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ASSESSMENT OF WATER USE AND GROUND WATER AVAILABILITY

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS

October 1994

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Preface

This report was first required by the 1989 Ground Water Act and subsequently modified by the 1994 legislature. The statutory authorization is found in Minnesota Statutes 103A.43, Section 11. The report is coordinated through the Environmental Quality Board.

This report is a compilation of data contained in other reports prepared by the Division of Waters. We prepare the following reports:

- *Biennial Water Year Data Summary (1991-1992)*, last published in May 1993. This publication provides a review and summary of basic hydrologic data gathered through the Division's climatology, surface water, ground water, and water use programs.

- *Annual Observation Well Data Summary*, last published in January 1994. This publication reports current ground water level data and discusses trends through comparison to previous years' data.

These reports are available upon request through the Division of Waters.

Surface water availability varies dramatically with changing climatic conditions. Surface water appropriations can exacerbate the effect of climate variations. DNR is currently evaluating flow needs of instream resources, and these studies will be used as a basis for developing resource based flow protection limits. Future water availability reports will include a full discussion of surface water availability.

WATER APPROPRIATION PERMIT PROGRAM

Minnesota Statutes 103G.265, Subdivision 1, requires the commissioner to develop and manage water resources to assure an adequate supply to meet long-range seasonal requirements for domestic, municipal, industrial, agricultural, fish and wildlife, recreational, power, navigation, and quality control purposes from waters of the state. This mission requires a balance between protection of the environment and allowing reasonable development and use of water resources. Department of Natural Resources Division of Waters surface and ground water programs monitor water resources and provide data to evaluate water use conflicts and applications for new water use requests.

The Water Appropriation Permit Program is responsible for managing water use in Minnesota. A water appropriation permit must be obtained from the Department of Natural Resources Division of Waters to withdraw surface or ground waters in excess of 10,000 gallons per day or one million gallons per year. Permit applications are evaluated to determine potential impacts on higher priority water users, impacts on water resources, and the efficiency of the water use.

Reported Water Use

All water appropriation permit holders are required to keep monthly records of water withdrawals and submit an annual report of water use along with a processing fee. The water use data along with observation well data, stream flow data, lake level data, and climatology data help determine seasonal and long-term impacts from permitted water withdrawals. Water use data are also used for identifying water use trends, water supply planning, and many other purposes.

Minnesota Rules require that water use be reported within ten percent accuracy. In 1990 the legislature passed a law requiring all permitted installations to be equipped with flow meters unless the Department approves another method of measurement. Over 90% of water withdrawals on a volume basis are measured with flow meters. Alternative methods of measuring water withdrawals for agricultural irrigation systems have been developed in cooperation with the Minnesota Irrigation Association and the Minnesota Extension Service.

Water losses or consumptive use is an important factor to keep in mind when discussing reported water use. Consumptive use is defined as water that is withdrawn from its source and is not directly returned to the source (M.S. 103G.005, Subd. 8). Under this definition, all ground water withdrawals are consumptive unless the water is returned to the same aquifer. Surface water withdrawals are considered consumptive if the water is not directly returned to the source so that it is available for immediate further use.

Major Water Use Categories

Figure 1, on page 3, shows 1993 total water use with breakdowns of surface and ground water use. Table 1, on page 4, provides a more detailed breakdown of reported water use for calendar years 1990-1993. The major water use categories are described in this section.

Thermoelectric Power Generation - water used to cool power generating plants. This is historically the largest volume use and relies almost entirely on surface water sources. Less than 1% of all water appropriation permits are represented by this category. Thermoelectric power generation is primarily a non-consumptive water use in that all but 2-4% of the water withdrawn is returned to its source. It should be noted that permits are not required for run of the river hydroelectric power production.

Public Water Supply - water withdrawn by public water suppliers for residential, commercial, industrial, and other types of uses. In 1993, public water suppliers accounted for 64.6% of all ground water use and 4.2% of surface water use. There are 970 active public water supply permits and approximately 335 of these suppliers provide water service to populations of more than 1,000 people. Public water suppliers serving more than 1,000 people are now required by statute to report water use by customer categories. The Department also encourages smaller systems to report water use by customer categories. Figure 2, on page 5, summarizes the responses from 371 water suppliers serving more than 3 million people.

Fifty percent of all water pumped by public water suppliers in 1993 was for residential users. This category includes essential domestic uses as well as non-essential uses such as lawn watering and car washing. Summer residential water demands for lawn watering and other non-essential water uses are often two to three times more than residential water demands during winter months.

Water for commercial purposes such as motels, hotels, restaurants, office buildings, and other businesses were the second largest users, with 26% of reported water use by public suppliers. Industrial users accounted for 15% of water provided by public suppliers.

Reported water use by customer categories will improve as local billing and reporting systems are upgraded. Customer data will be helpful to public water suppliers for evaluating demand reduction potential and developing allocation procedures in the event of water supply problems.

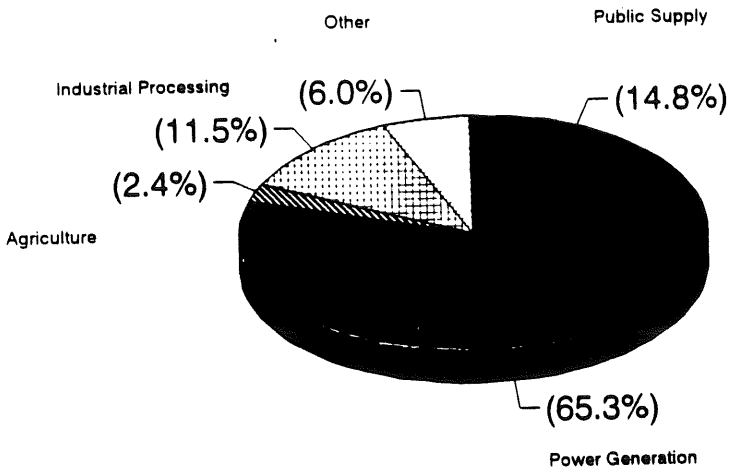
Industrial Processing - water used in mining activities, paper mill operations, and processing applications. There are 407 active industrial water use permits which accounted for 14.5% of total ground water use and 11% of total surface water use in 1993.

