ASSESSMENT OF WATER AVAILABILITY IN MINNESOTA

RECOMMENDATIONS ADOPTED BY
THE EQB WATER RESOURCES COMMITTEE

October 4, 1991

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Issues and Recommendations
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ISSUE: The state does not have sufficient information about ground water resources to adequately manage water appropriations and protect water quality. With the exception of several sand plain aquifers in central Minnesota and the Twin Cities Metropolitan Area (TCMA), the yield potential of most ground water sources in the state is uncertain and cannot be determined quickly. Information about buried aquifers is lacking. Presently, the state is accelerating regional aquifer assessments and county geologic atlases.

RECOMMENDATION: Continue the acceleration of regional aquifer assessments and county geologic atlas. Begin a concerted effort to identify buried aquifers. Develop an ongoing program to analyze aquifers for safe yield. Expand the observation well network so it can serve as a management tool. Work toward developing a TCMA and a statewide ground water model to assist water management efforts.

ISSUE: The state does not have sufficient information about surface water resources to adequately manage water use to protect stream flows. The stream gage network is limited. Ecological and recreational benefits of surface water are difficult to measure when allocating water among competing uses. There are few protected flows established for streams. Those that are established are not sufficiently supported by research.

RECOMMENDATION: Expand the state's streamflow gaging stations so that flow in the 81 watersheds can be ascertained with sufficient certainty to manage availability. Ensure that the contributing watershed is evaluated so that each gage can be accurately interpreted. Document ecological and recreational benefits. Accelerate comprehensive program development and determination of protected flows. Relate observation wells and precipitation to watersheds to better understand ground and surface water interconnections.

ISSUE: The state's water use and water supply data are not analyzed or disseminated to discern trends. Information about specific aspects of water use is missing, such as the domestic or industrial use of public supplies. Consumptive use is not reported or routinely calculated. Neither local government nor the state project future water use. Management is a reactive process.

RECOMMENDATION: Gather, analyze, and disseminate annual water use data for watersheds, aquifers, and counties, by major use categories so trends can be readily ascertained. Develop consumption coefficients for major water uses and estimate present and future water consumption. Local government and the state should project future water needs.

ISSUE: Relying on information from state permits poses problems for estimating water use. The state has little idea of how many appropriators fail to apply for required permits, or how many permitted appropriators fail to report accurate pumpage amounts. Because reporting is incomplete and unverified, the unreliability of the data make them difficult to use. In addition, a permit is not required from those appropriating less than 10,000 gpd or 1 million gpy.

RECOMMENDATION: Expand enforcement efforts in order to assure that all those requiring a permit have a permit. Ensure permit holders comply with requirements for pumpage reporting, contingency planning, and conservation planning. Work with the U.S.Geological Survey and U.S.Department of Agriculture to develop approaches for consistently estimating water use and consumption by non-permitted users.

ISSUE: The Minnesota Geological Survey (MGS) provides vital information about the state's hydrogeology. Its mapping and technical assistance is crucial for many programs, such as county geologic atlases. MGS is not funded for FY 1993 jeopardizing a great deal of geologic work underway.

RECOMMENDATION: Fully fund the MGS in FY 1993.

ISSUE: The state has a large number of multi-aquifer wells that were constructed before the well code prohibited them. This type of well can provide a conduit for pollution from upper aquifers to deep aquifers. Multi-aquifer wells to the deep, relatively pure Mt. Simon-Hinckley (MSH) aquifer are used extensively in southeast Minnesota, including the TCMA. In fact, multi-aquifer wells provide the second largest amount of ground water used in the TCMA. Although the well code now prohibits their construction, reconstruction is not required of existing multi-aquifer wells, unless they are a proven pollution hazard. Some factors hampering well sealing include the difficulty of identifying well owners and the refusal or inability of some owners to seal wells.

RECOMMENDATION: Promote sealing abandoned multi-aquifer wells. To accelerate this effort, create a revolving fund to seal abandoned wells where the current owner cannot be located or refuses to act. Make the MSH the initial priority for this fund with a five-year target for sealing all its multi-aquifer wells.

