Metropolitan Council

Metropolitan Area Master Water Supply Plan

Twin Cities Metropolitan Area, Minnesota

March 2010

Metropolitan Council

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EXECUTIVE SUMMARY

PURPOSE, SCOPE, COMPONENTS

The Metropolitan Area Master Water Supply Plan provides a framework water supply development that does not harm ecosystems, degrade water quality, or compromise the ability of future generations to meet their own needs. The analysis that underlies this plan indicates that overall, the region has adequate supplies to meet future demand but that there will be issues that need to be addressed and some communities may not be able to rely on traditional sources to meet projected demands.

The Metropolitan Area Master Water Supply Plan is the culmination of efforts initiated in 2005 in response to Minnesota Statutes, Section 473.1565. This statute requires the Metropolitan Council to carry out activities addressing the water supply needs of the region, including the development of a metropolitan area master water supply plan. The goal of these efforts, and of this plan, is to guide sustainable water use in the Twin Cities metropolitan area. This statute also requires that the Minnesota Department of Natural Resources (DNR), who has been a partner in its development, approve this plan.

Minnesota Statutes, Section 473.1565

This report is only one component of the plan. The core of the plan is the water availability analysis, the community profiles that ensue from it, and the datasets that underlie it. These core pieces, as well as the sub-regional scenarios and online tools, together constitute the Metropolitan Area Master Water Supply Plan. Links to all components of the plan are provided in this document and, where possible, appear in the appendices.

As a prerequisite to preparing this Master Water Supply Plan, existing water resource datasets were assembled and new datasets were created from numerous sources and organizations. These datasets are now available through the Metropolitan Council's online map

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library and are standardized and integrated with other Metropolitan Council planning data so that it is possible to analyze both the impacts on and demand for the region's water supply. Such systematic analyses serve as a logical foundation for future planning decisions. Besides projections of population growth, these datasets include supply-system infrastructure information, hydrogeologic data, information on groundwater and surface water interactions, and maps of areas of known groundwater contamination. The datasets were developed with information from state, regional and local governments, public water utilities, private sector consultants, and academia.

Metro Model 2, a numerical model of the region's groundwater flow, was developed to assess the consequences of various impacts on the water supply before those impacts become a reality. Analyses were run using this model to evaluate the effect of various pumping regimens on individual local and regional resources. Where these analyses indicated that unacceptable results would result from projected demands, that information was identified as an issue in the relevant community's profile. As situations change and new datasets are created, the model will be updated with this information.

Metro Model 2

The community profiles, which appear in Appendix 2, contain current and projected population, current and potential water supply sources and, where relevant, issues to be addressed. Appendix 3 provides appropriation permit guidance, which includes information communities must submit with their appropriation requests and permit conditions communities should expect to receive given specific water supply issues. Appendix 4 outlines regulatory requirements suppliers must take to ensure the quality of their water supply. The information in Appendix 3 and 4 was developed in consultation with the DNR and MDH, respectively, based on existing regulatory authority and past requirements for similar situations. The profiles and the appropriation permit guidance provide communities with

Community Profiles (Appendix 2)

Appropriation Permit Guidance (Appendix 3)

Water Quality Issue Guidance (Appendix 4)

	information that will allow them to plan for the actions they will have to take when they need to increase their appropriations, well before they need the additional appropriations. Providing information on the issue and actions communities need to take to address those issues early in the process will minimize the time-consuming, costly and politically challenging situations that have, delayed water supply development in the past. The Metropolitan Council will consider this master plan when preparing subsequent Regional Development Frameworks and reviewing local comprehensive plans. Although water supply will not be the only factor in forecasting growth, it will be considered alongside the other factors that shape the regional forecasts. In addition, communities will need to demonstrate in their local water supply plans, the steps they plan to take to address issues identified in this plan, including identification of alternative sources if the primary source proves to be unable to meet projected demands. This will allow planning for water supply even earlier in the development process, resulting in even longer-term consideration of sustainable sources to supply projected growth.	Regional Development Framework Local water supply plan template
DEVELOPMENT PROCESS: TRANSPARENCY AND INVOLVEMENT	The 2005 Minnesota Legislature established the Metropolitan Area Water Supply Advisory Committee, whose members represent state agencies, counties, local governments and the Metropolitan Council. The guidance provided by this group has been critical to the development of the plan, and the group's continued involvement will ensure that the ongoing planning will continue unabated. From its inception, the plan development process was both inclusive and transparent. The DNR and MDH played an integral part in the development of this plan. To develop Metro Model 2, Council staff sought input from technical experts, water supply consultants, water resource managers, and	Metropolitan Area Water Supply Advisory Committee Master Water Supply Plan

	other interested parties. A technical advisory committee of potential users, which included governmental scientists, private-sector consultants and representatives from academia, provided valuable guidance and feedback.	Technical Advisory Workgroup
	Through a series of workshops, the Council sought direction and input from a wide range of stakeholders who played an integral role in shaping the plan's contents and structure. When these groups requested a ready source of conservation information, the Council responded with an online Conservation Toolbox. Municipal water suppliers, who have direct responsibility for water supply in the region and who are most directly affected by planning activities, were critical participants in the development of this plan.	Stakeholder input Conservation Toolbox
PRINCIPLES AND BENEFITS	The Twin Cities metropolitan area is fortunate to have relatively abundant groundwater and surface water supplies. The region is unique among major metropolitan areas in that it rests atop a groundwater flow system—the bowl-shaped Twin Cities basin—that does not extend far beyond the region's boundaries. This unique geologic situation provides the region the ability and responsibility for managing much of its own water resource. The development of this plan is not motivated by widespread water shortages or immediate crises. Rather, it is in response to issues that have arisen in the past and in recognition of the importance water has in the lives of Minnesotans. Residents value the protection of wetlands, lakes and streams and hold a deep commitment to ensuring that plenty of water will be available to future generations. They also value a balance between multi-community cooperation and local control. It is these values that define the accepted limits, guide use of water resources, and ensure the sustainable development of water supplies. It is not surprising, then, that these same limits emerged during the process of defining the overarching goal and supporting principles to guide regional water supply planning.	

