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IMPACT STATEMENT
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RESPONSIBLE AGENCY:

THE MINNESOTA ENVIRONMENTAL QUALITY COUNCIL

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PREFACE

The purpose of an environmental impact statement is to inform public and private decision-makers and the public of the environmental effects of proposed actions. It is an informational document which enables environmental constraints and opportunities to be considered in the development of an action. However, unlike most major actions which require environmental impact statements under the Minnesota Environmental Policy Act and Regulations, power plant siting and transmission line routing projects are specifically governed by the Power Plant Siting Act and Regulations. Therefore, it is important to understand the purpose of this environmental impact statement with the two processes in mind.

Since the Power Plant Siting Act creates a public forum for the evaluation of the environmental impacts of the proposed transmission line routing alternatives, and because the Power Plant Siting Act provides the authority to the MEQC to grant a construction permit and designate a route, the public forum created by that Act is the most effective place for citizen involvement and action. It is intended that this draft environmental impact statement serve as a tool for the public by providing the basic information necessary to take part effectively at the public hearings held by the MEQC under the authority of the Power Plant Siting Act. The Power Plant Siting Rules and Regulations appear in Appendix C for reference purposes.

The routing alternatives contained in this Draft EIS are only those routes that have been proposed by Northern States Power Company. Among the alternatives is the route that is preferred by the utility company. It connects nodes 1-2-4-5-7-8-9-10-11-15-16-18-20-21-23-24 25-26-30-34-35 on the fold-out map in this section.

Other routing alternatives are currently being considered by the citizen's Route Evaluation Committee and the MEQC's Power Plant Siting Staff. The Route Evaluation Committee is an MEQC appointed committee of citizens that live in or near the affected area who analyze routing alternatives and make recommendations on a preferred route to the Hearing Examiner at the public hearings and to the MEQC prior to their final determination. The names and addresses of the members of the Citizens' Route Evaluation Committee appear in Appendix G.

The MEQC will determine which routes are to be considered at the public hearings which will be conducted in mid-November in each county through which the line passes. The final environmental impact statement will include the information generated on the routes considered at the public hearings.

INTRODUCTION

Pursuant to the provisions of the Power Plant Siting Act, Northern States Power Company applied for a permit for the construction of a single circuit 500 kV ac transmission line and associated facilities within the corridor approved by the Minnesota Environmental Quality Council on May 7, 1976 which extends from Forbes to near Warroad, Minnesota. The Minnesota Environmental Quality Council accepted the application on July 13, 1976 and pursuant to the provisions of the Minnesota Environmental Policy Act, ordered the preparation of an environmental impact statement, naming itself as the responsible agency.

The proposed project is one of four separate projects (See Figure i-1) which will comprise a high capacity interconnection between the Manitoba Hydro, Minnesota Power and Light and Northern States Power electric power systems. One of the projects will be a 500 kV transmission line to extend from Winnipeg, Manitoba to the Manitoba - Minnesota border and will not be reviewed by the State of Minnesota. The other three projects include a 345 kV/500 kV segment from the Twin Cities Metropolitan Area to the Kettle River in Carlton County; a 500 kV segment from the Kettle River to Forbes, which will tie into a proposed but yet unsited MP&L 800 MW generating unit; and the Forbes to Warroad segment which is evaluated herein. All three of the projects that are within this state must be evaluated and approved by the Minnesota Environmental Quality Council. The Minnesota Energy Agency issued a Certificate of Need for the interconnection in June 1976.

The following is a summary of the current status of the MEQC review of the three projects in Minnesota.

Twin Cities to Kettle River

The Corridor application for this project was accepted by the MEQC in December, 1974. Public hearings were held and the MEQC granted a Certificate of Corridor Compatibility in July, 1975. In February, 1976, NSP submitted an application for a construction permit to the MEQC. Public hearings were held in May and June and the MEQC designated a route and issued a construction permit in August, 1976.

Kettle River to Forbes

This project was originally included in the corridor application received in December, 1974, for a Twin Cities to Forbes project. After the MEQC granted the Certificate of Corridor Compatibility for the line, MP&L decided to upgrade the capacity of a proposed generating facility from 500 mW to 800 mW, necessitating a tie-in with the 500 kV transmission line. Since two of the three proposed generating sites were outside of the designated corridor, MP&L and NSP decided to divide the project in two in order to expand the northern portion of the designated corridor to include all of the proposed generating sites. To accomplish this, MP&L applied to the MEQC in February, 1976 for a new corridor that extended from the Kettle River to Forbes. The MEQC held a hearing in May and granted a Certificate of Corridor Compatibility in August, 1976. MP&L is expected to apply to the MEQC this fall for a route and a construction permit, pending designation of a site for the 800 MW generating unit.

Forbes to International Border

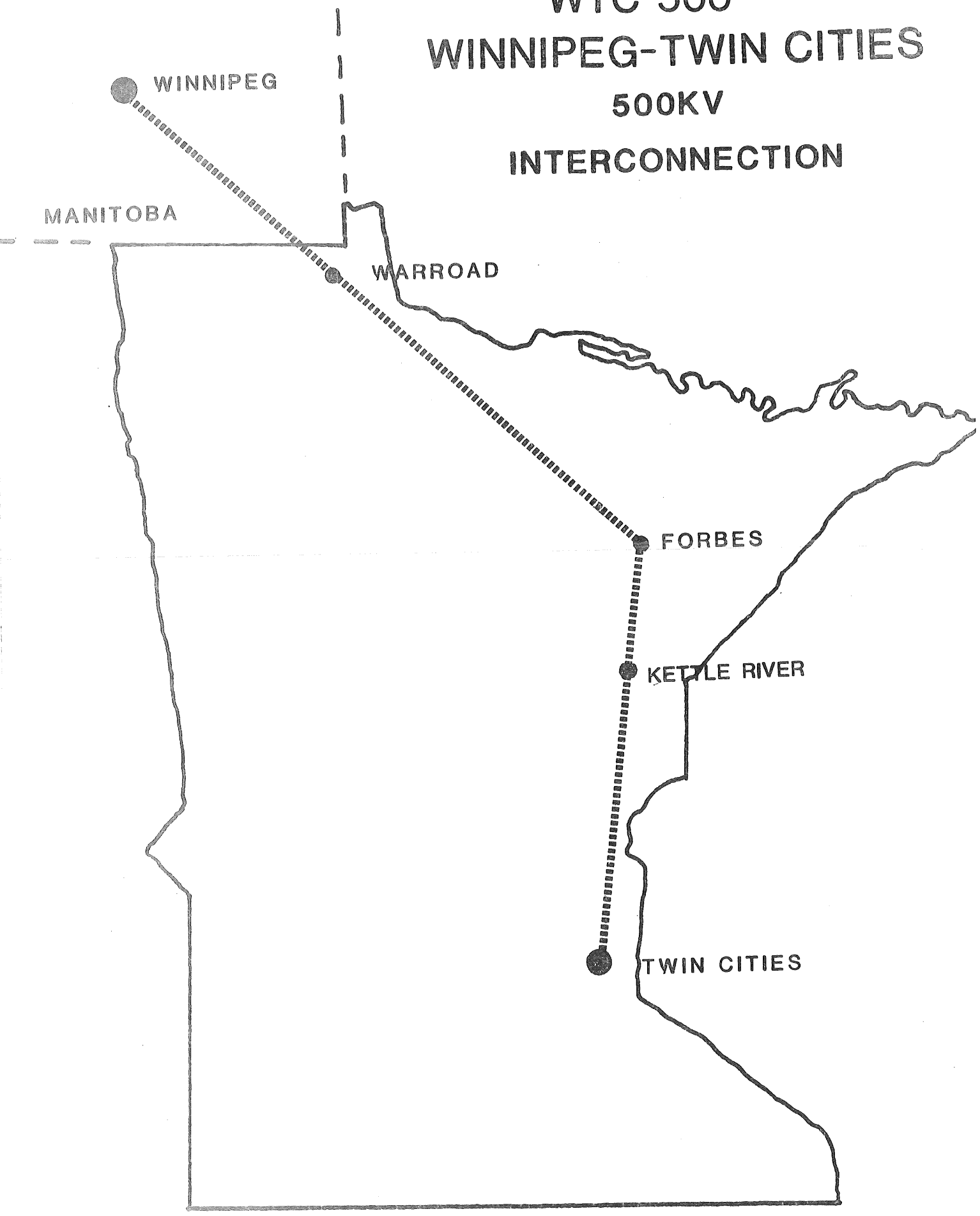
The MEQC approved a corridor for this project in May, 1976, after public hearings. NSP applied for a route and a construction permit in July, 1976. This application is the subject of the evaluation herein. The MEQC Findings of Fact, Conclusions and Corridor Designation can be found in Appendix E.

OTHER PERMITS

In addition to the MEQC Construction Permit and the Minnesota Energy Agency Certificate of Need, the following state and federal permits or certifications may have to be acquired:

Agency	Requirement
Minnesota Department of Natural Resources	Permit to Cross Public Waters Permit to Cross Public Lands Permit to Work in Public Waters
Minnesota Pollution Control Agency	Review of Water Crossings
Minnesota Department of Aeronautics	Review of Route to Determine Hazard to Aircraft (Airports, Spherical Marking, etc.)
Minnesota Highway Department	Permit to Cross State and Federal Highways
U.S. Corps of Engineers	Permit to Cross Navigable Waterways
Federal Aviation Administration	Notice of Construction and Determination of No Hazard to Aircraft (Structures over 200' high or near Airports)
Federal Power Commission	Permit to Cross International Boundary

WTC-500
WINNIPEG-TWIN CITIES
500KV
INTERCONNECTION



I PROJECT DESCRIPTION

CHAPTER 1 DESCRIPTION OF PROPOSED ACTION

1.1 PURPOSE OF PROJECT

As previously mentioned, the Forbes-International Border (F-IB) Project is one of four projects which will comprise a 500 kV interconnection between Winnipeg and the Twin Cities (WTC-500). The primary purpose of the F-IB project is to provide the third link in the interconnection.

WTC-500 has been proposed to provide a high capacity transmission network of mutual benefit to the electric systems involved: Manitoba Hydro, MP&L and NSP.

Manitoba Hydro's electric system receives energy from generating facilities powered by water, a shortage of which rarely occurs. As a result, the company will usually have surplus water which can be used to generate additional energy, given an accessible market. The electrical generating facilities in NSP's (and MP&L's) system are predominantly nuclear and fossil fueled.

Both systems have electrical generation facilities to insure an adequate supply of power in case of abnormal conditions, e.g. an equipment breakdown or shortage of water.

A connection of the two systems with a high capacity transmission line would benefit both. Peak demands on Manitoba Hydro's system occur in winter while peak demands on NSP's system occur in summer. During winter NSP could transmit excess power to help supply peak demands on Manitoba Hydro's system, with an opposite exchange occurring during the summer. In addition, the capacity for exchange would further insure the margin of energy reserve NSP is required to maintain as a member of a power pool. This issue is further addressed in the Certificate of Need.

1.2 PROJECT DESCRIPTION

The proposed F-IB Project consists of a 500 kV single circuit transmission line travelling north from a substation near Forbes, Minnesota, to a point on the US/Canadian border, approximately three miles west of Marvin Lake.

The engineering and construction specifications for the line are detailed in Section 2.1, Construction and Engineering Development. A detailed description of the geographic area through which the line will travel is presented in Section 1.3, Environmental Setting of the Project.

1.3 ENVIRONMENTAL SETTING OF THE PROJECT

1.3.1 NATURAL SYSTEMS

The soils, climate, depth of water table, geology and post glaciation history of the various physiographic regions within the corridor have resulted in a variety of vegetation and associated wildlife species. Natural systems over portions of the area have been greatly modified by man's activities, such as logging and agriculture. Other changes are the result of numerous forest fires which occurred in the past. The sections that follow discuss the vegetation types, plant communities and wildlife species that are presently within the corridor.

1.3.1.1 Vegetation and Habitat

1.3.1.1.1 Vegetational Types and Historical Changes

In contrast to the Forbes-Twin Cities corridor, the Forbes-International Border (F-IB) corridor does not traverse such a wide range of vegetative types, nor has this corridor been influenced as much by man's activities. A comparison of Marschner's (1930) map of the original vegetation of Minnesota with more modern maps indicates that several of the vegetational types originally found within the corridor remain largely intact. Table 1.3-1 gives the approximate percentage of each type originally occurring within each of three segments of the study area. There is a large amount of conifer bog and muskeg habitat, especially in northwestern portions of the corridor. Together, these two types represent nearly 50 percent of the total acreage of the corridor area and form the extensive deposits of peatlands, discussed in Section 1.3.4. They have, as yet,

been largely unaffected by man's activities. In contrast, several other habitat types, especially prairie and aspen-oak, have been greatly modified by man. These types mainly occurred in the northwestern segment of the study area and have since been largely converted to agriculture.

Other vegetative types have been greatly modified by insect damage, lumbering, natural and man-made fire, drainage, and other human activities. Heavy lumbering activities and the fires which followed (largely between the 1880's and the 1920's) eliminated most of the virgin stands of red and white pine timber once found in the upland areas. These original forests have been largely replaced by aspen and birch or by jack pine.

Stands of these "fire-successional" species are rather short-lived, however, for they are shade intolerant and cannot reproduce in their own shade. The aspen-birch types that comprised over 30 percent of the original vegetation (Marschner, 1930 and Table 1.3-1) became even more abundant and continued to dominate most of the upland area within the corridor during the 1930's and 1940's. This type, however, is now beginning to be replaced by the more shade tolerant conifers such as white spruce and balsam fir. Thus many areas within the corridor (at least those that have not been modified to any extent by agricultural practices) are now beginning to revert back to a climax coniferous vegetation.

1.3.1.2 Plant Communities of the Study Area

A number of authors have reviewed the kinds of plant communities to be found within the study area. Braun (1950) and Küchler (1964) have reviewed the present or potential vegetational communities of large areas of the U.S. On a more regional basis Curtis (1959) provides considerable detail concerning plant communities in forests of nearby Wisconsin, while Janssen (1967), Buell and Cantlon (1951), and Buell and Martin (1961) have discussed the plant communities of northwestern Minnesota. Ohman and Ream (1971) have reviewed the northeastern Minnesota plant communities found in the Boundary Waters Canoe Area. Heinselman (1963, 1970) has perhaps the most detailed and recent review of vegetational communities occurring in the peatlands of former glacial Lake Agassiz that covered such a large portion of the present study area. Table 1.3-2 reviews the plant community concepts of these latter two authors.

In any classification of vegetational communities it is difficult to delineate discrete types because most communities form a continuum, a gradual blending of one community into another along some environmental gradient, often determined by moisture availability. (See Curtis, 1959) In contrast, however, there may often be an abrupt replacement of one plant community with another, often over a distance of only a few feet. This is the case with several of the vegetational types discussed by Heinselman (1970), who found that several types of bog communities could be sharply differentiated from each other on aerial photographs.

The classification of plant communities is further complicated by several factors; one is the major influence of fire and man's activities in determining present vegetational communities. Another factor is that there are differing views on what the climax or final vegetational type

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will be in any given area. Heinselman (1963) largely rejected the climax concept for peatland communities while Buel and Cantlon (1951) postulate a poly-climax view. In the Itasca Park region, he considered the climax vegetation to be maple-basswood on fine-textured soils, fir-spruce-birch on coarser soils and ash-elm-fir on peatland soils. He also felt that an absence of fire and gradual climatic changes were bringing about a replacement of both pines and prairie by hardwoods.

Table 1.3-3 summarizes the classification of plant communities and lists typical plant species for each type. A more generalized view might have made this classification less detailed, for Küchler (1964) lists only three or four plant communities as potentially occurring within the area. His classification included: Great Lakes spruce-fir (white spruce, balsam fir), conifer bog (tamarack, black spruce and white cedar) and Great Lakes pine (jack, red and white pine). In contrast, Ohman and Ream (1971) list 12 communities for just the upland area of a much smaller region, the BWCA of northeastern Minnesota, while Heinselman (1970) has delineated seven separate communities within the rather restricted habitat of conifer bog and open muskeg peatlands of extreme northern Minnesota. (See Table 1.3-2 and 1.3-3.) Table 1.3-3a lists the common and scientific names of plants found in the study area.

1.3.1.2 Terrestrial and Aquatic Wildlife

1.3.1.2.1 Terrestrial Wildlife

The varied environment of the area, including bogs, muskegs and other wetlands, streams, lakes, forested lands, meadows, agriculture land and abandoned fields, provide habitat for a variety of wildlife and non-game species. Vegetative types range from Boreal forest to northern hardwood

and prairie. As a result, most species of wildlife characteristics of northern Minnesota occur within the study area. A summary of the more common birds and mammal species and the plant communities usually associated with them is given in Table 1.3-4. Table 1.3-5 lists the acreage of wildlife areas in the corridor by county.

1.3.1.2.1.1 Birds

The most important upland game birds of the area are three species of grouse: the ruffed, sharptailed and spruce grouse. The first species is strongly dependent on forests containing aspen. Ideal habitat for this grouse should contain a variety of age classes. It is found throughout the study area. Sharptailed grouse occur largely in the northwestern part of the study area, north and west of upper Red Lake, but also occur in the southeastern section, along the edge of the corridor in western St. Louis County. The preferred habitat of the sharptail is in open fields bordering brush lands. The spruce grouse prefers undisturbed coniferous forest and is closely associated with spruce bogs. While the first two grouse listed are important game birds in the area, the latter species is hunted very little and cannot be considered an important game species. The study area lies within its chief range within the state.

The woodcock, a migratory bird, is most abundant in alder and aspen-willow lowlands throughout the southern third of the corridor. It is absent or uncommon in much of the coniferous forest and bog region of the study area, for its chief range lies to the south and east. The introduced pheasant prefers agricultural habitat and is rare or absent this far north. Several species of waterfowl are largely restricted to nesting in this portion of the state. Included are the black duck, American widgeon, ring-necked duck, common goldeneye and the common and red breasted mergansers. Other species associated with an aquatic environment include the herring gull and common tern.

Avian predators, including hawks and owls, occur as migrants, summer residents and permanent residents. Upper and Lower Red Lake and other large lakes of the region are well known as nesting sites for the osprey and bald eagle. The breeding range of these two species is restricted to northern Minnesota and completely overlaps the study area (Green and Janssen, 1975). The goshawk, merlin and great gray owl are also typical of this region.

Green and Janssen (1975) list 60 species of birds with "primary habitat in the northern coniferous forests" of the study area. Besides the spruce grouse, birds of prey and water-associated birds cited above, important or distinctive species include the northern and black-backed woodpeckers, gray jay, raven, and several species of fly catchers, thrushes, kinglets, and vireos. The largest group of birds restricted to this type of habitat are the warblers (19 species) and finch group (eight species). Many of the warblers, and species such as the spruce grouse, hermit thrush and junco, are restricted to the muskeg-black spruce bogs of the peatland area. Additional information on the type of bird species utilizing specific vegetational types within the corridor is given in Table 1.3-6. Note the variety of plant communities needed to provide habitat for a diverse group of bird species and that some species are very specific in their habitat preferences.

1.3.1.2.1.2 Mammals

Approximately 55 species of mammals inhabit the study area. These range in size from small shrews to the moose. Many of these species are found throughout the state or reach the limit of the northerly range within the

study area. However, approximately 18 species are restricted to the coniferous forest region of northern and northeastern Minnesota. A listing of mammals and birds typical of this area and the plant communities in which they are most likely to be found is shown on Table 1.3-4. Characteristic of the large mammals most closely confined to the boreal forest of northern Minnesota (and adjacent Canada) are the fisher, marten, lynx, moose and formerly the caribou. Table 1.3-4 also lists several other species such as the snowshoe hare, red squirrel, porcupine and many smaller species of shrews, moles and mice (e.g. arctic and water shrews, star-nosed moles, bog lemmings and rock voles) which are characteristic of northern Minnesota bogs and coniferous forests.

Carnivores common to the area, but not confined to it, include the black bear, bobcat, coyote, otter and red fox. This is also the only area of the U.S. where the timber wolf is found in any number. This latter species is discussed in more detail in the next section on endangered species.

Furbearers associated with the aquatic environments are beaver, mink, muskrat, otter and raccoon. Other furbearers found in upland habitats include members of the weasel family, such as the striped skunk, several species of weasel and the fisher and marten previously mentioned.

White-tailed deer, the most abundant big game animal, finds its optimum habitat in the earlier stages of forest succession, such as the young aspen stands preferred by the ruffed grouse. Some agriculture with open fields is also desirable. Conifers are desirable for winter shelter, especially white cedar swamps which provide both food and shelter.

Much of the study area under consideration harbors a fair to good population of deer, especially the "common corridor" or lower end of the study area and that portion of the study area north and west of the vast area of open muskegs and black spruce swamps above Red Lake. Most of this latter type of vegetation furnishes rather poor derr habitat. An indication of the deer harvest in counties throughout the study area is tabulated below:

COUNTY	Harvest 1974	1975
Roseau	2125	2213
Lake of the Woods	1345	1431
Beltrami	3271	3542
Koochiching	2064	2255
Itasca	5505	5751
St. Louis	4452	4250

The moose population of northern Minnesota is split into two main ranges: the northeastern population, found chiefly along the North Shore and in the vicinity of the BWCA, and the northwestern population, which is located in the region bounded by the Red Lakes, the Red River Valley and Canada.

Although a few moose are found throughout much of the study area, the chief huntable population is located in the northwestern section in Roseau and Lake of the Woods Counties. During the 1975 moose permit seasons, hunter success in Zone 1, south of Warroad, was 79 percent (79 killed of an allowable 100). Hunter success in adjacent smaller zones to the west was 100 percent, with an overall average of 94.5 percent for the northwestern zone (Department of Natural Resources, news release dated December 31, 1975).

Moose are similar to deer in that they avoid the vast expanse of open muskeg of the bog area but find ideal habitat in the fringing conifer swamps and the aspen-willow brushlands characteristic of the northwestern portions of the study area.

1.3.1.2.1.3 Rare and Endangered Species

Moyle (1975) has discussed all rare and endangered species of Minnesota while the Department of the Interior (U.S.D.I., 1973, 1974) has reviewed those species considered to be endangered or threatened by the federal government. Morley (1972) has reviewed by county those species of plants thought to be rare in Minnesota. Table 1.3-7 sums up current information on species in need of "special consideration."

The peregrine falcon is the only species appearing on both these lists as endangered. It now occurs only as a rare migrant in Minnesota, although formerly it was a resident along the North Shore and in the BWCA. Nesting activities in these areas was last reported in 1964, (Janssen and Green, 1975). Other rare wildlife species which may occur in the area include the pine marten and greater sandhill crane. The latter species is largely confined to bog areas in the northwestern section of the study area in Lake of the Woods and Roseau Counties. The pine marten has only recently appeared in northeastern Minnesota after having been extirpated since some time before 1900 (Gunderson and Beer, 1953). Both of these are classified as "threatened species" by Moyle (1975).

Species such as the timber wolf, bald eagle and osprey occur in the area also but are "not presently considered endangered or threatened" by Minnesota authorities, although the Federal government considers the timber wolf as endangered and has given the pine marten an "undetermined" status

(U.S.D.I., 1973). A "recovery" plan for the wolf has recently been prepared by the State of Minnesota and cooperating federal agencies. Much of the main range of the wolf is within the study area.

Other animals typically found within the corridor that have been classified by Moyle (1975) as "species of special interest" include the bobcat, common loon, pileated woodpecker, common newt and several kinds of plants, including three species of ladyslippers and the eastern hemlock. Within or near the study area, small stands of the latter species are confined to a few localities in Itasca and St. Louis Counties.

Morely (1972) lists a number of plants considered to be rare within the counties of northern Minnesota. However, most of these species are listed for the specialized habitat found in St. Louis and/or Lake and Cook Counties of extreme northeastern Minnesota and probably do not occur within that small portion of west central St. Louis County within the study area.

1.3.1.2.2 Aquatic Wildlife

A variety of fish are found in the lakes and streams. For the most part the lakes are relatively shallow, warm-water fish lakes although deeper, cold-water lakes also occur. Streams vary from small, cold water trout streams chiefly in Itasca and St. Louis Counties, to larger, warm water rivers. Two chief rivers within the corridor are the Big Fork and Rapid Rivers. Warm water fish species include the common sucker, various species of redhorse, dace, shiners chubs and minnors, black bullhead, northern pike, yellow perch, walleye, small-mouth bass, large-mouth bass, sunfish, bluegill, black crappie and stickleback.

Trout occur principally in the small cold water feeder streams. They, together with one or more species of salmon, have also been planted in some of the smaller to medium-sized deep lakes, especially in Itasca County. The eastern brook or speckled trout are native to Minnesota and the study area. They have also been widely planted in area streams which did not originally have native populations. Brown trout and the rainbow trout have been introduced into streams of the area with varying degrees of success.

1.3.2 SURFACE HYDROLOGY

The corridor lies within three major watershed basins, the Hudson's Bay, Lake Superior and Mississippi River Basins. The Little and Big Fork Rivers, Red Lake River, Roseau River and Rainy River Basins are the most important subdivisions of the Hudson's Bay Basin in the corridor. The St. Louis River Basin is the only major subdivision of the Lake Superior Basin in the corridor. There are no major subdivisions of the Mississippi River Basin in the corridor.

There are no large concentrations of lakes within the corridor. The corridor passes near the northeast corner of Upper Red Lake and the southern margin of Lake of the Woods. The corridor also passes through a minor concentration of lake basins in Itasca County. School, Deer Creek, Birch and Bear Lakes are the lakes in the grouping with a significant amount of recreation home development.

The most significant hydrologic feature in the corridor is the Big Bog. The Big Bog is an extensive, poorly drained region, containing broad peat deposits, located in Koochiching, Beltrami, and Lake of the Woods Counties. The Big Bog was formerly the bottom of Glacial Lake Agassiz.

While the bog surface itself is mostly flat, in certain areas it is encised by streams and rivers such as the Big Fork. Drainage remains poor throughout, due to predominant flatness away from the rivers and the moisture retentive qualities of peat soils in the bog. Numerous other smaller bog areas also exist within the corridor. These are located throughout the Pine Moraine and transitional geomorphic regions, where successive ages of glaciation and erosion left the region with a poorly developed drainage system, characterized by numerous ridges and interspersed bog areas in the valleys.

Table 1.3-8 lists the major streams and rivers that cross the corridor. The Big Fork River is the only major river that must be crossed by the transmission line. The Big Fork originates in Itasca County and flows northerly through Koochiching County, to its confluence with the Rainy River on the Canadian-U.S. border. The most significant feature of the Big Fork River is its potential for recreation and its importance as a major feature of the local ecosystem. There is no significant use of the Big Fork River for municipal water, irrigation, industry or transportation.

1.3.3. CLIMATOLOGY

The study area lies within a continental climate zone having great extremes in temperature. Topography and vegetative cover moderately influence the weather. The eastern, somewhat hilly and heavily forested region is generally subject to greater precipitation and lower average wind velocities than the west, which is flat and less heavily forested.

Extreme temperatures for the period of record range from a minimum of -50^{o} to a maximum of 107^{o}. Precipitation ranges from 20 inches per year in the west to 28 inches in the east. Forty to 60 inches of snow per year is typical. (State Planning Agency, 1969). Mean wind speed varies from 9 to 12 mph. (Watson, 1975). Thunderstorms occur on about 29 days per year (State Planning Agency, 1969) with measurable precipiation occurring an average of 100 days per year in the west and up to 135 days per year in the east (National Oceanic and Atmospheric Administration, 1974).

Heaviest precipitation occurs during the summer months. Consult Tables 1.3-9 and 1.3-10 for information regarding intensity and duration of rainfall. Freezing rain and glaze occur only about once a year due to the lack of above-freezing temperature at high altitudes this far north during the winter. (National Oceanic and Atmospheric Administration, 1974). Frost generally penetrates 36 to 60 inches into the ground (State Planning Agency, 1969), providing excellent road foundations for winter construction in swampy areas. However, if heavy snows occur before protracted freezing, soils may freeze to only a few inches depth.

Climatic factors of special importance to transmission lines are strong winds, intensity and duration of rainfall and lightening. Strong winds are closely correlated with thunderstorm activity and severe winter storms. These may be gusty and shifting winds. Tornadoes with severe convective activity are infrequent, occurring only 0-2 times per year in the northern half of the state. (Flora, 1973). Lightening is frequent during thunderstorms. Heavy fog occurs on an average of 15 days per year in International Falls. (National Oceanic and Atmospheric Administration, 1974).

1.3.4 SOILS AND GEOLOGY

The soils in the corridor are largely a product of glaciation and lacustrine deposition. Both types have been modified by weathering, erosion and peat formation. Much of Koochiching, Roseau, Lake of the Woods and Itasca Counties were formerly covered by Glacial Lake Agassiz. Successive expansion and contraction of this former lake left a lacustrine soil base with numerous small beach ridges in these counties. The lacustrine soils consist of sand and clay deposits. The beach ridge materials consist more of sand and gravel. Decline of Lake Agassiz left a largely level, poorly drained topography ammenable to the development of peat soils. These peat soils overlay the lacustrine base and now cover large areas in Koochiching and surrounding counties.

Elsewhere in Itasca and St. Louis Counties, the soils are more a result of glaciation. Successive advances and retreats of the Rainy glacial lobe and the St. Louis sub-lobe left a typical glacial soils region of ice scoured ridgetops, with exposed bedrock interspersed with peat soils in the poorly drained valleys and sandy and gravelly soils in the level areas of glacial outwash.

Of particular geological note in the region is the Giant's Ridge, an elongated granite extrusion extending about 90 miles on a southwest to northeast orientation in Itasca and St. Louis Counties. The ridge is up to 500 feet higher than surrounding topography and has numerous granite outcroppings. It intersects and crosses the corridor about 10 miles northeast of the Forbes Substation.

Peat, iron, taconite, copper and nickel mineral resources occur within the corridor. In fact, there are extensive peat resources throughout northern Minnesota. About half of the mainland U.S. peat resources are located in Minnesota. Peat consists of an accumulation of vegetable matter in various stages of decomposition. It forms in locations where water retards aerobic decomposition during most of the year. The peat is found in beds up to 20 feet in depth with the average depth being closer to six feet. Peat varies in age from 100 to 10,000 years depending upon its depth in the deposit.

Peat has been used for a variety of purposes ranging from crop production to soil conditioner. Recently it has assummed importance as a potential energy resource. Its energy potential has been exploited elsewhere, notably in Ireland and Russia. Prior to recent increases in energy prices, generation of energy from peat was not considered economically feasible. In 1975 Minnegasco applied to the Department of Natural Resources for a lease on state lands containing peat deposits, with the intention of evaluating the tehnical and economic feasibility of natural gas generation from peat. The technical problems are not substantial, but economic limitations may be. Natural gas generation from peat is a labor intensive process. Also, peat has a low Btu content (6,800 Btu/lb) and high water content - up to 90 percent water content before drying and about 30 percent after drying.

Generation of natural gas from peat could also pose considerable environmental problems. These are currently being evaluated. Peat with the highest potential for natural gas generation occurs in numerous locations.

With respect to iron and taconite, knowledge of the resource is more definite than with peat. Based on years of mining and exploration experience, the iron mining industry has a better comprehension of the location and economic feasibility of the available resources in the Mesabi formation.

Much of this information is the proprietary knowledge of the various mineral leaseholders and is not available for publication. However, it is generally known that ores with recoverable concentrations of iron are located in the Mesabi Range on the south edge of Giant's Ridge. The Mesabi Range extends from Grand Rapids northeasterly to Babbitt. Open pit mines, tailings ponds, water storage reservoirs, taconite plants, associated mining facilities and a series of mining communities characterize the range area. The complex of existing and potential mining areas extends across the corridor northeast of the Forbes Substation.

Copper and nickel resources are also found within the corridor. The ore is low grade and, under present market conditions, may not be profitable to mine. The ore deposits are located north of Giant's Ridge in Itasca County. Exploration for additional ore deposits has also taken place in areas of the Big Bog.

1.3.5 AGRICULTURAL LAND USE

The significance of agriculture as a predominant economic activity varies substantially among the counties included in the corridor. Agriculture increases in significance from southeast to northwest. Except for Roseau County, the percentage of each county in farmland is quite low. As shown on Table 1.3-11, in 1975, 50.8 percent of

Roseau County was in farmland. Percent of the other five corridor counties in farmland ranged from 3.5 in St. Louis County to 11.4 in Beltrami County. The average for these five counties was 5.9 percent.

Substantially less of each county area is in harvested cropland. Table 1.3-11 shows that in 1973 a low of .8 percent of Koochiching County and a high of 19.5 percent of Roseau County was in harvested cropland. Of the total six-county area, only 3.0 percent was in harvested cropland in 1973. Excluding Roseau County, that figure falls to 1.6 percent. Hay is the predominant crop in terms of harvested acreage. Table 1.3-12 shows that oats and wheat were the other crops most commonly harvested in 1974. Close grown field crops rather than row crops predominate in this part of the state. This is significant since the transmission line will have less effect on production of close grown field crops than on row crops. Table 1.3-13 shows the acreage of total cropland actually within the corridor area. There are concentrations of cropland in Roseau and Lake of the Woods Counties and to a lesser extent in St. Louis County. Elsewhere in the corridor, cropland is widely dispersed.

In 1969 there were about 950 acres of irrigated cropland in the six counties. Since that time, irrigated acreage has likely increased, but probably not to any significant degree. There is no irrigated cropland within the corridor with the exception of canal irrigation used for rice crops near Upper Red Lake.

The number of farms in the six corridor counties has been steadily declining, or at best remaining constant after years of steady decline. This follows similar national and state trends of consolidating farm units with productive cropland and abandoning farm units with marginally productive cropland. Table 1.3-14 shows that between 1969 and 1973 the number of farms remained nearly constant in Koochiching and Beltrami Counties and declined in the other four counties. The number of farms in the six-county area declined by 9.1 percent, compared to a statewide decline of 4.1 percent for the same period.

The amount and types of agricultural land within the corridor are shown in Table 1.3-15. The good, average and marginal classifications are based on soil-types. (Minnesota Soils Atlas Project, 1971). This table indicates that very little productive agricultural land is located within the corridor. Climate, field size, soil fertility and soil wetness create substantial limitations for agricultural production in this region. Table 1.3-16 provides information on determination of soils classifications in terms of total digestible nutrients and likely productive for various crops.

In 1973 total cash receipts from livestock exceeded total cash receipts from crops in the six-county area by a margin similar to that found statewide. Table 1.3-17 shows that only in Roseau County did cash receipts from crops exceed cash receipts from livestock. This is significant since the transmission line would have considerably less effect on production of livestock than on production of crops. Government payments contributed a small share of the total farm income in 1973, and have since declined.

The 1973, average net income per farm was substantially lower in most of the corridor area than it was in the state as a whole. In Roseau and Lake of the Woods Counties, net income per farm in 1973 was comparable to the state average. Table 1.3-18 shows, however, that the net income for each of the other four counties in 1973 was substantially below the state average. This reflects the marginal capability of most land in this area for agricultural production.

Table 1.3-19 shows that in 1969 the average value of land and buildings per farm in the six corridor counties was less than half of the state average. This again reflects the marginal capability of most of this area for agricultural productivity.

Since 1969, average value per acre of farmland has increased throughout the corridor. In 1969, according to Raup and Christianson, the average value of farmland in northeast Minnesota was estimated to be $59 an acre. In 1974 it was estimated to be $144 an acre, an increase of 144 percent. In 1974 the average value of farmland statewide was estimated by Raup and Christianson to be about $425 per acre.

Irrigation for wild rice production occurs in and around Waskish on the northeast shore of Upper Red Lake. Wild rice irrigation is accomplished using canals to flood rice beds rather than the sprinkler systems that conflict with electrical transmission systems.

1.3.6 FORESTRY

Forestry is Minnesota's third largest industry and is particularly important in parts of northern Minnesota. Timber cutting occurs in all of the counties within the corridor. Grand Rapids (Blandin Paper Company) in Itasca County and International Falls (Boise Cascade) in Koochiching

County are important lumber and pulpwood milling centers and both draw on timber lands within the corridor.

Table 1.3-20 shows that in 1962 commercial forest land covered more than 60 percent of the land in all corridor counties, except Roseau. Commercial forest land is defined as land capable of producing 20 cords per acre of wood annually. Noncommercial forest land consists of land not capable of producing timber of sufficient quantity or size to be economically utilized. The latter category is subject to continuous redefinition as developing technology and varying consumer demand change the economic viability criterion. It is likely that substantial changes in technology and use of wood products since 1962 make that year's definition somewhat outdated. These data are currently being updated by the Minnesota Department of Natural Resources and the North Central Forest Experiment Station. The updated information will not be available in the near future. Apart from possible changes in the definition of noncommercial forest land, significant changes are unlikely in the updated inventory. Forestry functions on a sustained yield basis with cut-over areas being immediately reseeded. Harvesting since 1962 would not, therefore, significantly change the inventory of forest land. Table 1.3-20 also shows the 1962 growing stock and volume of saw timber available for harvesting. It is worth noting that in 1962 the six counties in the corridor accounted for over 50 percent of the entire state's growing stock. That same figure for 1976 would probably not differ substantially.

The forest land category includes all commercial and noncommercial forests, publicly and privately owned, having more than 10 percent crown cover. Tables 1.3-21 and 1.3-22 list forested and plantation lands within the corridor respectively. Most of the forested land outside of the bog

areas is of commercial quality. There are also pockets of merchantable timber within the Big Bog.

Production and use of forest products in this country will increase substantially in the near future. Forest products, as a renewable resource, preserve an ultimate alternative to the many petroleum-based plastics used for packaging and other purposes. In fact round wood production in Minnesota is projected to increase by more than 200 percent by the turn of the century. Table 1.3-23 shows that pulpwood production since 1970 has already increased by 30 percent in the six counties in the corridor and by 29 percent statewide. Most of the production increase has occurred in Itasca, Koochiching, Beltrami and St. Louis Counties. In 1974 no significant production of pulpwood was reported in Roseau County while production in Lake of the Woods County declined by one-third.

The existence of the forest industry in the corridor area is significant since tree growth in the transmission right-of-way would be restricted to low growing species. The transmission line can, however, provide a positive benefit in a timber region by functioning as a fire break.

1.3.7 RECREATION AND HISTORIC LAND USE, AESTHETICS

Recreation is an important facet of Minnesota's economy. In 1975 tourist travel generated $1,106,000,000 into the state economy. This accounted for 3.2 percent of total state transactions for that year. (Minnesota Department of Economic Development, Research Service). The recreation industry is an even more important facet of the economy of many local areas where recreation may be the primary economic activity, especially in parts of northern Minnesota. The

corridor passes through the heart of the Minnesota recreation region but avoids specific areas with high concentration of recreational activity. Such areas will also be avoided in the routing process. The Superior National Forest, Boundary Waters Canoe Area and Kabetogama National Park lie north and east of the corridor. The Chippewa National Forest and largest concentration of Minnesota recreation lakes lie south and west of the corridor.

The corridor contains a number of outdoor recreation facilities exclusive of municipal parks. Major recreation areas in and near the corridor include the Chippewa National Forest, Superior National Forest, Boundary Waters Canoe Area, Kabetogama National Park, Scenic River State Park, McCarthy Beach State Park, Hays Lake State Park, Zipple Bay Recreation Area, Big and Little Fork, St. Louis and Rainy Rivers. Of these, only the Big Fork and Rainy Rivers lie within the corridor. They are designated as canoe and boating rivers by the Minnesota Department of Natural Resources. Given the availability of funding, both will eventually be studied for inclusion in the Minnesota Wild, Scenic and Recreation Rivers System. The Big Fork runs diagonally across the corridor. The Rainy River, however, lies adjacent to the corridor and is not likely to be affected by the transmission project.

Scenic Rivers and McCarthy Beach State Parks, though not within the corridor, are also directly adjacent to the corridor boundary. This is significant since viewsheds from these parks would extend within the corridor.

In addition to these large formally designated recreation areas, there are numerous smaller designated recreation areas, as well as nondesignated areas within the corridor that serve a recreation function. These consist

of recreation lake-home development on School, Birch, Bear and Dear Creek Lakes, smaller and municipal park areas and public access and boat launching sites. Also of significance for recreation use are large blocks of public land which are commonly used for hunting, snowmobiling, camping and a variety of other outdoor recreation activities. There are several historic sites within the corridor. None has been developed for visitation or recreation purposes. Their only significance lies in potential disruption of the sites during construction of transmission facilities if their locations were not made known to construction personnel. At the request of the Minnesota Historical Society, exact locations are not mapped, to safeguard these sites from vandalism.

There is a wide range of scenic areas within and adjacent to the corridor. Many are found in parts of Itasca and St. Louis Counties where the combination of rolling terrain, coniferous forests and glacial lakes provide an exceptional visual resource. These visual amenities in a large part account for the number of designated recreation areas within the region.

1.3.8 RIGHT-OF-WAY SHARING

1.3.8.1 Existing Transmission Lines

Of the various utility corridors, existing transmission lines (69 kV and above) present the greatest opportunities for corridor sharing. Since such lines have already established a physical and visual intrusion in an area, and if all other factors are equal, a parallel line would create less additional impact than a new line.

There are several existing or proposed transmission lines which present opportunities for corridor sharing. Principal among them is the proposed MP&L-Minnkota Line (230 kV). Portions of this line in Roseau, western Lake of the Woods, southeastern Koochiching and Itasca Counties are included in the proposed routes. In St. Louis County the proposed 230 kV line from Shannon Substation northwest of Hibbing to the Forbes Substation is a potential shared route. Also in St. Louis County an existing 115 kV line runs west out of Forbes Substation to Kelly Lake. A proposed 115 kV line will connect this line to the Shannon Substation to the north.

A 69 kV line parallels State Highway 11 in Roseau and Lake of the Woods Counties. This line is deflected around several towns along the route and thus is not considered as a potential route. Other transmission lines exist in St. Louis County, but because of either their direction or route, do not lend themselves to corridor charing.

1.3.8.2 Oil/Gas Pipelines

Oil and gas pipelines present a minor opportunity for corridor sharing with transmission lines. Pipelines have a generally small initial impact both in terms of land use disruption and visual impact. Within the corridor only two pipelines could be paralleled. They are gas pipelines; one runs east-west from Eveleth to Keewatin, the other is a spur of this line which runs north to Chisholm and Buhl.

1.3.8.3 Railroads

Railroads present both opportunities and constraints to transmission routing. Opportunities exist with respect to corridor sharing and

minimizing overall impact. There are, however, several constraints presented by railroads. First, transmission lines create a visual impact upon passenger trains. A second constraint exists with the numerous communities situated adjacent to most rail lines. Such communities are often large enough to necessitate major deflections in transmission lines that would otherwise parallel the railroad right-of-way. For example, the Canadian National Railroad along State Highway 11 goes through Baudette, Williams, Roosevelt, Warroad, etc. Paralleling this trackage for any distance would necessitate many deflection points and cause much urban disruption. Transmission lines also have the potential for disrupting railroad communications along existing railroad lines.

1.3.8.4 Highways

Major highways considered as possible corridors for sharing were State Highways 1, 11, 37 and 72. A major problem when paralleling highways is avoiding buildings which are along the roads. Highways often pass through many small towns. For this reason available highways are discounted as routes when alternates are available. Visibility of transmission lines from highways is also a negative factor. Table 1.3-24 summarizes potential for utilization of existing rights-of-way.

1.3.9 URBANIZED LAND USE AND HUMAN SETTLEMENT

Municipal areas are unincorporated communities within the corridor are listed in Table 1.3-26. None of the unincorporated communities are large in population or built up area. Most of the corridor area is developed at a low density, with urban areas widely separated. One exception is the series of communities situated along Minnesota Trunk Highway 11

in Koochiching County. Baudette, Williams, Roseau and a number of unincorporated communities are located at about 10-mile intervals in this cluster.

Another exception is the concentration of Mesabi Range municipal areas, located diagonally across the corridor northwest of the Forbes Substation. These communities present a mostly continuous pattern of urban development and mineral extraction facilities and activities. Their location, coupled with the location of presently unexploited taconite resources, presents a constraint for transmission route selection.

There are additional minor clusters of development situated on lakeshore locations within the corridor. These occur mostly on Birch, Deer Creek, School and Bear Lakes in Itasca County.

Acreage from Red Lake and Deer Creek Indian Reservations lies within the corridor. There are numerous small concentrations on Red Lake Indian Reservation land in Roseau, Lake of the Woods, Beltrami and Koochiching Counties. Most of the Red Lake Indian Reservation land is located outside of the corridor.

The Deer Creek Indian Reservation occupies most of one township area, located in the center of the corridor in Itasca County. No other concentrations of Indian reservation land exist within the designated corridor.

The location of airports, microwave towers and other communication facilities is significant because of the potential disruption of their operation that may result from the location of a transmission line. The location of the Hibbing Airport and associated microwave communication facilities poses a particular constraint due to their proximity to the Forbes Substation.

1.3.10 SOCIOECONOMICS

Presented here are socioeconomic data which outline the corridor area's basic characteristics. Information on specific areas of social and economic importance is presented in other sections, e.g. Forestry, Agriculture.

1.3.10.1 Population Characteristics of the Study Area

Counties in the corridor area, excepting St. Louis, are rural in character and by nature very sparsely populated. Population density in these counties averages from three to 13.5 persons per square mile. St. Louis County, with a 1970 rural population of 61,721 and an urban population of 158,972, averaged 36.2 persons per square mile. Although this is the largest county in the area, only 14 communities, with a total population of 32,068, lie within the designated corridor. Local economies within the designated corridor are based primarily on forestry, mining and agriculture.

The total 1970 population of the counties in the corridor study area was 315,283. This indicates an overall population density of 18.1 persons per square mile. Included in the designated corridor itself are parts of 39 minor civil divisions (MCDs). The 1960 population of these MCDs totalled 45,734. The 1970 population was 41,046. This total excluded populations of the unorganized territories, for which 1960 data was unavailable. In 1970 the populations of the cities ranged from 48 in Fraser, in St. Louis County to 16,104 in Hibbing, also in St. Louis County. Chisholm, with a population of 5,913, is the only city in St. Louis County's corridor area with a population of greater than 4,000. The majority of MCDs included in the corridor are inhabited by less than 1,000 people.

Some of the population characteristics by county are outlined in Table 1.3-26. A further breakdown of population by MCDs is found in Table 1.3-27. As noted in the table, there were three MCDs that realized a population increase between 1960 and 1970. All other areas showed a decrease ranging from two to 49.5 percent. The estimated population for 1974 shows a decrease of one percent for St. Louis County and increases ranging from 2.4 percent for Koochiching County to 9.2 percent for Beltrami County. The overall population gain in corridor area counties is estimated at approximately one percent, which is somewhat lower than the 3.0 percent estimate for the state.

1.3.10.2 Employment

In 1970, on a six-countywide basis, the category of employment having the most members (18,005) was craftsmen, foremen and kindred workers. The category of employment with the fewest members (581) was farm laborers and farm forement. (See Table 1.3-28)

The percent of unemployment in the civilian labor force ranged from 6.9 percent in Beltrami County to 12.4 percent in Itasca, as shown on Table 1.3-29.

Median family income in the six corridor counties for 1970 ranged from $6061 in Lake of the Woods County, to $8997 in St. Louis County. (See Table 1.3-29) Throughout the six-county area most families came under the $10,000-$14,999 category of annual income. Only in Lake of the Woods County did a higher percentage of people come under another category. (See Table 1.3-29)

Further breakdowns of family incomes for each county are presented in Table 1.3-29. The following sections present employment profiles for each of the six corridor area counties, based on 1970 data.

1.3.10.2.1 Beltrami County

6.9 percent of the labor force (16 years and older) is unemployed. The median family income is $6995, with 10.7 percent of the families receiving $15,000 or more. The category of employment with the highest numbers of workers is service workers, other than private household. The category employing the least number of people is private household workers. (See Table 1.3-28)

1.3.10.2.2 Itasca County

12.4 percent of the labor force is unemployed here. The median income for families is $7985 with 7.7 percent earning $15,000 or more per year. The category of employment with the highest number of workers is craftsmen, foremen and kindred workers. The category employing the least number of people is farm laborers and farm foremen.

1.3.10.2.3 Koochiching County

8.2 percent of the labor force is unemployed in Koochiching County. The median income for families is $8508 with 11.7 percent earning $15,000 or more per year. The category of employment with the highest number of workers is operative, except transport. Farm laborers and farm foremen make up the category employing the lowest number of people.

1.3.10.2.4 Lake of the Woods County

Unemployment in Lake of the Woods County totals 9.0 percent. Median family income is $6061 per year with 5.6 percent earning $15,000 or more per year. Service workers, other than household, make up the category with the greatest number of workers. The category with the lowest number of employees is private household workers.

1.3.10.2.5 Roseau County

Total unemployment in Roseau County is 11.5 percent. Total median income for families is $7474 with 10.0 percent earning $15,000 or more per year. Farmers and farm managers make up the largest category of employment with private household workers making up the smallest category.

1.3.10.2.6 St. Louis County

Total unemployment in St. Louis County is 7.0 percent. Median income for families is $8997 with 13.1 percent earning $15,000 or more per year. Craftsmen, foremen, and kindred workers make up the largest category of employment with farmers and farm managers making up the smallest category.

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TABLE 1.3-1

APPROXIMATE PERCENTAGES OF ORIGINAL VEGETATIONAL TYPES WITHIN STUDY AREA*

	Common Corridor I	Common Corridor to Warroad II	West & South of of Warroad III	Complete Corridor IV
Approximate percentage of total corridor area	30	55	15	-
Aspen-Birch (potentially conifer)	50	20	23	29.5
Aspen-Birch (potentially hardwood)	8	2	1	5.0
Mixed hardwood and pine	3	-	-	.9
White and Norway pine	12	-	-	3.6
Jack pine	10	8	-	7.4
Conifer bogs and swamps	15	60	35	42.8
Open muskeg	-	8	5	4.5
River-bottom forest	<1	<1	1	1.0
Wet prairie	<1	<1	10	2.4
Prairie	-	-	5	.8
Brush prairie	-	-	15	2.2
Aspen-oak	-	-	5	.8

*Vegetational types as adapted from Marschner (1930)

TABLE 1.3-2

TWO CLASSIFICATIONS OF NATURAL PLANT COMMUNITIES
IN THE VICINITY OF THE STUDY AREA

BWCA Upland Natural Communities[1]		Peatland Plant Communities[2]
Community	Comments	
Lichen	On granite	1) Rich swamp forest (white cedar)
Jack pine (oak) Jack pine (fir) Jack pine-black spruce Black spruce-Jack pine	Successional black spruce or fir-birch	2) Poor swamp forest (tamarack)
Aspen-birch	Generally on better soils	3) Cedar string bog and fen complex
Maple-aspen-birch	As above, with red maple	4) Larch string bog and fen complex
White pine	Fire dependent	5) Black spruce-feather-moss forest
Red pine	As above	6) Sphagnum-black spruce, leatherleaf bog
Budworm-disturbed	Many dead balsam fir	7) Sphagnum-leatherleaf Kalmia-spruce heath
Fir-birch	"Climax" type, balsam fir dominates	
White cedar	On north-facing slopes	

[1]Adopted from Ohman and Ream, 1971.

[2]Adopted from Heinselman, 1970. These communities are reviewed in more detail in Part III of Table 1.3-3.

Table 1.3-3 CLASSIFICATION OF PLANT COMMUNITIES IN STUDY AREA

	COMMUNITY TYPE	MAJOR SPECIES	CHIEF ASSOCIATED SPECIES	COMMENTS
I.	Boreal forest (upland)			Characteristic of much of central and lower Canada
	Climax Stage			
	Spruce-fir	White spruce, Balsam fir	Conifers: white pine, red pine, white cedar Hardwoods: white birch, red maple, quaking aspen, mountain ash, balsam poplar Shrubs and herbs: beaked hazel, bush honeysuckle, speckled alder, mountain maple, dewberry, bishop's cap, blueberry, bunchberry, bedstraw, clintonia, large leaved aster, goldthread, starflower, sarsaparilla, Canada Mayflower. Many of these herbs are abundant and have a high constancy value, e.g., Canada Mayflower was found in every one of 110 boreal forest stands examined (Curtis, 1959)	Catastrophe, in the form of fire, wind or spruce budworm, often results in replacement of spruce-fir forest by even-aged stand of aspen and birch over wide areas.
	Successional Stages			
	Mixed conifer and hardwood	As above with red maple and some sugar maple		Shade tolerant hardwoods may gradually replace spruce-fir, especially on the southern, more mesic sites.
	Aspen-birch	White birch, quaking aspen and balsam poplar		Older aspen stands usually have a dense understory of balsam fir and white spruce. The aspen-birch (conifer) of Marschner, 1930.

Table 1.3-3

COMMUNITY TYPE	MAJOR SPECIES	CHIEF ASSOCIATED SPECIES	COMMENTS
II. Pine forests (Northern xeric forests) A. White pine - red pine	White and red pine	Conifers: white spruce, balsam fir, white cedar. Hardwoods: white birch, quaking aspen, red maple, northern pin oak. Shrubs & herbs - (Many similarities to boreal forest): beaked hazel, fly honeysuckle, Mountain maple, wintergreen, blueberry, Juneberry, sweet fern, sarsaparilla, feather mosses, bedstraw, Canada Mayflower, large-leaved aster.	These forests are fire dependent and most virgin stands of Jack and red pine are even-aged. Older stands without recent fire history may have dense understories of spruce-fir. White pine does best on the better sites
B. Jack pine	Jack pine	Red pine, northern pin oak, quaking aspen. May associate with black spruce, especially in northeastern Minnesota. Shrubs and herbs as in other pin forests but Jack pine barrens also include bearberry, bracken and reindeer moss.	Red and Jack pine may also occur together. Often found on sandy, glacial beach lines. Often dense, over-aged, may be an open forest (Jack pine "barrens").

Table ..3-3

COMMUNITY TYPE	MAJOR SPECIES	CHIEF ASSOCIATED SPECIES	COMMENTS
III. Conifer Bogs and Swamps[1]			Peatland vegetation-peat depths to 30'
A. Rich swamp forest	White cedar	Black ash, black spruce, tamarack, speckled alder, creeping snowberry, sphagnum, starflower, goldthread, twin flower, bunchberry and other herbs of the boreal forest.	Found on perimeter of peatlands on very wet sites. Merges with upland forests at edge of peatland
B. Poor swamp forest	Tamarack	Black spruce, white cedar, bog birch, bog rosemary, leather-leaf, bunchberry, bladderwort.	Open stands of pure tamarack are typical, the most extensive type on peatlands.
C. String bog-fen complexes	Dominated by either white cedar or tamarack	Black spruce, bog birch, bog rosemary, several sedges (Carex) pitcher plant, cotton-grass.	Characterized by open areas of sedge mats (fens) that will support a man, even though he may sink to his knees.
D. Black spruce-feather moss forest	Black spruce, feather mosses	Several species of blueberry, small cranberry, labrador tea and sphagnum	Tall, dense stands of mature black spruce.

1 Adapted from Heinselman (1970)

COMMUNITY TYPE	MAJOR SPECIES	CHIEF ASSOCIATED SPECIES	COMMENTS
IV. Open Muskeg or Heath	Sphagnum leather-leaf, bog laurel	Black spruce, small cranberry, cotton grass, reindeer moss	An open forest of stunted black spruce typified by "pillows" of sphagnum and other mosses. Trees cover 5-10 percent of the area. This type merges with the black spruce forest of III-D.
V. Upland Deciduous Forests		Hardwoods: Red maple, red oak, American elm, black ash, bur oak, paper birch.	
A. Northern hardwoods or mixed hardwood and pine	Sugar maple, basswood	Conifers: balsam fir, white pine. Shrubs & herbs: beaked hazel, mountain maple, red-berried elder, Canada Mayflower, sarsaparilla, twisted stalk, trillium.	This forest type covers a relatively small area in the southern portion of the study area.
B. Aspen Parkland (aspen-oak and brush-prairie of Marschner 1930)	Aspen, oak, willow	Quaking and big tooth aspen, bur oak, balsam poplar, northern pin oak, red oak, American elm, green ash, hazel, dogwood, cherries, Juneberry. Also many prairie species.	Mapped by Marschner at extreme western edge of study area. This type was largely fire dependent. Much of it is now in agriculture.

COMMUNITY TYPE	MAJOR SPECIES	CHIEF ASSOCIATED SPECIES	COMMENTS
VI. Lowland Hardwoods	American elm, black ash	Red maple, paper birch, balsam poplar, green ash, speckled elder, willows, high-bush cranberry, red-osier dogwood, nettle, sedges, grasses, jewelweed.	Contains a variety of species, may integrade with coniferous forest types.
Riverbottom Forests	Silver maple, American elm, black ash, cottonwood, willow	Many of the above species plus balsam fir. Wood nettle can be an abundant herb.	Riparian or flood plain vegetation covers an insignificant portion of the study area.
VII. Prairie and "Wet" Prairie (of Marschner, 1930)	Wet prairie - bluejoint grass, big bluestem, sedges	Speckled elder, bog birch rushes (Scirpus), cord grass	This type integrades with "brush" prairie (classified under Aspen-Parkland, V-B) and the shrub community of VIII-B. True prairie was an extremely minor element of the original vegetation at the western edge of the study area. It is now largely non-existent.

COMMUNITY TYPE	MAJOR SPECIES	CHIEF ASSOCIATED SPECIES	COMMENTS
VIII. Specialized Communities Within Major Vegetational Types			
A. Wet-marsh and open water	Bulrush and cattail	Arrowhead, common reed, water arum, water parsnip, sweet flag, wild rice, waterlilies, water milfoil, lesser duck weed, pondweeds, sedges, wild iris	This community includes several wetland types, as classified in USDI Circ. #39 (Shaw and Fredine, 1971).
B. Shrub Communities	Willows, alder, heaths, etc.	See discussion in III and IV for peatland communities. Speckled alder is a chief species in alder thickets	May occur on wet alluvial flood plain or peat soils and/or as a stage in plant succession.
C. Old Field Communities	Upland grasses and forbs	Canada and Kentucky bluegrass, red top, fescue, quackgrass, timothy, bluejoint, white clover, large-leaf northern aster, goldenrod, blackberry, blueberry, strawberry, raspberry, prickly rose.	This temporary community is largely composed of introduced or native "weedy" grasses and forbs.

TABLE 1.3-3a Sheet 1 of 4

SPECIES NOMENCLATURE
(after Gleason and Cronquist, 1963)

Common name	Scientific name
TREES	
American elm	Ulmus americana
Balsam fir	Abies balsamea
Balsam poplar	Populus balsamifera
Basswood	Tilia americana
Bigtooth aspen	Populus grandidentata
Black ash	Fraxinus nigra
Black cherry	Prunus serotina
Black spruce	Picea mariana
Box elder	Acer negundo
Bur oak	Quercus macrocarpa
Green ash	Fraxinus pennsylvanica
Mountain-ash	Sorbus spp
Northern pin oak	Quercus ellipsoidalis
Paper birch	Betula papyrifera
Quaking aspen	Populus tremuloides
Red maple	Acer rubrum
Red oak	Quercus borealis
Red pine	Pinus resinosa
Silver maple	Acer saccharinum
Sugar maple	Acer sachrum
Tamarack	Larix laricina
White-cedar	Thuja occidentalis
White oak	Quercus alba
White pine	Pinus strobus
White spruce	Picea glauca
Yellow birch	Betula lutea
TALL SHRUBS	
American hazel	Corylus americana
Beaked hazel	Corylus cornuta
Bog birch	Betula pumila
Bush honeysuckle	Diervilla lonicera
Chokecherry	Prunus virginiana
Downy arrowwood	Viburnum rafinesquianum
Fly honeysuckle	Lonicera canadensis
June berry	Amelanchier spp

TABLE 1.3-3a

Common name	
TALL SHRUBS - Cont	
Mountain maple	Acer spicatum
Pin cherry	Prunus pennsylvanica
Red-Osier dogwood	Cornus stolonifera
Round-leaved dogwood	Cornus rugosa
Speckled alder	Alnus rugosa
Spiraea	Spiraea spp
Sweet fern	Myrica asplenifolia
Willow	Salix spp
LOW SHRUBS	
Bearberry	Arctostaphylos Uva-ursi
Bog laurel	Kalmia polifolia
Bog rosemary	Andromeda glaucophylla
Creeping snowberry	Gaultheria hispidula
Currant	Ribes spp
Dewberry	Rubus pubescens
Labrador tea	Ledum groenlandicum
Late sweet blueberry	Vaccinium angustifolium
Leather leaf	Chamaedaphne calyculata
Prickly rose	Rosa acicularis
Red raspberry	Rubus strigosus
Small cranberry	Vaccinium oxycoccos
Sweet Gale	Myrica gale
Thimbleberry	Rubus parviflorus
Velvet-leaf blueberry	Vaccinium myrtilloides
Wintergreen	Gaultheria procumbens
FORBS	
Arrowhead	Sagittaria latifolia
Bedstraw	Galium triflorum
Bishop's Cap	Mitella nuda
Buckbean	Menyanthes trifoliata
Bunch berry	Cornus canadensis
Canada mayflower	Maianthemum canadensis
Clintonia	Clintonia borealis
Club mosses	Lycopodium spp
Dogbane	Apocynum androsaemifolium

TABLE 1.3-3a

Common name	
FORBS - Cont	
Goldenrod	Solidago spp
Goldthread	Coptis trifolia
Jack-in-the-pulpit	Arisaema triphyllum
Jewelweed	Impatiens capensis
Large-leaf northern aster	Aster macrophyllus
Little white waterlily	Nymphaea tetrogona
Marsh marigold	Caltha palustris
Nettles	Urtica spp
Pitcher plant	Sarracenia purpurea
Shinleaf	Pyrola rotundifolia
Strawberry	Fragaria virginiana
Sweet flag	Acorus calamus
Trillium	Trillium spp
Twin flower	Linnaea borealis
Water milfoil	Myriophyllum exalbescens
Water parsnip	Sium suave
Wild iris	Iris versicolor
Wild sarsaparilla	Aralia nudicaulis
White clover	Trifolium repens
White waterlily	Nymphaea tuberosa
Wood nettle	Laportea canadensis
Yellow waterlily	Nuphar variegatum
GRASSES - (GRAMINEAE)	
Big bluestem	Andropogon gerardi
Bluejoint	Calamagrostis inexpansa
Canada bluegrass	Poa compressa
Cord grass	Spartina pectinata
Fescue	Festuca spp
Kentucky bluegrass	Poa pratensis
Quackgrass	Aqropyron repens
Red top	Agrostis alba
Timothy	Phleum pratense
Wild rice	Zizania aquatica
Reed (Common)	Phragmites spp

TABLE 1.3-3a

Common name	
FERNS, MOSSES and Other Aquatic Species	
Bracken	Pteridium aquilinum
Reindeer moss	Cladonia spp
Feather moss	Pleurozium schreberi
Sphagnum	Sphagnum spp
Cat-tail	Typha latifolia
Sedges	Carex spp
Cotton grass	Eriophorum spissum
Bulrush	Scirpus spp
Rushes	Juncus spp
Pondweeds	Potamogeton spp
Duckweed	Lemna spp
Arrowhead	Sagittaria latifolia

TABLE 1.3-4

PLANT COMMUNITIES AND THEIR ASSOCIATED BIRD AND MAMMAL SPECIES

I. Primary habitat in climax boreal forests (and certain successional stags). (Types I, II and III of Table 1.3-3).	<u>Mammals</u> Moose, lynx, fisher, marten caribou (formerly), porcupine, snowshoe hare, red squirrel and small mammals such as arctic and pigmy shrews and northern bog lemmings. <u>Birds</u> Goshawk, merlin, great gray owl, Black-backed woodpecker, raven, red-breasted nuthatch, kinglets, vireos and many species of warblers, evening grosbeak, purple finch and crossbills.
(This group of birds is largely restricted to Black spruce-muskeg bogs, (Type III).	Spruce grouse, gray jay, hermit thrush, Nashville yellow-winged, palm and other warblers, dark-eyed junco and Lincoln sparrow.
II. Primary habitat in aspen-birch (successional Type I) or hardwood and aspen park-land types. (Type V).	White-tail deer, black bear, ruffed grouse, sharp-tailed grouse, snowshoe hare, moose, beaver, coyote, timber wolf, gray squirrel, raccoon and many smaller bird and mammal species including many of those listed for Types I, and II above.

Table 1.3-4 (Con't)

III. Special habitats	
a) Shrub, old field and wet prairie communities. (Types VII and VIII b,c,).	Sharp-tailed grouse, ruffed grouse, snow-hare, cotton-tail rabbit, white-tail deer, moose, red fox, coyote, bobcat. Typical small birds, include the: savanna, clay-colored and song sparrows.
b) Wet marsh and open water. (Type VII a).	Bald eagle, osprey, loon, black duck, American wigeon, ring-necked duck, golden-eye, common red-breasted merganser, herring gull, beaver, muskrat, otter and mink.

TABLE 1.3-5

WILDLIFE AREAS WITHIN THE CORRIDOR BY COUNTY

	St Louis	Itasca	Koochiching	Beltrami	Lake of the Woods	Roseau
MDNR Wildlife Areas	*	1.2	0	203.6	58.4	15.6
Environmental Education Areas	0	0	*	0	0	0
Unique Vegetation	0	0	200	0	11.6	0
Unique Wildlife	0	26	3.2	0	96	312.8
Trout Lakes	0	15.2	0	0	0	0
Trout Rivers	0	39.6	22	0	7.2	0

Figures in hundreds of acres

* Less than one hundred acres

TABLE 1.3-6 BIRD HABITAT[1,2]

Spruce-Fir w/under	Swamp without[3]	Spruce-Fir Upland	Aspen with	Aspen without	Aspen-Birch without	Aspen-Birch with	Aspen-Birch Fir	Birch-Fir Budworm - Healthy	Pine
								R T Hummingbird	
							Yellow S. Flicker		
								Hairy Woodpecker	
				Least Flycatcher					
								Winter Wren	
								Veary	
Kinglets									
									Red-eyed Vireo
								Black & White Warbler	
		Nashville Warbler							
								Parula Warbler	
				Black Capped Chickadee					
									Myrtle Warbler
									Blackburnian Warbler
		Chestnut-sided Warbler							
								Mourning Warbler	
					Cape May Warbler				
				Canada Warbler					
Yello Warbler									
		White-throated Sparrow							
		Song Sparrow							
								Pileated Woodpecker	
								Red Breasted Nuthatch	
		Cedar Waxwing							
								Solitary Vireo	
								Pine Warbler	
								Chipping Sparrow	
								Slate colored Junco	
	Swamp Sparrow								
	Yellow-throat								
	Tree Swallow								
				Whip-poor-will					

[1]Superior National Forest Supplement No. 3 - 4/75

[2]No two birds have the same habitat requirement. This table shows the variety of habitats needed to provide for a variety of birds.

[3]"With" means with shrub understory, "without" means without shrub understory.

TABLE 1.3-7
ANIMALS AND PLANTS IMPORTANT IN
THE CORRIDOR AREA

Species (in Need of "Special Consideration")*	Comments
Category I - Endangered Species **	
American Peregrine Falcon	Formerly was a resident, now extirpated, except as a rare migrant.
Eastern Timber Wolf ***	Considered endangered by Federal authorities, not by Moyle (1975).
Category II - Threatened Species	
Pine Marten	Extirpated by early 1900's but has since returned to Minnesota.
Greater Sandhill Crane	Rare breeding bird in corridor area.
Category III - Species of Changing or Uncertain States	
Canada Lynx	Rare, occasionally invades from Canada.
Eastern Timber Wolf	Listed in this category by Moyle.
Fisher	On the increase in Minnesota.
Common Tern	Large colonies occur in Lake of the Woods.
Coopers Hawk Marsh Hawk	Considered increasing in Minnesota.

Species (in Need of "Special Consideration")	Comments
Category III (Cont)	
Northern Bald Eagle	Considered increasing in Minnesota.
Osprey	Nests in corridor area.
Lake Sturgeon	Found in Red Lake and Lake of the Woods.

* Moyle, 1975

** Both species listed in this category are considered endangered by the Federal Government (USDI, 1973, 1974). These are the only species listed in this table which are mentioned in Federal lists of endangered species.