MDH, in cooperation with BWSR, should develop a plan for the timely assessment of operating multi-aquifer wells. Owners of multi-aquifer wells vunerable to contamination must immediately take corrective action to prohibit the introduction or spread of contamination. Other owners should propose within two years of notification by MDH, how and when any multi-aquifer wells will be made to conform to well code requirements. After the two year deadline, the state may require monitoring of multi-aquifer wells at the owner's expense as a condition of continued well operation.

ISSUE: Local government has land use and growth management authority. Some cities are expecting to double or triple current water use with little consideration given to the overall effect increased demand may have on watersheds and aquifers. Comprehensive water plans, prepared by counties in greater Minnesota can address water supply and water use issues. The state water appropriation program is reactive to many local decisions. The state has the authority to work with local government to develop Water Appropriation and Use Management Plans (MR 6115.0810).

RECOMMENDATION: Strengthen comprehensive local water plans in greater Minnesota to ensure they specifically address: water use anticipated for growth; the effect of growth on water demand; water demand management; and related water quality issues. Plans should coordinate water supplies and water use with other affected counties.

RECOMMENDATION: Establish a local-state pilot program for several counties experiencing growth pressure. For this program, the state would develop a Water Appropriation and Use Management Plan, working with comprehensive local water planning. The state would promote cooperation among water suppliers.

ISSUE: In the TCMA, there is no regional framework for water supply for the over 2.2 million people, 130 municipalities, and 1300 water appropriators. This has engendered a fragmented approach to surface and ground water management.

Comprehensive plans are required in the TCMA to manage growth. They must contain land use and public facilities components. The Metropolitan Council provides a regional framework for TCMA growth management. It is also responsible for developing a long-term water supply plan for the region. A Metropolitan Council plan can provide guidance to the TCMA for water supply use, conjunctive use, demand management, and water supply sharing.

RECOMMENDATION: The Metropolitan Council should provide a framework for managing water supplies, water demand, and water conservation in the TCMA. Local comprehensive plans should specifically address anticipated water use, conservation, and demand management and conform to the regional framework.

ISSUE. The existing permit system does not lend itself to managing the resource. MDH regulates well construction. It either permits or gets a notification of planned well construction. The DNR regulates water appropriations and requires a permit for larger volume water users. However, the law allows well construction before an appropriation permit is sought. There is an expectation a permit will be given, making the appropriation permit a reactive process.

The connection between surface and ground water is not recognized in the appropriation permit program, even when ground water use may draw down surface water supplies. Presently surface water appropriators face permit restrictions during times of drought, but ground water users do not. Surface water users must prepare contingency plans, but ground water users do not. Conjunctive use of surface and ground water is not promoted. Thus, once a ground water permit is given, the user ceases to use surface water even if more abundant.

Most water utilities profit from increased water use. Thus, there is little incentive to promote conservation or share supplies. Conservation plans are required only for new or amended permits. There are no state standards or teeth in conservation planning. There is little planning to manage demand.

300-900 high capacity wells are constructed ea year. They can c ate a large cone of depression. When an appropriator sites a well, insufficient consid ration is given to the closeness of other wells, the impact of additional pumping, or whether surface water or better demand management might be preferred.

RECOMMENDATION. Enact legislation to restructure the process for regulating water supply development according to the following three poi s. This includes legislation to prohibit well construction until after an appropriation permit or permit amendment is granted or conditional approval is given. Note: If an appropriation permit is not required, the process for well construction does not change.

1) An applicant for a water appropriation permit or permit amendment should be required to complete a "certificate of need", which must include documentation that:

   a. The need is legitimate and consistent with the local water plan, and that demand is properly managed;
   b. An acceptable contingency plan and conservation measures are proposed; and
   c. Conjunctive use between surface and ground water has been appropriately considered.

2) The DNR, in conjunction with state agen ies concerned with water quality and supply management, should conduct a resource assessment that includes:

   a. Verifying that the proposed water use and source are consistent with water use recommendations contained in the local water plan and in any Water Appropriation and Use Management Plans under MR 6115.0810;
   b. Determining the appropriate water supply is used (surface, ground, conjunctive, or reuse);
   c. Evaluating the proper placement of high capacity wells;

d. Determining appropriate permit conditions to safeguard environmental quality (e.g., incorporation of best management practices or water resources protection requirements for water quality protection, or to minimize soil erosion,);

e. Determining appropriate permit conditions for wells to ensure instream flow conditions are protected; and

f. Providing conditional approval for ground water appropriations until a water well record is submitted and any required pumping test is submitted.