Agricultural Irrigation - There are 3,807 active permits for agricultural irrigation which authorize the use of water on approximately 500,000 acres or about 2.3% of all cultivated acres in Minnesota. Agricultural irrigation permits comprise 60% of all active permits but accounted for only 2.4% of the total water use in 1993. However, agricultural irrigation water users account for

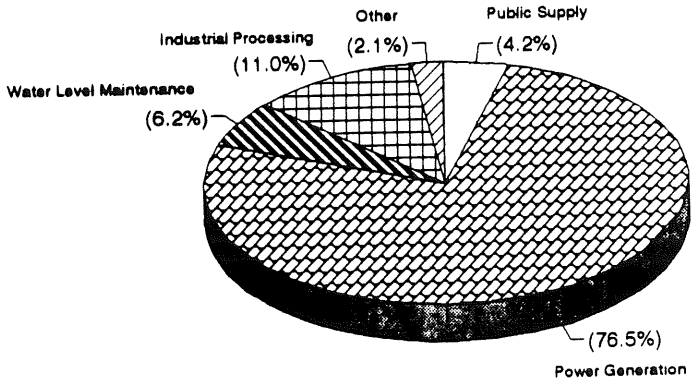
(text to page 6)

Figure 1:

1993 TOTAL WATER USE
1.11 TRILLION GALLONS



Surface Water Use By Category
942 BILLION GALLONS



Groundwater Use By Category
164 BILLION GALLONS

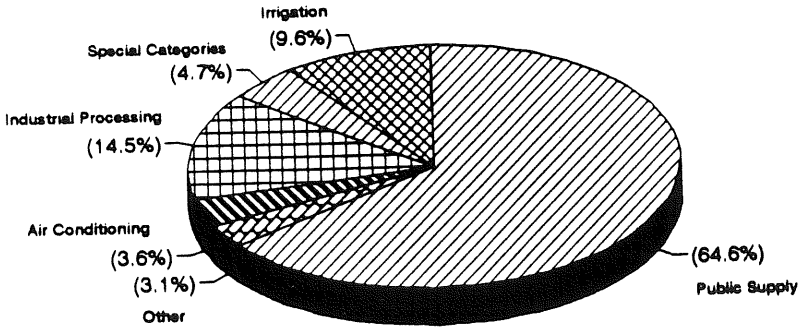


TABLE 1

MINNESOTA PERMITTED WATER USE, 1990 - 1993

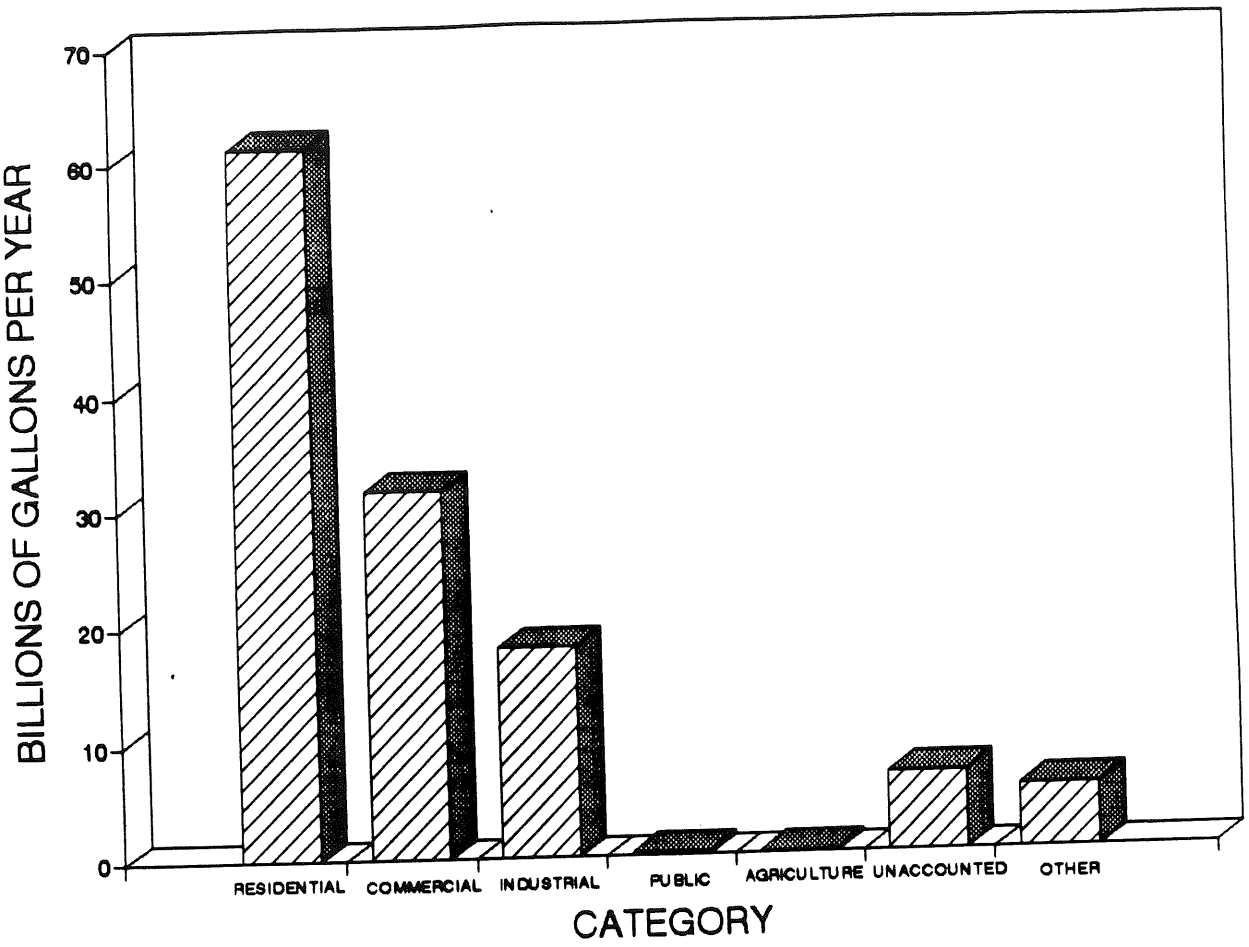
By Use Category and Source

(Million Gallons per Year)

