Investment	Tota Pl
-Commonwealth Edison		
($millions)	2,219	14.
(Inv. as % of)	100	

PLANT NAME Byron 2

Licensee: Commonwealth Edison

Major Owners	% Share	Mws	% 1984 Peak
-Commonwealth Edison	100	1,120	8

Location

-Site: Byron, Ill. (17 mi. SW of Rockford, Ill.)
-NRC Region: III

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Sargent & Lundy
-Principal Contractor: Commonwealth Edison
-Megawatt Rating: 1,120

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	11/82	416	NA	479
1980	11/84	968	NA	1,104
4/01/84	5/86	1,507	NA	1,682
12/31/84	9/86-11/86	1,672	NA	1,493
11/30/85	5/31/87	2,070	620	1,848

% currently completed: 85

Status of NRC Licensing Process (as of 9/3[illegible]5)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Issues:
-Advisory Committee on Reactor Safeguards review cor
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee	L
-Construction Completion:	10/85	2
-Hot Functional Test Complete:	2/85	8
-Fuel Load/Low Power License:	11/85	3
-First Criticality:	11/85	4
-Full Power License:	5/86	9
-Commercial Operation:	5/86	9

Capital Concentration ($mil. -- w/AFUDC -- as of: 6/

Major Owners	Current Investment	Tot P
-Commonwealth Edison ($millions)	1,479	14,
(Inv. as % of)	100	

PLANT NAME Callaway

Licensee: Union Electric

Major Owners	% Share	Mws	% 1984 Peak
-Union Electric	100	1,188	17

Location

-Site: 10 mi. SE of Fulton, MO.
-NRC Region: III

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Bechtel
-Principal Contractor: Daniel
-Megawatt Rating: 1,188

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
4/76	10/82	1,088	NA	915
1980	10/82	1,317	NA	1,109
3/11/84	12/84	2,850	NA	2,400
12/31/84	12/19/84	3,000	NA	2,525
6/30/85	12/19/84	3,100	1,200	2,583

% currently completed: 100

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	5/84
-Hot Functional Test Complete:	C
-Fuel Load/Low Power License:	5/84
-First Criticality:	6/84
-Full Power License:	10/84
-Commercial Operation:	12/84

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment
-Union Electric	
($millions)	3,100
(Inv. as % of)	100

P[illegible] NAME Catawba 1

Licensee: Duke Power Co.

Major Owners	% Share	Mws	% 1984 Peak
- Duke Power Co.	25	286	3
- No. Carolina Electric Membership Corp.	56	640	
- Saluda River Electric Cooperative	19	215	

Location

-Site: Clover, S.C. (6 mi. NNW of Rock Hill, S.C.)
-NRC Region: II

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Duke Power Co.
-Principal Contractor: Duke Power Co.
-Megawatt Rating: 1,145

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
10/72	1979	317	NA	269
1980	7/83	1,030	NA	903
3/19/84	6/85	1,950	NA	1,703
12/31/84	IIQ85	2,000	NA	1,747
6/30/85	6/29/85	1,950	683	1,703

% currently completed: 100

* Based on 50% of total cost of both plants.

Status of NRC Licensing Process (as of [illegible]0/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision (Safety Issues):
-Atomic Safety & Licensing Board Initial Decision (Emergency Planning):

Est. Licensing Action	6/84 Licensee
-Construction Completion:	5/84
-Hot Functional Test Complete:	C
-Fuel Load/Low Power License:	6/84
-Fuel Load/Low Power License:	*
-First Criticality:	8/84
-Full Power License:	1/85
-Commercial Operation:	6/85

* 7/18/84, license authorized fuel load only; 12/6/84 testing.

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment
-Duke Power Co.	
($millions)	187
(Inv. as % of)	100

PLANT NAME Catawba 2

Licensee: Duke Power Co.

Major Owners	% Share	Mws	% 1984 Peak
- Duke Power Co.	0*	0	0
- No. Carolina Municipal Power Agency No. 1	75	859	
- Piedmont Municipal Pwr. Agency	25	286	

* The Co. ownership share was transferred in full to the Piedmont Municipal Power Agency 12/21/84.

Location

-Site: Clover, S.C. (6 mi. NNW of Rock Hill, S.C.)
-NRC Region: II

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Duke Power Co.
-Principal Contractor: Duke Power Co.
-Megawatt Rating: 1,145

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
10/72	1980	317	NA	269
1980	1/85	1,030	NA	903
1/01/84	6/87	1,950	NA	1,703
12/31/84	IIQ86	2,000	NA	1,747
6/30/85	IIIQ86	1,950	683	1,349

% currently completed: 99

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit Issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review c
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

* Approval for Catawba 1.

Est. Licensing Action	6/84 Licensee
-Construction Completion:	10/86
-Hot Functional Test Complete:	6/86
-Fuel Load/Low Power License:	10/86
-First Criticality:	1/87
-Full Power License:	3/87
-Commercial Operation:	6/87

Capital Concentration ($mil. -- w/AFUDC -- as of: 6

Major Owners	Current Investment	To
-Duke Power Co. ($millions)	187	6
(Inv. as % of)	100	

ensee: Illinois Power

Major Owners	% Share	Mws	% 1984 Peak
– Illinois Power	82*	760	23
– Soyland Power Corp.	10	100	
– Western Illinois Power Coop.	8	90	

* An agreement to limit the cooperative's investment in Clinton to $450m causes these %s to change as total cost estimates change -- it expects its share to be 82-84% at the time Clinton becomes commercial .

Location

- -Site: Clinton, Illinois
- -NRC Region: III

Characteristics

- -Reactor Type: General Electric BWR
- -Architect/Engineer: Sargent & Lundy
- -Principal Contractor: Baldwin
- -Megawatt Rating: 950

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
10/73	1980	430	NA	453
1980	1983	1,700	NA	1,789
3/30/84	11/65	2,850	NA	3,000
12/31/84	7/86	3,148	NA	3,314
11/30/85	12/86	3,700	1,000	3,895

% currently completed: 95

Status of NRC Licensing Process (as of 30/8

- -Construction Permit application docketed:
- -Construction Permit issuance:
- -Operating License application docketed:
- -Final Environmental Statement completion:
- -Final Safety Analysis Report completion:
- -Safety Evaluation Report completion:
- -Safety Evaluation Report Supplement issues:
- -Advisory Committee on Reactor Safeguards reviev
- -FEMA review of offsite emergency planning:
- -Public hearings on Operating License:
- -Atomic Safety & Licensing Board Initial Decision:

* See section on "Major Contested Issues."

Est. Licensing Action	6/84 Licensee
-Construction Completion:	1/86
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	1-3/86
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	11/86

Capital Concentration ($mil. — w/AFUDC -- as of:

Major Owners	Current Investment	]
-Illinois Power ($millions)	2,591	
(Inv. as % of)	100	

PLANT NAME **Comanche Peak 1**

Licensee: Texas Utilities Generating Co.

Major Owners	% Share	Mws	% 1984 Peak
– Texas Utilities Electric Co.	88	1,010	7
– Texas Municipal Power Agency	6	71	
– Brazos Electric Power Coop.	4	44	
– Tex-La Elect. Coop. of Texas	2	25	

Location

-Site: 4 miles N. of Glen Rose, Texas.
-NRC Region: IV

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Gibbs & Hill
-Principal Contractor: Brown & Root
-Megawatt Rating: 1,150

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	1980	592	NA	516
1980	1982	1,341	NA	1,166
4/10/84	IQ85	2,334	NA	2,030
12/31/84	IVQ85	2,760	NA	2,400
11/18/85	7/87	3,275	980*	2,848

% currently completed: 99+

* We assume AFUDC represents about 30% of the total cost.

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review c
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	9/84
-Hot Functional Test Complete:	C
-Fuel Load/Low Power License:	9/84
-First Criticality:	10-12/84
-Full Power License:	10-12/84
-Commercial Operation:	1-3/85

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	T
-Texas Utilities (*$millions*)	1,957	
(*Inv. as % of*)	100	

PLANT NAME **Comanche Peak 2**

Licensee: Texas Utilities Generating Co.

Major Owners	% Share	Mws	% 1984 Peak
– Texas Utilities Electric Co.	88	1,010	7
– Texas Municipal Power Agency	6	71	
– Brazos Electric Power Coop.	4	44	
– Tex-La Elect. Coop. of Texas	2	25	

Location

-Site: 4 miles N. of Glen Rose, Texas.
-NRC Region: IV

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Gibbs & Hill
-Principal Contractor: Brown & Root
-Megawatt Rating: 1,150

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	1982	395	NA	343
1980	1984	894	NA	777
4/10/84	1986	1,556	NA	1,353
12/31/84	1Q87	1,840	NA	1,600
11/18/85	1Q88	2,185	655*	1,900

% currently completed: 74

* We assume AFUDC represents about 30% of the total cost.