With this plan, water supply planning becomes an integral component of long-term regional and local comprehensive planning. A strong foundation of accessible technical information, coupled with a set of workable principles, offer decision-makers both the tools and guidance they need to avoid costly, time-consuming water supply development delays. Costs associated with resource assessment are now reduced because publicly available and regionally consistent data are provided as a part of this plan.

Because communities now know the impending water supply issues facing them, they are able to plan in a more careful and informed manner. For some affected communities, the identification of water supply issues on a broader scale and earlier in the process will also create incentives for interjurisdictional cooperation and consideration of the benefits of the economies of scale. In addition, the Metropolitan Council can now consider water supply issues in the development of regional growth forecasts.

While the master plan is focused on municipal suppliers, the information provided in the plan can also be used for evaluating land use and water resource management decisions such as the siting of a water using industry or the permitting of non-municipal appropriations.

NEXT STEPS

The work that has been done is, however, the first step. The actions that follow will determine the ongoing viability and usability of this plan and the sustainability of water resources. For this plan to remain relevant and usable, additional information must be collected and incorporated into the analysis. As new tools are developed, they must be used to reevaluate and update the plan's conclusions, and especially the community profiles.

The final chapter in this report outlines current activities that should be continued and new ones that should be initiated. All these

activities are intended to meet five regional objectives:

1. Improve the predictive accuracy of the Twin Cities Metropolitan Area Groundwater Flow Model Version 2.00 (Metro Model 2).
2. Assess local conditions in areas where this plan predicts that issues may arise should withdrawals continue at projected levels and from traditional sources.

3. Develop a more thorough understanding of aquifer extent, capacity, and recharge, as well as long-term trends in the levels of the region's surface and groundwater systems to manage future water supply availability.

4. Develop a better understanding of the distribution of natural and manmade contaminants and source water vulnerability.

5. Guide water supply development toward regionally optimal locations and sources.

6. Incorporating new information and using updated tools will improve the evaluation of new pumping sources, locations, and pumping rates to determine regionally optimal withdrawal scenarios.

Twin Cities Metropolitan Groundwater Flow Model Version 2.00 Technical Report

Continuing the collaborative and transparent approach employed thus far, stakeholders will be engaged to ensure that the tools and processes continue to be relevant and useful. Inclusion and transparency, informed by ample and field-collected information, create the organizational basis that inspires better decision-making. Once that process is established, the state, region, counties, and communities will have the necessary foundation for ensuring that the region's natural ecology is protected and that future generations in this growing metropolis will have the water they need.
The Metropolitan Council will update the Master Water Supply Plan on

	the same schedule as it updates the comprehensive development guide for the metropolitan area. The Metropolitan Council's comprehensive development guide is updated in conjunction with the decennial review of the local comprehensive plans required under Minnesota Statutes, Section 473.864, and when the Council amends or modifies a metropolitan system plan. The community water supply profiles will be updated and made available on the Metropolitan Council's website when the Council revises the Master Water Supply Plan.	Metropolitan Area Land Planning Act (Minnesota Statutes, Section 473)

CHAPTER 1: REGIONAL WATER SUPPLY PLANNING PROCESS AND PRODUCTS

RATIONALE FOR WATER SUPPLY PLANNING

The Twin Cities metropolitan area is fortunate to have a relative abundance of high quality water. The area's plentiful water supplies and the proximity of navigable rivers sustained American Indian communities and supported the development of the region's growing cities. The Mississippi River and the region's prolific aquifers continue to provide residents with a reliable water supply, while its rivers and lakes are the natural highways that serve commerce, nurture wildlife, and offer people a variety of recreational opportunities.

Map of Metropolitan Area Communities (Appendix 1)

While there may be sufficient water supplies in the metropolitan area to meet future demand, the uneven distribution of aquifers consigns communities in some parts of the region to an ongoing concern regarding their water supply. For others, the competing demand between groundwater withdrawal and surface water protection poses a challenge. Contamination is a concern for all, as is the inevitability of occasional droughts.

Whether public or private, all water supplies are drawn from an essential natural resource that is shared by the entire region. The present and future challenge of providing citizens with an adequate supply of water cuts across community boundaries. However, municipalities have generally made independent water system investments and have conducted autonomous resource evaluations without interjurisdictional cooperation and with little consideration for the regional implications of their decisions. Currently, 110 municipal water suppliers are serving 123 communities in the region. In 2008, nearly 2.8 million metro area residents received their water through a municipal system, while approximately 240,000 residences relied on private wells. In addition, water is withdrawn directly from regional water resources to use for such purposes as irrigation, manufacturing, and power generation.