Major Use Code	Number of Permits Currently Active:	Active Permitted		Reported Pumpage:			
		ACRES	VOLUME	1990	1991	1992	1993
10 WATERWORKS	970		369519.4	164702.2	171161.8	174870.1	163803.8
Surface Water:	35		220039.3	58935.4	60233.4	61963.1	58112.8
Ground Water:	935		149480.1	105766.8	110928.4	112907.0	105691.0
20 POWER GENERATION	44		1184998.6	697431.1	680233.7	678968.4	721777.9
Surface Water:	24		1182730.3	696654.4	679243.7	677846.9	720701.4
Ground Water:	20		2268.3	776.7	990.0	1121.5	1076.5
30 AIR CONDITIONING	105		13053.2	8245.0	8186.1	6526.9	6879.8
Surface Water:	3		1843.4	531.4	487.0	971.7	719.5
Ground Water:	102		11209.8	7713.6	7699.1	5555.2	6160.3
40 INDUSTRIAL PROCESSING	411		301299.7	100917.3	127302.5	157726.9	127381.7
Surface Water:	115		261328.6	77189.4	102519.1	132748.4	103604.4
Ground Water:	296		39971.1	23727.9	24783.4	24978.5	23777.3
50 TEMPORARY	99		3587.1	3897.4	2696.4	2066.3	1459.2
Surface Water:	46		938.5	166.9	348.7	457.3	385.8
Ground Water:	53		2648.6	3730.5	2347.7	1609.0	1073.4
60 WATER LEVEL MAINTENANCE	127		84205.1	30594.4	28871.2	36603.2	40042.9
Surface Water:	98		82595.3	30003.1	28319.6	35893.3	39427.6
Ground Water:	29		1609.8	591.3	551.6	709.9	615.3
70 SPECIAL CATEGORIES	274		24530.2	10541.9	12499.0	13541.0	14717.9
Surface Water:	37		10491.8	5182.8	6234.7	6280.1	7106.4
Ground Water:	237		14038.4	5359.1	6264.3	7260.9	7611.5
80 NON-CROP IRRIGATION	540	29328.0	11652.2	4299.3	4288.9	4821.7	2863.4
Surface Water:	165	8277.0	2509.8	932.9	845.6	818.9	553.6
Ground Water:	375	21051.0	9142.4	3366.4	3443.3	4002.8	2309.8
90 MAJOR CROP IRRIGATION	3821	510339.0	174140.1	65997.8	55040.5	58048.2	26825.2
Surface Water:	750	92534.0	32938.1	12698.7	12134.4	13734.8	11179.5
Ground Water:	3071	417805.0	141202.0	53299.1	45906.1	44313.4	15645.7
STATEWIDE SUMMARY	6391	543330.0	2166985.6	1086626.4	1090280.1	1133172.7	1105751.8
Surface Water:	1273	101709.0	1795415.1	882295.0	890366.2	930714.5	941791.0
Ground Water:	5118	441621.0	371570.5	204331.4	199913.9	202458.2	163960.8

FIGURE 2

MUNICIPAL WATER USE BY CATEGORY



CATEGORY	GALLONS PER YEAR	PERCENT
RESIDENTIAL	61,380,000,000	50%
COMMERCIAL	31,550,000,000	26%
INDUSTRIAL	18,100,000,000	15%
PUBLIC	145,000,000	0%
AGRICULTURE	2,000,000	0%
UNACCOUNTED	6,740,000,000	5%
OTHER	5,447,000,000	4%
TOTAL	123,364,000,000	100%

a significant portion of total annual ground water withdrawals. Even in a wet year like 1993, agricultural irrigation was responsible for 9.6% of the total ground water withdrawals. In a dry year the use of ground water for irrigation can exceed 30% of the total ground water use in Minnesota.

The amount of surface water use for irrigation is fairly constant year to year because most of the water is used for paddy wild rice production. The number of acres in wild rice production has remained about the same for the last ten years, and water requirements for initial filling of wild rice paddies each spring does not change appreciably.

Water Level Maintenance - includes water withdrawals for dewatering and augmentation purposes. Most of the reported water use under this category is for dewatering purposes. There are approximately fifteen permits that authorize up to ten million gallons of ground water per year for purposes of maintaining levels of surface water basins. The use of ground water to augment surface water basins is also discussed on page 10.

Special Categories - includes snow making, aquaculture, pollution confinement, fire control, and other unique water uses.

Water Use Trends and Program Initiatives

There are currently about 6,336 active water appropriation permits. Figure 3, on page 7, shows the number of water appropriation permit applications submitted each year since 1938. In fiscal years 1993 and 1994, fewer permit applications were submitted due to above normal precipitation. As shown by Figure 3, the number of permit applications generally increases in dry years.

Figure 4, on page 8, shows water use trends for agricultural irrigation, public water supplies, and power generation from 1985 to 1993. Water use trends are similar for agricultural irrigation and public supply reflecting increases in water demands during dry years. Water use for power production appears to be less dependent on yearly precipitation and has increased from approximately 500 billion gallons in 1985 to over 700 billion gallons in 1993.

Figure 5, on page 9, shows 1993 reported water use by county. Areas with large water withdrawals are similar to previous years with the exception of Cook County. The increase in water withdrawals in Cook County relate to mining activities.

A number of efforts are under way to improve water use efficiencies and eliminate lower priority water uses. These efforts will impact water use trends for once-through systems, the use of ground water to augment lake levels, and water use by public water suppliers.