3) The DNR should develop a plan for the timely review of existing appropriation permits to ensure that: a) all appropriators meet requirements specified above, and b) all permits are reviewed within five-year increments.

STAFF DRAFT

The Setting

Minnesota has abundant water. However, water is not always available when and where it is needed. There are local areas in the state where demand for water exceeds the supplies at hand. There are local areas where, under certain conditions, an aquifer or stream is stressed from use. There are areas where water quality bars some uses. There are areas where the potential exists for a major spill to jeopardize key supplies. There are areas where problems will develop in the future without proper management. Some problem areas are identified, but many are not.

Precipitation, floods, drought, water use, and water quality are some of the factors that affect the amount of water available in any given place for any given use. To understand whether there is adequate water to meet present and future needs in any given location depends on:

1) understanding how much surface and ground water is present under differing climatic conditions;
2) having accurate, accessible data on amount and types of water use;
3) relating water use with surface and ground water supplies; and
4) projecting future water needs and tying projections to accessible water supplies.

Gaps in Information

Basic lack of information makes assessing water availability to meet present and future demands difficult. Minnesota does not have sufficient water supply information about many watersheds. Only 49 of the 81 major watersheds have stream gages. Many with gages do not acurately represent stream flows because they are not at the watershed outlet or dams influence the reading.(Figure 1)

Information about Minnesota's ground water system is lacking. The state has only 650 observation wells to monitor ground water levels. (Figures 2,3,4,5) Some aquifers do not have observation wells, and some aquifers have only a few in scatted locations. In contrast, North Dakota has abcut 1800 observation wells.

Water use information is incomplete. Much water use data is based on information from water appropriation permits and pumpage reports. The requirements for these have changed significantly throughout the years and data about water use have varied reflecting these changes. (Figure 6)

Even now, with the state requiring more complete information from water users, a pumpage report from one appropriator may reflect multiple uses. For example, municipal use may include industrial use, golf course irrigation, as well as domestic use, but these uses would not be broken out when reported.

Relying on information from state permits also pose problems since there are problems ensuring complete permit enforcement. There are estimates that 10-15 percent of the irrigators do not report their use, and an unknown number of users that are required to have a permit do not have one. Minnesota does not require a permit of domestic users serving less than 25 persons or those appropriating less than a minimum amount(10,000 gal/day or one million gal/year.) Thus these uses can only be estimated.

Water use records of the DNR, in conjunction with the USGS are the best source of information. However, relying on these agencies for usage is difficult because each estimates use differently. Each uses a different approach when aggregating categories of water use and when estimating different types of use. Presently, the state collects data, but does not routinely analyze data for any implications affecting water availability.

Overall use trends in water use are interesting. However, it is also essential to understand where water demand is occuring or is projected to occur in relationship to the location of water supplies. It is also important to understand how much of this use is consumed to understand whether it is available for other uses. Presently, the state does not estimate consumptive use.

The following are examples of water use and consumptive use. In 1985 irrigation, livestock, and agricultural processing represent 9 percent of all water withdrawals. However, these uses consumed 23 percent of water withdrawals. In contrast, power production uses the largest quantity of water. However, most of the water used is not consumed and thus is available for other uses.

Cities generally don't want it known if they have supply problems for fear it may deter growth. State agencies are very sensitive to this. Thus it is very difficult to get information about water availability problem areas.

<u>Minnesota Authority to Regulate Water Use</u>

Minnesota has authority in statutes and rules to limit water use for environmental protection and to safeguard water resources. These limitations include permit authority, establishing protected flows for watercourses, protecting elevations for water basins, and limiting use of aquifers to protect the safe yield. There are recent restrictions on use of ground water for once-through cooling systems and lake level augmentation. Certain uses of the Mount Simon-Hinckley aquifer are restricted in the Twin Cities Metropolitan Area (TCMA).