Map of Metropolitan Area Public Water Suppliers (Appendix 1)

	As the region's population growth continues and new businesses develop, some suppliers in the metropolitan region will confront greater challenges than others in providing their customers with an adequate water supply. Anticipated changes in climate will inevitably affect the water supply for everyone. It is likely that more communities will face water supply limitations associated with aquifer extent and productivity, groundwater and surface water interaction, and contamination. Without a forward-looking plan for supply development, costly, time-consuming, and politically challenging limitations will likely become more frequent and more acute.	
HISTORY OF REGIONAL WATER SUPPLY PLANNING	In 1973, the United States Geological Survey and the Metropolitan Council published the first comprehensive assessment of the Twin Cities metropolitan region's water supply, titled *Water Resources Outlook for the Minneapolis – St. Paul Metropolitan Area.* The report concludes that "the status of the present water resource system, how it operates, and how much it can be expected to supply in the future is not fully understood." It goes on to suggest that a "totally accurate long-term prediction" is not possible due to the complexity and size of the system and the unpredictability of future pressures. Detailed suggestions are made for monitoring and mapping the area's water supplies.	Water Resources Outlook for the Minneapolis – St. Paul Metropolitan Area
	Since 1973, numerous studies of the region's geology and water resources have been done, each building on previous results. Various plans addressed management of those resources. The Metropolitan Council's 1992 *Twin Cities Metropolitan Area Water Supply: A Plan for Action* describes the issues facing water suppliers and proposes possible actions to address those issues, including requiring water supply plans to be a part of local comprehensive plans. The report also recommends an ongoing program for assessing water resources and evaluating alternative water supplies. Since the drafting of that	Twin Cities Metropolitan Area Water Supply: A Plan for Action

report, the Metropolitan Council, along with partner entities, has periodically conducted studies to project demand and gather additional information on availability. However, until the initiation of efforts to develop this Metropolitan Area Master Water Supply Plan, a comprehensive approach did not exist. The question of projected demands and supply availability remained unassessed, and responses were not always well coordinated.

2005 Legislature Mandate

The expected pressures on the region's water supply led the Minnesota Legislature to initiate a comprehensive process for investigating water supplies and planning for their sustainable use. The legislature directed the Metropolitan Council, as the regional planning agency, to develop this Master Water Supply Plan and the Department of Natural Resources (DNR), as the agency that manages Minnesota's waters, to approve the plan to ensure that adequate water supplies are available for the region's present and future generations. The five specific requirements of the legislation and a summary of actions taken to fulfill each requirement are described below.

Minnesota Statutes, Section 473.1565

Requirement I
Develop and maintain a base of technical information needed for sound water supply decisions, including surface water and groundwater availability and analysis, water demand projections, water withdrawal and use impact analysis, and modeling.

Action
Building on previous efforts and interagency expertise, numerous datasets were created or assembled to evaluate surface and groundwater use and availability. Data came from many sources and included water supply system data, hydrogeologic information, well data, land use, past and projected water usage, and contamination data. Tools were developed and used to evaluate potential impacts of projected

GIS Data Library

Make-a-Map

demands on the region's water resources. All this information is now organized into coherent and easily accessed online tools and applications.

Requirement II
Develop and periodically update a Metropolitan Area Master Water Supply Plan, prepared in cooperation with, and subject to, the approval of the DNR Commissioner that:

- Provides guidance for local water supply systems and future regional investments.
- Emphasizes conservation, interjurisdictional cooperation, and long-term sustainability.
- Addresses the reliability, security, and cost-effectiveness of the region's water supplies.

Action
In addition to this report, the Metropolitan Area Master Water Supply Plan includes the online tools and references, groundwater flow model, community profiles and appropriation permit guidance, and maps, which constitute the heart of the plan. Those, in turn, are expressions of underlying research, measurements, databases, and analysis intended to ensure that the results and guidance presented are relevant and accessible.

This document outlines water supply issues for each community and provides guidance on how communities can address these issues. This document also outlines the process for essential ongoing data collection, analysis and planning. These ongoing efforts will ensure the reliability, security, and cost-effectiveness of water supplies over the long term.

Metro Model 2

Conservation Toolbox

Community Profiles (Appendix 2)

Appropriation Permit Guidance (Appendix 3)

Water Quality Issue Guidance (Appendix 4)

Requirement III
Provide recommendations for clarifying the appropriate water-resource planning roles and responsibilities of local, regional, and state government.

Action
Recommendations for clarifying government roles were developed and reported in the *Water Supply Report to the 2007 Minnesota Legislature*. This plan furthers that discussion by describing the unique roles and responsibilities of government agencies with this plan in place.

Requirement IV
Provide recommendations for streamlining and consolidating metropolitan area water supply decision-making and approval processes.

Action
The most valuable improvement to the decision-making process is early identification of potential water supply limitations. The Master Water Supply Plan clearly outlines issues to be addressed by applicants for water supply appropriations. The plan also lays out guidance for addressing those issues based on recent actions required by the DNR for similar circumstances. Because communities will be aware of impending issues, and steps to address those issues as part of their planning process, problems that led to appropriation permit delays in the past are reduced.

This planning process has also led to improved coordination among agencies, a centrally assembled set of data, and enhanced tools with which to clarify and streamline the well-siting and water-appropriation permitting process.

Water Supply Report to the 2007 Minnesota Legislature

Opportunities for sharing well-siting documentation submitted by communities have been identified among state agencies and the agencies have designed a process for implementation to ensure efficiencies. Implementation of this plan and associated state and local actions will increase the likelihood that both the quality and quantity of a future source is deemed sufficient prior to a community building a new well. Chapter 4 of this report describes the Master Water Supply Plan in the context of state and regional planners and regulators.

Requirement V

Develop recommendations for the ongoing and long-term funding of metropolitan area water supply planning activities and capital investments.

Action

The *Water Supply Report to the 2007 Minnesota Legislature* recommends that an appropriate level of state funding be supported for water system improvements that ensure water supply reliability, natural resource protection, and/or safety and security, including economic security, of the region and state. It is clear from stakeholder input that existing capital funding options, such as the State Drinking Water Revolving fund and state bonding, are appropriate funding sources and sufficient to meet current regional needs.

A funding source is needed, however, to meet this requirement's mandate for an ongoing Metropolitan Area Water Supply Plan. The groundwater model, community profiles, appropriation permit guidance, and a variety of analytical tools have been created, but they have barely begun to be used. Ongoing funding will be essential to allow the testing, updating, and refining of these tools and allow

users to apply them to answer difficult questions and resolve water supply problems. If the collective impacts of the anticipated increased groundwater use materialize, long-term funding for development of conjunctive use of surface and groundwater will also be needed. The legislature's initiative in recognizing the importance of water supply planning is prima facie evidence of the importance of this effort; its continuance depends on the extent to which funding is made available.