Status of NRC Licensing Process (as of 9[illegible]85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Issues:
-Advisory Committee on Reactor Safeguards review c
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	1/86
-Hot Functional Test Complete:	NE
-Fuel Load/Low Power License:	1/86
-First Criticality:	1/86
-Full Power License:	NE
-Commercial Operation:	7-9/86

* TXU estimates the schedule for Comanche Peak 2 t

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	T
-Texas Utilities (*$millions*)	1,305	
(*Inv. as % of*)	100	

PLANT NAME **Diablo Canyon 1**

Licensee: Pacific Gas & Electric

Major Owners	% Share	Mws	% 1984 Peak
- Pacific Gas & Electric	100	1,084	8

Location

-Site: 12 miles WSW of San Luis Obispo, CA.
-NRC Region: V

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Pacific Gas & Electric
-Principal Contractor: Pacific Gas & Electric
-Megawatt Rating: 1,084

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1970	1974	168	NA	155
1980	1981	1,320	NA	1,218
4/19/84	7/84	2,647	NA	2,442
12/01/84	2/85	3,240	NA	2,989
6/30/85	5/7/85	3,300	1,200	3,044

% currently completed: 100

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review c
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	9/81
-Construction Completion:	4/84
-Hot Functional Test Complete:	C
-Fuel Load/Low Power License:	9/81;
-Fuel Load/Low Power License:	12/83;
-Fuel Load/Low Power License:	4/84
-First Criticality:	4/29/84
-Full Power License:	7/84
-Full Power License:	--
-Commercial Operation:	NE

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	T
-Pacific Gas & Electric		
($millions)	3,000	
(Inv. as % of)	100	

PLANT NAME Diablo Canyon 2

Licensee: Pacific Gas & Electric

Major Owners	% Share	Mws	% 1984 Peak
- Pacific Gas & Electric	100	1,106	8

Location

-Site: 12 miles WSW of San Luis Obispo, CA.
-NRC Region: V

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Pacific Gas & Electric
-Principal Contractor: Pacific Gas & Electric
-Megawatt Rating: V

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1970	1975	188	NA	170
1980	1982	880	NA	797
4/19/84	4/85	2,235	NA	2,021
12/31/84	IIIQ85	2,160	NA	1,953
11/30/85	1/86	2,200	800	1,953

% currently completed: 99+

Status of NRC Licensing Process (as of 9/30/85

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	8/84
-Hot Functional Test Complete:	C
-Fuel Load/Low Power License:	8/84
-First Criticality:	9/84
-Full Power License:	NA
-Commercial Operation:	4/85

Capital Concentration ($mil. -- w/AFUDC -- as of

Major Owners	Current Investment
-Pacific Gas & Electric	
($millions)	2,200
(Inv. as % of)	100

PLANT NAME **Fermi 2**

Licensee: Detroit Edison

Major Owners	**% Share**	**Mws**	**% 1984 Peak**
– Detroit Edison	80	875	12
– Wolverine Power Supply Inc.	20	219	

Location

–Site: Laguna Beach, Michigan
–NRC Region: III

Characteristics

–Reactor Type: General Electric BWR
–Architect/Engineer: Sargent & Lundy
–Principal Contractor: Daniel
–Megawatt Rating: 1,093

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
12/75	1980	914	NA	836
1980	1983	1,800	NA	1,647
5/01/84	3/85	3,075	NA	2,813
12/31/84	6/85	3,375	NA	3,088
11/30/85	4-6/86	3,765	920	3,445

% currently completed: 100

Status of NRC Licensing Process (as of 9/30/85)

–Construction Permit application docketed:
–Construction Permit issuance:
–Operating License application docketed:
–Final Environmental Statement completion:
–Final Safety Analysis Report completion:
–Safety Evaluation Report completion:
–Safety Evaluation Report Supplement issues:
–Advisory Committee on Reactor Safeguards review cor
–FEMA review of offsite emergency planning:
–Public hearings on Operating License:
–Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	**6/84 Licensee**	**L:**
–Construction Completion:	9/84	
–Hot Functional Test Complete:	N/A	
–Fuel Load/Low Power License:	9/84	
–First Criticality:	NE	
–Full Power License:	NE	
–Commercial Operation:	3/85	

Capital Concentration ($mil. -- w/AFUDC -- as of: 6/

Major Owners	**Current Investment**	**Tot: P**
–Detroit Edison		
($millions)	2,983	8
(Inv. as % of)	100	

PLANT NAME **Grand Gulf 1**

Licensee: Mississippi Power & Light

Major Owners	% Share	Mws	% 1984 Peak
- Middle South Energy	90	1,125	11
- So. Miss. Electric Power	10	125	

Location

-Site: Port Gibson, Miss. (25 mi. S. of Vicksburg, Miss.)
-NRC Region: II

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,250

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1/75	1980	710	Not available	568
12/80	1982	1,920	Not available	1,545
1/30/84	IV84	3,220	Not available	2,600
12/31/84	IQ85	3,406	Not available	2,724
9/30/85	7/1/85	3,550	1,278	2,840

% currently completed: 100

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit Issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review cc
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	C
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	6/82
-First Criticality:	1982
-Full Power License:	6-7/84
-Commercial Operation:	12/84

Capital Concentration ($mil. -- w/AFUDC -- as of: 6.

Major Owners	Current Investment	Tot F
-Middle South Energy*		
(*$millions*)	2,939	11
(*Inv. as % of*)	100	

* Middle South Energy retains ownership of the Gran was allocated to subsidiary companies by FERC on proportions: Arkansas P/L 36%; La. P/L 14%; N. Orl P/L 33%. Court reviews of the allocation are pendi

PLANT NAME Grand Gulf 2

Licensee: Mississippi Power & Light

Major Owners	% Share	Mws	% 1984 Peak
- Middle South Energy	90	1,125	11
- So. Miss. Electric Power	10	125	

Location

-Site: Port Gibson, Miss. (25 mi. S. of Vicksburg, Miss.)
-NRC Region: II

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,250

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1/75	1984	565	Not available	452
1980	1986	1,313	Not available	1,057
1/30/84	4/90	3,820	Not available	3,056
12/31/84	4/90	3,820	Not available	3,056
11/30/85	NE	NE	NE	NE

% currently completed: 35

Major Contested Issues

-Contested issue: None
-Parties: None
-Current status: Not a contested OL proceeding.

Overall Evaluation

Our assessment of this situation remains the same as report in 5/84; we expect Grand Gulf 2 to be cancelled on this unit that is not expected by MP&L to be ready where only 35% of the construction has been complete construction completion/fuel load licensing date for the so far into the future. MPSC has ordered MPL to cance

MAY 2 '91 14:57 FROM NIRS-WASHINGTON,DC PAGE.028

[illegible]f NAME Harris 1

Licensee: Carolina Power & Light

Major Owners	% Share	Mws	% 1984 Peak
- Carolina Power & Light	84	767	13
- No. Carolina Eastern Municipal Power Agency	16	148	

Location

-Site: New Hill, NC (20 mi. SW of Raleigh, NC)
-NRC Region: II

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Ebasco
-Principal Contractor: Daniel
-Megawatt Rating: 915

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
9/71	1978	250	Not Available	273
1980	9/85	1,800	Not Available	1,967
5/01/84	3/86	2,546	Not Available	2,783
12/31/84	9/86	3,065	Not Available	3,350
12/18/85	IVQ86	3,636*	834	3,974

* As of 12/18/85 Caro. P&L's rate base included $923MM CWIP for Harris.

% currently completed: 91

Status of NRC Licensing Process (as of [illegible]0/85

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	6/85
-Hot Functional Test Complete:	1/85
-Fuel Load/Low Power License:	6/85
-First Criticality:	7/85
-Full Power License:	11/85
-Commercial Operation:	3/86

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	1
-Carolina Power & Light		
($millions)	2,047	
(Inv. as % of)	100	

PLANT NAME **Hope Creek 1**

Licensee: Public Service Electric & Gas

Major Owners	% Share	Mws	% 1984 Peak
– Public Service Electric & Gas	95	1,014	14
– Atlantic City Electric Co.	5	53	4

Location

-Site: Lower Alloways Township, NJ (18 mi. SE of Wilmington, Del.)
-NRC Region: I

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,067

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
12/74	1981	837	NA	784
1980	1986	2,700	NA	2,530
4/01/84	12/86	3,760	NA	3,524
12/31/84	12/86	3,795	NA	3,557
11/30/85	12/86	4,300	1,080	4,030

% currently completed: 99

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit Issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Issues:
-Advisory Committee on Reactor Safeguards review completion:
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

* A joint motion to dismiss the proceedings was filed 2/19/85. The motion was granted 2/28/85.

Est. Licensing Action	6/84 Licensee
-Construction Completion:	1/86
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	1/86
-First Criticality:	1/86
-Full Power License:	11/86
-Commercial Operation:	12/86

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	T
-Public Service E&G		
($millions)	3,300	
(Inv. as % of)	100	
-Atlantic City Elec. Co.		
($millions)	181	
(Inv. as % of)	100	

PLANT NAME **Limerick 1**

Licensee: Philadelphia Electric Co.