(text to page 10)

FIGURE 3

DNR APPROPRIATION PERMIT APPLICATIONS
1938 - 1994

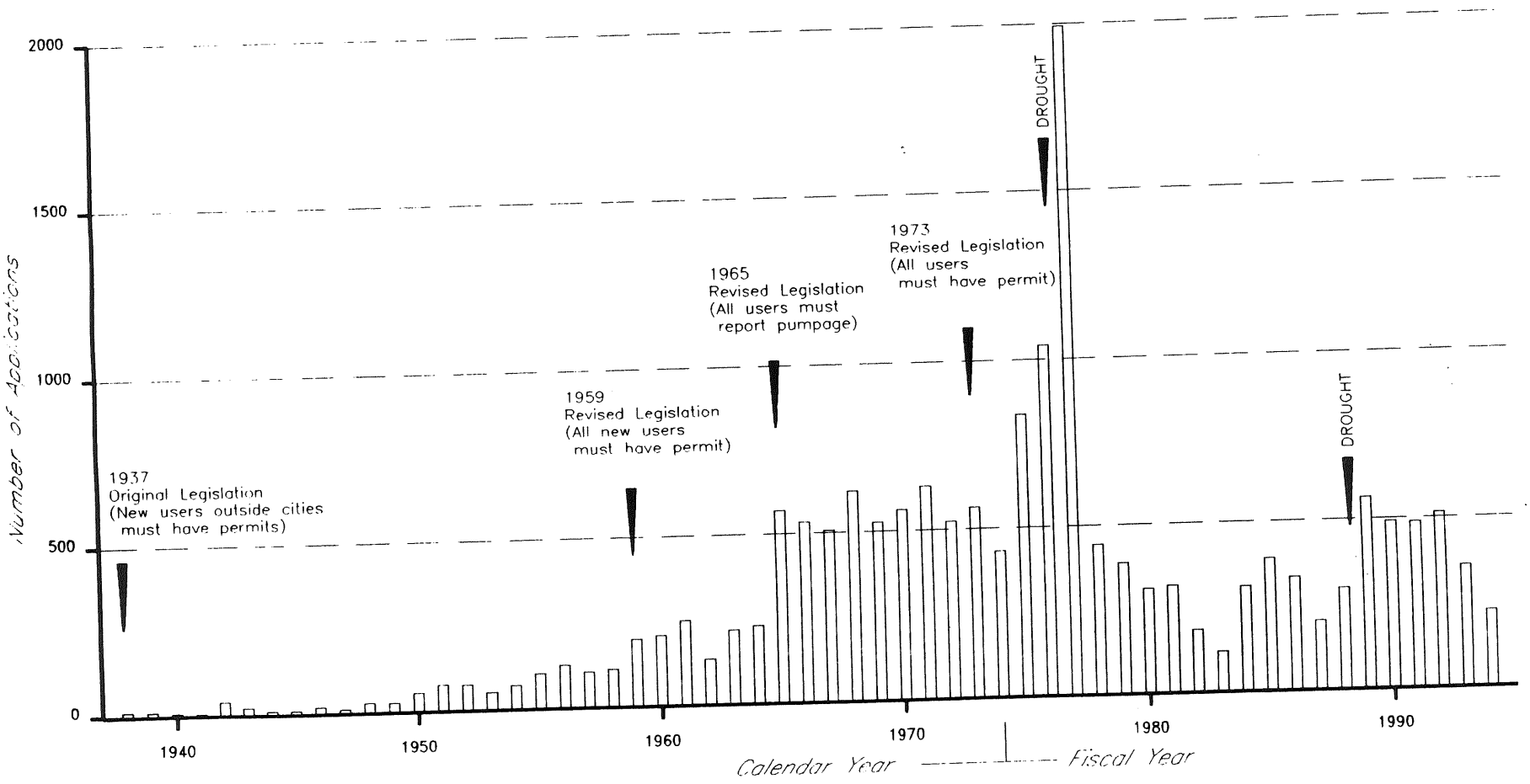


FIGURE 4

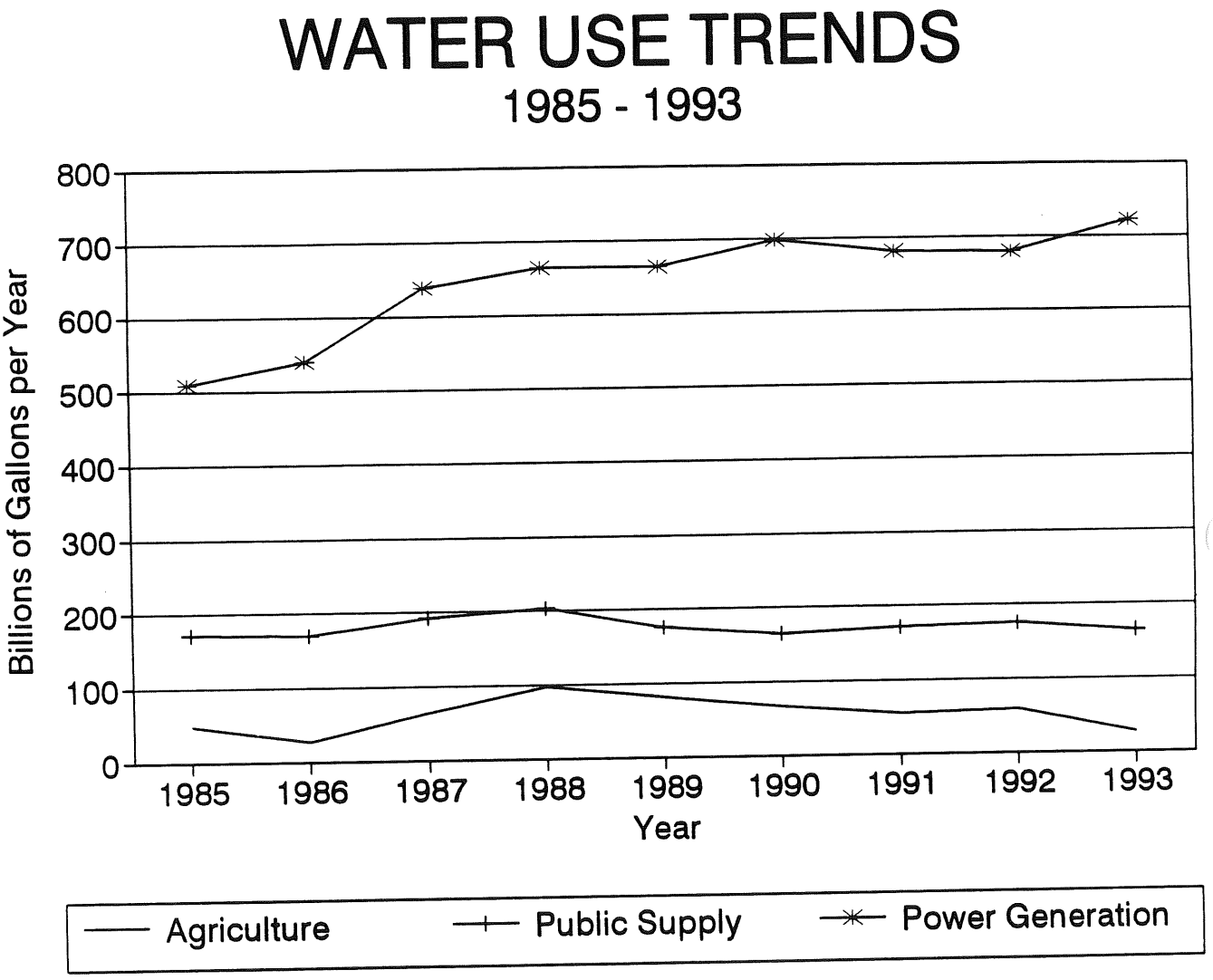
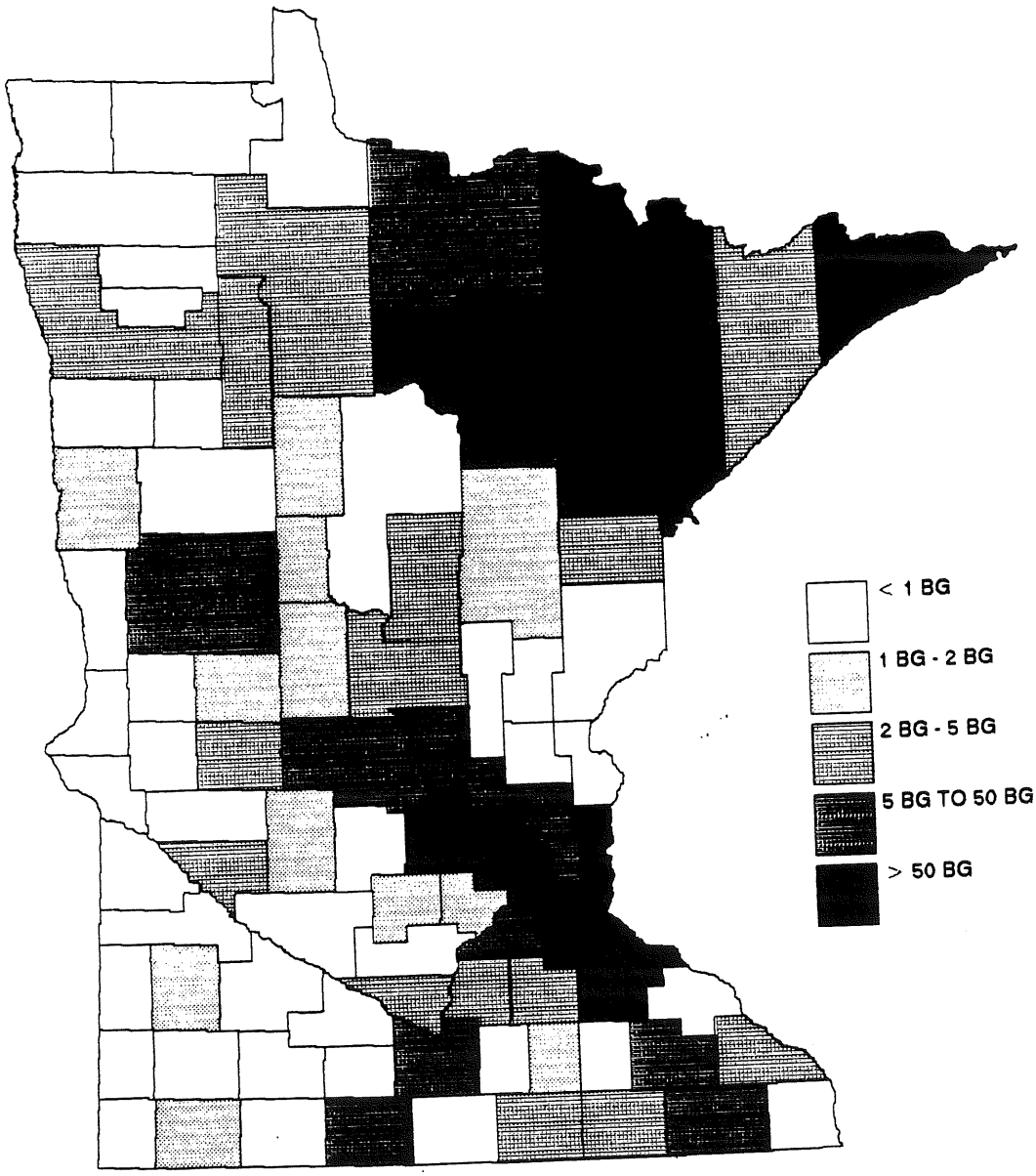

WATER USE TRENDS
1985 - 1993
Billions of Gallons per Year
800
700
600
500
400
300
200
100
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
Year
Agriculture
Public Supply
Power Generation

FIGURE 5

REPORTED WATER WITHDRAWALS BY COUNTY - 1993



DATANET PLUS MAPPING

Based on 1993 Water Use Reports.

NOTE: Cook County experienced a marked increase in water use in 1991 because LTV Steel Mining Company began appropriations in excess of 10 BGY. They continue to pump in excess of 50 BGY.

MINNESOTA

Department of Natural Resources

DIVISION OF WATERS

Once-Through Systems

There are 105 active permits authorizing the use of ground water for air conditioning and heating of office buildings. Ground water passes through a buildings heating and cooling equipment once and is then discharged to storm sewers or surface water bodies. The use of cooling towers to recycle water back through the heating or cooling systems and closed loop district heating and cooling systems or other water efficient alternatives can reduce water used for once-through systems by 95%.