*** Note listing in two categories.

Table 1.3-8 Major Streams and Rivers in the Corridor

Sprague Creek
Hay Creek
E Branch Warroad River
W Branch Warroad River
Clear River
Willow Creek
Winter Road River
Peppermint Creek
Baudette River
Rapid River
North Branch Rapid River
Troy Creek
Tamarack River
Sturgeon River
Dinner Creek
Caldwell Creek
Reilly Brook
Big Fork River
Valley River
Bear River
Prairie River
E Swan River
Dempsey Creek
W Two River
E Two River
St Louis River

TABLE 1.3-9

RAINFALL INTENSITY - DURATION - FREQUENCY FOR MINNEAPOLIS

Duration	Return Period-Years	Intensity-Inches Per Hour
15 Minutes	2	2.8
	10	4.4
	25	4.9
30 Minutes	2	2.0
	10	3.0
	25	3.5
1 Hour	2	1.3
	10	2.0
	25	2.4

SOURCE: Tech Bulletin No. N2, Background Information for Framework Statewide Water and Related Lake Resources Planning In Minnesota - State Planning Agency, 1969

TABLE 1.3-10

FREQUENCY OF DAYS WITH PRECIPITATION AND OF SELECTED PRECIPITATION AMOUNTS

Station	Record Period	% Days With Precip	Frequency of Precip. Amounts As A Percent of Days With Precipitation							
			Trace	0.01 In.	0.02 to 0.09 In.	0.10 to 0.24 In.	0.25 to 0.49 In.	0.50 to 0.99 In.	1.00 to 1.99 In.	2.0+ In.
Duluth	2/50-1/55	42.0	42.0	8.9	19.1	14.3	7.0	5.2	2.2	0.5
Minneapolis	1/51-12/60	52.1	52.1	8.4	20.5	12.1	8.9	5.3	2.1	0.5

SOURCE: *Tech Bulletin No. N2, Background Information for Framework Statewide Water and Related Lake Resources Planning in Minnesota - State Planning Agency, 1969.

TABLE 1.3-11

LAND IN FARMS, HARVESTED CROPLAND AND IRRIGATED ACREAGE

	Total County Area in Acres	Land in Farms In Acres (1973*)	% of County Area in Farms in 1973*	Harvested Cropland In acres (1969*)	% of County Area in Harvested Cropland in 1969*	Irrigated Acreage in 1969**
Beltrami	1,955,200	222,381	11.4%	62,653	3.2%	581
Itasca	1,856,000	114,454	6.2	29,468	1.6%	321
Koochiching	2,030,720	74,843	3.7	16,471	.8%	17
Lake of the Woods	1,147,520	99,266	8.7	32,944	2.9%	-
Roseau	1,073,280	545,501	50.8	209,165	19.5%	7
St Louis	4,295,040	152,456	3.5	56,336	1.3%	34
Total of Counties included in Corridor	13,509,760	1,208,901	8.9	407,037	3.0%	960

*Source "Minnesota Agricultural Statistics", State-Federal Crop and Livestock Reporting Service, Minnesota Department of Agriculture.

**Source "1969 U.S. Census of Agriculture" United States Bureau of the Census, Washington, D.C., U.S. Government Printing Office 1972.

TABLE 1.3-12

HARVESTED ACREAGE OF MAJOR CROPS IN 1974 (IN ACRES)*

County	Corn	Wheat	Potatoes	Oats	Barley	Flax	Hay	Major Crop in County
Beltrami	1,900	1,400	1,000	16,700	500	300	49,800	Hay
Itasca	700	200	400	2,900	100	-	40,400	Hay
Koochiching	300	800		1,000	200	200	24,500	Hay
Lake of the Woods	300	5,800	900	4,700	300	700	26,000	Hay
Roseau	1,400	44,600	300	36,700	7,300	33,500	91,800	Hay
St Louis	300	300	100	2,300	200	-	50,200	Hay

*Source "Minnesota Agriculture Statistics, 1975",
State Federal Crop and Livestock Reporting Service,
Minnesota Department of Agriculture.

TABLE 1.3-13

CULTIVATED LANDS WITHIN THE CORRIDOR BY COUNTY

	St Louis	Itaska	Koochiching	Beltrami	Lake of the Woods	Roseau
Hundreds of Acres	142.4	12	2.4	22	671.2	1144.4

PASTURE AND OPEN LANDS WITHIN THE CORRIDOR BY COUNTY

	St Louis	Itaska	Koochiching	Beltrami	Lake of the Woods	Roseau
Hundreds of Acres	249.2	184	69.6	26.4	368.8	360.4

TABLE 1.3-14

NUMBER OF FARMS AND AVERAGE FARM SIZE*

County	Number of Farms 1969	1973	1969-1973% Δ	Average Farm Size In Acres 1973
Beltrami	803	805	+ .2%	276
Itasca	637	540	-15.2%	212
Koochiching	311	312	+ .3%	240
Lake of the Woods	269	200	-25.7%	496
Roseau	1281	1230	-4.0%	443
St Louis	1063	879	-17.3%	173
Total of Counties ected by Corridors	4364	3966	9.1%	305
State	123,000	118,000	-4.1%	259

*Source "Minnesota Agricultural Statistics,"
State - Federal Crop and Livestock Reporting Service,
Minnesota Department of Agriculture.

TABLE 1.3-15

AGRICULTURAL LANDS WITHIN THE CORRIDOR BY COUNTY

	St Louis	Itasca	Koochiching	Beltrami	Lake of the Woods	Roseau
Cultivated with good soils	*	0	0	0	129.6	3.6
Cultivated with average soils	105.6	10	2.4	14.4	467.6	1038.4
Cultivated with marginal soils	33.2	1.6	0	7.6	74	102.4
Cultivated	3.2	*	0	0	0	0
Pasture with good soils	*	0	0	0	40.8	3.2
Pasture with average soils	170	150.4	45.6	6	204	229.2
Pasture	78.4	33.6	24	20.4	124	128

* Less than one hundred acres

Figures in hundreds of acres

TABLE 1.3-16

CROP PRODUCTION RATING RELATIONSHIPS

Crop Productivity Index		Equivalent TDN Yield Lbs/A	Corn Yield Bu/A	Alfalfa Tons/A	Oats Yield Bu/A	Wheat Yield Bu/A
	0	0- 582	0- 13	0 - .58	0- 26	0- 12
Marginal	1	583-1165	14- 26	.59-1.2	27- 52	13- 24
	2	1166-1747	27- 39	1.3 -1.7	53- 78	25- 36
	3	1748-2330	40- 52	1.8 -2.3	79-104	37- 48
Average	4	2331-2912	53- 65	2.4 -2.9	105-130	49- 61
	5	2913-3494	66- 78	3.0 -3.5	131-156	62- 73
	6	3495-4078	79- 92	3.6 -4.1	157-183	74- 85
Good	7	4079-4659	93-105	4.2 -4.7	- -	86- 97
	8	4660-5242	106-118	4.8 -5.2	- -	98-109
	9	5243-5824	119-131	5.3 -5.8	- -	110-121

TABLE 1.3-17

FARM INCOME BY SOURCE IN 1973*

County	Cash Receipts Livestock In 1000 Dollars	Cash Receipts Crops In 1000 Dollars	Government Payments	Other
Beltrami	6,937	4,284	105	1,059
Itasca	4,665	2,200	35	601
Koochiching	1,754	1,075	41	272
Lake of the Woods	1,590	1,254	56	282
Roseau	15,709	19,086	568	2,380
St Louis	5,480	2,871	69	1,261
Total of Counties Affected By Corridors	36,135	30,770	874	5,855
State	2,258,163	1,982,723	105,044	245,264

*Source Unpublished Computer Printout Statistics, Bureau of Economic Analysis, U. S. Department of Commerce.
Available in Minneapolis Area Office.

TABLE 1.3-18

TOTAL FARM INCOME IN 1973*

County	Total Net Income All Farms In 1000 Dollars	Total Net Income Farm Proprietor in 1000 Dollars	Total Gross Income All Farms In 1000 Dollars	Average Net Income Per Farm
Beltrami	7,168	5,859	12,385	7,278
Itasca	2,983	2,450	7,501	4,537
Koochiching	1,577	1,286	3,146	4,122
Lake of the Woods	3,494	2,850	5,324	14,250
Roseau	24,351	20,130	37,743	16,365
St Louis	2,979	2,430	9,681	2,764
Total of Counties Affected By Corridor	48,552	35,005	75,780	
State	2,421,801	1,997,896	4,591,194	16,931

*Source Unpublished Computer Printout Statistics, Bureau of Economic Analysis, U S Department of Commerce.

TABLE 1.3-19

VALUE OF FARMLAND AND BUILDINGS

Counties	Value of Farmland and Buildings (1969 U.S. Census of Agriculture)* County Total In 1000 Dollars	Average Per Farm
Beltrami	19,210,898	23,805
Itasca	11,494,106	22,146
Koochiching	5,741,682	21,504
Lake of the Woods	8,294,303	32,526
Roseau	38,477,232	28,930
St Louis	18,439,735	20,132
Total of Counties Affected By Corridor	101,657,956	24,837
State	6,512,324,734	58,803

*Source "1969 U.S. Census of Agriculture", United States Bureau of the Census, Washington, D.C., U.S. Government Printing Office, 1972.

TABLE 1.3-20

FORESTRY RESOURCES IN 1962

County	Non-Commercial Forest Land In Acres	Commercial Forest Land in Acres	Commercial Forest Land As A Percent Of County Land Area	Growing Stock In Thousand Cubic Feet	Saw Timber In Thousand Cubic Feet
Beltrami	185,200	993,000	62	479,245	685,140
Itasca	69,000	1,411,900	83	1,086,416	2,252,740
Koochiching	294,000	1,574,700	79	1,127,409	1,307,040
Lake of the Woods	94,900	528,500	63	219,083	239,400
Roseau	65,600	271,000	25	114,408	180,850
St Louis	260,300	3,204,300	80	1,987,932	2,385,630
Total Counties In Corridor	969,000	7,983,400	71	5,014,493	7,050,800
State	1,985,400	17,062,000	33	9,801,806	15,518,270
Counties in Corridor As A Percent of State	48.8	46.8		51.2	45.4

Source - Robert N Stone, "A Third Look At Minnesota's Timber",
North Central Forest Experiment Station.
U. S. Forest Service. Resource Bulletin NC-1 May, 1966

TABLE 1.3-21

FOREST LANDS WITH THE CORRIDOR BY COUNTY

	St Louis	Itasca	Koochiching	Beltrami	Lake of the Woods	Roseau
Coniferous with good soils	38.4	1116.4	498.8	0	322	65.6
Forested with good soils	438	826.8	552.8	8.4	529.8	32
Coniferous with average soils	22.8	590	829.6	57	248.4	263.2
Forested with average soils	381.2	107.6	236.4	21.2	115.2	172
Coniferous with marginal soils	30	35.2	18.4	587.6	548.4	444
Forested with marginal soils	192	4.8	2.4	12	566	207.6
Pasture with good soils	76	148.8	25.2	2	129.6	14.8
Forested	234	194.8	617.2	0	0	0

Figures in hundreds of acres

TABLE 1.3-22

PLANTATIONS WITHIN THE CORRIDOR BY COUNTY

	St Louis	Itasca	Koochiching	Beltrami	Lake of the Woods	Roseau
Coniferous Plantations	4.4	73.6	70	0	42.8	55.2
Forest Co Plantations	13.2	272	8	NA	NA	NA
Christmas Tree Plantations	0	0	*	0	0	3.2

Figures is hundreds of Acres

* Less than one hundred acres

TABLE 1.3-23

PULPWOOD PRODUCTION IN THE CORRIDOR

(THOUSAND STANDARD CORDS-ROUGHWOOD BASIS)

County	1 1970	2 1974	1970-1974 % Δ
Beltrami	77	99	+28.6%
Itasca	130	157	+20.8%
Koochiching	227	357	+57.3%
Lake of the Woods	36	24	-33.3%
Roseau	13	*	-100.0%
St Louis	299	383	+28.1%
Total of Counties In Corridor	782	1020	+30.4%
State	1224	1578	+28.9%
Six Counties as a % of State	63.9%	64.6%	

*None Reported

1
Source: James E Blyth "Pulpwood Production in the North Central Region By County 1970", Resource Bulletin NC-13, North Central Forest Experiment Station, USDA Forest Service, 1971.

2
Source: James E Blyth and Jerold T Hahn, "Pulpwood Production in the Lake States By County, 1974", Resource Bulletin NC-193, North Central Forest Experiment Station, - USDA.

Table 1.3-24 Potential for Utilization of Existing and Proposed Rights-of-Way.

St. Louis County

Proposed 230	32 miles
Existing 115	22 miles
Proposed 115	11 miles
Existing 69	27 miles
Railroads	10 miles
Pipelines	19 miles

Itasca County

Proposed 230	40 miles

Koochiching County

Proposed 230	23 miles

Lake of the Woods County

Proposed 230	32 miles
Proposed 69	10 miles

Roseau County

Proposed 230	27 miles
Proposed 69	4 miles

TABLE 1.3- 26

POPULATION CHARACTERISTICS by County

COUNTY	1970 Population Urban	1970 Population Rural	1970 Total Population	Land Area Sq Miles	Person Per Sq Mile	1960 Population Urban	1960 Population Rural	1960 Total Population	Percent Change Urban	Percent Change Rural	1973** Estimated Population	1973** Percent Change From 1970
Beltrami	11,490	14,883	26,373	2,507	10.5	9,958	13,467	23,425	15.4	10.5	28,789	9.2
Itasca	7,247	28,283	35,530	2,633	13.5	7,265	30,741	38,006	-0.3	-8.0	37,307	5.0
Koochiching	6,439	10,692	17,131	3,127	5.5	6,778	11,412	18,190	-5.0	-	17,542	2.4
Lake of the Woods	-	3,987	3,987	1,311	3.0	-	4,304	4,304	-	-7.4	4,111	3.1
Roseau	2,552	9,017	11,569	1,676	6.9	-	12,154	12,154	-4.8	-25.8	12,138	4.9
St Louis	158,972	61,721	220,693	6,092	36.2	172,057	59,531	231,588	-7.6	3.7	218,588	-1.0
TOTAL	186,700	128,583	315,283	17,346	18.1	196,058	131,609	327,667			318,475	1.0

* Source:
Characteristics of the Population - Minnesota - Volume I, Part 25. 1970.

** 1973 Population Estimates and Projection for Minnesota Census, 1974 pub. date.

Table 1.3-27

POPULATION BY MINOR CIVIL DIVISION
in Designated Corridor by County - 1960-1970

	1960	1970	% Change
Beltrami			
UT* Upper Red Lake	NA	239	NA
Itasca			
Townships			
Bearville	101	99	- 2.0
Carpenter	300	252	-16.0
Nashwauk	2,653	2,139	-19.4
UT Northeast Itasca	NA	1,130	NA
Villages**			
Effie	195	165	-15.4
Keewatin	1,651	1,382	-16.3
Koochiching			
UT Northwest Koochiching	NA	600	NA
UT South Koochiching	NA	900	NA
Lake of the Woods			
Villages			
Baudette	1,597	1,547	- 3.1
Williams	317	220	-30.6
UT Beltrami Forest	NA	95	NA
UT Rainy River	NA	2,036	NA

*UT = Unorganized Territory of.

**The names of all Minnesota villages were changed to "city" under a state law passed in 1973 (Minnesota Laws, 1973), Ch 123, Act 2, Sec 1).

Table 1.3-27 (Con't)

	1960	1970	% Change
Roseau			
Townships			
Cedar Bend	157	118	-24.8
Enstrom	239	196	-18.0
Falun	302	207	-31.5
Lake	NA	415	NA
Laona	249	223	-10.4
Malung	336	310	- 7.7
Morganville	392	334	-14.8
Roosevelt	145	104	-28.3
Spruce	283	297	4.9
Warroad	1,309	1,086	-17.0
UT North Roseau	NA	145	NA
UT Southeast Roseau	NA	117	NA
St Louis			
Townships			
Balkan	830	732	-11.8
Cherry	610	593	- 2.8
Clinton	896	1,075	20.0
French	275	183	-33.5
Great Scott	255	280	9.8
Lavell	406	330	-18.7
McDavitt	435	426	- 2.1
Stuntz	5,739	4,640	-19.1
Villages			
Buhl	1,526	1,303	-14.6
Hibbing	17,731	16,104	- 9.2
Kinney	396	325	-17.9
City			
Chisholm	7,144	5,913	-17.2
Fraser	95	48	-49.5
UT McCormack Lake	NA	116	NA

TABLE 1.3-28

NUMBER OF PEOPLE EMPLOYED, BY OCCUPATION,

IN CORRIDOR COUNTIES, 1970

Occupation	Beltrami	Itasca	Koochiching	Lake of the Woods	Roseau	St Louis	Total For Each Category
Professional Technical and kindred workers	1,519	1,452	690	124	481	11,036	15,302
Managers & Administrators, Except Farm	779	734	427	165	302	6,303	8,710
Sales Workers	527	498	281	31	140	4,951	6,428
Clerical & Kindred Workers	1,368	1,297	701	124	443	11,262	15,195
Craftsmen, foremen & Kindred Workers	955	1,948	812	128	489	13,673	18,005
Operatives, Except Transport	363	1,281	1,018	128	472	8,836	12,098
Transport Equipment Operatives	433	571	310	36	135	3,572	5,057
Laborers, Except Farm	432	711	606	44	95	3,889	5,777
Farmers & Farm Managers	477	175	82	122	501	355	1,710

TABLE 1.3-28

(continued)

Occupation	Beltrami	Itasca	Koochiching	Lake of the Woods	Roseau	St Louis	Total For Each Category
Farm Laborers and Farm Foreman	163	62	10	21	160	165	581
Service Workers, Except Private Household	1,583	1,514	698	180	434	10,888	15,297
Private Household Workers	128	156	41	4	41	1,000	1,370
Total	8,727	10,399	5,676	1,107	3,693	75,930	105,532

Source: U.S. Dept of Commerce, Bureau of Census
Series P-25 #258.
Issued June, 1975.

TABLE 1.3-29

ANNUAL INCOME[1] PER FAMILY[2], FOR CORRIDOR COUNTIES, 1970

County	Unemployed	Families with Income[3] Less than $3000	$3000-4999	$5000-6999	$10,000-14,999	$15,000-24,999	$25,000 or more	Total Median Family Income-all Families[4]
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Dollars
Beltrami	6.9	16.6	15.8	17.7	19.0	9.3	1.4	6995
Itasca	12.4	12.8	13.1	14.0	24.2	6.3	1.4	7985
Koochiching	8.2	10.4	12.2	12.9	26.3	9.9	1.9	8508
Lake of the Woods	9.0	17.6	18.6	19.1	15.6	3.9	1.7	6053
Roseau	11.5	16.2	14.4	15.2	19.8	8.5	1.6	7472
St Louis	7.0	9.0	10.0	11.9	28.7	10.9	2.1	8994

1. Income: money income and includes wage and salary income, nonfarm net self-employment income, farm net self-employment income, social security or other retirement income, public assistance income and all other money income. The figures represent income received before deductions for personal, income taxes, social security, bond purchases, dues, medicare deductions, etc.

2. Family: a household head and one or more other persons living in the same household who are related to the head by blood, marriage or adoption. All persons in a houshold who are related to the head are regarded as members of his or her family.

3. Families with income: the sum of income received by all family members 14 years of age and older.

4. Median Income: the amount which divides the distribution into two equal groups, one having incomes above the median and the other having incomes below the median.

Source: U S Dept of Commerce, County and City Data Book, 1972.
Bureau of Census. PP 246-257

2 ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

CHAPTER 2 ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

2.1 CONSTRUCTION AND ENGINEERING DEVELOPMENT

2.1.1 500 KV DESIGN PARAMETERS

This entire high voltage (EHV) transmission line and associated facilities have been designed to economically and reliably transmit the required amount of electrical power while maintaining the safety and comfort of employees and the general public.

Numerous studies relative to EHV transmission line design parameters have been conducted and some of the most significant areas were: conductor size and type, electrical clearances, structure type and configuration, meteorological and geologic conditions and alternate construction procedures.

Throughout these studies, rules for electrical clearances, structural strength and other safety considerations specified in the National Electrical Safety Code (NESC) have been incorporated in their respective areas of significance (the NESC has been adopted by the State of Minnesota as the State Electrical Code). The NESC embodies the most important features for the safety of employees and the public. In areas where considerations other than those specified in the NESC were deemed necessary, the design of the EHV transmission line will exceed the requirements of the NESC. In all other areas the EHV transmission line will be designed to meet the requirements of the NESC.

2.1.1.2 Structures

The 500 kV structures will be of three distinctly different structural configurations. The first type will be a self-supporting steel lattice structure, shown in Figure 2.1-1. The second type will be a guyed aluminum lattice structure, shown in Figure 2.1-2. The steel lattice structure will be four-legged, and will require no external means of support. The guyed aluminum structure will have a single vertical column and will require four guy wires and earth anchors to obtain the same structural stability as the steel lattice structure. The third type of structure is an internally guyed portal structure, shown on Figure 2.1-3. The internally guyed portal structure will be considered as an alternate to the self-supporting steel lattice structure, and will similarly be used primarily in agricultural areas.

All structures in the 500 kV line will be designed to meet the strength requirements for the Heavy Loading District, as defined by the NESC. In addition, the following loadings in excess of NESC requirements will be incorporated in the structure designs:

- an 80 mile-per-hour ground-level wind on the bare cables and structures
- a longitudinal load resulting from one broken conductor, or one-inch differential ice loading on one three-conductor bundle
- a longitudinal load resulting from one-inch differential ice loading on either of the shield wires
- a vertical load resulting from one-inch radial ice on all conductors and shield wires with no wind.

For each structure type, a series of angle and dead end structure designs will be prepared in addition to the tangent design. The loadings for these structure designs will be in accordance with NESC requirements, which call for a 4 psf (40 mph) wind on the structures and conductors with a one-half inch radial ice. In addition, the angle structures must be designed to withstand the loads resulting from the transverse component of the tension of the conductors and shield wires due to change in direction of the line. The dead end structures must be designed for both of the loading conditions for angle structures, plus the loads resulting from the in-line tension of the conductors and shield wires. Each additional loading for line angle or dead end conditions results in a heavier, more costly structure, which requires larger foundations and additional conductor accessories, making the introduction of frequent line angles an economic detriment. A table of relative structure weights and in-place costs for a normal series of structure designs for steel towers follows:

Angle Design	Nominal Structure Weight	Estimated In-Place Costs
0^0 (Tangent)	26,000#	$22,000
2^0 - 10^0	32,000#	$27,500
10^0 0 30^0	38,000#	$34,000
30^0 - 45^0 (dead end)	62,000#	$59,000
45^0 - 90^0 (dead end)	74,000#	$71,000

The basic foundation for the self-supporting structure will be reinforced concrete drilled shafts shown on Figure 2.1-4. This foundation consists of an augered hole filled with concrete reinforced with steel, with a stub angle installed for attachment of the structure. The diameter and depth

of the drilled shafts will vary, dependent upon soil conditions at the structure locations. Alternate foundation types will be utilized at major angle points and at structure locations that exhibit poor soil conditions.

The foundation for the guyed aluminum structure will be a "foundation anchor" shown on Figure 2.1-5. This foundation will consist of a tripod arrangement of large helix screw anchors with steel pipe extensions. A fabricated steel assembly will connect the three steel pipes at the ground line to support the structure base. Four helix screw anchors for the guy wires will also be installed around the foundation anchor. No excavation will be required for this foundation installation.

The foundations for the internally guyed portal structure will be reinforced concrete drilled shafts similar to those proposed for the steel lattice structures.

2.1.1.2 Conductors

Each of the three phases of the 500 kV line will consist of a triangular, three-conductor bundle with 18-inch conductor spacing, as shown on Figure 2.1-6. The conductor for the 500 kV portion of the EHV transmission line will be 954,000 circular mil aluminum conductor steel-reinforced (ACSR) with seven steel core strands and 54 outer aluminum strands. The industry code word for this conductor is "CARDINAL." The conductor has an overall diameter of 1.196 inch.

Two shield wires will be installed on the structures to provide protection from lightning strokes to the conductors. The shield wires will be seven No. 7 Awg aluminum-clad steel cable with a diameter of 0.432 inch.

2.1.1.3 Line Design

The line design of the 500 kV line includes the selection of structure type and structure locations, determination of structure heights and preparation of construction drawings.

The selection of structure types will be based on the predominant land use in the area traversed by the line. In general the guyed aluminum structure will not be used in areas of intense agricultural activity. In these areas the self-supporting steel structures will be utilized. The selection of structure types will be made on a general basis for a major section of line. Structure types will generally not be mixed within a section of line.

A minimum clearance of 39 feet between the ground and conductors at 120° F conductor temperature will be maintained in the design of the line. Distances between structures will range from 1200 to 1400 feet due to physical constraints and topography, with one-quarter mile spans being a desired average. In flat terrain without physical constraints, a 1320-foot span would result in an overall structure height for the self-supporting steel structure and guyed aluminum structure of 120 feet and 150 feet, respectively. Structure heights throughout the line will vary, depending upon topography and other constraints.

2.1.1.4 Right-of-way Requirements

Two different right-of-way requirements exist on the preferred route. In the area that the existing 230 kV transmission line can be paralleled, right-of-way requirements are reduced by right-of-way sharing. One hundred and sixty feet of additional right-of-way would be required adjacent to the

existing 130-foot right-of-way. In areas that right-of-way sharing is not possible 200 feet of right-of-way will be required.

2.1.1.5 Design Summary

1) Voltage Level
   a) Nominal operating: 500 kV ac
   b) Maximum operating: 550 kV ac
2) Conductor: Three-conductor bundle of "CARDINAL" 954 kcmil ACSR 54/7 (1.196 inch diameter) per phase.
3) Structures
   a) Self-supporting steel structures
   b) Guyed aluminum structures
4) Ground Clearance: 39 feet minimum at 120° F conductor temperature.
5) Right-of-Way
   a) 160 feet adjacent to existing 230 kV right-of-way.
   b) 200 feet wide independent right-of-way.
6) Length: 200 miles (approximately).

2.1.1.6 Material Requirements

The construction of this EHV transmission line will require the use of nonrenewable resources including steel, aluminum, zinc and concrete. The table below summarized these material requirements for each type of construction on a per-mile basis.

500 KV INTERNALLY GUYED ALUMINUM STRUCTURES

Steel

Conductor	8 T/Mile
Shield Wire	2 T/Mile
Foundations	9 T/Mile
Guy Wires	1 T/Mile
Total	20 T/Mile

Aluminum

Structures	20 T/Mile +
Conductor	22 T/Mile
Total	42 T/Mile

Concrete

Foundations	120 CY/Mile

2.1.2 COST ANALYSIS

Estimated construction costs for the transmission line have been made on a per-mile basis. Present day costs have been used in preparing the estimates with no escalation provided for adjustment to actual construction dates. Cost analyses for each of the alternate routes are found on Table 2.1-1.

Detailed design and cost estimates for the 500 kV internally guyed aluminum portal structures are not yet available. Further investigations will be necessary to clarify these points, but the probable costs are near enough to the $275,000-per-mile cost of the steel lattice structures to warrant further investigation.

2.1.3 PROJECT IMPLEMENTATION

2.1.3.1 Centerline Determination

Following MEQC designation of a route one kilometer wide (3280 feet) NSP engineering, right-of-way and environmental personnel will determine the exact alignment of the EHV transmission line within the designated route. The alignment will be determined by use of aerial photography and by information obtained by field reconnaissance in critical areas, or where the photography is not sufficient. Property owners will not be contacted at this time, and the routing personnel will restrict their reconnaissance efforts to areas accessible by public roads.

Once a centerline alignment has been established, a plan view and ground profile drawing of the area traversed by the transmission line will be prepared from aerial photography by photogrammetric processes. In areas of dense ground cover, or where additional information to adequately describe the location of the transmission line is required, field survey crews will be used. The property owners will be contacted by NSP right-of-way agents prior to the survey to obtain written permission for this activity on their property.

2.1.3.2 Right-of-way Acquisition

Once the exact alignment has been established, NSP will identify the owners of all lands which will be affected by the transmission line. NSP will then conduct a land evaluation study to determine the market value of the lands. From this study, a payment schedule will be developed to determine the price to be paid for the land rights. This payment schedule will be

applied to each parcel of private property. Right-of-way agents from NSP will then contact each property owner and negotiate for an option for easement or for an easement. The property owner will be informed of the location of the line in general, the location of the line with respect to his property and the schedule of payment for the land rights to be acquired. Provisions for settlement of damages to crops, fences, livestock, roads and fields by construction activities will also be discussed at this time. Negotiations will continue with the property owners until all the questions pertaining to the line are answered. In the event a satisfactory settlement cannot be reached with the property owner in a reasonable amount of time, as dictated by the project schedule, NSP will petition the court to initiate condemnation proceedings in accordance with the laws of eminent domain.

Permits from the DNR will be required for the line to cross state lands, over which a major portion of the corridor lies. The permits will grant NSP the use of the land for 50 years.

2.1.3.3 Construction Procedures

Following the acquisition of right-of-way, the major construction activities will commence and proceed in as continuous a manner as possible.

The first activity will be a ground survey to establish and stake the centerline of the transmission line. Staking for right-of-way clearing will also be done at this time in areas requiring clearing. Clearing contractors will then proceed to clear the right-of-way as required and the installation of structure foundations will proceed. The next activity will be the erection of the structures on the foundations, followed by the stringing of shield wires and conductors. This will complete the construction

of the transmission line, and at this time the right-of-way will be restored as nearly as possible to the condition existing prior to construction. All excess construction material and packing debris will be removed from the right-of-way and settlements for construction damages will be obtained.

2.1.3.3.1 Right-of-way Clearing

Clearing of the right-of-way, the first major phase of transmission line construction, is necessary to provide required clearances from the conductor, to eliminate possible hazards to the line from falling trees, as well as to facilitate construction operations.

The width of the right-of-way to be cleared for the project will vary with the line voltage and the opportunities for right-of-way sharing. On the 500 kV line where a 200-foot right-of-way is required, 180 feet will be cleared. Where the line parallels the existing 230 kV line a 160-foot right-of-way and 150-foot clearing are required.

In general, the right-of-way will be clear-cut to the widths mentioned above. Tall or dangerous trees outside the cleared right-of-way which present a potential hazard to the line will also be removed.

Where the right-of-way goes through areas of low-growing brush, muskeg swamps or black spruce bogs, the right-of-way clearing will normally be reduced in widths to approximately the center one-third.

In some areas, such as at major road and stream crossings, selective cutting will be used. Such areas will be designated by the company and selective cutting requirements made part of clearing contracts. Appendix A shows the Specifications for Right-of-Way Clearing that will be followed.

2.1.3.3.2 Foundation Installation

Following the clearing of the right-of-way, the foundations for the structures will be installed. The foundations will be of two basic types, reinforced concrete drilled shafts and foundation anchors.

The reinforced concrete drilled shafts will be dug using a truck or crane mounted drilling rig capable of augering holes three to eight feet in diameter. During the drilling, the hole will be kept open by means of either temporary steel casing or a bentonite slurry. When the hole has been drilled to design depth, the reinforcing steel will be placed, and ready mix trucks will deliver concrete to the site for placement. The 15 to 40 cubic yards of soil excavated for each structure site will be leveled evenly around the site, or if necessary, it will be hauled away and disposed of.

The foundation anchors for the guyed aluminum structures will require no excavation or placement of concrete, which greatly reduces the amount of equipment required for installation. The foundation anchors will be installed by use of a rubber-tired or track-mounted vehicle equipped with a hydraulic operated rotary motor. The pipe portion of the foundation anchors will be installed in 10-foot lengths to the depths required to develop a specified torque which will provide the required bearing capacity. When all three of the foundation anchors have been placed, a fabricated steel assembly connecting the three anchors will be installed. Following the installation of the foundation anchors, four guy anchors will be installed at the site before the equipment moves to the next site.

The foundation types discussed are the basic designs for tangent and angle structures. Alternate foundation types such as spread foundations or foundations supported on piling may be required at structure sites where soil conditions will not support the basic foundation types.

2.1.3.3.3 Structure Erection

The assembly and erection of structures will follow the installation of foundations. The 500 kV steel lattice structures will be hauled to the structure sites unassembled. An approximately 150-foot square area adjacent to the foundation will be required to assemble the structure. If the site is uneven, some temporary grading may be necessary. The assembly crews will consist of eight to ten men and a 15 to 30-ton mobile crane. Assembly of each structure will require an average of two to three days. After the structure has been assembled on the ground, the assembly crew will move to the next site and the erection crew will follow to erect the structure on the foundation. The erection crews will consist of eight to ten men with a rubber-tired or track-mounted 75 to 90-ton crane. Depending upon access to the sites, two to four structures per day can be erected by one crew.

An alternate construction procedure will be utilized for erection of the 500 kV guyed aluminum structures. The guyed aluminum structures will be delivered to marshalling yards located near the line and 10 to 20 miles apart. The structures will be assembled in the marshalling yards by a crew of eight to ten men. Assembled structures will have the four guy wires attached, and will then be stored at the yard until erection.

Erection of the assembled structures will be accomplished by the use of a helicopter capable of lifting 7000 to 8000 pounds. The helicopter will be equipped with a sling that will be attached to the structure at the marshalling yard. The helicopter will then lift and fly the structure to the site of erection. A ground crew of six to eight men will be at the site when the helicopter arrives. The helicopter will hover over the site as one of the ground crew directs the pilot in setting the base of the structure on the foundation. The four guy wires will then be temporarily tied off to the guy anchors, allowing the helicopter pilot to release the structure by activating an electrically operated mechanism in the sling. The helicopter will then return to the marshalling yard to pick up another structure while the ground crew moves to the next site. Another crew of five or six men will then follow to plumb the structure and make the permanent guy wire attachments to the anchors. Transportation of the crews to the structure sites will be accomplished by truck, all-terrain vehicle, or if necessary, by helicopter.

Internally guyed aluminum structures can be constructed by either of the above methods. The method used will be decided on when construction begins, that decision being based mainly on economics.

2.1.3.3.4 Conductor Stringing

The stringing and sagging of the shield wires and conductors is a multi-faceted activity. During a stringing operation 40 to 50 men and a large amount of specialized equipment will be required. A normal stringing operation will entail stringing two to four miles of line in one set-up of equipment, and will require one to three weeks to complete.

Prior to the stringing operation, stringing dollies, which are neoprene line sheaves, must be hung on each structure along with the required insulator assemblies. During this same period, "guard poles," temporary structures consisting of two wood poles with a wood crossarm between, are placed at all locations where the transmission line crosses roads, railroads or existing overhead facilities. Lead lines of polypropylene rope are then installed between the structures in the section to be strung and are placed in the stringing dollies. At one end of the operation, the tugger, mounted on a truck or semi-trailer, is moved into position. The tugger consists of a series of motor driven drums and reels that pulls the conductors into position. At the other end of the set-up, the tensioner, also mounted on a truck or semi-trailer, is moved into position along with the conductor trailers, reel strands and reels of conductor. The tensioner consists of two motor driven wheels per conductor, that provide braking action during the strining operation to prevent the conductor from touching the ground, and to facilitate pulling the conductor up to proper sag.

Before the conductors are strung, steel cables and shield wires are attached to the polypropylene lead lines and the tugger reels up the lead line pulling the steel cable and shield wires into position. Temporary anchors are used to secure them until the set-up is completed. The conductors are then strung, one phase at a time, which results in either two or three conductors being strung in one operation. When all conductors and shield wires have been pulled into position, they are pulled up to the proper sag, and final attachments are made at each structure.

The construction activities discussed will be performed sequentially. It will take many months to complete all construction activities in any one section of line. Activities will not be continuous but will occur periodically as different crews move from site to site.

2.1.3.3.5 Debris Removal

Clean-up and restoration of the right-of-way will be the final activity and will entail moving excess materials and general construction debris as well as repairing damages done to the right-of-way. Damage settlements will then be secured from the individual property owners.

The construction activities will occur as outlined in the schedule shown on Figure 2.1-7.

2.1.4 RIGHT-OF-WAY-MAINTENANCE

2.1.4.1 Operational Maintenance

Following construction clean-up, the right-of-way will be restored according to the Right-of-Way Maintenance Specifications contained in Appendix A. Those restoration practices that will be used where necessary or desirable include: grading to restore natural ground surfaces; seeding the cleared right-of-way with low-growing species that will not endanger the line or that will benefit wildlife; seeding those temporary access roads that will not be retained by owners; removal of temporary structures at stream crossings.

The right-of-way restoration and on-going maintenance programs are aimed at soil stabilization and controlling vegetation to prevent re-establishment of tall-growing species that could be hazardous to the line. Another objective of this project is to improve the habitat for game. Appendix A

which details the Right-of-Way Game Habitat Improvement Program to be followed on the transmission right-of-way, is intended to provide selective vegetation management to maximize those types of plant communities most favorable to wildlife.

The general management practices outlined in Appendix B indicate that the center tract of the right-of-way will generally be maintained in a grassy-herbaceous type of cover. Supplemental plantings of clover and grass mixtures with potential wildlife food value will be used where desirable native type grasses are lacking. The outer two-thirds of the right-of-way will be managed to encourage a variety of herbs, shrubs and low-growing trees which have a potential value to wildlife found in the area. As noted in Appendix B, special management practices may be used in certain unique instances and locations.

2.1.4.2 Abandonment and Restoration of Right-of-Way

In the event that the 500 kV transmission line should lose its functional utility at some time in the future, the transmission line would be removed. All towers would be dismantled and the conductors and other materials removed from the right-of-way. Structure foundations would be removed to a minimum depth of 18 inches below ground level. In areas that this activity would create potential for soil erosion, grading and reseeding would be performed. The natural process of vegetative succession would be allowed for the right-of-way and access roads to return to their prior condition. The land rights obtained for this transmission line would be retained as a possible route for future transmission lines.

2.2 ENVIRONMENTAL IMPACT

2.2.1 INTRODUCTION

The proposed transmission line is a single circuit 500 kV ac line that will extend for approximately 200 miles between Forbes and the Minnesota-Manitoba border near Warroad. The right-of-way requirement is 200 feet, or 160 feet where the 500 kV line parallels the proposed Minnkota/MP&L 230 kV line. Therefore, the total of land affected by the Forbes to Warroad segment of the project is, at most, 5000 acres.

Environmental effects of the proposed transmission line include impacts on the physical environment, impacts on certain economic activities, and impacts upon people who reside along the route. Most of the impact on the physical environment will occur during the right-of-way clearing operation and construction. However, electrical effects and maintenance practices occurring during the operation of the line will cause continuing impact on the physical environment. Effects on economic activities such as agriculture and forestry will occur during construction and continue to seom degree for as long as the line is in use. Impact on residents along the line will also occur during construction and continue for the life of the facility.

2.2.1.1 Construction

Construction impacts are mainly on the physical environment. Construction activities will be carried on by utility personnel and by construction contracting companies who specialize in such work and will involve the use of heavy equipment.

Areas of impact occurring during construction are identified as agriculture, forestry, wildlife and terrestrial vegetation, aquatic natural systems, recreation and historic areas, soils, and local socio-economic systems. People who live near tower placements will experience "nuisance" impacts during construction such as the noise and dust that result from the use of heavy equipment.

2.2.1.1.1 Agriculture

Impacts on agricultural activities occurring during construction of an EHV line include soil compaction and crop damage caused by heavy equipment, and soil mixing caused by foundation excavation. These impacts occur near the tower placement site and to areas required for access.

2.2.1.1.2 Forestry

Some of the most significant impacts of constructing this EHV transmission line are on forested lands. This is the result of the 160 to 200 foot right-of-way required for reliability reasons and also because access roads will be required in some places. Except in special circumstances the right-of-way will be clear cut to a width of 180 feet and herbicides will be applied to inhibit future growth of tall species. In some instances tall trees outside of the right-of-way will be taken.

2.2.1.1.3 Wildlife and Terrestrial Vegetation

Impacts on wildlife and terrestrial vegetation will occur during construction. Construction noise and disturbances to habitat will cause some wildlife to leave the area, at least temporarily. Construction practices can also have adverse impact on the quality of water in streams thereby affecting fish habitat.

2.2.1.1.4 Soils

Impact on soils occur when construction activities expose soil surfaces through foundation construction, access road construction, or by removal of vegetation. Besides exposing soils to nature's erosive elements, these activities can alter drainage patterns and expose other, not yet disturbed areas.

2.2.1.1.5 Socio-Economic

Socio-economic impacts associated with EHV transmission line construction will be similar to those of most large construction projects. However, construction personnel will generally commute to work, eliminating any major impact on housing and public services in the area. Some local labor may be used in unskilled work for short periods of time.

2.2.1.1.6 Human Settlement

Impact on human settlement during construction will be caused by the operating of heavy equipment and will be of the nuisance variety.

2.2.1.2 Operation

Environmental effects associated with the operation of the line include electrical effects, the effect of the visual and physical intrusion of structures on humans, impacts resulting from maintenance practices, loss of efficiency in agricultural and forestry operations, and interference to communication facilities.

2.2.1.2.1 Electrical Effects

Electrical effects of a high voltage transmission line include corona, electrostatis, electromagnetic and long-term field effects. Corona discharge produces audible noise, radio and television interference and the gaseous oxidents, ozone and oxides of nitrogen.

The Minnesota Power and Light and Northern States Power Companies contracted with Power Technologies, Inc. (PTI) to study safe, reasonable electrical effects criteria for all EHV transmission lines. Their report, Electrostatic and Electromagnetic Environmental Criteria for EHV Overhead Transmission Lines, appears in Appendix H of this report. A summary of that report is contained in this section. The report assumes a three conductor bundle of "CARDINAL" 954 kcmil ACSR 54/7 (1.196 inch diameter) with a minimum ground clearance of 39 feet at 120^{o} F conductor temperature. Additionally, Appendix D contains that portion from the MP&L-TR-1 hearing examiner's findings of fact, conclusions and recommendations.

2.2.1.2.1.1 Electrostatic Effects

2.2.1.2.1.1.1 Shock Hazard

Vehicular Shock Criteria for Areas of Occasional Exposure Under Ideal Conditions

	Measure	Probability	Applicability	on ROW	off ROW
Safety	5 mA	.5%	All	X	X
	25 j	.5%	All	X	X
Annoyance	2 mA	50%	Adult Males	-	X
	2 mj	50%	Adult Males	-	X
Perception	1.1 mA	50%	Adult Males	-	-
	.12mj	59%	Adult Males	-	-

Limiting Gradients for Given Criteria (kV/m)

	Criteria	Vehicles			
		A	D	B	C
Safety	5 mA	22.32	11.62	10.86	6.33
	25 j	259.00	167.00	159.00	106.50
Annoyance	2 mA	8.92	4.65	4.35	2.50
	2 mj	2.37	1.47	1.41	.95
Perception	1.1 mA	4.91	2.56	2.39	1.39
	.12mj	.58	.36	.35	.23

In the case of permanent structures, annoyance and perception off the ROW can and should be eliminated with proper grounding procedures.

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2.2.1.2.1.1.2 Fuel Ignition

Restrictions should be placed on vehicle fueling in those locations where stored energy exceeds 0.25 millijoule.

2.2.1.2.1.1.3 Pacemakers

With improvements in pacemaker design, the probability of interference from exposure to EHV lines is declining with time.

2.2.1.2.1.2. Electromagnetic Effects

Since magnetic field effects are a function of line current and not voltage, EHV transmission raises no new problems that have not already been studied in connection with lower voltage high-current lines.

2.2.1.2.1.3 Corona Effects

2.2.1.2.1.3.1 Audible Noise

As a general criterion, it is recommended that, during wet-conductor conditions, such as following precipitation or during dense fog, the long-time average L_{50} audible noise at the edge of ROW should not exceed 50 dBA.

2.2.1.2.1.3.2 Radio Interference

Two criteria are proposed, one being conformance with edge of ROW noise levels from existing successfully operating lines. The other is to use a fair weather signal-to-noise ratio not below 26 dB for stations within their primary service area.

2.2.1.2.1.3.3 Television Interference

The criterion for edge of ROW signal-to-noise ratio is 17 dB or better for stations in the normal service area.

2.2.1.2.1.3.4 Gaseous Oxidents

Presently available evidence shows that at ground level, measurable concentrations of oxidents from EHV lines are essentially zero.

2.2.1.2.1.4 Long-Term Field Effects

2.2.1.2.1.4.1 Human Exposure

Available present evidence considers 10 kV/m to be a safe level for humans under EHV lines. Work is progressing and higher levels may subsequently be shown to be safe. A conservative magnetic field criterion of 1 gauss is not likely to be exceeded at ground level at any location. The MP&L-TR-1 hearing examiner's finding $50 indicates that the testimony of Drs. Becker and Marino before the New York Public Service Commission is of questionable validity. Some elaboration of the finding is included in the following paragraphs.

The testimony given by Dr. Marino and Dr. Becker was based on the conclusions they derived from two studies conducted by them relating to the health effects on rats and mice exposed to electric fields at 60 hz, similar to those produced by EHV transmission lines. Also to substantiate their theory that continuous exposure to electric fields will have biological effects on humans, they have cited numerous studies done in the area of biological effects of electric fields and related phenomena.

Dr. Marino, a biophysicist, conducted the actual experiments, the statistical analysis of the data, and formulated the general hypothesis that exposure to extra-low-frequency (ELF) electric fields will produce biological effects in test animals. Dr. Becker, a medical doctor, then carried it further and concluded from their studies and current literature on the topic that there is possible medical significance to the continuous exposure of humans to ELF electric fields. Neither doctor will testify to any specific effects that electric fields might have on humans nor do they know or are they willing to estimate what lengths of exposure or maximum strength of electric fields they would consider unsafe. The strongest statement either doctor will testify to is that they believe there is a biological effect caused by exposure to ELF electrical fields and that further study in this area is definitely needed to ascertain any specific effects these fields might have on humans.

During the cross-examinations of Dr. Marino and Dr. Becker, a number of points were brought out that severely questioned the scientific credibility of the two doctors' testimony regarding their hypothesis. To begin with the limited number of experiments and the very small statistical significance of these experiments appears inadequate for a theory of the magnitude presented by the doctors. There was also some questionable experimental protocol involved in the measurement and collection of data. Other weaknesses of their testimony were lack of comprehensive peer review of the studies conducted, a somewhat liberal interpretation of the literature used to verify their theories and the obvious need for more complete studies to be made in this area. Lastly, probably the strongest argument made against the doctors' testimony was the absence of any harmful health effect ever being detected or reported in relation to electric fields from power lines over the course of the long history of human interaction with these power lines.

The matter of the safety level for electric fields of 1.5 volts/cm or .15 kv/m that is recommended by Dr. Marino deserves further elaboration concerning its derivation. In the doctors' two studies an electric field of 150 volts/cm is used on the exposed rats and mice. To derive a safety level Dr. Marino then concludes that 150 volts/cm will cause biological effects and applies a factor of safety of 100 to arrive at the 1.5 volts/cm figure. He uses the factor of safety of 100 because this is the same safety factor the Federal government uses in connection with the use of food additives. His reasoning that the safety factor of food additives would apply for electric field exposure is that there is a similar balance situation involving the manufacturer wanting to gain an economic advantage with the government's desire to protect the public health. He further states that the two situations are similar because both deal with involuntary exposure of the general population. But most importantly Dr. Marino states both in his testimony and cross-examination that he presents his 1.5 volts/cm safety level only as a starting point for further discussion and analysis and attaches no further significance to it than that.

2.2.1.2.1.4.2 Flora and Fauna Exposure

Available evidence indicates criteria at least as high if not higher than for human exposure.

2.2.1.2.2 DESIGN PARAMETERS

2.2.1.2.2.1 Shock Hazard

The PTI report recommends that steady short circuit current induced on objects in the right-of-way be limited to less than 5 milliamperes. The lines will be designed to meet this criteria. In areas where large vehicles are likely,

the height of the line will be raised to provide the clearance needed to result in a less than 5 milliampere short circuit current.

The PTI report recommends that a spart energy induced on objects in the right-of-way be limited to less than 25 joules. Based on clearances needed to meet the 5 milliampere limit, the maximum spart energy will be approximately 100 millijoules; far below the recommended criteria.

2.2.1.2.2.2 Fuel Ignition

The line design will exceed the 0.25-millijoule limit for fuel ignition. As part of the easement process NSP/MP&L will inform landowners not to fuel their vehicles in proximity to the transmission line.

2.2.1.2.2.3 Pacemakers

As concluded in the PTI report, the line has little probability of interference with pacemakers.

2.2.1.2.2.4 Electromagnetic Effects

As concluded in the PTI report, the standard procedures for dealing with electromagnetic effects will eliminate any potential problem.

2.2.1.2.2.5 Corona Effects

2.2.1.2.2.5.1 Audible Noise

The TPI report recommends that the mean (L_{50}), wet-conductor audible noise (technically, a condition in which precipitation has stopped and the conductor is wet) should not exceed 50 dB(A) at the edge of the right-of-way.

In evaluating audible noise certain considerations must be remembered:

(1) The only time the line could produce significant audible noise is when the line is wet (due to heavy rain, light rain, snow, dense fog, etc.). This condition can be expected no more than 15-20 percent of the time, based on data from the Minneapolis weather station (Commonwealth, 1975).

(2) Outdoor activity by residents along the ROW will generally cease or generally decrease during most of the periods of inclement weather associated with most heavy rain, snow, etc., conditions.

(3) Mean audible noise during wet-conductor conditions means that 50 percent of that time the noise will be less than that level.

(4) Audible noise increases with voltage level. The 500 kV line is designed for a 10 percent over-voltage of 500 kV; however, it is expected that the line will generally operate at less than this maximum. The line will be designed so that the noise levels from the transmission line under wet-conductor conditions will be as follows:

	Voltage Level		
	500 kV	525 kV	550 kV
Estimated mean audible noise (dB(A)) (50% level) at edge of 200 ft. right-of-way	38.6	42.3	45.5

(5) Under dry conductor conditions (over 80 percent of the time) and some of the time under wet conductor conditions the noise level at the edge of the right-of-way will be much less and unnoticeable compared to the ambient noise level.

2.2.1.2.2.5.2 Radio and Television Interference

The PTI report recommends that the radio and television, signal to noise ratios, in fair weather be limited to 26 dB and 17 dB respectively. In order to calculate the signal-to-noise ratio studies must determine what

the radio or television signal strength is in different areas. Northern State Power Company made measurements on radio and television signal strengths before routing its existing 345 kV transmission lines and these measurements did little to predict actual radio and TV interferences. Therefore, no study of signal strengths has been completed for this project.

For radio and TV interference, the transmission lines have been designed to approximately the same criteria as NSP's existing 345 kV transmission lines. NSP has received few complaints on radio and TV interference caused by their 345 kV lines.

The figures below are radio noise levels (not signal-to-noise ratios) and can be compared with Table 13, PTI report, page 38.

	Voltage Level		
Radio Noise at Edge of 200 ft. Right-of-Way	500 kV	525 kV	550 kV
Fair Weather*	44.5**	46.1	47.7
Foul Weather	66.5	68.1	69.7

The same meteorological condition that causes increased audible noise causes increased radio noise. Therefore, fair weather values can be expected for at least 80 percent of the time.

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* Fair weather levels calculated to be 22 dB lower than foul weather values (PTI report page 50)

**Radio noise in dB(A) - decibels referenced to 1 microvolt/meter

2.2.1.2.2.5.3 Gaseous Oxidents

The PTI report determined that no evidence could be found to support the theory that EHV transmission lines cause ground levels of ozone to be higher than ambient. Calculations have shown that the maximum one-hour concentrations during foul weather at 550 kV (worst case) would be .0057 parts per million. This corresponds to the MPCA regulations which limit one-hour concentrations to .07 parts per million.

2.2.1.2.2.5.4 Long Term Field Effects - Human Exposure

The PTI report recommends 10 kV/meter to be a safe level for humans under EHV lines. The fields associated with the 500 kV line appears below:

		Electrostatic Field in kV/M at Lateral Distance from Tower in Feet		
Voltage	Maximum	50	100	150
500	6.9	5.9	1.6	.5
525 (5%)	7.2	6.2	1.6	.5
550 (10%)	7.6	6.5	1.7	.6

All values are calculated at minimum ground clearance. Minimum ground clearance for this line is 39 feet at a conductor temperature of 120°. Also approximately half of the line is at the minimum clearance in any span. From the table, it can be seen that the field strength decreases rapidly with distance from the structures.

2.2.1.2.2.5.5 Flora and Fauna

Levels which, as indicated in the PTI report, are safe for humans are also safe for flora and fauna.

2.2.1.2.3 Human Settlement

Impacts on residents along the route due to the physical and visual intrusion of the structures are difficult to ascertain. Some residences or other structures will require removal from the right-of-way. Residents who own land at structure sites, or who own land under conductors are compensated, as well as those whose property location necessitates the removal of a home or other structure, according to the effect of the action on the assessed valuation of the property. Theoretically, at least, the resulting change in the assessed valuation of the property should reflect the magnitude of the loss in property value and in amenity. Those people who own land or reside near the power line, but do not own property within the right-of-way are not compensated.

In any case, the physical and visual intrustions of the structures taken together with the inconveniences of audible noise, radio and television interference, possible shocks and electromagnetic effects, are a substantial burden for the people who reside along the route.

2.2.1.2.4 Agriculture

Disruption of agricultural activities by EHV transmission lines are particularly apparent to producers of row crops. When alignment of the structures does not follow land lines or coincide with field boundaries, reductions in crop yields and inefficient patterns of farm machinery use will result.

Transmission lines also present a hazard to low-flying aircraft used in spraying crops as well as presenting severe restrictions on the use of certain methods of irrigation.

2.2.1.2.5 Forestry

As was previously mentioned, the major disruption to forestry land uses caused by EHV lines occurs during construction. However, the possibility of interference with forest management practices also exists if a line bisects management units, decreasing the economic feasibility of harvest and disrupting long-range plans for multiple use.

2.2.1.2.6 Communications

Three possible effects on communication facilities exist as a result of EHV line location. First, transmission lines absorb and reradiate radio waves. Second, certain locations of towers can cause attenuation of radio wave strength due to the physical obstruction. Third, electrical transmission equipment can cause the reflection of radio waves of certain frequencies.

2.2.1.3 MAINTENANCE

Impacts associated with maintenance practices result from the use of herbicides such as 2, 4, 5-T, the possible use of heavy equipment in emergency situations, and from monthly surveillance of the line from low-flying aircraft.

The commonly accepted use of the herbicide 2, 4, 5-T by electrical utilities has recently been called to question by the Minnesota Legislature because of the herbicide's content of the deadly poison dioxin. Resulting legislation is now in effect and regulations concerning the use of herbicides will be complied with by the utilities.

2.2.1.4 CONCLUSION OF OPERATION

This EHV transmission line is expected to be in operation for 30 to 40 years. When the line is no longer serviceable most of the elements such as the

conductors and the structures are recycleable. However, it is the common practice of electric utilities to retain easements for possible future use.

2.2.1.5 RARE OR UNIQUE RESOURCES OF THE REGION

An adequate discussion of this topic appears in Chapter 1.

TABLE 2.1-1

Cost Analysis

Network 1 Iron Range Area

Route Segment		Nodes
	*1	1 2 4 5
	2	1 3 5
	3	5 8 9
	4	5 6 9
	*5	5 7 8 9

Route Segment	1	2	3	4	5
Land & Land Rights	200,000	175,000	245,000	350,000	250,000
Clearing	80,000	70,000	180,000	180,000	180,000
Steel Towers & Fixtures	950,000	970,000	1,050,000	1,095,000	1,150,000
Conductors & Devices	900,000	900,000	985,000	1,035,000	1,050,000
Construction Labor	1,295,000	1,310,000	1,475,000	1,530,000	1,550,000
Total Construction Cost	3,425,000	3,425,000	3,935,000	4,190,000	4,180,000
Engineering & Administration	365,000	360,000	395,000	415,000	415,000
Interest During Construction	435,000	435,000	500,000	520,000	520,000
TOTAL COST	4,225,000	4,220,000	4,830,000	5,125,000	5,115,000

* preferred route

Network 2 Central

Route Segment 1 Nodes 9 10 12 14 17 19 20
2 9 10 11 13 14 17 19 20
*3 9 10 11 15 16 18 20

Route Segment	1	2	3
Land and Land Rights	620,000	610,000	60,000
Clearing	1,775,000	1,700,000	1,650,000
Steel Towers & Fixtures	430,000	430,000	610,000
Aluminum Towers & Fixtures	5,010,000	4,900,000	4,560,000
Conductors & Devices	6,175,000	6,050,000	5,900,000
Construction Labor	6,700,000	6,600,000	5,950,000
Total Construction Cost	20,710,000	20,290,000	19,270,000
Engineering & Administration	2,600,000	2,550,000	2,500,000
Interest During Construction	2,640,000	2,650,000	2,460,000
TOTAL COST	25,950,000	25,490,000	24,230,000

* preferred route

North Network

Route Segment	Nodes
1	20 21 24 27
*2	20 21 24 25 26
3	20 21 22 25 26
4	26 29 31 33 34 35
*5	26 28 30 34 35
6	27 28 30 34 35

Route Segments	1	2	3	4	5	6
Land & Land Rights	300,000	290,000	305,000	275,000	255,000	245,000
Clearing	485,000	410,000	310,000	325,000	340,000	220,000
Steel Towers & Fixtures	215,000	275,000	500,000	1,285,000	1,285,000	1,320,000
Aluminum Towers & Fixtures	1,960,000	1,910,000	1,830,000	810,000	560,000	480,000
Conductors & Devices	2,510,000	2,475,000	2,620,000	2,235,000	1,915,000	1,835,000
Construction Labor	2,580,000	7,960,000	8,365,000	2,530,000	2,245,000	2,185,000
Total Construction Cost	8,050,000	7,960,000	8,365,000	7,460,000	6,600,000	6,385,000
Engineering & Administration	1,070,000	1,045,000	1,110,000	945,000	810,000	7,700,000
Interest During Construction	1,030,000	1,020,000	1,070,000	9,550,000	840,000	815,000
TOTAL COST	10,150,000	10,025,000	10,545,000	4,460,000	8,250,000	7,970,000

* preferred route

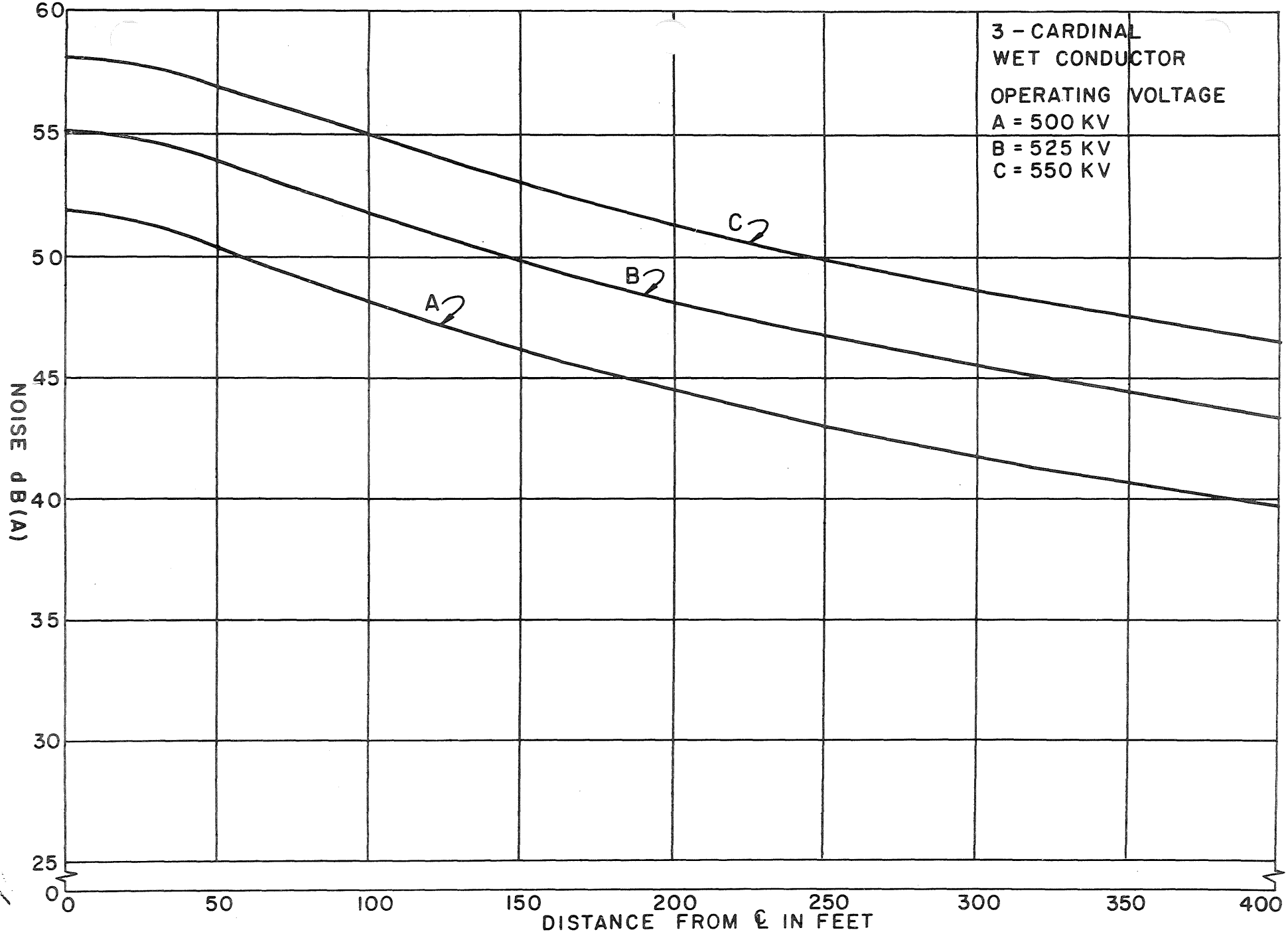
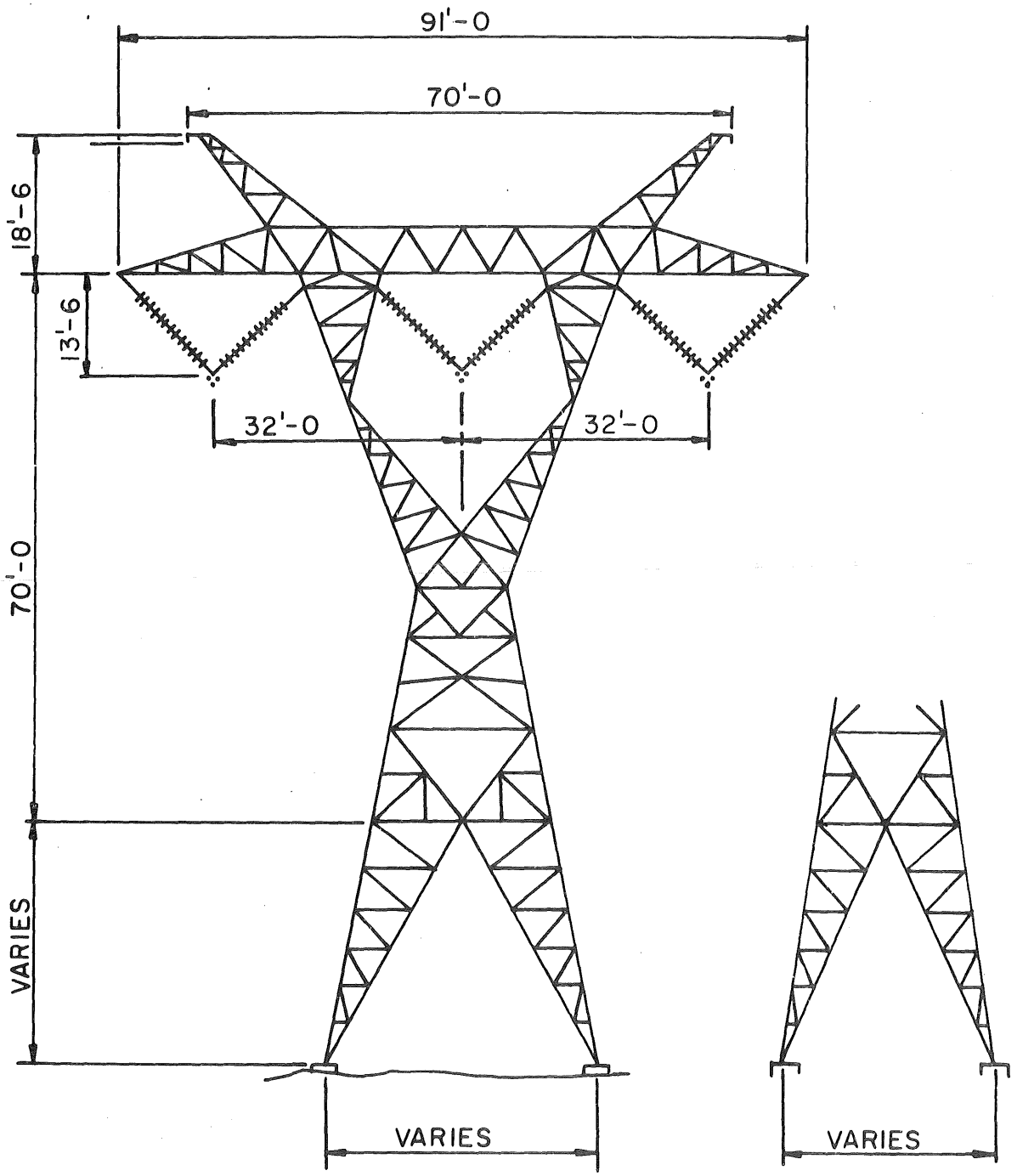

3 - CARDINAL
WET CONDUCTOR
OPERATING VOLTAGE
A = 500 KV
B = 525 KV
C = 550 KV
C
B
A
NOISE dB(A)
60
55
50
45
40
35
30
25
0
0
50
100
150
200
250
300
350
400
DISTANCE FROM ℄ IN FEET