Major Owners	% Share	Mws	% 1984 Peak
– Philadelphia Electric Co.	100	1,065	18

Location

-Site: Limerick Township, Pa. (35 mi. NW of Philadelphia, PA)
-NRC Region: 1

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,065

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
6/74	1979	1,050	NA	986
1980	1985	2,460	NA	2,310
8/21/84	4/85	2,800	NA	2,629
12/31/84	6/85-9/85	3,050	NA	2,864
11/14/85	3/86	4,150	1,245*	3,897

* We assume AFUDC represents about 30% of Limerick 1's total cost.

% currently completed: 100

Status of NRC Licensing Process (as of 9/30/85

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	8/84
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	8/84
-First Criticality:	1/85
-Full Power License:	2/85
-Commercial Operation:	4/85

Capital Concentration ($mil. -- w/AFUDC -- as o

Major Owners	Current Investment
-Philadelphia Electric (*$millions*)	2,921*
(*Inv. as % of*)	100

* This amount includes $2,344 billion in direct c "common plant."

PLANT NAME **Limerick 2**

Licensee: Philadelphia Electric Co.

Major Owners	**% Share**	**Mws**	**% 1984 Peak**
– Philadelphia Electric Co.	100	1,065	18

Location

-Site: Limerick Township, Pa. (35 mi. NW of Philadelphia, PA)
-NRC Region: I

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,065

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
6/74	1980	700	Not Available	657
1980	1987	1,640	Not Available	1,540
3/21/84	4/90	3,650	Not Available	3,427
12/31/84	II-IIIQ-90	3,850	Not Available	3,615
6/30/85	12/90	3,200*	960**	3,005

* This estimate is for direct costs only and does not include any "common plant."

** We assume AFUDC represents 30% of the total cost.

% currently completed: 31

Status of NRC Licensing Process (as of 9/30/8!

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards revie
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	**6/84 Licensee**
-Construction Completion:	1990
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	2/90
-First Criticality:	?
-Full Power License:	?
-Commercial Operation:	4/90

Capital Concentration ($mil. -- w/AFUDC -- as of

Major Owners	**Current Investment**
-Philadelphia Electric (*$millions*)	1,427*
(*Inv. as % of*)	100

* This amount includes $850 million in direct cos "common plant."

PLANT NAME **Midland 1**

Licensee: Consumers Power Co.

Major Owners	% Share	Mws	% 1984 Peak
-Consumers Power Co.	100	492	11

Location

-Site: Midland, Mich.
-NRC Region: III

Characteristics

-Reactor Type: PWR (Babcock & Wilcox)
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 492*

* Energy produced by Midland 1 was to be used in part to produce electricity and in part to produce process steam for Dow Chemical.

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
7/75	1981	NE	NA	NE
1980	1985	NE	NA	NE
4/10/84	NE	NE	NA	NE
12/31/84	NE	NE	NA	NE
6/30/85	NE	NE	NA	NE

% currently completed: 85

Status of NRC Licensing Process (as 9/30/8

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards revie
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	NE
-Hot Functional Test Complete:	NE
-Fuel Load/Low Power License:	NE
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	NE

Capital Concentration ($mil. -- w/AFUDC -- as o

Major Owners	Current Investment
-Consumers Power ($millions)	2,050
(Inv. as % of)	100

PLANT NAME Midland 2

Licensee: Consumers Power Co.

Major Owners	% Share	Mws	% 1984 Peak
-Consumers Power Co.	100	818	18

Location

-Site: Midland, Mich.
-NRC Region: III

Characteristics

-Reactor Type: PWR (Babcock & Wilcox)
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 818

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
7/75	1982	700	NA	856
1980	1984	1,500	NA	1,895
4/10/84	12/86	3,950	NA	4,829
12/31/84	NE	NE	NA	NE
6/30/85	NE	NE	NA	NE

% currently completed: 83

Status of NRC Licensing Process (as of 9/30/8

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards revie
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	8/84 Licensee
-Construction Completion:	6/86
-Hot Functional Test Complete:	NE
-Fuel Load/Low Power License:	6/86
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	12/86

Capital Concentration ($mil. -- w/AFUDC -- as c

Major Owners	Current Investment
-Consumers Power ($millions)	2,050
(Inv. as % of)	100

PLANT NAME **Millstone 3**

Licensee: Northeast Nuclear Energy

Major Owners	% Share	Mws	% 1984 Peak
-Connecticut Light & Power	53	605	18
-Western Mass. Electric Co.	12	141	22
-New England Power Co.	12	141	4
-Montaup Electric Co.	4	46	6
-United Illuminating Co.	4	43	4
-P.S. Co./New Hampshire	3	32	3
-Central Maine Power	2	29	2
-Others	10	116	

Location

-Site: Waterford, CT (3.2 mi. WSW of New London, CT)
-NRC Region: I

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Stone & Webster
-Principal Contractor: Stone & Webster
-Megawatt Rating: 1,156

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1/75	11/79	800	Not available	692
1980	1986	2,600	Not available	2,249
4/01/84	5/86	3,556	Not available	3,085
12/31/84	5/86	3,900	Not available	3,369
11/30/85	5/86	3,825	1,045	3,309

% currently completed: 99+

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit Issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	11/85
-Hot Functional Test Complete:	6/85
-Fuel Load/Low Power License:	11/85
-First Criticality:	12/85
-Full Power License:	4/86
-Commercial Operation:	5/86

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment
-Connecticut Light & Power	
($millions)	1,690
(Inv. as % of)	100
-Western Mass. Electric Co.	
($millions)	396
(Inv. as % of)	100
-New England Power Co.	
($millions)	412
(Inv. as % of)	100
-United Illuminating Co.	
($millions)	130
(Inv. as % of)	100
-P.S. Co./New Hampshire	
($millions)	102
(Inv. as % of)	100

PLANT NAME **Nine Mile Point 2**

Licensee: Niagara Mohawk Power Corp.

Major Owners	% Share	Mws	% 1984 Peak
-Niagara Mohawk Power Corp.	41	637	12
-NY State Electric & Gas Corp.	18	194	9
-Rochester Gas & Electric Corp.	14	151	14
-Central Hudson Gas & Elec.Corp.	9	97	14
-Long Island Lighting Co.*	18	194	6

* See "Miscellaneous Comments."

Location

-Site: 8 mi. NE of Oswego, NY
-NRC Region: I

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Stone & Webster
-Principal Contractor: Stone & Webster
-Megawatt Rating: 1,080

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1971	1977	360	Not Available	333
1980	IV86	3,800	Not Available	3,519
3/29/84	IV86	5,100	Not Available	4,792
12/31/84	IV86	5,100	Not Available	4,792
8/31/85	IV86	5,350	1,770	4,954

% currently completed: 98

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit Issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	2/86
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	2/86
-First Criticality:	4/86
-Full Power License:	9/86
-Commercial Operation:	11/86

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment
-Niagara Mohawk Power	
(*$millions*)	1,667
(*Inv. as % of*)	100
-NY State Electric & Gas	
(*$millions*)	749
(*Inv. as % of*)	100
-Rochester Gas & Electric	
(*$millions*)	584
(*Inv. as % of*)	100
-Central Hudson Gas & Electric	
(*$millions*)	372
(*Inv. as % of*)	100
-Long Island Lighting	
(*$millions*)	865
(*Inv. as % of*)	100

PLANT NAME Palo Verde 1

Licensee: Arizona Public Service Co.

Major Owners	% Share	Mws	% 1984 Peak
-Arizona Public Service Co.	29	370	12
-El Paso Electric Co.	16	201	25
-Southern California Edison	16	201	1
-Public Service Co./New Mexico	10	130	13
-Salt River Project	18	222	
-Others	12	147	

Location

-Site: Wintersburg, AZ (36 mi. W of Phoenix, AZ)
-NRC Region: V

Characteristics

-Reactor Type: PWR (Combustion Engineering)
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,270

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1974	1981	1,080	Not available	850
1980	5/83	2,200	Not available	1,732
3/22/84	12/85	3,710	Not available	2,750
12/31/84	1985	3,710	Not available	2,750
12/30/85	12/29/85	3,366*	1,025*	2,650

* These amounts are extrapolations of APS' estimated $976mm total, and $297mm AFUDC component, for its 29% ownership share.

% currently completed: 100

Status of NRC Licensing Process (as of 9/30/85

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	3/85
-Hot Functional Test Complete:	C
-Fuel Load/Low Power License:	3/85
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	12/85

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	
-Arizona Public Service		
(*$millions*)	885	
(*Inv. as % of*)	100	
-El Paso Electric		
(*$millions*)	439	
(*Inv. as % of*)	100	
-Southern Calif. Edison		
(*$millions*)	469	
(*Inv. as % of*)	100	
-P.S. Co./New Mexico		
(*$millions*)	301	
(*Inv. as % of*)	100	

PLANT NAME **Palo Verde 2**

Licensee: Arizona Public Service Co.