Metropolitan Area Water Supply Advisory Committee

The 2005 Minnesota State Legislature established the Metropolitan Area Water Supply Advisory Committee to assist the Metropolitan Council in its water supply planning activities and to advise the Council in developing the Master Water Supply Plan.

The Advisory Committee consists of 13 members and includes a representative from the DNR, Department of Agriculture (MDA), Minnesota Department of Health (MDH), and Minnesota Pollution Control Agency (PCA). In addition, two members are officials representing metropolitan counties, and five are officials representing local governmental units. The chair of the Metropolitan Council chairs the Advisory Committee and a member of the Metropolitan Council serves as vice chair. The Advisory Committee has provided guidance regarding planning activities throughout the design and development of this plan. Members have advised the plan development, crafted recommendations and principles, and provided direct input during the plan's development. The Committee met monthly in 2006 and 2008 and held quarterly meetings in 2007. The Committee will continue to meet regularly through 2010 in order to guide implementation of the Master Water Supply Plan.

Metropolitan Area Water Supply Advisory Committee

PARTNERS AND STAKEHOLDERS

Early in the process, it was recognized that the participation of those who are involved in water resource and supply management is critical for this to be a successful and useful effort. To gather input on the plan and its components, stakeholder workshops were

	designed and carried out. These involved a wide base of regional planners, municipal water suppliers, government officials and interested citizens. Throughout the process, meetings and public forums with the state's and region's agencies and planning partners were held to ensure that actively stakeholders would be involved in the ongoing development of the plan. As the need to develop technical information and tools emerged in 2007, a technical advisory group was convened to ensure the accuracy of data and the usability of its analysis. As planning continues into the future, the collaborative process that has been established between stakeholders and the Metropolitan Area Water Supply Advisory Committee will also continue.	
Technical Advisory Group	In 2007, a technical advisory work group was established to provide guidance regarding water supply availability and analysis, and specifically to guide the development of Metro Model 2. This group met periodically to discuss the model's assumptions, conceptual framework and scenario results. The involvement of this knowledgeable and diverse group results in an increased likelihood that this Master Water Supply Plan includes the best available data and analysis, and recognizes the views and values of the region.	Master Water Supply Plan Technical Advisory Workgroup
Planning Partners	Beyond their role on the Metropolitan Area Water Supply Advisory Committee, each state agency represented played a unique role in the development of this plan. Because this plan focuses on water resource availability, the DNR, with its charge to manage Minnesota's water resources, was an intimate partner in the plans development. The plan is also subject to the approval of the DNR Commissioner. The Metropolitan Council and the DNR worked together to identify	

	water supply options and conditions of use that are presented in this plan. Decision-makers from the two organizations met routinely, and will continue to meet, to discuss each community's potential sources and projected water use conditions, and to guide water supply development to ensure protection and sustainable use of the region's water resources. The MDH, with its role in protecting public health by ensuring a safe and adequate supply of drinking water at all public water systems, provided significant assistance and guidance in the development of this plan. The MDH guided the discussion about providing additional resources to water suppliers in order to ensure the safety and security of water supply systems and sources. The MDH will continue to work with communities to identify opportunities to develop interconnections enabling them to share water during short-term water shortages. The PCA and MDA both administer programs that protect the quality of region's water resources. In addition, both organizations monitor and compile data on the quality of water resources. These data were used in the analysis of supply availability in the development of this plan. Through the cooperative efforts of all these agencies, this plan provides the best available water demand and supply data while providing guidance toward managing withdrawals sustainably. Continued cooperation among these agencies will ensure that this plan continues to be an effective resource and guide.	
Stakeholders	Municipal water suppliers, who have direct responsibility for water supply in the region and who are most directly affected by planning activities, have been critical participants in the development of this plan. In the Spring of 2006, three workshops were held to solicit public comment. Thirty-two communities were represented among the 115 attendees. Participants discussed their concerns regarding	Water Supply Report to the 2007 Minnesota Legislature: Stakeholder Input

drinking water quality, supplies, safety, security, and funding. What emerged as a central issue was the need to link water supply to overall planning. Attendees suggested that evaluating resources in the context of planned growth is necessary if we are to address potential limitations. They emphasized that, to the extent possible, a thorough evaluation should occur prior to development.

These workshops began what continued to be an open collaborative process as this Master Water Supply Plan was developed. An email list was established with over 140 contacts from the public and private sectors. These contacts received updates on the development process, and provided ideas and direction regarding its progress.

A second workshop was held in the fall of 2006 to elicit feedback on the draft interim Report to the Legislature. From 2006 through 2008, meetings were held with various groups, including the Northwest Metro Water Supply Work Group, American Water Works Association–Minnesota Section Water Utility Council, Southwest Metro Groundwater Work Group, partner agencies, and others to provide updates and gather input. In addition, presentations on the planning effort were given at several conferences, including the Minnesota Section of the American Public Works Association; the Civil Engineer Association of Minnesota; Minnesota Air, Water, and Waste; and Minnesota Water Resources Conference. In 2008, additional stakeholder workshops were held to gather stakeholder views regarding the region's role in addressing water resource limitations.

BENEFITS OF THE METROPOLITAN AREA WATER SUPPLY PLANNING PROCESS

The development of this plan is not motivated by widespread water shortages or crises. Rather, this plan is in response to the recognized benefits of developing and maintaining a plan that ensures supplies are developed sustainably without adverse impact to natural resources. The plan focuses on stakeholder-identified issues that have limited water supply availability in the past and those that may

occur in the future. Results of a metropolitan area water supply availability assessment are presented at both a regional and community scale, in order to identify and coordinate water supply planning activities among utility, local planning, and regional planning and technical staff. By using the tools and guidance found in the components of this plan, decision-makers may avoid many of the costly and time-consuming delays in water supply development, as well as the challenging appropriation decisions, that have been faced in the past.