Establishing protected flows enables the state to ensure that the ecology of the stream is protected. The DNR has established protected flows on portions of 45 water courses. Only 19 of these streams have gages which makes enforcement difficult. Minnesota has restricted permits so as not to safe yields and has denied at least one permit.

During the drought of the late 1980s, Minnesota suspended 195 permits from numerous surface water systems: 167 for agricultural irrigation; 17 for golf courses; and 11 others. (Figure 7) Ground water users were not restricted. This is a problem because wells in adjacent alluviial aquifers directly affect streams.

Figure 8 shows the similarity between stream flow and ground water levels on the Pomme de Terre. While surface water appropriators were restricted, ground water users were not. The river went dry.

Work Underway

To manage water efficiently, the state cannot wait for the inevitable crisis to develop information about water supplies and use. It must systematically build adequate information systems and work with local governments as they plan their growth to ensure that water resources limitations are considered throughout the local and state planning processes.

Several initiatives are underway to improve the information base. In work with the U.S.G.S., the Department of Natural Resources is setting up a data system so that ground water use is tied to the appropriate aquifer. DNR is establishing more gaging stations and observation well stations.

The Land Management Information Center is establishing a ground water clearing house that will tie together aquifer and water use information. The Metropolitan Council has conducted an extensive study of water availability for the Metropolitan area. This analysis points the way to the type of analysis needed in other places.

Through recent EQB efforts, the Department of Health agreed to change its Municipal Water Supply Survey Form. In the future it will request more information from municipal water suppliers about the types of water uses in each system.

Water Resources of Minnesota

Surface Water System

The distribution of surface water and ground water varies considerably throughout Minnesota. Runoff is greatest in northeast Minnesota and least in western Minnesota.

In 1987, DNR compared available surface water supplies with present offstream and instream water use demands. Water shortages and excesses for an aggregation of 39 watersheds were identified. (Figure 9) Data constraints for this study were significant. Of particular note is that only 20 of the 39 principal watersheds had continuous gaging of streamflow at the mouth of the watershed. Water supply for the remaining 19 watersheds was estimated. Ground water supply information was lacking and the amount available was calculated on water use.

STAFF DRAFT

The analysis demonstrated that some areas of the state have a water supply that is highly variable and more vulnerable to drought. Insufficient water supply during critical low flow periods occurs most often in the western and central regions.

Ground Water System

Ground water is available across Minnesota from a wide variety of sources. However, there are significant differences in ground water conditions. (figure 10) Highly productive sedimentary bedrock aquifers underly the southern and eastern part of the state. This includes the TCMA. The Prairie du Chien-Jordan (PDCJ) is the first high-yielding bedrock aquifer and supports the heaviest use. The deepest aquifer is the Mount Simon-Hinckley (MSH), which contains relatively pure, soft water. Because it recharges at a very slow rate, it is greatly affected by pumping.

Surficial sand and gravel aquifers are near the land surface in about one-third of the state. Th' makes them very vunerable to contamination. The amount of water they contain varies considerably. The highest yields come from alluvial deposits along major river valleys, and from glacial sand and gravel deposits. For example, many are not able to supply high rates of pumping needed for irrigation. In areas of the eastern portion of the vast Anoka Sand Plain north of the Twin Cities, the outwash is too thin to maintain high water yields.

Sand and gravel deposits, buried in the glacial drift, constitute important aquifers. They are especially important in western Minnesota where the drift is thickest and where bedrock aquifers have small yields.

Ground and Surface Water Links

The relationship between streams and ground water is dynamic and may vary seasonally because of floods and summer pumpage. Floods raise stream levels relative to ground water levels in banks surrounding the stream. This then slows or reverses the ground water flow to the stream.

During summers, increased pumpage for air-conditioning, irrigation, and municipal supply reduces ground water levels and, consequently, the rate of ground water discharge to streams. Under certain conditions, increased pumpage may be great enough to reverse normal gradients and induce water from streams to flow into ground water systems.

Special studies in various locations demonstrate the interconnection between ground and surface water. Studies demonstrate that water discharge from aquifers to streams is a significant part of streamflow. For example, studies of the Mississippi River at Prescott, Wisconsin, indicated that during January 1977 (a dry year) and January 1982 (a wet year), ground water discharge contributed about 25% and 15% respectively, of the mean monthly flow of the Mississippi River.