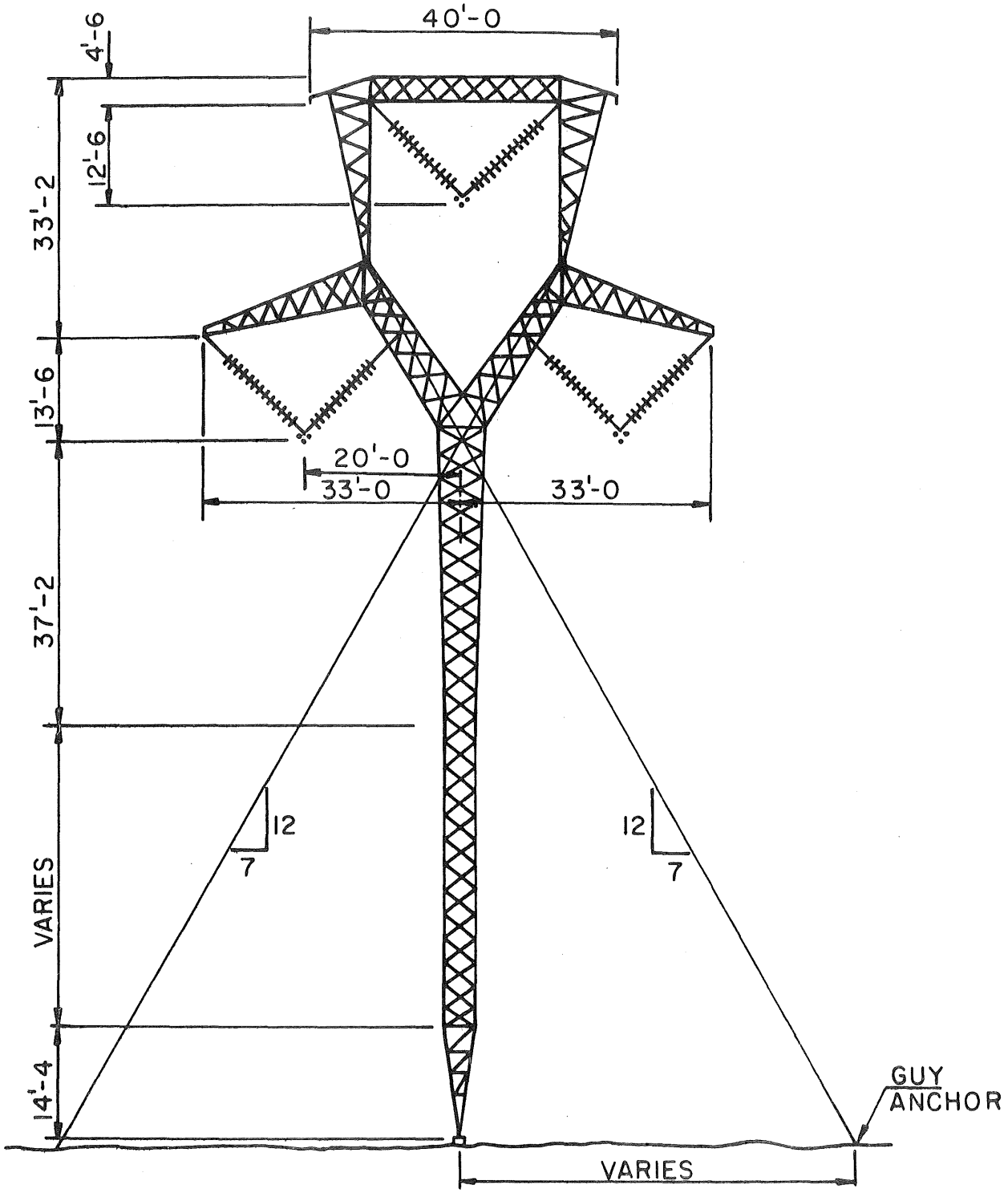
FIGURE 2.1-0



500 KV SELF-SUPPORTING STEEL STRUCTURE

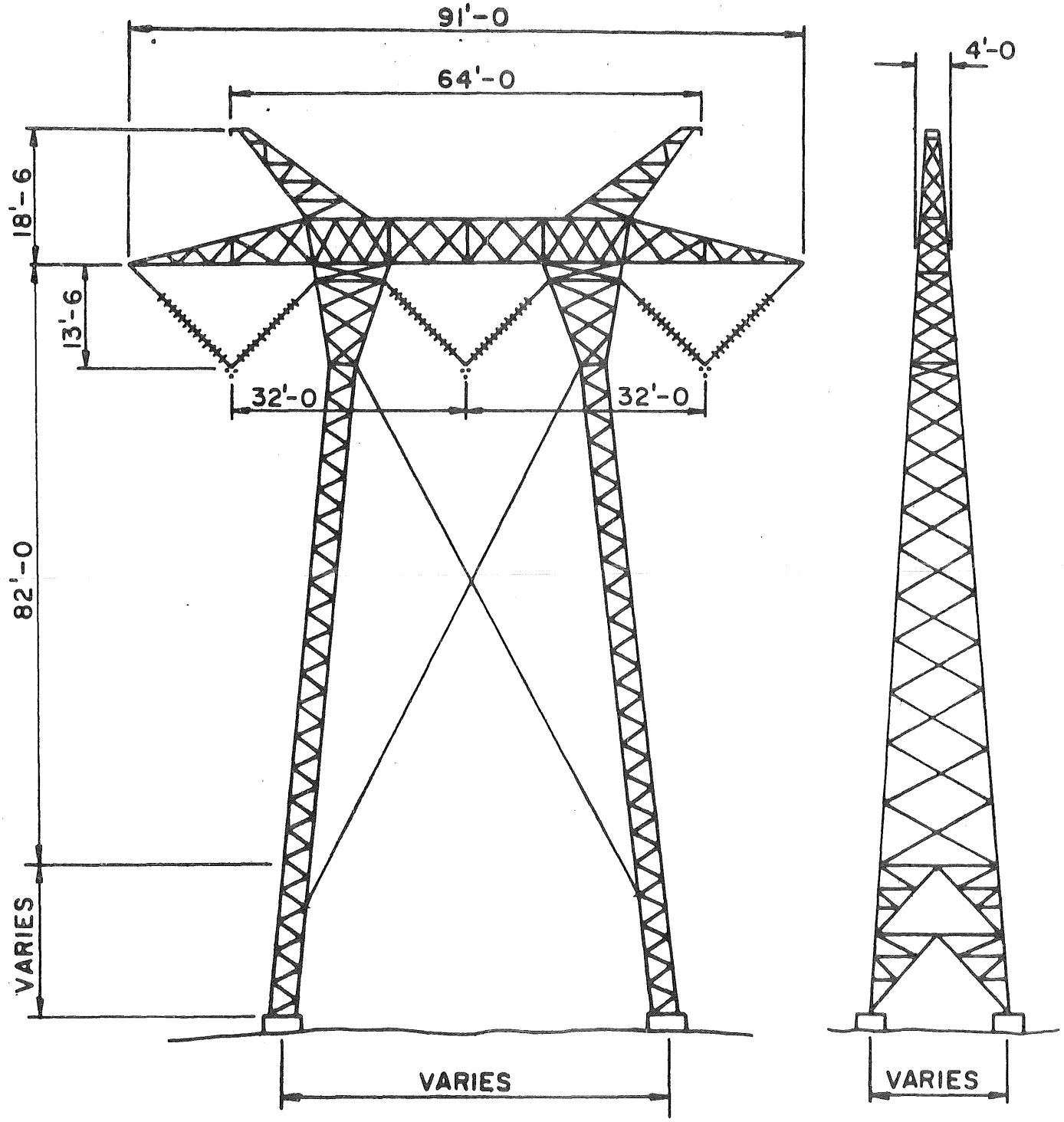
FIGURE 2.1-1

E 1.1



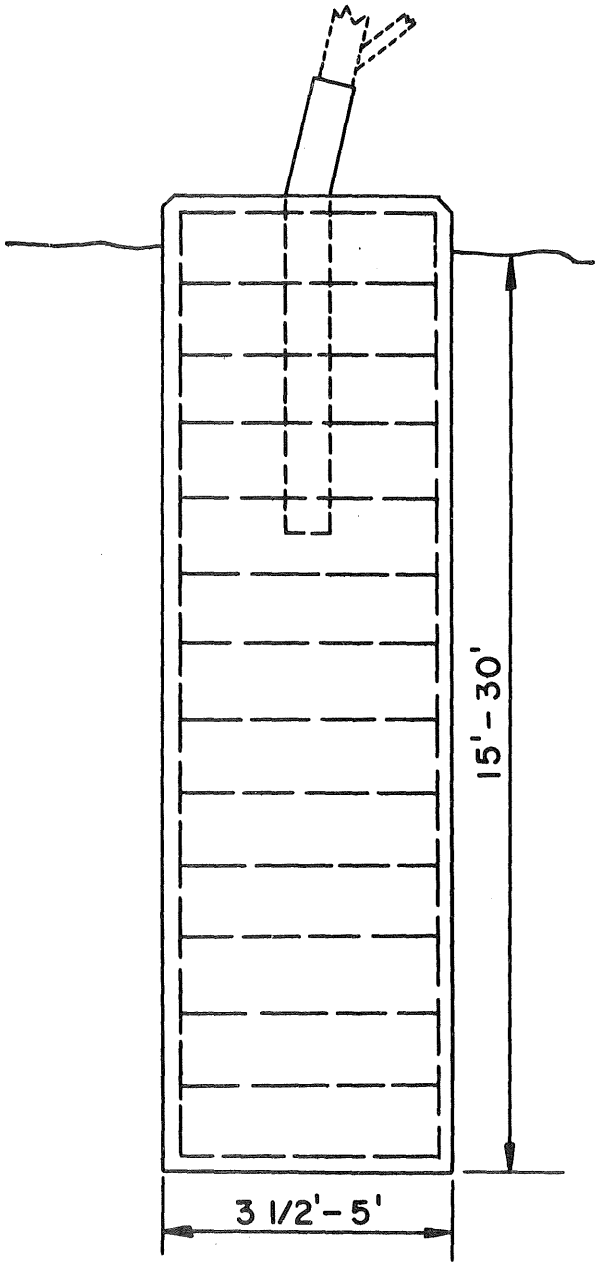
500 KV GUYED ALUMINUM STRUCTURE

FIGURE 2.1-2



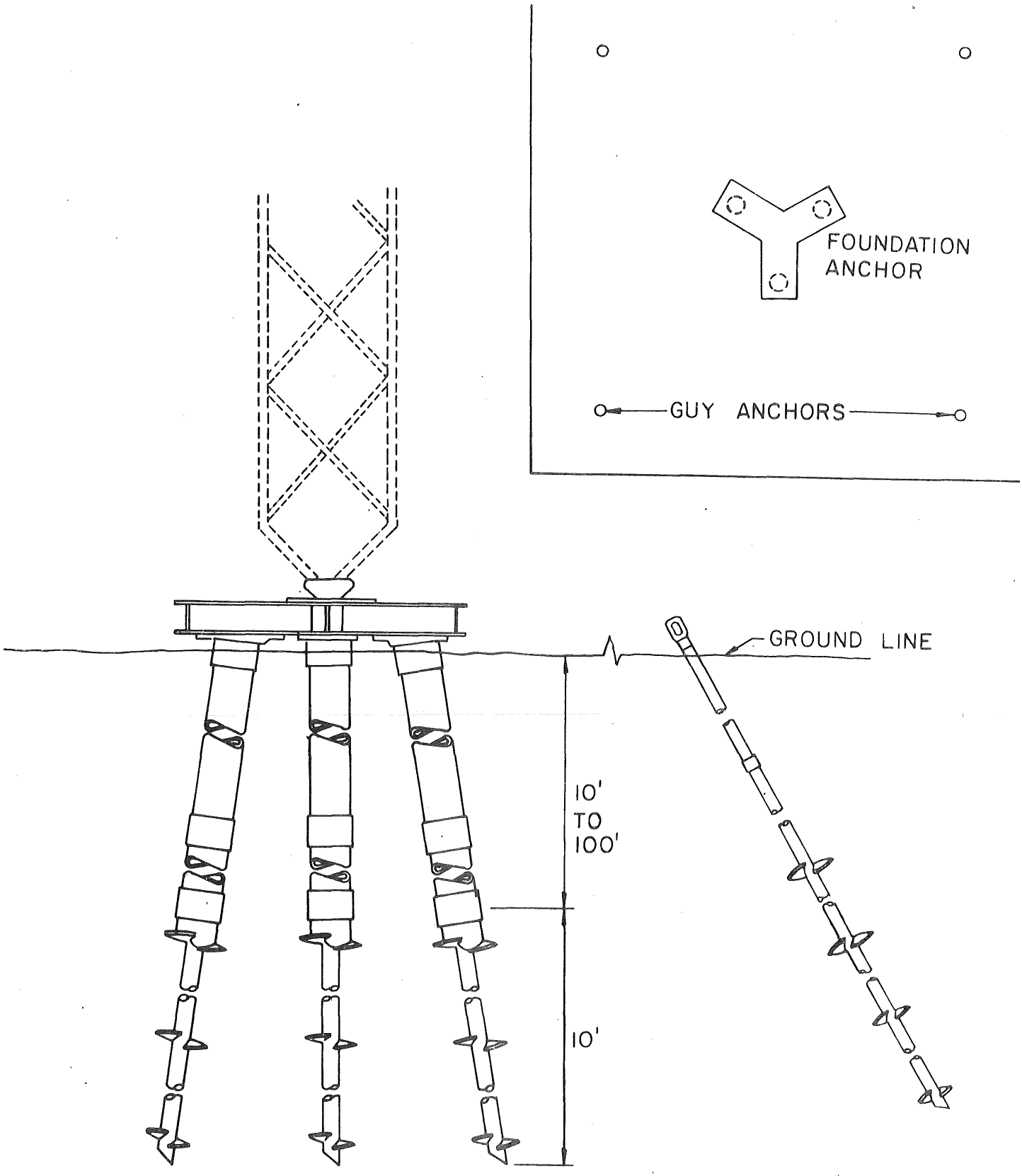
500 KV INTERNALLY GUYED
ALUMINUM PORTAL STRUCTURE

FIGURE 2.1-3



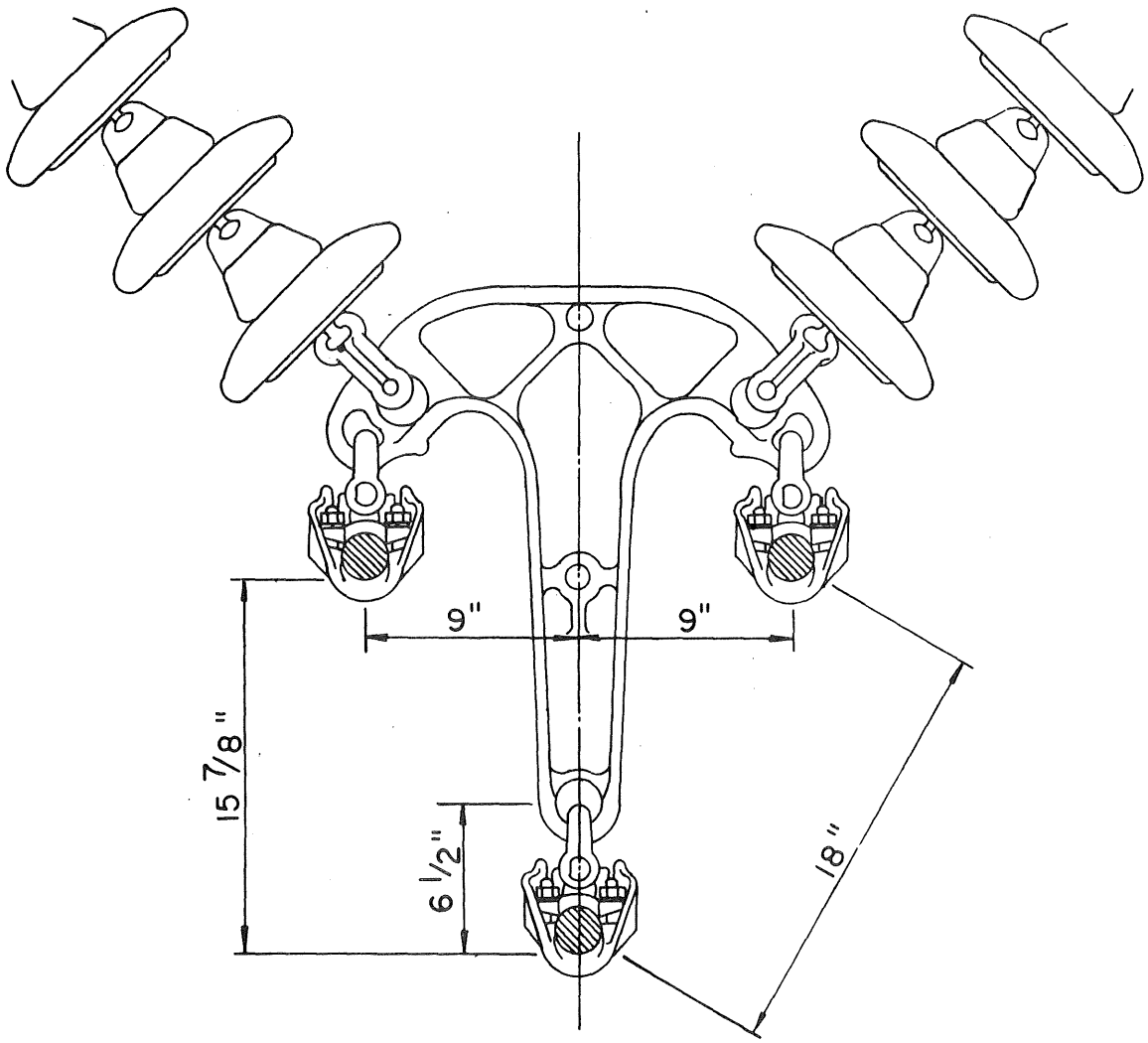
DRILLED SHAFT FOUNDATION
FOR STEEL LATTICE STRUCTURE
(FOUR REQUIRED PER STRUCTURE)

FIGURE 2.1-4



FOUNDATION ANCHOR ASSEMBLY
(GUYED ALUMINUM STRUCTURE)

FIGURE 2.1-5



500 KV THREE CONDUCTOR BUNDLED ASSEMBLY

FIGURE 2.1-6

TENTATIVE CONSTRUCTION SCHEDULE (FORBES TO INTERNATIONAL BORDER)

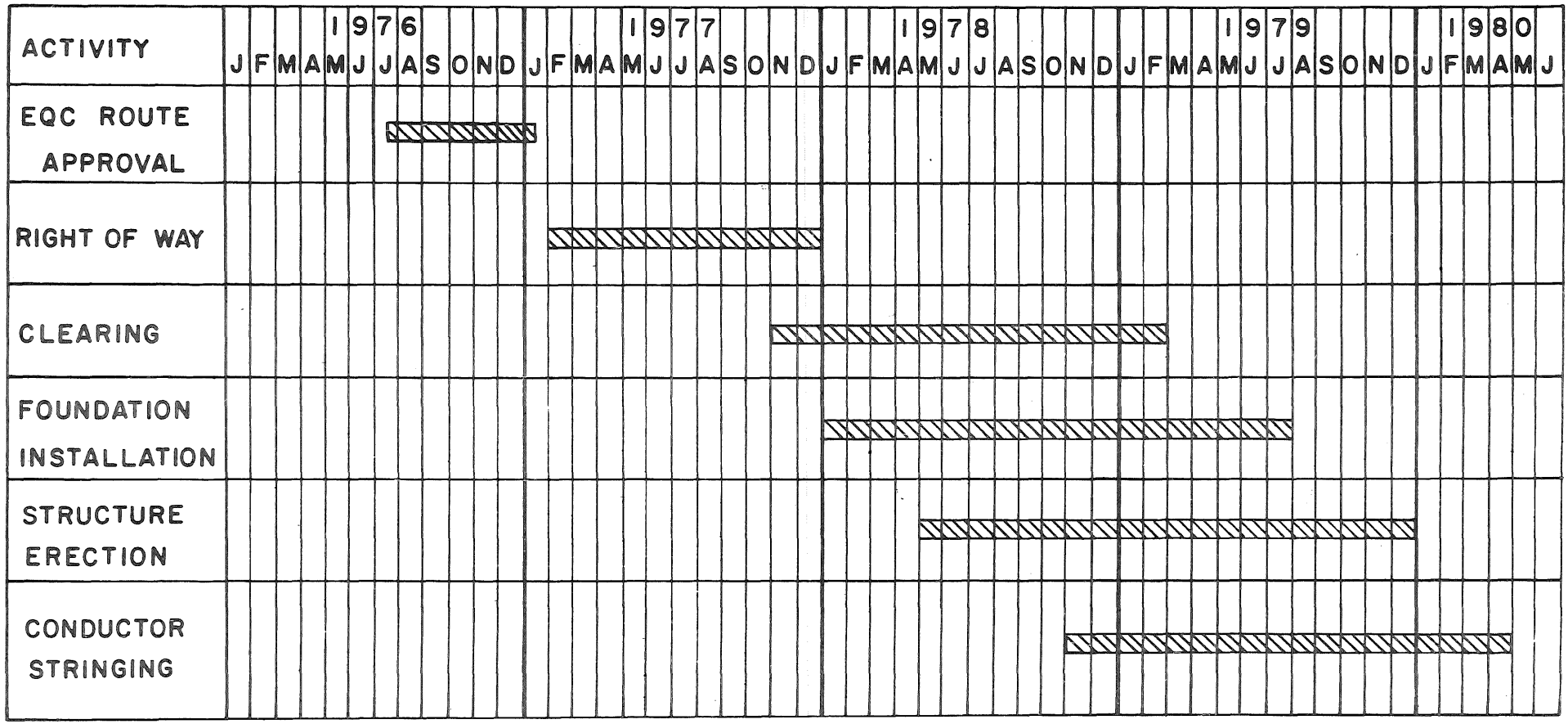


FIGURE 2.1-7

3 DIRECT AND INDIRECT ENVIRONMENTAL, ECONOMIC, AND EMPLOYMENT EFFECTS THAT CANNOT BE AVOIDED

CHAPTER 3

3.1 ADVERSE EFFECTS OF THE PROPOSED TRANSMISSION LINE

The adverse effects of the transmission line project have been discussed earlier in the report. However, they can be briefly summarized.

1. Disruption to human settlement on or near the route.
2. Disruption or destruction of natural vegetation within the right-of-way during construction, and to areas where access roads will be built.
3. Soil erosion resulting from construction activities.
4. Effects on water quality as a result of erosion and siltation, and possibly from the use of herbicides.
5. Effects on wildlife habitat.
6. Disruption of agricultural activities during construction and operation.
7. Effects of forestry management practices.
8. Electrical effects.

3.2 BENEFICIAL EFFECTS

Besides the obvious benefit to users of electricity, the proposed interconnection could potentially generate other benesits. These other benefits are chiefly economic in nature. However, there is a possibility for some environmental benefits.

Approximately $51 million will be invested by NSP for this segment of the project. This investment will employ many people in the production of materials and in the engineering and construction of the line. In general, this investment will stimulate the economy.

Another economic benefit to be derived from the interconnection is the more efficient use of generating facilities. The Winnipeg-Twin Cities interconnection will make surplus hydroelectric energy available to the Minnesota companies, displacing their higher-cost, fossil-fuel generated electric energy. This is probably the single, most important reason for constructing the line.

The interconnection will also make it possible for the utilities to gain efficiencies associated with the staggered relationship of their respective peak demand periods. Manitoba Hydro and MP&L experience the greatest demand for electric energy in the winter months due to system heating requirements. NSP's peak demand occurs in the summer as a result of the extensive use of air conditioners. With the interconnection, the utilities will be able to buy electric energy wholesale during their peak demand periods in lieu of firing up inefficient, usually oil-fueled peaking plants.

In the case of MP&L, whose system demand is expected to double within the next five years. the interconnection will buy them time until they are able to construct adequate generating facilities.

Potential for environmental benefits resulting from this project are directly related to the displacement of fossil fuel-generated electricity by water-generated electricity and to the efficient use of generating facilities mentioned earlier. These benefits are discussed again in Chapter 5.

3.3 MITIGATING MEASURES

3.3.1 Human Settlement

For the most part, human settlement impacts are mitigated by avoiding the critical areas. However, when the route does pass through areas where there are residences or where there is human activity, certain electrical performance standards will be applied to ensure the health and safety of the public.

3.3.2 Agriculture

Principal farm products in the proposed area of construction are hay and livestock. These crops can be grown in the right-of-way with some modification in the pattern of use of farm machinery. In cultivated areas, the structures will be freestanding, not guyed, to minimize the amount of land affected by the structure. Where possible, the transmission line and transmission structures will be located along legal survey lines, land lines, ditches or field borders. Access to construction sites will occur on existing farm roads and along land lines wherever possible. Owners will be compensated for all damages incurred during construction as well as for any damages which occur during emergency maintenance operations.

3.3.3 Natural Vegetation

In order to minimize possible impacts, vegetative clearing and management will be carefully controlled as described in the Right-of-Way Maintenance Program, Appendix B. It should be noted here, however, that the clearing and revegetation practices to be employed provide for early reseeding of cleared areas.

3.3.4 Forestry

Wherever possible in forested areas, access roads will be provided on the cleared right-of-way or on existing logging or other roads. Where this is not possible, new access roads will be located to minimize their effect on forest management units, stands of valuable timber or potential logging operations.

The Right-of-Way Maintenance Program, outlined in Appendix B, details the proposers' plans for cooperation in multiple use programs on right-of-way located on public land. Recreational activities such as snow-mobiling, horseback riding and cycling, which do not interfere with the normal maintenance of the line will be encouraged on public land. Where the line easement is on private land, the rights of owners must be considered.

3.3.5 Aquatic Systems

Necessary fording will be coordinated with the local Minnesota Department of Natural Resources managers and their recommendations will be followed. Surface runoff will be controlled by selective cutting within an appropriate distance from the water's edge. Where the situation dictates, seeding of desirable grass-clover mixtures will be accomplished on both sides of water crossing. Selective cutting will be utilized to leave as much riparian vegetation as possible minimizing the possibilities of sedimentation, increased turbidity and water temperature with their impacts on aquatic life. In those areas adjacent to streams, where it will be necessary to control vegetation with herbicides, selective ground application methods will be employed and only approved herbicides will be used.

3.3.6 Recreational and Historical Land Uses

The best way to reduce impact on recreational or historical land uses is to avoid those areas. Vegetative screens will be developed where appropriate. Where consistent with safety considerations, original vegetation will be left. In the event that historical or archaeological sites are discovered during the course of the survey, clearing, or line construction, such work will be stopped and the Minnesota Historical Society advised.

NOTE: When the Minnesota Environmental Quality Council issues a construction permit for this project, other, more specific mitigative measures will be specified as conditions of the construction permit.

4 IRRETRIEVABLE AND IRREVERSIBLE COMMITMENTS OF RESOURCES

CHAPTER 4

Resources to be used for this project are basically land, labor and material.

Except for the effects of soil erosion, land used for right-of-way and access for this project can eventually be restored to its original uses. However, it is unlikely that the utility will release easement rights in the foreseeable future.

Most of the material used for the towers and conductors (steel and aluminum) is recycleable and has value enough to justify such action economically. (See Chapter 2 for an itemization of the materials used.)

5 TRADE-OFFS BETWEEN SHORT TERM ENVIRONMENTAL GAINS VERSES LONG TERM GAINS OR LOSES

CHAPTER 5

Short and long term environmental losses have already been discussed in this report. There is a potential for offsetting environmental gains which could be the result of the implementation of this project.

The Manitoba Hydro Electric Board has an excess capacity of electrical energy generated by means of a renewable resource. This energy will average 1.5 billion kWhr each year during the term of the agreement. Since Manitoba Hydro's hydroelectric generation utilizes a renewable resource, a portion of which will not be usable in Canada in the next several years, it is practical and economically beneficial for both utilities to transfer this excess energy to NSP where generation is based primarily on non-renewable resources such as coal and oil.

Manitoba Hydro will also have capacity surpluses in the summer when NSP has its peak power requirements. These surpluses will provide NSP with 200 MW of peaking capacity during the 1980-1992 summer seasons. Along with the surplus energy and peaking capacity, Manitoba Hydro will also make available an additional 300 MW of peaking capacity to NSP in the 1980-1992 summer seasons as part of a summer-winter diversity capacity exchange. NSP will make available the 300 MW of peaking capacity in the following winter season when NSP has surplus generating capacity while Manitoba experiences its peak power requirements. Energy deliveries associated with these capacity transactions will be approximately 440,000 MWhr in the summer seasons and 265,000 MWhr in the winter seasons.

In addition, in the event of adverse water conditions in Manitoba, NSP will deliver up to 1.5 billion KWhr to Manitoba Hydro in a winter season. The interconnection will also be used for daily energy exchanges between off-peak and on-peak hours. After 1992, the proposed facility will be utilized to continue to transfer capacity and energy between the two systems to improve economy of operation and enhance system reliability, and reduce generating facility requirements.

6 ALTERNATIVES TO THE PROPOSED ACTION

CHAPTER 6 ALTERNATIVES TO THE PROPOSED ACTION

At this point in time the only routing alternatives that have been proposed have been proposed by Northern States Power Company. The Minnesota Department of Natural Resources is currently in the final stages of collecting data on a route alternative proposal, as is the citizen's Route Evaluation Committee. These additional route segments, if approved for study by the MEQC at its September 14, 1976 meeting, will be considered at the public hearings along with the NSP route network and will be detailed in the Final EIS.

The NSP routing alternatives have been divided into three networks. Network #1 includes the alternatives between nodes 1 and 9 and is located in the Iron Range area. Network #2 continues from node 9 to node 20 and includes parts of Itasca, Koochiching and Beltrami Counties. Network #3 extends from node 20 to node 35 passing through Lake of the Woods and Roseau Counties.

Network #1 has five distinct route segments. Table 6.1-2 identifies each of the route segments in this network by node number and summarizes potential impacts along each segment. Altogether by combining the route segments, there are six different routing possibilities in Network #1.

In Network #2, three possible routes have been identified. Table 6.2-2 identifies each of the routes by node numbers and summarizes potential impacts associated with each routing alternative.

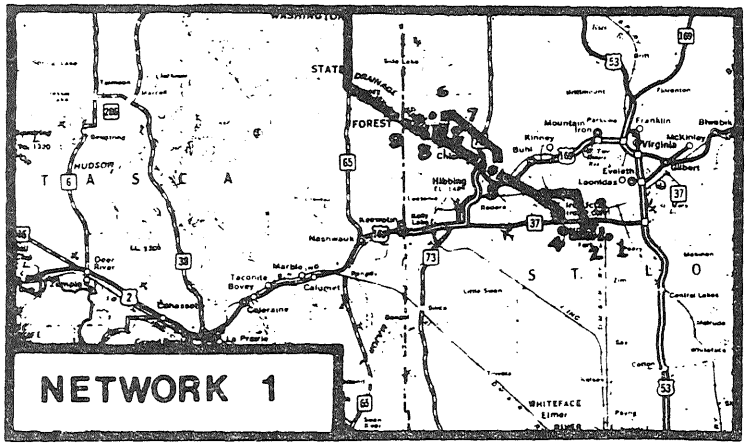
The NSP Network #3 offers six different routing alternatives which are combinations of six distinct route segments. Table 6.3-2 identifies the segments by node numbers and summarizes potential impacts along each route segment.

The data provided on the following pages were compiled from the Minnesota Land Management Information System (MLMIS) by the project proposer. The MLMIS is a computer data bank located at the University of Minnesota and operated jointly by the University of Minnesota and the Minnesota State Planning Agency. Computer data maps for the NSP route network can be found in NSP's application for a construction permit for this project.

TABLE 6.1-2

NETWORK 1 - IRON RANGE

	WEIGHT	ROUTE IMPACT IN MILES				
		1	2	3	4	5
Human Settlement						
Federal land - BIA	very high	0.00	0.00	0.00	0.00	0.00
Zoned industrial - heavy	low	0.50	0.00	9.75	4.75	6.00
Zoned residential I (20,000-40,000 Sq Ft Min Lot Size)	medium	0.00	0.00	0.00	0.00	0.00
Zoned residential II (40,000-80,000 Sq Ft Min Lot Size	low	0.50	0.00	0.25	0.00	0.25
Zoned residential III (80,000 Sq Ft - 5 acreas Min Lot Size	low	10.50	11.25	0.00	5.75	3.00
Potential mining - Submarginal deposits (2400-3600 ft)	very high	0.00	0.00	2.75	2.50	2.75
Urban and non-residential or mixed residential	medium	0.00	0.25	0.50	0.25	0.25
Proposed airport 1-3 mile constraint	medium	0.00	0.00	0.00	0.00	0.00
MHD gravel pits	very high	0.00	0.00	0.00	0.00	0.00
Industrial - light zoning	low	0.00	0.00	0.00	0.00	0.00
Urban residential	very high	0.00	0.00	0.50	0.25	0.00
Low density residential planned	medium	0.00	0.00	0.00	0.00	0.00
20-year sewer zoning	low	0.00	0.00	0.00	0.00	0.00
Incorporated areas	very high	0.00	0.00	2.00	1.00	1.50

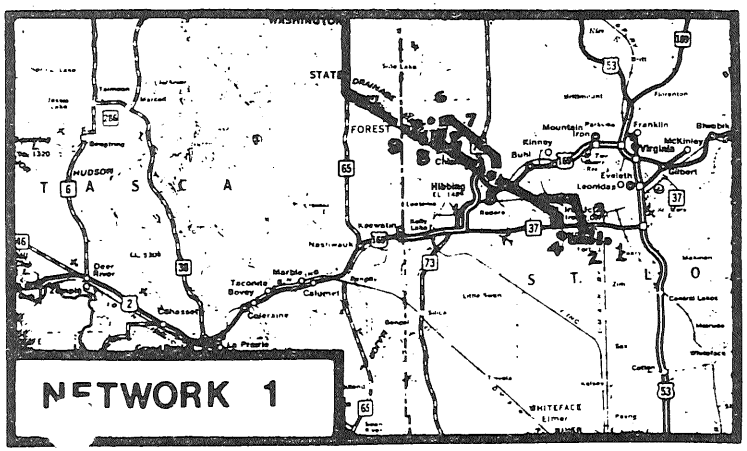


Segment Number	Segments Connect These Nodes	Length in Miles
1	1 2 4 5	14
2	1 3 5	13.75
3	5 8 9	15.2
4	5 6 9	16
5	5 7 8 9	16

TABLE 6.1-2

NETWORK 1 - IRON RANGE

	WEIGHT	ROUTE IMPACT IN MILES				
		1	2	3	4	5
Visual Impact						
Incorporated + 1 mile buffer	high	0.00	0.00	4.00	4.00	3.75
Unincorporated + 1 mile buffer	high	0.00	0.50	3.75	10.50	5.00
Institution + 1 mile buffer	medium	0.00	0.00	0.00	0.00	0.00
Commercial-industrial + 1 mile buffer	low	2.00	2.50	3.00	5.75	3.50
Residential Exp. + 1 mile buffer	low	14.25	11.50	9.75	14.25	8.25
Commercial-Industrial exp. + 1 mile buffer	low	2.00	1.50	13.50	10.50	9.75
State park and wayside + 1 mile buffer	very high	0.00	0.00	1.50	0.00	1.25
County and local parks + mile buffer	high	2.00	0.00	1.50	0.00	1.25
Public access + 1 mile buffer	medium	0.00	2.75	0.00	2.00	0.00
Other public rec + 1 mile buffer	medium	0.00	0.00	0.00	0.00	0.00
Public rec land + 1 mile buffer	medium	4.75	5.50	0.00	1.50	0.00
Private rec 1 + 1 mile buffer	medium	0.00	0.00	0.00	0.00	0.00
Private rec 2 + 1 mile buffer	medium	4.75	1.75	2.00	0.00	1.50
Sewer exp + 1 mile buffer	low	0.00	0.00	0.00	0.00	0.00
Two land state or federal + 1 mile buffer	medium	2.75	2.75	1.75	5.00	2.75
Two land county paved + 1 mile buffer	low	12.00	11.50	9.00	12.00	7.50
Recreation zoned lakes + 1 mile buffer	high	3.50	0.25	4.50	0.00	0.00
Canoe rivers + 1 mile buffer	high	0.00	0.00	0.00	0.00	0.00
Scenic roads + 1 mile buffer	high	0.50	0.00	3.75	3.00	3.00
Four land other + 1 mile buffer	high	0.00	0.00	3.75	3.50	3.25
Right-of-way Sharing		7.00	6.40	7.00	0.00	10.00

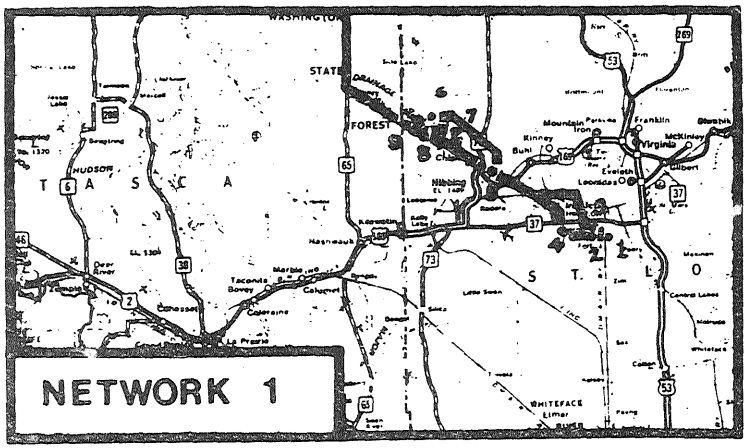


Segment Number	Segments Connect These Nodes	Length in Miles
1	1 2 4 5	14
2	1 3 5	13.75
3	5 8 9	15.2
4	5 6 9	16
	5 7 8 9	16

TABLE 6.1-2

NETWORK 1 - IRON RANGE

	WEIGHT	ROUTE IMPACT IN MILES				
		1	2	3	4	5
Agricultural Resources						
Wild Rice	very high	0.00	0.00	0.00	0.00	0.00
Cultivated/rated as average	high	0.00	0.75	0.00	0.00	0.00
Pasture/rated as average	low	2.25	0.50	0.75	1.25	1.75
Cultivated/rated as good	high	0.00	0.00	0.00	0.00	0.00
Cultivated/rated as marginal	medium	0.00	2.00	0.00	0.00	0.00
Pasture/rated as good	medium	0.00	0.00	0.00	0.00	0.00
Pasture/rated as marginal	low	1.50	0.25	0.00	0.75	0.00
Forestry Resources						
Valuable Timber	very high	0.00	0.00	0.00	0.00	0.00
Blandin Paper Co/Valuable timber	very high	0.00	0.00	0.00	0.00	0.00
Coniferous/good soil	high	0.50	0.25	2.25	3.00	2.75
Forested/good soil	medium	0.25	0.00	6.25	4.75	5.00
Coniferous/average soil	medium	0.25	0.25	0.50	0.00	0.50
Forested/average soil	low	3.00	4.25	0.25	0.00	0.25
Coniferous/marginal soil	low	2.50	0.25	0.00	0.00	0.00
Pasture/good forestry soil	low	0.00	0.00	0.00	0.00	0.00
Coniferous plantations	very high	0.00	0.00	0.00	0.00	0.00
Forest Co owned plantations	high	0.00	0.00	0.00	0.00	0.00
Forested marginal	low	0.00	0.00	0.00	0.00	0.00



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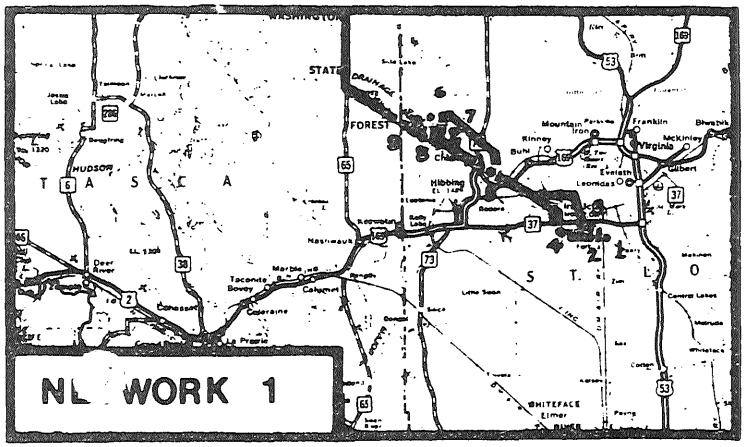
1	1 2 4 5	14
2	1 3 5	13.75
3	5 8 9	15.2
4	5 6 9	16
5	5 7 8 9	16

TABLE 6.1-2

NETWORK 1 - IRON RANGE

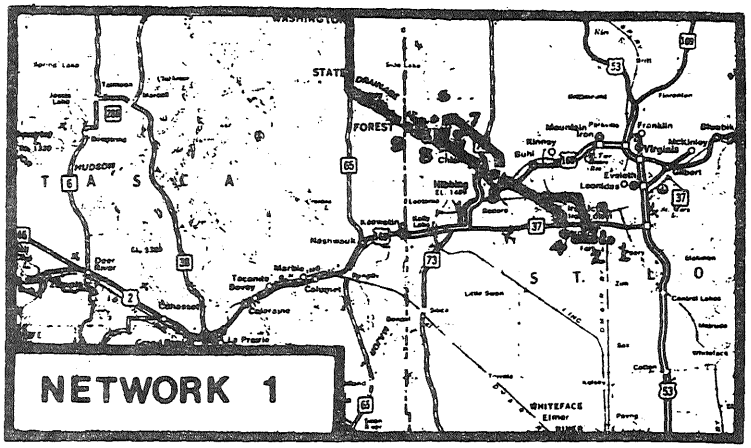
	WEIGHT	ROUTE IMPACT IN MILES				
		1	2	3	4	5
Vegetation Wildlife						
Marsh	medium	0.75	0.00	0.00	0.00	0.00
Pasture-open	low	3.75	0.75	0.75	2.00	1.75
Trout lake	very high	0.00	0.00	0.00	0.00	0.00
Trout river and stream	very high	0.00	0.00	0.00	0.00	0.00
Intermittent river and stream/trout	very high	0.00	0.00	0.00	0.00	0.00
Unique vegetation bog	very high	0.00	0.00	0.00	0.00	0.00
Unique wildlife deer yard	medium	0.00	0.00	0.00	1.00	0.00
Unique wildlife waterfowl	very high	0.00	0.00	0.00	0.00	0.00
Game trails	medium	0.00	0.00	0.00	0.00	0.00
Wildlife mgmt. area with resident manager	high	0.00	0.00	0.00	0.00	0.00
Unique wildlife (other)	low	0.00	0.00	0.00	0.00	0.00
One-half mile from waterfowl area	high	0.00	0.00	0.00	0.00	0.00
Non-fish and game recommended fish and game	high	0.00	0.00	0.00	0.50	0.00
White, red or Jack pine	very high	0.00	0.00	1.00	1.75	1.50
Spruce fir	high	5.50	1.50	2.00	2.50	2.00
Elm, ash, cottonwood	medium	0.00	0.00	0.00	0.00	0.00
Aspen, Birch	medium	4.25	6.25	7.50	7.00	6.00
Deer yard and mature timber	medium	0.00	0.00	0.00	0.00	0.00
Aquatic Resource						
Water	very high	0.00	0.00	0.50	0.00	0.25
Lake oriented	high	0.25	0.00	1.75	1.00	2.75
Perm river and stream oriented	medium	1.75	1.75	1.50	1.75	1.75
Intermittent river and stream oriented	low	0.00	0.00	0.75	0.00	0.00



Segment Number	Segments Connect These Nodes	Length in Miles
1	1 2 4 5	14
2	1 3 5	13.75
3	5 8 9	15.2
4	5 6 9	16
5	5 7 8 9	16

Table 6.1-2 (Continued)

	WEIGHT	ROUTE IMPACT IN MILES				
		1	2	3	4	5
Recreation and Historic						
Scenic river	high	0.00	0.00	0.00	0.00	0.00
Historic sites 40-80 acres	high	0.00	0.00	0.00	0.00	0.00
Scenic roadway	very high	0.00	0.00	0.50	0.50	1.00
Historic location 120-160 acres	medium	0.00	0.00	0.00	0.00	0.00
Resort	high	0.00	0.00	0.00	0.00	0.00
Lakeshore zoned heavy residential	high	0.00	0.00	0.00	0.00	0.00
Other State or County lands recommended for recreational use	medium	0.25	0.25	0.00	0.00	0.00

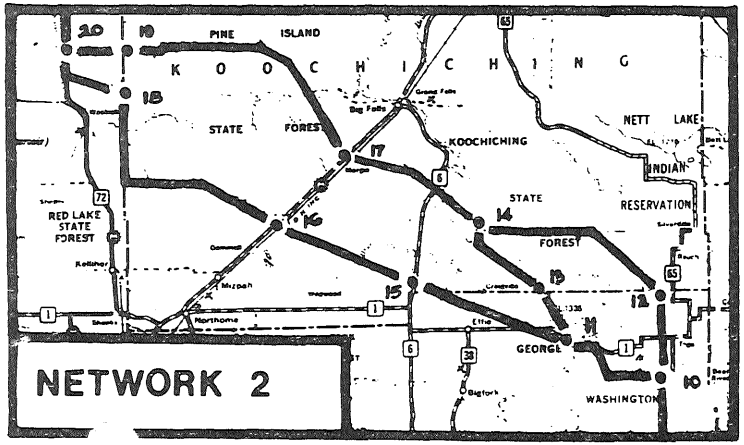


Segment Number	Segments Connect These Nodes	Length in Miles
1	1 2 4 5	14
2	1 3 5	13.75
3	5 8 9	15.2
4	5 6 9	16
5	5 7 8 9	16

TABLE 6.2-2

NETWORK 2 - CENTRAL

Human Settlement	WEIGHT	ROUTE IMPACT IN MILES 1	2	3
Federal land - BIA	very high	0.00	0.00	0.00
Zoned industrial - heavy	low	0.00	0.00	0.00
Zoned residential I (20,000-40,000 Sq Ft Min Lot Size)	medium	1.00	1.00	1.25
Zoned residential II (40,000-80,000 Sq Ft Min Lot Size)	low	1.50	2.00	4.50
Zoned residential III (80,000 Sq Ft - 5 acres Min Lot Size)	low	0.50	0.50	0.00
Potential mining - Submarginal deposits (2400-3600 Ft)	very high	23.50	31.00	41.50
Urban and non-residential or mixed residential	medium	0.50	1.25	2.50
Proposed airport 1-3 mile constraint	medium	0.00	0.00	0.00
MHD gravel pits	very high	0.00	0.00	0.00
Industrial - light zoning	low	0.00	0.00	0.00
Urban residential	very high	0.00	0.00	0.00
Low density residential planned	medium	0.00	0.00	0.00
20-year sewer zoning	low	0.00	0.00	0.00
Incorporated areas	very high	0.00	0.00	0.00

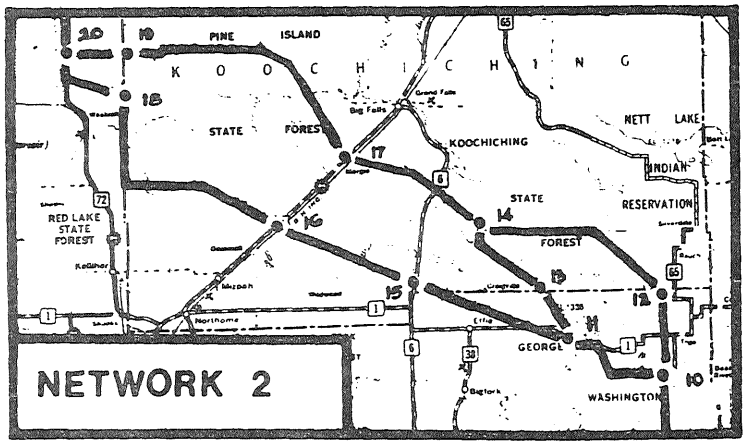


Segment Number	Segment Connect These Nodes	Length in Miles
1	9 10 12 14 17 19 20	100.2
2	9 10 11 13 14 17 19 20	98.0
3	9 10 11 15 16 18 20	96.2

TABLE 6.2-2

NETWORK 2 - CENTRAL

	WEIGHT	ROUTE IMPACT IN MILES 1	2	3
Visual Impact				
Incorporated + 1 mile buffer	high	0.00	0.00	3.50
Unincorporated + 1 mile buffer	high	0.00	1.50	2.00
Institution + 1 mile buffer	medium	0.00	0.00	0.00
Commercial-industrial + 1 mile buffer	low	0.50	5.75	3.75
Residential Exp. + 1 mile buffer	low	30.50	32.25	38.75
Commercial-industrial exp + 1 mile buffer	low	0.50	1.75	1.75
State park and wayside + 1 mile buffer	very high	0.00	0.00	2.25
County and local parks + 1 mile buffer	high	0.00	0.00	0.00
Public access + 1 mile buffer	medium	3.75	4.25	4.25
Other public rec + 1 mile buffer	medium	0.00	0.00	0.00
Public rec land + 1 mile buffer	medium	9.00	18.25	22.25
Private rec 1 + 1 mile buffer	medium	0.00	0.00	1.75
Private rec 2 + 1 mile buffer	medium	1.75	0.00	0.00
Sewer exp + 1 mile buffer	low	0.00	0.00	0.00
Two land state or federal + 1 mile buffer	medium	23.75	1.25	3.25
Two lane county paved + 1 mile buffer	low	0.00	0.00	0.00
Recreation zoned lakes + 1 mile buffer	high	2.25	3.25	3.25
Canoe rivers + 1 mile buffer	high	2.00	2.00	5.75
Scenic roads + 1 mile buffer	high	0.00	0.00	0.00
Four lane other + 1 mile buffer	high	0.00	0.00	0.00
Right-of-way Sharing		45.20	15.60	15.60



Segment Number	Segment Connect These Nodes	Length in Miles
1	9 10 12 14 17 19 20	100.2
2	9 10 11 13 14 17 19 20	98.0
3	9 10 11 15 16 18 20	96.2

Table 6.2-2 (Continued)

	WEIGHT	ROUTE IMPACT IN MILES 1	2	3
Recreation and Historic				
Scenic river	high	0.25	0.25	0.50
Historic sites 40-80 acres	high	0.00	0.00	0.00
Scenic roadway	very high	0.00	0.00	0.00
Historic location 120-160 acres	medium	0.00	0.00	0.00
Resort	high	0.00	0.00	0.00
Lakeshore zoned heavy residential	high	0.25	0.25	0.25
Other State or County lands recommended for recreational use	medium	0.25	0.75	0.15
Agricultural Resources				
Wild Rice	very high	0.00	0.00	1.00
Cultivated/rated as average	high	0.00	0.00	0.50
Pasture/rated as average	low	0.25	0.50	1.75
Cultivated/rated as good	high	0.00	0.00	0.00
Cultivated/rated as marginal	medium	0.00	0.00	0.00
Pasture/rated as good	medium	2.00	2.00	3.00
Pasture/rated as marginal	low	0.00	0.00	0.00

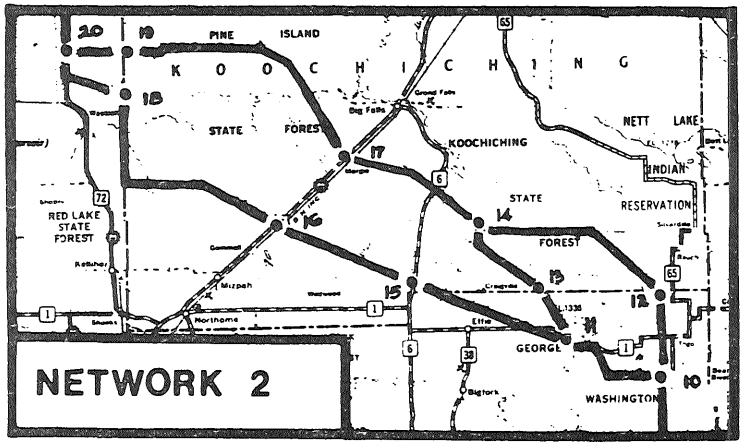


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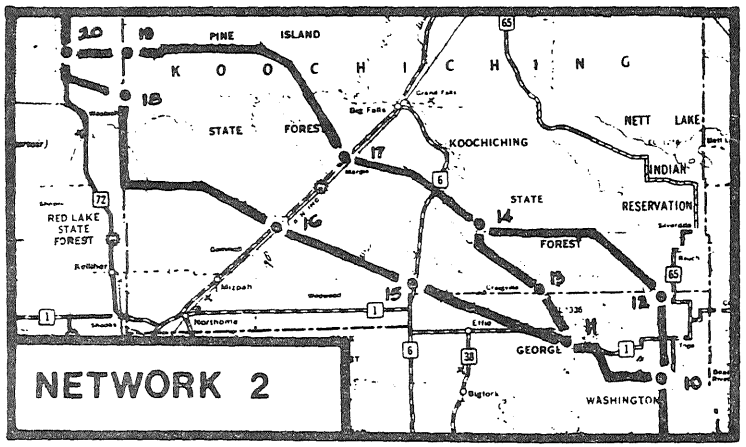
TABLE 6.2-2
NETWORK 2 - CENTRAL

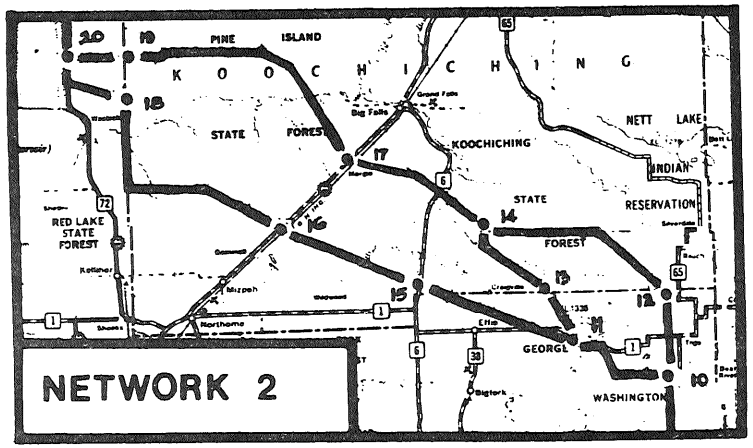
	WEIGHT	ROUTE IMPACT IN MILES 1	2	3
Vegetation Wildlife				
Marsh	medium	10.25	10.25	10.75
Pasture-open	low	0.50	1.25	2.50
Trout lake	very high	0.00	0.00	0.00
Trout river and stream	very high	0.25	0.00	0.00
Intermittent river and stream/trout	very high	0.00	0.00	0.00
Unique vegetation bog	very high	0.25	0.25	0.50
Unique wildlife deer yard	medium	0.00	0.00	0.00
Unique wildlife waterfowl	very high	0.00	0.00	0.00
Game trails	medium	0.00	0.00	0.00
Wildlife mgmt. area with resident manager	high	0.00	0.00	0.00
Unique wildlife (other)	low	0.00	0.00	0.00
One-half mile from waterfowl area	high	0.00	0.00	0.00
Non-fish and game recommended fish and game	high	0.50	1.25	4.50
White, red or Jack pine	very high	14.50	17.25	11.25
Spruce fir	high	39.75	55.50	50.75
Elm, ash, cottonwood	medium	0.00	0.00	0.00
Aspen, birch	medium	18.50	12.75	18.00
Deer yard and mature timber	medium	0.00	0.00	0.00
Aquatic Resource				
Water	very high	0.00	0.00	0.00
Lake oriented	high	0.50	1.75	1.50
Perm river and stream oriented	medium	2.00	3.50	4.00
Intermittent river and stream oriented	low	7.75	7.75	7.50



Segment Number	Segment Connect These Nodes	Length in Miles
1	9 10 12 14 17 19 20	100.2
2	9 10 11 13 14 17 19 20	98.0
3	9 10 11 15 16 18 20	96.2

Table 6.2-2 (Continued)

Forestry Resources	WEIGHT	ROUTE IMPACT IN MILES 1	2	3
Valuable Timber	very high	0.00	0.75	0.00
Blandin Paper Co/Valuable timber	very high	0.00	0.00	0.50
Coniferous/good soil	high	17.00	17.50	17.25
Forested/good soil	medium	12.50	9.00	9.25
Coniferous/average soil	medium	17.50	18.75	19.00
Forested/average soil	low	0.50	0.50	3.25
Coniferous/marginal soil	low	2.00	2.00	3.00
Pasture/good forestry soil	low	0.00	0.00	0.00
Coniferous plantations	very high	2.50	2.25	0.75
Forest Co owned plantations	high	0.75	0.75	1.75
Forested marginal	low	0.00	0.00	1.00

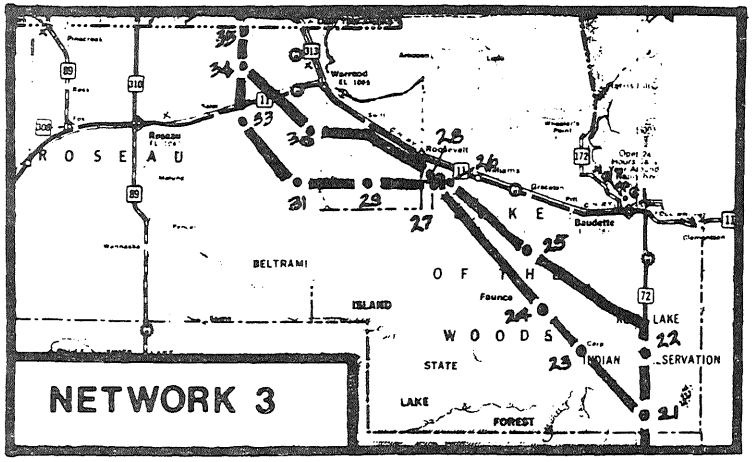


Segment Number	Segment Connect These Nodes	Length in Miles
1	9 10 12 14 17 19 20	100.2
2	9 10 11 13 14 17 19 20	98.0
3	9 10 11 15 16 18 20	96.2

TABLE 6.3-2

NETWORK 3 - LAKE OF THE WOODS AND ROSEAU

	WEIGHT	ROUTE IMPACT IN MILES					
		1	2	3	4	5	6
Human Settlement							
Federal land - BIA	very high	0.50	0.00	0.25	0.00	0.00	0.00
Zoned industrial - heavy	low	0.00	0.00	0.00	0.00	0.00	0.00
Zoned residential I (20,000 40,000 Sq Ft Min Lot Size)	medium	0.00	0.00	0.00	0.00	0.00	0.00
Zoned residential II (40,000-80,000 Sq Ft Min Lot Size)	low	0.00	0.00	0.00	0.00	0.00	0.00
Zoned residential III (80,000 Sq Ft - 5 acres Min Lot Size)	low	0.00	0.00	0.00	0.00	0.00	0.00
Potential mining - Submarginal deposits (2400-3600 Ft)	very high	0.00	0.00	0.00	0.00	0.00	0.00
Urban and non-residential or mixed residential	medium	0.00	0.00	0.00	0.00	0.00	0.00
Proposed airport 1-3 mile constraint	medium	0.00	0.00	0.00	0.00	0.00	0.00
MHD gravel pits	very high	0.00	0.00	0.00	0.00	0.00	0.00
Industrial - light zoning	low	0.00	0.00	0.00	0.00	0.00	0.00
Urban residential	very high	0.00	0.00	0.00	0.00	0.00	0.00
Low density residential planned	medium	0.00	0.00	0.00	0.00	0.00	0.00
20-year sewer zoning	low	0.00	0.00	0.00	0.00	0.00	0.00
Incorporated areas	very high	0.00	0.00	0.00	0.00	0.00	0.00

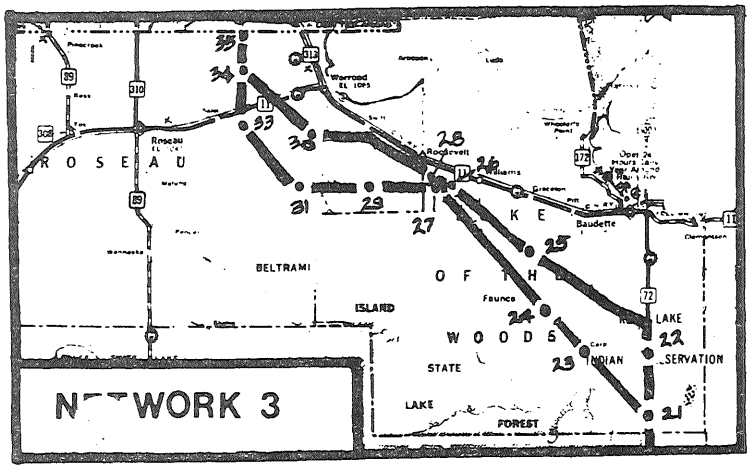


Segment Number	Segment Connect These Nodes						Length in Miles
1	20	21	24	27			41
2	20	21	24	25	26		40.5
3	20	21	22	25	26		43
4	26	28	30	33	34	35	35.6
5	26	28	30	34	35		30
6	27	28	30	34	35		29

TABLE 6.3-2

NETWORK 3 - LAKE OF THE WOODS AND ROSEAU

	WEIGHT	ROUTE IMPACT IN MILES					
		1	2	3	4	5	6
Visual Impact							
Incorporated areas + 1 mile buffer	high	0.00	0.00	0.00	0.00	2.25	1.75
Unincorporated + 1 mile buffer	high	0.00	0.00	0.00	0.00	2.00	1.25
Institution + 1 mile buffer	medium	0.00	0.00	0.00	0.00	0.00	0.00
Commercial-industrial + 1 mile buffer	low	0.00	0.00	0.00	0.00	0.00	0.00
Residential exp. + 1 mile buffer	low	0.00	0.00	0.00	0.00	0.00	0.00
Commercial-industrial exp. + 1 mile buffer	low	0.00	0.00	0.00	0.00	0.00	0.00
State park and wayside + 1 miel buffer	very high	0.00	0.00	0.00	0.00	0.00	0.00
County and local parks + 1 mile buffer	high	0.00	0.00	0.00	0.00	0.00	0.00
Public access + 1 mile buffer	medium	0.00	0.00	0.00	2.25	0.00	0.00
Other public rec + 1 mile buffer	medium	0.00	0.00	0.00	2.25	2.25	0.00
Public rec land + 1 mile buffer	medium	2.00	4.25	4.25	0.75	3.75	2.00
Private rec I + 1 mile buffer	medium	0.00	0.00	0.00	0.00	0.00	0.00
Private rec II + L mile buffer	medium	0.00	1.75	1.75	0.00	0.00	0.00
Sewer exp. + 1 mile buffer	low	0.00	0.00	0.00	0.00	0.00	0.00
Two lane state or federal + 1 mile buffer	medium	7.50	7.50	18.25	3.00	6.50	4.75
Two lane county paved + 1 mile buffer	low	3.00	3.00	3.00	0.00	6.50	6.00
Recreation zoned lakes + 1 mile buffer	high	0.00	0.00	0.00	0.00	0.00	0.00
Canoe rivers + 1 mile buffer	high	0.00	0.00	0.00	0.00	0.00	0.00
Scenic roads + 1 mile buffer	high	0.00	0.00	0.00	3.00	2.25	2.25
Four lane other + 1 mile buffer	high	0.00	0.00	0.00	0.00	6.50	6.00
Right-of-way Sharing							
		0.00	13.80	13.80	2.40	31.20	26.00



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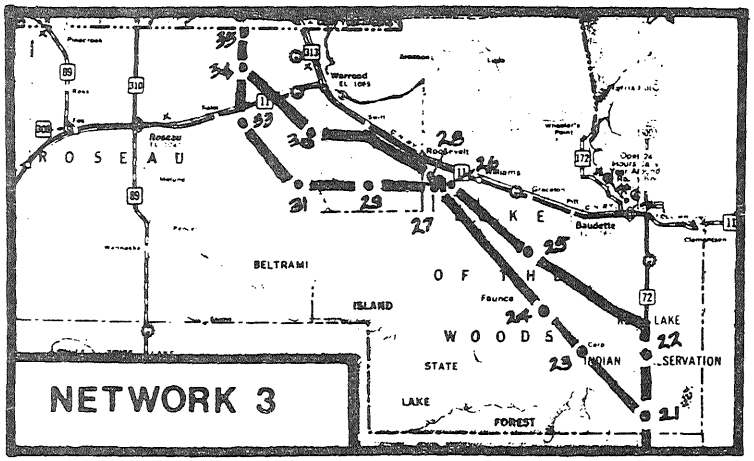
5	26	28	30	34	35		30
6	27	28	30	34	35		29

TABLE 6.3-2

NETWORK 3 - LAKE OF THE WOODS AND ROSEAU

	WEIGHT	ROUTE IMPACT IN MILES					
		1	2	3	4	5	6
Agricultural Resources							
Wild rice	very high	0.00	0.00	0.00	0.00	0.00	0.00
Cultivated/rated as average	high	0.25	0.50	1.75	4.50	7.50	7.50
Pasture/rated as average	low	0.25	1.25	1.50	0.75	0.25	1.25
Pasture/rated as marginal	low	1.25	0.25	0.50	2.75	1.50	1.25
Cultivated/rated as good	high	0.00	0.00	0.00	0.00	0.00	0.00
Cultivated/rated as marginal	medium	0.00	1.50	1.50	0.50	2.50	2.25
Pasture/rated as good	medium	0.50	0.00	0.00	6.75	6.00	4.25
Forestry Resources							
Valuable timber	very high	6.50	6.00	3.50	2.75	2.00	1.50
Blandin Paper Co/valuable timber	very high	0.00	3.75	0.50	0.00	0.00	0.00
Coniferous/good soil	high	3.25	3.75	0.50	0.00	0.00	0.00
Forested/good soil	medium	2.50	4.50	7.25	0.00	0.00	0.00
Coniferous/average soil	medium	6.25	5.25	0.00	8.75	4.25	3.75
Forested/average soil	low	3.50	0.75	0.75	1.50	5.75	5.50
Coniferous/marginal soil	low	10.50	10.75	5.50	6.75	4.75	4.25
Pasture/good forestry soil	low	0.25	1.75	2.75	0.00	0.00	0.00
Coniferous plantations	very high	0.00	0.00	0.00	10.00	0.50	0.25
Forest Co owned plantations	high	0.00	0.00	0.00	0.00	0.00	0.00
Forested marginal	low	3.00	3.25	5.75	2.75	6.50	8.00



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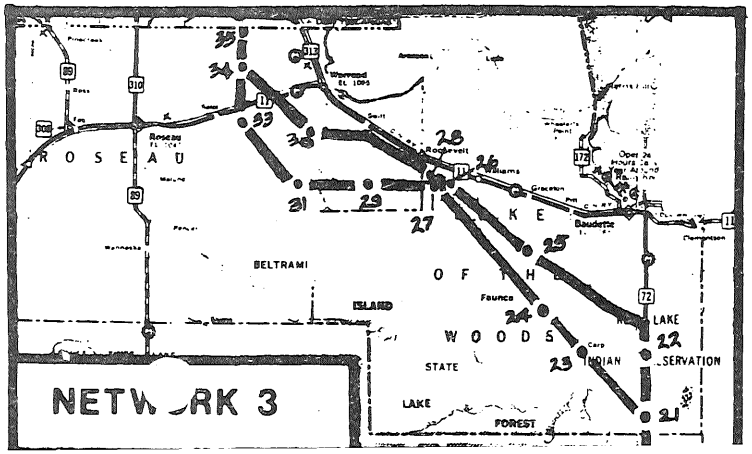
4	26	28	30	33	34	35	35.6
5	26	28	30	34	35		30
6	27	28	30	34	35		29

TABLE 6.3-2

NETWORK 3 - LAKE OF THE WOODS AND ROSEAU

	WEIGHT	ROUTE OF IMPACT IN MILES					
		1	2	3	4	5	6
Vegetation Wildlife							
Marsh	medium	8.00	12.00	19.25	4.75	2.50	2.25
Pasture-open	low	2.00	2.00	2.00	3.50	2.75	2.50
Trout lake	very high	0.00	0.00	0.00	0.00	0.00	0.00
Trout river and stream	very high	0.00	0.00	0.00	0.00	0.00	0.00
Intermittent river & stream/trout	very high	0.00	0.00	0.00	0.00	0.00	0.00
Unique vegetation bog	very high	0.00	0.00	0.00	0.00	0.00	0.00
Unique wildlife deer yard	medium	0.00	0.00	0.00	0.00	0.00	0.00
Unique wildlife waterfowl	very high	0.00	0.00	0.00	0.00	0.00	0.00
Game trails	medium	0.00	0.00	0.00	0.00	0.00	0.00
Wildlife mgmt. area with resident manager	high	0.00	0.00	0.00	0.00	0.50	0.50
Unique wildlife (other)	low	0.00	0.00	0.00	5.75	4.00	4.00
One-half mile from waterfowl area	high	0.00	0.00	0.00	0.00	0.00	0.00
Non-fish & game recommended fish & game	high	0.00	0.00	0.00	0.00	0.00	0.00
White, red or Jack pine	very high	0.00	19.25	6.25	0.00	0.00	0.00
Spruce fir	high	20.25	0.00	0.00	15.50	10.25	9.25
Elm, ash, cottonwood	medium	7.25	8.20	10.00	3.00	11.75	10.75
Aspen, birch	medium	3.75	4.75	11.50	2.00	5.00	5.00
Deer yard and mature timber	medium	0.00	0.00	0.00	0.00	0.00	0.00

		ROUTE OF IMPACT IN					
		1	2	3	4	5	6
Aquatic Resource							
Water	very high	0.00	0.00	0.00	0.00	0.00	0.00
Lake oriented	high	0.00	2.25	0.00	0.50	0.00	0.00
Perm river and stream oriented	medium	1.75	0.00	2.50	1.00	1.50	1.25
Intermittent river and stream oriented	low	0.25	2.50	2.00	1.50	3.25	3.25



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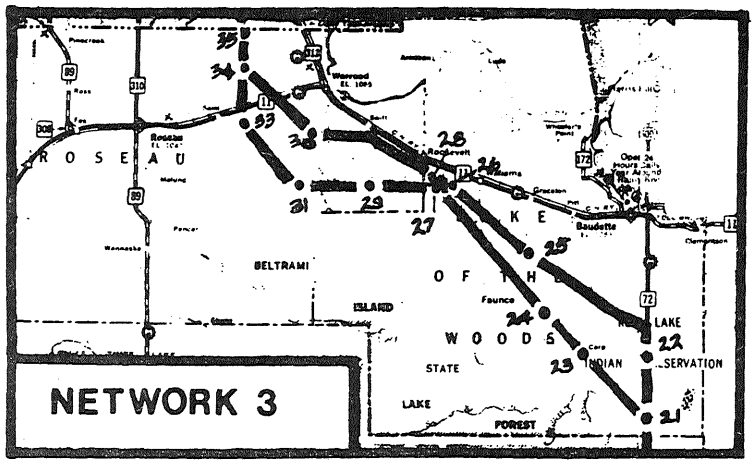
1	20 21 24 27	41
2	20 21 24 25 26	40.5
3	20 21 22 25 26	43
4	26 28 30 33 34 35	35.6
5	26 28 30 34 35	30
6	27 28 30 34 35	80

Table 6 .3-2

	WEIGHT	ROUTE IMPACT IN MILES					
		1	2	3	4	5	6
Recreation and Historic							
Scenic river	high	0.00	0.00	0.00	0.00	0.00	0.00
Historic sites 40-80 acres	high	0.00	0.00	0.00	0.00	0.00	0.00
Scenic roadway	very high	0.00	0.00	0.00	0.50	0.25	0.25
Historic location 120-160 acres	medium						
Resort	high	0.00	0.00	0.00	0.00	0.00	0.00
Lakeshore zoned heavy residential	high	0.00	0.00	0.00	0.00	0.00	0.00
Other State or County lands recommended for recreational use	medium	0.00	0.75	0.75	0.00	0.75	0.00



Segment Number	Segment Connect These Nodes						Length in Miles
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2	20	21	24	25	26		40.5
3	20	21	22	25	26		43
4	26	28	30	33	34	35	35.6
5	26	28	30	34	35		30
6	27	28	30	34	35		29

7 IMPACT ON STATE GOVERNMENT OF ANY FEDERAL CONTROLS ASSOCIATED WITH THE PROPOSED ACTION

CHAPTER 7 IMPACT OF FEDERAL CONTROLS ASSOCIATED WITH PROPOSED ACTION

A permit must be secured from the Federal Power Commission pursuant to Executive Order No. 10485, dated September 3, 1953 (3 CFR, 1949-1953 Comp., p. 970) for the construction, operation, maintenance and connection, at the borders of the United States, of facilities for the transmission of electric energy between the United States and a foreign country. The Commission may issue a permit for border transmission facilities if the Commission (1) finds the issuance is consistent with the public interest and (2) obtains favorable recommendations of the Secretaries of State and Defense concerning the issuance.