Major Owners	% Share	Mws	% 1984 Peak
-Arizona Public Service Co.	29	370	12
-El Paso Electric Co.	16	201	25
-Southern California Edison	16	201	1
-Public Service Co./New Mexico	10	130	13
-Salt River Project	18	222	
-Others	12	147	

Location

-Site: Wintersburg, AZ (36 mi. W of Phoenix, AZ)
-NRC Region: V

Characteristics

-Reactor Type: PWR (Combustion Engineering)
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,270

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1974	1982	675	Not available	531
1980	5/84	1,375	Not available	1,083
3/22/84	IIQ86	2,320	Not available	1,827
12/31/84	IIQ86	2,320	Not available	1,827
11/30/85	IIQ86	2,920*	1,010*	2,300

* These amounts are extrapolated from APS' estimates for their 29% ownership share.

% currently completed: 99+

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review cc
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee	
-Construction Completion:	12/85	
-Hot Functional Test Complete:	NE	
-Fuel Load/Low Power License:	12/85	
-First Criticality:	NE	
-Full Power License:	NE	
-Commercial Operation:	4-6/86	

Capital Concentration ($mil. -- w/AFUDC -- as of: 6

Major Owners	Current Investment	To
-Arizona Public Service		
($millions)	553	4
(Inv. as % of)	100	
-El Paso Electric		
($millions)	274	1
(Inv. as % of)	100	
-Southern Calif. Edison		
($millions)	293	9
(Inv. as % of)	100	
-P.S. Co./New Mexico		
($millions)	188	2
(Inv. as % of)	100	

PLANT NAME Palo Verde 3

Licensee: Arizona Public Service Co.

Major Owners	% Share	Mws	% 1984 Peak
-Arizona Public Service Co.	29	370	12
-El Paso Electric Co.	16	201	25
-Southern California Edison	16	201	1
-Public Service Co./New Mexico	10	130	13
-Salt River Project	18	222	
-Others	12	147	

Location

-Site: Wintersburg, AZ (36 mi. W of Phoenix, AZ)
-NRC Region: V

Characteristics

-Reactor Type: PWR (Combustion Engineering)
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,270

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1974	1984	945	NA	744
1980	5/86	1,975	NA	1,516
3/20/84	4-6/87	3,248	NA	2,557
12/31/84	7-8/87	3,248	NA	2,557
11/30/85	IIQ87	3,100*	1,155*	2,441

* These amounts are extrapolated from APS' estimates for their 29% ownership share.

% currently completed: 97

Status of NRC Licensing Process (as of -/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review (
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	3/87
-Hot Functional Test Complete:	NE
-Fuel Load/Low Power License:	3/87
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	IIQ87

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	T
-Arizona Public Service		
($millions)	775	
(Inv. as % of)	100	
-El Paso Electric		
($millions)	384	
(Inv. as % of)	100	
-Southern Calif. Edison		
($millions)	410	
(Inv. as % of)	100	
-P.S. Co./New Mexico		
($millions)	264	
(Inv. as % of)	100	

PLANT NAME **Perry 1**

Licensee: Cleveland Electric Illuminating Co.

Major Owners	% Share	Mws	% 1984 Peak
-Cleveland Electric Illum.	31	375	11
-Ohio Edison Co.*	35	424	11
-Toledo Edison Co.	20	240	18
-Duquesne Light Co.	14	166	7

* Includes Pennsylvania Power Co's. 5.2% share.

Location

-Site: No. Perry, Ohio (7 mi. NE of Painesville, Ohio)
-NRC Region: III

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Gilbert Commonwealth
-Principal Contractor: Kaiser
-Megawatt Rating: 1,205

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1973	1979	600	Not Available	498
1980	1984	1,600	Not Available	1,328
4/03/84	12/85	3,470	Not Available	2,880
12/31/84	IVQ85	3,900	Not Available	3,237
11/30/85	IIQ86	4,000	1,200	3,320

% currently completed: 96

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	6/85
-Hot Functional Test Complete:	N/A
-Fuel Load/Low Power License:	6/85
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	12/85

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	1
-Cleveland Electric Illum.		
(*$millions*)	1,058	—
(*Inv. as % of*)	100	—
-Ohio Edison Co.		
(*$millions*)	1,359	—
(*Inv. as % of*)	100	—
-Toledo Edison Co.		
(*$millions*)	743	—
(*Inv. as % of*)	100	—
-Duquesne Light Co.		
(*$millions*)	505*	—
(*Inv. as % of*)	100	—

* Includes all Perry common plant - $145.

PLANT NAME Perry 2

Licensee: Cleveland Electric Illuminating Co.

Major Owners	% Share	Mws	% 1984 Peak
-Cleveland Electric Illum.	31	375	11
-Ohio Edison Co.*	35	424	11
-Toledo Edison Co.	20	240	18
-Duquesne Light Co.	14	166	7

* Includes Pennsylvania Power Co's. 5.2% share.

Location

-Site: No. Perry, Ohio (7 mi. NE of Painesville, Ohio)
-NRC Region: III

Characteristics

-Reactor Type: General Electric (BWR)
-Architect/Engineer: Gilbert Commonwealth
-Principal Contractor: Kaiser
-Megawatt Rating: 1,205

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1973	1982	600	Not Available	498
1980	1988	2,400	Not Available	1,992
4/03/84	NE	2,600	Not Available	2,158
12/31/84	NE	NE	NE	NE
6/30/85	NE	NE	NE	NE

% currently completed: 44

Status of NRC Licensing Process (as of 9/30/85

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards reviev
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	NE
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	NE
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	NE

Capital Concentration ($mil. -- w/AFUDC -- as of

Major Owners	Current Investment
-Cleveland Electric Illum.	
(*$millions*)	333
(*Inv. as % of*)	100
-Ohio Edison Co.	
(*$millions*)	430
(*Inv. as % of*)	100
-Toledo Edison Co.	
(*$millions*)	234
(*Inv. as % of*)	100
-Duquesne Light Co.	
(*$millions*)	159*
(*Inv. as % of*)	100

* Includes no common plant.

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PLANT NAME **River Bend 1**

Licensee: Gulf States Utilities

Major Owners	% Share	Mws	% 1984 Peak
-Gulf States Utilities	70	654	12
-Cajun Electric Power Coop.	30	280	

Location

-Site: St. Francisville, LA (24 mi. NNW of Baton Rouge, LA)
-NRC Region: IV

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Stone & Webster
-Principal Contractor: Stone & Webster
-Megawatt Rating: 934

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	NE	700	Not Available	749
1980	1984	1,700	Not Available	1,820
5/20/84	12/85	3,927	Not Available	4,205
12/31/84	12/85	4,000	Not Available	4,283
11/30/85	1Q86	4,120	865*	4,411

* We assume that GSU's AFUDC is about 30% of the company's 70% share at the unit's total cost.

% currently completed: 99+

Status of NRC Licensing Process (as of 9/30/85

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review completion:
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	4/85
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	4/85
-First Criticality:	4/85
-Full Power License:	12/85
-Commercial Operation:	12/85

*I.e. "construction completion" for NRC licensing pu

Capital Concentration ($mil. — w/AFUDC — as of

Major Owners	Current Investment
-Gulf States Utilities ($millions)	2,524
(Inv. as % of)	100

ANT NAME **Seabrook 1**

Licensee: Public Service Company of New Hampshire (PSNH)

Major Owners	% Share	Mws	% 1984 Peak
-PSNH	36	426	35
-United Illuminating	18	210	21
-New England Power Co.	10	119	4
-Central Maine Power	6	72	6
-Connecticut Light & Power	4	48	2
-Others	27	323	

Location

-Site: Seabrook, NH (13 mi. S of Portsmouth, NH)
-NRC Region: I

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: United Engineers & Contractors
-Principal Contractor: United Engineers & Contractors
-Megawatt Rating: 1,198

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
10/75	11/80	930	Not Available	776
1/1980	4/83	1,900	Not Available	1,586
4/19/84	2/86	4,100	Not Available	3,422
12/31/84	9/86	4,500	Not Available	3,756
7/24/85	10/31/86	4,560	1,670	3,806

% currently completed: 90

Status of NRC Licensing Process (as of [illegible]/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review c
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	12/85
-Hot Functional Test Complete:	NE
-Fuel Load/Low Power License:	12/85
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	6/86

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	Current Investment	T
-Public Service of New Hampshire		
(*$millions*)	1,308	2
(*Inv. as % of*)	100	
-United Illuminating		
(*$millions*)	620	1
(*Inv. as % of*)	100	
-New England Power Co.		
(*$millions*)	340	1
(*Inv. as % of*)	100	
-Central Maine Power		
(*$millions*)	250	
(*Inv. as % of*)	100	
-Connecticut Light & Power		
(*$millions*)	147	4
(*Inv. as % of*)	100	

PLANT NAME **Seabrook 2**

Licensee: Public Service Company of New Hampshire (PSNH)

Major Owners	% Share	Mws	% 1984 Peak
-PSNH	36	426	35
-United Illuminating	18	210	22
-New England Power Co.	10	119	4
-Central Maine Power	6	72	6
-Connecticut Light & Power	4	48	1
-Others	27	323	

Location

-Site: Seabrook, NH (13 mi. S of Portsmouth, NH)
-NRC Region: I

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: United Engineers & Contractors
-Principal Contractor: United Engineers & Contractors
-Megawatt Rating: 1,198