STAFF DRAFT

Studies in the Rochester area indicate that the South Fork of the Zumbro River loses water to the ground water system. This loss is assumed to be caused by pumping of nearby high-capacity wells.

Shifts in Water Supplies due to Climate

Variable weather conditions greatly affect water supplies. The past ten years show how quickly conditions can change from high water problems to water shortages. From 1977-1986, Minnesota experienced some of the wettest conditions on record.

In 1985, water table levels were near or above their highest known levels in response to 10 years of above normal precipitation. Dozens of landlocked lakes rose to high levels flooding hundreds of lakeshore homes and cabins. Lake Pulaski in Wright county rose 5.9 feet from 1983 to 1986.

Then in the late-1980s, drought was a major water-related concern. The weather shifted dramatically beginnning in the fall of 1986. April through May precipitation, in 1988, was 6.61 inches - the second driest in the last 100 years. The drought caused ground water levels to decline below previously recorded levels in most of the state. Levels were typically 3-5 feet below summer averages and about one foot below the recorded lows in 1976-77. These levels were typically 8 feet below the recorded high levels in 1985.

The Mississippi River at St. Paul reached low levels previously experienced only in 1934 and 1976. Many lake levels dropped significantly. For example, Lake Minnetonka levels receded by 4.4 feet, while White Bear Lake levels dropped by 4.3 feet.

Confined aquifers, whether buried drift or bedrock, are slower to show the effects of climatic changes than unconfined aquifers. Many of these are still declining, even though there is presently increased precipitation. Only the northeastern and north central regions of the state had water table levels that remained near seasonal averages. figure 11

Water Quality affects availability

Water quality is directly linked to water availability. If water is polluted, it is not available for certain uses. The historic answer to polluted water is to dig deeper wells or look for other sources. This is not always possible. Some individual and municipal water supplies are contaminated and there are no easily accessible sources of clean water.

St. Paul and Minneapolis rely on Mississippi River water for their water supplies. Recently a major petroleum spill occured near the headwaters area of the river. Fortunately, the polluted water did not contaminate the Mississippi, but next time this may not be the case.

A recent study demonstrates how water use influenced domestic water supplies. Water infiltrating through the Anoka Sand Plain is usually relatively clean water with low total dissolved solids. Where it has passed through heavily fertilized fields, it leaches out nitrogen. Normally this water would stay near the top of the water table and discharge to surface water. However, in a study at Lakewood Shores in Benton County, high capacity well pumpage artifically transported the water deep into the aquifer to the point where domestic well users are impacted. Shallow monitoring wells showed had low nitrate levels. Whereas domestic wells at 60 and 70 feet had over 20 ppm nitrate (exceeding drinking water standards).

Surface Water and Ground Water Use

Trends in Water Use

Water resources have always been important in Minnesota. People settled near rivers and used the vast surface water supplies. Ground water gradually became a vital water source in the early 1900s. Early uses were for self supplied industrial, municipal supplies, and water-driven sawmills, flour mills, and hydroelectric plants.

Water use varies across the state. The TCMA uses large amounts for its population and industries. In northeastern Minnesota, large amounts of water are used for iron-ore mining and ore-processing. Irrigation is important across the state.

Water use for public supplies and irrigation is increasing. Since the late 1970s, the source for these uses has changed from surface water sources to ground water sources. Per capita water use approximately doubled from the 1940s to the late 1970s and continues to increase. Irrigation water use has increased dramatically with the greater use of ground water.(figure 12)

Water for industrial use is declining. Some of the decline can be attributed to industries switching from self supplied to public systems. Water used for sugar beet processing demonstrates another type of recent industrial change in water use. To comply with environmental concerns, the five major Minnesota processing plants dropped their water use from 3094 acre feet in 1973 to 806 acre feet in 1985. These plants converted to a closed loop system where water is recycled through the plant many times before it is finally treated and discharged. While this decreases the amount withdrawn, it increases the percentage consumed.

Power generation is the biggest water use. However, much of this water is not consumed, meaning it is available for other uses.