An order must be secured from the Commission pursuant to Section 202(e) of Part II of the Federal Power Act (49 Stat. 849, 16 U.S.C. 824a(e)) for the transmission of electric energy from the United States, a State, a political subdivision of a State, or a public agency or officer exempt from the requirements of Part II by virtue of Section 201(f) thereof (49 Stat. 848, 16 U.S.C. 824 (f)). Prior to issuing an export order, the Commission must find that the proposed exportation will not impair the sufficiency of electric supply within the United States and will not impede or tend to impede the coordination in the public interest of facilities subject to the Commission's jurisdiction. Electric energy may be transmitted from a foreign country to the United States without obtaining Commission authorization.

All agencies of the Federal Government, including the Commission, are required by Section 102(2)(C) of the National Environmental Policy Act of 1969 (83 Stat. 853, 44 U.S.C. 4332) to "include in ... major Federal actions significantly affecting the quality of the human environment, a detailed statement... on (i) the environmental impact of the proposed action..."

NSP will apply for a permit from the Federal Power Commission and will supply all needed information.

8 ORGANIZATIONS AND PERSONS CONSULTED

CHAPTER 8 ORGANIZATIONS AND PERSONS CONSULTED

Forestry Division, DNR

Region 6 Metro Area Forest Manager	Darwin Anderson
Region 3 Deer River Area Forest Manager	Roy Tarbell
Land Specialist, Bemidji	Ted Wilde
Baudette Forest Area Manager	Wallace Richards

Information and Education Bureau, DNR

Environmental Education Section	Roger Grosslein

Fish & Wildlife Division, DNR

Supervisor of Wildlife Section	Roger Holmes
Region 2 Regional Wildlife Manager	Jerome Janacek
Region 2 Grand Rapids Area Wildlife Manager	Bob Chesness
Region 3 Ely Area Wildlife Manager	Fred Thunhorst
Region 2 International Falls Area Wildlife Manager	Jim Schneeweis
Region 3 Regional Wildlife Manager	Henry Wulf
Region 6 Regional Wildlife Manager	Roger Johnson
Management Unit, Public Lands Development	Richard Carlson
Record Section	Earl Johnson

Asplundh Environmental Services

Landscape Architect & Regional Planner	Dennis Holewinski
Terrestrial Ecologist	Tom Mayer
Forest Ecologist	Hyland Johns
Forester	Willard Grubb
Landscape Architect	Andrew Ziegler
Forester & Plant Pathologist	Dr. Bramble

Forest Ecologist & Agronomist	Dr. William Brynes
Forester & Botanist	Dr. Kenneth Carvell

Legislators

Senator Richard Fitzsimons

Senator Norbert Arnold

Senator George Perpich

Representative Irvin Anderson

Representative Arthur Braun

Representative Norman Prahl

Representative John Spanish

Representative Peter X. Fugina

Individuals & Organizations With Interest
Interest in Study Area

Wayne Oak, Project Coordinator Onanegozie RC&D

Tim Engels, Minnesota Analysis & Planning System

Paul Davis, PCA Water Quality Division

Members of the Great Lakes Deer Group

Steve Oney, Assistant Director Nature Conservancy

Wood Industries

Potlatch Corp., Forester	Art Appledorn
Diamond International Corp., Chief Forester	Edward Ballman
Kimberly-Clark Company, Minnesota Land Agents	Tom Spooner

Earth System Research, Inc.

Paul Sand

Mike Cohen

Department of Agriculture

Randy Young

Minnesota Historical Society

Coordinator National Register Program	Tom Lutz
Research & Survey Specialist	John Jackett
Historian	Chuck Nelson
Survey Archaeologist	Doug George
Field Services Historian and Archaeological Division	Alan Woolworth

Minnesota Department of Highways

Director, Environmental Services	Dr. Lawrence Foote
Environmental Services	Herm Juffer

Parks and Recreation Division, DNR

Director	Donald Davison
Recreational System Coordinator	Milton Krona
Parks Visitor Services	Gerald Jensen
Rivers Coordinator	Michael Priesnitz

Soil Conservation Service

Duluth Field Office	Royce R. Lewis
Hibbing Field Office	Charles Lamong

University of Minnesota

Botany Professor	Donald Lawrence
Plant Ecology Professor	Edward Cushing
Irrigation Specialist	Fred Bergsrud
Biology Professor	Dan Frenzel

Soil Department, U of M

Dick Rust

Rouse Farnham

Lowell Hanson

Center for Urban and Regional Affairs, U of M

George Orning

Will Craig

Al Robinette

Jim Mentor

Jeff Anderson

Beck & Associates

Director	William S. Beck
Natural Systems Specialist	Harold E. Anderson

Parks and Recreation Division, DNR & State Planning

Trails System Coordinator	Donald Ledin
Trails System Coordinator	Larry Bucholtz
Project 80	Don Yaeger

Environmental Planning and Protection, DNR Bureau

Comprehension Planning Section	Ken Wald
Administration, Engineering	John Poate
Environmental Review Section	Vonny Hagen Tom Balcom

Mines and Metallurgy, DNR

Ted Dingler

Marshall County

County Zoning Administrator	Einar Johnson
County Agricultural Extension Agent	Charles Peterson
County Historian	Neil Mattson

Roseau County

County Auditor	Dick Bergen
County Agricultural Extension Agent	Hilbert Pfeifer, Jr.
County Historian	Leah Strandquist
County Board of Commissioners	

St. Louis County

County Seat Forester	Leonard Rowson
Duluth District Forester	Egil Hedman
Duluth District Forester	Jim Mills
Virginia District Forester	Denny Bone

County Extension Agent, Virginia	Pat Wiecherding
County Extension Agent, Hibbing	Carol Giesler
Director of Planning & Zoning	Bill Boynton
Arrowhead Regional Development Commission	Earl Norstrand
USDA Agricultural Extension Agent	Dayton Larson
USDA Agriculture Extension Agent	Arnold Keikilla
County Historian	Frank Young and Buzz Ryan
Planning & Zoning, Virginia	Jim McKenzie
Auditor, County Board	Andrew Korda
County Board of Commissioners	

Beltrami County

County Zoning Administrator	Bill Patnaude
Area Wildlife Manager	Norman Ordal
County Agricultural Extension Agent	Elmo Skare
Regional Agricultural Extension Agent	William J. Sliney
County Historian	C.L. Johnson

Itasca County

County Land Commissioner	Bill Marshall
County Agricultural Extension Agent	Albert Page
County Historian	Dennis Brown

Koochiching County

County Zoning Administrator	Ruth McLinn
County Agricultural Extension Agent	Don Petman
Regional Agricultural Extension Agent	William J. Slinly
County Historian	Mildred Savard
County Board of Commissioners	

Lake of the Woods County

County Planner	Gary Lockner
County Agricultural Extension Agent	Otto Lee
Regional Agricultural Extension Agent	William J. Sliney
County Historic Sites Secretary	Joyce Lockhart
County Board of Commissioners	

APPENDIX A

Appendix A

METHODOLOGY

and

DATA

Minnesota Land Management Information System (MLMIS)

The primary goal of the Minnesota Land Management Information System (MLMIS) project is to improve the quality of public- and private-sector decisions about the environment. MLMIS is doing this by providing extensive information, previously unavailable, on present land use and economic and social conditions.

The project is achieving its goal in two ways:

Examining and revising present data collection and storage techniques relating to land use in attempt to establish standards to be utilized in a statewide data system. This means combining in compatible computer systems a broad range of data now collected routinely and maintained separately by government agencies in their regular licensing, regulating, and management functions. These data have not been readily available for use by agencies other than the collecting agency, partly because most of the data has not been collected, stored, or coded in a compatible way. What has been missing is a framework (an information transfer point common to all agencies) in which to put all the data, so that it could be easily retrived and summarized for use in planning and in helping to answer broad policy questions. Groundwork done by the study can assist in formulating standards for establishing structured data collection and storage techniques.

Promoting long-term cooperation and coordination among researchers and public officials. This is being done to ensure that the standardized information is of value to both groups and will be utilized by public officials as they manage Minnesota's resources. This objective is being met in three ways:

1. The MLMIS study group is undertaking interdisciplinary research projects within the University of Minnesota and joint University-state agency research projects. All the research projects are coordinated through the Center for Urban and Regional Affairs at the University.

2. Encouraging public officials to use new techniques such as computer mapping that have been developed by MLMIS researchers. Four state agencies are currently utilizing these computer techniques: Department of Natural Resources, State Planning Agency, Minnesota Highway Department and Department of Administration.

3. Encouraging the cooperation of state agencies in keeping resource data current and in adding new data to the existing computerized collection.

MLMIS Data

The MLMIS project uses the 40-acre parcel (forty) as its basic building block for data collection. For each forty, the following information was collected:

(1) Location - county; township and range; section and 40-acre parcel location; government lot number; latitude and longitude; minor civil division (township, village, city, etc.).

(2) Ownership - public agency managing the land; how public land was acquired.

(3) Land use - use to which the land is devoted, based on the following classifications: forested, cultivated, water, marsh, urban residential, urban non-residential or mixed residential, open and pasture, extractive, transportation. Also included are the recommended uses for each parcel in state or county ownership, the recommended disposition of these lands, and the management unit status of these lands.

(4) Zoning - county zoning class governing the use of each parcel.

(5) Bedrock geology - type of bedrock underlying the land surface.

(6) Mineral potential - the potential of mining a particular mineral resource from a parcel.

(7) Copper/nickel leases - existence of active federal and state copper and nickel mining leases.

(8) Soils - description of the soil with regard to texture, color, and drainage capability, as well as relief characteristics. Interpretations are available for numerous capabilities and limitations.

(9) Forest cover - predominant tree species on parcels with at least 10 percent crown cover of trees.

(10) Water orientation - information on a parcel's contiguity to a lake, river, or stream.

(11) Highway orientation - information on a parcel's contiguity to various classes of roads and intersections.

Environmental Planning Programming Language (EPPL)

The resource analysis process is characterized by an information base of natural resource characteristics and a rational procedure attempting to simulate and predict the consequences of alternate actions. MLMIS is the statewide information base providing basic data and a structure for additional data. EPPL is a computer program to allow manipulation of that data by planners and resource specialists. EPPL has been developed by Earth Systems Research, Inc. through the University of Minnesota, CURA and the Minnesota State Planning Agency. It is being used throughout the state by public agencies, university researchers, and private consultants.

EPPL is a packaged computer program that allows its users to access the data and manipulate it in many ways. Computer maps are a means of displaying resource information on a scaled map with symbols or tones. The computer allows interpretation of data such as soils to display various characteristics, such as engineering limitations. Data can be combined through logical or arithmetic tehcniques to create a new map describing composite characteristics. Spatial analysis makes it possible to determine "distance from" certain areas to create a buffer around sensitive features. By these analytical means it is possible, step by step, to describe land use suitabilities and potential environmental impacts.

MLMIS and EPPL are currently being applied to such land use issues as copper-nickel mining, solid waste disposal site selection, and comprehensive county - regional planning as well as power plant siting and transmission line routing. The application of an information base and a rational procedure is serving to make land use decisions more explicit and, therefore, more accountable.

Soil information played an important role in routing methodology. The following excerpt from Soils Information and Interpretive Procedures, an MLMIS publication, explains the soils classifications and imterpretations used for this study.

INTRODUCTION

Soils information is one of the most significant physical elements in the computer files of the Minnesota Land Management Information System (MLMIS). This data is currently being used for pilot land use suitability studies in the Itasca County and Arrowhead Region land use studies. Soil interpretations are needed to predict the types of problems which are likely to occur when land is used for specific purposes, such as crop and forest production, outdoor recreation, and residential development.

This report attempts to answer the most fundamental questions about taxonomy and interpretation for the soils information currently being employed by MLMIS. Of course, these soil classification systems and interpretative methods change as new information about soils and refinements in interpretation accrue.

MINNESOTA'S TWO SOIL SURVEYS

The MLMIS has collected soil information from two principal sources. They are the Minnesota Soil Atlas and the Arrowhead Region soil survey. The Minnesota Soil Atlas is an effort of the Department of Soil Science of the University of Minnesota. The present coverage of the Minnesota Soil Atlas is complete for parts of north central Minnesota with additions to coverage underway. The Arrowhead Region soil survey was conducted by the U.S. Soil Conservation Survey under contract with the Arrowhead Regional Development Commission. Although the scale of the survey is smaller (1:62,000) than the county surveys more commonly prepared by the S.C.S. (1:15,000 - 20,000), the methods used and series identified are the same. Since each of these programs has used a unique approach to mapping Minnesota soils, this report will treat each separately and then follow with a discussion of their common features and interpretive techniques.

Minnesota Soil Atlas

The Minnesota Soil Atlas is a cooperative project conducted by the Department of Soil Science, University of Minnesota, and the U.S. Soil Conservation Service (S.C.S.). The Atlas provides basic soil information for broad land use planning purposes. It is not intended to replace the

more detailed county soil survey reports,* but rather to provide necessary soil information until the surveys can be completed. Where available, SCS surveys have been utilized in the development of the Minnesota Soil Atlas.

The Minnesota Soil Atlas consists of a generalized soil map and accompanying bulletin which provide information concerning the nature and character of the soil. The atlas maps, called sheets, are being published at a scale of 1:250,000. This scale is consistent with one series of U.S. Geological Survey topographic maps. The State of Minnesota will be covered by eleven Atlas sheets (see Appendix A). To date, three sheets have been published and the eight remaining are in final mapping stages. One additional map, the Twin Cities Sheet, which covers the Minneapolis-St.Paul seven county metropolitan area, has been added to the original Atlas list. This sheet is published at a scale of 1:125,000 to provide more detailed information on this highly developed urbanized area.

The mapping unit designed for use in the Atlas series is called the Soil Landscape Unit. This unit is designed to help the user with a minimum knowledge of soils to readily understand the basic properties of the mapped soils. The smallest area delineated in the Atlas is approximately 600 acres. As a result, a number of associated soils series, delineated in much greater detail, may be found within the soil landscape units on Soil Atlas maps. The Soil Landscape Unit is based on the following factors:

First Letter	1)	Texture of the underlying soil material usually below 5 feet: sandy (S), loamy or silty (L), clayey (C), mixed sandy and loamy (X), and mixed silty and clayey (Y).
Second Letter	2)	Texture of the upper material usually above 5 feet, or a significant part of it: (may be only upper 1 to 4 feet in soils with contrasting materials): sandy (S), loamy or silty (L), and clayey (C).
Third Letter	3)	Drainage: water table generally below rooting zone (W), or water table commonly in the rooting zone unless artificially drained (P).
Fourth Letter	4)	Color of surface soil as a reflection of accumulated organic matter: dark (D) and light (L).

* These surveys are published cooperatively by the Minnesota Agricultural Experiment Station and the Soil Conservation Service.

For example, a Clarion series would appear on the map as LLWD and would be interpreted from the map as a dark colored, well-drained soil over loamy material. Downs, Port Byron, and Ostrander soils could also be found within this soil landscape unit as well as smaller areas of other soils with contrasting texture and drainage.

In addition to the soil landscape unit itself, the Atlas identifies the specific physiographic entity upon which soil landscape units have evolved. These entities are termed geomorphic regions. Geomorphic regions are the topographic settings and constitute the parent material for soil development. Although, generally, the boundaries of the soil landscape units coincide with the boundaries of the geomorphic regions, in some cases a geomorphic boundary passes through a soil landscape unit. The map will then show similar adjacent soil landscape units differing only in the parent material and topography of the geomorphic region on which they developed. While a single soil landscape unit may be appropriate to classify a soil anywhere in the state, geomorphic regions do not have this mobility since they define unique combinations of geomorphological features.

Arrowhead Region Soil Survey

The U.S. Soil Conservation Service, under contract with the Arrowhead Regional Development Commission, mapped the soil associations[1] for the Arrowhead Region in 1973 and spring of 1974. Soil associations were identified from 1964 1:90,000 high altitude imagery of northeast Minnesota. Only limited field checking was undertaken to verify the character and boundaries of associations. In most cases, associations consist of known soil series. However, soil descriptions and interpretations were developed for some soils units different from already established series. Generally, the smallest soil unit identified on Arrowhead survey maps is approximately 160 acres. Organic (peat) soils pose a minor exception, since peat lands are so easily distinguished on air photos. Deposits of these smaller than 160 acres were usually mapped.

Because the Minnesota Soil Atlas and the Arrowhead Soil Survey use different schemes to map soils, it is important to note the basic character-

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[1] Soil Association: A group of defined and named soil units that occur in an individual geographic pattern. The soils in an association may be derived from the same kind of parent material and be similar in characteristics, or they may be derived from different kinds of parent material and be dissimilar in characteristics.

istics of each. This permits the user to select the soil information source which best suits the needs of any land use analysis.

Minnesota Soil Atlas

a) Map scale is 1:250,000. Soil units of approximately 600 acres or more are mapped. Soil units smaller than 600 acres are included in larger soil units.

b) The mapping unit is the soil landscape unit which is composed of soil series having similar texture, drainage conditions, and color.

c) Geomorphic regions are delineated on the Soil Atlas sheets. Each geomorphic region is a specific physiographic unit in Minnesota and describes, for the soil landscape units located within it, the parent material for soil development as well as the topographic setting.

d) The Minnesota Soil Atlas is scheduled to publish soil maps and accompanying bulletins for the entire state of Minnesota.

Arrowhead Soil Survey

a) The map scale of this survey is 1:62,000, which discriminates soil units of approximately 160 acres or larger. Peat deposits of less than 160 acres may also be mapped.

b) The mapping unit is the soil association. The soil association is a common mapping unit used in soil classification.

c) This survey is only available for the Arrowhead Region of Minnesota.

SOIL INTERPRETATIONS

The physical and chemical properties of a soil unit determine its suitability for various uses. This is true whether the intended use involves construction, mining, waste disposal, or agriculture, for example. The process by which soil is evaluated for its use suitabilities is termed interpretation. By applying soil interpretive criteria to a study area, it is possible to specify the acreage and distribution of land suitable for various uses. Personnel from MLMIS, Department of Soil Science, and SCS have developed a system of interpreting (rating) the suitabilities of soils for crop production (grain and forage crops), forest production, and non-urban residential development, which is described below.

The soil landscape/geomorphic region combinations of the Minnesota Soil Atlas and the soil associations of the Arrowhead USSCS soil survey are rated in a similar fashion.

Soil Atlas Ratings

Each soil landscape unit within a geomorphic region is given a separate rating for each specified land use. The combination of soil landscape unit/geomorphic region is significant. As mentioned previously, the delineation of geomorphic regions provides information about the parent material of the soil landscape unit and assigns soil units to specific locations. Thus, similar soil landscape units in different geomorphic regions may be given separate ratings for any specified land use. The ratings for soil landscape units are stored in tabular form, called a J Table, on a deck of keypunch cards. For each 40 acre parcel, the computer can use the data on the soil landscape unit and geomorphic region as an address to locate the land use suitability ratings for that parcel on the J Table.

Arrowhead Survey Ratings

Each soil association of the Arrowhead Survey is given a specific rating for each specified land use. These ratings are also stored in tabular form (G Table).[2] The computer, again, uses the data on the soil association for any 40 acre parcel as an index to locate the suitability ratings for that parcel.

While both the Soil Atlas soil landscape unit/geomorphic region combinations and the Arrowhead associations are rated using the same soil interpretation scheme, any 40 acre parcel in the Arrowhead Region may have one rating for a particular land use on the J Table and a different rating for the same land use on the G Table. This is because the two mapping programs are prepared at different scales and employ different criteria in mapping units. However, over broad areas, the general ratings of the associations and soil landscape units are expected to be similar.

The interpretation or rating of soil suitabilities for various kinds of use, it must be emphasized, should be considered an initial and somewhat

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[2] The suitability ratings incorporated in the Land Use Interpretations (J and G Tables) are based largely on data in single sheet Soil Series Interpretations published by the Soil Conservation Service.

generalized analysis. Soil characteristics and performance under different uses are defined in gross rather than in detailed terms. Related to this is the size of our analysis unit (the 40 acre parcel) and the scale constraints of the soil landscape unit (resolution about 600 acres) and soil association unit (about 160 acres). Obviously, at the scale of the site, analysis based on such large units can be regarded only tentatively and field analysis must follow. Finally, the preparation of soil interpretations involves a bit of subjective judgement since ratings are principally derived from soil series descriptions. Therefore, the proportion of specific soil series in a soil landscape unit or soil association must be hypothesized before a rating can be given the larger units.

Soil Interpretations for Crop Production

Approximately 16 million acres of cropland are harvested yearly - a significant percentage of Minnesota's 51 million acres of land. The major crops include corn, soybeans, oats, hay, and wheat. They account for 88 percent of the total harvested cropland acreage.

In order to develop a generalized index for rating the quality of land for crop production, it was necessary to find a common unit of crop yield so that yield data for different crop varieties could be compared throughout the state. The total digestible nutrients (TDN) unit was chosen. TDN is an energy-based feed value term.[3] TDN values are available for all crops harvested in Minnesota.

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[3] A TDN value is the sum of all of the digestible organic nutrients - protein, fiber, nitrogen free extract, and fat. (The latter is multiplied by 2.25 because its energy value is approximately 2.25 times that of protein or carbohydrates.) The digestibility is on the basis of ruminant animals. Morrison, Frank B., Feeds and Feeding (The Morrison Publishing Co., Ithaca, New York), 1948.

Table 1: Crop Production Rating Relationships

Crop Productivity Index	TDN Yield Lbs/A	Equivalent TDN Yield: Corn Yield Bu/A	Alfalfa Hay Tons/A	Oats Yield Bu/A	Wheat Yield Bu/A
0	0- 582	0- 13	0 - .58	0- 26	0- 12
1	583-1165	14- 26	.59-1.2	27- 52	13- 24
2	1166-1747	27- 39	1.3 -1.7	53- 78	25- 36
3	1748-2330	40- 52	1.8 -2.3	79-104	37- 48
4	2331-2912	53- 65	2.4 -2.9	105-130	49- 61
5	2913-3494	66- 78	3.0 -3.5	131-156	62- 73
6	3495-4078	79- 92	3.6 -4.1	157-183	74- 85
7	4079-4659	93-105	4.2 -4.7	- -	86- 97
8	4660-5242	106-118	4.8 -5.2	- -	98-109
9	5243-5824	119-131	5.3 -5.8	- -	110-121

The relationship of soils to cropland productivity is assumed to be relatively constant over time. However, the absolute yield may change substantially because of changes in technology and possible modification of the soil environment itself through practices such as irrigation and drainage. One of the objectives in developing a rating scheme is to make it adjustable to change and to show the yield implications of modification practices. Therefore, yield ratings are made for both modified and unmodified soil conditions.

A ten category productivity rating scheme is being used. This is compatible with the Crop Equivalency Rating (CER) system which has been used in several individual county soil survey interpretations. One cropland productivity rating defines the highest category, 9 (equal to the range of 90 to 100 in the CER system), as the most productive cropland in the state. At the present time, the 9 rating would be equivalent to 119 to 131 bushels of corn per acre or the range of 5,243 to 5,824 pounds of TDN/acre. See Table 1.

Productivity ratings are made for both grain and forage crops because of differences in potential yield and value of the two types of commodity. The ratings are based on the yields produced by the top one-third of

commercial farmers. The rating of either a soil landscape unit or soil association is based on the percentages of soil series occupying the larger unit and the yield rating assigned the component series. For example, Unit 1 could have 50% of soil A with a rating of 8 and 50% of soils B and C with a rating of 4. These are averaged and Unit 1 is given a rating of 6. This rating gives a realistic estimate of total crop production that can be expected from an area of Unit 1 if soils are properly managed. The rating does not consider overhead costs (land clearing, drainage, etc.) engendered in farming.

Ratings for grain are based on corn for much of the state. However, corn is not well adapted to the northern part of the state, and in these areas small grains are used as a rating standard.

Soil Interpretation for Forest Production

The rating of soils for forest production is based upon the potential growth rates of the key species (tree species best suited) for a particular soil type. Two measures of growth rate are employed (see Table 2). The site index of any tree species is the measure of the rate of upward linear growth of a species. The second measure, growth class, is volumetric. It expresses growth rate in cubic feet per acre per year. Table 2 relates both measures by tree species type.

The growth classes at the top of Table 2 are arranged in four classes, although class 1 is reserved for soils for which no key species or growth rates are available, e.g., prairie soils in western Minnesota. Classes 2 through 4 rank increasing productivity rates for each species listed vertically on the left of Table 2. Notice that no site index numbers appear under some growth class categories for most of the species listed. Such blanks indicate that for the growth class categories above, no realistic rating can be assigned that species. Jack pine, for instance, never manifests growth class rates above category 3 in Minnesota under normal management conditions (Table 2) no matter what the soil type.

In those instances when a soil unit is composed of contrasting soil types, an average of the productivity by the key species for each component soil type is computed. For example, if Soil Unit I is composed of 60% soil type A and 40% soil type B, the growth class for type A (key species Aspen), 4, is averaged with the growth class for type B (key species Black Spruce), 2, such that Soil Unit I has an overall rating of class 3.

The resource capability approach utilized in the rating procedure for forest products omits a number of significant variables. Questions of existing cover type, desirability and marketability of species, accessibility to markets, tree size, and other economic and technological considerations are not included. Growth figures taken from forest survey data represent an average of the full range of management. Variation in annual production due to different levels of management intensity is not considered. The incorporation of these variables into analysis should proceed from the resource capability/analysis of this first stage.

Table 2: Annual Production by Species and Site Index

Class	4	3	2	1
Growth (cu.ft./A/yr.)	80+	50-80	-50	Not Rated
Species	- - - -	S I T E	I N D E X -	- - - - - -
Red Pine	62+	47-61	-46	
Jack Pine		59-70	-58	
White Spruce	50+			
Tamarack	44+	31-39		
Cedar			-38	
Hardwoods	75+	60-74	-59	
Oak		49-68	-48	
Aspen	70+	53-69	-52	
Black Spruce			-40	

Source: North Central Forest Experiment Station Unpublished Data.

Soil Interpretations for Residential Development

Rating soil capability for residential development involves the interpretation of six soil characteristics. Each of these characteristics uniquely affects a site's physical capability to support residential development, since each may pose a hazard to one or more aspect(s) of development. The ratings for each soil landscape unit are based on the interpretation of the dominant soil series within the soil landscape unit. The ratings assume a typical residential site to have the following attributes: 1) 80,000 square feet minimum lot size, 2) two story single family detached dwelling with basement, and 3) on site water supply and sewage disposal.

The six soil characteristics referenced for residential development include:

Soil Strength: The expected soil performance when used for residential development. Ratings consider bearing strength, shear strength, and shrink-swell characteristics.[4] Soils with slight limitations are given a rating of "1," moderate a rating of "2," and severe a rating of "3."

Flooding: A temporary covering of land surface by water from any source, such as stream overflow and runoff from adjacent slopes. Soils which are flood-free or flooded only under unusual circumstances are given a rating of "1." Soils occasionally flooded (likely less than once in two years) are given a rating of "2." Soils subject to more frequent flooding are given a rating of "3."

Wetness: The degree of saturation throughout the year based on natural conditions without artificial drainage. Ratings assigned as follows:

1 = (Slight) Well to excessively drained soils.

2 = (Moderate) Moderately well and somewhat poorly drained soils.

3 = (Severe) Poor and very poorly drained soils.

Slope: The hazard of erosion and degree of difficulty in working with the landscape for residential development. Ratings assigned as follows:

1 = (Slight) zero to six percent slopes.

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[4] Soil Conservation Service, Guide for Interpreting Engineering Uses of Soils, November 1971.

2 = (Moderate) six to twelve percent slopes.

3 = (Severe) over twelve percent slopes.

Septic Field: Suitability or limitations are based on soil permeability and the depth to water table or bedrock. Slope is not considered in this rating. Limitation is based on these items in Guide Sheet Three[5] and ratings assigned as follows:

1 = Slight

2 = Moderate

3 = Severe

Groundwater Contamination: Indicates the hazard of contaminant leaching through the soil profile. Two categories are developed. A rating of "1" is given to those soils in which there is no serious hazard of contamination. Only well to somewhat poorly drained soils underlain by sandy or gravelly material or bedrock are considered as having a potential hazard.

The limitations of the 40 acre parcel prohibit the use of this data for specific residential site selection. The residential rating given a particular parcel reflects the dominant condition found in an entire soil landscape unit or soil association. Individual tracts or lots may differ greatly in suitability from this dominant condition.

The significance of the hazard ratings is a function of the particular development being planned. It may be necessary to consider a combination of the residential ratings when determining the suitability of the soil to support development. Some ratings may be more significant than others, depending on the nature of the structure. All of the soil limitations considered in the rating scheme can be overcome at a cost. The cost may be quite modest; for example, to ameliorate a soil strength problem for a single family frame house by employing larger foundation footings. However, in other cases - heavy duty roads or large buildings - the soil strength factor may be quite important. Slope is a factor that may be interpreted in a positive or negative manner, depending on the values of the user. Steep slopes usually involve higher construction and service costs for intensive uses such as residential, commercial, or industrial. However, steep slopes and high relief usually have a high amenity value and are often preferred building sites.

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[5] Soil Conservation Service, op.cit., footnote 4, p. 23.

OTHER SOIL INFORMATION STORED ON MLMIS COMPUTER FILES

Each bulletin published with the Minnesota Soil Atlas sheets provides tabular information describing the character of the geomorphic areas and the soil landscape units found within them. This data was converted to numerical expressions and stored on a J Table with the land use ratings for the respective geomorphic area/soil landscape unit combinations. This additional data has not been used by MLMIS, but such information may prove useful for more intensive analysis of soils, especially for agricultural purposes.

The legend for the Arrowhead Soil Survey provides information on slope, local relief, and landform type of mapped units. This information has been converted to numerical expressions and is stored on the G Table.

Appendix B of this report contains the descriptive legends for the J and G Tables. Since the same rating scheme (for crop production, forest production, and non-urban residential development) was applied to the soils listed in both the Minnesota Soil Atlas and the Arrowhead Soil Survey, the legend of the J and G Tables for the land use ratings are identical. The additional data compiled for the geomorphic region/soil landscape unit combinations and the soil associations do not conform to a common format, therefore, the legends for these portions of the J and G Tables (J14-J25 and G14-G16) are not identical.

SUMMARY AND RECOMMENDATIONS

The value of the soils information in the Minnesota Soil Atlas, the Arrowhead Soil Survey, and the soil rating scheme has not been thoroughly tested. However, the current application of this soils data to the problem of locating lands best suited for crop production, forest production, and non-urban residential development in the Arrowhead Region should be instructive.

The further development of the soils information component of MLMIS will be enhanced by the implementation of the following recommendations:

1) The standardization and careful documentation of soil interpretive procedures is desirable as increasing numbers of clients begin to use MLMIS soils information in planning and resource management. Appendix C contains

two versions of a rating format for soils interpretation. The quick reference sample rating sheet shown is the one used for interpretation presently. The proposed rating format, the second item in Appendix C, would provide more thorough documentation of the procedures employed in interpretation.

2) The present system should be thoroughly tested. The observed performance of a soil should be reflected by the rating assigned that soil. Verification can only be accomplished by extensive field work. MLMIS could conduct suitability studies in relatively small areas where the utility of the soil rating scheme can be carefully evaluated. Only one study (Forestry Demonstration Case, MLMIS Report 4003) used field work to support the predictions it made concerning the production of aspen in nine Itasca townships. This type of research should be conducted simultaneously with broad regional studies in order to assure that the latter are based on reliable data.

3) Soils information requires updating as better source material becomes available. Revisions in the interpretations will be necessary as new types of land use questions are asked. MLMIS is not properly staffed to handle this task alone. A soils information review committee of members from the Department of Soil Science and MLMIS staff should be convened to assure that the most recent information is available in a format useful to current land use questions.

4) Since, ultimately, soil capability ratings are intended for use by local planners and other local land use decision makers, it is important that members of local units of government be involved in the development of soil interpretations. They are the best judges of their own needs for soil information and its application. Also, their early involvement in the process may render them more receptive to land use recommendations emanating from MLMIS and other agencies and groups influencing land use planning.

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University of Minnesota, Agricultural Experiment Station, "Twin Cities Sheet," Minnesota Soil Atlas, Miscellaneous Report 150, 1975.

VARIABLE NUMBER: V01

VARIABLE NAME: SITE

SOURCE: MLMIS STUDY, Center for Urban and Regional Affairs, University of Minnesota

COLLECTED: 1974

INTERPRETATION: MLMIS Staff

VARIABLE DESCRIPTION: Representation of the area showing the disparity between the Land Survey, with irregular forties, and the cell file's uniform 40-acre grid. The manipulation of parcels for the purpose of mapping, described below, is only a visual convenience. Information is not lost or gained in the tabulation of data for any parcel.

The accommodation of the difference between a geometrically perfect grid and imperfect government 40-acre survey units is accomplished through a policy of: (a) for gaps in fit--filling gaps with the 40-acre parcel to the south or west, and (b) for overlaps in fit--dropping out the parcel with no road or the inferior road. Accordingly, the levels for this variable are:

Data Level	Map Symbol	Definition	Description
1	A	Gap	Parcel has been filled in from neighboring parcel.
2	B	OK	No geometric distortion
3	C	Overlap	Parcel with no road or inferior road has been omitted.

VARIABLE NUMBER: V05

VARIABLE NAME: Federal, State and County Ownership

SOURCE: Agency Land Ownership Records; Department of Natural Resources, Land Classification Study

COLLECTED: 1973 - State BIA and Forest Service
1969 - All other Federal

INTERPRETATION: Minnesota Land Management Information Systems Staff

VARIABLE DESCRIPTION: Publicly-owned lands of Federal, State or County Jurisdiction Comprise this Variable

Data Level	Map Symbol	Definition	Description
0	: :	No public ownership	
3	C	Bureau of Land Management	Federal Jurisdiction
4	D	National Wildlife Refuge	Federal Jurisdiction Refer to V33 data level 5
10	J	Other Federal Agencies	Owned by federal agencies other than Bureau of Indian affairs; Corps of Engineers; National Park Service; Bureau of Sports, fisheries and wildlife; Bureau of Land Management; U. S. Forest Service.
11	K	Bureau of Indian Affairs Tribal/Resettle	Land which falls under Federal Jurisdiction and is Tribal Land or Resettled Land

Data Level	Map Symbol	Definition	Description
12	L	BIA allocated	Bureau of Indian Affairs (Individual Allocation), Federal
13	M	BIA Government	Bureau of Indian Affairs (Reservation), Federal
18	R	Random Error	
20	T	Lands and forest lands within state forest	Land under state jurisdiction
21	U	Lands and forest lands outside state forests	Land under state jurisdiction
22	V	Water, soils and minerals	State Jurisdiction
30	3	Wildlife management areas with resident managers and other wildlife management areas.	State Jurisdiction. Refer to V33 data levels 1, 2 and 3.
32	5	Fisheries "L & S" units	State Jurisdiction
40	/	DNR DN Parks & Recreation .State Parks .State Rec. Areas .State Waysides .State Monuments .State Trails .State Historic Sites (DNR)	State Jurisdiction. Refer to Variables 29 and 30.

Data Level	Map Symbol	Definition	Description
49	[	State Historic Sites (Minnesota Historical Sites)	State Jurisdiction. Refer to Variable 29.
50	]	MHD rest areas	State Jurisdiction, Minnesota Highway Department. Refer to V30 data level 8)
51	:	MHD adjacent to lakes and streams	Land owned by the Minnesota Highway Department, falling under state jurisdiction.
52	≠	MHD maintenance and storage	Land owned by Minnesota Highway Department for maintenance and storage sites.
53	⁘	MHD gravel pits	Land owned by Minnesota Highway Department, State jurisdiction.
60	⌙	Military Affairs	Land falling under state jurisdiction and being utilized for military affairs.
64	ı	U of M	Land under state jurisdiction and owned by the University of Minnesota.
68	⁞	Other state agencies	
70	⁘	County Forests	County Jurisdiction. Forest designated and managed by the county.
71	⁘	Other county (tax forfeit only)	Land acquired by the county through tax forfeiture.
72	⁘	County Parks	County Jurisdiction. Refer to V30 data level 13.

Data Level	Map Symbol	Definition	Description
74		Other county acquired land	County land other than county forests, tax forfeiture land, county parks, county right-of-way, and partial ownership land.
75		Partial ownership	County level. Land which is owned partially by the county.

VARIABLE NUMBER: V07

VARIABLE NAME: Highest recommended use of state or county owned lands from DNR land classification study.

SOURCE: Department of Natural Resources land classification program.

COLLECTED: 1973

INTERPRETATION: By D.N.R. land classification program staff.

VARIABLE DESCRIPTION: Recommendations for use of state or county owned lands, by 40-acre parcel, in nine categories.

Data Level	Map Symbol	Definition	Description
0		Private Land	Land which is not included in the following nine categories.
1	A	Urban Development	Tracts of land which are best suited for some type of urban development including residential, industrial, and commercial use.
2	B	Agriculture	These tracts because of soil, vegetative cover, drainage, roads, public utilities and adaptability are best suited for agricultural development.
3	C	Agriculture (no year-long occupancy)	These tracts of land because of soil and roads have been used for agriculture after the area has been abandoned by general agriculture. These lands are open and also suited for wild rice cultivation.

Data Level	Map Symbol	Definition	Description
4	D	Mining and Mining Facilities	These tracts because of known minerals or potential mineral content are most highly suitable for mining. The value derived from this land as mineral production would give mining highest priority.
5	E	Recreational or Aesthetic	Lands because of soil, vegetative cover, water, drainage, aesthetic value or location are best adapted to a specific or multiple type of long range conservation use. This would include recreational lands, game and fish units, and multiple use forestry lands. The lands are classified as to their highest possible use in these areas.
6	F	Multiple Use Forestry (including watershed)	
7	G	Game or Fish (including flowage)	
8	H	Commercial Peat or Gravel	These tracts because of commercial deposits of peat or gravel should be retained in state ownership and be as commercial, peat or gravel.
9	I	Access to lake or other land	These tracts because of their location in most instances would be managed as conservation lands but its highest preferred use would be access to lakes and streams, state land and other lands.
15	O	Random Error	

VARIABLE NUMBER: V09

VARIABLE NAME: Management Unit Status if State or County Owned

SOURCE: Department of Natural Resources Land Classification Program

COLLECTED: 1973

INTERPRETATION: D.N.R. Land Classification Program Staff

VARIABLE DESCRIPTION: V09 indicates whether a 40-acre parcel of state or county owned land is or is not in a management unit.

Data Level	Map Symbol	Definition	Description
0	:	No management unit	The publicly owned parcel is not in a management unit.
1	A	In management unit	The publicly owned 40-acre parcel is presently in a management unit.
2	B	In proposed management unit	The publicly owned parcel is in a proposed management unit
3	C	Random error	

VARIABLE NUMBER: V10

VARIABLE NAME: County Zoning Class

SOURCE: County Zoning Ordinance

COLLECTED: 1973

INTERPRETATION: MLMIS Staff

VARIABLE DESCRIPTION: V10 assigns 40-acre parcels to a county zoning class

Data Level	Map Symbol	Definition	Description
0	::	No zoning recorded	A parcel which has not been assigned to a zoning class
1	A	Open space	No residential allowed, a few permitted uses include minimally-tilled land, pasture, forestry and public open space recreation uses.
2	B	Water	Parcels with no land use.
3	C	Public	Includes publicly owned lands and land with public institutions sited.
4	D	Municipal Area	Parcels in incorporated jurisdiction
5	E	Industrial (light)	Permitted uses include wholesaling, warehousing, offices, and manufacturing process that do not cause nuisance.
6	F	Industrial (heavy)	All industrial activities that require open docking and create pollutants including resource processing, mining, and heavy manufacturing.
8	H	Seasonal Residential	Permits seasonal residences only.
9	I	Residential Class I	(20,000 to 40,000 sq. ft. minimum lot size) Permitted Uses include single and multiple family residences and accessory buildings, and in some cases, essential services such as neighborhood grocery and drug stores.
10	J	Residential Class II	(40,000 - 80,000 sq. ft. minimum lot size)
11	K	Residencial Class III	(80,000 sq. ft. to 5 acres minimum lot size)

VARIABLE NUMBER: V12

VARIABLE NAME: Mining Potential

SOURCE: MLMIS Staff

COLLECTED: 1974

INTERPRETATION: MLMIS Staff

VARIABLE DESCRIPTION: Mineral potential represents the potential of mining a particular mineral resource throughout the study area.

Data Level	Map Symbol	Definition	Description
0	::	Not related	Signifies no apparent potential
1	A	Non-mineral deposits	
2	B	Submarginal deposits	3600-4800 ft. depth
3	C	Submarginal deposits	2400-3600 ft. depth
4	D	Paramarginal deposits	1200-2400 ft. depth
5	E	Paramarginal deposits	600-1200 ft. depth
6	F	Currently mineable deposits	
7	G	Copper occurences	
8	H	Sulfide occurences	

VARIABLE NUMBER: V13

VARIABLE NAME: Copper Nickel Leases

SOURCE: Department of Natural Resources, state and federal leasing records

COLLECTED: 1974

INTERPRETATION: MLMIS Staff

VARIABLE DESCRIPTION: Both state and federal copper nickel leasing is referenced through this variable.

Data Level	Map Symbol	Definition	Description
o	::	No lease	
1	A	Federal lease outstanding	
2	B	State lease outstanding	Outstanding connotes active or in force
3	C	State and federal leases outstanding	

VARIABLE NUMBER: V15

VARIABLE NAME: Soil Associations

SOURCE: U. S. Soil Conservation Service, Arrowhead Region General Soil Map

COLLECTED: 1973

INTERPRETATION: MLMIS

VARIABLE DESCRIPTION: A group of defined and named soils associated in a characteristic geographic pattern. Factors considered in defining soil series and associations are profile, color, structure, consistency, sequence of horizons, conditions of relief and drainage, and origin and mode of formation. Interpreted for cell size of 160 acres.

Data Level	Map Symbol	Definition	Description
1	A	Ontonagon-Bergland	A) Ontonagon, Typic Eutroboralf, very fine mixed B) Bergland, Aeric Haplaquept, very fine mixed C) Minor soils
2	B	Dusler-Duluth	A) Dusler, Aeric Glossaqualfs, fine-loamy, mixed B) Duluth, Glossic Eutroboralfs, fine-loamy, mixed C) Minor soils
3	C	Duluth-Dusler	A) Duluth, Glossic Eutroboralfs, fine-loamy, mixed B) Dusler, Aeric Glossaqualfs, fine-loamy, mixed C) Minor soils
4	D	Ahmeek-Ronneby	A) Ahmeek, Typic Fragiochrepts, coarse-loamy, mixed B) Ronneby, Aeric Fragiaqualfs, coarse-loamy, mixed C) Minor soils
5	E	Newfound-Newfound	A) Newfound, Typic Fragiochrepts, coarse-loamy, mixed B) Newfound (wet), Aeric Fragiaqualfs, coarse-loamy, mixed C) Minor soils
6	F	Unnamed-Toivola	A) Unnamed, Typic Haplorthods, coarse-loamy over sandy skeletal B) Toivola, Typic Udorthents, sandy skeletal, mixed C) Minor soils
7	G	Toivola-Unnamed-Cloquet	A) Toivola, Typic Udorthents, sandy-skeletal, mixed B) Unnamed, Typic Haplorthods, coarse loamy over sandy skeletal, mixed C) Cloquet, Typic Dystrochrepts, coarse loamy over sandy or sandy skeletal, mixed D) Minor soils
8	H	Mesaba-Barto	A) Mesaba, Typic Dystrochrepts, coarse-loamy, mixed B) Barto, Lithic Dystrochrepts, loamy, mixed C) Quetico, Lithic Dystrochrepts, loamy, mixed D) Minor soils
9	I	Conic-Insula	A) Conic, Typic Fragiochrepts, coarse-loamy, mixed B) Insula, Lithic Dystrochrepts, loamy, mixed C) Quetico, Lithic Dystrochrepts, loamy, mixed D) Minor soils
10	J	Quetico-Bedrock	A) Quetico, Lithic Dystrochrepts, loamy, mixed B) Bedrock Outcrop C) Minor soils
11	K	Indus-Wildwood	A) Indus, Typic Ochraqualfs, very fine, montmorillonitic B) Wildwood, Histic Humaquepts, very fine, montmorillonitic C) Taylor, Aquic Eutroboralfs, very fine, montmorillonitic D) Minor soils
12	L	Taylor-Indus	A) Taylor, Aquic Eutroboralfs, very fine, montmorillonitic B) Indus, Typic Ochraqualfs, very fine, montmorillonitic C) Wildwood, Histic Humaquepts, very fine, montmorillonitic D) Minor soils

Data Level	Map Symbol	Definition	Description
13	M	Taylor-Alluvial	A) Taylor, Aquic Eutroboralfs, very fine, montmorillonitic B) Alluvial Land, Fluvaquents C) Minor soils
14	N	Unnamed Undulating Association	A) Aquic Eutroboralfs, fine, mixed B) Typic Ochraqualfs, fine, mixed C) Minor soils
15	Ø	Unnamed Hilly association	A) Aquic Eutroboralfs, fine, mixed B) Typic Ochraqualfs, fine, mixed C) Minor soils
16	P	Nebish-Beltrami-Shooker	A) Nebish, Typic Eutroboralfs, fine-loamy, mixed B) Beltrami, Aquic Eutroboralfs, fine-loamy, mixed C) Shooker, Aeric Ochraqualfs, fine-loamy, mixed D) Minor soils
17	Q	Nebish-Mooselake-Shooker	A) Nebish, Typic Eutroboralfs, fine-loamy, mixed B) Mooselake, Typic Borohemists, euic C) Shooker, Aeric Ochraqualfs, fine-loamy, mixed D) Minor soils
18	R	Warba-Stuntz undulating	A) Warba, Glossic Eutroboralfs, fine-loamy, mixed B) Stuntz, Aeric Glossaqualfs, fine-loamy, mixed C) Minor soils
19	S	Warba-Stuntz hilly	A) Warba, Glossic Eutroboralfs, fine-loamy, mixed B) Stuntz, Aeric Glossaqualfs, fine-loamy, mixed C) Minor soils
20	T	Cushing-Alstad undulating	A) Cushing, Glossic Eutroboralfs, fine-loamy, mixed B) Alstad, Aquic Eutroboralfs, fine-loamy, mixed C) Minor soils
21	U	Cushing-Alstad hilly	A) Cushing, Glossic Eutroboralfs, fine-loamy, mixed B) Alstad, Aquic Eutroboralfs, fine-loamy, mixed C) Minor soils

Data Level	Map Symbol	Definition	Description
22	V	Spang-Hill City undulating	A) Spang, Glossic Eutroboralfs, coarse-loamy, mixed B) Hill City, Glossic Eutroboralfs, coarse-silty, mixed C) Minor soils
23	W	Spang-Unnamed-Hill City hilly	A) Spang, Glossic Eutroboralfs, coarse-loamy, mixed B) Unnamed, Glossic Eutroboralfs, coarse-loamy, over sandy, mixed C) Hill City, Glossic Eutroboralfs, coarse-silty, mixed D) Minor soils
24	X	Mosomo-Shawano	A) Mosomo, Alfic Udipsamments, mixed B) Shawano, Typic Udipsamments, mixed C) Minor soils
25	Y	Cormant-Shawano	A) Cormant, Mollic Psammaquent, mixed B) Shawano, Typic Udipsamments, mixed C) Minor soils
26	Z	Menahga-Cutfoot undulating	A) Menahga-Typic Udipsamments, mixed B) Cutfoot, Alfic Udipsamments, mixed C) Minor soils
27	0	Menahga-Cutfoot hilly	A) Menahga, Typic Udipsamments, mixed B) Cutfoot, Alfic Udipsamments, mixed C) Minor soils
28	1	Unnamed undulating	A) Unnamed, Arenic Eutroboralfs, fine-loamy, mixed B) Unnamed, Typic Haplaquents, sand/loamy, mixed C) Minor soils
29	2	Unnamed hilly	A) Unnamed, Arenic Eutroboralfs, fine-loamy, mixed B) Unnamed, Typic Haplaquents, sandy/loamy, mixed C) Minor soils
30	3	Baudette-Spooner	A) Baudette, Aquic Eutroboralfs, fine-silty, mixed B) Spooner, Typic Ochraqualfs, fine-silty, mixed C) Minor soils

Data Level	Map Symbol	Definition	Description
31	4	Alluvial land	A) Fluvaquents B) Borosaprists C) Minor soils
32		(reserved)	
33	6	Unnamed undulating	A) Unnamed, Typic Eutroboralfs, coarse-loamy, mixed B) Unnamed, Typic Ochraqualfs, coarse-loamy, mixed C) Mosomo, Alfic Udipsamments, mixed D) Minor soils
34	7	Spooner-Unnamed-Baudette	A) Spooner, Typic Ochraqualfs, fine-silty, mixed B) Unnamed, Mollic Haplaquept (fine-silty) C) Minor soils
35	8	Mesaba-Barto	A) Mesaba, Typic Dystrochrepts, coarse-loamy, mixed B) Barto, Lithic Dystrochrepts, loamy, mixed C) Quetico, Lithic Dystrochrepts, loamy, mixed D) Minor soils
36	9	Nashwauk-Keewatin	A) Nashwauk, Glossic Eutroboralfs, fine-loamy, mixed B) Keewatin, Aeric Glossaqualfs, fine-loamy, mixed C) Minor soils
37	+	Nashwauk-Keewatin	A) Nashwauk, Glossic Eutroboralfs, fine-loamy, mixed B) Keewatin, Aeric Glossaqualfs, fine-loamy, mixed C) Minor soils
38	-	Cloquet-Ahmeek-Omega	A) Cloquet, Typic Dystrochrepts, coarse-loamy/sandy or sandy skeletal B) Ahmeek, Typic Fragiochrepts, coarse-loamy, mixed C) Omega, Spodic Udipsamments, mixed D) Minor soils
39	*	Cloquet-Ahmeek-Omega hilly	A) Cloquet, Typic Dystrochrepts, coarse-loamy/sandy or sandy skeletal, mixed B) Ahmeek, Typic Fragiochrepts, coarse-loamy, mixed C) Omega, Spodic Udipsamments, mixed D) Minor soils

Data Level	Map Symbol	Definition	Description
40	1	Omega-Cromwell	A) Omega-Spodic Udipsamments, mixed B) Cromwell, Dystric Eutrochrepts, sandy, mixed C) Minor soils
41	(	Cloquet-Emmert undulating	A) Cloquet, Typic Dystrochrepts, coarse-loamy over sandy or sandy skeletal B) Emmert, Typic Udorthents, sandy skeletal, mixed C) Minor soils
42	)	Cloquet-Emmert hilly	A) Cloquet, Typic Dystrochretps, coarse-loamy over sandy or sandy skeletal B) Emmert, Typic Udorthents, sandy skeletal, mixed C) Minor soils
43	$	Bergland-Ontonagon	A) Bergland, Aeric Haplaquepts, very fine, mixed B) Ontonagon, Typic Eutroboralfs, very fine, mixed C) Minor soils
44	=	Chilgren-Indus	A) Chilgren, Typic Ochraqualfs, fine-loamy, mixed B) Indus, Typic Ochraqualfs, very-fine, montmorillonitic C) Minor soils
45	(blank)	Grygla-Enstrom	A) Grygla, Mollic Haplaquents B) Enstrom, Aquic Udorthents, sandy over loamy C) Minor soils (deep wet sands)
46	,	Gunflint	A) Gunflint, Typic Fragiothods, coarse-loamy, mixed B) Gunflint (wet), Aeric Fragiaqualfs, coarse-loamy, mixed C) Minor soils
47	.	Grygla	A) Grygla, Mollic Haplaquents, sandy over loamy, mixed B) Histic Humaquent, sandy over loamy C) Minor soils
48	≡	Nemadji-Newson	A) Nemadji, Spodic Udipsamments, mixed B) Newson, Humaqueptic Psammaquents, mixed C) Minor soils

Data Level	Map Symbol	Definition	Description
49	[	Unnamed-Hibbing nearly level	A) Unnamed, Aquic Eutroboralfs, fine, mixed B) Hibbing, Typic Eutroboralfs, fine, mixed C) Minor soils
50	]	Hibbing-Unnamed undulating	A) Hibbing, Typic Eutroboralfs, fine, mixed B) Unnamed, Aquic Eutroboralfs, fine, mixed C) Minor soils
51	:	Flak-Brainerd	A) Flak, Typic Tragiochrepts, coarse-loamy, mixed B) Brainerd, Aquic Fragiochrepts, coarse-loamy, mixed C) Minor soils
52	≠	Alstad	A) Alstad, Aquic Eutroboralfs, fine-loamy, mixed B) Alstad (wet) C) Minor soils
53	r°	Amery-Ronneby	A) Amery, Glossic Eutroboralfs, coarse-loamy, mixed B) Ronneby, Aeric Fragiaqualfs, coarse-loamy, mixed C) Minor soils
54	✓	Brickton-Spooner-Dalbo	A) Brickton, Mollic Ochraqualfs, fine, mixed B) Spooner, Typic Ochraqualfs, fine-silty, mixed C) Dalbo, Aquic Eutroboralfs, fine, mixed D) Minor soils
55			
56	↑	Shooker	A) Shooker, Aeric Ochraqualfs, fine-loamy, mixed B) Unnamed, Histic Humaquept, fine-loamy,mixed C) Minor soils
57	↓	Greenwood	A) Greenwood, Typic Borohemists, dysic B) Minor soils
58	<	Mooselake	A) Mooselake, Typic Borohemists, euic B) Minor soils

Data Level	Map Symbol	Definition	Description
59	>	Waskish-Lobo	A) Waskish, Typic Sphagnofibrist, dysic B) Lobo, Hemic Sphagnofibrist, dysic C) Minor soils
60	≤	Mine	
61	≥	Urban	
62	—	Water	

VARIABLE NUMBER: V16

VARIABLE NAME: Land Use

SOURCE: Land Management Information Study

COLLECTED: 1969

INTERPRETATION: By MLMIS Staff

VARIABLE DESCRIPTION: Dominant land use for forty-acre parcels determined from aerial photographs.

Data Level	Map Symbol	Definition	Description
1	A	Forested	A forty in which there is at least a 10% crown cover of deciduous or coniferous trees.
2	B	Cultivated	A forty in which dominant land use appears (on aerial photographs) to consist of recently tilled or harvested land.
3	C	Water	A forty in which permanent open water is the dominant surface feature.
4	D	Marsh	A forty in which the dominant land use consists of non-forested, vegetated areas which are permanently wet.
5	E	Urban Residential	A forty containing five or more residential buildings (seasonal homes, resorts, mobile homes, etc.) and no commercial buildings.
6	F	Extractive	A forty in which the dominant land use consists of the extraction of minerals, and includes such features and facilities as mines, tailings, gravel pits, quarries, crusheries and storage facilities.
7	G	Pasture - Open	A forty in which the dominant land use consists of pasture land or land not used for any other identifiable purpose.
8	H	Urban and Non-Residential or Mixed Residential	Containing at least one commercial, industrial, or institutional development. Examples: Schools, factories, hospitals, nurseries, cemeteries, golf courses, gun clubs, athletic fields, organized recreational facilities, business districts, churches, filling stations, government buildings, warehouses, storage tanks, grain elevators, military installations, sewage disposal facilities, fish rearing areas, radio and television stations, drive-in theaters, state and county garages, prisons, motels, nursing homes and junk yards.
9	I	Transportation	A forty in which the dominant land use consists of facilities for the conveyance of people and/or materials. Examples: Airports, railroad yards, highway interchanges, rights-of-way.
15	O	Random Error	

VARIABLE NUMBER: V17

VARIABLE NAME: Forest Cover

SOURCE: U. S. Forest Survey, North Central Forest Experiment Station, 1962.

COLLECTED: 1962

INTERPRETATION: By MLMIS Staff

VARIABLE DESCRIPTION: Forest Cover was interpreted from aerial photos for 160 acre cells which had at least 10% cover of tree crowns. Accuracy, thus, is not guaranteed for parcels smaller in size than 160 acres. MLMIS land use codes used the same cover definition, but for 40 acre parcels. Nonforested lands by this definition were removed from the forest cover category and coded "0."

Data Level	Map Symbol	Definition	Description
0	::	Nonforested	A 160-acre parcel with less than 10% tree cover
1	A	White, Red or Jack Pine	Dominant tree cover is white, red or jack pine.
2	B	Spruce, Fir	Dominant tree cover is spruce - fir.
3	C	Oak - Hickory	Dominant tree cover is oak - hickory.
4	D	Elm - Ash - Cottonwood	Dominant tree cover is elm - ash - cottonwood
5	E	Maple - Birch - Basswood	Dominant tree cover is maple - birch - basswood
6	F	Aspen - Birch	Tree cover is predominantly aspen - birch.
7	G	Unproductive	A parcel with a severely limited tree cover which is considered to be unproductive.
9	I	Nonforested	

VARIABLE NUMBER: V18

VARIABLE NAME: Water Orientation (amended)

SOURCE: Original - U.S.G.S. Topographic Maps
Amendments - Minn. Dept. of Natural Resources, Wildlife Section
Parks and Recreation

COLLECTED: Original - USGS Map Publish Date
Amendments - 1976

INTERPRETATION: Original - MLMIS Amendments - NSP

VARIABLE DESCRIPTION: Those 40-acre parcels with any part of the parcel adjoining water are considered water oriented. In addition parcels on state designated trout streams and canoe and boating rivers, and waterways considered scenic are also noted.

Data Level	Map Symbol	Definition	Description
0	: :	Not orientated	A 40-acre parcel which is not adjoining water.
1	A	Island	Lake or river orientated land on islands
2	B	Lake orientated	Lake orientated parcel
3	C	Permanent River & Stream	River orientated parcel
4	D	Intermittent Rivers & Stream	Seasonal River orientated parcel
5	E	Drainage Ditch	Parcel adjoining a drainage ditch
6	F	Trout Lake	Parcel adjoining a lake which is being managed by the DNR for trout production
7	G	Trout River & Stream	Parcel adjoining a river or stream which is being managed by the DNR for trout production.
8	H	Intermittent Stream - Trout	Parcel adjoining an intermittent stream which is being managed by the DNR for trout production.
9	I	Drainage Ditch - Trout	Parcel adjoining a drainage ditch which is being managed by the DNR for trout production.
10	J	Lake and Designated Scenic River	Parcel adjoining a lake which is connected with a river that is designated scenic.
11	K	Permanent river and stream designated scenic	Parcel adjoining a permanent river or stream which has been designated scenic
14	N	Trout Stream and designated scenic river, and year-round river.	Parcel adjoining a permanent river or stream that is being managed for trout, and that is designated as scenic.

VARIABLE NUMBER: V19

VARIABLE NAME: Highway Orientation (amended)

SOURCE: Original - Minnesota Department of Highway Maps
Amendment - Minnesota Department of Highways - Env. Section

COLLECTED: Original - 1973
Amendment - 1976

INTERPRETATION: Original - MLMIS Staff
Amendment - NSP

VARIABLE DESCRIPTION: Those forty-acre parcels adjacent to roads and intersections are considered highway oriented. In addition, if the highway was considered scenic this is also noted.

Data Level	Map Symbol	Definition	Description
0		No roads	
1	A	Four lane controlled access or interstate	To distinguish this class from the following note that the major intersections are controlled access.
2	B	Four lane other	Four lane highways where access is not controlled.
3	C	Two lane state and federal	Two lane highways under state or federal jurisdiction.
4	D	Two lane county paved	Two lane paved road under county jurisdiction.
5	E	Unpaved	Gravel, stone, soil surfaced, and/or graded and drained roads. Unimproved or primitive roads are not to be included in this classification scheme.
6	F	Residential street	This is a designation given to all forties in an urban area which do not touch or contain roads in data levels 1 to 4. Roads in this class may be paved or unpaved, but most importantly designate a dense grid pattern of roads typical to urban areas.
7	G	Four lane controlled access or interstate and four lane controlled access or interstate	Intersection of two data level ones.
8	H	Four lane controlled access or interstate and four lane other	Intersection of data level one and data level two.
9	I	Four lane other and four lane other	Intersection of two data level twos.
10	J	Four lane controlled access or interstate and two lane state and federal	Intersection of data level one and data level 3.
11	K	Four lane other and two lane state and federal	Intersection of data level 2 and data level 3.
12	L	Two lane state and federal and two lane state and federal	Intersection of two data level threes.
13	M	Four lane controlled access or interstate and two lane county paved	Intersection of data level one and data level four.
14	N	Four lane other and two lane county paved	Intersection of data level two and data level four.
15	Ø	Two lane state and federal and two lane county paved	Intersection of data level three and data level four.
16	P	Two lane county paved and two lane county paved	Intersection of two data level fours.

Data Level	Map Symbol	Definition	Description
17	Q	Four lane controlled access or interstate and an unpaved road	Intersection of data levels one and five.
18	R	Four lane other and an unpaved road	Intersection of data levels 2 and 5.
19	S	Two lane state and federal and an unpaved road	Intersection of data levels 3 and 5.
20	T	Two lane county paved and an unpaved road	Intersection of data levels 4 and 5.
21	U	An unpaved road and an unpaved road	Intersection two data level fives.
22	V	Four lane controlled access or Interstate and scenic	Data level 1 considered to be scenic.
23	W	Four lane other and scenic	Data level 2 considered to be scenic.
24	X	Two lane state and federal and scenic	Data level 3 considered to be scenic.
25	Y	Two lane county paved and scenic	Data level 4 considered to be scenic.

VARIABLE NUMBER: V20

VARIABLE NAME: Counties

SOURCE: General County Highway Maps - Minnesota State Highway Department

COLLECTED: 1974

INTERPRETATION: NSP

VARIABLE DESCRIPTION: This variable locates those parcels which belong to one of either six counties located in the study area

Data Level	Map Symbol	Definition	Description
1	A	Roseau County	On west file.
3	C	Lake of the Woods County	On west file.
4	D	Beltrami County	On west file.
1	A	Koochiching County	On east file.
2	B	Itaska County	On east file.
5	E	St. Louis County	On east file.

VARIABLE NUMBER: V21

VARIABLE NAME: Soil Landscape Units

SOURCE: Agricultural Experiment Station, University of Minnesota, Minnesota Soil Atlas, Miscellaneous Report 110, 1971.

COLLECTED: 1971

INTERPRETATION: Soil Science Department, University of Minnesota and U. S. Soil Conservation Service

VARIABLE DESCRIPTION: A soil landscape unit (type) is a group of soils generalized into a unit (minimum size 400-600 acres) based upon the following factors:

1. Texture of the soil material below five feet characterized as sandy (S), loamy or silty (L), clayey (C), mixed sandy and loamy (X), mixed silty and clayey (Y), and bedrock (R).
2. Predominant texture of the material above five feet characterized as sandy (S), loamy or silty (L), and clayey (C).
3. Drainage capability of the soil designated (W) for moderately well, and excessively drained, and (P) for poorly drained. (W) units generally have water tables below the rooting zone while (P) units typically have water tables within the rooting zone.
4. Color of surface soil in which (D) designates dark color, and (L) light.

This, CSWL represents a soil landscape unit in which the material below five feet is clayey, the top five feet is sandy, drainage is good, and color of the surface material is light.

Data Level	Map Symbol	Definition	Description
1	A	RLWL	Loamy over rocky, well drained, light
2	B	HHHH	Water
3	C	LLWL	Loamy over loamy, well drained, light
4	D	SSWL	Sandy over sandy, well drained, light
5	E	Peat	
6	F	CCWL	Clayey over clayey, well drained, light
7	G	Rock	Bedrock
8	H	SLPL	Loamy over sandy, poorly drained, light
9	I	RCWL	Clayey over rocky, well drained, light
10	J	LLPL	Loamy over loamy, poorly drained, light
11	K	CCPL	Clayey over clayey, poorly drained, light
12	L	Peat	
13	M	SPSP	Peat over sand deposits
16	P	SSPL	Sandy over sandy, poorly drained, light
17	Q	XLWL	Loamy over mixed sandy loamy, well drained, light
18	R	NPNP	Non-acid peat
19	S	APAP	Acid peat
20	T	AAAA	Alluvial soils
21	U	APAP	Acid peat
22	V	SLWL	Loamy over sandy, well drained, light
23	W	BPBP	Raised bog

Data Level	Map Symbol	Definition	Description
24	X	LCPL	Clayey over loamy, poorly drained, light
25	Y	LSPL	Sandy over loamy, poorly drained, light
26	Z	CSWL	Sandy over clayey, well drained, light
27	0	CSPL	Sandy over clayey, poorly drained, light
28	1	LSWL	Sandy over loamy, well drained, loamy
29	2	MDMD	Mine dump
30	3	YLWL	Loamy over mixed silty and clayey, well drained, light
31	4	CLPL	Loamy over clayey, poorly drained, light
32	5	CCPD	Clayey over clayey, poorly drained, dark
33	6	CLWL	Loamy over clayey, well drained, light
34	7	RBRB	Raised bog
36	9	LCWL	Clayey over loamy, well drained, light
38	+	GGGG	Peat
39	*	XCWL	Clayey over mixed sandy and loamy, well drained, light
40	/	RSWL	Sandy over rocky, well drained, light
42	)	LPLP	Peat
43	$	LSPD	Sandy over loamy, poorly drained, dark
44	=	MMMM	Marsh

VARIABLE NUMBER: V22

VARIABLE NAME: Geomorphic Regions

SOURCE: Agricultural Experiment Station, University of Minnesota, Minnesota Soil Atlas.

COLLECTED: 1969-70. Updated 73-74

INTERPRETATION: MLMIS

VARIABLE DESCRIPTION: 16 geomorphic areas are delineated to illustrate broad physiographic features and to provide some identification as to the nature of parent materials on which the soils have developed.