For communities whose current withdrawals are already affecting wetlands and other surface water, this plan is an invaluable source of information and options. Such an information resource is critical as we are already observing the reduction of water levels along the Minnesota River, reduced flows into wetland fringes, and a lowered water table with associated dewatering of wetlands in the northern suburbs.

Better Data, Better Analyses

The specific water supply sources and the associated regional and local issues identified in this plan are supported by analyses based on the best available regionally consistent data. These data include supply system infrastructure information, existing hydrogeologic data, groundwater and surface water interactions, and areas of known groundwater contamination. To develop these data, this plan draws on state, regional and local governments, public water utilities, private sector consultants, and representatives from academia.

This regional approach to water supply assessment objectively highlights potential problem areas and thus reduces the likelihood that water supply problems will develop “under the radar” in communities not currently planning for high growth or in communities whose focus on other issues precludes close attention to their water resource availability and future needs.

	Data and analyses are available to the public as regional map themes through the Make-a-Map application on the Metropolitan Council website. Information found there will help regional and local planners address water supply limitations so that they may find ways to meet community demand while protecting valuable natural resources.	Make-a-Map
Identification of Potential Supply Problems Early in the Planning Process	In the past, there were instances when, after a new well had been installed, the community's water appropriation was limited because of insufficient aquifer productivity or impacts of pumping on other users or on surface water features. In these cases, communities had to invest time and resources to find and develop alternative or additional water supply sources. In some cases, community development plans were adapted to slow population growth, allowing time to explore options. Because communities will now know the impending, known water supply issues facing them, they will be able to plan in a more careful and informed manner. This will also give the Metropolitan Council an opportunity to consider the impact of potential limitations on regional growth forecasts. For some affected communities, the identification of water supply issues on a broader scale and earlier in the process will also create incentives for interjurisdictional cooperation and consideration of the benefits of the economies of scale. Rather than limiting community growth based on the available water resource, this plan identifies how each community may address predicted water supply issues prior to needing the water. To ensure that each community addresses its water supply needs in a manner that results in sustainability for the region, future community water supply plans must address any issues associated with using a planned source and identify alternatives to use in the event that the issues with the preferred source(s) cannot be addressed.	

	The Metropolitan Master Water Supply Plan uses the same assumptions and long-term forecasts as the systems that are included in the Metropolitan Council's Regional Development Framework and local plans (transportation, parks and open space, aviation, and wastewater). Ongoing consistency among the Regional Development Framework, local plans, and this plan will ensure water supply is an integral component of long-term regional and local comprehensive planning and the sustainable use of the region's water supplies.	Regional Development Framework
Simplified Permitting and Approval Processes	The regional and local water supply issues identified in this plan were assessed in close cooperation with the DNR, and issues relevant to each community are outlined in the community's profile. When a community's revisions of its local water supply plan are consistent with this Master Water Supply Plan, that plan will not only be approved, but that approval will ensure that its water appropriation permit requests are more likely to be granted. Because aspects of each community's water supply plan are unified under one rubric, the community, Council, and DNR may avoid time-consuming, costly and politically challenging delays in water supply development.	Community Profiles (Appendix 2) Appropriation Permit Guidance (Appendix 3) Water Quality Issue Guidance (Appendix 4)
Economies of Scale	This plan helps communities realize economies of scale in multiple ways. Costs associated with resource assessment are now reduced or eliminated because publicly available and regionally consistent data is provided as a part of this plan. Additional resources, including Metro Model 2 and the Conservation Toolbox, are also provided on the Metropolitan Council's website.	Metro Model 2 Conservation Toolbox
	As development expands and demand increases, opportunities for interjurisdictional partnerships will, too. Continuous updating of Metro Model 2 and the associated community profiles will identify such opportunities for cooperation to supply water in both the short and long term.	Metro Model 2

The data, analysis, and tools that comprise this plan provide communities the basis for resource planning so that they no longer need to start from scratch. To that extent, the Metropolitan Master Water Supply Plan is a service not only for regional planners and state agencies, but for county and community planners and water resource managers, water suppliers, and the residents of the communities they serve.

CHAPTER 2: THE BASIS OF WATER SUPPLY PLANNING: GOAL AND GUIDING PRINCIPLES

DEVELOPMENT OF PLANNING PRINCIPLES

The Twin City metropolitan area is fortunate to have relatively abundant groundwater and surface water supplies. Although water is abundant, its use must be guided by the values held by the citizens of the region and the State of Minnesota. Citizens value protection of wetlands, lakes and streams. They hold a deep commitment to future generations and want to ensure that there will be reliable supplies of water for them. They also value a balance between multi-community cooperation and local control. It is these values that define our accepted limits, guide our use of water resources, and ensure the sustainable development of our water supplies.

In attempting to infuse the Metropolitan Area Master Water Supply Plan with these values, the Metropolitan Council recognized that the development process needed to be characterized by transparency and inclusiveness. Therefore, Council staff sought input from technical experts, municipal water supply staff, water supply consultants, water resource managers, elected and appointed leaders, and the Metropolitan Area Water Supply Advisory Committee, as well as citizens at large. Stakeholders played an integral role throughout the process, but the role they played in framing the principles on which the Water Supply Plan rests has been invaluable (Partners and Stakeholders, Chapter 1).

An overarching goal and seven supporting principles emerged from the workshops, meetings, and discussions held over the course of 2008. This goal and these principles are intended to guide water supply planning and development in the region. They are consistent with existing Minnesota Statutes and Rules and reaffirm what is already generally accepted by the leaders, planners, and citizens of the region.