A law passed by the 1990 legislature required existing once-through systems to be converted to water efficient alternatives within the design life of the heating and cooling equipment. A number of once-through systems have already been converted to water efficient alternatives, and about 58 of the 105 existing systems will be converted in 1995. The remaining once-through systems have conversion dates from 1996 to 2010.

Ground water use for once-through systems has been decreased from approximately 11 billion gallons in 1988 to 5.8 billion gallons in 1993. Higher water use fees for once-through systems have also helped reduce water use by encouraging long-term building improvements that will save on energy costs for heating and cooling.

Once-through water use will continue to decrease as the remaining buildings with once-through systems gradually convert to water efficient systems in the next fifteen years. The elimination of once-through water use will significantly decrease ground water use in the Twin Cities Metropolitan Area where most of the buildings with these systems are located.

Ground Water for Augmentation of Surface Water Basins

Lower lake levels resulted from the 1988-89 drought. The Department received many requests from people who were interested in using ground water for maintaining desirable water levels on basins ranging from small storm water ponds to lakes the size of Lake Minnetonka and White Bear Lake. Recognizing the dynamic nature of lake levels and the need to protect ground water resources for higher priority purposes, the Department suspended all existing permits authorizing the use of ground water for lake level augmentation. In 1993 the Minnesota Legislature supported the Department's position and passed a law prohibiting the use of ground water, in excess of ten million gallons per year, for purposes of maintaining the levels of surface water basins. In January 1994, the Department terminated existing permits for basins that require more than ten million gallons per year. This change eliminated a wasteful use of water and will help protect ground water resources for future domestic and economic purposes.

Public Water Suppliers

Laws of Minnesota 1993, Chapter 186, included provisions related to public water suppliers that are intended to improve water use efficiencies and emergency planning. By January 1, 1996, public water suppliers that serve more than 1,000 people must develop water emergency and

conservation plans. These plans will include procedures to reduce water demands for short-term emergencies and identify programs for long-term improvements in water efficiencies. The DNR in cooperation with the Metropolitan Council and industry representatives developed guidelines that can be used for developing local water emergency and conservation plans. Many communities are currently working on these plans.

Another provision of the 1993 legislation requires public water suppliers serving more than 1,000 people to employ demand reduction measures before requesting approvals for new wells or increases in authorized volumes of water. Programs for reducing water demands are similar to demand reduction programs for energy utilities. Reducing water demands can be a low cost alternative when compared to construction costs for new water sources or expanding wastewater treatment capacities to meet demand. The legislation recognizes the importance of public education for improving water use efficiencies and reducing water demands. Water customers can save on water, wastewater, and energy bills and can also help protect water quality by reducing wastewater discharges.

The design and demand for water and wastewater treatment systems will also be impacted by the 1992 Federal Energy Policy Act. The 1992 Federal Energy Policy Act established manufacturing standards that require water efficient toilets, showerheads, faucet aerators, and other water efficient plumbing fixtures. These water efficient plumbing fixtures are required on most new construction and will be used on existing structures that gradually replace old plumbing fixtures over the next twenty years. Some estimates indicate these new plumbing fixtures will reduce water used in the average 2.63-person household from 121 gallons per day to 55 gallons per day. Public water suppliers can achieve significant water savings through public education programs or incentive programs that encourage replacement of older, less efficient plumbing fixtures.

Emerging Issues

There is a need to balance water appropriation requests with water quality protection measures. Proposals for developing rural water systems and agricultural irrigation projects are two examples of the need to consider the relationships between water quantity and quality.

Rural Water Systems

There are currently several proposals for development or expansion of rural water systems in Minnesota. Rural water systems use extensive pipelines to provide water service to rural farmsteads and small communities. Poor water quality and the limited availability of known ground water resources are reasons cited for needing rural water systems. The availability of federal funding for rural water systems also makes rural water an attractive water supply alternative.

There are both natural and man-made water quality problems with existing individual water wells that are being replaced with rural water systems. Some water quality problems are due to land use activities including livestock operations which account for over 50% of the water supplied by

some rural water systems. With a reliable water source livestock producers can increase the size of their operations, and there are concerns that expanded livestock production will add to existing water quality problems. The shallow wells used by several rural water systems are also susceptible to contamination from agricultural runoff and other non-point sources.

Land use practices and well head protection programs are needed to protect ground water quality for individual farmstead wells and sources of water used by rural water systems. Protection of water quality and sustainable development issues need to be addressed as part of funding and permitting requirements for rural water systems.

Agricultural Irrigation

Concerns over potential water quality impacts from existing and proposed agricultural irrigation operations have increased in recent years. Irrigation, especially on coarse-textured (sandy) soils and with shallow-rooted crops, increases the chances that applied nitrogen will leach or wash away before it can be absorbed. Soil and water conservation plans and the use of best management practices can minimize potential water quality problems.

All permit applicants are required to contact their local Soil and Water Conservation Districts to obtain an approved soil and water conservation plan. Permit conditions require compliance with conservation plans and best management practices that may be required by the Soil and Water Conservation District. However, Soil and Water Conservation Districts do not have adequate staff or funding for developing plans and monitoring compliance. Best management practices to protect water quality also need to be developed for potato crops that are water sensitive and have shallow root systems.

This section briefly described two water management issues. The Department is involved with many other issues related to resource protection and identifying water sources for human needs and proposals for economic development. The next section describes some of the programs for assessing ground water availability and the need to enhance these efforts.

ASSESSMENT OF GROUND WATER AVAILABILITY IN MINNESOTA

Ground water sources are variable throughout the state. Ground water occurs in both bedrock and unconsolidated geologic formations. Bedrock aquifers include sandstones, carbonates, quartzite, and granites along with other types of crystalline and sedimentary formations. Bedrock aquifers occur in the southwest, northeast, southern, and eastern parts of the state. Unconsolidated aquifers consist of surficial and buried sand and gravel deposits and occur in nearly all areas of the state. Surficial sand and gravel aquifers cover about one-third of the state. Although occurring in many places in the state, buried sand and gravel aquifers are especially important in western Minnesota where the glacial drift is the thickest, making bedrock aquifers less accessible.