Data Level	Map Symbol	Definition	Description
1	A	Tower Ely glacial drift and bedrock complex	
2	B	Highland flutes, rocky, strongly sloping	
3	C	Highland moraine, loamy rolling to hilly	
4	D	Toimi drumlin area, loamy	
5	E	Nemadji-Duluth lacustrine plain, clayey	
6	F	Vermillion moraine	

Data Level	Map Symbol	Definition	Description
7	G	Sawhill outwash plain	
8	H	Mesabi range	
9	I	Big Rice moraine	
10	J	052	
11	K	St. Croix moraine complex, loamy, rolling to hilly	
12	L	Turtle River till plain, loamy	
13	M	Wahsten moraine	
14	N	Nickerson moraine, loamy to clayey	
15	Ø	McGrath till plain	
16	P	Thomson-Cloquet moraine-complex	
17	Q	Automba Drumlin area	
18	R	Willow River outwash plain	
19	S	1A	
20	T	Durora till plain	
21	U	Uphum lacustrine plain	
22	V	Sawyer-Cloquet outwash plain	
23	W	Swatara plain	

Data Level	Map Symbol	Definition	Description
24	X	Agassiz peatlands	
25	Y	Aitkin lacustrine plain	
26	Z	Rashwauk-Warba moraine	
27	0	Sugar Hills moraine complex	
28	1	Marcell moraine complex	
29	2	Prairie River plain	
30	3	Agassiz lacustrine plain, Big Fork Valley area	
31	4	Bagley outwash plain	
32	5	Bimidji sand plain	
33	6	Northome moraine	
34	7	Brimson outwash plain	
35	8	Allen moraine	
36	9	Big Rice outwash plain	
37	+	Guthrie till plain	
38	-	Falk till plain	
39	*	Itaska moraine complex	
40	1	Fosston till plain	
41	(	Clearbrook moraine	
42	)	Erskine moraine	

Data Level	Map Symbol	Definition	Description
43	$	Agassiz lacustrine plain, Red Lake Area	
44	=	Agassiz peatlands	
45		Agassiz lacustrine plain, Red River Valley Area	
46	,	Agassiz lacustrine plain, Inter-beach area	
47	•	Agassiz lacustrine plain, Beltrami Island area	

VARIABLE NUMBER: V29

VARIABLE NAME: Historic & Archaeologic Sites

SOURCE: State Historic Society
Selected Rivers of Minnesota, Recreational Analysis
County Historic Societies

COLLECTED: 1975

INTERPRETATION: NSP

VARIABLE DESCRIPTION: Those 40-acre parcels which contain an historic or archaeologic site designated by the state, county or studies.

Data Level	Map Symbol	Definition	Description
1	A	Archaeologic Sites	Archaeologic sites as described by the State Historical Society and located by a 40-80 acre site.
2	B	Historic Locations	Historic or achaeologic sites which are located by a 120-640 acre site.
4	D	Historic Twsps.	Historic ghost towns which are not proven to exist and are located only by a township area.
5	E	Historic Sites	Historic sites or markers which are located by a 40-80 acre site.
7	G	Historic and Archaeologic sites	These parcels contain both historic and archaeologic sites.

VARIABLE NUMBER: V30

VARIABLE NAME: LAND USE - SPECIAL FEATURES

SOURCE: Minnesota Department of Natural Resources
Enforcement Section
Lands and Forest Section
Parks and Recreation Section
Planning
Regional Forestry Offices
Minnesota State Planning Agency - Project 80
Minnesota Highway Department
Minnesota Department of Agriculture
County Officials
County Extension Agents
Minnesota Association of Resort Owners
Minnesota Association of Campground Owners

COLLECTED: 1975

INTERPRETED: NSP

VARIABLE DESCRIPTION: Those 40-acre cells which have key facilities are considered to be recreation or agricultural areas.

Data Level	Map Symbol	Definition	Description
1	A	Commercial Farms & Research Areas	Agricultural research areas such as Northrup King and other research stations.
3	C	Fur Farms	A 40-acre parcel in which the breeding and raising of mammals for the fur industry is considered to be the parcel's key facilities.
4	D	Poultry Farms	A 40-acre parcel's key facility is considered to be a poultry farm.
5	E	Wild Rice	The cultivation of wild rice is considered to be the parcel's key facilities.

Data Level	Map Symbol	Definition	Description
6	F	Irrigation	Agricultural land which is presently being irrigated.
8	H	State Wayside	A wayside rest area currently being managed by the Minnesota State Highway Department.
10	J	State Park	Parks currently being managed by the state. Their boundaries were located by County General Hwy. Maps.
11	K	Municipal Park	Public parks being managed by the municipality. Park boundaries were taken from S.C.O.R.P. maps and verified by county officials.
12	L	Private Recreation	Privately owned parks and other recreation facilities as gun clubs and race tracks.
13	M	County Parks	Parks managed by the county. Park boundaries were taken from S.C.O.R.P. maps and verified by county officials.
14	N	State Campgrounds	This includes state campground which are inside and outside of State Park boundaries. Locations where taken from S.C.O.R.P. maps and verified by county officials.
15	O	Group Campgrounds	Campgrounds which are operated by private group organizations. Locations taken from SCORP maps and verified by county officials.
16	P	Private Campgrounds	Campgrounds which are owned, and operated by private individuals. Locations taken from SCORP maps and verified by county officials.
17	Q	Resorts	Privately owned resorts. Locations taken from SCORP maps and verified by county officials.

Data Level	Map Symbol	Definition	Description
18	R	Golf Courses	Public and private golf courses. Located from SCORP maps and verified by county officials.
21	U	Hunting Preserves	Privately owned and managed wildlife hunting areas.
22	V	Public Access	The parcel's key recreational facility is considered to be a public access to water.
24	X	County Parks & Access	A combination of data levels 13 and 22.
25	Y	Institutions	This parcel's key facility is a school building and athletic fields.
26	Z	School Forest	A parcel which contains tree species owned by public schools for study.
28	1	Valuable Timber	These sites represent stands of mature timber which are nearing the stage to be cut for lumber as defined by area forest managers.
29	2	Coniferous Plantations	These sites are planted and managed coniferous tree stands as defined by area forest managers.
30	3	Christmas Tree Plantation	These sites are planted and managed coniferous tree stands to be used as Christmas trees.
31	4	State Campground & Access	Combinations of data level 14 and 22.
35	8	State Park & Access	Combinations of data level 10 and 22.
39	*	Municipal Campground	A campground owned and operated by a municipality as obtained from SCORP maps.

Data Level	Map Symbol	Definition	Description
40	/	Municipal Forest & Pine Plantation	These parcels contain municipal owned forest land as identified by SCORP maps and pine plantation as defined by area forest managers.
46	,	State Campground, Wayside & Access	Combinations of data level 14, 8 and 22.
47	.	Landfill	These lowlands have been filled as defined by county officials.
49	[	State Campground & Valuable Timber	Combinations of data level 14 and 28.
50	]	Private Recreation & Conif. Plantation	Combinations of data level 12 and 29.
51	:	Private Campground & Access	Combinations of data level 16 and 22.
52	≠	Resort & Access	Combinations of data level 17 and 22.
53	↱	Private Recreation & Access	Combinations of data level 12 and 22.
59	>	DNR Recreation	These parcels contain recreation sites as identified by MDNR being campsites and water access.
48	≡	Group Campground & Access	Combinations of data level 15 and 22.

VARIABLE NUMBER: V31

VARIABLE NAME: Planning Documents

SOURCE: State Planning Agency
Minnesota Department of Natural Resources
County Comprensive Plans
County Water and Sewer Plans

COLLECTED: 1975

INTERPRETATION: NSP

VARIABLE DESCRIPTION: Planning documents were searched and those 40 acre parcels with anticipated uses were noted.

Data Level	Map Symbol	Definition	Description
1	A	New State Park	These boundaries were determined by State Planning's Project 80 and the Department of Natural Resources (DNR).
2	B	Potential Mining	These areas have been identified by county officials as having future mining resources.
5	E	Park	These include county and municipal park development as obtained from county plans and verified by county officials.
6	F	Stur-Shan Dam	This is a St Louis County projected engineered by SCS for recreation and wildlife land uses.
10	J	Proposed Trail	Multi-purpose trails located by DNR trail planners.
12	L	Medium Density Residential	Four to six units per acre located from county comprehensive development plans and updated by county officials.
13	M	Commercial	Located from county comprehensive development plans and updated by county officials.
14	N	Industrial	Located from county comprehensive development plans and updated by county officials.
15	O	Potential Private Campgrounds	These are sites identified by county officials as having near future campground development.
18	R	Low Density Residential	Two units or less per acre as located by county planner.
20	T	Potential Wild Rice	These are parcels identified by county officials as having good commercial wild rice potential.
21	U	Potential Landfill	These are parcels identified by county officials as requiring landfill for development.
24	X	Potential Campsite	The future location of a campsite along a scenic and wild river district.
33	6	Medium Density Residential	Same as data level 12.

VARIABLE NUMBER: V32

VARIABLE NAME: SEWER

SOURCE: County Water and Sewer Plans

COLLECTED: 1975

INTERPRETATION: NSP

VARIABLE DESCRIPTION: Those 40 acre cells for which a sewer system exists or a sewer system is planned.

Data Level	Map Symbol	Definition	Description
2	B	Long term sewer	Parcels which are to be sewered in 20 years as collected from County Plans booklet.
3	C	Existing sewer	Parcels which currently have a sewer system outside of city limits.

VARIABLE NUMBER: V33

VARIABLE NAME: Wildlife

SOURCE: Minnesota Department of Natural Resources:
- Fish and Game Section
- Regional Game Managers
- Parks & Recreation Section
- Bureau of Information and Education
- Land and Forests Section

Bureau of Sports, Fisheries and Wildlife
Nature Conservancy
Audubon Society
Izaak Walton League
North Central Forest Experiment Station
University of Minnesota
- Entomology Department
- Fisheries and Wildlife Dept.
- Botany Department

Minnesota Science Museum

COLLECTED: 1975

INTERPRETATION: Northern States Power Company

VARIABLE DESCRIPTION: Those 40-acre parcels with significant wildlife or natural vegetation.

Data Level	Map Symbol	Definition	Description
2	B	MDNR WMA's Upland Game	Minnesota Wildlife Management Area managed primarily for upland game species, particularly deer and grouse.
3	C	MDNR WMA's General (both)	Minnesota wildlife management area managed equally for waterfowl, upland game and hunting in general. Some of these areas are less intensively managed than others.
6	F	Game Refuges Unique Political Only	These are areas where firearms are restricted but are not usually unique habitat areas. The areas were set up when local opposition to hunting influenced political decisions to create a refuge.
7	G	Game Refuges Good Habitat Value	These are true game refuges. They serve as an outlet for game in heavily hunted areas. They are usually game concentration and quality habitat areas.
8	H	Unique Vegetation Bog	Includes bog areas considered to be of scientific value.
9	I	Unique Vegetation - Mature, Relic Timber	These are virgin pine stands or hardwood stands that represent impressive relics of pre-settlement vegetation.
10	J	Unique Vegetation Other - General	Includes areas of rare or unique plant communities other than bog or virgin timber, such as rare wild-flowers, prairie tracts, or areas indicated by professionals as unique.
11	K	Unique Wildlife Area Deer Yard	Deer yards are frequently low land areas of cedar or upland areas of conifer where deer seek winter shelter in large herds. These areas are fairly traditional and depending on snow conditions are used each year. They vary in size from a few acres to a square mile.
12	L	Unique Wildlife Waterfowl Area	These are wetland areas indicated by area game managers as prime waterfowl habitat.

Data Level	Map Symbol	Definition	Description
13	M	Unique Wildlife Bald Eagle	Bald eagle nest sites.
14	N	Unique Wildlife Sandhill Crane Area	Sandhill crane nesting sites.
15	O	Unique Wildlife Other	This category includes such items as sharp-tail grouse dancing grounds and quality habitat in general.
17	Q	Unique Wildlife Quality Game Trails	These are trails managed by DNR wildlife managers for quality hunting. No motorized vehicles allowed. Plantings along trails are maintained to attract upland game.
18	R	Environmental Education Areas	These areas are owned by schools or other organizations for the purpose of education in the natural sciences.
20	T	Scientific and Natural Areas	These are state owned areas of highly restricted use. Only two are designated in the study area at this time.
21	U	Proposed state wildlife area	Potential management areas indicated by area wildlife managers.
22	V	Deer Yard in WMA	Combination of data levels 11 and 13.
26	Z	Experimental Forest	Parcels which contain forest land used for experimental study by local and regional foresters.
34	7	Potential WMA with General Habitat	Areas identified by local foresters as having good habitat value which should be included in MWMA.
35	8	Deer yard and Mature Timber Area.	Combinations of data level 9 and 11.

VARIABLE NUMBER: V35

VARIABLE NAME: Forest Company Ownership

SOURCE: Blandin, Diamond, Kimberly Clark and Potlatch Companies

COLLECTED: 1974

INTERPRETATION: NSP

VARIABLE DESCRIPTION: V36 represents the ownership and partial evaluation of private forest companies lands.

Data Level	Map Symbol	Definition	Description
1	A	Diamond International Corp.	Parcels which are owned and managed by Diamond International Corp.
2	B	Blandin Paper Co. High Value	Parcels which are owned by Blandin and are rated as High Value.
3	C	Blandin Paper Co. Low Value	Parcels which are owned by Blandin and rated as Low.
4	D	Kimberly Clark Corp.	Parcels which are owned and managed by Kimberly Clark Corp.
5	E	Potlatch	Parcels which are owned and managed by Potlatch.

VARIABLE NUMBER: V36

VARIABLE NAME: Airports and Communication

SOURCE: Minnesota Aviation System Plan Phase II, Department of Aeronautics, February 1974. Minnesota Airport Directory, Dept. of Aeronautics, St Paul, MN.

COLLECTED: 1975

INTERPRETATION: NSP

VARIABLE DESCRIPTION: Those 40-acre parcels within avoidance zones for airports and communication equipment.

Data Level	Map Symbol	Definition	Description
1	A	Airport one mile constraint radius	Any airport with a paved runway of less than 32,000 feet has a constraint radius of one mile.
2	B	Airport one-three mile constraint radius	Any airport with a paved runway of 3,200 ft or greater has a constraint radius of three miles.
3	C	Proposed airport one-three mile constraint radius	A three-mile constraint area from an airport which plans on extending a paved runway to a distance of 3,200 ft or greater.
4	D	One-mile seaplane constraint area	This is a one mile constraint area for seaplane bases.
5	E	Microwave tower constraint radius	The area of avoidance surrounding a microwave tower which functions as a relay for a microwave beam.
6	F	Two-way VHF constraint radius	The avoidance area surrounding a radio transmitting tower.

Data Level	Map Symbol	Definition	Description
7	G	AM tower constraint radius	The avoidance area surrounding an amplitude modulation broadcasting tower.
8	H	TV Tower	Parcels containing a television transmission tower.
10	J	VOR constraint area	The avoidance area surrounding an aviation directional device.
15	O	Microwave tower is an AM constraint	Combination of data levels 5 and 7.
16	P	Microwave beam and AM constraint area	Combination of data level 7 and 17.
17	Q	Microwave beam	The beam being transmitted between two microwave towers.
19	S	Microwave beam through 1-3 mile constraint radius of impact	Combinations of data level 2 and 17.
20	T	Microwave beam through 1 mile constraint radius of airport	Combination of data levels 1 and 17.
21	U	Microwave beam and 1-3 mile proposed airport expansion	Combination of data levels 3 and 17.
24	X	AM constraint area and 1-3 mile airport constraint radius	Combination of data levels 2 and 7.
26	Z	Microwave tower within 1-3 mile airport constraint radius	Combination of data levels 2 and 5.

Data Level	Map Symbol	Definition	Description
34	7	VHF in one mi. airport constraint radius	Combination of data levels 1 and 6.
35	8	VHF in one-three mi. airport constraint radius	Combination of data levels 2 and 6.
36	9	TV tower in 1-3 mi. airport constraint radius	Combination of data levels 2 and 8.
37	+	AM constraint area within 1 mile airport constraint radius	Combination of data levels 1 & 7.

VARIABLE NUMBER: V41

VARIABLE NAME: Soils Rated for Agricultural Capability

SOURCE: Soil Survey Interpretations forms
Minnesota General Soil Map for Land Use Interpretation

COLLECTED: 1974

INTERPRETATION: MLMIS

VARIABLE DESCRIPTION: This variable describes a 40-acre parcel's capability of being used for the production of forage and grain crops.

Data Level	Map Symbol	Definition	Description
0		Not capable	Equivalent TDN yield lbs/acre 0-582
1	A	Marginal	Equivalent TDN yield lbs/acre 583-2330
2	B	Average	Equivalent TDN yield lbs/acre 2331-4078
3	C	Good	Equivalent TDN yield lbs/acre 4079 - 5824 and above.

VARIABLE NUMBER: V42

VARIABLE NAME: Soils Rated for Forest Capability

SOURCE: Soil Survey Interpretation forms
Minnesota General Soil Map for Land Use Interpretations

COLLECTED: 1974

INTERPRETATION: MLMIS

VARIABLE DESCRIPTION: This variable describes a 40-acre parcel's capability of being used for forest production based on the area's key species and its relative growth rate in terms of cubic feet of wood per acre per year, and site index information for the dominant soils in that area.

Data Level	Map Symbol	Definition	Description
0		Non-classed	
1	A	Class 1	Not rated on interpretive sheets
2	B	Class 2	Parcel is capable of producing less than 20 cubic feet/acre/year of timber.
3	C	Class 3	Parcel is capable of producing 20 to 40 cubic feet/ acre/year of timber.
4	D	Class 4	Parcel is capable of producing 40 to 50 cubic feet/ acre/year of timber.
5	E	Class 5	Parcel is capable of producing 50 to 60 cubic feet/ Acre/year of timber.
6	F	Class 6	Parcel is capable of producing 60 to 70 cubic feet/ acre/year of timber.

Data Level	Map Symbol	Definition	Description
7	G	Class 7	Parcel is capable of producing 70 to 80 cubic feet/ acre/year of timber.
8	H	Class 8	Parcel is capable of producing 80 to 90 cubic feet/ acre/year of timber.
9	I	Class 9	Parcel is capable of producing 90+ cubic feet/acre/year of timber.

APPENDIX B

Appendix B

SPECIFICATIONS

FOR

RIGHT-OF-WAY CLEARING

500 KV FORBES-INTERNATIONAL BORDER

TRANSMISSION LINE

GENERAL CLEARING SPECIFICATIONS

500 KV FORBES-INTERNATIONAL BORDER TRANSMISSION LINE

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FIGURES AND TABLES

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Figure 2 - Methods of Disposal

Figure 3 - Right-of-Way Screens and Access Roads at Public Roads and Waterways

Table 1 - Desirable Native Plant Species

1.0 GENERAL INFORMATION

1.1 SCOPE

The right-of-way shall be cleared of all obstructions which interfere with the construction and operation of the electric power line.

The contractor shall observe special conditions applicable to any particular description or tract of land.

1.2 DEFINITIONS

Desirable Species - Those plants which, at maturity, will not reach a height that will endanger the line and those which will provide food and cover for wildlife. Specific species which have been indentified as desirable species are listed in Table 1.

Tree - A woody plant normally maturing at 20 feet or more in height and achieving a diameter of at least four inches or more at four and one-half feet above ground.

Brush or Shrub - A woody plant normally maturing less than 20 feet in height with generally bushy appearance because of its several erect spreading or prostrate stems. It usually attains a diameter of less than four inches at four and one-half feet above ground.

Slash - Branches and tops less than four inches in diameter within the right-of-way boundaries.

Debris - Scattered logs, uprooted stumps and/or trees or other foreign material located within the right-of-way boundaries.

Clear Cutting - Removal or cutting of all vegetation (i.e. trees, shrubs, etc) within the right-of-way boundaries to a maximum height above ground, not to exceed three inches.

Selective Cutting - Removal from within the right-of-way boundaries of only that vegetation which would potentially interfere with the construction and/or operation of the transmission line, or is undesirable for wildlife food or habitat.

General Construction Area - Areas such as tower sites, staging areas, access roads or other locations where construction activities and traffic will take place.

Contractor - Person, persons, partnership, company or corporation entering into an agreement for the performance of work required.

Company - A designated representative of Northern States Power Company, with its main office in Minneapolis, Minnesota.

1.3 FIELD LOCATIONS

Field survey stakes will be established by the company designating the centerline of the right-of-way. All survey stakes designating points on tangents (hub stakes) and points of intersection shall be preserved by the contractor. Should any of these stakes be removed or destroyed by the

contractor, they will be replaced by the company at the contractor's expense.

1.4 ROUTE MAPS

General location of the right-of-way shall be indicated on drawings supplied by the company, showing the location of all areas to be cleared as described in the contract agreement.

1.5 RIGHT-OF-WAY WIDTH

Prior to the start of clearing operations on any portion of the transmission line, the company shall flag the edges of the right-of-way. The company will also designate areas of selective cutting, the location of such to be designated on company drawings and at appropriate field locations and/or by written instructions.

1.6 ACCESS

The contractor and a company representative shall jointly make all arrangements necessary for crossing private property when necessary for ingress and egress for the right-of-way. Any damages resulting from such ingress and egress to the right-of-way shall be the responsibility of the contractor who shall indemnify and save the company harmless from all claims or causes of action arising or to arise therefrom.

1.7 DANGER TREES

Danger trees will be designated by the company

and are defined generally as those trees outside of the right-of-way which, in falling, could contact the line, or other trees with a definite lean toward the power line which are not presently danger trees, but have high potential for becoming danger trees. Such trees outside of the specified right-of-way width shall be hand cut with additional compensation as provided in the Agreement.

1.8 STANDARD GATE DETAILS

At specified locations designated by the company, the contractor shall install gates in accordance with specifications shown on Company Standard Gate Details (Figure 1). These gates shall be constructed with material at least equal in quality to the existing fence. All gates and fences used during the construction period shall be maintained to prevent the possible escape of livestock from or onto adjacent lands.

1.9 ENERGIZED LINES

When working near energized lines the contractor shall use putting lines, or some other method, to prevent trees from falling into the lines. The contractor shall notify the company daily of work being done near an energized line and when the work is completed for the day. Specific work locations shall be identified by line number, road location and/or structure number.

1.10 RIGHT-OF-WAY INSPECTION

Contractor's work shall at all times be subject

to inspection by the company and public authorities. Contractor shall notify the company of any proposed changes in daily crew assignments in sufficient advance to allow suitable inspection by the company. Contractor shall advise where work will be carried on from day to day as work progresses.

1.11 ESTABLISHED LAND SURVEY CORNERS

It will be the contractor's responsibility to properly preserve all established corners or other permanent landmarks which may be encountered in the clearing operation. Destruction of such landmarks may require additional surveys for re-establishment of same, for which contractor will be liable.

2.0 GENERAL CLEARING GUIDELINES

All work to be performed under the supervision of the contractor shall be conducted in a manner such that all phases of the clearing, such as cutting, disposal and final clean-up, shall progress concurrently.

2.1 CUTTING PROCEDURES

2.1.1 All trees and brush shall be cut with a saw or other device to eliminate pointed spikes. No stumps or stubble shall be left standing higher than three inches above ground for trees with trunk diameters of 12 inches and under and six inches above ground for trees with trunk diameters of 12 inches and over. (Stump height measured on high side of sloping terrain).

2.1.2 Clearing will be permitted by mechanical operation unless otherwise specified. Generally, shearing will be restricted to slopes less than 15 degrees.

After any mechanical operation the contractor shall, as nearly as possible, restore the natural contour existing prior to the start of work.

2.2 DISPOSAL PROCEDURES

As specified by the company, all trees, brush and other debris shall be disposed of in accordance with the procedures outlined below. Under no circumstances will windrowing be permitted on or off the right-of-way.

2.2.1 Burning

Slash to be burned shall be piled within the cleared areas such that damage to adjacent trees or other vegetation will not occur. A small amount of debris left from burning may be buried on the right-of-way with a minimum of three feet of cover and at least 60 feet from the centerline of the right-of-way. Contractor shall be responsible for acquiring all required burning permits and conform to applicable established regulations.

2.2.2 Lop and Scattering of Slash

In areas approved by the company, lopping and scattering of slash may be accomplished such that slashings shall not exceed 18 inches in height.

2.2.3 Chipping

Chips shall be disposed of in such a manner

that they will accumulate to depths no greater than 12 inches. The chipping should be accomplished in such a manner that no chipped material will enter any open water.

2.2.4 Corduroy

In some swamp areas, where the stumpage is the property of the company, the contractor may dispose of some, or all of the trees and slash by placing trees, slashing, etc., perpendicular to the right-of-way and packed down to a maximum height of 30 inches, by running over this material with crawler type equipment provided such disposal is located on the outside 20 feet (both sides) of the right-of-way. Angles must be kept clear. See Figure 2.

2.2.5 Salvage of Timber

All timber which is placed along the edge of the right-of-way shall be trimmed flush to the trunk and piled neatly in lengths as specified by the company (Figure 2). Log piles shall not exceed five feet in height and shall not extend out into the right-of-way, by more than 20 feet. At no time will log piles obstruct trails, access roads or the general construction area, or be piled up against standing trees on edge of right-of-way. When salvaging timber designated by landowners, wastage shall be held to a minimum.

2.3 HERBICIDE TREATMENT OF CUT STUMPS

All hardwood stumps shall be treated by the end of the same day before becoming covered with snow, ice, leaves or other debris. The type of herbicide used, including appropriate mixtures, shall be designated by the company. When using solutions, the outer portion of the stump in the bark zone shall be treated to achieve runoff, using care to thoroughly soak the root collar area. It shall be the contractor's responsibility to assure that the use and application of herbicides are in compliance with applicable state and federal laws and regulations.

3.0 ENVIRONMENTAL CONSIDERATIONS

Clearing shall be performed to maximize preservation of natural beauty and conservation of natural resources, and minimize adverse effects of the landscape or silting of streams. Where the entire width of the right-of-way traverses vegetation types such as low growing brush, muskeg swamps or black spruce bogs or when crossing a deep valley or ravine, the right-of-way clearing shall be reduced in width to approximately the center one-third. Also, where selective cutting may be beneficial, this type of clearing will be accomplished as designated by the company. In areas where company has purchased timber rights, efforts shall be made to salvage as much merchantable wood as possible, provided it is economically feasible.

3.1 SELECTIVE CUTTING

Selective cutting will be accomplished in specific areas so designated on the company drawings,

generally in areas of high public exposure, including interstate and U S highways, heavily traveled state and county roads, streams and lakes as well as other environmentally sensitive areas, such that a natural vegetative screen remains. A list of native plant species which should be selected for these areas is shown in Table 1. Such trees and shrubs shall be marked or otherwise designated by the company. If natural vegetation is such that a screen cannot be left and suitable natural regeneration does not occur within two years following clearing the planting of native types of shrubs and low growing trees to provide adequate screening shall be considered (Figure 3).

3.2 ACCESS ROAD

In areas where selective cutting is to be accomplished, access roads will be constructed at an angle to avoid a vista down the right-of-way (Figure 3). All access roads will be located to minimize destruction of desirable plants and damage to cultivated fields.

3.3 SEEDING

If the ground surface is severely disturbed in areas where potential erosion problems may exist, seeding with mixture of grasses and clover shall be considered.

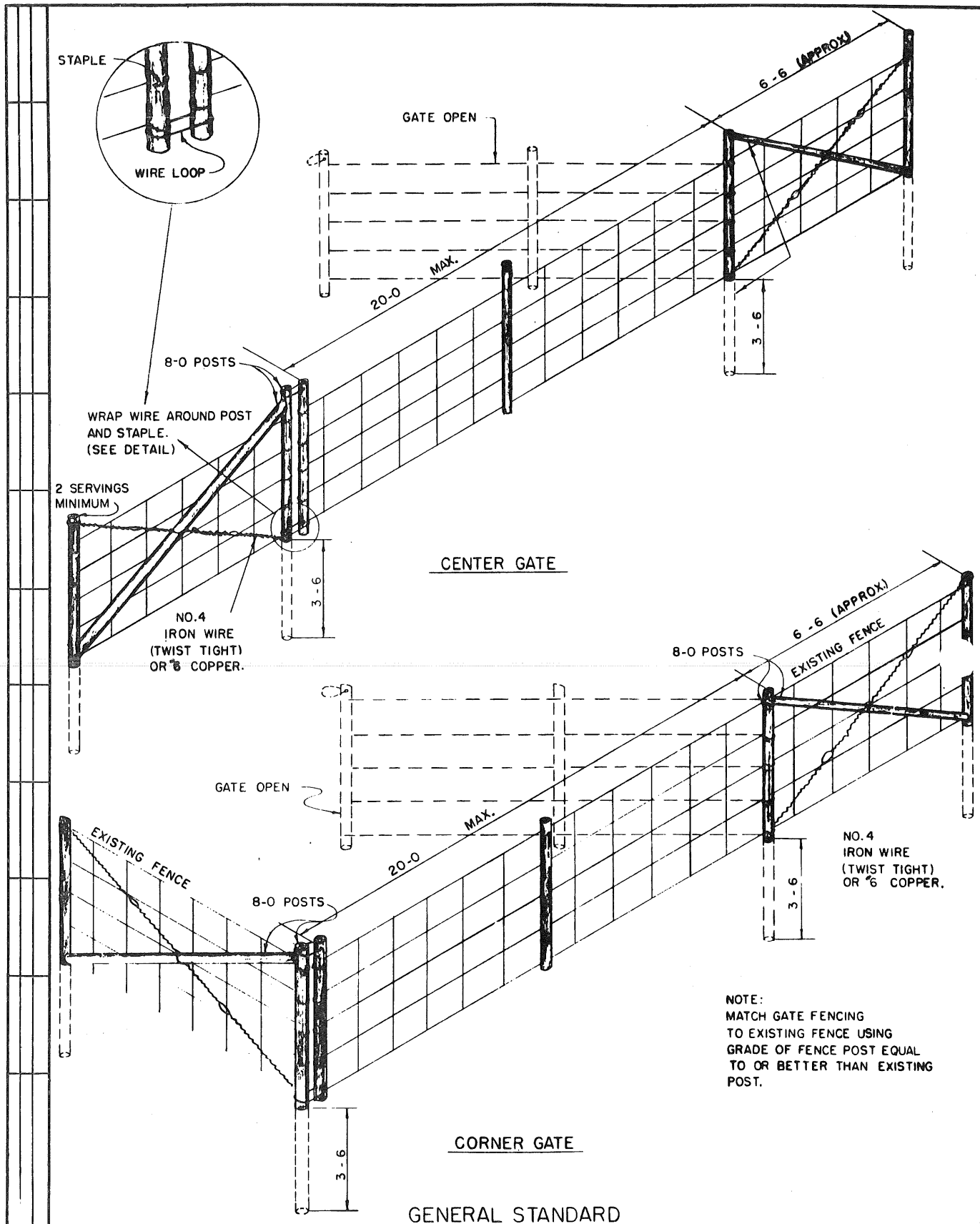
3.4 STREAM CROSSINGS

In areas where it is necessary to cross streams and/or rivers, they may be forded by the contractor

only upon written approval from the company and/or the Minnesota Department of Natural Resources.

In some areas, it may be necessary or advantageous to install culverts. Prior to the installation of any culvert, written permission must be received from the Minnesota Department of Natural Resources.

FIGURE 1 STANDARD GATE DETAILS



GENERAL STANDARD

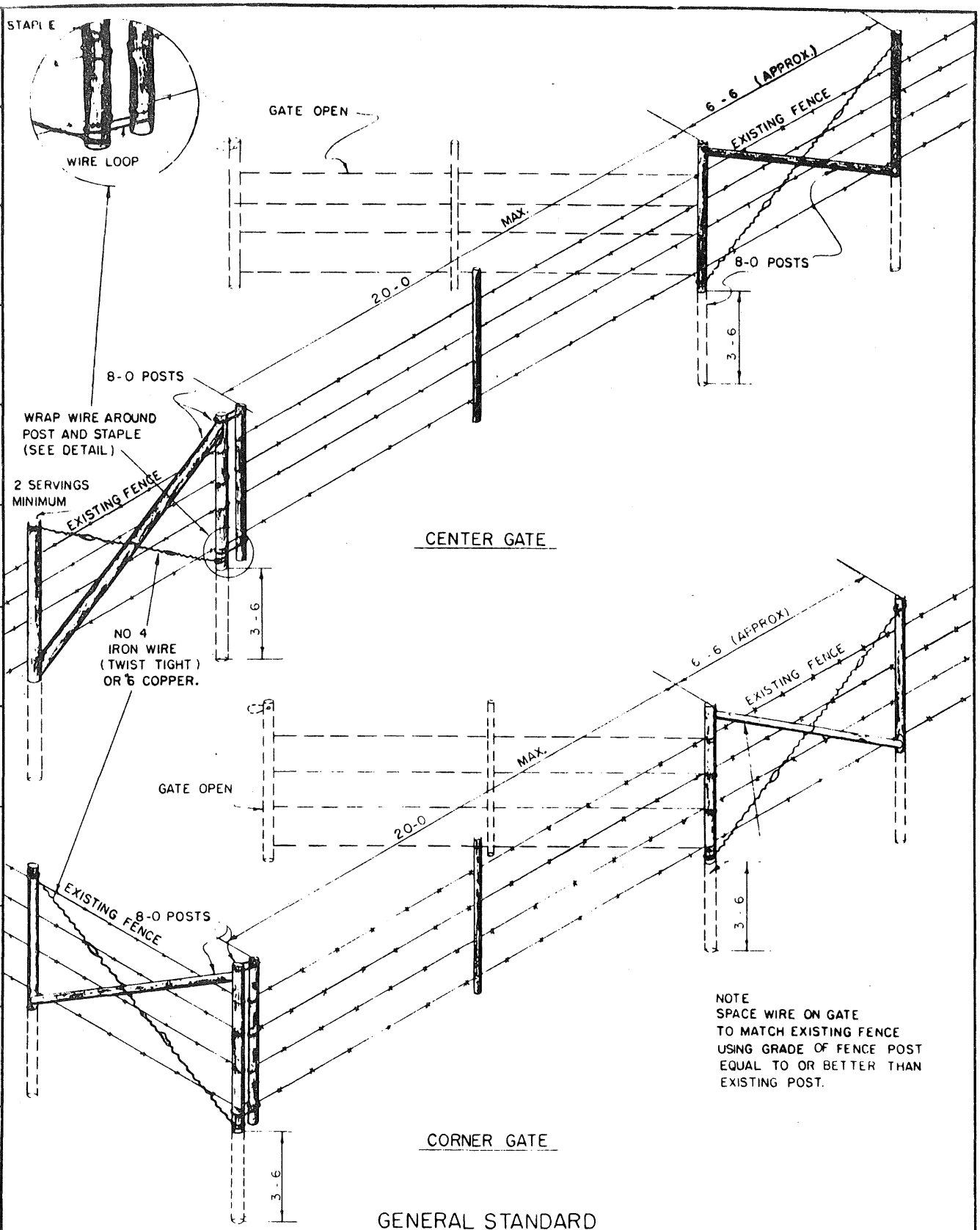
METHODS OF OPENING FENCES FOR CONSTRUCTION

(VARIOUS TYPES OF WOVEN FENCES)

APPROVED

DATE

NORTHERN STATES POWER COMPANY ENGINEERING DEPARTMENT	DRAWN CDJ	FILMED	REV.	TRANSMISSION STANDARDS
	CHECKED	APPROVED		SHEET OF TP .0801
	DATE 3-13-67			



NOTE
SPACE WIRE ON GATE TO MATCH EXISTING FENCE USING GRADE OF FENCE POST EQUAL TO OR BETTER THAN EXISTING POST.

GENERAL STANDARD
METHODS OF OPENING FENCES FOR CONSTRUCTION
(BARBED WIRE FENCING)

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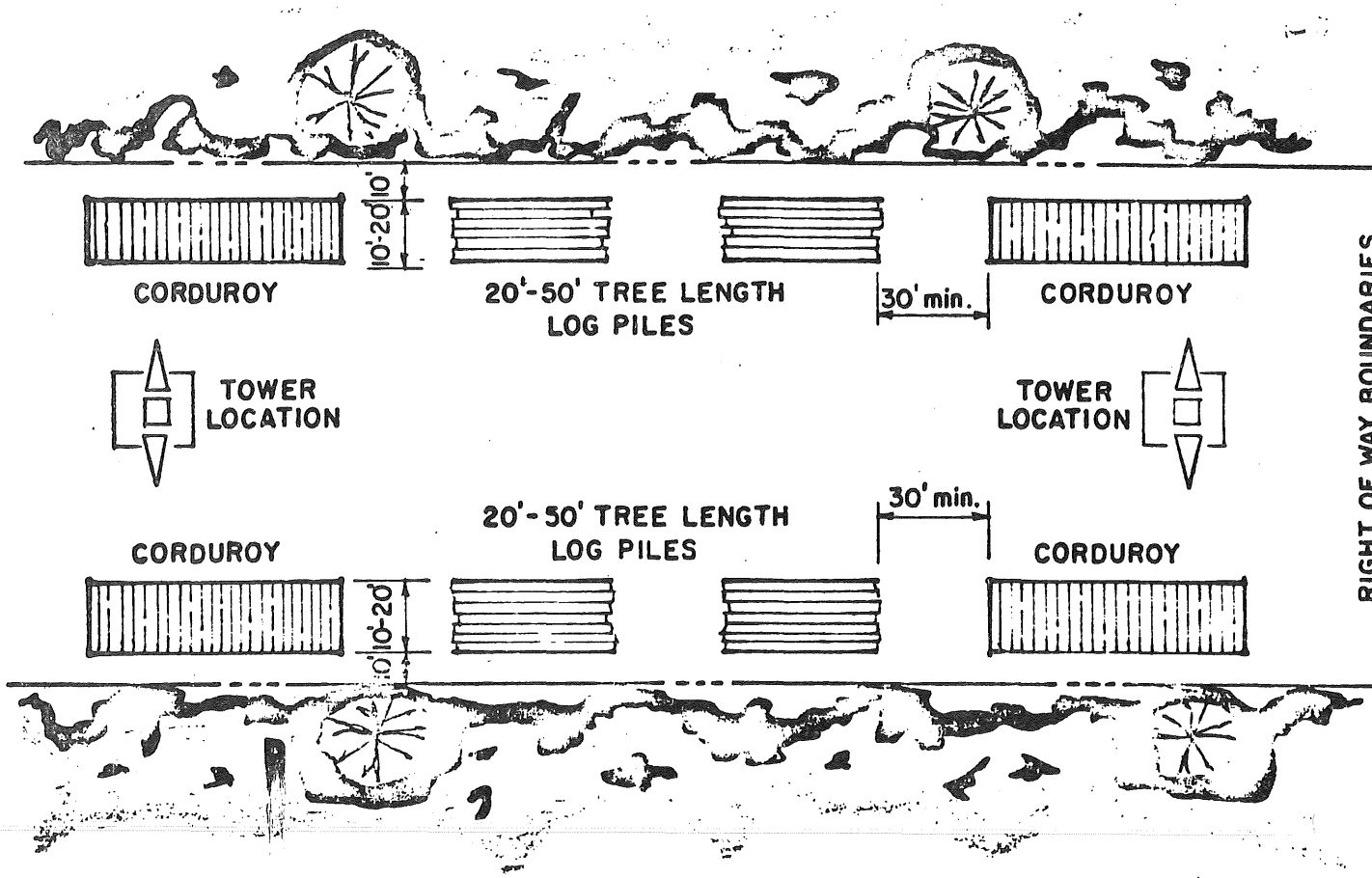
FIGURE 2 METHODS OF DISPOSAL



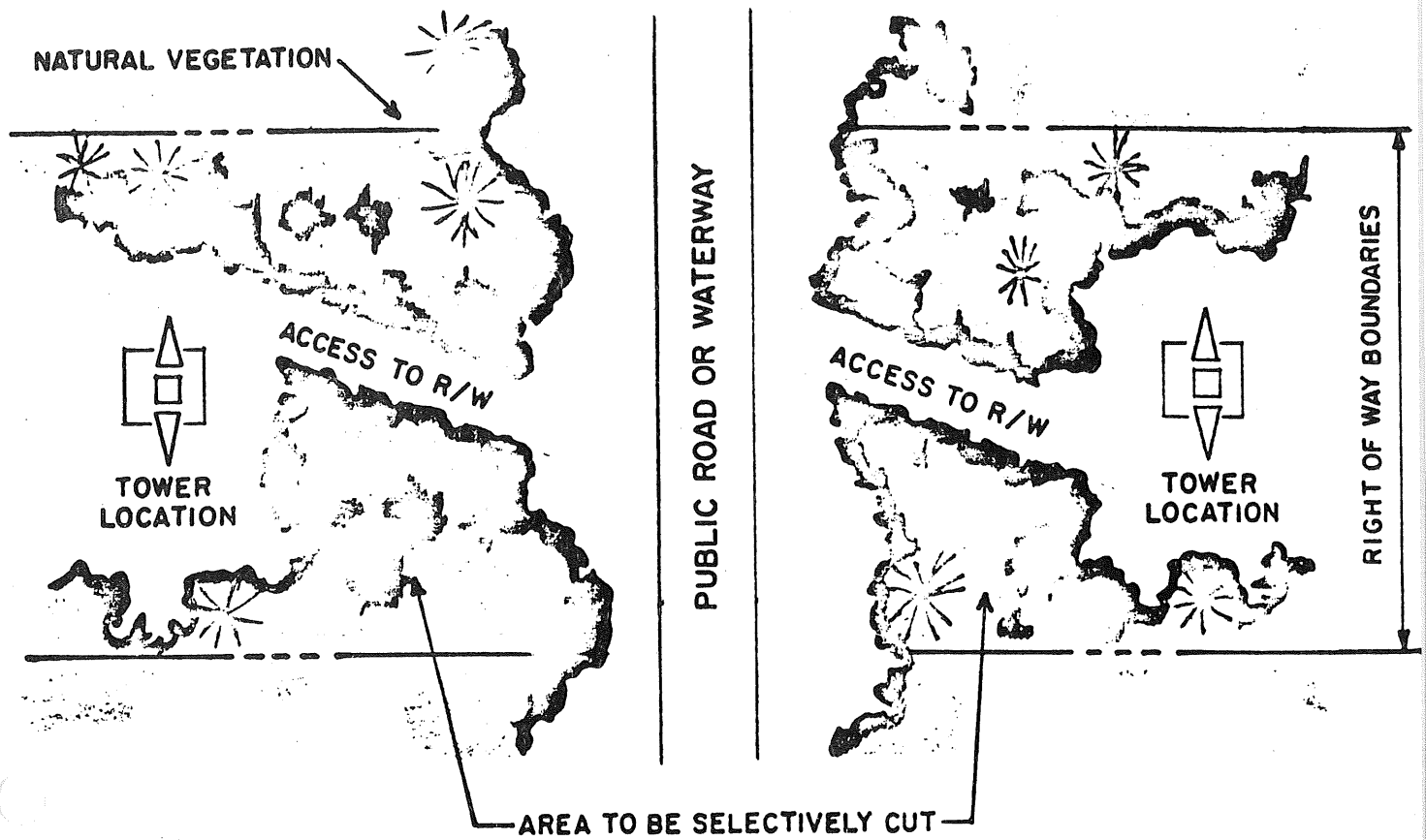
NOTE:

1) Take care not to pile within the General Construction Area.

2) When corduroying, all material must be perpendicular to the right of way and must not exceed a height of 30 inches.

3) When disposing of trees in tree lengths or as otherwise specified, the maximum height of the piles must not exceed three (3) feet.

FIGURE 3
RIGHT OF WAY SCREENS AND ACCESS ROADS AT PUBLIC ROADS AND WATERWAYS



NOTE:

1) When possible, bushes and other low growing vegetation in right of way areas shall be left. Vegetation shall be maintained to allow safe operation of the transmission line.

2) Large trees outside the right of way boundaries shall be examined and any unsound specimens removed if they present a danger to the transmission line.

3) Tree stumps or stubble shall be no higher than three (3) inches above normal ground level. Chemical treatment shall be applied to the stump to prevent regrowth.

4) In areas of selective cutting, clear cutting will only be used at construction access roads and at structure erection sites.

5) Where clearing exposes soil, immediate measures will be taken to stablize the soil to prevent erosion.

6) The right of way, in all cases after construction, will be leveled of any ruts, ditches and roads will be repaired and all unusual material and equipment will be removed from the construction area and right of way.

7) When natural vegetation is such that a screen cannot be left and suitable natural vegetation does not occur within two (2) years following clearing, the planting of native types of shrubs and low growing trees shall be considered to provide adequate screening.

TABLE 4.4-1

DESIRABLE NATIVE PLANT SPECIES WHICH SHOULD BE ENCOURAGED ON SELECTED AREAS OF RIGHT-OF-WAY

CONIFEROUS TREES

Northern White Cedar
Red Cedar (Juniper)
Norway Pine*
White Pine*
White Spruce*

DECIDUOUS TREES

Basswood*
Paper Birch*
Yellow Birch*
Black Cherry*
Choke Cherry (f)
Pin Cherry (f)
Hackberry
Ironwood
June Berry (f)
Red Maple*
Red Oak*
White Oak*
Wild Plum (f)

SHRUBS (1)

Red-Osier Dogwood (fc)
Other Dogwood Species (f)
Mountain Maple
Sumac (c)
Mountain Ash (c)
Arrowwood (f)
High-bush Cranberry (fc)
Hazel
Honeysuckle
Smooth Wild Rose (f)

(1) Majority of shrub species listed are beneficial to white-tailed deer and ruffed grouse.

(f) Conspicuous flowering shrub.

(c) Bright autumn or winter colors (fruit, leaves, or stems).

(*) Areas within the right-of-way where these trees will be permitted must be approved by the Company.

Appendix Bb

RIGHT-OF-WAY MAINTENANCE PROGRAM

FOR DEVELOPMENT OF WILDLIFE HABITAT

FOR

FORBES-INTERNATIONAL BORDER 500 KV TRANSMISSION LINE

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1.0 INTRODUCTION

Power line rights-of-way within the forested regions of north-central and north-eastern Minnesota have the potential to make signficant contributions to the betterment of wildlife habitat. This in part is due to the fact that much of the forested area in this region is maturing and therefore does not provide the type of diverse habitat required by most game species. White-tailed deer, for example, need dense cover for protection, yet many of their preferred foods grow best in young forest openings where sufficient sunlight is available. Power line rights-of-way which traverse such forested areas can be managed to provide for these openings and edges, with the resultant diversity of vegetative plant communities required by wildlife.

The proposed expansion of Northern States Power Company's transmission system with a 500 kv transmission line between Forbes and the International Border will provide opportunities for improvement of habitat for a variety of wildlife species including: upland game, large and small mammals, birds of prey, songbirds and others. Through a program of selective vegetation management on this right-of-way, a variety of desirable herbs, shrubs and small growing trees, such as mountain maple, dogwood, juneberry, chokecherry and pincherry can be propagated for the benefit of wildlife.

Forest openings, including rights-of-way in otherwise forested areas, are often one of the first sources of grasses, sedges and other herbaceous food for the white-tailed deer in the early spring when other areas of the

forest are yet snow covered. This early availability of nutritious vegetation can play a very important role in both deer and ruffed grouse reproduction success as well as subsequent health and survival of newborn wildlife. Young ruffed grouse also often use these "open" rights-of-way in the early spring and summer by feeding on the abundant insect life, developing seeds of sedges, strawberries, raspberries and blueberries as well as other succulent greenery such as clover and bunchberry.

Although habitat management within the right-of-way will be primarily directed toward the major game species including white-tailed deer, ruffed grouse and woodcock, many of the associated game as well as "nongame" animals and birds will also benefit. This is because the general needs of most wild animals are much alike, in that each must have a sufficient quantity and variety of food and cover to meet their physiological needs. NSP's right-of-way management program is developed around the principal of "habitat diversity" and "type interspersion," with the objective of maximizing those types of plant communities most favorable to wildlife.

2.0 GENERAL RIGHT-OF-WAY/HABITAT MANAGEMENT PRACTICES

In an attempt to develop habitat diversity and to meet the multiple needs of the various wildlife species in our area, the central one-third area of the right-of-way will generally be maintained in a grassy-herbaceous type of cover. The outer two-thirds of the right-of-way on both sides of the grassy-herbaceous cover will be

managed to encourage the development of a variety of herbs, shrubs and low-growing trees which have potential value as wildlife food and/or cover. In selected areas on upland sites, consideration will also be given to the planting of fruit-bearing shrubs and small trees such as hawthorn, mountain ash and other fruit-producing shrubs, in an effort to improve existing habitat conditions. Also in areas where it is desirable to maintain alder communities for woodcock habitat, cutting to rejuvenate the alder will be accomplished at intervals of 15 to 20 years.

3.0 SPECIAL RIGHT-OF-WAY/HABITAT MANAGEMENT PRACTICES

The following specific management practices will be carried out in a further attempt to meet the multiple needs of the major wildlife species.

3.1 DEER YARDS

In areas where the right-of-way falls near known or potential winter deer yarding areas, a greater portion than the central one-third area of the right-of-way will be maintained in the grassy-herbaceous stage of succession in order to maximize the quantity of grasses, sedges and other herbaceous foods for early spring grazing. Areas of the right-of-way that pass in closer proximity to deer yards will be maintained entirely in shrubs and other young tree shoots in order to maximize the quantity of winter browse food.

3.2 STREAM AND OTHER WATER CROSSINGS AND ROAD CROSSINGS

In areas where the right-of-way crosses major streams and marshes, waterfowl food and nesting cover will be developed and maintained. Where deemed advisable, desirable grass-clover mixtures will be seeded up to 300 feet on both sides of the water crossing. In areas where the right-of-way intersects small streams or intermittent waterways, a brushy cover of alder and other shrubs will be maintained to provide food and cover for ruffed grouse and woodcock. Wildlife will also use these areas as travel lanes across the right-of-way.

In areas where the right-of-way intersects roadways, a "screen" of native vegetation will be developed to prevent long vistas down the right-of-way. When natural vegetation does not provide an adequate "screen", supplemental plantings of slow-growing conifers and low-growing deciduous trees and shrubs will be made.

3.3 WILDLIFE TRAVEL LANES

In addition to the vegetative cover which will be maintained along waterways, cover for wildlife travel lanes will also be maintained within the right-of-way at locations of known wildlife crossings.

4.0 INTEGRATION WITH FOREST COVER TYPES

The aforementioned management practices will generally apply to the improvement of wildlife habitat within the right-of-way for all upland forest cover types including:

aspen-birch, northern hardwoods, oak-hickory, upland, spruce-fir, jack pine as well as the white and Norway pine types. In specific areas, however, modifications of the general recommendations will be made to adjust for variations in local situations and for differences in seasonal uses of the right-of-way by wildlife. For example, in selected locations on the right-of-way within the coniferous timber types it may be beneficial to maintain strips of low growing conifers for wildlife travel lanes and shelter.

Management of the right-of-way in the swamp conifer type will be directed toward the production of a maximum quantity of low tree and shrub cover for browse throughout the right-of-way and to promote as much cedar growth as possible.

Since the black spruce timber type has limited applications for wildlife habitat improvement, the general management policy that will be followed in these areas is to maintain the type insofar as possible in its natural condition. Much of this type occurs as "stunted spruce bogs," and therefore very minimal disturbance, such as clearing of only the center one-third area of the right-of-way, will normally be required for construction and maintenance.

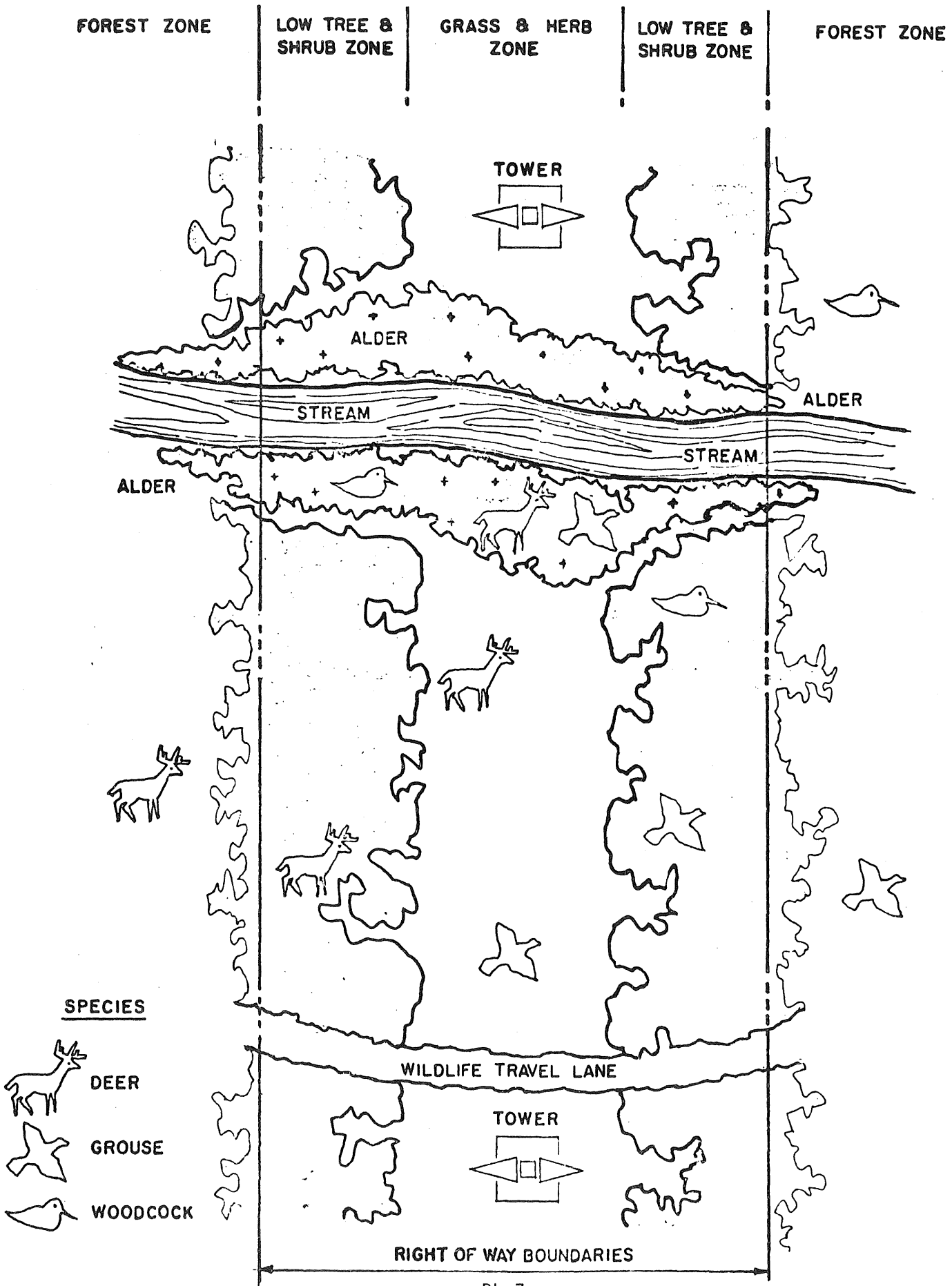
The general policy of "minimal disturbance" will also apply to the nonforested upland and lowland shrub types.

5.0 INTEGRATION WITH FARMING

Game habitat improvement in farm land will be coordinated with the individual landowners as well as with the

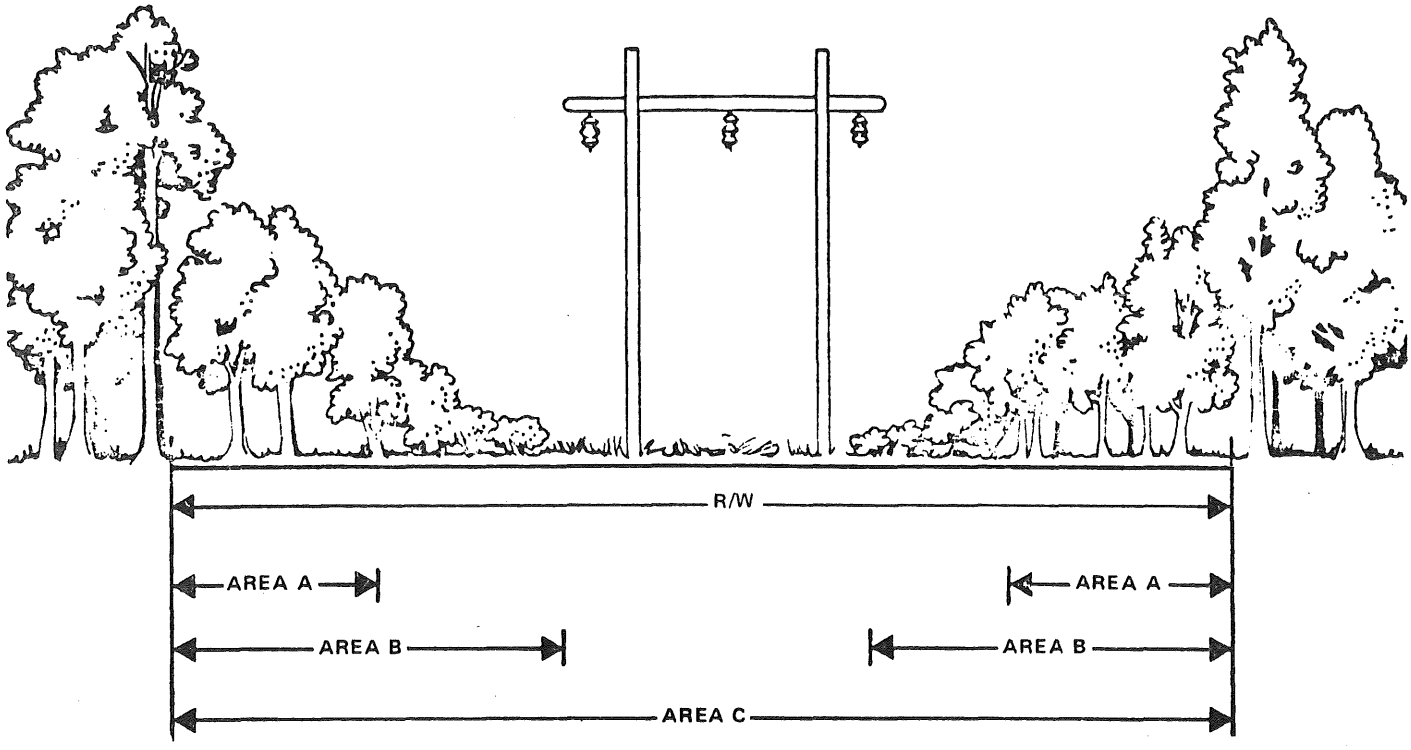
Minnesota Department of Natural Resources. In these areas, NSP will encourage discing and seeding of the entire right-of-way for pasture land and the maintenance and development of wildlife food and cover along fence rows and around tower sites.

RIGHT-OF-WAY - WILDLIFE USE



APPENDIX II

CROSS-SECTION DIAGRAM OF TYPICAL RIGHT-OF-WAY MAINTENANCE PROGRAM FOR DEVELOPMENT OF WILDLIFE HABITAT 1/



VEGETATION FOR RESPECTIVE AREAS

AREA "A"	AREA "B"	AREA "C"
Northern White Cedar	Juneberry	Grasses
Red Cedar	Wild Plum	Clover
Juniper	Pin Cherry	Herbs
Ironwood	Choke Cherry	Ferns
	Elderberry	Other grazing vegetation
	Hawthorne	
	Dogwood Species	
	Mountain Maple	
	Mountain Ash	
	High-bush Cranberry	
	Hazel	
	Arrow wood	
	Wild Rose	
	Honeysuckle	
	Sumac	
	Snowberry	

1/ Objective of Management Program is to maximize the Shrub-Grass-Herbaceous communities of vegetation in order to increase ground cover which minimizes invasion and re-establishment of new tree growth which could pose a hazard to the power line. Methods of vegetation management will be accomplished through the use of governmental approved herbicides as well as by the use of mechanical equipment.

APPENDIX III

List of native plant material utilized by the major game species of Central and Northern Minnesota which should be encouraged on selected areas of rights-of-way.

Coniferous Trees*

Northern White Cedar
Jack Pine
White Pine

Deciduous Trees*

Aspen
Basswood
Paper Birch
Yellow Birch
Red Maple
Sugar Maple
Red Oak

Herbs - Forbs

Sweet Fern
Blueberry
Blackberry
Labrador Tea
Clover & Other Legumes
Strawberry
Various Plant Crop Materials
Alfalfa

Shrubs and Small Trees

Red-Osier Dogwood
Other Dogwood Species
Mountain Maple
Currant
Sumac
High-Bush Cranberry
Hazel
Viburnums
Honeysuckle
Elderberry
Leatherwood
Yew
Chokecherry
Juneberry
Pin Cherry
Wild Plum
Mt. Ash

*Trees to be generally maintained at a maximum height of 15 feet.

APPENDIX IV

White - Tailed Deer

(General Information)

The white-tailed deer is undoubtedly the most popular big-game animal in Minnesota. Although they are generally thought to be a product of forested lands, they usually maintain higher densities and productivity in forested areas which are interspersed with cropland, grassland and other similar "openings".

Food preferences vary with season of year and region, however, variety is essential for proper nutrition. Research studies indicate that deer weighing 150 pounds need approximately 5 to 6 pounds (dry weight) of good browse daily to satisfy growth requirements.

Contrary to common belief, white-tailed deer do not travel great distances. Although movement from winter to summer range may vary from 1.5 miles to 6 miles, movement during the winter months usually does not exceed 1/4 mile from yarding areas.

APPENDIX V

Ruffed Grouse

(General Information)

The ruffed grouse or partridge as it is commonly called, is the principal woodland gamebird of central and northeastern Minnesota. They occur in both brown and grey plumage and average 1 to 1 3/4 pounds in weight. Good grouse range contains three kinds of vegetation: (1) Shrubs and low growing ground cover for rearing broods and for summer and fall foods, (2) Hardwoods for nesting and for fall and winter foods and (3) Conifers for winter cover. Although the very young grouse appear to be largely dependent upon insects for their early growth and development, they soon become vegetarian and feed on the same plant materials utilized by the older grouse. The plant foods taken first by chicks are the developing seeds of sedges as well as other young succulent greenery. Later in the summer they feed on other leafy foods and fruits including raspberries, strawberries, and blueberries while in the fall and winter their food consists primarily of buds and catkins of aspen, birch and hazel.

Daily movements of the ruffed grouse for feeding and roosting is usually less than 1/4 of a mile. The average home range of broods is about 40 acres with seasonal movements not likely to exceed 6-7 miles.

APPENDIX VI

American Woodcock

(General Information)

The American woodcock is a small gamebird, averaging approximately 1/2 pound in weight, which inhibits meadows, grassy areas as well as low-land hardwoods. Nesting sites normally occur on the ground in brushy fields or along the edges of wooded areas.

Food requirements of the woodcock consists primarily of earthworms and insects. The minor amount of plant food eaten by this bird includes leaves, seeds and fruits of sedges, alder, raspberries and blackberries and other plants.

The woodcock is a migratory species with wintering grounds in states bordering the Atlantic Ocean and the Gulf of Mexico. It is generally believed that they do not change their location to any marked degree from the vicinity of their nesting and breeding ground during the summer months.

APPENDIX C

LEGISLATIVE REFERENCE LIBRARY
STATE OF MINNESOTA

Minnesota Environmental Quality Council

Rules and Regulations

for

POWER PLANT SITING AND TRANSMISSION LINE ROUTING

CHAPTER 21

CONTENTS

MEQC 71 Authority, Purpose, Definitions

MEQC 72 Responsibilities of Utilities

MEQC 73 Procedural Aspects of Power Plant Siting and Transmission Routing

MEQC 74 Substantive Aspects of the Power Plant Siting Process

MEQC 75 Public Participation

CHAPTER TWENTY-ONE: MEQC 71-90

POWER PLANT SITING AND TRANSMISSION LINE ROUTING

MEQC 71 AUTHORITY, PURPOSE, DEFINITIONS

(a) **Authority.** The regulations contained herein are prescribed by the Minnesota Environmental Quality Council pursuant to the authority granted to the Council in Minn. Stat., Sect. 116C.53 (Supp. 1973) to provide for power plant site and transmission line corridor and route selection and in Sections 116C.55, 116C.57, and 116C.66 to establish regulations to give effect to the purposes of Minn. Stat., Sect. 116C.51 to 116C.69 (Supp. 1973), herein referred to as the Power Plant Siting Act. The Power Plant Siting Act deals with the siting of large electric power generating plants and high voltage transmission lines. No large electric power generating plant or high voltage transmission line shall be constructed except on a site or route designated by the Council. No site or route shall be designated that violates state agency regulations.

(b) **Purpose.** The purpose of these regulations is to provide for the implementation of Minn. Stat., Sect. 116C.51 to 116C.69 (Supp. 1973).

(c) **Policy.** It is the policy of the State to site large electric power facilities in an orderly manner compatible with environmental preservation and the efficient use of resources. Sites shall be selected by the Council that minimize adverse human and environmental impact while insuring continuing electric power system reliability and integrity and insuring that electric energy needs are met and fulfilled in an orderly and timely fashion.

(d) **Definitions.** As used in these Regulations, the following terms shall have the following meanings, unless otherwise defined:

(1) "Candidate areas" means sub-regions of the State that are determined by the absence of exclusion factors and that are homogenous enough in geography, land use, and land cover such that selection criteria for specific power plant sites and transmission line corridors and routes may be used with the same weighting factors within each candidate area.

(2) "Construction" means significant physical alteration of a site or route but not including activities incident to preliminary engineering or environmental studies.

(3) "Corridor" means the general location of a high voltage transmission line. For the inventory, the end points should be defined and the width may be variable up to approximately 30 kilometers. In a certificate of corridor compatibility, the end points shall be defined, and the width at all points shall be specified by the Council.

(4) "Council" means the Minnesota Environmental Quality Council, established pursuant to Minn. Stat., Sect. 116C.01 et seq. (Supp. 1973).

(5) "Designated corridor" means a transmission line corridor that has been granted a certificate of corridor compatibility by the Council.

(6) "Designated site" means a power plant site that has been granted a certificate of site compatibility by the Council.

(7) "Development Region" means a geographic region of the State designated pursuant to the Regional Development Act of 1969, Minn. Stat., Sect. 462.381 et seq. (1971).

(8) "Exclusion criteria" means criteria that remove geographic areas from consideration for power plant sites and transmission line routes.

(9) "High voltage transmission line" means a conductor of electric energy and associated facilities designed for and capable of operation at a nominal voltage of 200 kilovolts or more. Associated facilities shall include, but not be limited to, insulators, towers, and substations and terminals operating at a nominal voltage of 200 kilovolts or more.

(10) "HVTL" means high voltage transmission line.

(11) "Large electric power generating plant" means electric power generating equipment and associated facilities designed for or capable of operation at a capacity of 50,000 kilowatts or more, including, but not limited to, fossil fuel, nuclear fuel, pumped storage and hydroelectric plants.

(12) "LEPGP" means large electric power generating plant.

(13) "Person" means an individual, partnership, joint venture, private or public corporation, association, firm, public service company, cooperative, political subdivision, municipal corporation, government agency, public utility district, or any other entity, public or private, however organized.

(14) "Power plant avoidance areas" means those areas in which a large electric power generating plant shall not be located for reasons of human and environmental impact when feasible and prudent alternatives exist.

(15) "Potential sites" means small sections of candidates areas identified by the general application of power plant site selection criteria as possible large electric power generating plant sites in the inventory.

(16) "Receipt of application" means the date of a Council meeting at which the application is presented to the Council.

(17) "Route" means the specific location of a high voltage transmission line between two end points specified by the Council. The specified route may have a variable width of up to one kilometer.

(18) "Selection criteria" means criteria used for identifying and ranking potential power plant sites and transmission line routes and corridors, that shall form the basis upon which judgmental weightings can be made.

(19) "Site" means the location of a large electric power generating plant.

(20) "Transmission line avoidance areas" means those areas through which a transmission line shall not be routed for reasons of human and environmental impact when feasible and prudent alternatives exist.

(21) "Utility" means any entity engaged in this state in the generation, transmission or distribution of electric energy, whether for sale to others or for use by the owner, including, but not limited to, a private investor owned utility, cooperatively owned utility, a public or municipally owned utility, and a private corporation.

MEQC 72 RESPONSIBILITIES OF UTILITIES

(a) **Submission of Data.** All utilities shall submit the required data in the form and manner prescribed by the Council.

(b) **Facility Forecast.** Every utility that owns, operates, or plans within the next 15 years to own or operate LEPGP's or HVTL's shall develop facil-

ity forecasts. On or before July 1 of each even-numbered year, the utility shall submit to the Council a report containing the information required in MEQC 74(a). The report may be appropriate portions of a single regional forecast or may be jointly prepared and submitted by two or more utilities. Joint forecasts shall distinguish clearly among the utilities.