ENCOMPASSING GOAL

Ensure a sustainable water supply for current and future generations.

Without exception, stakeholders accepted the premise of sustainability as the foundation of water supply planning. There has been, however, much discussion, beyond this water supply planning process, surrounding the meaning of "sustainable use."

Minnesota Statute defines sustainable development for local government as:

> *"…development that maintains or enhances economic opportunity and community well-being while protecting and restoring the natural environment upon which people and economies depend. Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs."*

Minnesota Statutes, Section 4A.07

The Department of Natural Resources (DNR) is charged with managing the state's water resources to ensure adequate supply to meet long-range seasonal requirements for domestic, agricultural, fish and wildlife, recreational, power, navigation, and quality-control purposes. Sustainable use of groundwater is defined by the DNR as:

Minnesota Statutes, Section 103G.265

> "… use of water to provide for the needs of society, now and in the future, without unacceptable social, economic or environmental consequences."

Department of Natural Resources: Sustainability of Minnesota's Ground Waters

The 2009 Minnesota State Legislature provided the following definition for the purpose of developing comprehensive statewide sustainable water resources detailed framework:

> "…water use is sustainable when the use does not harm ecosystems, degrade water quality, or compromise the ability of

Minnesota Session Law 2009 c 172

future generations to meet their own needs."

This plan adopts the preceding definition, accepts the responsibility of calculating sustainability as it relates to the waters of the region, and applies it to water supply planning.

Every use of water has some consequences. For instance, groundwater withdrawals in the metropolitan area result in some reduction in base flow to the major rivers. Because of the magnitude of the major rivers and the groundwater system, this is not even measurable and is an acceptable consequence by most standards. In another case, however, a groundwater withdrawal might directly affect a local wetland, which may indeed be an unacceptable consequence.

Sustainable water supply management does not occur in a vacuum. Any real-world water supply planning framework must include an understanding of the links between surface water and groundwater, water quality and quantity, and water and land use. As these links are explored and evaluated, both objective technical information and subjective human values come into play. In this expected interplay that constitutes policy-making and planning, the following principles will continue to be the foundation on which decisions are made in our region.

PRINCIPLE 1

Water supply planning is an integral component of long-term regional and local comprehensive planning.

In the past, regional and local planning often considered water supply as an afterthought. For the most part, this has been successful, as the prolific groundwater system and abundant surface water were able to support development. However, there have been instances where growth has been delayed due to water supply limitations identified late in the development process. The significant added cost and hardship that ensued in such cases could have been avoided had water supply

been considered earlier in the planning process.

As directed by Minnesota Statute, the Metropolitan Council prepares and updates, every 10 years, a comprehensive development guide for the metropolitan area. The comprehensive development guide considers the impact of four regional systems, and plans for their orderly expansion. The systems are transportation, parks and open space, aviation, and wastewater. As future comprehensive development guides are prepared, this Master Water Supply Plan will be incorporated into the planning considerations. In addition the Council will update the plan using the same forecasts and on the same timeframe as the comprehensive development guide. Communities will in turn reflect the issues and steps to address them, including alternatives to meet projected demands if the issues identified limit use of the preferred source, in their local comprehensive plan (water supply plans).

Minnesota Statutes, Section 473.145

Regional Development Framework

Water supply availability will not in itself limit nor be the only reason growth occurs in a specific area; rather, the region will identify sources available for a community's use and will highlight issues associated with these sources. The Metropolitan Council and communities will consider this water supply availability information along with factors affecting regional systems to determine where growth should occur. If it makes sense to grow due to reasons other than water supply but water supplies are limited, the communities affected and the Council will work together to ensure an adequate supply source is identified prior to development.

PRINCIPLE 2

An understanding of the region's long-term water supply availability and demand is necessary to identifying a specific community's or sub-region's water sources.

Water supply decisions based on immediate needs or short-term solutions may create supply limitations for some communities in the

	future and may cause adverse impacts to water-dependent features over the long-term. To meet water demand over the long-term, the characteristics and limitations of water supply sources must be understood. Without that understanding, it is not possible to ensure that future needs will be met or that water-dependent natural features will be protected.	
	This plan identifies areas where groundwater withdrawals are likely to adversely affect surface water features, alter aquifer properties, or degrade water quality. In calculating the long-term need for water, the plan considered water demand up to the year 2050 based on Metropolitan Council and local comprehensive plan population projections. When population projections are overlaid on hydrogeologic data that describes the region's total water supply, geographic areas of vulnerability and potential limitation emerge. Early attention to the issues emerging from development of these areas ensures that the region's water supply is equitably and fairly apportioned among communities and across generations.	Maps (Appendix 1) Community Profiles (Appendix 2)
	Regardless of the degree to which water availability is understood, uncertainty is a constant factor. Water supply planning must be done in such a way that the plans can adapt to factors such as climate changes, technology and emerging contaminants. In order to maintain a current and appropriate level of guidance, this plan will be updated as new technology emerges and as analyses are revised with new data.	
PRINCIPLE 3	**All hydrologic system components, naturally occurring and man-made, must be carefully evaluated when making water infrastructure plans.** The interrelated nature of such hydrologic system components as surface water features, watershed boundaries, groundwater divides and recharge, aquifer chemistry, stormwater and wastewater	

management, and human water uses create a challenge for those responsible for planning for the region's future. Most communities successfully meet the water quality and quantity needs within their boundaries. However, political boundaries do not encompass either water supplies or human needs.

In fact, water quality and quantity issues typically follow naturally occurring and man-made hydrologic boundaries within a geographical region. Evaluating the adequacy of supplies at this larger scale is challenging, if not impossible, at the community level.