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
10/75	NA	620	Not available	518
1/80	1985	1,265	Not available	1,056
4/19/84	6/88	2,800	Not available	2,337
12/01/84	NE	NE	NE	NE
6/30/85	NE	NE	NE	NE

% currently completed: 22

Status of NRC Licensing Process (as of 9/30/8

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards revie
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	1/88
-Hot Functional Test Complete:	2/87
-Fuel Load/Low Power License:	4/87
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	6/88

Capital Concentration ($mil. -- w/AFUDC -- as

Major Owners	Current Investment
-Public Service of New Hampshire	
($millions)	360
(Inv. as % of)	100
-United Illuminating	
($millions)	104
(Inv. as % of)	100
-New England Power Co.	
($millions)	85
(Inv. as % of)	100
-Central Maine Power	
($millions)	51
(Inv. as % of)	100
-Connecticut Light & Power	
($millions)	24
(Inv. as % of)	100

PL[illegible] NAME Shoreham

Licensee: Long Island Lighting Company

Major Owners	% Share	Mws	% 1984 Peak
-Long Island Lighting Co.	100	820	25

Location

-Site: Brookhaven, New York (Long Island)
-NRC Region: I

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Stone & Webster
-Principal Contractor: Stone & Webster
-Megawatt Rating: 820

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
7/76	1980	969	Not Available	1,182
1980	1983	2,200	Not Available	2,683
3/30/84	7/85	4,200	Not Available	5,122
12/31/84	10/85	4,500	Not Available	5,488
11/30/84	11Q87*	4,500	1,425	5,488

% currently completed: 100

* DLJ estimate of the earliest date at which commercial operation is possible.

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review con
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

*See "Miscellaneous Comments" and "Major Contested I:

Est. Licensing Action	6/84 Licensee	Li
-Construction Completion:	5/84	
-Hot Functional Test Complete:	NA	
-Fuel Load/Low Power License:	8/84	11/
-Fuel Load/Low Power License:	8/84	
-First Criticality:	NE	
-Full Power License:	NE	
-Commercial Operation:	7/85	1

** NRC decision authorizing fuel load and cold criticality license was issued 12/7/84.

Capital Concentration ($mil. -- w/AFUDC -- as of: 6/3

Major Owners	Current Investment	Tota Pl
-Long Island Lighting Co. ($millions)	4,000	6,6
(Inv. as % of)	100	

PLANT NAME South Texas 1

Licensee: Houston Lighting & Power Company

Major Owners	% Share	Mws	% 1984 Peak
-Houston Lighting & Power Co.	31	385	4
-City P. S. of San Antonio	28	350	
-Central Power & Light Co.	25	315	3
-City of Austin	16	200	

Location

-Site: 12 mi. SSW of Bay City, Texas
-NRC Region: IV

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Bechtel
-Principal Contractor: Ebasco
-Megawatt Rating: 1,250

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	1980	600	Not available	480
1980	2/84	2,243	Not available	1,794
3/29/84	6/87	4,500	Not available	3,600
12/31/84	6/87	4,500	Not available	3,600
11/30/85	12/87	4,650	1,380	3,720

% currently completed: 80

Status of NRC Licensing Process (as of 9/30/8

-Construction Permit application docketed:
-Construction Permit Issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Issues:
-Advisory Committee on Reactor Safeguards revie
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

* 3/28/84 an ASLB issued a partial initial decision and character issues.

Est. Licensing Action	6/84 Licensee
-Construction Completion:	12/86
-Hot Functional Test Complete:	10/86
-Fuel Load/Low Power License:	12/86
-First Criticality:	Q1/87
-Full Power License:	Q2/87
-Commercial Operation:	6/87

Capital Concentration ($mil. -- w/AFUDC -- as o

Major Owners	Current Investment
-Houston Lighting & Power Co.	
($millions)	812
(Inv. as % of)	100
-Central Power & Light	
($millions)	743
(Inv. as % of)	100

PLANT NAME South Texas 2

Licensee: Houston Lighting & Power Company

Major Owners	% Share	Mws	% 1984 Peak
-Houston Lighting & Power Co.	31	385	4
-City P. S. of San Antonio	28	350	
-Central Power & Light Co.	25	315	3
-City of Austin	16	200	

Location

-Site: 12 mi. SSW of Bay City, Texas
-NRC Region: IV

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Bechtel
-Principal Contractor: Ebasco
-Megawatt Rating: 1,250

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	1989	400	Not available	320
1980	2/86	1,495	Not available	1,196
3/29/84	6/89	3,000	Not available	2,400
12/31/84	6/89	3,000	Not available	2,400
11/30/85	1989	3,150	920	2,520

% currently completed: 55

Status of NRC Licensing Process (9/30,

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement Issues:
-Advisory Committee on Reactor Safeguards rev
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decisior

Est. Licensing Action	6/84 Licensee
-Construction Completion:	12/86
-Hot Functional Test Complete:	9/88
-Fuel Load/Low Power License:	12/88
-First Criticality:	Q1/89
-Full Power License:	1989
-Commercial Operation:	1989

Capital Concentration ($mil. -- w/AFUDC -- as

Major Owners	Current Investment
-Houston Lighting & Power Co.	
($millions)	542
(Inv. as % of)	100
-Central Power & Light	
($millions)	495
(Inv. as % of)	100

PLANT NAME **Susquehanna 2**

Licensee: Pennsylvania Power & Light Co.

Major Owners	**% Share**	**Mws**	**% 1984 Peak**
-Pennsylvania Power & Light	90	947	17
-Allegheny Electric Coop.	10	105	

Location

-Site: 7 mi. E of Berwich, PA
-NRC Region: I

Characteristics

-Reactor Type: General Electric BWR
-Architect/Engineer: Bechtel
-Principal Contractor: Bechtel
-Megawatt Rating: 1,052

Cost/Completion Estimates

As of:	**Commercial Operation**	**Total Cost ($000,000)**	**AFUDC Component**	**Total Cost per Kw**
1973	1981	600	Not Available	570
1980	6/83	1,400	Not Available	1,331
4/15/84	10/84 - 12/84	2,100	Not Available	1,987
12/31/84	1/85	2,100	Not Available	1,987
6/30/85	2/12/85	2,085	626	1,982

% currently completed: 100

Status of NRC Licensing Process (as of 9/30/85)

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards review
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	**6/84 Licensee**
-Construction Completion:	3/84
-Hot Functional Test Complete:	NA
-Fuel Load/Low Power License:	3/23/84
-First Criticality:	4/84
-Full Power License:	5/84
-Commercial Operation:	11/84

Capital Concentration ($mil. -- w/AFUDC -- as of:

Major Owners	**Current Investment**	T
-Pennsylvania Power & Light		
($millions)	1,890	
(Inv. as % of)	100	

PLANT NAME **Vogtle 1**

Licensee: Georgia Power Co.

Major Owners	% Share	Mws	% 1984 Peak
- Georgia Power Co.	46	553	5
- Oglethorpe Power Corp.	23	278	
- Municipal Electric Authority of Georgia	18	214	
- City of Dalton	2	19	

Location

-Site: Waynesboro, Georgia (25 mi. SSE of Augusta, GA).
-NRC Region: II

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Southern Co. Services Inc./Bechtel
-Principal Contractor: Georgia Power Co.
-Megawatt Rating: 1,210

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	1983	1,356	Not Available	1,121
1980	1985	2,300	Not Available	1,901
5/01/84	3/87	3,960	Not Available	3,273
12/31/84	3/87	4,320	1,650	3,570
11/30/85	6/87	5,008	1,785	4,140

% currently completed: 80

Status of NRC Licensing Process (as of 8/30/8!

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards revie
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	9/86
-Hot Functional Test Complete:	7/86
-Fuel Load/Low Power License:	9/86
-First Criticality:	9/86
-Full Power License:	10/86
-Commercial Operation:	3/87

Capital Concentration ($mil. -- w/AFUDC -- as o

Major Owners	Current Investment
-Georgia Power (*$millions*)	1,819
(*Inv. as % of*)	100

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PLANT NAME **Vogtle 2**

Licensee: Georgia Power Co.