Understanding the ground water system and assessing availability is much more difficult than understanding the surface water system because the resource is under ground. The volume of ground water available for use in Minnesota is difficult to assess because of our diverse geological environment and lack of hydrogeologic information. Efforts to better define Minnesota's ground water resources have been ongoing but much remains to be done. More recent efforts to provide understanding of the ground water system includes: county geologic atlases, regional hydrogeologic assessments, regional aquifer studies, hydrogeologic modeling, and the DNR's observation well and geophysics programs. Following is a brief description of these efforts:

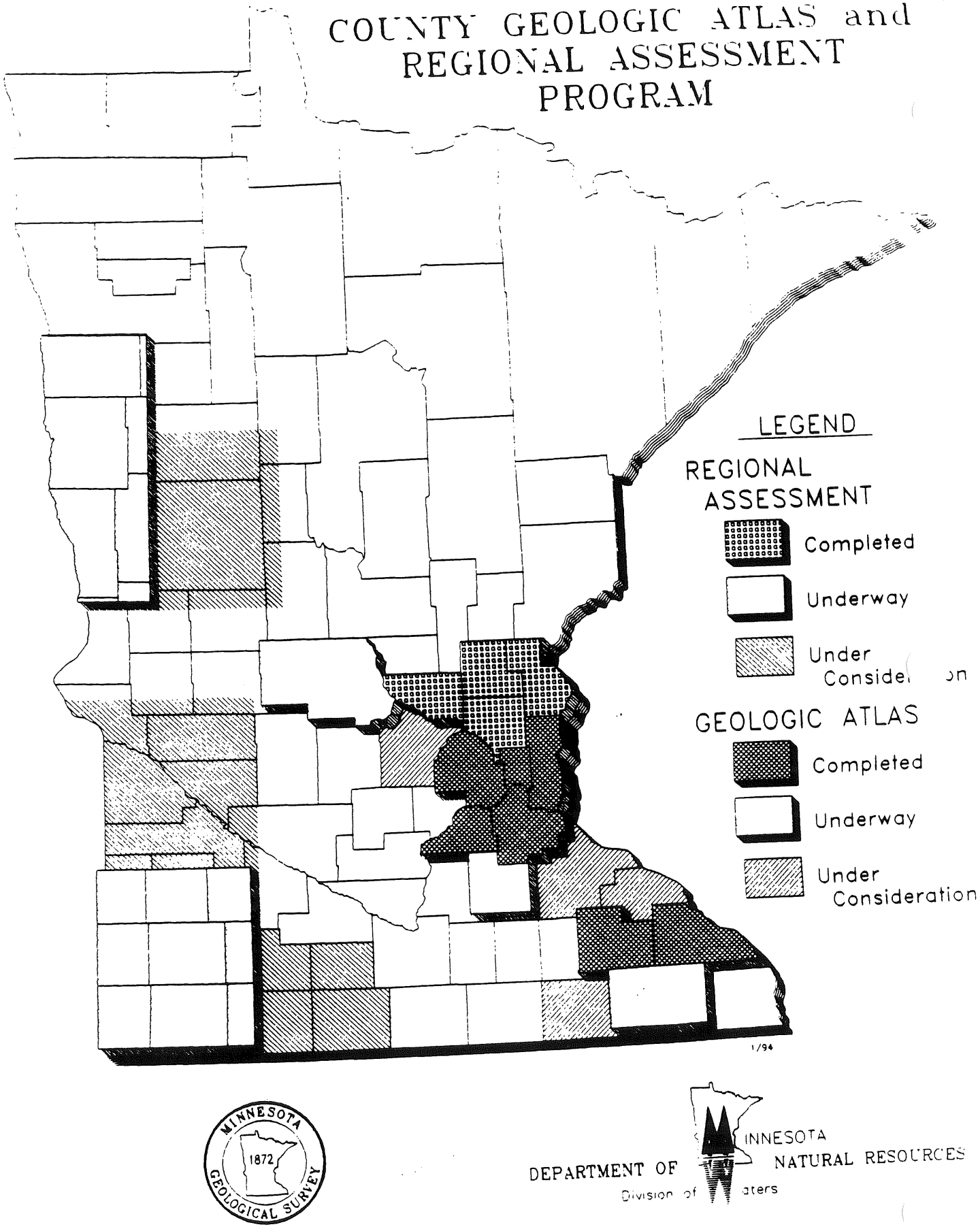
County Geologic Atlas and Regional Hydrogeologic Assessment Program

This program is a joint effort by the DNR and the Minnesota Geological Survey (MGS). These products provide a comprehensive, systematic summary of the geologic and hydrologic conditions of a county or multi-county area. The information provided is at a level of detail to enable sound planning and management of land and water resources. To date, ten counties have had atlases completed or have one underway; one regional assessment has been completed, and two are currently in progress (Figure 6, on page 14).

This program has been mainly funded through the LCMR with some support from the general fund through the 1989 Ground Water Act. The LCMR is recommending that it not provide further support for this program but recommends that it be fully supported through the general fund. If this program does not receive adequate funding, the future rate of production of county atlases and regional assessments will decline substantially. This would mean that counties which lack atlases or assessments will have to wait much longer for these basic tools for managing land and water resources.

Regional Aquifer Studies

These are technical investigations conducted by the U.S. Geological Survey (USGS) in cooperation with the DNR. The studies encompass portions of several counties or address the entire area where an aquifer is present beneath the surface. The projects involve intensive data


COUNTY GEOLOGIC ATLAS and
REGIONAL ASSESSMENT
PROGRAM
LEGEND
REGIONAL
ASSESSMENT
Completed
Underway
Under
Consider
on
GEOLOGIC ATLAS
Completed
Underway
Under
Consideration
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NATURAL RESOURCES
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Figure 6

gathering, modeling of the flow system, prediction of yield capability, and resultant water level change for estimated future levels of development and ground water quality information. These studies are generally 50 percent funded by the USGS, with the remainder being paid by the DNR and local contributors. Currently, there are projects underway in the southern Red River Valley, southwestern Minnesota, the Rochester area, and Otter Tail County.