As communities work to meet demands placed on their water resources, it is important that they understand the larger hydrologic cycle so they can fulfill their needs without creating unintended problems for others. This Master Water Supply Plan integrates many of the components of the hydrologic cycle and thus provides a framework for the planning of the region and communities within it.

As refinement and expansion of the plan continues, the region's hydrologic factors will be further integrated into the decision-making process. When long-term solutions to water supply needs are developed, they will rest on a thorough understanding of all components of the hydrologic cycle: naturally occurring, man-made, within community boundaries, and beyond them.

PRINCIPLE 4

The quality of the region's water is a critical component of water supply planning.

Clean and safe drinking water is an important part of a healthy environment and is essential to protecting public health. Surface and groundwater contamination can occur from both natural sources and human activities. Protecting water quality is a two-tiered effort. First, it is important to protect the water at its source; secondly, it is important to ensure that after treatment and distribution, water supplies meet current drinking water quality standards.

	Numerous federal, state, regional, and local programs are in place to protect water quality at the source and to ensure safe drinking water. For instance, stormwater regulations enforced at multiple levels of government ensure that water quality is improved before stormwater is allowed to flow to surface water bodies. Assessment of the impacts of stormwater ponds and rain gardens on groundwater quality is now underway. Naturally occurring contaminants are also present throughout the region, and the Minnesota Department of Health (MDH) is in the process of mapping those which are of particular concern. Programs such as the Wellhead Protection Program and the Source Water Protection Program, both of which are administered by the MDH, address potential contaminant sources in areas that contribute water to a public water supply well or surface water intake. This plan identifies areas where groundwater is especially susceptible to contamination, as well as areas where groundwater contamination exceeding health-risk limits has resulted in special well construction requirements. Local water quality issues will continue to be addressed by water suppliers and the local and state agencies that have a role in managing water quality. To reduce exposure to contaminants and meet the requirements of the Safe Drinking Water Act, consideration should be given to adopting all water supply system development options available, including alternative sites and methods of treatment.	Wellhead Protection Source Water Protection
PRINCIPLE 5	**Interjurisdictional cooperation is a viable option for managing short-term water supply disruptions and sustainably meeting long-term water supply needs.** As the region continues to grow and water supply withdrawals increase with it, opportunities for interjurisdictional cooperation will emerge. Interconnections among neighbors may resolve the need for back-up water supplies during short-term water emergencies. Co-development of supply sources and systems may offer economies of scale while addressing resource limitations. In addition, cooperation among	

	agencies and water suppliers will result in timely regulatory decisions. Many communities in the region have at least one emergency interconnection with another supplier. In addition, there are several situations where one community supplies another on a retail or wholesale basis. Most communities, however, still maintain and operate their own independent systems to supply their regular demand. This Master Water Supply Plan and the associated ongoing evaluation of water resource availability will help to identify issues that might best be resolved by interjurisdictional cooperation. The region will provide assistance by helping communities identify water supply options, facilitating interjurisdictional discussions, and assisting in the development of economic and feasibility studies.	
PRINCIPLE 6	**Regional and local cost-effectiveness and equity are considered when identifying water supply options.** The cost of supplying adequate drinking water to customers depends on various factors, chief among which is the source itself. Costs rise if withdrawals adversely affect valued natural features, water quality, or surrounding wells. Stringent treatment requirements tend to make surface water-dependent systems more expensive to run than groundwater-dependent systems. On the other hand, treating contaminated groundwater to meet health standards can add cost. Water usage itself also affects cost. For instance, per capita use in the metropolitan area tends to be higher than elsewhere in the state, so greater costs are incurred. Recognizing that owning and operating water supply systems is a local responsibility, this plan does not dictate to a community which source it must use. Rather, this plan identifies the issues the community must address in order to use each source available to it. The cost associated with addressing these water supply issues depends on the severity of	

	the issue and other factors. Providing options, however, allows planners to select a source that serves the community's needs as economically as possible. In cases where information is insufficient to determine the best available option, the plan identifies the issues to be resolved or additional information to be gathered in order to assess supply availability prior to selecting a water supply source. If a community's planned expansion of use from its traditional source negatively impacts its neighbors or the region's natural resources, planners may need to choose a more costly option. For this discussion, "traditional source" refers to the existing source or sources most heavily relied on by the community. There will also be situations where a capital project provides a state or regional benefit, such as the proposed interconnection between the Minneapolis and St. Paul water supply systems to improve security and reliability of supplies for a significant portion of the region. In both of these types of situations, an appropriate level of state funding should be considered, as recommended in the *Water Supply Report to the 2007 Minnesota Legislature*.	Water Supply Report to the 2007 Minnesota Legislature
PRINCIPLE 7	**Wise use of water supplies is critical to ensuring adequate supplies for future generations.** The region's ample water resources support all kinds of life, whether vegetable or animal, terrestrial or aquatic. As the region continues to grow, the demand for water is putting greater pressure on the resource that residents, human and other, depend on for their very survival. Wise development of the water resource can help to alleviate some of this pressure. Nevertheless, it is also essential that the region does not waste this critical resource. Just as every action we take has consequences, the use of water even in areas where supplies are plentiful has some impact on the overall water system and requires the use of energy, chemicals, and other resources to supply demands.	

Activities designed to improve the efficiency of water use also help the region use water, and resources associated with water supply development, wisely. Demand management for an urban water supply utility encompasses a range of possible measures, such as cost-reflective pricing, universal customer metering, leak detection and repair, zone and customer pressure reduction, use of reclaimed water, and temporary or permanent water use restrictions.

Communities throughout the region are already providing water conservation education, and they are implementing programs to promote the efficient use of water. In addition, the DNR and Metropolitan Council have established water use benchmarks that communities in the region must meet or work toward as they implement water conservation programs.