Major Owners	% Share	Mws	% 1984 Peak
- Georgia Power Co.	46	553	5
- Oglethorpe Power Corp.	30	363	
- Municipal Electric Authority of Georgia	23	278	
- City of Dalton	2	19	

Location

-Site: Waynesboro, Georgia (25 mi. SSE of Augusta, GA).
-NRC Region: II

Characteristics

-Reactor Type: PWR (Westinghouse)
-Architect/Engineer: Southern Co. Services Inc./Bechtel
-Principal Contractor: Georgia Power Co.
-Megawatt Rating: 1,210

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1975	1984	904	Not Available	747
1980	1987	1,300	Not Available	1,074
5/01/84	9/88	2,640	Not Available	2,182
12/31/84	9/88	2,880	1,100	2,380
11/30/85	9/88	3,338	1,190	2,760

% currently completed: 51

Status of NRC Licensing Process (as of 9/30/85

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards reviev
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	3/88
-Hot Functional Test Complete:	2/88
-Fuel Load/Low Power License:	3/88
-First Criticality:	NE
-Full Power License:	NE
-Commercial Operation:	9/88

Capital Concentration ($mil. -- w/AFUDC -- as o

Major Owners	Current Investment
-Georgia Power (*$millions*)	337
(*Inv. as % of*)	100

PLANT NAME **Washington Nuclear 3**

Licensee: Washington Public Power Supply System

Major Owners	% Share	Mws	% 1984 Peak
- WPPSS	70	869	
- Pacific Power & Light Co.	10	124	3
- Portland General Electric Co.	10	124	4
- Puget Sound Power & Light Co.	5	62	2
- Washington Water Power Co.	5	62	4

Location

-Site: Satsop, Wash. (26 mi. W of Olympia, Wash.)
-NRC Region: V

Characteristics

-Reactor Type: PWR (Combustion Engineering)
-Architect/Engineer: Ebasco
-Principal Contractor: Ebasco
-Megawatt Rating: 1,242

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
1973	9/81	751	NA	605
1980	1986	3,500	NA	2,818
4/27/84	12/89	5,000	NA	4,000
12/31/84	NE	NE	NE	NE
6/30/85	NE	NE	NE	NE

% currently completed: 75

Status of NRC Licensing Process (as of 9/30/8

-Construction Permit application docketed:
-Construction Permit issuance:
-Operating License application docketed:
-Final Environmental Statement completion:
-Final Safety Analysis Report completion:
-Safety Evaluation Report completion:
-Safety Evaluation Report Supplement issues:
-Advisory Committee on Reactor Safeguards revie
-FEMA review of offsite emergency planning:
-Public hearings on Operating License:
-Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
-Construction Completion:	1989
-Hot Functional Test Complete:	NE
-Fuel Load/Low Power License:	1989
-First Criticality:	1989
-Full Power License:	1989
-Commercial Operation:	12/89

Capital Concentration ($mil. -- w/AFUDC -- as

Major Owners	Current Investment
-Pacific Power & Light Co.	
($millions)	40*
(Inv. as % of)	100
-Portland General Electric Co.	
($millions)	235
(Inv. as % of)	100
-Puget Sound Power & Light	
($millions)	139
(Inv. as % of)	100
-Washington Water Power Co.	
($millions)	166
(Inv. as % of)	100

* See "Miscellaneous Comments."

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PLANT NAME **Waterford 3**

Licensee: Louisiana Power & Light

Major Owners	% Share	Mws	% 1984 Peak
– Louisiana Power & Light	100	1,151	27

Location

–Site: 20 mi. W of New Orleans, LA
–NRC Region: IV

Characteristics

–Reactor Type: PWR (Combustion Engineering)
–Architect/Engineer: Ebasco
–Principal Contractor: Ebasco
–Megawatt Rating: 1,151

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
10/77	1981	815	Not Available	708
1980	1983	1,500	Not Available	1,303
1/30/84	12/84	2,650	Not Available	2,302
12/31/84	II-IIIQ85	2,733	Not Available	2,375
10/30/85	9/24/85	2,800	840*	2,433

* We assume AFUDC represents about 30% of the unit's total cost.

% currently completed: 100

Status of NRC Licensing Process (as of 9/30/

–Construction Permit application docketed:
–Construction Permit issuance:
–Operating License application docketed:
–Final Environmental Statement completion:
–Final Safety Analysis Report completion:
–Safety Evaluation Report completion:
–Safety Evaluation Report Supplement Issues:
–Advisory Committee on Reactor Safeguards revi
–FEMA review of offsite emergency planning:
–Public hearings on Operating License:
–Atomic Safety & Licensing Board Initial Decision:

Est. Licensing Action	6/84 Licensee
–Construction Completion:	5/84
–Hot Functional Test Complete:	Complet
–Fuel Load/Low Power License:	5/84
–First Criticality:	NA
–Full Power License:	NA
–Commercial Operation:	12/84

Capital Concentration ($mil. -- w/AFUDC -- as o

Major Owners	Current Investment
–Louisiana Power & Light (*$millions*)	2,713
(*Inv. as % of*)	100

T NAME Wolf Creek

Licensee: Kansas Gas & Electric Co.

Major Owners	% Share	Mws	% 1984 Peak
- Kansas Gas & Electric Co.	47	540	35
- Kansas City Power & Light	47	540	22
- Kansas Electric Power Coop.	6	69	

Status of NRC Licensing Process (as of 85)

- -Construction Permit application docketed:
- -Construction Permit issuance:
- -Operating License application docketed:
- -Final Environmental Statement completion:
- -Final Safety Analysis Report completion:
- -Safety Evaluation Report completion:
- -Safety Evaluation Report Supplement issues:
- -Advisory Committee on Reactor Safeguards review co
- -FEMA review of offsite emergency planning:
- -Public hearings on Operating License:
- -Atomic Safety & Licensing Board Initial Decision:

Location

- -Site: Burlington, Kansas
- -NRC Region: IV

Est. Licensing Action	6/84 Licensee	t
-Construction Completion:	9/84	
-Hot Functional Test Complete:	5/84	
-Fuel Load/Low Power License:	9/84	
-First Criticality:	8/84	
-Full Power License:	4/85	
-Commercial Operation:	4/85	

Characteristics

- -Reactor Type: PWR (Westinghouse)
- -Architect/Engineer: Bechtel
- -Principal Contractor: Bechtel
- -Megawatt Rating: 1,150

Cost/Completion Estimates

As of:	Commercial Operation	Total Cost ($000,000)	AFUDC Component	Total Cost per Kw
5/77	4/83	1,000	Not Available	870
1980	1984	1,700	Not Available	1,478
12/31/83	4/85	2,670	Not Available	2,322
12/31/84	IIIQ85	2,920	Not Available	2,539
11/30/85	9/04/85	3,000	900	2,609

% currently completed: 100

Capital Concentration ($mil. -- w/AFUDC -- as of: 6/

Major Owners	Current Investment	Tot P
-Kansas Gas & Electric Co. (*$millions*)	1,400	2,
(*Inv. as % of*)	100	
-Kansas City Power & Light (*$millions*)	1,420	2,
(*Inv. as % of*)	100	

STATE OF MINNESOTA
ENVIRONMENTAL QUALITY BOARD

In the Matter of the Final Environmental Impact Statement on Northern States Power Company's Proposed Prairie Island Independent Spent Fuel Storage Facility

PROPOSED FINDINGS OF FACT CONCLUSIONS, AND ORDER

FINDINGS OF FACT

Introduction

EIS Order

1. At its regularly scheduled meeting on December 21, 1989, the Minnesota Environmental Quality Board (EQB) ordered the preparation of an Environmental Impact Statement (EIS) on a proposal by Northern States Power Company (NSP) to construct an Independent Spent Fuel Storage Installation (ISFSI) at the Prairie Island Nuclear Generating Plant (PI). The proposal had been presented to the EQB as an information item at its November 16, 1989 meeting. Staff had monitored status of the proposal since NSP made the proposal public in June, 1989.

2. The project, as proposed, does not fall within the mandatory EIS categories (Minn. Rule. part 4410.4400). However, Minn. Rule, part 4410.2000, subpart 3, item B provides that a discretionary EIS shall be prepared when the RGU and the proposer agree that an EIS should be prepared. NSP, in a letter dated November 28, 1991, agreed to the preparation of an EIS on the project.

3. The EQB was determined to be the Responsible Governmental Unit (RGU) for the preparation of the EIS pursuant to related responsibilities in Minnesota Rules, part 4410.4400, subp. 2, and part 4410.0500, subp. 2.

Authority, Scope, and Purpose

4. Environmental review procedures in the State of Minnesota are implemented under authority granted in Minnesota Statutes, chapter 116D.

5. The proposed NSP project is within the scope of environmental review procedures as defined by Minn. Rules 4410.0300, subp. 2.

6. As stipulated in Minnesota Statutes, section 116D.04, subd. 2a, EIS's shall be analytical rather than encyclopedic, and must describe the proposed action in detail, analyze its significant impacts, discuss appropriate alternatives and their impacts, explore methods by which adverse environmental effects of an action could be mitigated and analyze unavoidable impacts of a proposed action.

7. Minn. Rules 4410.0300, subp. 3, states that the purpose of environmental review is to aid in providing an understanding of the impacts a proposed project will have on the environment, through the preparation and public review of environmental documents. Environmental documents must address significant environmental issues and be available to governmental units and citizens early in the decision making process. Environmental documents shall not be used to justify a decision, nor shall indications of adverse environmental effects necessarily require that a project be disapproved. Environmental documents shall be used as guides in issuing, amending and denying permits and carrying out other responsibilities of governmental units to avoid or minimize adverse environmental effects and to restore and enhance environmental quality.