STAFF DRAFT

Population Change

Population growth directly affects amounts of water use. Twin Cities population growth is greatest in newer suburbs and fringe areas. Outward expansion of the densely settled urban areas slowed during the early 1980s, but resumed in the last half of the decade. (Figure 13) Population and economic growth outside the Twin Cities is increasingly concentrated in a series of regional trade and service centers. Populations of almost all of these centers are growing more rapidly in their suburban or fringe areas than in the city proper. Populations of small towns near the regional centers are also growing rapidly. (Figure 14)

The St. Cloud area demonstrates this type of growth pattern. From 1980 to 1990, St. Cloud's population grew from about 42,000 to 49,000. Surrounding cities and townships grew by even higher rates.

Twin Cities Ground Water Use

In the beginning of the century, self-supplied industry was the primary user of ground water. Withdrawals from all aquifers were concentrated within Minneapolis and St. Paul. The earliest industrial and public-supply wells in the Twin Cities were generally completed into the uppermost bedrock aquifer. (Figure 15)

After 1910, the Prairie du Chien-Jordan (PDCJ) was used to meet the demand for more water in downtown Minneapolis and St. Paul areas. It still is the most heavily used aquifer in the TCMA. While the PDCJ is available in the southern portion of the TCMA, the northwestern and southwestern portions lie on the outer edge of the aquifer. These area are not likely to have access to the PDCJ. (Figure 16)

Wells cased to the Mount Simon-Hinkley (MSH) were first drilled in 1922. Most of the early use was industrial. These uses included those requiring soft water, especially for steam boilers, and breweries, laundries, and hospitals. MSH is the second most used aquifer in the TCMA, although it has never supplied more than 25 percent of the total ground water withdrawn.

In the 50s, industrial use of the MSH peaked and was still concentrated within city limits of Minneapolis and St. Paul. Public supply use was only 13 percent. Since the 1960s, many new MSH wells were drilled in suburban areas for public supply, expecially in areas where PCJ is missing.

In the 1970s, withdrawals from PDCJ and MSH declined within Minneapolis and St. Paul city limits. However, growth in suburban areas resulted in a rapid increase in ground water use for public and industrial supples. The new pumping in the surburbs caused pumpage to be less concentrated in the downtown area. The drift is used extensively in western portions of the TWMA where the PDCJ is not available.

STAFF DRAFT

There are 490 municipal water wells in the region. The PDCJ supplies 66.5 percent of the capacity from these wells. Multi-aquifer wells that pass through several units are the second largest supplier at 13.2 percent. Most of these wells take full advantage of the deep system and pass through to the MSH. These wells do not comply with the state well code and can bring contamination to the MSH.

The surficial drift supplies 9.8 percent. This aquifer is very vunerable from contamination from land sources. The MSH directly supplies 7.1 percent. 25 percent of these 490 wells were built in the 1980s, and another 29 wells are currently planned for installation in the early 1990s. The state limits MSH use in the TCMA for other than public supply.

Specific Water Use

Public Supply. Public supply is a significant water use. Much of this increase is due to an improved standard of living, increased population, and many industrial and commercial users switching from self supplied to public supplies.

Since the St. Paul and Minneapolis municipal water systems rely on surface water, the population using surface water is large. However, most public systems in the state rely on ground water and two-thirds of the withdrawals for public supply is from ground water. However, there are places in Minnesota, such as northeast and southwest Minnesota, where ground water is limited and surface water is used. Figures 17,18

Figures 19,20 show recent increases in ground water use. In 1980, 16 counties used more than 500 million gallons and by 1989 43 counties were using that amount. The increased use corrolates to areas increasing growth.

Industrial. Early industrial use of water was for processing agricultural products. Dairy, beverage, meat and sausage, poultry, and vegetable processing use the most water. Today this use has declined for the following reasons: total employment in agricultural processing decreased from 37,375 workers in 1972 to 31,189 workers in 1985; there are declines in meat and sausage production; and changes in processing methods to use less water, such as in sugar beet processing.

In the 1950s and 1960s the use of ground water for air conditioning increased throughout the metro area. Industrial water use increased until the late 1960s, and decreased starting in the late 1960s, with a 23 percent decrease since 1980. These decreases resulted mainly from improved efficiency, increased recycling to meet water quality discharge standards, and a regional decline in some industries that use large amounts of water. Most of the decreases have been in the use of surface water. Decreases in air-conditioning water use is expected due to the rise in fees.