Hydrogeologic Modeling

Hydrogeologic modeling is conducted for the DNR's ground water allocation program. The modeling results provide information for resolution of well interferences, water use conflicts, and contamination remediation pump-out permits. Specific modeling studies include assessing the impacts on ground water of resource development actions, quantifications of ground water supplies, and providing the technical understanding for ground water/surface water management.

Observation Well Program

The DNR observation well network has been developed to record water levels in areas of present or expected ground water use. These data are used to assess ground water supplies, to interpret impacts of pumping and climate, to plan for water conservation, to evaluate local water complaints, and to otherwise provide for the management of the resource. The network is composed of approximately 625 wells (Figure 7, on page 16) throughout the state. The network includes aquifers in common use and is expanded when funding allows. Current emphasis for expansion is in areas of the state where water supplies are limited in quantity or quality such as in the southwest and northwest. A summary of the observation well data is published annually.

Geophysics Program

The Geophysics Group applies seismic reflection and refraction, electrical resistivity, and electromagnetic induction techniques to map subsurface geologic units, evaluate mineral resources, quantify ground water supplies, locate buried wastes, and trace contaminant plumes. A major part of this program provides geophysical support for the Division of Waters' cooperative programs with the MGS and USGS.

Recommendations for Continued and Enhanced Ground Water Efforts

Ground water resources are relatively scarce in the southwest corner of the state and the Red River Valley. Many of the towns, rural water systems, and irrigators in these areas rely upon shallow wells drilled into surficial or buried outwash channels that are susceptible to water level decline during drought, contamination, or excess withdrawals over recharge. Many of the rural communities and farms have experienced water supply problems enticing them to connect to the rural water systems servicing both southwest and northwest Minnesota. In order to continue and enhance efforts to better define and quantify the state's ground water resources in these areas and throughout the state the following are needed:

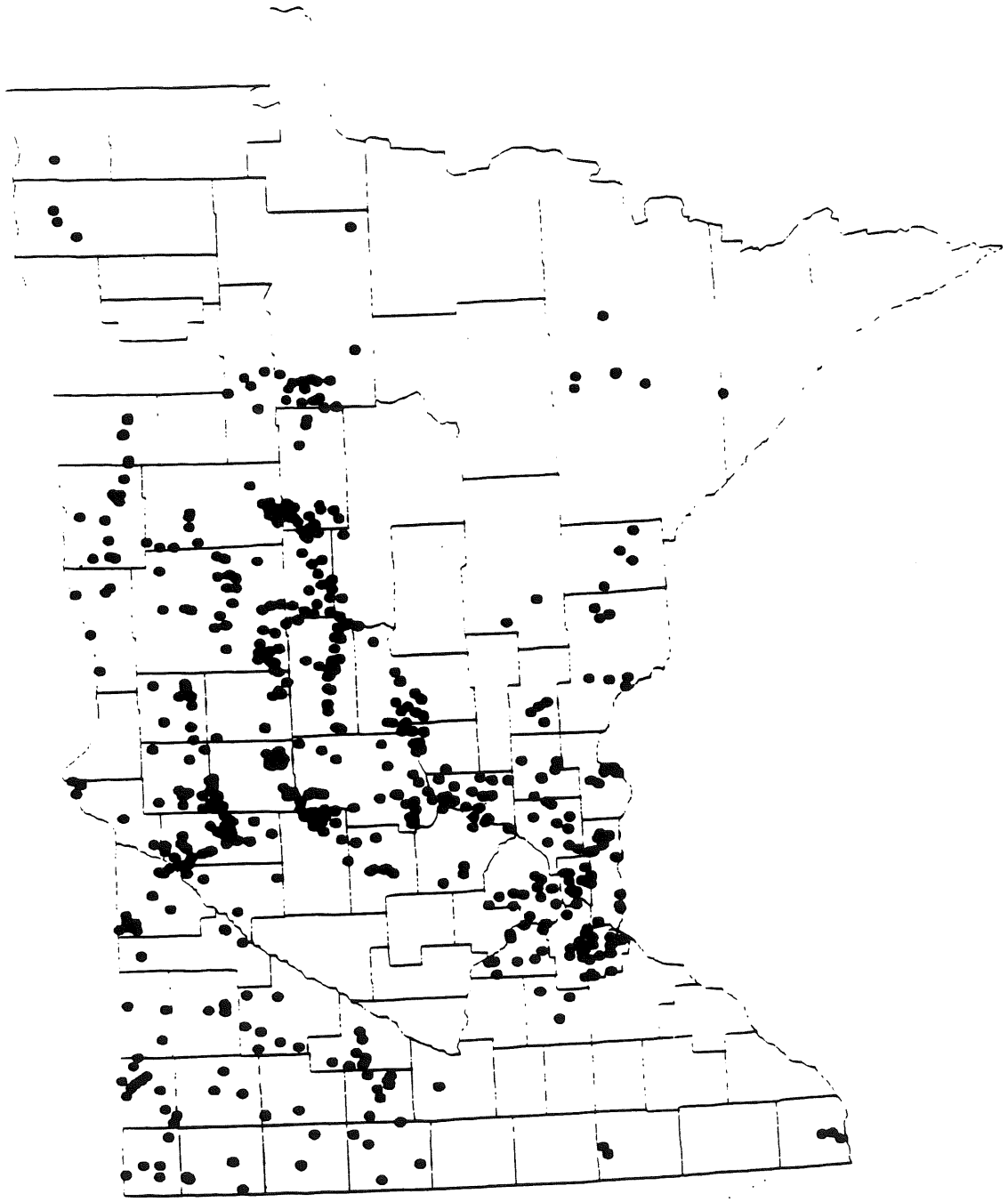

Figure 7: Location of active obwells

- adequate secure funding for continuation of the County Geologic Atlas and Regional Hydrogeologic Assessment programs.
- continued effort to identify and quantify buried aquifers.
- expansion of the observation well network so it can serve as a management tool to better protect ground water resources.
- support for a drilling program that would allow for systematic drilling and exploration for ground water resources to further economic development, especially in the western part of the state.
- development of an integrated state ground water information system and regional ground water flow model.
- development of an ongoing program to analyze aquifers for safe yield.