(c) **Facility Development Plans.** Every utility that owns, operates or plans within the following five years to start construction on, own or operate LEPGP's or HVTL's shall prepare facility development plans of facilities that it will need to meet and fulfill the expected demands for electric energy during the five-year period. The plans may be appropriate portions of a single regional plan or may be jointly prepared and submitted by two or more utilities. Joint development plans shall distinguish clearly among the utilities.

(2) The utility shall submit to the Council its plans containing the information required in MEQC 74(b) on or before July 1 of each year with the first submission due on July 1, 1976.

(d) **Annual Assessment.**

(1) **Purpose.** An annual assessment shall be made against all utilities for the purpose of financing the Council's base line studies, general environmental studies, development of criteria, inventory preparation and all other work pursuant to the Act, other than specific site, corridor, and route selection.

(2) **Determination.**

(aa) On or before April 1 of each year, each utility shall submit to the Council a report of its retail kilowatt-hour sales in the State and its gross revenue from retail kilowatt-hour sales in the State for the preceding calendar year.

(bb) The share of each utility shall be determined by the Council as follows:

(i) the ratio that the annual retail kilowatt-hour sales in the State of each utility bears to the annual total retail kilowatt-hour sales in the State of all such utilities, multiplied by 0.667, plus

(ii) the ratio that the annual gross revenue from retail kilowatt-hour sales in the State of each utility bears to the annual total gross revenues from retail kilowatt-hour sales in the State of all such utilities, multiplied by 0.333.

(cc) The total assessment shall be based on actual expenses of the Council for the first nine months of the fiscal year and on its estimated expenses for the last three months of the fiscal year. Underpayments or overpayments shall be adjusted on the succeeding bill. In no case shall the total assessment be greater than the annual expenditures of the Council required to carry out the purposes of MEQC 72(d)(1).

(3) **Payment.**

(aa) Before May 15 of each year, the Council shall bill each utility for its share of the assessment. The bill shall constitute notice of the assessment and demand of payment thereof.

(bb) The utility shall pay the assessment to the State Treasurer within 30 days after receipt of the bill.

MEQC 73 PROCEDURAL ASPECTS OF POWER PLANT SITING AND TRANSMISSION ROUTING

(a) Inventory of Potential Large Electric Power Generating Plant Sites and High Voltage Transmission Line Corridors.

(1) **Responsibility.** The Council shall assemble and publish an inventory of potential LEPGP sites and HVTL corridors on the advice and recommendation of its advisory bodies.

(2) **Public Participation.** The Council shall provide for public input into the development and revision of its inventory as required in MEQC 75.

(3) **Publication.** The inventory report shall be published on or before July 1, 1975. It shall include the criteria, standards, and methodology used in developing the potential site and corridor inventory, and a statement of the reasons each site or corridor was included. It shall also include a general description of the various candidate areas within the state and the weighting factors that shall be applied within those candidate areas to the site selection criteria. In developing the weighting factors the Council shall regard health effects, water and air quality, water appropriation, and large generating capacity as generally more important than other considerations.

(4) **Update and Revision.**

(aa) After completion of the initial inventory of potential sites and corridors, the Council shall have a continuing responsibility to evaluate, update annually, and publish its inventory.

(bb) When, as a result of changed circumstances or information, a site or corridor is inconsistent with prescribed criteria or no longer meets prescribed standards, the Council shall remove the site or corridor from the inventory of potential sites and corridors.

(b) **Designation of Sites and Corridors.**

(1) **Application.**

(aa) A utility shall submit to the Council an application for designation of a specific power plant site or transmission line corridor, that shall contain the supporting information required in MEQ 74(f)or(g).

(bb) The applicant shall pay to the Council a fee in an amount equal to $500 for each $1,000,000 of production or transmission line plant investment in the proposed installation as defined in the Federal Power Commission Uniform System of Accounts. For a power plant site, 25 percent of the fee shall accompany the application, and the balance is payable in three equal installments at the end of 90, 180, and 270 days. For a transmission line corridor, 25 percent of the fee shall accompany the application, and the balance is payable in three equal installments at the end of 45, 90, and 135 days. The applicant shall pay within 30 days of notification such additional fees as are reasonably necessary for completion of the plant site or transmission line corridor evaluation and selection process by the Council. In no event shall the total fees required of the applicant under this subdivision exceed an amount equal to 0.001 of said production or transmission line plant investment ($1,000 for each $1,000,000) except that the minimum application fee shall not be less than $5,000. In the event that the expenses incurred in processing applications are less than the fee paid, the excess shall be refunded to the applicant.

(2) **Council action on site or corridor designation application.** Upon the receipt of an application, the Council shall immediately initiate the study, evaluation, and hearings on any sites or corridors proposed by the utilities and on such other sites or corridors as the Council deems necessary. When the Council studies other sites or corridors, in addition to those submitted by the applicant, the Council shall inform the applicant and the public. The Council shall use the following procedure:

(aa) **Notice.** Within 15 days of the receipt of an application, the Council shall mail a notice of the receipt of the application to the appropriate state, federal, and local agencies and to other persons who have requested notification. The notice shall include a map showing the proposed sites or corridors.

(bb) **Advisory Committee.** Within 60 days of the receipt of an application, the Council shall appoint a site evaluation committee or may appoint a corridor evaluation committee as set forth in MEQC 75.

(cc) **Public Hearings.**

(i) The Council shall hold public hearings to meet the following requirements:

(aaa) The Council shall hold at least one public hearing in each county where a site is being considered for designation.

(bbb) The Council shall hold at least one public hearing in each development region where a corridor is being considered for designation.

(ii) Notice of public hearings shall be given by the Council at least 30 days in advance but no earlier than 45 days prior to such hearings. Notice shall be by publication in a legal newspaper of general circulation in the county or counties in which the site or corridor is being considered; by mailed notice to the applicant, the chief executive of each development region and county within which the site or corridor is being considered, each legislator within whose district the site or corridor is being considered, and the chief executive of each incorporated municipality within the involved counties; by press release; and by paid radio, television or newspaper advertisement in the area.

(iii) The Council may hold one or more public informational meetings preceding each public hearing. Notice shall be by publication in a legal newspaper of general circulation in the county or counties in which the site or corridor is being considered; by mailed notice to the applicant, the chief executive of each development region and county within which the site or corridor is being considered, each legislator within whose district the site or corridor is being considered, and the chief executive of each incorporated municipality within the involved counties; by press release; and by paid radio, television or newspaper advertisement in the area.

(dd) **State Agency Participation.** State agencies with the authority to issue permits or certification required for construction or operation of LEPGP's or HVTL's shall participate in and present the position of the agency at public hearings and all other activities of the Council on specific site, corridor or route designations. Each shall clearly state whether the proposed site, corridor, or route will be in compliance with the state agency standards, regulations or policies insofar as it can be determined based on the information available at that time. When a state agency does not present

a written statement of its position upon the request of the Council, within the time preiod specified by the Council, the Council shall so notify the applicant.

(ee) **Federal Agency Participation.** Federal agencies with the authority to grant construction and operating permits for LEPGP's and HVTL's shall be invited by the Council to present their position.

(ff) **Other Participation.** All agencies, including regional and local governments, planning agencies, and other organizations (including citizen groups) with the authority to grant permits or certifications for, or are known by the Council to be concerned with, the construction or operation of LEPGP's and HVTL's shall be invited by the Council to present their positions.

(gg) **Designation of a Site or Corridor.**

(i) The site or corridor shall be designated in accordance with MEQC 74 by the issuance to the utility of a certificate of site or corridor compatibility.

(ii) The Council shall designate a site for a specific size and type of LEPGP within one year of the receipt of an application. The Council shall designate a corridor within 180 days of the application. The time for designation of a site may be extended for six months by the Council for just cause.

(iii) When the Council has designated the site or corridor, it shall notify the following:

(aaa) The units of government within the designated site or corridor;

(bbb) The state and federal agencies that process permits on the site or route;

(ccc) The formal participants at the public hearings;

(ddd) Requesting persons; and

(eee) Legislators whose districts are partially or wholly within the site or corridor.

The notice shall include a precise description of the locale of the site or corridor, the type of facility, and the reasons for the Council's selection.

(iv) When the Council denies an application, it shall state the reasons for the refusal and the changes in the size, type, and/or location of the facility necessary to designate a site or corridor in compliance with the standards.

(c) **Construction Permits for Transmission Lines**

(1) **Application.** Within two years from the date of the issuance of a certificate of corridor compatibility, the utility shall apply to the Council for a construction permit for a HVTL within the approved corridor. The application shall contain the information required in MEQC 74 (h).

(2) **Fees.** The applicant shall pay the Council a fee in an amount equal to $500 for each $1,000,000 of transmission line plant investment in the proposed installation as defined in the Federal Power Commission Uniform

System of Accounts. Twenty-five percent of the fee shall accompany the application, and the balance shall be payable in three equal installments at the end of 45, 90, and 135 days. The applicant shall pay within 30 days of notification such additional fees as are reasonably necessary for completion of the transmission line route evaluation and selection process by the Council. In no event shall the total fees required of the applicant under this subdivision exceed an amount equal to 0.001 of said transmission line plant investment ($1,000 for each $1,000,000) except that the minimum application fee shall not be less than $5,000. When the expenses incurred in processing applications for permits in accordance with these Regulations are less than the fee paid, the excess shall be refunded to the applicant.

(3) **Route Evaluation Committee.** Upon receipt of an application by a utility for a construction permit, the Council shall appoint a Route Evaluation Committee as set forth in MEQC 75.

(4) **Public Hearings.** The Council shall hold at least one public hearing in each county where a route is being considered for the issuance of a permit for construction of a HVTL. Notice of public hearings shall be given by the Council at least 30 days, but no earlier than 45 days, prior to the hearings. Notice shall be by publication in a legal newspaper of general circulation in the county in which the public hearing is to be held; by mailed notice to the applicant, the chief executive of each development region and county within which the route is being considered, each legislator within whose district the route is being considered, and the chief executive of each incorporated municipality within the involved counties; by press release; and by paid radio, television, or newspaper advertisement in the area.

(5) **Public Informational Meetings.** The Council shall hold one or more public informational meetings preceding each public hearing. Notice shall be as required in MEQC 73(c)(4).

(6) **Council Action.** Following study and evaluation by the Council of the type, design, routing, right-of-way preparation, and facility construction identified in the utility's application and, when possible, alternatives, and following public hearings by the Council, the Council shall issue a HVTL construction permit specifying the location and width of the route, the width of the right-of-way and other appropriate conditions. The permit shall be issued by the Council in a timely manner and published no later than 180 days after receipt of the application by the Council. Following issuance of a construction permit, a utility shall file with the Council its construction plans for each phase of the application at least 60 days prior to commencement of construction of that phase.

(7) **Local Regulations, State Permits, State Agency Participation, Federal Regulations.** The provisions of MEQC 73(b)(2)(dd), 73(b)(2)(ee), 73(b)(2)(ff), and 73(g) shall also apply to this permit consideration.

(d) **Emergency Certification**

(1) **Application**

(aa) Any utility whose electric power system requires the immediate construction of a LEPGP or a HVTL may apply to the Council for an emergency certificate of site compatibility or permit for the construction of a HVTL.

(bb) The application shall include the supporting information required in MEQC 74(i).

(2) **Fees.** The fee shall be $500 for each $1,000,000 of power plant investment or $1,000 for each $1,000,000 of transmission line investment in the proposed installation as defined in the Federal Power Commission Uniform System of Accounts. Twenty-five percent of the fee shall accompany the application, and the balance is payable in three equal installments at the end of 45, 90, and 135 days. The applicant shall pay within 30 days of notification such additional fees as are reasonably necessary for completion of the plant site or transmission line route evaluation and selection process by the Council. In no event shall the total fees required of the applicant under this subdivision exceed an amount equal to 0.001 of said power plant investment ($1,000 for each $1,000,000) or 0.002 of said transmission line investment ($2,000 for each $1,000,000) except that the minimum application fee shall not be less than $5,000 in the case of a power plant or $10,000 in the case of a transmission line.

(3) **Public Hearing**

(aa) A public hearing on whether or not a demonstrable emergency exists shall be held within 60 days of the receipt of the application.

(bb) If the Council finds that an emergency exists, a second public hearing, on the merits of the site or route for which application is being made, shall be held in the development region within which the site is being considered or in one development region through which the route under consideration passes. Any sites or routes proposed by the Council shall also be considered.

(cc) Notice shall be by publication in a legal newspaper of general circulation in each county in the development region in which the hearing is to be held; by mailed notice to the applicant, the chief executive of each development region and each county involved, each legislator within whose district the site or route is being considered, and the chief executive of each incorporated municipality within the involved region; by press release; and by paid radio, television or newspaper advertisement in the area. Notice shall be given by the Council at least 30 days in advance, but no earlier than 45 days, prior to the hearing.

(4) **Council Action**

(aa) The Council shall apply the criteria of MEQC 74(i) to determine within 90 days of receipt of the application whether a demonstrable emergency exists that requires immediate construction and whether adherence to the procedures and time schedules required under these Regulations would jeopardize the utility's electric power system.

(bb) If the Council finds that a demonstrable emergency does not exist, the Council shall issue a final order to that effect. All expended fees shall be forfeited by the applicant.

(cc) If the Council finds that a demonstrable emergency exists, such that adherence to the non-emergency siting procedures and time schedules set forth in these regulations would jeopardize the utilities electric power system, the Council shall apply the criteria of MEQC 74(c). 74(d) and the considerations of MEQC 74(j) and issue and publish a certificate or permit within 180 days of receipt of the application. Notice of the Council action

shall include a precise description of the locale of the site or route, the type of facility and the reasons for the Council's selection.

(dd) If the Council denies an application, it shall state the reasons for the refusal and the changes in the size, type or location of the facility necessary to allow site designation or issuance of a construction permit in compliance with the standards.

(5) **Local Regulations, State Permits, State Agency Participation, Federal Regulations.** The provisions of MEQC 73(b)(2)(dd), 73(b)(2)(ee), 73(b)(2)(ff), and 73(g) shall also apply to emergency certification.

(e) **Improvement of Acquired Plant Sites and Route Locations**

(1) **Delay in Construction.** Utilities that have acquired a power plant site or transmission line route may proceed to construct or improve the site or route, in accordance with these Regulations. However, when the construction and improvement has not commenced four years after the site certificate or construction permit has been issued by the Council, the utility shall certify to the Council that there has been no significant changes in any material aspects of the conditions or circumstances existing when the certificate of site compatibility or transmission line construction permit was issued. When the Council determines that there is a significant change, the Council may suspend the certificate or permit and order a new hearing and further Council consideration of the matter.

(2) **Minor Alterations in HVTL Construction Permits.** Following the issuance of a HVTL conditional or final construction permit, a utility may, if necessary, apply to the Council for minor alterations on conditions specified in the permit. The Council shall determine within 45 days of the application:

(aa) Whether or not the requested changes are significant enough to warrant Council study and approval;

(bb) Whether or not to order public hearings near the affected areas;

(cc) Whether or not additional fees shall be assessed; and

(dd) The amount of time necessary for the Council to complete its studies.

Within 60 days of its decision to study the application, the Council shall determine whether it would be impracticable for the utility to proceed without the minor alterations and shall grant or deny the utility's application.

(f) **Transmission Line Exemption.** Transmission line additions or modifications under 1.6 kilometers in length may be exempted from these Regulations by Council action. The following procedure shall be used:

(1) **Application.** A utility shall submit to the Council an application for exemption of a specific transmission line containing the following information:

(aa) the engineering design concepts;

(bb) the proposed route;

(cc) description of the plans for right-of-way preparation and for construction; and

(dd) description of the setting, including a generalized field survey and the environmental impact of the proposed action.

(2) **Council Action.** The Council shall approve or deny the application within 60 days of receipt.

(g) **Council Preemption of Siting and Routing Activities**

(1) **Regional and Local Regulations**

(aa) The issuance of a certificate of site compatibility or transmission line construction permit and the subsequent purchase and use of the site or route locations by the utility, pursuant to the certificate or permit, shall be the sole site approval required of the utility.

(bb) The certificate or permit shall supersede and preempt all zoning, building, or land use rules, regulations, or ordinances promulgated by regional, county, local or special purpose governments.

(2) **State Permits**

(aa) Utilities shall obtain state permits or certifications that may be required to construct and operate LEPGP's and HVTL's. However, a state agency in processing a utility's facility permit application shall be bound by the decisions of the Council regarding the site designation for the LEPGP or the corridor or route designation for the HVTL, and other matters for which authority has been granted to the Council by the Act and these Regulations.

(h) **Failure To Act.** If the Council fails to designate a LEPGP and HVTL corridor or route as provided in these Regulations, the affected utility may seek an order of the District Court requiring the Council to designate a site, corridor, or route.

(i) **Judicial Review**

(1) Any utility, party or person aggrieved by:

(aa) the issuance of a certificate or emergency certificate of site compatibility or transmission line construction permit;

(bb) a certification of continuing suitability filed by a utility with the Council; or

(cc) a final order issued by the Council in accordance with these Regulations

may appeal therefrom to any District Court where the LEPGP or HVTL is to be located.

(2) The appeal shall be made and perfected within 60 days after the issuance of the certificate or permit by the Council, the certification filed with the Council or the filing of any final order by the Council.

(3) The notice of appeal to the District Court shall be filed with the Clerk of the District Court and a copy thereof mailed to the Council and affected utility.

(4) Any utility, party or person aggrieved by a final order or judgment rendered on appeal to the District Court may appeal therefrom to the Supreme Court in the manner provided in civil actions.

(j) Enforcement, Penalties

(1) Any person who violates this Act or these Regulations, or knowingly submits false information in any report required by this Act shall be guilty of a misdemeanor for the first offense and a gross misdemeanor for the second and each subsequent offense. Each day of violation shall constitute a separate offense.

(2) The provisions of the Act and these Regulations may be enforced by injunction, action to compel performance or other appropriate action in the District Court of the county wherein the violation occurs. The Attorney General shall bring any action under these Regulations upon the request of the Council.

(3) When the Court finds that any person has violated the Act or these Regulations, knowingly submitted false information in any report required by the Act or these Regulations, or has violated any court order issued under the Act or these Regulations, the Court may impose a civil penalty of not more than $10,000 for each violation.

MEQC 74 SUBSTANTIVE ASPECTS OF THE POWER PLANT SITING PROCESS

(a) **Content of Facility Forecast.** A facility forecast shall contain the following information:

(1) Identification of the location, generating capacity (over one megawatt), type, and fuel of all existing electric power generating plants and of the location, transmission capacity, and type of all existing transmission lines designed to operate at a nominal voltage of 100 kilovolts or more;

(2) Identification of the location, generating capacity (over one megawatt), type, and fuel of all existing electric power generating plants and of the location, transmission capacity, and type of all existing transmission lines designed to operate at a nominal voltage of 100 kilovolts or more intended to be removed from service in the fifteen-year period; description of land use plans for the sites and routes involved;

(3) Identification of the location, generating capacity (over one megawatt), type, and fuel of all electric power generating plants and of the location, transmission capacity, and type of all transmission lines designed to operate at a nominal voltage of 100 kilovolts or more removed from service in the preceding five-year period; statement of the disposition of the sites and routes involved (real property and easements);

(4) Description of the tentative regional location, generating capacity, type, fuel, land and water areas involved, anticipated maximum water demand (maximum rate and yearly volume), and source of water for all new LEPGP's and the tentative regional location, transmission capacity, and type of all new HVTL's to be constructed, owned, or operated by the utility in the fifteen-year period;

(5) Statement of the projected demand for electric energy for the fifteen-year period and the underlying assumptions for this forecast, the information to be as geographically specific as possible as to where this demand will occur; and statement of the demand for the past ten years;

(6) Description of the capacity of the electric power system to meet such demands during the ensuing fifteen years;

(7) Description of the current transmission grid and of the forecasted grid together with the reasons for changing the capacity and reliability of the grid;

(8) Description of the utility's relationship to other utilities and regional associations, power pools or networks; and

(9) Other relevant information as may be requested by the Council.

(b) **Content of Facility Development Plan.** The facility development plans shall contain the following information:

(1) Identification of the location, generating capacity (over one megawatt), type, and fuel of all existing electric power generating plants and of the location. transmission capacity, and type of all existing transmission lines designed to operate at a nominal voltage of 100 kilovolts or more;

(2) Identification of the location, generating capacity (over one megawatt), type, and fuel of all existing electric power generating plants and of the location, transmission capacity, and type of all existing transmission lines designed to operate at a nominal voltage of 100 kilovolts or more intended to be removed from service in the five-year period or on completion of the construction of large electric power generating plants and high voltage transmission lines;

(3) Identification of the location, generating capacity (over one megawatt), type, and fuel of all electric power generating plants and of the location, transmission capacity, and type of all transmission lines designed to operate at a nominal voltage of 100 kilovolts or more removed from service in the preceding five-year period; statement of the disposition of the sites and routes involved (real property and easements);

(4) Description of the generating capacity, type, water demand (maximum rate and yearly volume), land and water area, fuel, and proposed source of water and fuel of all LEPGP's and of the transmission capacity and type of all HVTL's on which construction is to be commenced or for which an application is to be filed with the Council by the utility in the five-year period;

(5) Identification of the location of the tentative preferred site and at least one alternative site for all LEPGP's, and the tentative preferred corridors and at least one alternative corridor for all HVTL's on which construction is intended to be commenced or for which an application is to be filed with the Council in the five-year period, and preliminary indication of the potential impact of the planned plants and lines on existing environmental values, and how potential adverse effects on the values shall be avoided or minimized at least detriment to the public and to the total environment. After July, 1976, at least one site identification shall be made from the inventory published by the Council. In the event a utility identifies a plant site or transmission line corridor not contained in the Council's inventory of potential sites and corridors, the utility shall set forth the reasons for the identification and shall make an evaluation of the identified sites and corridors using the Council's plant siting and routing criteria.

(c) **Criteria For LEPGP Siting.** The following criteria and standards shall be used by the Council in the preparation of an inventory of potential LEPGP sites and to guide the site suitability evaluation and selection process. These criteria are not grouped according to their application to nuclear

plants, as opposed to fossil fuel and other types of plants. Not all site selection criteria are applicable to all plants to the same degree. Sites which are environmentally sound should not be excluded from the inventory due to costs or limited generating capacity.

(1) **Exclusion Criteria.**

(aa) No LEPGP shall be sited in violation of any federal or state law or regulation. No area shall be considered in which a LEPGP is not licensable by all appropriate state and federal government agencies.

(bb) The following land areas shall be excluded: national parks; national historic sites and landmarks; national historic districts; national monuments; national wilderness areas; national wildlife refuges; national, wild, scenic, and recreational riverways; state wild, scenic, and recreational rivers and their land use districts; state parks; Nature Conservancy preserves; state scientific and natural areas; state wilderness areas; and any area designated a LEPGP exclusion area by the Council.

(cc) No area shall be considered which does not have reasonable access to a proven water supply sufficient for plant operation. No use of ground water shall be permitted where mining of ground water resources will result. "Mining" as used herein shall mean the removal of ground water that results in material adverse effects on ground water in and adjacent to the area, as determined in each case.

(dd) No water shall be transferred between the four major drainage basins within the state: that is, the Missouri River drainage basin, the Mississippi River drainage basin, the Lake Superior drainage basin, and the Red-Rainy River drainage basin.

(ee) Water intake structures and water pipelines shall not necessarily be prohibited from land areas excluded for power plant sites.

(2) **LEPGP Avoidance Areas.**

(aa) In addition to exclusion areas, the following land use areas shall not be approved for LEPGP sites when feasible and prudent alternatives with lesser adverse human and environmental effect exist. Economic considerations alone shall not justify approval of avoidance areas. Any approval of such areas shall include all possible planning to minimize harm to these areas. LEPGP avoidance areas are: state registered historic sites; state historic districts; state wildlife management areas (except in cases where the plant cooling water is to be used for wildlife management purposes); county parks; metropolitan parks; designated state and federal recreational trails; designated trout streams; and the rivers identified in Minn. Stat. § 85.32, subd. 1 (1971); and any other area designated a LEPGP avoidance area by the Council.

(bb) LEPGP avoidance areas also apply to new transportation access routes and storage facilities associated with the plant in addition to the plant itself. Water intake structures and water pipelines shall not necessarily be prohibited from LEPGP avoidance areas.

(cc) No transfer of water between sub-basins within each of the four major drainage basins shall be permitted except where it can be clearly demonstrated that the transfer will not have an adverse effect on water supplies or water quality in the areas involved.

(dd) The use of ground water for high consumption purposes, such as cooling, shall be avoided if feasible and prudent surface water alternatives less harmful to the environment exist. Ground water use to supplement available surface water shall be permitted if the cumulative impact minimizes environmental harm.

(3) **Site Selection Criteria.** The following criteria shall be applied in the selection of sites:

(aa) Preferred sites require the minimum population displacement and disruption of local communities and institutions.

(bb) Preferred sites minimize adverse health effects on human population.

(cc) Preferred sites do not require the destruction or major alteration of land forms, vegetative types, or wildlife habitat which are rare, unique, or of unusual importance to the surrounding area.

(dd) Preferred sites minimize the visual and audible impingement on waterways, parks, or other existing and proposed public recreation areas.

(ee) Preferred sites minimize the removal of valuable and productive land and water from other necessary uses and minimize conflicts among water users.

(ff) Preferred sites maximize reliability with respect to climate and geology.

(gg) Preferred sites permit significant conservation of energy or utilization of by-products.

(hh) Preferred sites are located near large load centers.

(ii) Preferred sites maximize the use of already existing operating sites and transportation systems.

(jj) Preferred sites allow for larger rather than smaller generating capacity.

(d) **Criteria for HVTL Corridor Selection.** The following criteria and standards shall be used by the Council in the preparation of an inventory of HVTL corridors and to guide the Council in the evaluation and selection of HVTL routes.

(1) **Exclusion Criteria.**

(aa) No HVTL shall be routed in violation of any federal or state agency regulations.

(bb) No HVTL shall be routed through national wilderness areas, state wilderness areas or through any area designated a HVTL exclusion area by the Council.

(2) **Transmission Line Avoidance Areas.** In addition to exclusion areas, the following land use areas shall not be approved for HVTL routes when feasible and prudent alternatives with lesser adverse human and environmental effects exist. Economic considerations alone shall not justify approval of avoidance areas. Any approval of such areas shall include all possible planning to minimize harm to these areas. HVTL avoidance areas are: national parks; national historic sites and districts and natural landmarks; national monuments; national wildlife refuge areas; national wild,

scenic, and recreational riverways; state wild, scenic, and recreational rivers and their land use districts; state parks; state registered historic sites; state historic districts; Nature Conservancy preserves; state scientific and natural areas; county parks; metropolitan parks; designated state and federal recreational trails; designated state canoe and boating routes; and any other area designated a transmission line avoidance area by the Council.

(3) **Selection Criteria.** The following criteria shall be applied in the selection of corridors:

(aa) Preferred corridors and routes minimize disruption to existing urbanized land uses and human settlement.

(bb) Preferred corridors and routes minimize disruption to existing and potential irrigated and non-irrigated agricultural land uses.

(cc) Preferred corridors and routes minimize disruption to recreational and historical land uses.

(dd) Preferred corridors and routes minimize disruption to natural systems including vegetation, wildlife, and water.

(ee) Preferred corridors and routes maximize utilization of existing and proposed rights-of-way.

(ff) Preferred corridors and routes minimize visual impact on urbanized land, recreational land and water, and transportation corridors.

(gg) Preferred corridors and routes optimize cost of materials, labor, right-of-way acquisition, project schedules, and maintenance.

(hh) Preferred corridors and routes minimize disruption to existing and potential forestry land uses.

(ii) Preferred corridors and routes minimize impact upon projected human settlement.

(jj) Preferred corridors and routes maximize reliability with respect to climate, soils, geology, and vandalism.

(kk) Preferred corridors and routes maximize accessibility.

(ll) Preferred corridors and routes minimize disruption to existing and potential extractive and storage resources.

(e) **Inventory.** The inventory report shall include the criteria, standards, and methodology used in developing the site and corridor inventory and the inventory itself.

(f) **Site Application.** An application for the designation of a specific LEPGP site shall contain the following information:

(1) The size and type of the plant;

(2) The preferred site;

(3) At least one alternate site;

(4) The engineering design concepts for the plant;

(5) An engineering analysis of each of the proposed sites;

(6) An environmental analysis of each of the proposed sites;

(7) A cost analysis of the plant to be constructed on each of the proposed sites;

(8) A statement of ownership of the plant and an affidavit that the applicant is authorized to act on behalf of the owner; and

(9) The procedures and practices for ultimate abandonment and restoration of the site.

Additional topics for analysis shall include the environmental criteria listed in these Regulations, the considerations provided in these Regulations, the requirements that shall be met to obtain the necessary permits from state and federal agencies, site preparation procedures, and construction practices. After July 1976, at least one site identification shall be made from the inventory published by the Council.

(g) **Corridor Application.** An application for the designation of a specific HVTL corridor shall contain the following information:

(1) The size and type of the line;

(2) The preferred corridor;

(3) At least one alternate corridor;

(4) The engineering design concepts for the line;

(5) A preliminary engineering analysis of each of the proposed corridors;

(6) A preliminary environmental analysis of each of the proposed corridors;

(7) A preliminary cost analysis of the line to be constructed on each of the proposed corridors; and

(8) A statement of ownership of the line and an affidavit that the applicant is authorized to act on behalf of the owner.

Additional topics for analysis shall include the environmental criteria listed in these Regulations, the considerations provided in these Regulations, the requirements that shall be met to obtain the necessary permits from state and federal agencies, right-of-way preparation procedures, and construction practices.

(h) **HVTL Construction Permit Application.** The application for a construction permit for a HVTL shall contain the following information (in more detail than in the application for corridor designation as is appropriate):

(1) The proposed route of the line within the designated corridor;

(2) The engineering design concepts for the line;

(3) An engineering analysis of the proposed route;

(4) A cost analysis of the line;

(5) Any environmental impact of the line, route, construction practices, right-of-way preparation that was not discussed in the application for corridor designation;

(6) Procedures and practices for ultimate abandonment and restoration of the route; and

(7) Any other factors that have changed since the application for corridor designation was submitted.

(i) **Emergency Certification**

(1) **Application.** The Emergency Certification Application shall include the following:

(aa) The preferred location of the LEPGP or the preferred route of the HVTL, and at least one alternative site or route;

(bb) The engineering design concepts for the plant or line;

(cc) An engineering analysis for each of the proposed sites or routes;

(dd) An analysis of the environmental impact of the factility and construction process for each of the proposed sites or routes;

(ee) A detailed statement and analysis of the reasons why the application is considered to be an emergency, including the reasons why the project was not forecast if such is the case;

(ff) A cost analysis of the project;

(gg) Site preparation and construction plans and practices;

(hh) Procedures and practices for ultimate abandonment and restoration of the site or route; and

(ii) A statement of ownership of the plant or line and an affidavit that the applicant is authorized to act on behalf of the owner.

After July 1976, at least one site identification shall be made from the inventory published by the Council.

(2) **Criteria.**

(aa) The Council in determining whether or not an emergency exists shall consider evidence concerning any or all of the following:

(i) that the situation could not reasonably have been anticipated in time to utilize the normal application procedure;

(ii) that there was no opportunity for more timely notice of its need;

(iii) that the situation resulted from conditions beyond the control of the utility;

(iv) That the situation is not the result of unreasonable demands upon the utility resulting from inadequate planning and/or dilatory practices on the part of consumers in its service area;

(v) that there is no feasible and prudent alternative available to the utility under its statutory responsibilities other than immediate construction of facilities, and that the utility is prepared to and will upon authorization carry out the acquisition and construction program at the maximum practicable rate of progress.

(bb) If an emergency is determined to exist, then the site or route selection criteria shall be the same as in MEQC 74(c) and MEQC 74(d). In its evaluation, the Council shall be guided by the considerations in MEQC 74(j).

(j) **Evaluation of Proposed Sites or Corridors.** To facilitate the study, research, evaluation and designation of sites and corridors for LEPGP's and HVTL's and the approval of specific transmission line facilities and their routes, the Council shall be guided by, but not limited to, the following responsibilities, procedures, and considerations:

(1) Evaluation of research and investigations relating to the effects on land, water and air resources of LEPGP's and HVTL's and the effects of water and air discharges from such plants on public health and welfare, vegetation, animals, materials, and aesthetic values, including base line studies, predictive modeling, and monitoring of the water and air mass at proposed sites and sites of operating LEPGP's, evaluation of new or improved methods of minimizing adverse impacts of water and air discharges and other matters pertaining to the effects of power plants on the water and air environment;

(2) Evaluation of the environmental effects of LEPGP sites and HVTL corridors and routes proposed for future development and expansion and their relationship to the land, water, air, and human resources of the State;

(3) Evaluation of the effects of new electric power generation and transmission technologies and systems related to power plants designed to minimize adverse environmental effects;

(4) Evaluation of the potential for beneficial uses of waste energy from proposed LEPGP's;

(5) Analysis of the direct and indirect economic impact of proposed LEPGP's and HVTL's;

(6) Evaluation of adverse direct and indirect environmental effects that cannot be avoided should the proposed site and transmission line corridor or route be accepted;

(7) Evaluation of alternatives to the proposed site and transmission line corridors and routes;

(8) Evaluation of irreversible and irretrievable commitments of resources should the proposed site and transmission line corridor or route be approved; and

(9) Consideration of problems raised by other state and federal agencies and local entities, where appropriate;

MEQC 75 PUBLIC PARTICIPATION

(a) **General Policy.** The Council shall provide for the maximum practicable public input into the power plant siting and transmission line routing process.

(b) **Advisory Committees.** The Council shall appoint one or more advisory committees to assist it in carrying out its duties and responsibilities. Members of the committees shall be reimbursed for expenses incurred pursuant to the regulations that govern expenses of state employees.

(1) **Power Plant Siting Advisory Committee.** The Power Plant Siting Advisory Committee shall work closely with the Council staff in reviewing, advising, and making recommendations to the Council with regard to the development, revision, and enforcement of any regulation, inventory, or

program initiated under the Act or these Regulations. The Council shall provide additional guidance to the Committee in the form of an annual charge and through specific requests. The Committee shall be comprised of 15 to 25 persons appointed by the Council for a one-year term corresponding to the fiscal year. It shall include a majority of private citizens and at least one representative from each of the following: utilities; regional development commissions; county governments; and municipal governments.

(2) **Site Evaluation Committee.** Committees shall be appointed to assist the Council in the evaluation of plant sites that are being considered for designation. The Council shall provide a charge to the committee and a date by which the committee is to complete its evaluation. The committee shall be comprised of as many persons as may be designated by the Council, but shall include at least one representative from each of the following: a public or municipally owned utility; a private investor owned utility; a cooperatively owned utility; and each regional development commission, county, and municipal corporation in which a LEPGP site or HVTL corridor is proposed to be located. A majority of the members shall be public representatives.

(3) **Corridor Evaluation Committee.** Committees may be appointed to assist the Council in the evaluation of transmission line corridors that are being considered for designation. The Council shall provide a charge to the Committee and a date by which the Committee is to complete its evaluation. The Committee shall be comprised of as many persons as may be designated by the Council, but shall include at least one representative from each of the following: a public or municipally owned utility; a private investor owned utility; a cooperatively owned utility; and each regional development commission, county, and municipal corporation in which a LEPGP site of HVTL corridor are proposed to be located. A majority of the members shall be public representatives.

(4) **Route Evaluation Committee.** Committees shall be appointed to assist the Council in the evaluation of transmission line routes over 40 kilometers in length that are being considered for a construction permit. The Council shall provide a charge to the committee and a date by which the committee is to complete its evaluation. Members of this committee may be the same as those on the appropriate Specific Corridor Evaluation Committee. The Council may appoint a committee to assist it in the evaluation of routes under 40 kilometers in length.

(c) **Other Participation.** All agencies, including federal and state agencies, regional and local governments, planning agencies, and other organizations (including citizen groups) which are authorized to grant permits or certifications for, or are known by the Council to be concerned with, the construction or operation of LEPGP's and HVTL's shall be invited by the Council to present their positions with respect to the development and revision of the inventory and with respect to the designation of a site, corridor, or route.

(d) **Informational Meetings.** The Council, at its discretion, may hold informational meetings to present major issues and alternatives under consideration by the Council, to present an outline of the information upon which the issues shall be decided, and to answer questions of the public. Public notice will be made through the media best serving the area primarily affected by the issues under consideration.

(e) **Annual Public Hearing.** The Council shall hold an annual public hearing on the second Saturday in September at 10:00 A.M. in St. Paul in order to afford interested persons an opportunity to be heard regarding its inventory of potential sites and corridors, its Regulations, any other aspects of the Council's activities and duties or the policies set forth in these Regulations.

Filed August 2, 1974.

APPENDIX D

FINDINGS OF FACT
ELECTRICAL ENVIRONMENTAL EFFECTS

42. That the public hearings referred to hereinabove and held April 15, 1976, and June 17, 1976, concern electrical environmental effects of the 500 kV transmission line.

43. That the electrical environmental effects considered, included both corona discharge and field effects. With regard to corona discharge, evidence appears in the record concerning radio and television interference, audible noise and the production of oxidants. With regard to field effects, evidence in the record pertains to the following: Conductive effects (direct contact); electrostatic induction (including "shock," "spark," and "let-go levels"); electromagnetic induction; physiological effects; long and short term biological effects; and, parallel conductor effects as could apply to fences, shelters, houses and irrigation equipment.

44. That generally, radio and television interference is not a significant problem with 500 kV lines. When interference does occur, it is electromagnetic interference. Most radio and television interference that does occur, will occur in the proximity of a 500 kV line when the receiver is far removed from the transmitter and usually during foul weather conditions. Generally, television interference can be lessened by relocating the reception antenna or by extending an existing TV cable system. The Applicant assumes the responsibility for remedial action in the event television interference is experienced because of the 500 kV line (Tr. pp. 56-66, June 17, 1976). It would be most impractical for a citizen whose receiver is adversely affected by the 500 kV line, to bear the burden of showing causation relates to the HVTL.

45. That generally, audible noise is not a substantial problem with 500 kV transmission lines. The audible noise problem will normally occur during moist or wet weather conditions. The noise has a hissing or crackling sound with a 120 Hz hum occasionally superimposed. The sound level near the transmission line depends on the electric field strength at the conductor surface, the size and number of conductors, and the weather. The decibel scale is a logarithmic scale and a doubling of the distance from the audible noise source will decrease the levels by 3dB which means the sound pressure level is reduced by one-half. Noise levels greater than 58.5dB(A) will result in numerous complaints. Noise levels less than 52.5dB(A) will result in few, if any, complaints.

The Minnesota Pollution Control Agency has established audible noise standards for the State of Minnesota. However, issue has been raised that the standards as may apply to the within subject matter are standards and not mandatory requirements which cannot be varied without appropriate variance procedures. Furthermore, the MPCA noise standards apply to a receiver or receiving property rather than applying to the edge of the property line of the land use upon which the noise producing source is located. Both the Minnesota Environmental Quality Council and Applicant presented testimony which consents to an audible noise emission limitation at the edge of right-of-way.

It is reasonable for the HVTL to be designed, constructed and operated in such a manner that audible noise from the HVTL at the edge of the right-of-way shall not exceed 52dB(A) under wet conductor conditions. However, considering Minn. Reg. MEQC 74(d)(l)(aa) and MPCA testimony, it is found that MPCA Noise Regulation NPC-2 is

the audible noise regulation applicable to HVTLs.

46. That in the small volume of air surrounding a conductor where corona is present, chemical reactions take place. They include the production of ozone and nitrous oxides. The amount of nitrous oxides produced by transmission lines is about 10 times less than ozone. There has been no substantial showing that the presence of oxidants including ozone and nitrous oxides, emanating from a HVTL are harmful to humans, animals or plants.

47. That electrostatic induction affects objects which possess conductive characteristics and are insulated from the ground. Such objects can acquire electrostatic effects if located near an energized conductor. Tne intensity of the charge is measured in kV/m. The threshold or sensation level is about 15kV/m. It has been recommended by the National Electric Safety Code that a maximum limit of 5 milliamperes be established for electrostatic short circuit current.

Electrostatic induction will effect "shock value," "spark value" and "let-go value." A maximum electrostatic short circuit current will be within safety requirements if such current shall be limited to 5 milliamperes rms AC and the maximum capacitive discharge energy limited to 25 joules between the ground and any large object under or near the HVTL.

48. That the largest and most significant issue raised with regard to electromagnetic induction is its effect upon cardiac pacemakers. There is no substantial evidence in the record of the within proceedings that the HVTL designed in accordance with the criteria of Applicant's Permit Application will effectuate harmful

malfunction of a cardiac pacemaker.

49. That the 500 kV line will be capable of creating an induced current on parallel conductors upon such objects as fences and irrigation equipment. Methods are available for safeguarding against the adverse effects created by a grounded object which becomes a parallel conductor. The most substantial problem concerns irrigation equipment. NSP has stated that there are ways to design irrigation systems so as to eliminate the parallel conductor effect. NSP also testified that they will be available to come out and offer any help in working on this problem with private land owners (Tr. p. 29, May 25, 1976).

50. That there has been no substantial showing of adverse physiological effects or short-term/long-term biological effects which will be produced by the 500 kV line. The Council has studied at length all evidence in the record concerning health and safety aspects of the 500 kV line. The Council is also cognizant of the Soviet studies on substation workers and the fact that such study indicated detrimental health effects from continued exposure to the substation workers. However, it is also noted that the Soviet study concerned electrical workers who are continually exposed in the immediate vicinity of the electrical source and that American studies contradict the Soviet study.

Hearing were held before the New York Public Service Commission in cases 26529 and 26559. The Council has reviewed the direct testimony in the New York cases of Andrew A. Marino, Ph. D. JD; Robert O. Becker, M.D.; and the cross-examination concerning these New York cases which has been submitted into the

record of the within proceedings. Although the New York proceedings tend to indicate new finds in adverse health effects regarding HVTL sources, the data basis for such conclusion was sufficiently challenged to cast doubt on the validity of the conclusions therein.

51. The entire question of electrical health effects concerning high voltage transmission lines is a substantial issue with the citizenry of the State of Minnesota. In order to initiate a process of definitive determinations concerning electrical health effects with regard to all transmission lines in the State of Minnesota, generic public hearings on this subject should be conducted. Furthermore, substantial issue was raised concerning re-radiation problems caused by HVTL towers near AM radio transmission facilities. Since the route recommended in this Report does not run in the vicinity of the KSTP radio station transmitter, the re-radiation problem was not discussed herein. However, the problem can be expected to arise again in the future and should also be the subject of generic hearings.

52. That the proposed 500 kV transmission can be designed, constructed and operated in such a manner that the electric field measured one meter above ground level shall not exceed 8.0 kV/mrms. It is specifically not determined that the 8.0 Kv/m value is, or is not a requirement necessary to protect public health and safety. It has been suggested that 10 kV/m rms would be adequate to protect public health and welfare but a determination of this issue is not necessary inasmuch as the line can be designed to the more stringent criteria.

APPENDIX E

STATE OF MINNESOTA

COUNTY OF RAMSEY

ENVIRONMENTAL QUALITY COUNCIL

- -

In the Matter of the Application by Northern States Power Company and Minnesota Power & Light Company for a Corridor Designation for a High Voltage Transmission Line and Associated Facilities.

FINDINGS OF FACT
NSP-TC-2

- -

The Minnesota Environmental Quality Council (MEQC), upon all records, files, evidence, arguments of counsel and written comments, hereby makes and issues the following Findings of Fact, Conclusions and Corridor Designation:

FINDINGS OF FACT

1. An application for corridor designation from Northern States Power Company (NSP) was accepted by the MEQC on December 9, 1975. It is in all respects proper in form, content, execution and filing. The application seeks corridor compatibility for a single circuit, 500,000 volt, alternating current (ac), high voltage transmission line (HVTL). The HVTL corridor will extend from the Canadian border between Warroad and Pine Creek, Minnesota, to a substation in the vicinity of the existing Forbes substation owned and operated by Minnesota Power and Light Company (MP&L). NSP will share certain responsibilities of the transmission line with MP&L. (Applicant Exhibit 1).

2. This project is the second part of a two-part project designed to provide a high capacity interconnection between the Manitoba Hydro, MP&L and NSP systems. The first part will be a 500 kV HVTL connecting a substation near the Forbes substation with a new substation to be located in Chisago county, and from there, a double circuit 345 kV line connecting with NSP's King Terminal 345 kV line. (Applicant Exhibit 1). The MEQC designated a corridor for this portion of the project on July 8th, 1975.

3. The Order for Hearing issued December 17, 1975, was in all respects proper in form, content, execution and filing.

4. Due, timely and adequate legal notice of the hearings ordered by the MEQC was properly published, served and filed. (MEQC Ex. C). The hearings were held as follows:

January 22, 1976 - St. Paul, St. Paul Technical Vocational Institute
January 26, 1976 - Roseau, Roseau County Courthouse
January 27, 1976 - Baudette, Lake of the Woods County Courthouse
January 28, 1976 - International Falls, Rainy River Community College
January 29, 1976 - Hibbing, Hibbing Community College

5. All other substantive and procedural requirements of statute or rule have been complied with. (MEQC Exs. A, B, D, E).

6. The design and specifications, (Applicant Exhibit 1) of the proposed HVTL are as follows:

a. Nominal Voltage Level: 500 kV ac

b. Right-of-Way: 160-240 feet

c. Tower Height: 130-150 feet

d. Span Length: 1100-1600 feet

e. Structure Type: Self-supporting steel lattice towers and guyed aluminum towers;

approximately four structures per mile.

f. Line Length: 180-200 miles

g. Cost: $217,000 per mile

7. The corridors described in the application were labeled as A, B, and C. Corridor B is the corridor preferred by the applicant. Corridor D was proposed by the Hearing Examiner. (Baudette, p. 68). No additional corridors were proposed by any party or individual.

8. The citizen's Corridor Evaluation Committee (CEC) recommended Corridor B with some reservations. The Committee reported to the Hearing Examiner at the January 22nd hearing and stated, "The Committee feels that Corridor B has good routing potential only if routing alignment follows the logical interface between agricultural and forestry land uses. Generally, this area could be described as the extreme southern portion on Corridor B through Roseau, Lake of the Woods and Koochiching Counties." (St. Paul, pp. 65-66).

9. The Power Plant Siting Staff (PPSS) recommended Corridor B based on an analysis of the corridors using the avoidance and selection criteria in Minn. Reg MEQC 74(d). (PPSS Report).

10. The Department of Natural Resources indicated a preference for Corridor B with the following statement: "It is the opinion of the DNR that Corridor B offers the greatest number of options availalable for selecting a transmission line route that would minimize adverse impacts to natural resources. . . ." (DNR Ex. 1).

11. No other state agency indicated a corridor preference

12. There are no exclusion areas as defined in Minn. Reg.

MEQC 74(d)(1) in any of the alternative corridors.

13. The only avoidance areas, as defined in Minn. Reg. MEQC 74(d)(2) large enough to be significant factors in selection of a corridor are as follows:

a. The Hayes Lake State Park and the Upper Red Lake National Natural Landmark in Corridor C. Hayes Lake State Park is approximately 2680 acres and could easily be avoided during the routing stage of the process. However, the Upper Red Lake Peatlands National Natural Landmark is 137,920 acres and would limit routing possibilities in Corridor C. (Applicant Exhibit 10; PPSS Report).

b. The Big Fork River, a designated canoe and boating route, occurs in all three corridors. However, the Big Fork River presents special problems in Corridor A as it meanders for approximately 55 miles in that Corridor. The Big Fork River extends for 15 miles in Corridors B and C (MEQC Exhibit K).

14. Also, in Corridor A is the proposed Black River Peatlands, recently nominated to be considered by the National Park Service for designation as a National Natural Landmark. If designated, this area would become an MEQC avoidance area. (PPSS Report).

15. Minn. Reg. MEQC 74(d)(3) specifies the criteria to be applied in the selection of a corridor. The selection criteria are meant to guide the evaluation of corridor alternatives by defining categories of potential impact and requiring that the impacts associated with each category be addressed.

16. "(3) Selection Criteria. The following criteria shall be applied in the selection of corridors:

(aa) Preferred corridors and routes minimize disruption to existing urbanized land uses and human settlement.'

Most of the corridor study area is of low population density. The only area of intense human settlement is the Iron Range area whi

is common to all three corridors and, therefore, is not a significant factor in selecting a corridor. (Applicant's Ex. 1).

17. The incorporated areas included within the corridors, not including the Iron Range communities, are Big Falls, Roosevelt and Williams. Big Falls is in Corridor A. Roosevelt and Williams are in the common area of Corridors A and B.

18. One area where human settlement is a factor in selecting a corridor is along Highway 11 in northern Koochiching, Lake of the Woods, and Roseau Counties. (CEC Report, PPS Report, Lake of the Woods County Exhibit 1). Corridor A contains the longest length of Highway 11 of any of the corridors; approximately 70 miles. Corridor B includes approximately 40 miles of Highway 11. Since the Minnkota Power Cooperative 230 kV line is currently being built approximately parallel to and from one to ten miles south of Highway 11 in Koochiching and Lake of the Woods Counties and crosses Highway 11 in Roseau County, its impact on human settlement becomes significant if paralleling the 500 kV and 230 kV lines is considered a desirable alternative.

19. Use of public lands as opposed to private lands can be a factor which influences the degree of impact a transmission line has on human settlement. This was considered a significant factor by local people in attendance at the hearings in Roseau and Baudette, and was recognized by the Power Plant Siting Staff at the Hibbing hearing when it was stated, ". . . private lands in this part of the state are often higher quality lands by virtue of the fact that much of the state land was acquired through tax forfeiture." (Hibbing, p. 29). However, public ownership of land is extensive in all of the corridors (MEQC Exhibit L).

20. "(bb) Preferred corridors and routes minimize disruption to existing and potential irrigated and non-irrigated agricultural land uses."

Agriculture is not a predominate land use in any of the corridors. However, the greatest potential for disruption to agricultural land uses occurs in Roseau and northern Lake of the Woods Counties, and to a lesser extent in northern Koochiching County. (Applicant Exhibits 9 and 10; DNR Exhibit 1, CEC Report, PPSS Report). For the most part, all three corridors are coincident in Roseau County. In northern Lake of the Woods County, Corridors A and B are common in the area of potential impact on agriculture. Corridor A passes through the area of potential impact in Koochiching County.

21. "(cc) Preferred corridors and routes minimize disruption to recreational and historical land uses."

No evidence was introduced into the record that contradicted the contention in the application that "all three corridors contain approximately the same amount and type of recreational land."

22. Sites of historical significance were identified (MEQC Exhibit H), but were treated by all parties as insignificant as a factor in corridor selection.

23. "(dd) Preferred corridors and routes minimize disruption to natural systems including vegetation, wildlife, and water."

Natural systems large enough to be a constraint during the corridor selection process include the peatlands and the Red Lake Wildlife Management area. Peatlands occur throughout the corridor study area with concentrations in Corridors C and B, and to a lesser extent in Corridor A. (MEQC Exhibit H, PPSS Report, Baudette, p. 49). The Red Lake Wildlife Management area coincides roughly with the Upper Red Lake National Natural Monument. (MEQC Exhibit H,

24. Adverse impact on natural systems will occur mainly to the vegetation within the right-of-way during the clearing operation and the greatest amount of clearing would have to be done in Corridor A. (Applicant Exhibit 1).

25. The extent of the disruption to the peatlands during the clearing and construction operations was never clearly established. The applicants suggested once in their testimony that the peatlands in Corridors B and C offer the opportunity to minimize impact on natural systems because much of the spannable marsh will not require clearing. (Applicant Exhibit 1). However, the applicant also described the peatlands as ". . . a very fragile and very sensitive environment. . . ." (St. Paul, pp. 55-56); that the bog areas lack proper access roads (St. Paul, p. 49); and that access road construction is ecologically damaging in the bog areas (Baudette, p. 53). An expert at the University of Minnesota consulted by the MEQC staff advised that the bog would be largely impenetrable, that any penetration would leave permanent scars, and that very little is known on the subject of drainage (Baudette, p. 69). The Department of Natural Resources experts indicated that construction would leave scars, but that impact on drainage would be minimal (Hibbing, pp. 23-24). Local loggers in Baudette testified that the bog was easily penetrable during the winter and that scars disappear within a year.

26. "(ee) Preferred corridors and routes maximize utilization of existing and proposed right-of-way."

The MP&L-Minnkota 230 kV transmission line offers the only significant opportunity for right-of-way sharing (MEQC Exhibit K). Where

the lines are constructed parallel to one another the total right-of-way saving is 20 feet of width or approximately 2.5 acres per mile (Applicant Exhibit 1). The 80 miles in Corridor B without potential for right-of-way sharing would thus lose approximately 200 acres of potential savings of land uses for routing. (Applicant Exhibit 1). Assuming 20 extra miles would be involved in paralleling to 230 kV line entirely in Corridor A, the applicant would need to clear and acquire approximately 500 additional acres in order to share this potential 200.

27. In regard to Corridor C, there is no potential for sharing the 230 kV line right-of-way outside of the areas where the corridors are common.

28. "(ff) Preferred corridors and routes minimize visual impact on urbanized land, recreational land and water, and transportation corridors."

All three corridors are in common in the urbanized region of the Iron Range, making visual impact on this urbanized land an insignificant factor in corridor selection. Since recreational areas were previously found to be evenly distributed throughout the corridor study area, visual impacts on these areas are found to be an insignificant factor in corridor selection.

29. "(gg) Preferred corridors and routes optimize cost of materials, labor, right-of-way acquisition, project schedules, and maintenance."

Extensive testimony throughout the hearings upheld the applicant's contention that Corridor B optimizes the cost of the project. Length of the line was established as a single, most important factor in determining costs for the project and routes in Corridor B would be 5 to 20 miles shorter than routes in Corridors A or C. (St. Paul and International Falls transcripts).

30. Another significant cost consideration concerns the potential problems of construction in the bog areas. However, testimony never clearly established the magnitude of the problem except to indicate that the problems were related to access road construction and project schedules. (St. Paul and International Falls transcripts).

31. "(hh) Preferred corridors and routes minimize disruption to existing and potential forestry land uses."

Approximately 60% of the lands in corridor study area are forested. (PPSS Report).

32. Extensive DNR testimony (Hibbing pp. 16-27) established that Corridor B affords the best opportunity to minimize impact on forestry land uses. (DNR Exhibit 2).

33. "(ii) Preferred corridors and routes minimize impact upon projected human settlement."

Outside of the Iron Range area common to all corridors, the only reference to projected human settlement was of possible peat mining - related development of Upper Red Lake. (PPSS Report, CEC Report).

34. "(jj) Preferred corridors and routes maximize reliability with respect to climate, soils, geology, and vandalism."

Reliability with respect to geology, climate and vandalism was treated as an insignificant factor in corridor selection by all parties. (PPSS Report, Applicant Exhibit 1).

35. Reliability with respect to soils was treated as a significant factor in corridor selection and all parties agreed that Corridors C, then B, were least reliable. (PPSS Report,

CEC Report, Applicant Exhibit 1).

36. "(kk) Preferred corridors and routes maximize accessibility" The testimony indicated that in Corridor C existing access was inadequate (CEC Report, Applicant Exhibit 1), that access roads were adequate in Corridor B, (St. Paul, p. 49), and that the best access exists in Corridor A. (Applicant Exhibit 1).

37. "(ll) Preferred corridors and routes minimize disruption to existing and potential extractive and storage resources."

The only potential for disruption to extractive resources outside of the Iron Range area, is the possibility of peat mining at some time in the future in Corridors B and C (PPSS Report, CEC Report). There is no other evidence in the record on this subject other than applicant's contention that a HVTL would have only minimal impact on exploitation of peat resources. (Applicant Exhibit 1).

38. At the request of the Hearing Examiner, much testimony was received on the subject of double circuiting the MP&L/MPC 230 kV transmission line. That is, to replace the 230 kV structures with a structure capable of carrying both the 500 kV and 230 kV circuits. This is specifically found to be unfeasible because the Minnesota Environmental Quality Council clearly lacks the authority to halt construction on the MP&L/MPC line and require that a different structure be used.

CONCLUSIONS

1. The Minnesota Environmental Quality Council duly acquired and now has jurisdiction over the subject proceeding.

2. Study Area 1, defined as the Iron Range area in the application for corridor designation, is not a sufficient factor in the selectio

of a corridor because all of the corridors are common in that area.

3. Corridor B has the least potential for adverse impact on avoidance areas as defined in Minn. Reg. MEQC 74(d)(2).

4. The potential for adverse impact on existing urbanized land uses and human settlement, Minn. Reg. MEQC 74(d)(3)(aa), is greater in Corridors A and B than in Corridor C, though not substantially. However, routes could be found in any of the corridors which would minimize impact on human settlement.

5. A route in Corridor C could minimize impact on agricultural land uses as defined in Minn. Reg. MEQC 74(d)(3)(bb). However, the magnitude of the difference in potential impact between the three proposed corridors is not great enough as a single factor to preclude finding a route in any of the corridors which would minimize impact on agriculture.

6. The potential for right-of-way sharing is greatest in Corridor A and least in Corridor C, but between Corridors A and B, the greater potential for right-of-way sharing in Corridor A is negated by the fact that Corridor B is shorter and would actually require less clearing in total. Therefore, Corridor B, with its potential for sharing the 230 kV line right-of-way for part of its length optimizes the right-of-way sharing criterion, Minn. Reg. MEQC 74(d)(3)(ee).

7. Based on considerations of length and soil conditions, Corridor B optimizes the cost criterion, Minn. Reg. MEQC 74(d)(3)(gg).

8. The testimony from the Department of Natural Resources established that Corridor B is the corridor that would minimize the potential for adverse impact on forestry land uses, Minn.

Reg. MEQC 74(d)(3)(hh). Since 60% of the lands in the corridor study area are forested, this selection criterion takes on greater importance as a factor in selecting a corridor.

9. With respect to Minn. Reg. MEQC 74(d)(3)(jj), Corridor C, then B, are least reliable.

10. The lack of access roads in Corridor C makes it the least desirable corridor with respect to Minn. Reg. MEQC 74(d)(3)(kk).

11. Minn. Reg. MEQC 74, selection criteria (cc)(dd)(ff)(ii) and (ll) are not significant corridor differentiation factors.

12. The occurrance of the Upper Red Lake National Natural Landmark, the lack of adequate access roads and poor soil conditions are the major factors which preclude further consideration of Corridor C as a viable alternative for routing a HVTL.

13. Double circuiting the 500 kV line with the MP&L/MPC 230 kV line in Corridor A is unfeasible.

14. Corridors A and B are nearly equal in the potential for adverse impacts on human settlement and agriculture.

15. The consideration of right-of-way sharing, adverse impacts on forestry land uses and costs favor designation of Corridor B.

CORRIDOR DESIGNATION

The Minnesota Environmental Quality Council hereby issues a Certificate of Corridor Compatibility to Northern States Power Company and Minnesota Power and Light Company designating Corridor B as defined in Application For a Certificate of Corridor Compatibility For a High Voltage Transmission Line and Associated Facilities as a suitable corridor within which to construct a single

circuit 500 kV ac HVTL extending from, at, or near the Forbes Substation in St. Louis County to the Minnesota - Manitoba international border between Warroad and Pine Creek.

The MEQC also directs its legal staff to further consider the authority of the MEQC to order an applicant to double circuit a proposed HVTL with an existing transmission line.

Dated: May 7, 76

STATE OF MINNESOTA

ENVIRONMENTAL QUALITY COUNCIL

By Peter Vanderpoel
Peter Vanderpoel, Chairman

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STATE OF MINNESOTA

APPENDIX F

NSP

NORTHERN STATES POWER COMPANY

MINNEAPOLIS, MINNESOTA 55401

August 11, 1976

Peter Vanderpoel, Chairman
Minnesota Environmental Quality Council
Capitol Square Building
550 Cedar Street
St Paul, Minnesota 55101

MINNESOTA ENVIRONMENTAL QUALITY COUNCIL
Conditions for Acceptance of a Construction Permit Application for a HVTL from near Forbes, Minnesota to the Minnesota-Manitoba International Border (NSP-TR-1)

The following information is intended to supplement Northern States Power Company's (NSP) Construction Permit Application for a 500 kv line between Forbes and the International Border, as requested in your letter dated July 7, 1976. The questions included in that letter were directed primarily at the construction engineering aspects of the anticipated Minnesota Department of Natural Resources (DNR) bog route. In response, we have limited ourselves to those technical and economic issues involved.

The DNR has furnished us with a route segment. However, it is our understanding that the route provided is preliminary and may be subject to modification after further study by DNR personnel. It should be noted that the information presented herein pertains to the routes as they are located on the attached map. That information could change significantly depending on the extent and location of any modifications.

To assist us in construction planning and in our response to your questions, we have requested eight transmission line contractors to provide informational labor bids on the DNR bog route ("Ditch 8" route) and the northern alternate. The contractors were also asked to respond to your specific questions. Since these were only information bids, NSP felt obligated to compensate the contractors for the expenses they incurred during the necessary field work and bid preparation. The answers given here are, to a large degree, based on the replies we received. The amount of time available for analysis and response was quite limited, and

although we believe the information is very useful, it is subject to modification as additional data becomes available.

1. An engineering analysis of the "bog segment" to be proposed by the DNR which shall include,

   a. A description of the equipment available which would be necessary to construct the proposed HVTL on the DNR segment.

      All ground vehicles including wire tensioning equipment used on the "Ditch 8" segment must be either wide-track or flotation tire mounted. Even with this type of equipment it is anticipated that movement in this area will be restricted to winter only, with frozen roads required. The North route would require comparable equipment for less than 40 percent of its length.

      Helicopters would be used to erect the structures on both routes, but longer flights would be required on the "Ditch 8" route due to lack of suitable marshalling yards. Also erection crews would most likely have to be transported by helicopter due to ground and access conditions on the "Ditch 8" segment.

   b. A description of the construction materials involved and the methods that could be used in handling them along the DNR segment.

      Material requirements would be similar on either segment and would include anchor foundation material, aluminum structures, insulators, hardware, shield wire and conductor.

      Handling material on the "Ditch 8" segment would require transportation by truck from main storage yards to sub-material yards and by tracked vehicle from the sub-material yards to the structure sites.

      In contrast, a majority of the North route material could be transported by truck from main storage yards directly to the structure sites.

c. An indepth discussion of the stringing operation and the methods that could be implemented to ameliorate the anticipated access problems which could occur if the DNR segment were ultimately designated.

There is little that can be done to minimize the wire stringing access problems on the "Ditch 8" route.

It is deemed necessary on both routes to double sock the wire in order to cut the number of wire set-ups in half by making four mile pulls. This entails a large expenditure for stringing blocks, but it is the only reasonable solution in this area. To increase the length of wire pulls beyond four miles becomes prohibitive due to the disruption of construction activities and equipment requirements.

It is also deemed necessary that the wire stringing operation on the "Ditch 8" segment would utilize single drum rather than triple drum tensioning equipment due to the lighter weight of the single phase tensioning equipment. This can more readily be mounted on tracked equipment and transported to the necessary sites. This operation results in a slower, more costly stringing operation, but once again is required due to the ground conditions. No additional, reasonable, means of mitigating the access difficulties associated with the wire stringing operation are apparent to us at this time. We must therefore rely on good winter construction conditions to allow us to accomplish the described stringing operation.

2. An estimate of any additional costs that may be incurred by the applicant if the DNR segment were designated and a delineation of where these additional costs would occur.

The combination of an in-house analysis supplemented by the informational bids supplied by the transmission line contractors contacted indicate that the additional cost of the "Ditch 8" route over the North route would be approximately $1,000,000. (See Attachment A) This figure was arrived at by evaluating all factors with the information now available.

Land and Land Rights were assumed to be essentially equal between the two route alternatives due to their similarity in length and ownership.

Distinct differences exist in the type, amount and difficulty of clearing between the two route segments. More cords of wood would have to be cut on the North route, but the lack of access, poor soil conditions and scheduling difficulties on the "Ditch 8" route lead us to the subjective conclusion that it will cost as much, if not more, to accomplish the necessary clearing on the "Ditch 8" route as it will on the North route.

Structure and conductor materials are slightly less, $175,000, for the "Ditch 8" route since it is approximately two miles shorter in length than the North route.

The Construction Labor figures were arrived at by averaging the labor figures submitted by the line contractors for the North route and the "Ditch 8" route. This resulted in an additional labor cost of $900,000 for the "Ditch 8" route due to the following factors:

1. The requirement of additional tracked, low pressure, vehicles due to poorer access.

2. Fewer feasible material yard sites resulting in uneconomical distances of helicopter flights for structure erection.

3. Limiting construction to "winter only" on "Ditch 8" due to soil conditions and lack of access resulting in slower production.

4. Additional costs of snow plowing and "Driving-down" frost to facilitate access.

5. Additional roads that will have to be improved or built where frost will not penetrate to sufficient depths to support equipment.

6. Complicating the living accommodation problems by requiring a highly concentrated work schedule during the winter months.

It is our present opinion that the contractors' labor estimates for the "Ditch 8" route may be optimistic due to the limited time to fully evaluate the subject area and additional winter construction areas of the project. We feel that contractors have identified the prominent problems of the "Ditch 8" route, but feel that additional study may reveal additional problems with the probability of the cost differential increasing much greater than the cost differential decreasing.

3. An estimate of the number of miles and approximate location of access roads that would be anticipated as necessary to construct the proposed HVTL on the DNR segment and a discussion of the adequacy of ditch grade road along the DNR segment for the purposes of supporting the equipment that would be used for construction in the bog.

The amount of road construction will, to a large degree, depend on the weather conditions at the time of construction. If contractors are able to complete the job during the winter months with good frost conditions, road construction can be kept to a minimum. By keeping a path cleared of snow and the ground frozen, personnel and materials can be moved by tracked vehicle to the work sites. However, it is the opinion of some of the contractors that a portion of the work would have to be accomplished during summer months.

The concensus seems to be that an attempt would be made to move men and materials across the bog using flotation or tracked vehicle with as little construction of roads as possible. Local soil conditions will determine if corduroy or fill material will be necessary to support equipment. With poor soil, high water, and poor weather conditions, as much as 30 miles of access will have to be maintained on the "Ditch 8" route and as many as 15 miles on the northern alternate. There are several obvious access points to the route in the area as indicated on the attached map. While contractors were unable to indicate the exact location of access roads, it seems reasonable to assume that equipment will probably move to the right of way from several of these points.

Regarding the adequacy of the ditch grade roads along the DNR segment, the following statement typifies the response of all the contractors contacted.

> "We do not consider this embankment to be a viable road. It is simply too fragile. Our experience on routes of this sort is that we get one or two trips, if we are lucky, with a low ground pressure vehicle, before the ground surface breaks up and the equipment goes down."

4. If the DNR segment were designated, what would be the effect on the project schedule?

The effect on the overall project schedule the "Ditch 8" segment would have is very difficult to evaluate. Construction problems in the "Ditch 8" segment and the balance of the project must be evaluated together as a whole. The North route, or our preferred route, already represent construction activities that present a challenging schedule. The introduction of the "Ditch 8" segment increases the overall "winter only" construction by nearly 35 miles or 17 percent of the total project. The modifications required of the construction activities such as additional winter work, additional man-power, additional tracked equipment, additional road construction and the additional unknowns of the "Ditch 8" segment lead us to believe that meeting the schedule may be possible, but the comparative probability of not meeting the schedule is increased to the neighborhood of 50 percent. This alone is not the major concern, but rather the ramifications of not finishing the "winter only" construction during the 1979-1980 winter season due to poor winter conditions, inavailability of man-power, etc. There would not be a 2 - 3 month delay, but rather a one-year delay waiting for the next winter to complete the construction, the resulting costs of this delay would be dramatic.