Procedural

8. Notice of the EIS order was published in the EQB Monitor on January 8, 1990.

Scoping

9. The EIS scoping process was conducted pursuant to Minn. Rules 4410.2100, and included the following:

a. A draft scoping decision document, including an Environmental Assessment Worksheet and project description prepared by NSP, was prepared and distributed in compliance with Minn. Rules 4410.1500, item A. It was prepared by EQB staff with the assistance of an independent technical consultant and an interagency Technical Work Group, represented by staff from the Pollution Control Agency, the Public Utilities Commission, and the Departments of Public Safety, Public Service, Health, Natural Resources, and Agriculture.

b. Notice of the draft scoping decision document availability was published in the EQB Monitor and the 30 day comment period began on March 19, 1990.

c. A press release on the draft scoping decision document availability was provided on March 16, 1990 in compliance with Minn. Rules 4410.1500, item B.

d. Paid advertisements of the draft scoping decision document availability, public meetings and comment procedure were published the week of April 9, 1990 in the Red Wing Republican Eagle, the St. Paul Press Dispatch and the Minneapolis Star-Tribune. Pursuant to Minn. Rules 4410.1500, item B, NSP agreed to pay for the advertisements.

e. Public scoping meetings were held in Red Wing, MN on April 16 and in St. Paul on April 17, 1990. The first meeting was held 28 days after the Monitor notice. Registered attendance was 15 in Red Wing and 11 in St. Paul.

f. The public comment period closed on April 26, 1990. The comment period ran for 38 days. Six comment letters were filed with the Board.

g. The Board approved a final scoping decision at its May 17, 1990 meeting. The decision document contained the information included in Minn. Rules 4410.2100, subp.6, items A-G, and responses to all written and public meeting comments.

h. Notice of the Board's approval of the scoping decision and order of an EIS was published in the June 25, 1990 EQB Monitor, 39 days after the decision was issued. A press release was issued on June 22, 1990. The notice and press release were provided in compliance with Minn. Rules 4410.2100, subp. 9.

i. The EIS scoping decision document identified the following issues relevant to the proposed project. The location of the discussion in the Final EIS is shown to the right.

	Final EIS
Direct and indirect effects of construction:........	p. 4.1
a. land use and terrestrial resources	
b. water use and aquatic resources	
c. other environmental	
- ambient noise	
- fugitive dust	
- air quality and odor	
- erosion and runoff	
d. socioeconomics (work force)	
e. cultural resources	
Non-radiological direct and indirect effects of operation:....................................	p. 4.7
a. land use and terrestrial resources	
b. water use and aquatic resources	
c. socioeconomics	
d. other environmental	
- fogging and other related problems from heat dissipation	
- ambient noise	
e. runoff	
Impacts and protection from natural calamity:.......	p. 4.13
a. Seismic event (earthquake)	
b. Flood (100 year, 500 year)	
c. Tornado, tornado-propelled projectiles	
d. Lightning strike	
e. Extreme climatic conditions	
Radiological impact from routine operation:.........	p. 4.17
a. collective occupational dose commitment	
b. off-site dose commitment	
c. on-site spent fuel movement	
1) in pool, with standard and non-standard fuel	
2) in transfer to storage location	
Impacts from accidents:............................	p. 4.19
a. during loading and sealing operations	
b. during transfer to the storage location	
c. during storage	
d. emergency planning	
Safeguards from theft, diversion, sabotage..........	p. 4.21
Decommissioning of the storage facility.............	p. 4.23

j. The EIS scoping decision document identified the following alternatives to the proposed project. The location of the discussion of the alternative in the Final EIS is shown on the right.

Final EIS

Similar Facility at Another Site (at-reactor)....... p. 6A.1
Dry Spent Fuel Storage Technologies................. p. 5.13
a. Modular Concrete Storage
b. Vault
c. Concrete Casks
d. Other Metal Storage Cask Designs
e. Dual Purpose (Storage/Transport) Casks
Modified or New Pool Storage........................ p. 5.20
a. Expansion of Existing Pool
b. Construction of a New Pool
Increase Storage Capacity of Existing Pool...........p. 5.20
a. Reracking
b. Spent Fuel Rod Consolidation
c. Two-Tiered Racks
Shipment to Other Spent Fuel Storage Facilities..... p. 5.30
a. Transhipment to Monticello Pool
b. Transhipment to Pathfinder
c. Shipment to a Commercial Storage Facility
Shipment to a Federal Facility...................... p. 5.34
a. Shipment to a DOE Repository
b. Shipment to a Monitored Retrievable Storage Facility
Reprocessing.. p. 5.38
Higher Burnup Fuel.................................. p. 5.44
No Action... p. 5
Reduce Prairie Island Operation..................... p. 5.6
Increase Customer Conservation...................... p. 5.7

Draft EIS

10. The Draft EIS was prepared in compliance with Minn. Rules 4410.0200 to 4410.6500 and in accord with the scoping determination. It was prepard by EQB staff. The interagency Technical Work Group continued to advise EQB staff during preparation of the Draft EIS.

11. The process consisted of the following:

a. The Draft EIS included the issues and alternatives identified in the scoping decision and approved by the Board. To support this analysis, information was gathered from a wide variety of independent sources. The references used in development of the EIS are listed in the document, either within the text or at the end of each section.

b. The Draft EIS included the following sections and content, in compliance with Minn. Rules 4410.2300:

A. Cover sheet. (first page of Draft EIS)
The cover sheet included the information required by Minn. Rule 4410.2300, item A.

B. Summary. (Chapter 1 of Draft EIS)
The summary stressed the major findings, areas of controversy and the alternatives.

C. Table of contents. (second page of Draft EIS)

D. List of preparers. (first page of Draft EIS)

E. Project Description. (Chapter 3 of Draft EIS)
The project description described the proposed project with sufficient detail to allow the public to identify the purpose of the project, its size, scope, environmental setting, geographic location, and the anticipated phases of development.

F. Governmental approvals required. (Chapter 2 of Draft EIS)
The following governmental approvals were identified:
1. Federal License: A Part 72 license must be issued by the U.S. Nuclear Regulatory Commission. NSP filed its application in August, 1990, and anticipates completion of the review process in late 1991.
2. Certificate of Need: A Certificate of Need from the Minnesota Public Utilities Commission is required pursuant to Minnesota Rules, Chapter 7855. NSP filed this application on April 29, 1991. The Environmental Impact Statement is part of the record in this filing.
3. A local building permit will also be required.
No governmental permits were identified for which all necessary information was included in the EIS.

G. Alternatives. (Chapter 4 of Draft EIS, proposed project impacts and Chapter 5, alternatives impacts)
The alternatives section compared the environmental impacts of the proposal with other reasonable alternatives, specifically those identified in the scoping process (Finding 5j). The alternative of a similar facility (dry cask) at another site (away-from-reactor site in Minnesota) was not included. This alternative was considered unreasonable and infeasible. There was no support from any interested party for this alternative. Alternative at-reactor sites have been included in the Final EIS. The alternative of no action was addressed.

H. Environmental, economic, employment and sociological impact. (Chapter 4 and 5 of the Draft EIS).
This section included, for the proposed project and each major alternative, a thorough but succinct discussion of any direct or indirect, adverse, or beneficial effect generated. The discussion concentrated on those issues considered to be significant as identified by the scoping process. Data and analysis was commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced. The EIS identified and briefly discussed major differences of opinion concerning impacts of the proposed project and the effects the project may have on the environment.

I. Mitigation measures. (Chapter 4, page 4.14 of the Draft EIS)
This secion identified measures that could reasonably eliminate or minimize any adverse environmental, economic, employment, or sociological effects of the proposed project.

J. Appendix. (Appendix in Draft EIS)
The appendix included information in compliance with Minn. Rules 4410.2300, item J.

c. Notice of the Draft EIS availability was published in the EQB Monitor on November 26, 1990, in compliance with Minn. Rule 4410.2600, subp. 5 and 7. The Draft EIS was distributed in compliance with Minn. Rule 4410.2600, subps. 3 and 4. A press release was provided as required in Minn. Rule 4410.2600, subp. 6 and 7.

d. Optional paid advertisements were published as described in Finding 5(d).

e. Public comment meetings were held in St. Paul on December 17, 1990, and in Red Wing, MN on December 18, 1990. The first meeting was held 21 days after the Monitor notice. A typewritten summary and an audio-recorded transcript of the meetings were made. Registered attendance was 26 in St. Paul and 22 in Red Wing.

f. The public comment period closed on January 7, 1991. The comment period ran for 42 days. It remained open for 20 days after the last public comment meeting. Eighteen comment letters were filed with the Board and 26 oral comments were recorded at the public meetings.

Final EIS

12. The Final EIS was prepared in compliance with Minn. Rules 4410.2700. The preparation process consisted of the following:

a. The Final EIS includes responses to timely substantive comments on the Draft EIS in compliance with the scoping decision. All comments are provided in Chapter 7 of the Final EIS. Responses are provide in Chapter 8 of the Final EIS

b. The responses resulted in significant changes in the Draft EIS, and the Final EIS has been rewritten so that necessary changes in the text are incorporated in the appropriate places. In addition to incorporated text, the following sections have been added to the Final EIS:

Chapter 6, which is a health risk assessment prepared by the Minnesota Department of Health.

Chapter 6A, which is an analysis of two alternative at-reactor locations, resulting from the assessment in Chapter 6.