During the 60s, locations of most of the chemical processing companies, new heavy industries, and many of the new large commercial buildings moved outside the Mpls-St. Paul City limits. Development of new pumping centers in the suburbs caused pumpage to become less concentrated in the downtown area.

Metal, paper, pulp, and chemical processing are the industries with the largest water use in Minnesota. (figures21,22)

Mining. Mining has been an important user since iron-ore mining started in the 1880s. Today water is used to dewater iron mines and in the many sand and gravel pits throughout the state. Presently mining use is considered as a component of industrial use.

Power Generation. Thermoelectric power is a current major water user and has been historically. This is the largest volume use and is supplied mainly from surface water. Less than one percent of all permits are for power generation, but it accounted for 60 percent of the water used in 1988.

Irrigation. Irrigation began in the early 1920s. By 1961, the state issued permits for 5,902 million gallons (mostly surface water) to be applied to about 20,000 acres. In 1989, 86 billion gallons were used on 540,450 acres with mostly ground water used.

Only 2.3% of all cultivated land is irrigated, although the percentage is much higher for some crops, such as wild rice and potatoes. Half of all irrigated acreage is for corn, followed by soybeans, alfalfa, and potatoes. Much fruits and vegetables grown for local markets is irrigated. Counties with greatest number of irrigated acres are Dakota, Otter Tail, Pope, Stearns, Sherburne, and Swift.

Surface water was initially the primary source of irrigation water. The greatest concentration of surface water permits is in Wadena, Todd, and Sherburne counties. Rivers and ditches supply almost all of irrigation water for wild rice which accounts for 45 percent of all surface water irrigation acreage. Most wild rice is grown in Clearwater, Aikin, and Beltrami counties.

Ground water use increased in the late 1970s. Ground water is currently used in over 70 percent of irrigation. Most irrigation occurs in sandy soils of glacial outwash plains. Irrigation is a highly consumptive water use.

Figures 23,24,25 show the increase in ground water use. In 1980, 18 counties used more than 500 million gallons. By 1989, 25 counties were using over 500 million gallons. Twenty five counties experienced a 100 to 1000 percent increase in use between 1980-1989. Mome of the heavy use is in the same areas where population is increasing.

Livestock: Much livestock production is concentrated in a band running from Winona County to Otter Tail County. Most beef cattle and hogs are raised in counties along the Iowa border. Stearns County is a leading dairy producer, and is also major source of turkeys and chickens. Decline in total water use from 112,000 to 70,300 acre feet per year between 1959 and 1985 probably reflects the decrease in cattle population. While production of other animals increased during this time, the water consumption is small compared to that of cattle on a per-animal basis. (Figure 26)

Seasonal Variation in Water Use

Some water uses vary with the seasons. This variation is greatest for irrigation, air conditioning, and public supply. Industrial use is relatively stable throughout the year. With withdrawals for irrigation, air conditioning, and public supply increasing, while industrial use is decreasing, seasonal variations in water use is more pronounced. This will probably continue although the effect of recent fee increases on air conditioning may reduce this use.

Effects of water use on supplies

From 1880 to 1980, ground water withdrawals had caused long-term declines of water levels of as much as 90 feet in the PDCJ and 240 feet in the deeper MSH aquifer.

The DNR has not found evidence that pumpage for irrigation, livestock, or agricultural processing has resulted in the long term mining of aquifers anywhere in the state. However, the potential for mining exists, particularily in areas of intensive irrigation water use.

Well interference conflicts occur even in years of normal and above normal precipitation because of the lag in the timing of drought effects. If the complaint is valid, the appropriator must provide the higher priority domestic well owner with an adequate water supply. In the past three years, the DNR found 16 out of 55 well interference complaints valid.

During the recent drought, many municipalities had to lower pump intakes and institute conservation measures.

Projections for Water Use

Metropolitan Area

The Metropolitan Council has studied water availability for the TCMA. It found that because TCMA is growing, demand for water is increasing - but not in all use categories. Some uses are being phased-out, thereby diminishing demand, while others are leveling out. Projections indicate that by 2010 overall residential demand will increase by 17 percent from 1988 levels. Commercial use is projected to rise 12 percent.