Attachment A

COST COMPARISON SUMMARY

($1000's)

	North Route (57 miles)		"Ditch 8" Route (55 miles)	
	Present Day Costs	In-Service Costs	Present Day Costs	In-Service Costs
Land & Land Rights	$ 175	$ 175	$ 175	$ 175
Clearing	800	875	800	875
Structures	2,850	3,600	2,800	3,525
Conductors & Devices	3,425	4,300	3,300	4,150
Construction Labor	3,350	3,625	4,250	4,600
Construction Cost	$10,600	$12,575	$11,325	$13,325
Engineering & Administration	1,325	1,575	1,425	1,675
Interest During Construction	1,350	1,600	1,450	1,700
Total Cost	$13,275	$15,750	$14,200	$16,700

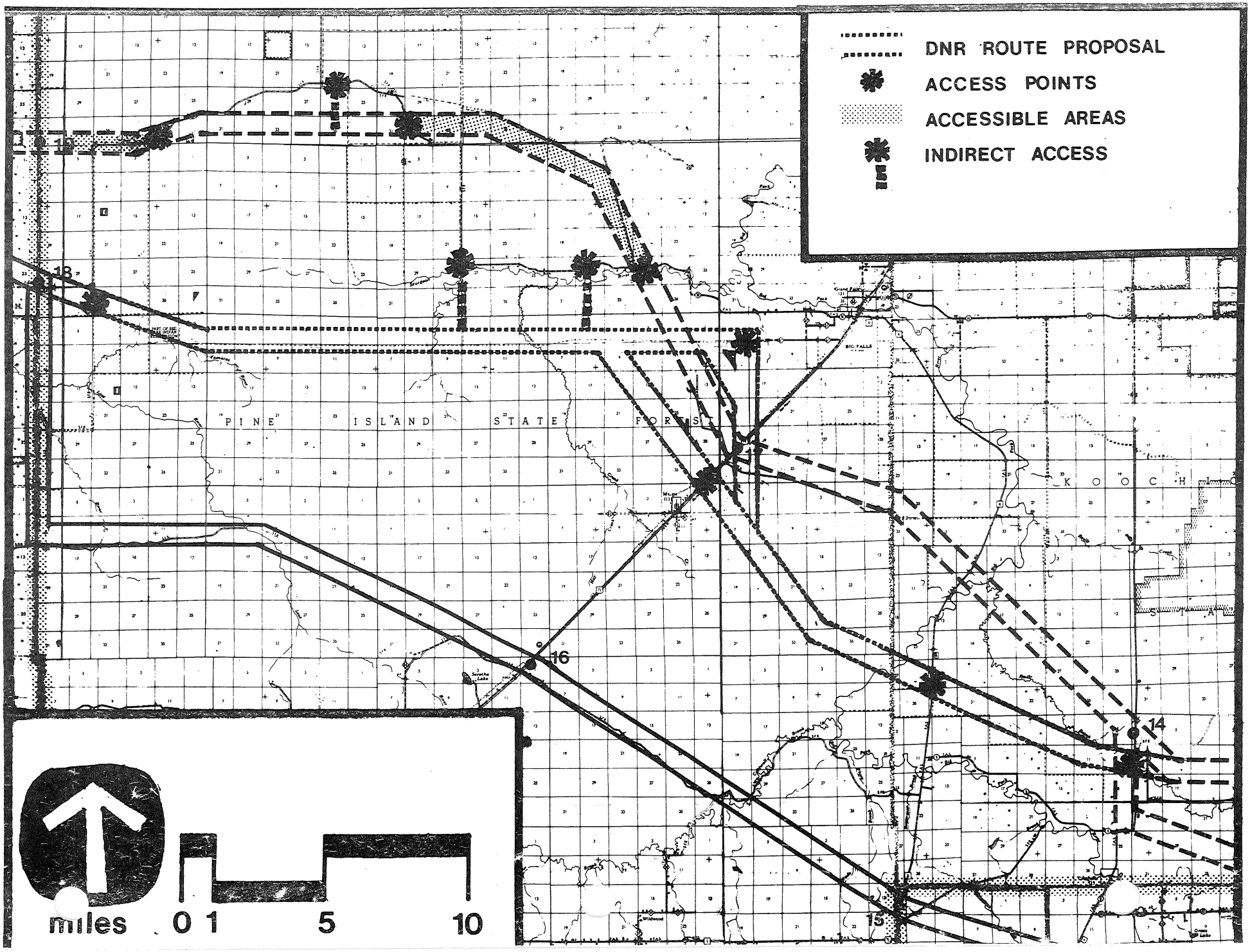
We trust this information adequately responds to the concern of the MEQC Power Plant Siting Staff and therefore satisfies the conditions for acceptance of the construction permit application for the subject project.

G V WELK, Manager
Regulatory Activities

alm

Enclosure

Cc Robert Herbst
John Hynes


DNR ROUTE PROPOSAL
ACCESS POINTS
ACCESSIBLE AREAS
INDIRECT ACCESS
PINE ISLAND STATE FOREST
K O O C H
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APPENDIX G

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APPENDIX H

APPENDIX D

Electrostatic and Electromagnetic Environmental Criteria for EHV Overhead Transmission Lines

for Northern States Power Company

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R. E. Clayton
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Power Technologies, Inc.
Schenectady, New York
January 1976

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Technologies,
Inc.

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1.0 INTRODUCTION

1.1 Generalized Problem Statement

In the past, environmental concern over the electrical effects of transmission lines was in the area of maintaining adequate clearances to prevent dangerous flashovers. This concern is embodied in the National Electric Safety Code with "provisions for the safeguarding of persons from hazards arising from the installation, operation, or maintenance of 1) conductors and equipment in electric supply stations, and 2) overhead and underground electric supply and communication lines." The NESC is an American National Standard which "implies a consensus of those substantially concerned with its scope and provisions." It is intended as a guide and does not preclude nonadherence to its provisions. In fact, its provisions are constantly being revised to improve adequacy of coverage and to clarify requirements.

While clearance requirements are still of the utmost concern, other safety factors not presently part of the Code have become important with the advent of EHV transmission.[1,2] A prominent concern is the possibility of exposure to dangerous electric discharges from objects in the electrostatic or electromagnetic field of the line. A suggested revision to the Code that is presently undergoing examination uses the same criteria for assessing hazard as is recommended in this report.

In addition to this concern, other areas of possible hazard currently receiving much attention are fuel ignition and interference with wearers of prosthetic devices. Fuel ignition when refueling a vehicle in the vicinity of the line has been shown to be theoretically possible from an arc between the pourer and the vehicle. Pacemakers may be susceptible to interference from electrostatic and electromagnetic fields depending upon field magnitude and pacemaker characteristics. There is a great variety of pacemaker types presently in use, some of which are more sensitive to interference than others. In both these areas there have been no records of either event occurring; but despite this, prudent measures can be taken to set and follow design criteria.

Other environmental concerns not directly related to safety but rather to annoyance are over shock sensations and noise from the line. The shock sensation may occur with discharges from objects in the field of the line in the same manner as the previously discussed discharges The differences are in the magnitude of the discharge current and also the possibility of having an annoying spark discharge before good contact is made.

The noise concerns are threefold: audible noise, radio noise, and television noise. All these are manifestations of conductor corona and as such are associated with corona loss. Thus any measure reducing one will tend to reduce all; and in as much as corona can be a significant loss, the utility industry has a dual interest in controlling conductor corona. Audible noise occurs generally in wet weather and is most obvious after rain or during fog when ambient levels are low. It attenuates slowly away from the line and any criteria chosen has a significant effect on ROW width or conductor specifications. Radio noise predominates in the AM band, attenuates quicker than audible noise, and will generally not interfere with local or strong stations. Television interference is of much less significance by virtue of its low noise generation.

There have been reports of gaseous oxident generation associated with conductor corona. Studies reported herein have shown this to be an invalid concern.

Finally, there have been some studies suggesting and in one case reporting long-term and subtle effects to humans from exposure to the field of the line. Some studies have indicated small changes in response time, for example, by virtue of exposure to a field similar to t' of a transmission line. However, it has not been conclusively shown that any of the changes are due to the field exposure. The possibility of experimental protocol interfering with the results has been suggested. Other studies have found no changes with field exposure both in laboratory experiments and extensive examinations of utility linemen. All these studies are detailed in this report. Possible effects on flora and fauna are also discussed.

Statistical concepts have been utilized throughout this report. It is appropriate for instance to consider unlikely conditions when setting and applying safety criteria by virtue of possible consequences. Annoyance criteria on the other hand need not be so stringent, and mitigating factors can be considered. For example, selecting an audible noise criteria never to be exceeded may result in an unrealistic line design. The maximum noise could occur under rain conditions but would have a significant statistical distribution. Such a criterion would not recognize the distribution, implying that the extreme noise level should be used even though its occurrence is improbable. In addition, under these conditions the ambient noise is very high, and also the probability of people being there to listen and be annoyed is very low. Thus a better criteria would recognize ambient conditions, take account of land use, and give a range or a specific number and a probability as a criterion. In all matters of annoyance and safety, the above considerations were fully explored.

2.0 ANALYSIS OF ELECTRICAL EFFECTS

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2.1 Clearance and Insulation Design

Clearance and insulation design are important on two counts: firstly, sufficient clearances must be maintained in areas where humans may be exposed to hazard; and secondly, adequate clearances must be maintained for satisfactory operation of the line. The latter consideration has not been examined in this report.

Safety requirements to avoid hazards to humans are given in the National Electric Safety Code.[3] However, this code per se is a guide only and is constantly being revised. Therefore, examination of safe clearance requirements should be concerned with both the requirements of the NESC and other appropriate requirements not covered by the code but governed by current design and operating practice.

2.1.1 National Electric Safety Code

Identification and Description of Electric Effect

From the point of view of environmental impact, the critical clearance of concern is the minimum midspan conductor to ground clearance. The National Electric Safety Code presently addresses this problem based upon flashover considerations and does not consider current safety considerations concerning electric field effects or operation at temperatures exceeding 120°F. However, the NESC is a nationally accepted guide, and in some states, law, and as such its requirements are generally complied with. High temperature operation is dealt with in the following section and electric field effects discussed in Section 2.2.

Criteria for Assessment of Electrical Effect

--Midspan ground clearance--

Basic conductor clearances from NESC are as shown in Table 1 from Rule 232A.

232. A. Basic Clearances—Continued

TABLE 1.—*Minimum vertical clearance of wires above ground or rails*

[Supply wires include trolley feeders]

Nature of ground or rails underneath wires	Guys; messengers; communication, span, and lightning protection wires; communication cable supply cable having effectively grounded continuous metal sheath, or insulated conductors supported on and cabled together with an effectively grounded messenger, all voltages	Open supply line wires, arc wires and service drops [10]			Trolley contact conductors and associated span or messenger wires [1]	
		0 to 750 volts	750 to 15,000 volts	15,000 to 50,000 volts	0 to 750 volts to ground	Exceeding 750 volts to ground
WHERE WIRES CROSS OVER						
Track rails of railroads (except electrified railroads using overhead trolley conductors) handling freight cars on top of which men are permitted [3] [10]	Feet [3] [13] 27	Feet [3] 27	Feet [3] 28	Feet 30	Feet [4] 22	Feet [4] 22
Track rails of railroads (except electrified railroads using overhead trolley conductors) not included above [3]	18	18	20	22	[5] 18	[5] 20
Public streets, alleys or roads in urban or rural districts	[6] [13] 18	18	20	22	[5] 18	[5] 20
Driveways to residence garages	10	10	20	22	[5] 18	[5] 20
Spaces or ways accessible to pedestrians only	[7] 15	[8] 15	15	17	[9] 16	[9] 18
WHERE WIRES RUN ALONG, AND WITHIN THE LIMITS OF PUBLIC HIGHWAYS OR OTHER PUBLIC RIGHTS-OF-WAY FOR TRAFFIC						
Streets or alleys in urban districts	[10] [11] [12] 18	[10] 18	20	22	[5] 18	[5] 20
Roads in rural districts	[10] [11] [12] 14	[10] 15	18	20	[5] 18	[5] 20

Footnotes on following page.

Table 1

Thus for areas accessible by vehicles, adders are 0.4"/kV over 50 kV, plus 0.1 ft/10 ft span over 175 ft for heavy loading conditions (.15 ft/10 ft over railroads) up to 75 percent of maximum sag increase at 120° F; i.e.,

$$\text{clearance} = 22 + \frac{0.4}{12} \times \left(\frac{500}{\sqrt{3}} - 50\right) + k$$

where for a 1200 ft span:

$$k < \frac{1200-175}{10} \times 0.1 \quad \text{(up to 75\% of max. sag increase)}$$

$$= 22 + 7.96 + (<10.25)$$

Stringing data can be used to determine what 75 percent of the maximum sag increase would be. For the 1200-foot span, the MSI might be 3.10 feet.

Thus, minimum clearance is estimated as:

$$= 22 + 7.96 + 75\% \times 3.10$$

$$= 32.29 \text{ feet.}$$

Midspan clearances as determined by NESC Rule 232A recognize conductor temperatures up to 120°F. In fact, many lines now in operation operate at temperatures in excess of 120°F, and thus have greater sag. If high temperature operation is envisioned, it is prudent to increase the midspan clearance from the minimum required by NESC.

Many utilities assume a temperature of 180°F for operation under emergency conditions and for calculation of the maximum sag increase. This is then used to calculate the minimum midspan clearance instead of the maximum sag increase at 120°F as outlined in NESC, Rule 232A. It

is conservative criteria to meet the code under emergency operating conditions. For a more precise estimate of conductor temperature, standard weather conditions can be assumed and the conductor temperature calculated under the most extreme load conditions. Current practice in the U.S. is to assume weather conditions of 40°C ambient temperature and a 2-foot per second wind.

2.2 Electrostatic Effects

Environmentally, the main concern of the public and the utility industry over the operation of transmission lines is, and has been, possible hazards. These concerns historically have been in the areas of flashover and mechanical integrity. Recently, with the advent of EHV, there has been an increasing awareness and concern over electrostatic field effects. These include the long-term effects on humans in the field (Section 2.5), the short-term effect on pacemakers, etc. (Sections 2.2.3 and 2.3.4), fuel ignition (Section 2.2.2), and discharge from an insulated object through a human. Table 2 shows typical gradients associated with lines at different voltage levels.

System Voltage (kV)	Maximum Gradient (kV/m)	EROW Gradient (kV/m)	EROW + 100' Gradient (kV/m)
345	5	1.0	.15
500	7	1.5	.25
765	10	2.5	.50

Table 2

Electric Field Gradient at Ground Level

2.2.1 Shock Hazard: Safety, Comfort, Perception

Identification and Description of Electrical Effect

This section will deal with the effects on humans through discharges from insulated objects. Typically these are vehicles, buildings, and fences that become charged to some level depending upon a large number of variables as discussed later. The effects may be described as short-term in that they are usually manifest in the form of a shock. The shock itself may take the form of a primary shock[4] caused by the flow of current through the body and accompanied by muscle contraction, inability to let go and for large currents, ventricular fibrillation. Table 3[4] gives average values for all the various effects, rangir from no perception (.3-.4 mA), perception (1.1-.7 mA),shock (1.8-1.2 mA), let go threshold (16-10.5 mA), severe shock (23-15 mA), and possible ventricular fibrillation (1000 mA). These are 50 percent points, and lower values of current would affect fewer people in each of the categories.

Table 3

The Effects of Electric Current on Man

Effect	CURRENT IN MILLIAMPERES					
	Direct Current		60 Cycle RMS		10,000 Cycles RMS	
	Men	Women	Men	Women	Men	Women
1. No sensation on hand	1	0.6	0.4	0.3	7	5
2. Slight tingling. Perception threshold	5.2	3.5	1.1	0.7	12	8
3. Shock - not painful and muscular control not lost	9	6	1.8	1.2	17	11
4. Painful shock - painful but muscular control not lost	62	41	9	6	55	37
5. Painful shock - let-go threshold	76	51	16.0	10.5	75	50
6. Painful and severe shock muscular contractions breathing difficult	90	60	23	15	94	63
7. Possible ventricular fibrillation from short shocks:						
a) Shock duration 0.03 sec	1300	1300	1000	1000	1100	1100
b) Shock duration 3.0 sec	500	500	100	100	500	500
c) Ventricular fibrillation	1375	1375	275	275	1375	1375

Current values less than those necessary to cause primary shock may be annoying or painful and their effects may be termed secondary shock.[4] Before steady state current can flow, a contact has to be made and an arc may occur causing voluntary or involuntary withdrawal. This may in fact act as a safety mechanism warning or preventing contact. The involuntary reaction may in itself constitute a hazard due to secondary causes such as falling from roofs, etc.

Clearly safety considerations are of prime importance but also of concern in certain areas are annoyance and perception effects. These may be applicable in high exposure areas such as schools, parks, or industrial areas; in general, urban or suburban locations. However, dwellings of any kind in close proximity to the line warrant especial consideration.

Criteria for Assessment of Electrical Effect

The parameter used to determine the primary shock hazard is that of current. Selection of a proper level should be based upon the most unlikely conditions as matters of public and utility personnel safety are concerned. For this reason, scenarios must be established by which exposure to shock may come about, both with respect to human tolerance and likelihood of exposure.

Dealing first with human tolerance, Dalziel has done extensive work in this area.[5,6,7,8] He found that 99.5 percent of all men and women tested would be able to let go of a current up to 9 and 6 mA respectively. These levels are generally accepted as conservative cri-

teria for adults. However since the ability to let go has been found to be related to muscular development of the wrist and forearm[6], it is clear that the level for children will probably be lower than that for adults. Whitaker[9], in the absence of direct experimental evidence on children, has estimated 5 mA as the maximum safe current. His work concerned testing of different species of animals and relating the results to the human condition. Dalziel did not perform particular tests but was of the opinion that 4.5 mA may be the appropriate number for children.[6] Underwriters' Laboratories, Inc. has recognized 5 mA as being the maximum allowable leakage current from appliances and was until recently the level recommended by ANSI. Presently ANSI[10] recommends .5 mA as maximum leakage current from appliances but based upon perception considerations. This change resulted from consideration of the high exposure of people to appliances and hence the desirability of reducing leakage current below perception levels. Thus, for use as a primary shock criteria, a level of 5 mA with the associated probability of .5 percent is recommended. This may be stated as greater than 99.5 percent of <u>all people</u> will be able to voluntarily let go of currents up to 5 mA. It is noteworthy that from Table 3 ventricular fibrillation occurs at currents at least an order of magnitude higher than these levels. Further justification in the use of this criteria lies in consideration of the conditions to which it applies. Since safety is concerned, the most extreme conditions are chosen, which by their nature are unlikely to occur. This will further reduce the probability of exposure below the .5 percent probability as discussed below.

Another possible primary shock situation may be due to spark discharge prior to good contact being made. The transient currents involved will be of very short duration; and as the severity of shock is related to time of exposure, currents that may be dangerous will consequently be of larger magnitude than the 5 mA criterion cited above. Values of energy have been suggested which represent dangerous thresholds for transient discharges at an associated probability of less than .5 percent and range from 25 to 50 joules.[4] These are based on animal tests and Dalziel's "electrocution equation":[5]

$$i = \frac{K}{\sqrt{t}}$$

where i = current in amperes

K = an empirical constant for the particular body under consideration

$\sqrt{t}$ = exposure time in seconds.

While it is unlikely that either of these limits will be exceeded, it is suggested that the lower level of 25 joules be adopted as a criterion.

Common situations where a person may contact an insulated object in the presence of a field are related to vehicles, buildings, and fences. Of these the vehicular condition is of most concern as they are mobile and not easily grounded in a permanent manner. Generally as a matter of policy buildings and fences will be properly grounded according to well established procedures, and they are not of concern. Grounding is discussed further in Appendix 2. Vehicle size is important in that a large vehicle will have a large capacitance and coupling to the line, and thus a higher induced energy than a smaller vehicle. Standard vehicle sizes have been suggested [4] and are listed below together with the dimensions of a crop wagon (D) which might be judged as the largest practical vehicle that may be exposed to the proposed lines under field conditions.

Table 4

Vehicle Dimensions

Vehicle	Length (ft)	Overall Height (ft)	Width (ft)
A. Autos, pickups	20	8	6
D. Crop Wagons	20	13.0	7
B. Farm vehicles	25	13.5	8
C. Buses, trailer trucks	50	13.5	8

Having accepted Vehicle D as the vehicle with which to test the criterion, some further points regarding the likelihood of exposure are relevant. These also apply to subsequent discussions on perception and annoyance criteria.

The conditions upon which the criterion is applied should be the most extreme; i.e., no tire or other leakage path to ground, complete grounding of the person involved, steady contact, and favorable orientation of the vehicle (parallel to the line). These assumptions are appropriate in applying safety criteria, but in fact the probability of their occurring simultaneously will be much less than unity. For instance, any moisture or mud on the vehicle tires will remove the charge. If a plow or harrow is involved, again there is good ground contact. For a discharge to ground the most likely situation would be from hand, through

body and legs to ground. Thus shoes or boots will alleviate the problem. For conditions where footwear is soaked, it is well to remember that the vehicle tires will also be wet. It is most likely that before a good contact is made, sparking will give warning of the charge or make contact difficult to hold because of involuntary reaction. Vehicle orientation is significant in the case of long vehicles. Thus the real probability of exposure will be much less than the .5 percent cited above.

While it is appropriate to consider extreme conditions when dealing with safety, the annoyance or perception criteria may be based on average probabilities since primary shock is not involved and, again, the probability of exposure will be low. Further, since farm workers will be the people generally exposed to the line, it is appropriate to select levels based on adult males. Dalziel [7] determined the 50 percent perception and annoyance levels for adult males as being 1.1 and 2 mA respectively. These levels relate to the 60 Hz body current after good contact is made.

The other criteria of annoyance and perception is that of spark energy. The vehicle will have a voltage induced on it depending upon size, etc. An arc will be drawn between the vehicle and generally the finger when attempting to contact it. In the case of a relatively large available current, the current density at the fingertip may be large enough to cause a voluntary or involuntary withdrawal. Thus a measure of annoyance is the available energy from the vehicle as calculated from $1/2\ CV^2$. Where V is the open circuit voltage on the object or vehicle. Levels for perception in adult males have been suggested [11] as equivalent to .12 mjoules. Based upon personal experience of the authors and others under laboratory conditions, a level for annoyance in adult males is suggested as 2 mjoules. Both these values have been assumed to correspond to average values for adult males; that is, annoyance and perception will be experienced by 50 percent and not experienced by the other 50 percent. Concern over annoying spark discharges from umbrella stems over handles to hand have prompted the Japanese to adopt a 3 kV/m criterion.[12] Extensive umbrella use is not expected on U.S. ROW's and as such this criterion will not be limiting.

The applicability of these criteria to various locations should be discussed. Clearly safety criteria should apply both on and off the ROW. However it would be unreasonable to apply the criteria of perception and annoyance on the ROW in areas of limited exposure such as rural farming lands. In these areas it is reasonable to limit annoyance from vehicles off the ROW or at least be aware of possible problems that may occur under ideal conditions. Annoyance and perception off the ROW in the case of permanent structures can and should be eliminated with proper grounding procedures.

The above criteria are summarized in Table 5 below.

Table 5

Vehicular Shock Criteria for Areas of Occasional Exposure
Under Ideal Conditions

	Measure	Probability	Applicability	on ROW	off ROW
Safety	5 mA	$\leq$ .5%	All	X	X
	25 j	$\leq$ .5%	All	X	X
Annoyance	2 mA	50%	Adult Males	-	X
	2 mj	50%	Adult Males	-	X
Perception	1.1 mA	50%	Adult Males	-	-
	.12mj	50%	Adult Males	-	-

Various methods exist for the calculation of electrostatic fields and effects on vehicles. While calculation of the field at ground level is a well-established procedure, methods for prediction of available short-circuit currents from vehicles have varied. Prominent among ...se have been Deno,[11] Rene and Comsa,[13] and Tranen and Wilson.[14] The first and last give similar results, while Rene and Comsa tend to be less conservative. Recent tests at the BPA test facility indicate the validity of Deno's approach, and for this reason the methods outlined in his paper have been adopted here.

Basically Deno has related the short circuit current to the undisturbed field gradient for insulated objects by test data. Then assuming a constant current source and using a Norton equivalent circuit involving the object's capacitance and conductance, energy calculations can be made. The assumption of a constant current source is valid considering the high source impedance from the object to the line.

Table 6 lists the criteria adopted previously and shows the field gradients necessary to meet the criteria for the various vehicles. The relationships used for the various vehicles are shown in Table 7 and follow the procedures outlined in Reference 11.

Table 6

Limiting Gradients for Given Criteria (kV/m)

	Criteria	Vehicles			
		A	D	B	C
Safety	5 mA	22.32	11.62	10.86	6.33
	25 j	259.00	167.00	159.00	106.50
Annoyance	2 mA	8.92	4.65	4.35	2.50
	2 mj	2.37	1.47	1.41	.95
Perception	1.1 mA	4.91	2.56	2.39	1.39
	.12 mj	.58	.36	.35	.23

Table 7

Electrical Data on Vehicles

	Vehicle			
	A	D	B	C
$\frac{Isc}{E}$ $\frac{mA}{kV/m}$	.244	.43	.46	.79
C (pf)	1000	1400	1500	2000

Peak Energy = $\frac{1}{2} C \hat{V}oc^2$ where $\hat{V}oc$ is crest voltage

$= C\ Voc^2$ where Voc is rms voltage

$Voc = Isc/\omega C$

$Isc = .43\ E$ etc.

2.2.2 Fuel Ignition

Identification and Description of Electrical Effect

The question of accidental fuel ignition from an electric discharge is a very complex one, and one on which there has been a wide diversity of opinion. Under high voltage transmission lines, it is well known that high voltages can be induced on vehicles near or under the line. Should such a vehicle run out of fuel in the vicinity of the line and be refueled from a can, there is a possibility of a spark from the vehicle to the can igniting fuel vapors. Any resulting fire is a hazard.

The range of opinion is seen in the diversity of standards given by different investigators to insure intrinsic safety. These range from the .25 mj specified by BPA [20] to something on the order of 5 mj from Project UHV data. [21]

This section is devoted to investigating whether accidental fuel ignition is really in the realm of possibility, and if so, what precautions should be taken. The speculation is raised despite the large operating experience obtained with overhead transmission without confirmed incident of this type.

Criteria for Assessment of Electrical Effect

A flammable mixture has a certain minimum energy and temperature in order for it to ignite. A spark may raise a small volume to above the ignition temperature, but the flame has a certain minimum size in order to be self-continuing. Since the area of the surface of a sphere is a function of the square of the radius and the volume is a function of the cube of the radius, for small enough spheres heat is lost faster than it is developed and the temperature drops below the point for continued combustion. On the other hand, for sizes above the critical minimum, energy is developed faster than it is dissipated, and the flame becomes self-propagating.

The most basic data available concerns the minimum energy required to ignite an ideal mixture of fuel and air. This value is variously cited as .24 [15] or .25 mj. [16,17] United Kingdom procedures [17] give the determination of this figure as the value which in 100 trials will not ignite the most easily ignitable mixture, and which, if increased by approximately 5 percent will cause at least one ignition in 100 tries. Other testing agencies have used different criteria, but the number of trials in each is greater than 100. The above given value is considered to be valid for gasoline, propane, and butane.

This .25 mj figure is questioned by Bridges, et al, [18] who claim that when the gap voltage and current waveforms are integrated to obtain true gap energy, the true ignition threshold energy is of the order of .038 mj. For this same test the energy measured by methods used by other investigators is 0.247 mj. Since the measurements and calculations used in transmission line fuel ignition more closely approximate the conventional approach, the .25 mj value will continue to be used herein.

Under normal conditions, more than the minimum energy is needed for ignition [16,19] for a combination of reasons:

1) A part of the energy is dissipated in circuit resistance and is not available in the spark gap.
2) A portion of the energy available goes into heating the electrodes. This is more pronounced with short, blunt gaps, and is known as the quenching effect. Lower voltage, high current arcs tend to put more of their energy into the electrodes rather than the arcs.
3) The spark gap may be so long that the energy is distributed over too long a gap length, resulting in the energy not being concentrated sufficiently to heat the mixture to ignition temperature.
4) The figure cited is for the minimum energy as a function of mixture. This mixture is slightly richer than stoichiometric, and the energy requirement increases as the mixture varies toward the lean or rich side of the flammable range.
5) Gas temperature, pressure, and the humidity are also factors influencing the energy needed for ignition. Humidity especially is a critical factor.

Considering the above factors, practical experience is cited [16] as indicating that it takes from two to ten times more energy than the experimentally determined minimum to ignite flammable mixtures under normal field conditions.

In addition to a certain minimum energy being required for ignition, it is generally recognized that a minimum voltage is also needed. This is based on the practical consideration that for low voltages there is more quenching effect with the consequence that a larger percentage of the energy goes into heating the electrodes and less into heating the arc. A value of 1500 volts peak or 1000 volts rms is generally cited as a valid minimum voltage for ignition. Care must be used with any voltage criterion, however, because while the energy standard is intrinsically safe, the voltage one is not. Voltages as low as 20 volts have been known to cause ignition with energies in the 20 mj range.

For comparison purposes, Marks' Mechanical Engineers' Handbook [22] lists typical ignition coil parameters for a 6 volt car as: primary coil resistance of from .9 to 2 ohms; inductance of 5 to 10 millihenries; and turns ratio of 1:40 to 1:100. A 10 to 20 kV peak is cited for reliable ignition, with the required value increasing with increasing mixture pressure.

function of the coil is to store energy in the primary and to discharge it to the plugs through the secondary. Considering the lowest energy from the above range of values, which would occur for a primary of 2 ohms and 5 millihenries, the stored energy would be of the order of 22.5 millijoules. Much of this energy is then lost in the coil and distributor. The significance of this is to point out the range in energies between the minimum required to produce ignition and the value used to assure ignition under varying conditions (changing fuel/air mixture, etc.). This range is also narrowed somewhat by considering typical engine overdesign and the fact that more energy is required for ignition at engine pressure than is needed at atmospheric pressure.

Data from Project UHV [21] gives a different form of criterion for fuel ignition. Observing that surface quenching or conduction of heat from the arc to the electrodes is a critical factor led to an empirical finding that the minimum voltage necessary to cause ignition on a warm day is $V = 4.6\ C^{-.3}$ where V is the open circuit rms voltage and C is the capacitance in farads. This relation holds for the range of 100 to 10,000 pf.

In surface quenching, factors involved include:

1. Thin electrodes will conduct less heat away from the arc than fat electrodes.

2. Long (high voltage) arcs will have a lower proportion of heat removed from the ard than short arcs.

3. Long arcs will have higher resistances than short arcs.

4. Small objects will have a higher voltage induced on them than larger objects but the energy storage will be less ($1/2\ CV^2$).

The net effect is that smaller objects can ignite fuels with less energy than larger objects by virtue of the higher induced voltage on them.

For comparison with the energy criteria, Table [8] lists a man and three typical vehicles together with their capacitances and induced voltages required for ignition by the UHV formula. Stored energy under these conditions is also given. Energies are seen to fall in roughly the 2 to 8 millijoule range; of the order of 10 to 30 times the minimum energy required for ig ion under ideal circumstances.

It is recognized that energy and voltage requirements for ignition are sensitive to humidity. On a damp day ignition is impossible under conditions that easily give ignition on a dry day. Thus the UHV formula will be very sensitive to humidity.

Table 8

Ignition Energies from UHV Formulas

	Capacitance (pf)	Voltage (kV,rms)	Energy (mj)
Man	100	4.6	2.2
Automobile	1000	2.3	5.3
Crop Wagon	1400	2.1	6.1
Vehicle C	3000	1.65	8.2

Several points tend to favor a low value to be specified for safety purposes:

1) The BPA reference cited earlier[20] points out that on a hot dry day the UHV criteria may approach the .25 mj figure.
2) The firing energy is quite dependent on the fuel/air ratio, rising rapidly from the minimum value as the ratio departs from optimum. On the other hand, in a situation where an accident is possible, the ratio will be continuously variable from pure fuel vapor at the surface of the liquid to clean air not far away. This make it nearly certain that there will be an optimum mixture not far from the spark, if one occurs.
3) There is a reported effect under continuous sparking, in which the voltage on the sparking electrode was observed to raise to twice its peak value. Consequently, the energy associated with the discharge in this case might rise to four times the value for the initial spark. This effect is given as very dependent on leakage resistance and is only present when the leakage resistance is high.

Along with this note on continuous sparking, it is well to recall that the .25 mj criterion was developed for a single discharge from energy stored either in a capacitor or an inductor. Under more or less continuous sparking, which could result from the conditions under a transmission line, this energy is being replenished by induction from the line. Hence, there is a continuous flow of energy going into heating the fuel/air mixture, the effect of which may be somewhat unclear, but is certain to argue for retention of the low limit for safety purposes.

It is therefore recommended that .25 mj be accepted as the safety criterion for the minimum energy necessary for final ignition. It is recognized that the actual figure under field conditions may be considerably higher than this.

A relationship can be derived to relate peak stored energy to the electric field curves given elsewhere.[11] For a vehicle, assumed perfectly insulated from the ground, the short circuit current to ground is given by:

$$I_{SC} = j \omega \varepsilon_0 E A$$

where A = the equivalent area in square meters, and $j \omega \varepsilon_0 E$ is the displacement current in amperes per square meter. The open circuit voltage and short circuit current are related by the capacitance to ground C as follows:

$$V = \frac{I_{SC}}{\omega C}$$

From this, the peak energy can be related to the short circuit currents plotted on the electric field curves in the electrostatic data:

$$W = C (V_{OC})^2$$

where W is the peak energy, giving for current:

$$W = \frac{(I_{SC})^2}{\omega^2 C}$$

Considering, for the moment, an energy of .25 mj, it remains to determine the field required for a peak energy of this magnitude to be stored on a vehicle.

For example, a conservative estimate for a crop wagon is a capacitance to ground of 1400 picofarads. This value of .25 mj corresponds to a short circuit current of about .22 mA, which current could result from an electric field of the order of .5 kV/m. For an automobile of assumed capacitance of 1000 picofarads (a rather large car or a station wagon), this corresponds to a short circuit current of the order of .19 mA which would result from a field of .8 kV/m.

Considering the open circuit voltage, a value of 1000 volts rms was cited as a minimum to generally obtain ignition. Due to the aforementioned voltage doubling effect, this should be reduced to 500 volts. For an energy of .25 mj the automobile above has an open circuit voltage of 500 volts, so the two criteria give the same answer. For the crop wagon, the open circuit voltage for .25 mj is 425 volts. Considering 500 volts, this occurs at a field of .59 kV/m.

There are mitigating circumstances involved, such as leakage in the vehicle's tires, which would reduce the probability of occurrence. However, the energies involved are a matter of concern as they can be beyond the value where ideal conditions are required and are into the values used for practical ignition systems for vehicles on the ROW.

Regarding the fact that there has been no record of this happening before, it should be noted that the exposure is low. Considering the probability of a tractor in a field running out of fuel directly under a line, together with the fact that tractors are usually on soft, perhaps wet earth which would tend to ground them, this particular exposure is low.

In addition, the higher clearances that exist at road crossings, etc. will reduce the electrostatic field gradient which in turn will reduce the effective exposure from this sou
Despite this, it is still true however that there are many thousands of miles of EHV line operating for many years without confirmed incident of this type.

2.2.3 Pacemakers

Identification and Description of Electrical Effect

For the purposes of this report the generic term "electromagnetic fields" has been used in those cases where the induction or radiation fields are predominant. This naturally occurs at frequencies above 60 Hz. At 60 Hz the near or quasi-static fields are predominant and in this case the component fields are decoupled, making it possible to discuss separately the magnetic field (associated with current) and the electric field (associated with voltage).

Electromagnetic compatibility with pacemakers has been a subject of continuing concern.[23, 24,25] Microwave ovens, broadcast transmitters, and ignition systems for internal combustion engines have been cited as sources of difficulty to these devices. In the case of microwave ovens, the primary cause of the interference is not the carrier (915 or 2450 MHz are common frequencies), but the mode stirrer which is a fan-like device to more evenly distribute the microwave energy in the oven cavity. As the stirrer directs the field by the door, radiation may be emitted by leaks around the door in the form of pulses at a rate comparable to the normal heart beat rate. It is this pulsed radiation which is the primary source of difficulty. With ignition systems the problem is similar, being due to electromagnetic pulses produced in the firing of the spark plugs.

Warnings have been issued from time to time to pacemaker users to beware of these sources of radiation. However, a leading manufacturer of pacemakers reports that these warnings are based on anecdotal reports of problems rather than hard numerical data. In order to reduce these potential problems, the manufacturers have incorporated improved shielding techniques and band pass filters to diminish any susceptibility to steady state ac currents over a wide range of frequencies.

Pacemakers do differ in their potential susceptibility to electromagnetic effects. Of the two generic types of pacemaker, the asynchronous type is more nearly immune to this type of problem. It pulses at a constant base rate but in certain circumstances of normal operation can compete with the normal heart rate. To avoid this difficulty, the synchronous types were developed. Most of the interference difficulties occur in the circuits used to sense normal heart activity in the synchronous type of pacemaker. There are three types of synchronous pacemakers, the atrial synchronous, the R-wave or ventricular synchronous, and the R-wave inhibited.

The atrial type is synchronized with the atrial rate and the ventricular synchronous type operates in a similar fashion off the ventricular rate, but both revert to a base rate in the absence of a signal. The R-wave inhibited, on the other hand, is idle during normal heart activity, only pulsing the heart muscle during periods when the pacemaker fails to sense the normal heart signal, at which time it reverts to a base rate pulsing. This latter type has advantages, besides lack of competition, in that it has a long life and it does not distort the electrical heart signals during normal operation of the heart.

Criteria for Assessment of Electrical Effect

Electric field research with pacemakers at 60 Hz is not as advanced as is the magnetic case. Work is currently underway at several places. Illinois Institute of Technology Research Institute is currently making investigations, but the results are not presently available.

The problem of assessing the degree of interference is one of determining the voltage developed across the terminals of an implanted pacemaker from an external field. Interference can then be determined depending upon the type of pacemaker. The electrode voltage from an external field is clearly dependent upon the magnitude of the field and the amount of attenuation the body affords. The body surface gradient can be measured or estimated, but to date no accurate determination of the attenuation of this gradient from the body surface to the pacemaker is available. Estimates range from no attenuation (worst case) to attenuation by a factor of 10. This may be critical in the determination of interference.

Various modes of interference exist depending upon type of pacemaker and the characteristic of the interfering signal. Firstly, asynchronous types do not have sensing electrodes and are less prone to interference than the synchronous types. Of the latter the sensitivity of the device plays an important role. The sensitivity is the minimum signal required for satisfactory operation. Thus for the atrial and ventricular types an interfering signal greater than their

sensitivity and at an abnormal rate may cause a trigger rate change or irregular beating. In the case of the R-wave inhibited type, operation may be inhibited when it should not be by the presence of an interfering signal greater than the sensitivity level. For large interfering signals, some of the synchronous types will revert to fixed rate pacing in a fail-safe mode.

Thus, the sensitivity of a pacemaker is recommended as an adequate criterion with which to judge interference.

No published work has presented data on body surface gradients, attenuation effects of the body, or the results of investigations on a comprehensive range of pacemakers. However, using a simplified approach, it is possible to estimate the order of magnitude of these effects as a function of the electric field gradient.

It has been reported that the total body displacement current due to an electric field is in the order of 14 μa per kV/m.[75] In a field of 10 kV/m, this is equivalent to a current of .14 mA flowing longitudinally through the body. Assuming that at 60 Hz the body trunk acts internally as a relatively uniform resistance with a resistivity of 100 Ω-cm[76] and a cross-sectional area of 600 cm^2, it is possible to calculate the internal gradient. That is:

$$E = Je$$

where E = gradient

J = current density

e = resistivity

Thus, for these conditions:

$$E = \frac{.14}{10^3} \quad \frac{100}{600} = 23.3 \text{ μv/cm.}$$

For unipolar pacemakers, electrode separation can be 7.5 inches (19 cm) giving a voltage across the electrodes of .443 mv. For bipolar pacemakers with 1-inch electrode spacing, the voltage will be correspondingly lower. The sensitivity of these devices is in the order of .5 to 2 mv, showing at least a potential for interference at the low end of the range.

The effect of non-uniform current distribution due to greater resistivity of some parts of the body may raise the voltage insignificantly. However, the physical electrode arrangement with respect to the field will in most cases reduce it considerably.

Another aspect affecting the possible interference is that probability of exposure will be low. A wearer has to be directly under or close to the line with a synchronous type of pacemaker and, in the most serious case, at a time when pacing is required. For atrial or ventricular pacemakers the interference will probably be in the form of temporary irregularity or rate change that may only cause some discomfort. For the R-wave inhibited pacemaker, the interference may be more serious in that it could inhibit necessary operation if the need for pacing were concurrent with being in the vicinity of the line. However, much of this is of necessity conservative speculation and actually the pacemaker's own characteristic shielding, filtering, and interference rejection systems will further reduce the potential for interference. Newer pacemakers contain more adequate interference elimination designs and are claimed by the manufacturer to be almost immune to this kind of problem.

It is concluded that the probability of interference from exposure to EHV lines is negligible.

2.3 Electromagnetic Effects

At 60 Hz and the dimensions commonly encountered in power frequency work, electric and magnetic phenomena are essentially independent. Since under these conditions the electromagnetic equations decouple into their electrostatic and magnetostatic counterparts (the quasi-static condition), the electric field under a transmission line is primarily a function of the line voltage and the magnetic field is primarily a function of line current. This being so, it is apparent at the outset that magnetic effects from a 500 kV line may be no more severe than a high current, lower voltage line with its lower clearances.

Note that in comparing electric and magnetic effects on metallic fences and buildings, the BPA Transmission Maintenance Standard [26] considers magnetically induced effects to be insignificant when compared with electrostatic effects.

Other magnetic effects concern induced voltages in parallel circuits, power or communication,[27] as well as pipelines. These are discussed in subsequent sections.

2.3.1 Induced Voltages: Shock Hazard, etc.

Identification and Description of Electrical Effect

Electromagnetically induced voltages differ from their electrostatic counterparts in that magnetic voltages are induced in conducting objects of considerable extent parallel to the transmission line. The induced voltage is distributed along the conductor in such a way that grounding at a single point is insufficient to insure safety. Grounding resistance is more critical as well in that a high resistance ground is sufficient to bleed off static voltages, but for magnetically induced voltages low resistance grounds are required to handle the induced currents.

Consider a fence parallel to the transmission line. For fence on the edge of the right-of-way with 4000 amperes line current and 50 feet conductor height, the induced voltage in the fence would be of the order of 300 volts per mile. A fence one mile long and grounded at one end would have a potential of 300 volts at the other end. Were the fence to be grounded at the center, a potential of 150 volts would appear at each end of the fence. The voltage on the fence under short circuit conditions involving zero sequence currents in the transmission line would be markedly higher.

This effect is of no consequence for objects of small extent such as automobiles, since the parallel distance to the line is small. Grounding techniques such as grounding fences at specified intervals are well established.

Criteria for Assessment of Electrical Effect

Electric shock criteria were described in Section 2.2.1 under electrostatic effects and need not be repeated here since the person experiencing electric shock has no mechanism to determine the source of the shock.

2.3.2 Parallel Piping

Identification and Description of Electrical Effect

The effects of high voltage transmission on pipe lines has been known and studied for some time.[28-31] Some of the problems incurred include impairing of cathodic protection and increased corrosion of the pipeline, as well as possible personnel hazards. Under fault conditions, additional problems can occur such as the breakdown of the insulating flanges installed as part of the cathodic protection scheme.

Regarding corrosion,[31] the relative corrosive effect of a given rms magnitude of 60 Hz current is approximately 1 percent of an equivalent direct current. The effect of an ac current, however, is more pronounced in a steel structure when access to air is restricted, as in the case in a buried pipeline. Alkaline soil is a less severe condition for reaction with steel. AC discharge can cause an especially high corrosion rate with buried aluminum, magnesium, or zinc. AC can greatly affect the ability of magnesium to serve as a sacrificial anode--the protective system can be actually reversed in some conditions, causing damage to the system it was designed to protect.

The magnitude of potential induced in a pipeline is a function of (a) the distance between the overhead line and pipeline; (b) the length which the pipeline is parallel to the transmission line; (c) the current in the transmission line; (d) the configuration of the overhead line; (e) the magnitude of the zero sequence current; (f) the coating conductance of the pipeline; (g) the size of the pipeline; (h) the resistivity of the soil surrounding the pipeline; and (i) the resistance and reactance of the pipeline.

Due to the large number of parameters involved, and their variability, the actual field measurements are often only a fraction of the calculated values. The coating conductance of the pipeline is especially difficult to predict, since it is a function of the induced voltage. The higher the induced voltage, the more current discharge paths will be formed, and hence the higher the conductance.

2.3.3 Communications Coordination

Identification and Description of Electrical Effect

The coordination of power and communications systems is an old study[32] but one of increasing importance with large capacity power transmission. Magnetic coupling in telephone and railway signalling [33] systems are areas of concern.

Again, since this is magnetic coupling under consideration, the effects are a function of line current rather than line voltage, and so can be equally severe under proximity to much lower voltage, but high current circuits. Magnetic coupling effects are worst for communications circuits running parallel to the transmission line in question.

2.3.4 Pacemakers

Identification and Description of Electrical Effect

A description of pacemaker types and their relative susceptibility to electromagnetic effects was given in Section 2.2.3 under electrostatic effects. The difference which occurs in magnetic fields is that the connecting leads and body organs form a loop which is linked by the magnetic flux from the transmission line. By Faraday's Law, a voltage is induced in the loop by the time varying magnetic field. This voltage appears across the pacemaker terminals with the waveform of the heart which the pacemaker is designed to sense. Under the right circumstances, the interfering voltage can confound the sensing circuits in the pacemaker, giving faulty operation. The size of the loop depends, among other things, upon the particular form of installation of the individual pacemaker.

Criteria for Assessment of Electrical Effect

At 60 Hz, extensive work has been done on the effects of magnetic fields on pacemakers in connection with the government's Sanguine project.[23] From these tests, a magnetic field of approximately 1 gauss is found to be a safe level. Manufacturers concur that 1 gauss is conservatively a safe level. Another study was done by men from the George Washington University School of Medicine and the Federal Aviation Administration in connection with magnetometers used as weapons detectors in airports.[24] They report that 1.34 gauss and above there was a small increase in rate, when the pacemakers were immersed in a saline bath in a field. In animals, increased rate and loss of synchronism occurred at magnetic fields of 6 gauss or higher. As expected, these results showed synchronous pacemakers to be more susceptible than asynchronous, and unipolar models to be more susceptible than bipolar. More testing is being done by a manufacturer using a Helmholtz coil at 60 Hz. Elsewhere, some comment has been made about a study showing effects evident at 2 gauss.[34]

Unpublished manufacturers' data reports that most manufacturers demand models under the influence of steady 60 Hz fields would, under strong enough fields, at worst revert to a steady and normal rate of pulsing. No damage is done to the instrument and, when the field is removed, the pacemaker restores itself to its normal mode of operation.

All criteria developed for magnetic effects at 60 Hz upon pacemakers give values of 1 gauss or higher, hence it may be concluded that 1 gauss is conservatively a safe value to use.

As had been noted under electric field effects, a considerably worse situation would occur were the 60 Hz to be pulsed, the ideally bad waveform being half of a cycle (60 Hz) with one second spacing. This pulsed waveform could easily interfere with the synchronous pacemaker's circuits designed to sense the normal heart activity. However, this steady pulsing is not a situation to be encountered under 60 Hz power lines. The more common occurrence would be a single large transient, such as might be produced by a switching surge. Unpublished data indicates that the worst which could generally be expected to happen under such conditions would be for the pacemaker to skip a beat. Skipping a heartbeat occurs in normal people from time to time. In connection with this, the transient encountered from being near lightning discharges during a thunderstorm would be a greater hazard with respect to this effect.

With regard to pulsed waveforms, riding a snowmobile with its nearby ignition wiring would be more hazardous than proximity to a steady 60 Hz field.

In consideration of magnetic effects, it is well to put the field from a transmission line into its proper perspective. The steady magnetic field from the earth has a strength of about .5 gauss.

It has been reported that the field near an electric heating pad is around 2 gauss [35] and that environmentally likely fields may be as high as 10 gauss.[36]

2.4 Corona Effects

Conductor corona is the main source of audible, radio, and television noise from a transmission line. Discrete sources such as line-end hardware and insulators may produce corona if they are defective or under unusual operating conditions such as scintillation from contamination. However, these conditions are not normal, and the sources will be at isolated locations. They may be identified, and in the case of defective equipment, repaired. Conductor corona however may be extant along the whole length of the line depending upon conditions enumerated in the following sections.

2.4.1 Audible Noise

Identification and Description of Electrical Effect

EHV transmission lines produce significant audible noise during conditions of wet conductor surface. The generation of audible noise is caused by point source corona in the same way as RI and TVI. As such, vital factors in its generation are the conductor voltage gradient and the number of irregularities in energized hardware. The major cause of these irregularities is water droplets which deform to point sources in the electric field, producing high local gradients and thus corona sources. Consequently, fair weather audible noise is generally imperceptible.

The noise manifests itself as a sizzle, crackle, or hiss and a low frequency hum. The former is a "white" noise extending over the entire aural range (20-10^4 Hz) caused by the random point source discharges, while the latter is caused by space charge movement around the conductor at a frequency of 120 Hz and its harmonics. Unlike RI and TVI, audible noise is more localized in character in that the noise is propagated via the air and that discharges a few spans away do not affect local measurements. This allows local remedial action, if necessary.

Annoyance by the noise depends upon many qualitative factors. Herein lies the difficulty in specifying fixed levels for measuring annoyance. Such general factors as land use characteristics and ambient noise together with personal factors as activity and duration of exposure must be recognized. For example, it would be unreasonable to use the same criteria for a line running by an industrial facility and a hospital. As another example, a line running through a populous area clearly has more potential for annoyance than one through non-populous land. Another factor affecting annoyance is motivation. Highway noise is generally accepted as a matter of course because of the immediate and obvious benefit a highway brings to the public. The benefits of electricity are not associated

with transmission lines especially when one's personal supply cannot be identified as deriving from an EHV line. Better acceptance may come with public awareness of the economic trade-off between cause and effect.

Criteria for Assessment of Electrical Effect

Audible noise is generally measured by the db(A) scale, where dB is defined as follows:

$$dB = 20 \log_{10} \frac{P_1}{P_2}$$

and P_1 = measured sound pressure

P_2 = reference sound pressure

The reference sound pressure is normally chosen as the average minimum level that a person can detect at a frequency of 1 kHz. The "A" suffix refers to the weighting network used in the measurement. This is necessary as the ear does not have the same flat response as a meter; i.e., the ear attenuates low frequency noise below 1 kHz and above 6 kHz, while it amplifies midrange frequencies. This is the reason for the remarkable frequency range of the ear. The A network is an attempt to simulate the ear's response. However, annoyance cannot be based upon simulation of the ear's response alone but should also recognize frequency components. This is because low frequency hum (120 Hz), even though it is heard with a low amplitude, may be more annoying than larger amplitude, high frequency noise. The A network attenuates hum so that it negligibly affects the A reading. Little quantitative data exists on the correlation between annoyance and hum, but one study indicates[37] that the 120 Hz hum alone has minor annoyance potential compared to random noise.

The hum noise level is highly dependent upon location and may vary by 20 dB over an 8-foot distance. Close to the line, hum noise arrives at any location from the phases with a 120° phase relationship and also may be affected by reflections. Due to the spatial separation of the phase locations, the effect at ground level is therefore to cause considerable fluctuation in amplitude, depending upon location.

The study previously mentioned also indicated that the dB(B) weighting network gives a better correlation with juror annoyance ratings of transmission line noise than the A network. This is probably due to the less severe attenuation of the low frequency noise with the B network. However, the dB(A) scale is in universal use for general noise ordinances with excellent prior experience. Typical noise levels and network

responses are given in Figures 1 and 2. Figure 3 shows the frequency spectrum for typical transmission line noise.

The criterion is based on experience with other lines, current noise regulations, and typical ambient levels in the different areas of land usage. In addition it is proposed that the criterion be applied only for those conditions when by virtue of activity, annoyance may occur. The line noise under heavy rain conditions may be 6 dB(A) higher than under conditions where the conductor is merely wet. The latter may occur after rain, heavy fog, etc. However it is unlikely that the heavy rain condition would cause annoyance because of the high ambient level and low exposure characteristics. Therefore it is more appropriate to consider the wet conductor level because of its higher exposure probability.

A general guideline to acceptability was given in Reference 38 and is reproduced in Figure 4. It is based upon public response to noise from existing lines at 100 feet from center of ROW and shows that less than 52.5 dB(A) resulted in no complaints. Table 9 lists operating experience for the AEP [39] and Hydro Quebec [39] 765 kV systems.

Table 9

Operating Experience with AN

Utility	Voltage (kV)	Conductors	Phase Spacing (fb)	AN (@C ROW) dB(A)	Experience
AEP	700	4 x 1.165"	42	-	no complaints
"	735	4 x 1.165"	42	-	some "
Hydro Quebec	735	4 x 1.385	50	52	no "
"	"	4 x 1.2	45	58	" "

The levels shown for Hydro Quebec apply to the wet conductor condition. The Hydro Quebec ROW is 300 feet, and thus a correction factor to determine the level at the edge of ROW must be applied. A typical attenuation in the order of 1 dB(A) per 100 feet may be expected and thus the corresponding levels at the edge of ROW would be 49.5 and 56.5 dB(A).

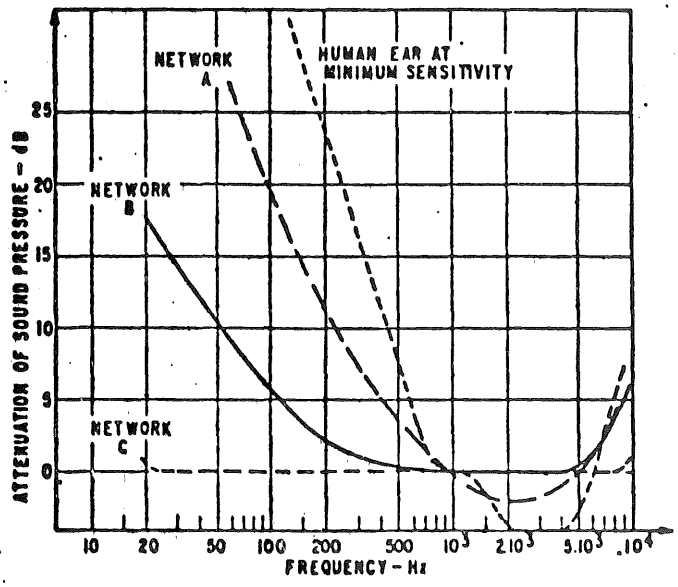
Regulations on audible noise occur at the local, state, and national level. Current regulations in force in New York City are the New York City Zoning Resolution, the Building Code, and New York City Noise Control Code. Their requirements are listed in Table 10.

Sound pressure in bar	Sound level in dB		Environmental conditions
		140	
1 mbar	134	130	Threshold of pain
			Pneumatic chipper
		120	
100 μbar	114	110	Loud automobile horn (dist. 1 m)
		100	
10 μbar	94	90	Inside subway train (New York)
			Inside motor bus
		80	
1 μbar	74	70	Average traffic on street corner
			Conversational speech
		60	
0.1 μbar	54	50	Typical business office
			Living room, suburban area
		40	
0.01 μbar	34	30	Library
			Bedroom at night
		20	
0.001 μbar	14	10	Broadcasting studio
0.0002 μbar		0	Threshold of hearing

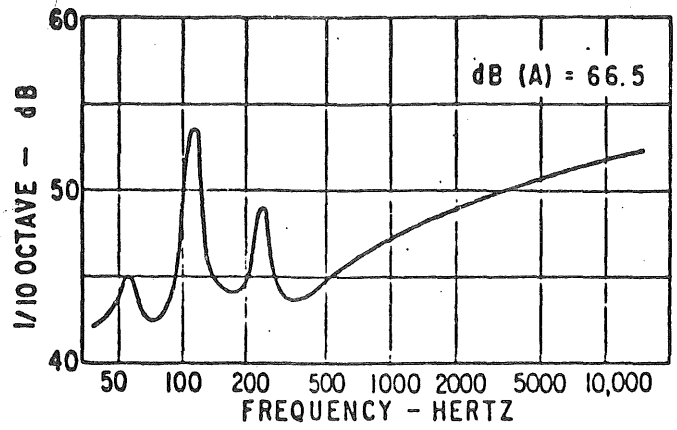
where the reference sound pressure is 0.0002 μbar

Common Noise Levels

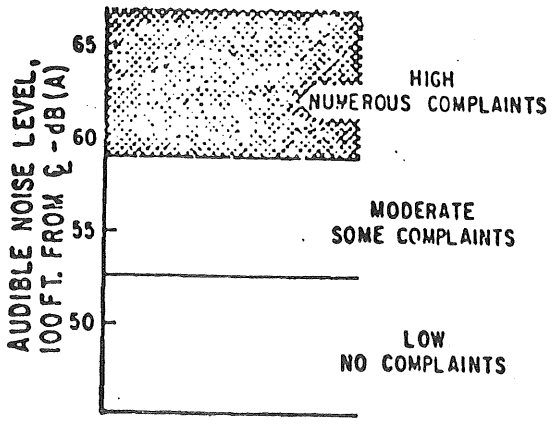
Figure 1



Network Responses
Figure 2



Frequency Spectrum
Figure 3



Probability of AN Complaints
Figure 4

Table 10

New York City Audible Noise Codes

Code	Application	Level	Comments
NYC Zoning Resolution	Industrial areas	60 dB(A)	At property line.
NYC Building Code	Commercial air conditioning	45 dB(A)	Within building, windows open.
NYC Noise Control Code	General	45 dB(A)	//

The U.S. Department of Housing and Urban Development requirement for a "Normally Acceptable" level in a residential area is similar to the NYC Noise Control Code requirements. Attenuation from outside to inside a residence with open windows has been measured as at least 10 dB(A).

Ambient noise levels are shown in Figure [1], others include: 53-67 dB(A) mean nighttime NYC highway noise; 44.2 dB(A) mean nighttime residential suburban noise; 65.5 dB(A) mean nighttime city noise; 50-55 dB(A) residential air conditioners at property line; and 40-53 dB(A) rain noise in rural areas.

Any audible noise criterion chosen to assess transmission line noise should recognize the statistical nature of the noise generation. It varies from being imperceptible during fair weather to being noticeable over ambient during wet conditions and higher but imperceptible over ambient during rain conditions. It would be unrealistic to apply an absolute noise level as a criterion never to be exceeded in, for example, desert. There it may only rain, and cause the criterion to be exceeded, once a year. A more realistic criterion would assess the impact of the noise through consideration of weather conditions, land use, subjective assessment of noise, and the noise characterics themselves.

For example, at any given location the number of hours per year of wet conductor conditions may be 500, corresponding to an annual probability of .057 (500/(365 x 24)). Assume that the probability of one person being at the edge of ROW during wet conductor conditions is .01. Also, study of the subjective rating of noise measured on the dB(A) scale by a jury indicates that for 99 percent of the population there may be an 8 dB(A) spread in noises judged to be identical. Thus if the criterion applies to the mean of the population, any noise level equal to the criterion will be annoying to only 50 percent of the population. In addition, the wet conductor line noise itself will vary about a mean; 50 percent of the

time being higher, and 50 percent of the time being lower. The range during wet conductor or fog conditions may be 24 dB(A) or larger.[77]

The combined probability of annoyance occurring is therefore:

$$.057 \times .01 \times .5 \times .5 = .00014$$

or 1.4 in every 10,000 per year. This is a somewhat crude analysis but indicates the point. Depending upon conditions, these numbers may change, but they give a true indication of the impact of the line due to audible noise. There are other considerations that may further reduce the impact. For example, the combined probability of having a residence, with its bedroom windows open and facing the line, at the edge of ROW should be considered. When one considers also that line routing has been chosen to avoid residential areas, it is clear that possible interference will be limited to isolated locations for short periods of time.

Thus, as a general criterion, it is recommended that, during wet conductor conditions, the mean audible noise at the edge of ROW should not exceed 50 dB(A). This is less than present regulations require and is the same order as many ambient levels considered acceptable.

The method of calculation was similar to that reported in Reference 40. From single phase cage tests, the generated acoustic power can be measured as a function of the conductor gradient. These can be summed for the three phases to give a lateral audible noise profile. Comparison with measured results indicates an accuracy to within $\pm$ 3 dB(A).

2.4.2 Radio Interference

Identification and Description of Electrical Effect

Transmission line radio noise profiles are of concern since AM radio reception may be adversely affected by the presence and operation of the line. Since the noise generated by conductor corona predominates in the .5 to 1.5 MHz frequency band and falls off rapidly at higher frequencies, short wave, FM, and TV reception is not generally affected. The noise is caused by discrete corona sources on the conductor surface. These sources may be due to nicks and burrs produced during line construction, dirt, or bugs on the conductor, in general any imperfection on the surface of the conductor. Generally a line will have a few dB more noise generation when new, falling as the conductor becomes weathered and the imperfections smooth out. These imperfections produce localized high gradients which tend to go into corona and produce loss. During foul weather water droplets on the conductor tend to deform in the field and become high point sources of corona. The currents associated with the loss are predominantly during the positive half cycle and may be as high as 50 mA with a frequency of 1 kHz. They are random in nature and propagate down the conductor setting up a field away from the line whose magnitude is dependent upon the sources on all phases. The field thus produced dominantly affects AM signals expecially in the Standard Broadcast band. Higher frequency AM bands may be affected, but considering the rapid drop off with frequency of noise and the relatively low usage of these bands, the probability of interference is generally negligible.

Lateral profiles are of interest as they show decreasing RI levels with increasing distance from the center of the transmission line. Of particular interest is the level at the edge of right-of-way as this is the most adverse location that a radio receiver operated by a member of the public may be permanently located.

However, the degree of interference is not a function of the transmission line noise alone. It is also dependent upon the signal strength, ambient noise levels, and population density. A radio receiver amplifies equally the signal and noise received within the receiver's band width and at the tuned frequency. Thus, a signal that is large compared to the noise may be listened to comfortably by adjusting the volume control. A weak signal, however, would have to be listened to with the volume turned up which would also amplify the noise. Most modern sets have an automatic volume control in addition to the manual control. This will boost a weak input and attenuate a strong one; thus when tuning a set from a strong t a weak station, interference may become apparent without adjustment of the manual volume control. Thus, the signal-to-noise ratio is of importance and not necessarily the absolute value of the noise alone.

Ambient noise levels are relevant as these are present before the line is even constructed. In this case the presence of the line may not significantly affect the overall noise level. Ambient noise[41] may be produced by atmospheric activity, galactic radiation (mostly solar), and other man-made sources such as factories, offices, neon signs, etc. Of these, atmospheric activity in the form of thunderstorms tends to predominate in the AM band, with typical measured values being 26, 23, and 20 dB in city, urban, and rural areas respectively.

Finally, the statistical nature of radio interference should be stressed. There is a significant variation in transmission line noise due to weather effects. Variation in humidity, air density, wind, and rain all affect the noise level. Under the worst conditions, i.e., rain, up to 22 dB may be added to the fair weather profile. In addition, there may be seasonal variations of up to 12 dB which appear to be independent of the factors already mentioned. The broadcast signal itself varies from day to night and is affected by weather conditions.

Criteria for Assessment of Electrical Effect

As outlined above, the recommended criterion for assessing interference is the signal-to-noise ratio. It is certainly possible to select a suitable S/N ratio for satisfactory listening but geographical factors must be recognized. For instance, it would be impossible to apply this criteria to all stations receivable near the line location. Weak signals may be received there from distant stations, but their FCC licensed service areas would probably be located some distance from the receiver location.

Generally speaking, radio reception is effected by ground wave (primary service) and sky wave (secondary service) signals. The latter is receivable at a considerable distance from the station but is subject to large variations in intensity from day to night, depending on ionospheric conditions. Between the primary and secondary service areas lies an intermittent service area also subject to variation in intensity. Thus the primary service area is of greatest concern as reception within it is not subject to natural variations. The power company's major responsibility lies, therefore, in possible interference with stations within their primary licensed area.

The FCC classifies Standard Broadcast stations according to Table 11[41] below.

Table 11

Classification of Standard-Broadcast Stations

Class of Channel	Class of Station	Permissible Power (kW)	Signal-Intensity Contour of Area Protected from Objectionable Interference (microvolts/meter)		Permissible Interfering Signal on Same Channel (microvolts/meter)	
			Day[1]	Night	Day[1]	Night[3]
Clear	I-A	50	Sc=100 Ac=500	Sc=500[2] Ac=500[1]	5	25
	I-B	10-50	Sc=100 Ac=500	Sc=500[2] Ac=500[1]	5	25
	II-A	0.25-50 day 10-50 night	500	500[1]	25	25
	(II-B II-D)	0.25-50	500	2500	25	125
Regional	III-A	1-5	500	2500[1]	25	125
	III-B	0.5-5 day 0.5-1 night	500	4000	25	200
Local	IV	0.1-1 day 0.1-0.25 night	500	not prescribed	25	not prescribed

Notes:
Sc—same channel, Ac—adjacent channel.
[1] Ground wave. *
[2] 50% sky wave.
[3] 10% sky wave.

*Primary service

Depending upon the class of station, whether the service is primary or secondary, and whether it is day or nighttime, the service is protected from interference from other stations on the same or adjacent channels. Primary service is provided and protected 100 percent of the time during the day. During the nighttime some stations provide primary service 100 percent of the time and secondary service for 50 percent of the time via the sky wave. They are protected from interference on the same channel for 90 percent of the time. In general primary service during the day is protected 100 percent of the time and 90 percent of the time during the night. Secondary service is provided by some classes of station at night 50 percent of the time and is protected 90 percent of the time. Thus it is recognized that secondary service area reception will be naturally intermittent.

Federal Communications Commission rules on interference from sources other than other stations says: [42]

> "Standards have not been established for interference from atmospheric or man-made electric noise as no uniform method of measuring noise or static has been established. In any individual case objectionable interference from any source, excluding other broadcast signals, may be determined by

"comparing the actual noise interference reproduced during reception of a desired broadcast signal to the degree of interference that would be caused by another broadcast signal within 20 Hz of the desired signal and having a carrier ratio of 20 to 1 with both signals modulated 100% on peaks of usual program. Standards of noise measurement and interference ratios for noise are now being studied."

Thus it would appear that the degree of interference from other sources is measured by the equivalent interference from other stations. In as much as the signal to noise ratio for permissible interference from other stations from Table 11 is approximately 26 dB, it is appropriate to use the same criterion for interference from other sources.

Table 12 [43] shows the results of subjective listening tests correlating the quality of reception and the signal-to-noise ratio. This indicates that 26 dB is on the border of very good and fairly satisfactory.

Table 12

Signal-to-Noise Ratio in dB	Reception Quality	Class
>32	Entirely satisfactory	A
27--32	Very good, background unobtrusive	B
22--27	Fairly satisfactory, background plainly evident	C
16--22	Background very evident, speech easily understood	D
6--16	Speech understandable only with severe concentration	E
7	Speech unintelligible	F

The purpose of establishing a signal-to-noise criterion is to ensure that receivers located without the ROW are not subject to objectionable interference. Thus, knowing the signal strength, ambient noise level, and lateral noise profile from the line, it is possible to determine the required ROW width for that station to be listened to satisfactorily. However, using this procedure for all stations would result in unreasonably large ROW widths for the weak stations. Thus a compromise must be reached whereby the ROW width is set so that the primary service of stations is not interfered without the ROW. The others may be dealt with on a case-by-case basis as interference is encountered.

A secondary consideration in determining ROW width should be those widths judged acceptable for EHV lines in current operation. Table 13 shows RI noise levels at the edge of ROW for several U.S. utilities with 500 kV lines from an unpublished survey.

Table 13

Utility	RI at Edge of ROW (dB>1μv/m)
Bonneville Power Authority	52
Pacific Gas and Electric	42
Pacific Gas and Electric	47
Pacific Power and Light	47
Portland General Electric	55
Southern California Edison	40
U.S. Bureau of Reclamation	46

Figure 5 [44] shows the 1 MHz lateral profiles for 500 kV lines resulting from a world wide IEEE/CIGRE survey. The survey does not report ROW widths corresponding to the various lines, but assuming a typical value of 175 feet, Table 14 was constructed from the fair weather profiles (classified with a "B" notation; e.g., E06(510,B.2.c)).