Apendices K through V, which are attachments to comment letters and additional supporting material.

c. Notice of the availability of the Final EIS was published in the EQB Monitor on April 15, 1991. The notice and a press release were provided in compliance with Minn. Rules 4410.2700, subp. 5 and 6.

d. The Final EIS was distributed in compliance with Minn. Rules 4410.2700, subp. 3. It was mailed to all persons on the official distribution list on April 19, 1991. The official distribution list consisted of 153 individuals. A copy was provided to all persons who requested the Final EIS. It was mailed to all Board members on April 23, 1991.

e. The comment period on the Final EIS closed May 6, 1991. The comment period ran for eleven work days and seventeen calendar days after mailing. Nine comment letters were properly filed with the Board before close of the comment period.

Addendum

13. The attached addendum was prepared by staff to correct omissions and provide clarification of the discussion in the Final EIS on the alternative of conservation. The addendum is needed to clarify the analysis of conservation potential and costs. Pursuant to Minn. Rules 4410.3000, subp. 2, the EQB can make minor revisions to a Final EIS by use of an addendum. Upon approval by the EQB, the addendum becomes part of the Final EIS. It has been distributed in compliance with the cited rule.

Comments on Final EIS Adequacy

14. Timely comment letters pertaining to adequacy of the EIS:

a. A total of nine letters were received during the 10-day comment period on the final EIS. Of these, two did not discuss adequacy. In these two letters, content issues were raised, but no position was taken as to whether the shortcomings noted were sufficient to cause the EIS to be determined "inadequate".

b. Comments received favoring adequacy decision. Two letters were received which indicated that the EIS adequately addressed the scoped issues, alternatives, impacts and comments.

c. Five letters were received questioning the adequacy of the Final EIS. The issues raised in these letters were:

i. Long-term potential risks to health and the environment, and testing of casks, were not adequately addressed. These areas are fully covered in Chapters 4 and 6 of the EIS. Comments did not specify areas which were inadequate.

ii. More detailed health studies and monitoring are needed. The health risk assessment provided in Chapter 6 of the Final EIS is a reasonable level of analysis to address this issue. The impossibility of directly observing health effects of such low doses of radiation, and consequent necessity for extrapolation downward from epidemiological studies of higher doses, is discussed in the Final EIS at page 6.7 to 6.8 and 6.12 to 6.13. Responses from the Minnesota Department of Health, dated May 10, 1991, address this issue in more detail.

iii. The calculated health risk number has changed. The reason that the calculated health risk number in the FEIS is different than that which appeared an earlier memo from the Department of Health is discussed on pages 6.8 and 6.9 of the FEIS. The way in which the number was calculated is described on pages 6.10 through 6.12. Responses from the Minnesota Department of Health, dated May 10, 1991, address this issue in more detail.

iv. More discussion is needed of the conservation alternative, and the EIS should designate conservation as the preferred alternative to the proposed project. Conservation as an alternative is discussed in the EIS on pages 5.7 through 5.12, and as a possible component of a combination of alternatives on page 5.47. The EQB is not required to designate any alternative as "preferred" - refer to Minn. Rules 4410.003, subp. 3, cited in paragraph 7 of these findings. An EIS should provide sufficient information for decision makers to decide if an alternative is feasible and prudent, and the subject Final EIS provides this level of information.

v. Technical and legal assistance was not provided to the Indian community. This issue is discussed on page 8.8 of the EIS, item 15A.

vi. Several more specific comments on adequacy were also received:

Maps in the EIS did not show proximity of Indian community to proposed project. This proximity is clearly shown on maps on pages 6A-8 through 6A-10. These maps are new material added since the draft EIS.

Alternatives are not adequately discussed and cannot be easily compared. As discussed in paragraph 9 of these findings, scoped issues were covered for the proposed project as well as each alternative. The format used for discussion of each alternative parallels that for the proposed project, and the Table of Contents clearly gives the location of each within the EIS.

The EIS did not consider final removal and disposition of spent fuel from Prairie Island. This is not part of the proposed project, was not an issue which was included in scoping, and is beyond the scope of the EIS.

The EIS did not go far enough in considering flood, airplane crash, and security problems. Minn. Statutes, section 116D.04, states that EIS's should be analytic, not encyclopedic. Available information was used in preparing the EIS, and all comments received on the draft in these areas were addressed. The level of detail is sufficient to inform the decision maker.

Determination of Adequacy

15. The EQB is the Responsible Governmental Unit and must determine the adequacy of the Final EIS.

16. Minn. Rules 4410.2800, subp. 1a requires that certain evidence of compliance with EIS procedure must be on file. All information required by this rule is on file with the EQB.

17. Minnesota Statute, section 116D.04, subd. 2a(g) and Minn. Rules 4410.2800, subp. 3 require that a determination of adequacy of the Final EIS be made within 280 days after the preparation notice was published in the EQB Monitor unless the time is extended by consent of the proposer and the EQB or by the governor for good cause. The 280 days lapsed on April 1, 1991. By letter dated March 18, 1991, NSP agreed to extend the adequacy decision to the May 16, 1991, EQB meeting.

18. Minn. Rules 4410.2800, subp. 4 governs the determination of adequacy of a Final EIS. The following conditions must be met:

a. The Final EIS must address the issues raised in scoping so that all issues for which information can be reasonably obtained have been analyzed.

b. The Final EIS must provide responses to the substantive comments received during the Draft EIS review concerning issues raised in scoping.

c. The Final EIS must be prepared in compliance with the procedures of the act (Minn. Statutes, section 116D.04) and Minn. Rules 4410.0200 to 4410.6500.

CONCLUSIONS

19. The EQB has the authority to determine the adequacy of the Final EIS on NSP's propose Prairie Island Independent Spent Fuel Storage Installation.

20. The Final EIS is in compliance with statutory and agency rule guidelines which establish the purpose and content of an EIS. The Final EIS is analytic rather than encyclopedic, and describes reasonable alternatives and significant impacts of the proposal and alternatives.

21. Notice and availability of information relative to the environmental review of the proposal was provided to the public and government agencies early in the process and in compliance with all

requirements. The scoping decision, Draft EIS and Final EIS were provided to all persons who requested them.

22. The Final EIS, including the addendum:

a. addresses the issues raised in scoping so that all issues for which information can be reasonably obtained have been analyzed;

b. provides responses to the substantive comments received during the Draft EIS review concerning issues raised in scoping; and

c. was prepared in compliance with the procedures of the act (Minn. Statutes, section 116D.04) and Minn. Rules 4410.0200 to 4410.6500.

ORDER

Based on the Findings of Fact and Conclusions contained herein and the entire record:

The Environmental Quality Board hereby determines the Final Environmental Impact Statement of the Prairie Island Independent Spent Fuel Storage Installation, including the addendum, to be adequate.

Approved and adopted May 16, 1991.

State of Minnesota
Environmental Quality Board

Robert Dunn, Chair

MINNESOTA ENVIRONMENTAL QUALITY BOARD
300 Centennial Building · 658 Cedar Street · St. Paul, Minnesota 55155
612-296-2603

May 9, 1991

TO: All Persons Who Received Final EIS on the Prairie Island Independent Spent Fuel Storage Installation

FROM: EQB Staff

The attached addendum will be incorporated in the Final EIS upon approval by the EQB at its May 16, 1991 meeting. As provided in Minn. Rule 4410.3000, subp. 2, the EQB may make minor revisions to a final EIS by use of an addendum, and shall distribute it to any person who received the final EIS document, and to any other person upon written request.

ADDENDUM

To The
Final Environmental Impact Statement
Prairie Island Independent Spent Fuel Storage Project

Revised text underlined.

Page 3.14, under Cask Leakage, item 1. Specification:
strike atmospheres per.

Page 4.27, under K. Cost of Project, second sentence:
36 casks corrected to 48 casks.

Page 5.12, last sentence revised to read:
"The numbers in the second figure indicate that NSP would need to spend approximately $150 million to provide non-diversified energy conservation resources equal to the generation resources provided by the PI plant in 1989 (8,279 gigawatt-hours).

Page 5.12, title of both figures revised to read:
"Non-diversified Electric Energy Conservation Supply".

Page 5.12, footnote added below second figure:
Prepared by EQB staff based on assumption that energy use in the NSP system is similar to energy use in Minnesota.

Page 5.12, add third paragraph:
The conservation and cost estimates stated above and represented in the graphs below do not account for system "diversity" or "coincidence". Diversity is broadly defined as a measure of the probability that energy conservation savings by individual electricity consumers will occur at different times. Coincidence is defined as the probability that savings will occur at the same time. In order for energy conservation to be an effective alternative to a base-load generating plant such as PI facility, conservation activities must be evenly distributed across nearly every hour of the year, and at each hour the amount of capacity saved must be equal to generating capacity lost. Individual conservation projects deliver unequal conserved energy resources at all time periods. To replace the constant block of energy provided by a base-load plant, conservation must be carefully mixed and matched to provide that same block across time. Therefore, a much more highly-detailed and more complex analysis of conservation options than is presented in this document would be required before any final determination can be made of how much conservation spending would be required to offset the PI facility.

Table of Contents, Appendices, add:
V. NSP Letter: Radiological Analysis

Appendices Cover Page, after page 8.12, add:
V. NSP Letter: Radiological Analysis