STAFF DRAFT

Most of the predicted growth will be in the communities served by ground water. Thus it is likely that the increases in demand will be focused on ground water. While the PDCJ is available in the southern portion of the region, the northwestern and southwestern portions lie on the outer edge of the aquifer. (Figure 27)

U.S.G.S. developed a model of present and projected ground water withdrawals in the Twin Cities. Model simulations suggest that the effects of increasing withdrawals can result in increased capture of that part of precipitation which percolates to the water table. This would result in decreased discharge of ground water to streams, and increased induced infiltration of surface water in rivers, lakes, and wetlands.

The model further indicated that even small increases in withdrawals focused in existing pumping centers could reduce water levels in the major aquifers significantly. Perhaps even reaching the point in both the PDCJ and MSH aquifers of legally defined "ground water mining." This may be sufficient during periods of low precipitation to reduce the ground water contribution to surface flow out of the study area by more than 40%. Another consequence of changes in the ground water flow system might possibly be decreased time for contaminants to travel from shallow to intermediate to deep ground water flow sources.

Future water availability depends on the pattern of development and the source from which the water is withdrawn.

Greater Minnesota

The US Corps of Engineers used the IWR-MAIN Water use Forcasting System, a computer model, to estimate the year 2000 water demand for the 80 Minnesota counties outside the Metropolitan Area. The model forcasts a 23 percent increase in residential use; a 6 percent increase in commercial/institutional; an 18 percent increase in institutional; and a 15 percent increase in miscelaneous use.

Selected Problems

Twin Cities Metropolitan Area. Studies by the Metropolitan Council point out the problems with water availability. The overall forecasts suggest that, under normal conditions, the demand for water can be easily met. However, this overall forecast does not concentrate the demand where it actually occurs - rather it spreads it out over the entire TCMA.

Instead of uniform growth throughout the area, projected increases for Burnsville, Apple Valley, Eagan, and Rosemount account for roughly 46 percent of the total increase in water use from 1988-2010. The increases for Maple Grove, Brooklyn Park, Brooklyn Center and Playmouth in northeastern Hennepin county account for a 30 percent increase, while Minnetonka, Chanhassen, and Chaska account for 12 percent. Figure 27

STAFF DRAFT

These increases are made even more significant by the fact that the three growth centers also occur in areas that rely solely on ground water as their source of supply.

The USGS model results suggest that even a small increase in ground water withdrawals focused in existing pumping centers could reduce water levels in the major aquifers significantly. As more and more water is pumped from these areas, large cones of depression can be expected to develop. This translates into greater energy costs for pumping, in additon to possible reduction in stream flow in the TCMA.

One way to reduce the likelihood of these kinds of problems is to control the spacing of high capacity wells. With a more even distribution of wells, hydraulic head losses would not be concentrated in a small zone, thus reducing the local impact on the resource. Water could also be shared across political boundaries.

The Metropolitan Council study concludes that the regional surface water system capacity far outweighs the capacity of the ground water system. However, during severe drought, surface water system can be stressed beyond its capacity. It is suggesting new supplies rely on surface water sources.

Clearwater and Buffalo Rivers On a few streams in the state particularly the Clearwater and Buffalo Rivers, the combined pumpage by all withdrawal users may consititue 75% or more of the total flow. This magnitude of pumpage presents a significant threat to the ecology of the local watershed.

Pomme de terre and Chippewa Rivers Studies of the surficial and confined aquifers in this area indicate that during drought periods ground water use reduces streamflow and in extreme cases could eliminate flow in the Pomme de Terre River during low base-flow conditions.

Worthington Water Supply In the late 1970s, Worthington had a water supply problem it wanted to solve by discharging sewage into lakes that recharge water supply wells. The state wouldn't approve this strategy. To improve supply, Worthington instituted a conservation program. One large industrial user instituted process changes that greatly relieved the demand problem.

Rural Water Supply Districts Rural water supply districts are forming in northeastern, south central, and southwest Minnesota because of water quantity and quality problems. The numbers are increasing. (get numbers)

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