Table 14

Line Code	RI @ 175' from CROW (dB>1μV/m)
E06(510,B.2.c)	38
E04(595,B.3.d)	56
E08(549,B.0)	52
E23(560,B.2.b)	28
E07(495,B.2.c)	29
E25(520,B.2.c)	20
E02(510,B.4.c)	23
E01(480,B.2.d)	28
E03(527,B.3.c)	44
E17(500,B.0)	42
E19(500,B.0)	39

Thus a considerable range is indicated but interpretation is difficult as ROW widths were not indicated.

Fair weather conditions are generally assumed in calculating the lateral profile as these are the conditions under which the line will be predominantly operating. During foul weather conditions the line will produce more noise, but it is unlikely to have the impact of audible noise under these conditions. Whereas audible noise can affect all aspects of activity, radio noise can only affect the activity of listening to a particular AM radio station. Depending upon signal strength, receiver location, listening characteristics, etc.,

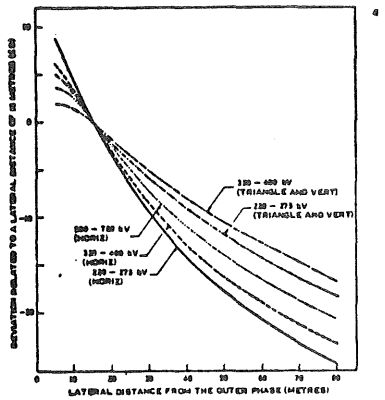


Fig. 1. Typical lateral attenuation curves for high-voltage lines

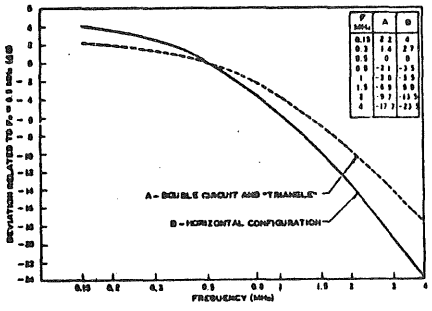


Fig. 2. Typical frequency spectra for high-voltage lines[14]

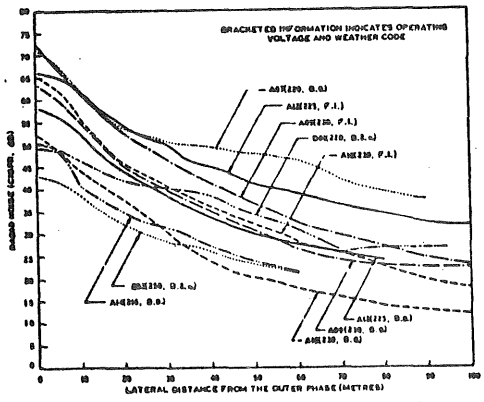


Fig. 3. Lateral profiles of radio noise, 200-275-kV lines

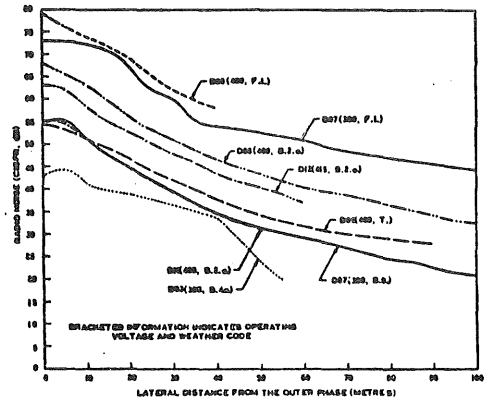


Fig. 4. Lateral profiles of radio noise, 400-kV horizontal lines

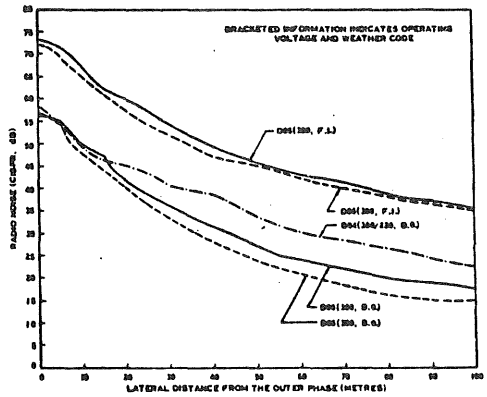


Fig. 5. Lateral profiles of radio noise, 400-kV triangular and vertical lines

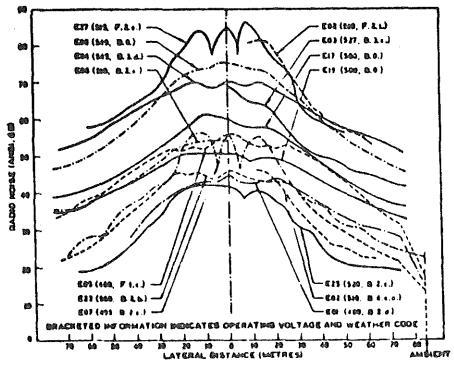


Fig. 6. Lateral profiles of radio noise, 500-kV lines

Figure 5

foul weather may very well have no impact whatsoever. Thus fair weather conditions are considered appropriate for assessing the impact of a line due to radio noise.

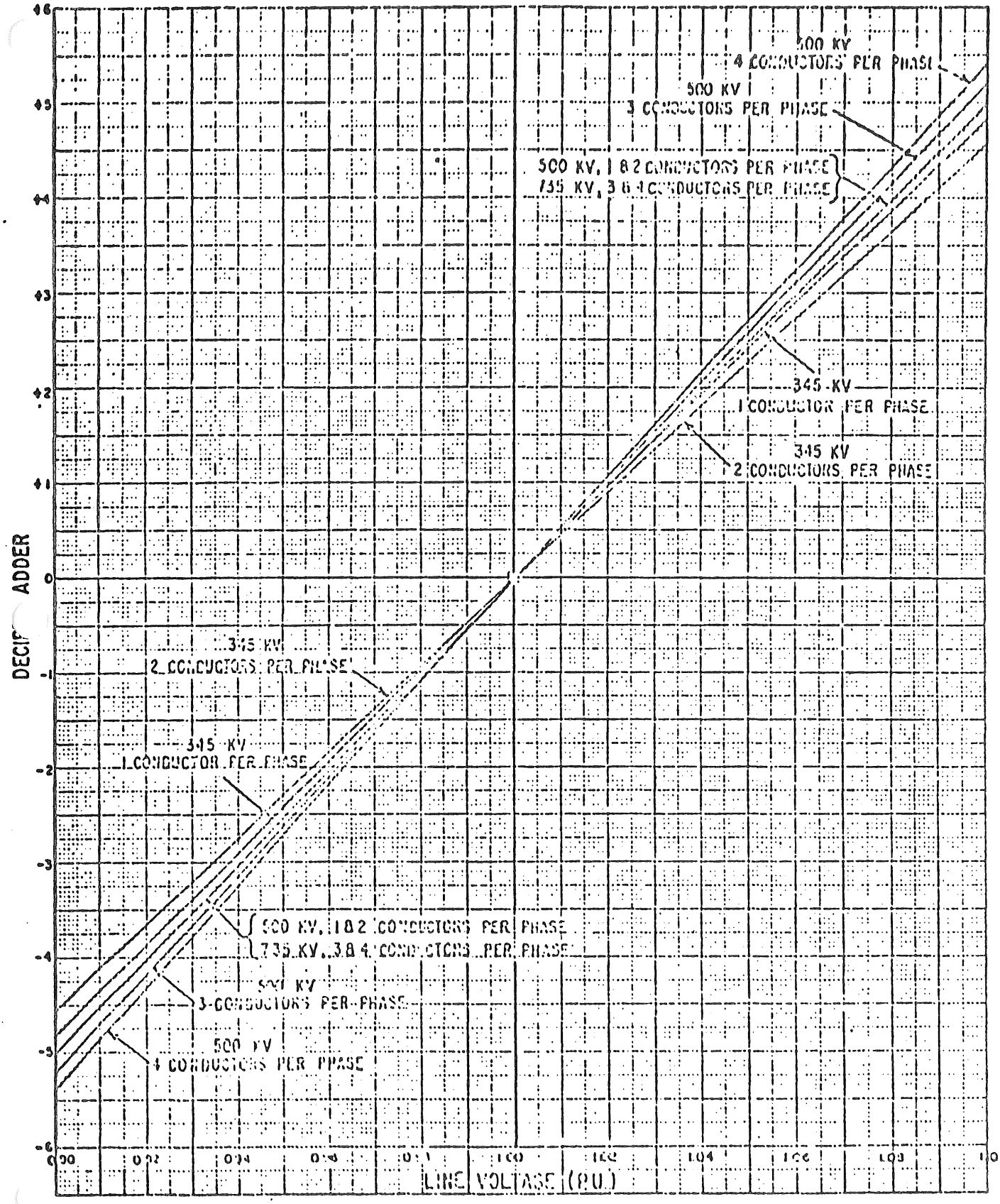
The RI lateral profiles can be calculated using a correlated complex mode analysis and spectral density of generation argument based on earlier work by Adams.[45] The results are in close agreement with the older but still valid procedure shown in Reference 46 and with field checks.

The profiles may be calculated for "fair weather" conditions, which are defined as follows:

surface factor	.7 p.u.
relative humidity	50.0 %
relative air density	1.0 p.u.
wind speed	0.0 mph
rain rate	0.0 inch/hr

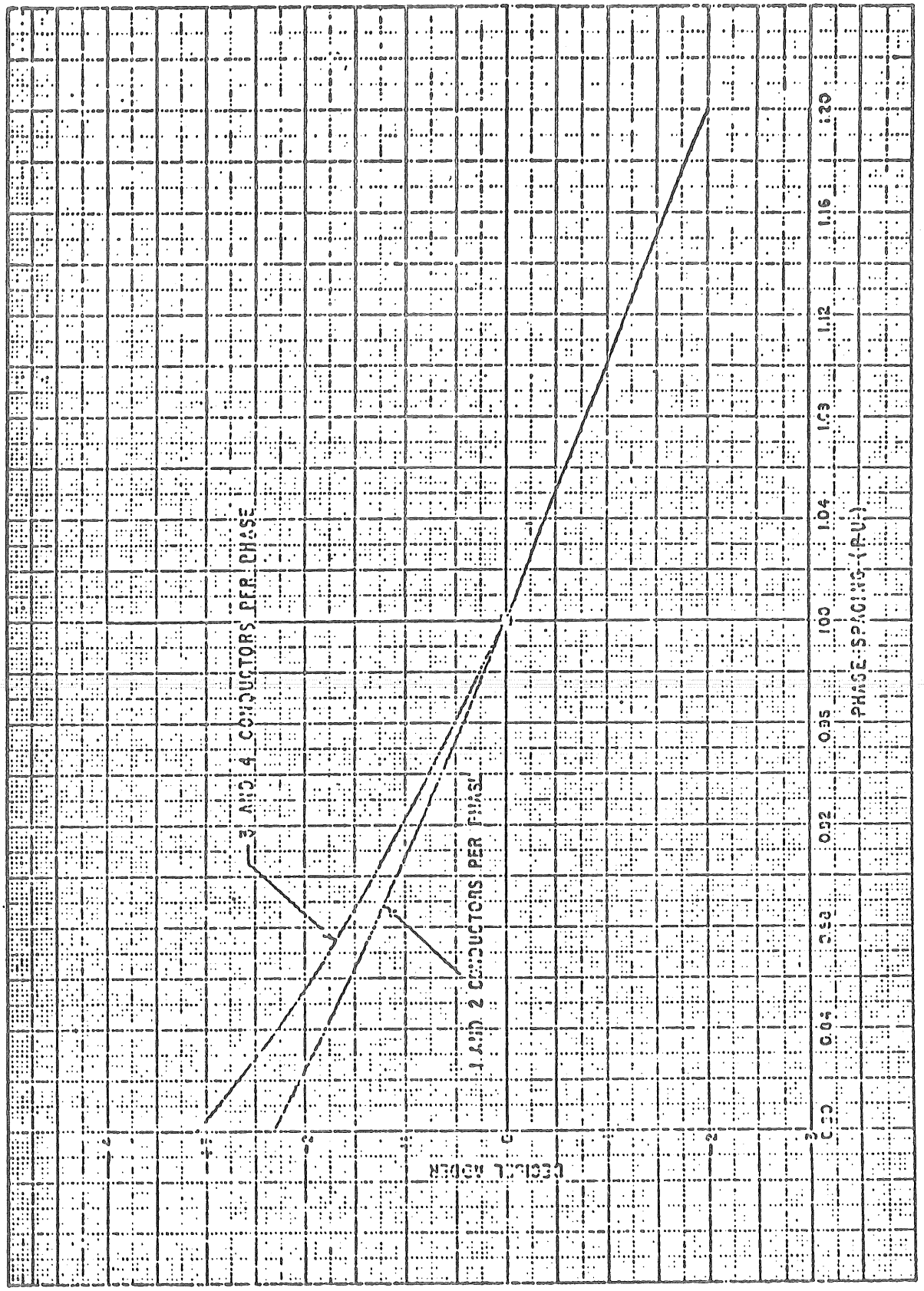
Surface factor is defined as the ratio of the corona starting gradient of the conductor to the corona starting gradient of a completely smooth cylinder of the same diameter. It is a measure of the roughness of the surface with values ranging from .65 for a conductor with many nicks and burrs to .75 for a very carefully strung conductor. Generally its value will increase from its initial low value as the conductor ages and contamination effectively smooths the surface.

The frequency is 1 MHz and a ground resistivity of 166.7 ohm-m. The general effect of variations from the base cases may be illustrated by use of the correction curves[46] shown in Figures 6 through 14.



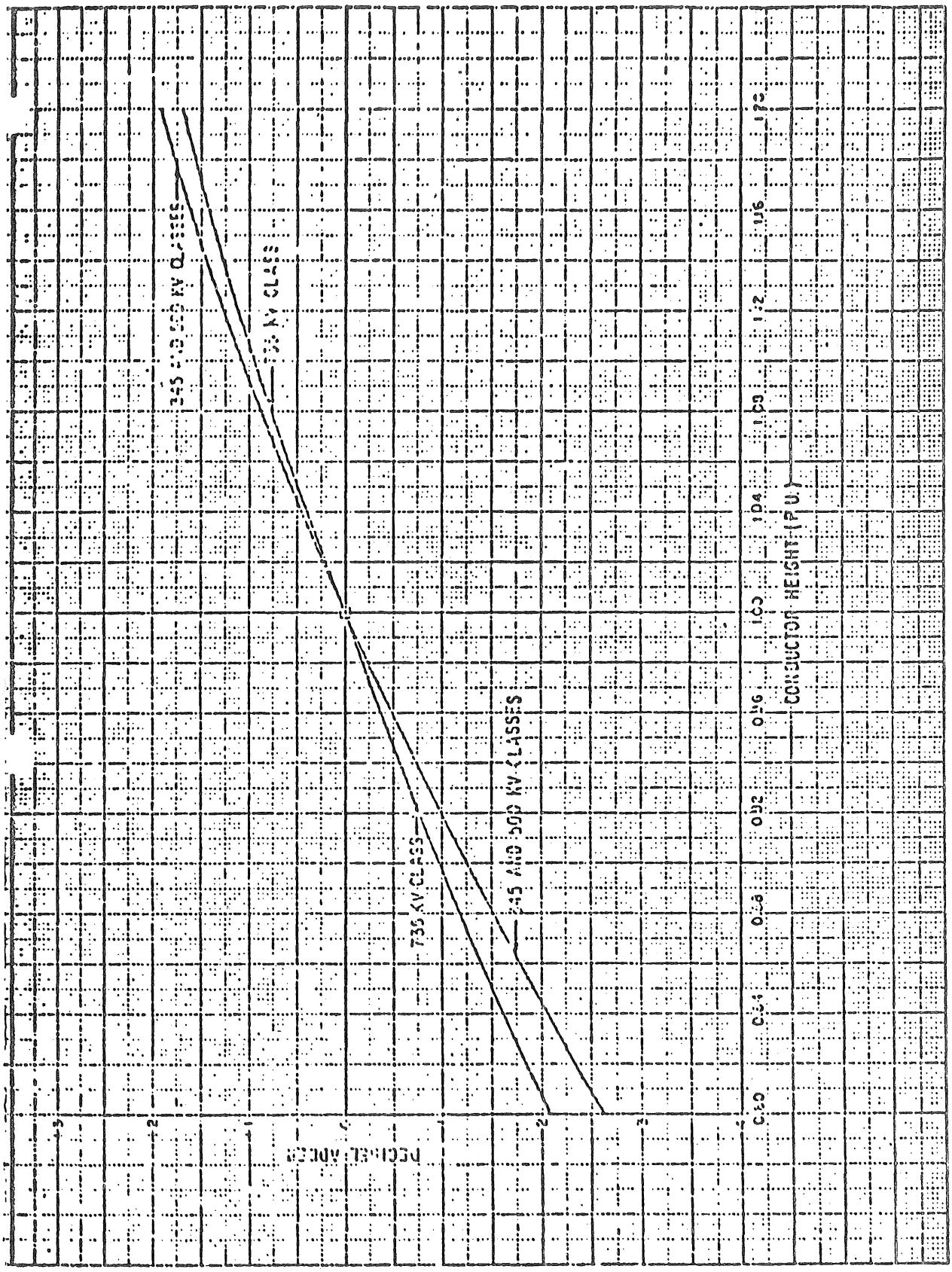
—Effect of line voltage on RI (single and double circuit—all phasings).

Figure 6



—Effect of phase spacing on RI (single circuit).

Figure 7



—Effect of height on RI (single circuit).

Figure 8

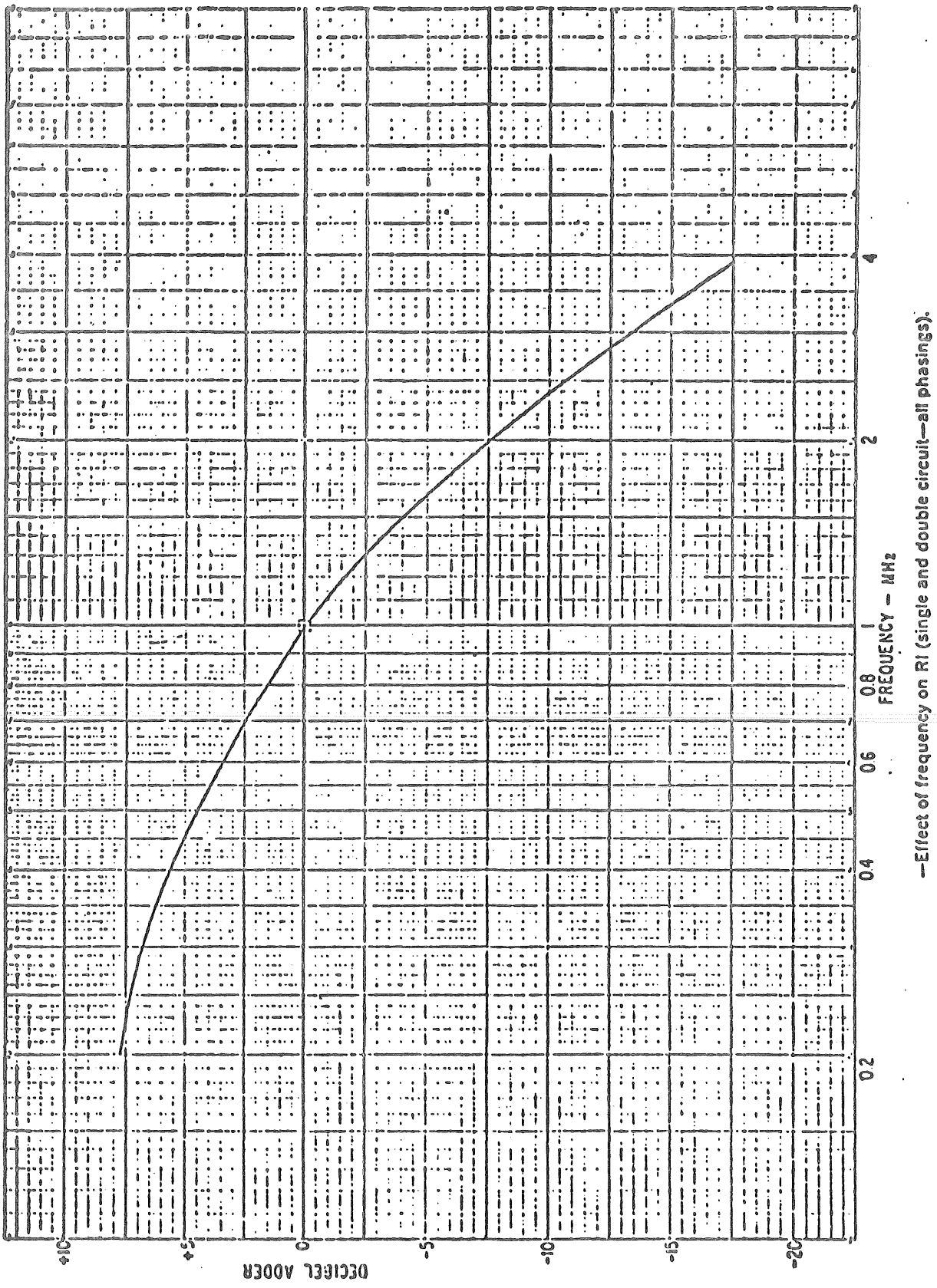
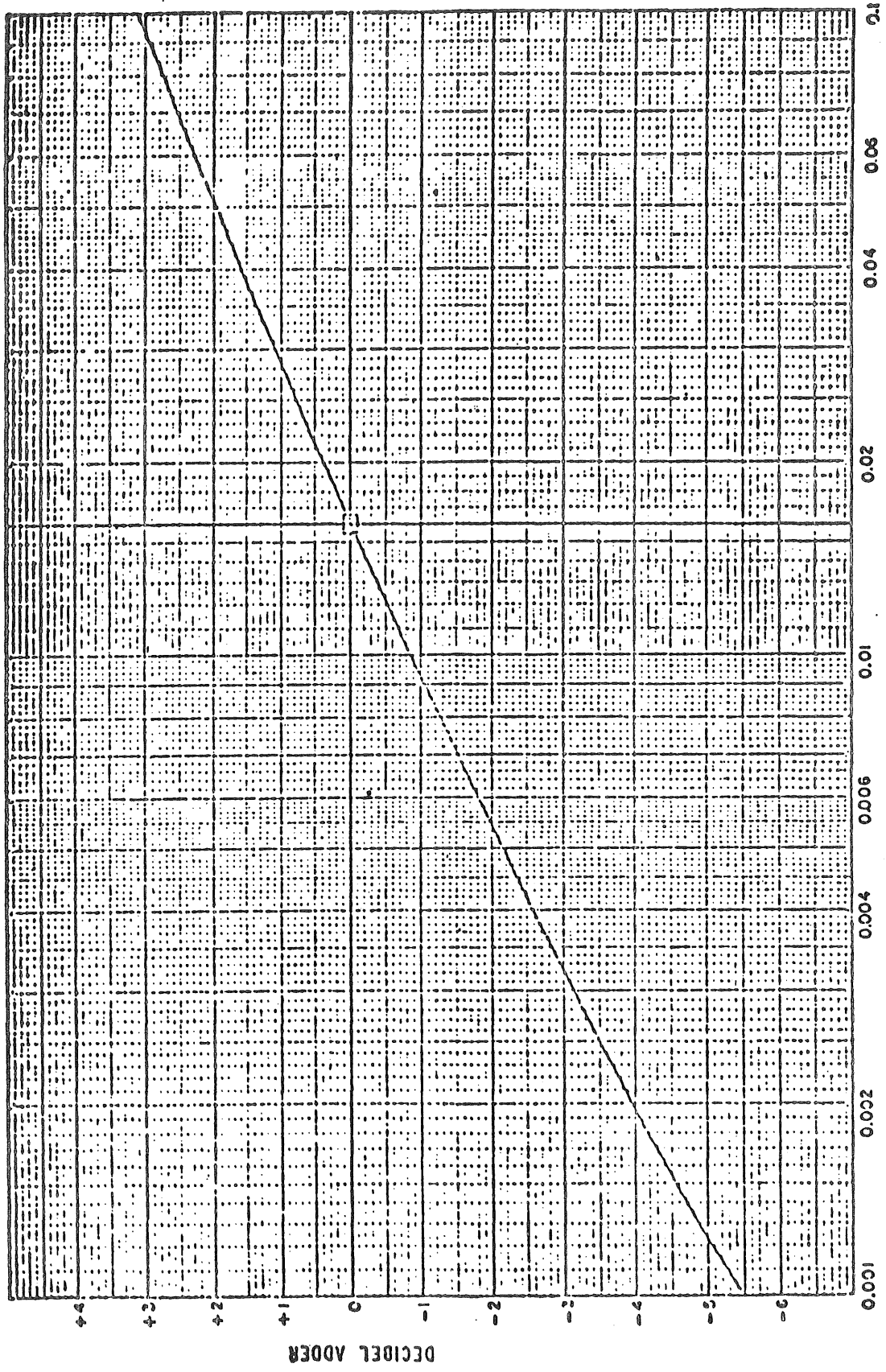
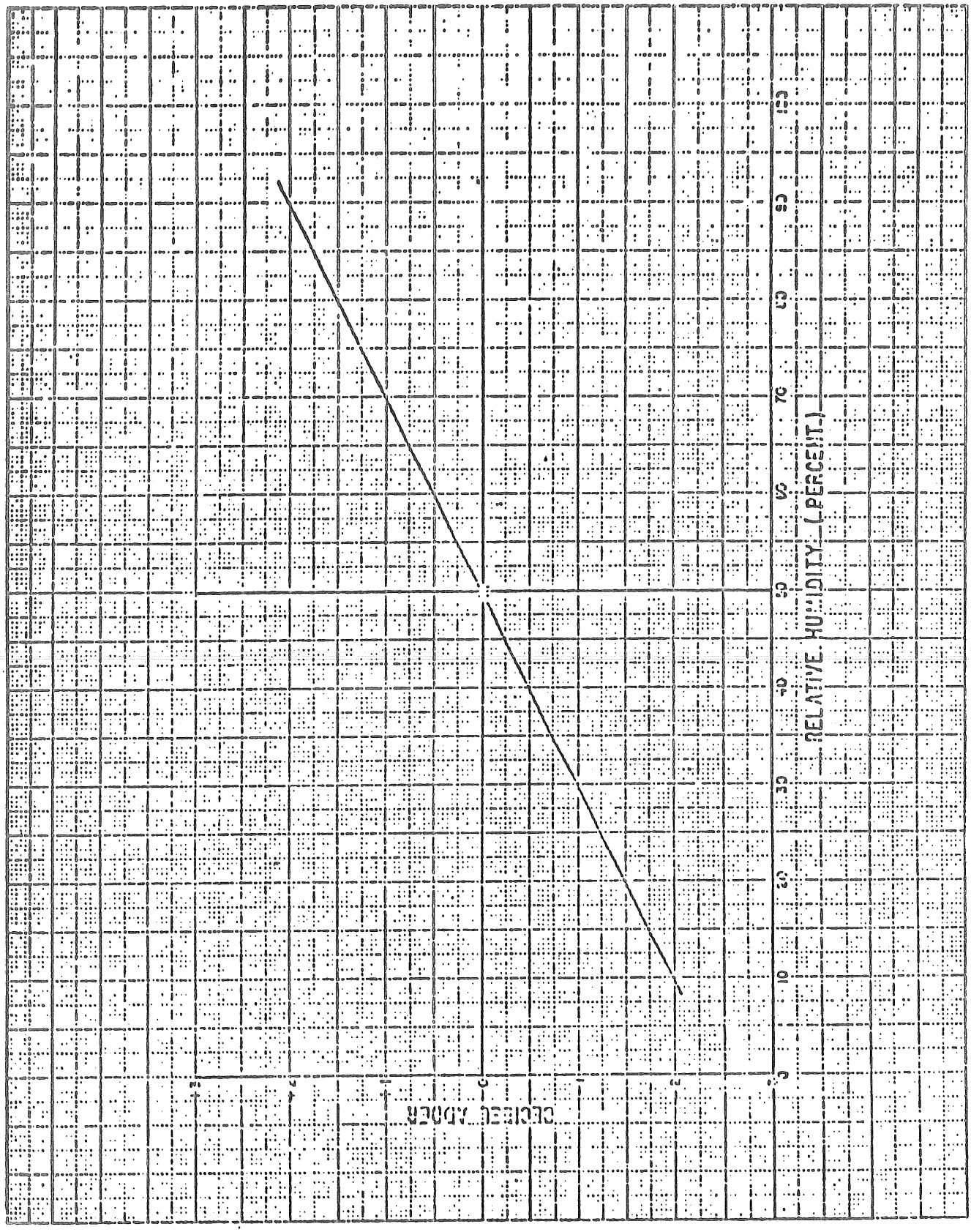

DECIBEL ADDER
+10
+5
0
-5
-10
-15
-20
0.2
0.4
0.6
0.8
1
2
4
FREQUENCY — MHz
—Effect of frequency on RI (single and double circuit—all phasings).

Figure 9



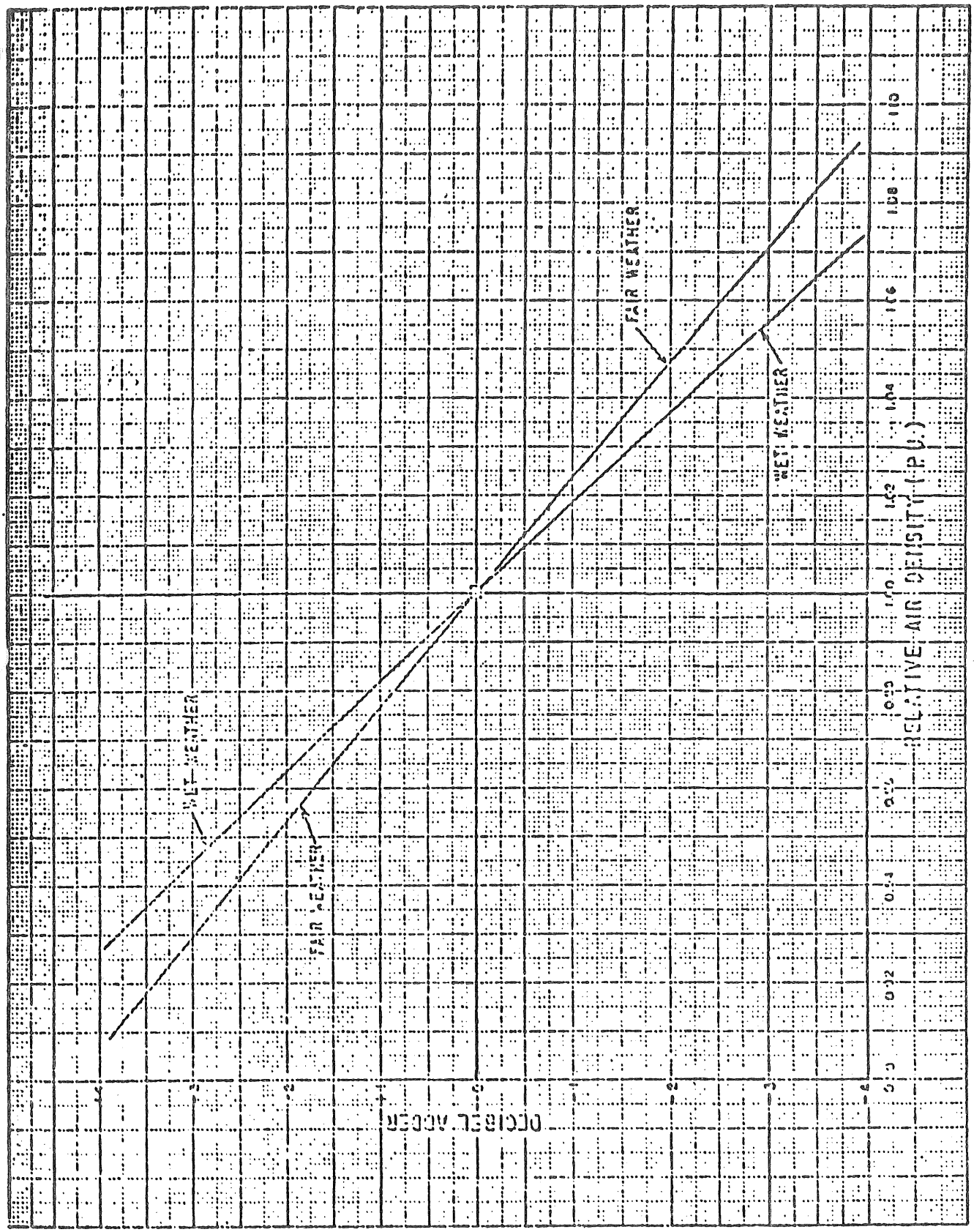
—Effect of ground conductivity on RI (single circuit).

Figure 10



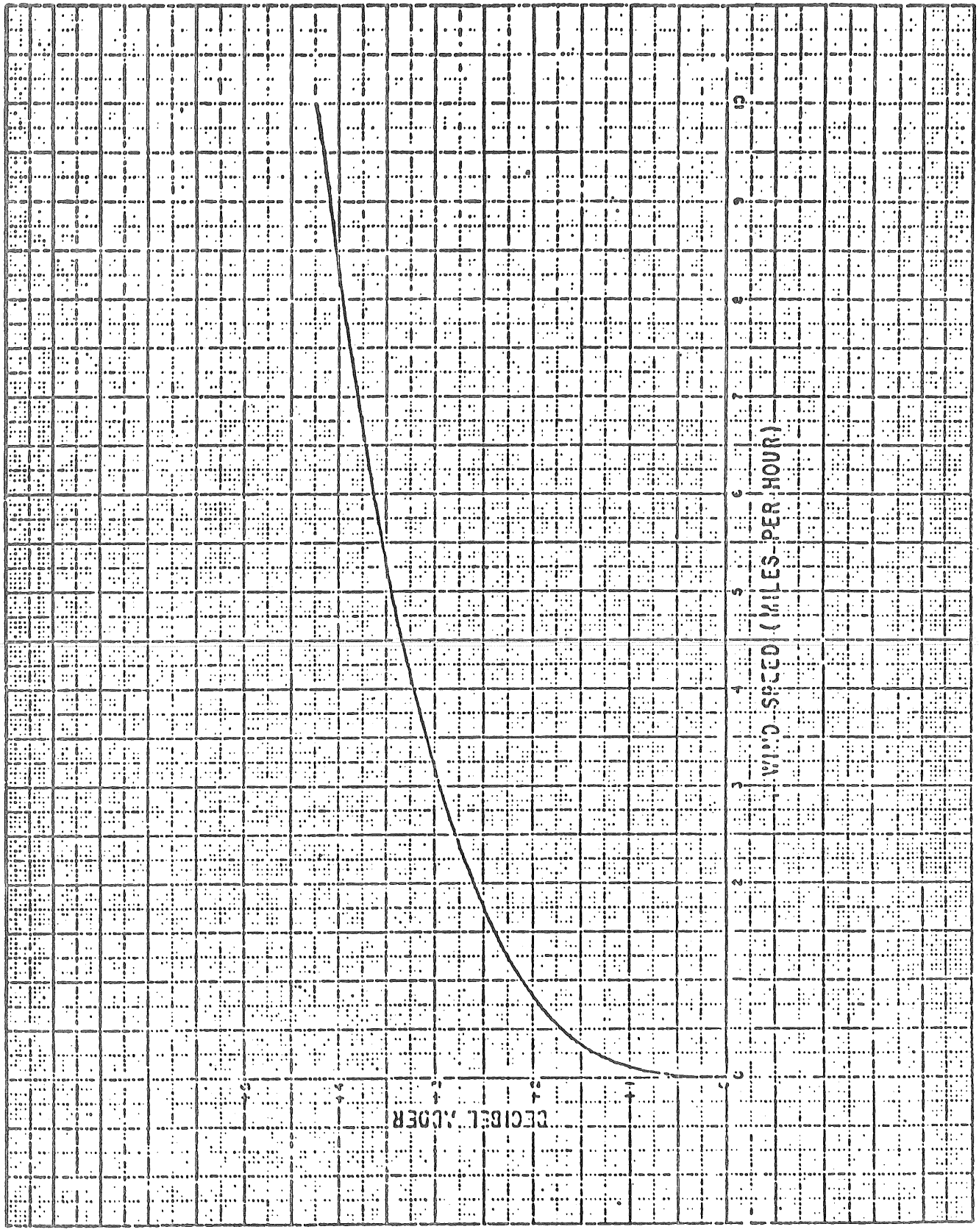
—Effect of relative humidi RI (single and double circuit—all phasings).

Figure 11



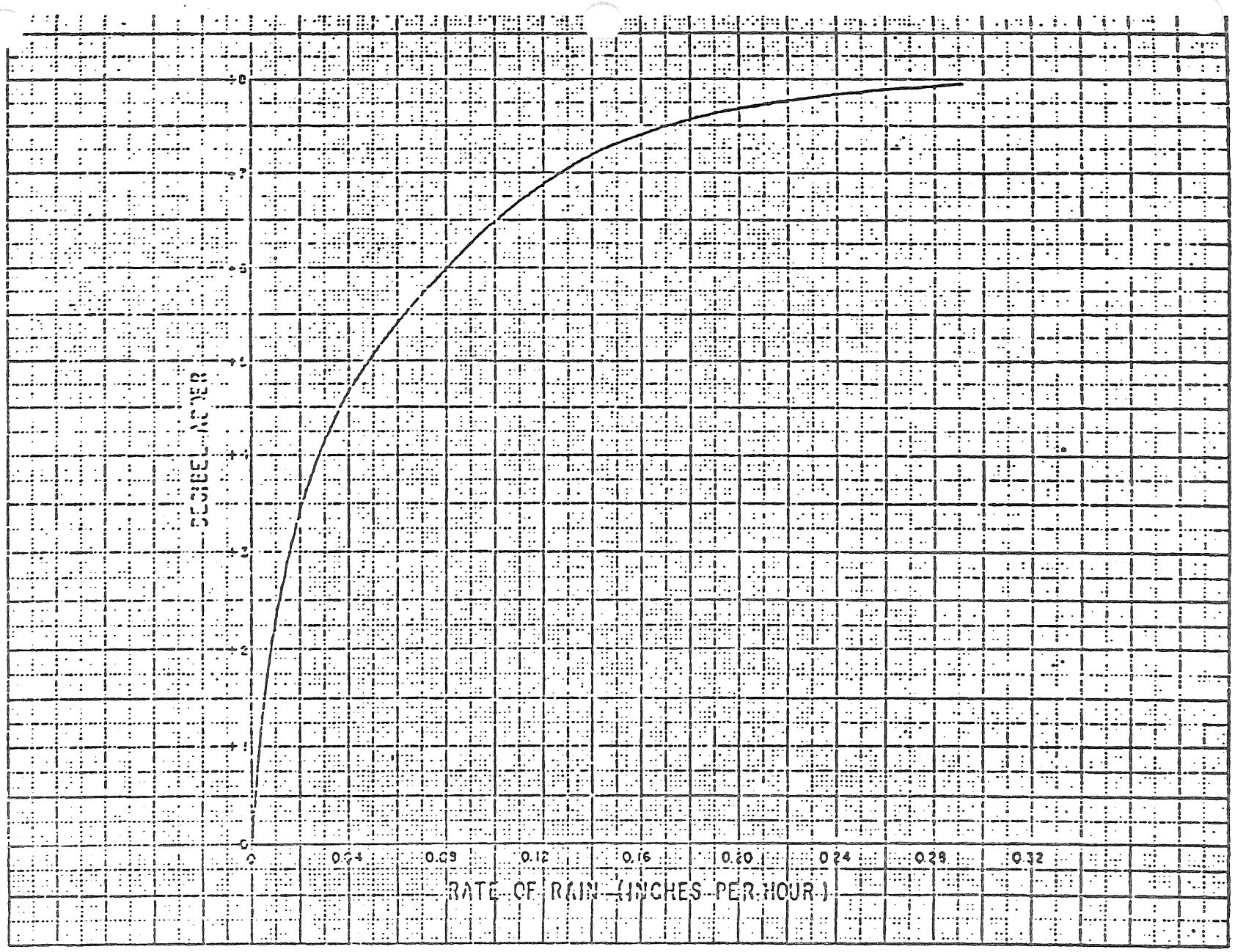
—Effect of relative air density on RI (single and double circuit—all phasings).

Figure 12



—Effect of wind speed on RI (single and double circuit—all phasings).

Figure 13



-Effect of rate of rain on RI (single and double circuit—all phasings).

N.B. Standard adder of + 17 dB whenever rain occurs. Adders above are in addition to 17 dB.

Figure 14

There is some variation in levels calculated depending upon method. The method used above calculates fair weather RI directly. Other methods calculate foul weather RI and subtract 22 dB to obtain the fair weather level. The 22 dB is based upon the IEEE/CIGRE survey which does not provide sufficient information to be statistically sure that the difference between the mean fair and foul weather levels is 22 dB. However, using such an approach yields levels of up to 5 dB lower.

Two criteria are proposed, one suggesting a fair weather signal-to-noise ratio not below 26 dB, and the other suggesting conformance with noise levels at the edge of ROW from other successfully operating lines.

The FCC recommends signal strengths for primary service to various locations as shown in Appendix 3, "RI Notation." They range from 80-94 dB in city areas, 66-80 dB in residential areas, and 40-54 dB in rural areas.

In consideration of the 26 dB S/N ratio criterion, it is noteworthy that in rural areas the S/N may be below the recommended criterion even before the line is in operation. Also, it should be noted that the location chosen is the most severe--i.e., edge of ROW. Consider able care should be taken to ensure that the line route avoids habitations and thus, in most cases, receivers will be located at some considerable distance from the edge of ROW.

2.4.3 Television Interference

Identification and Description of Electrical Effect

Television interference from transmission lines primarily results from the effects of isolated noise sources caused by sparking hardware, for example. As such, this source of interference can be located and corrected in the field by normal maintenance methods.

Noise generated by conductor corona predominates in the Standard Broadcast band, falling off rapidly with increasing frequency. Table 15 indicates normal frequency bands for broadcasting services.

Table 15

Frequency Bands (MHz)

.535-1.605	Standard Broadcasting	AM	
54-88	TV, VHF Channels 2-6	Audio	FM
		Video	AM
88-108	FM Broadcasting		
174-216	TV, VHF Channels 7-13	Audio	FM
		Video	AM

It should be noted that corona noise will not affect FM signals due to the nature of the modulation and the interference. Thus only video interference on a TV set may be expected. In certain cases TVI from sources other than the conductor may become apparent. There may be loose or defective hardware causing some sparking to occur.

Criteria for Assessment of Electrical Effect

Many of the comments in the radio noise section apply here also. The signal-to-noise ratio is again the criterion for quality of reception and the principal service area is again the area of major concern. As in the radio noise case, a table may be constructed of reception qualities [34] in terms of S/N ratio as shown below.

Table 16

Reception Qualities

Signal-to-Noise Ratio in dB	Reception Quality
> 36	Excellent
27-36	Very Good
17-26	Good
4-16	Poor
-10-3	Very Poor
<-10	Intolerable

From this table it is clear that a signal-to-noise ratio greater than 17 dB will result in good reception quality. The criterion for television interference is thus recommended as being 17 dB or better. It is further recommended that this criterion be applied to fair weather conditions using the same rationale previously employed in the radio noise section.

Presently no theoretical methods exist for prediction of TVI. However, the relationship between frequency and noise is known and it is possible to estimate TVI knowing RI. Since a TV receiver's bandwidth is in the order of 3 MHz compared to an AM radio's bandwidth of 5 kHz, a correction must be made for this also.

Pakala and Chartier[47] determined empirically a general relationship between noise and frequency. It may be stated as:

$$\Delta dB_f = -20 \log_{10} F$$

where ΔdB_f is the frequency dB correction factor, and

F is the frequency in MHz.

No extensive tests were made to test this relationship except to determine that it is dependent upon the lateral distance away from the line and holds true for lines of different voltage. An estimate of its average accuracy is $\pm$ 5 dB.

Correction of noise to different bandwidths may be accomplished with the relationship:

$$\Delta dB_f = 20 \log_{10} \left(\frac{F_2}{F_1}\right)^{\frac{1}{2}}$$

where

ΔdB_f is the bandwidth correction factor, and

F_2 is the desired bandwidth, and

F_1 is the reference bandwidth.

The most conservative case to analyze will be determining the interference on Channel 2. Here the noise will be at its greatest as it decreases with frequency. Thus, assuming a video carrier frequency of 55 MHz and a receiver bandwidth of 3 MHz:

$$\Delta dB_f = 20 \log_{10} 55 = -34.7 \pm 5 \text{ dB}$$

$$\Delta dB_f = 20 \log_{10} \left(\frac{3}{.005}\right)^{\frac{1}{2}} = \underline{28.0}$$

$$\underline{\underline{-6.7}} \pm 5 \text{ dB}$$

The total correction is -6.7 ± 5 dB.

The FCC recommended signal strength for the principal service area for Channels 2-6 is 74 dB, and for Channels 7-13 is 77 dB.[42]

Assuming that foul weather RI is 17 dB above the fair weather RI and that the frequency correction holds in foul weather, it is possible to estimate the foul weather TV reception quality.

..4.4 Gaseous Oxidants

Identification and Description of Electrical Effect

Gaseous oxidants may be produced by corona activity in air. The operation of a transmission line can produce corona under certain conditions. These generally are associated with imperfections in the energized line hardware caused by line construction, component manufacture, or natural conditions. The latter includes airborne contaminants and rain conditions. The utility has an incentive in reducing these imperfections as they constitute a corona loss; however, some do occur, mainly due to damage when stringing the conductor and the natural effects.

These oxidants are of concern as they may produce adverse effects on flora and fauna in the form of air pollution.[46] The main concern is over the production of ozone (O_3) and nitrogen oxides (NO and NO_2). Ozone is the major constituent in the oxidant produced.

Criteria for Assessment of Electrical Effect

The National Primary Air Quality Standard issued by the Environmental Protection Agency for photo-chemical oxidant has been adopted by New York State and prescribes:

> "... a level of 0.08 parts per million by volume (ppm) as a maximum one-hour arithmetic mean concentration not to be exceeded more than once a year. Air Quality Standards issued by individual states are generally consistent with Federal requirements but in some cases more restrictive. For example, Ohio calls for a maximum one-hour mean of 0.06 ppm and a maximum 24-hour mean of 0.02 ppm."

Ozone may be detected by smell at concentrations of .02 to 0.5 ppm.

It has been determined that oxidant half-life is less than one hour, and is inversely proportional to humidity; this being due to recombination of the oxidants in the presence of water. In addition, wind plays an important role in diffusing the oxidants produced.

Analytical studies and field measurements on EHV lines and based on conservative assumptions have determined that measurable concentrations of oxidants at ground level are essentially zero.[49] Their conclusion was found to be valid under all weather conditions and in no case were concentrations measured above ambient at ground level.

Other work on oxidant production is reported in References 50-53, which completely supports the findings cited above. In general the instrumentation used was capable of detecting concentrations in the order of .002 ppm and in no case was any concentration above ambient levels measured. Ambient levels may typically be .04-.06 ppm on a sunny day.

2.5 Long-Term Field Effects

The short-term biological effects of electrostatic and electromagnetic fields have been discussed in Sections 2.2.1, 2.2.3, and 2.3.4. These generally involve an immediate physical reaction from shock or bodily malfunction and may be characterized as short-term and transient. After this type of exposure, there is no evidence to indicate any delayed physiological changes. It has been suggested[35,54-59] however that exposure to these fields may have subtle and possibly lasting influences on bodily processes both at the physiological and behavioral levels.

2.5.1 Human Exposure

Identification and Description of Electrical Effect

Long term effects such as "headaches...shattering dynamic state of the central nervous system, heart and blood vessel system and in changing blood structure...reduced sexual potential" were reported in Reference 54 from exposure to the field. Also claimed was "disturbances in the stimulating and checking processes in the cortex which bring about involuntary movement reaction...respiration and heart rhythm can be disturbed too" from the influence of discharges. Others cited a decrease in response time in monkeys,[55] eeg changes in cats,[56] possible affect on serum triglycerides in humans,[35] increase in reaction time in humans,[57] and unspecific magazine reports.[58,59]

Much of the work reported in References[35, 55-59] has been on animals or under laboratory conditions. Korobkova[54] et al is the only report directly relevant to field conditions but as will be shown later, their procedures and conclusions have been criticized as being clinically suspect. On the other hand, however, there is a body of work and opinion[60-67] indicating no long-term effects whatsoever under field conditions.

Finally, there is extensive utility experience with exposure to lines of lower voltage (besides that reported in References 61,62,64). To date there have been no reports of any ill effects.

Analysis of the work to date is presented in the following discussion.

Criteria for Assessment of Electrical Effect

The Russian[54] CIGRE paper and its related references is so far the only work available positively claiming ill effects in humans and recommending rules to avoid these effects in humans and recommending rules to avoid these effects. These rules are reproduced in Table 17.

Table 17

Nos.	Electric field intensity kV/m	Permissible duration of personnel stay in electric field during 24 hours min	Notes
1.	5	unlimited	Points 2, 3, 4 and 5 of the regulations are valid if 1) all the remaining time a man is in areas where electric field intensity is less than or equal to 5 kV/m 2) a possibility of electrical discharge influence is eliminated
2.	10	180	
3.	15	90	
4.	20	10	
5.	25	5	

The reported ill effects were associated with direct exposure to the field and electrical discharges. From Table 17 it can be seen that the rules for fields above 5 kV/m confine their application to the effects of direct exposure only, where the possibility of shock discharge has been eliminated. From practical experience and discussions with workers in the field, it it agreed that the effects of constant spark discharges are annoying, create tension, and eventually tiredness. There is no published work to substantiate this, but the problem is recognized by utilities and prevented with appropriate grounding procedures. In any case it is unlikely that a person experiencing an annoying discharge would continue the action producing it and thus suffer from the above effects. The real problem lies in identifying critical areas and in correct grounding procedures.

Direct exposure to the electric field was reported as having various ill effects as outlined previously. These were based upon medical and physiological examinations of personnel working in HV substations. Lack of data from these examinations and on other working conditions in the USSR, as well as historical medical data on the subject, has prevented analysis of the Russian findings.[60]

As a follow up, on February 18-19, 1975, the USA-USSR Working Group on UHV Transmission met in Washington, D.C.[63] The USSR representatives presented a paper giving current USSR line design gradient standards as:

20 kV/m	for difficult terrain
15-20 kV/m	for non-populated regions
10-12 kV/m	for road crossings.

In this the cumulative effect of the field due to "infrequent and nonsystematic exposure of the local population and the agricultural workers can practically be disregarded." These standards are based on extensive experience on 500 kV lines with 10-14 kV/m gradients.

Page 3 of this same reference [63] quotes from a letter from one of the Russian authors about USSR linemen not complaining of any effects to their health as opposed to the men working in substations of the same voltage class.

Discussions[60] (Caleca and Barnes) to the Russian paper in 1972 indicated that no ill effects had been noted in the USA as a result of a study of linemen on the AEP system. They were exposed to gradients of up to 15 kV/m with no shielding and 470 kV/m partial shielding.[61,62] Exposure was estimated as being about 100 hours per year at average field strengths of 11-12 kV/inch (433-472 kV/m). In addition they are exposed to lesser levels at ground level during the course of their work. Another discusser[60] (Singer) showed an increase in human reaction time after application of a 15 kV/m field.

Reference 64 reports the final findings of the Johns Hopkins study of AEP linemen that was previously reported.[61,62] The study was over a period of nine years and involved originally 11 and finally 10 linemen. One dropped out of the study as he gave up his employment before the study completion. Complete medical history, physical and phychological examinations were performed at intervals over the nine years. It reports that "...the health of these 10 men has not been changed in any way by their exposure to HV lines...." A direct comparison with the Russian results is difficult as neither paper gives actual field exposure times at each gradient level. This is not surprising due to the inherent difficulty in collecting such data. However, it is possible to make some general observations about average exposures in the US study. Based on the 100 hour per year exposure mentioned previously and assuming 244 work days per year, the AEP linemen were exposed to fields of 433-472 kV/m for approximately 25 minutes each work day. This exceeds the limits shown in Table 17 by approximately 25 times the recommended maximum field of 18 kV/m for a 25-minute exposure. From these considerations it seems that the exposures experienced by the AEP linemen were at least an order of magnitude more severe than their Russian counterparts, and with no reported ill effects.

Dr. Knickerbocker et al [66] made tests on mice with fields of up to 160 kV/m and did not determine any ill effects. Extrapolation of these results to the human condition is not suggested as possible but is reported as relevant preliminary background data.

Dr. R. Adey of UCLA has reported [55] some decrease in the response time of monkeys when they are subjected to electric fields of 10 kv/m at frequencies of up to 16 Hz. Also reported were some non-significant eeg changes in cats from VLF fields.[56] However, in a letter [65] to Dr. John Simmons of the Committee on Science and Astronautics for the House of Representatives he states that "tests on monkeys with field frequencies in the range of 45-75 Hz indicate that these fields are less capable of altering nervous functions and thus that susceptability to electric fields from power lines and domestic appliances operating at 60 Hz may be quite small." He has not reported any 60 Hz tests at field levels associated with power lines which are several orders of magnitude greater than his 10 v/m and thus conclusions on the effect on humans must await further work.

In Munich, Germany, preliminary studies [57] are under way with humans exposed to electric fields of up to 15 kV/m at 50 Hz with alternating exposures of 45 minutes on and 45 minutes off. Tests on pulse rate, blood pressure, ecg, and eeg have not indicated any changes.

Reaction times, however, have increased marginally after application of the field. This work is ongoing and no conclusions have yet been formed.

It is interesting to note that utilities around the world have reacted to the Russian findings in different ways. In England, the CEGB [68] has stated that "a suitable, though possibly rather conservative 'reference level' of field strength (for UHV lines) is 10 kV/m." The State Electricity Commission of Victoria in Australia has adopted the Russian criteria as an interim measure but feels that they are "far more severe" [69] than necessary. The Norwegian Research Institute of Power Supply [70] reports that "the Russian reports seem to give very pessimistic figures. . . ," while the Electricite de France [71] considers the Russian statements "much too severe." Finally, the Swedish State Power Board [72] has been making tests with 50 Hz fields with levels of 100 kV/m with some effects being noted "but they have not shown statistical significance."

Concerning electromagnetic fields, a study has been made on the possibility of direct human perception of magnetic fields. [36] Sixty Hz fields in the neighborhood of 10 gauss rms were used. Summarizing the results, the authors report that "it is unquestionable that subjects can, under some conditions, sense the presence of a magnetic 60 Hz field or subtle clues incidental to its generation. . . (at present) it would be impossible for us to conclude that there is no direct magnetic perception, but on the other hand, there is. . . no overwhelming evidence for such perception."

The Project Sanguine of the U.S. Navy has made extensive tests on the effects on man of magnetic fields [35] at frequencies of 45 Hz. The field level was 1 gauss which compares to a sample maximum transmission line field under emergency loading conditions of .8 gauss at 60 Hz. Their findings were that "no effects were seen that could be definitely linked with the magnetic field; however, serum triglycerides in most subjects appeared to be affected by some factor or combination of factors associated with the experimental protocol." In a letter, Dr. P. E. Tyler, [67] Head of the Navy's Electromagnetic Radiation Research Division, states that:

> "I should point out that while several projects have found indications of possible biological effects, none have been proven to be the sole result of electromagnetic radiation exposure. The main thrust of our future research will be to verify the previous findings and if the alternations are caused by electromagnetic radiation, to determine the biological significance of the alternations.

"As noted above, the changes observed to date have generally been in small animals. Together with the positive findings have been several programs which found no effects. At the present time I would hesitate to describe the possible effects as hazardous, for as you may be aware, there are several studies underway in medical centers using electrical stimulation to enhance wound and fracture healing. Again, most of the studies are in early stages of research, but if proven, certainly will be of great benefit to medicine."

A report by G. E. Kaufman and S. M. Michaelson of the University of Rochester School of Medicine and Dentistry [73] gives results of experiments performed to determine the effects of static and alternating magnetic fields on man, as well as shielding man from the normal geomagnetic field. As a result of tests on animals and careful observation of personnel employed at the center, the Stanford Linear Accelerator Center has established a set of safety standards for human exposure to magnetic fields. These are given in Table 18. Messrs. Kaufman and Michaelson also give results of some Russian experiments on workers occupationally exposed to magnetic fields to their hands. General symptoms reported include headache, fatigue, low blood pressure, and decreased white cell count. Also specific effects to the hands included sweating of the palms, high skin temperature, subcutaneous edema, and shedding of skin on the palms. As a result of this study, criteria were formulated which are given in Table 19. Since these criteria are orders of magnitude higher than magnetic fields likely to be found under power transmission lines, small refinements in the data would leave the conclusions unchanged.

TABLE 18

SAFETY STANDARDS FOR MAGNETIC FIELDS RECOMMENDED BY THE STANFORD LINEAR ACCELERATOR CENTER

	Extended Periods (Hours)	Short Periods (Minutes)
Whole body or head	200 G	2,000 G
Arms and Hands	2000 G	20,000 G

TABLE 19

SAFETY STANDARDS FOR MAGNETIC FIELDS RECOMMENDED BY A.M. VYALOV

	Field	Gradient
Whole Body	300 G	5-20 G/cm
Hands	700 G	10-20 G/cm

There is no evidence of x-ray radiation from transmission lines. Kouwenhoven [62] attached photographic negatives to an energized 345 kV line for nine weeks. No evidence of x-ray radiation was noted on the film or on other detection devices at any time.

In conclusion, a discussion on the probability of members of the public encountering these fields is in order. The maximum electrostatic field from EHV lines is normally less than 10 kV/m under the most severe conditions. Even at this, the exposure area is confined to a small area beneath midspan on each span of the line. The ROW has restrictions on use for other reasons, and thus activities within the ROW are essentially transient in nature. In other words, exposure to these fields will be naturally limited to passing under the line with a tractor, walking under the line, etc. Even the Russian criteria allows a three-hour exposure per day to fields of 10 kV/m. Thus, in practical cases, what is generally acknowledged as the most severe criteria will probably not be exceeded. Outside of the ROW where fields are generally less than 2.5 kV/m, there will be no problem with unlimited exposure with the same criteria. The conservative electromagnetic criterion of 1 gauss is normally not exceeded at ground level either on or off the ROW under any condition. These maximum fields must be confirmed for any specific line in question.

2.5.2 Flora and Fauna Exposure

Identification and Description of Electrical Effect

The previous discussion concentrated on humans, but naturally flora and fauna will be exposed to the same fields from the line. Presently there is no evidence and, therefore, no basis to believe that there will be any ill effects. Inasmuch as large farm animals such as pigs, cattle, etc. have the same relative biological characteristics as humans, some of the shock effects may be present. Animals, however, tend to be better grounded in natural conditions than humans and there is plenty of experience with livestock grazing beneath power lines. The same is true of crops. At experimental stations higher gradients than those projected for EHV lines have been employed for some time with no ill effects noted. Further, the Hydro Quebec 735 kV and AEP 765 kV systems have both been operating for a number of years over hundreds of miles with no ill effects of this nature being reported.

Considering the bird problem, there is field evidence that birds will avoid EHV energized hardware. The higher voltages are in fact safer for birds by virtue of the increased clearances and lower probability of flashover.

Criteria for Assessment of Electrical Effect

The Kaufmann and Michaelson report cited in Section 2.5.1 indicates no clear evidence exists for a harmful effect due to low frequency electric fields. Knickerbocker's study [66] on 22 mice in electric fields of the order of 150 kV/m for approximately 1500 hours over a period of 10.5 months concludes: "...there have been no signs of a detrimental effect of this field on the animals. Likewise, there is no significant beneficial effect. Male progenies of these animals did not grow to be quite as heavy as progenies of control animals, the difference being small but significant and the reasons not evident." Hence, no criteria exist for animals in an electric field, and, at any event, would be greater than the fields experienced under transmission lines.

Regarding magnetic fields, the Kaufmann and Michaelson report gives results of animals being exposed to very high fields. Mice, monkeys, and Drosophila were among the animals investigated. In all cases, the fields involved were orders of magnitude higher than would be involved in power transmission, and hence no meaningful criteria can be set.

As for the case of human exposure, the field intensities under transmission lines are significantly below the criteria. Long-term effects of exposure to the field are not a matter of concern. More to the point is electric shock to animals, which comes under consideration of grounding of structures close to the line.

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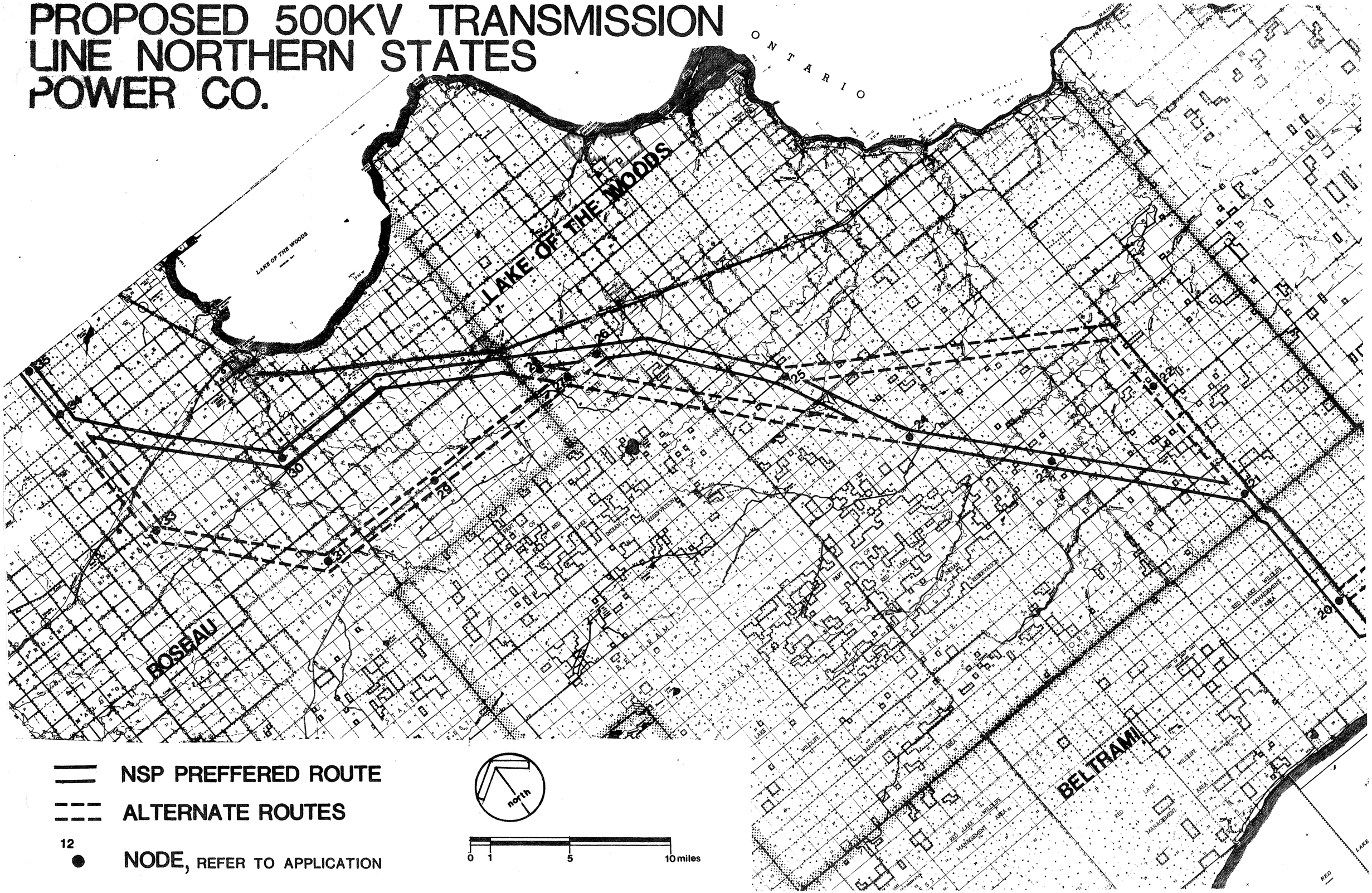
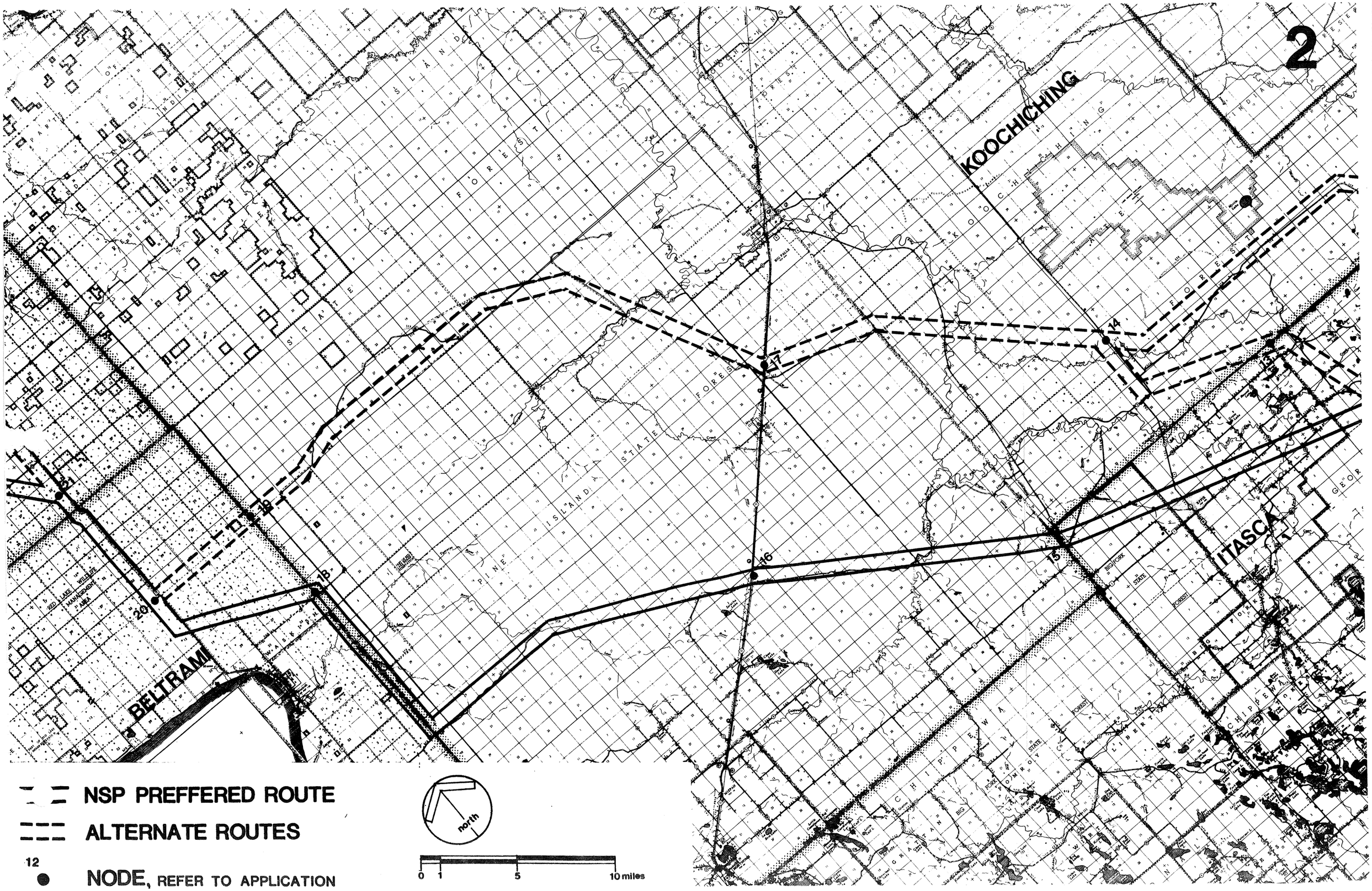
PROPOSED 500KV TRANSMISSION LINE NORTHERN STATES POWER CO.



NSP PREFFERED ROUTE

ALTERNATE ROUTES

12 ● NODE, REFER TO APPLICATION


2
KOOCHICHING
ITASCA
BELTRAMI
PINE ISLAND STATE FOREST
STATE FOREST
INDIAN RESERVATION
RED LAKE WILDLIFE MANAGEMENT AREA
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KOOCHICHING

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