Water Use Benchmarks

One component of this plan is an online Water Conservation Toolbox that provides communities with program ideas to help them meet the water use benchmarks. These benchmarks and conservation programs will be evaluated periodically so that recommendations for changes to local or regional programs can be made. Local water suppliers will include water conservation in their water supply plans, and they are encouraged to select water conservation programs that target outdoor water use.

Water Conservation Toolbox

As the region continues to grow, new technologies develop, and new infrastructure is constructed, opportunities will arise for furthering wise use of the region's water resources. Water conservation should continue to be woven into the fabric of development planning and policy.

CHAPTER 3. WATER SOURCES AND THE FORCES AFFECTING THEM

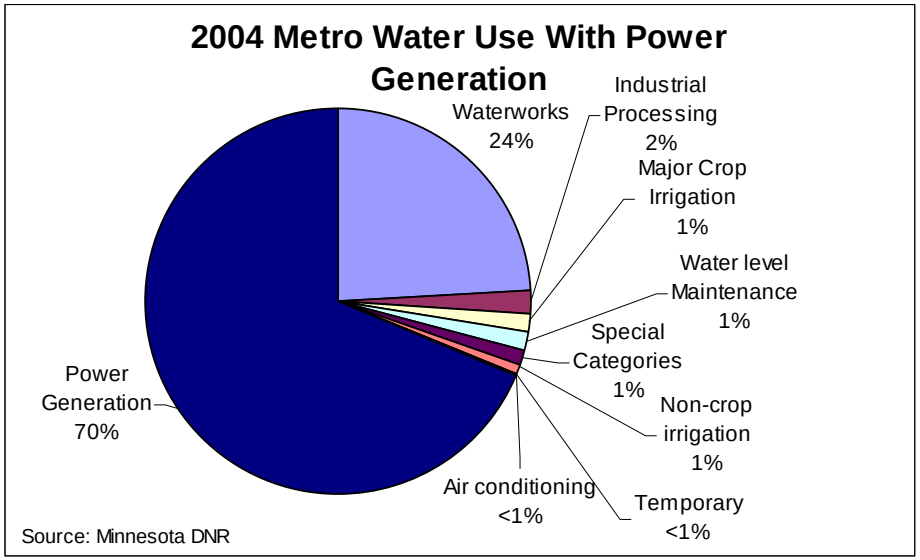
WATER USAGE OVERVIEW

The Twin Cities metropolitan area is unique among major metropolitan areas in that it rests atop a groundwater flow system—the bowl-shaped Twin Cities basin—that does not extend far beyond the region's boundaries. The Twin Cities basin is filled with up to 1,000 feet of sedimentary rock layers that act as aquifers with intervening confining layers. This unique geologic situation provides the region the ability and responsibility for managing much of its own groundwater resource. The same cannot be said for surface water. The major rivers flowing through the metropolitan area have the majority of their watersheds outside the region, making management of the resource a challenge. However, with prudent planning and management of the water resources, the majority of communities within the seven-county area will not suffer serious water limitations for at least many decades.

In 2008, an average water demand year, the metropolitan area used approximately 490 billion gallons of water. While power generation accounts for about 320 billion gallons, only about 1% of the water used for power generation was actually consumed; the remaining 99% was returned directly to the source from which it was obtained. About 120 billion gallons of the water used was supplied through 110 municipal systems serving residential, commercial, and industrial customers in the region's 123 communities. The remainder of the total—approximately 50 billion gallons of water—was appropriated for a variety of uses: industrial processing, major crop irrigation, water level maintenance, non-crop irrigation, air conditioning, and other special or temporary needs. Municipal systems in the metropolitan area are publicly owned and operated. Most belong to individual communities, but three are governed and operated through arrangements that include a public utility commission, regional governing board, or joint water commission.

DNR Water Use Categories

Map of Metropolitan Area Public Water Suppliers (Appendix 1)



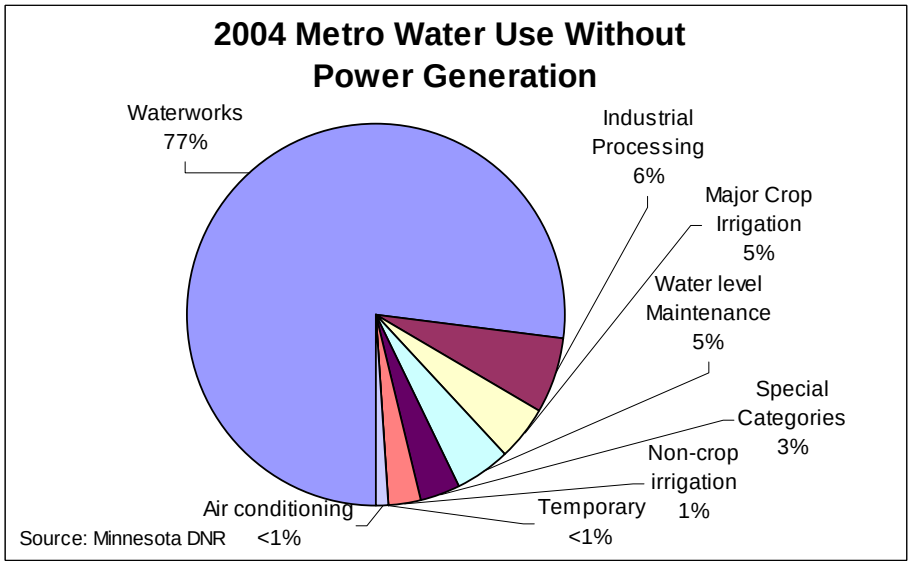


FIGURE 1: METROPOLITAN AREA WATER USE

	While municipal water suppliers provide water to commercial, industrial, and institutional users, residential use accounts for 70% of municipal demand. Approximately 90%, or 2.5 million residents, receive water from municipal systems. Approximately 10%, or 290,000 residents, rely on private wells. The smallest municipal system serves fewer than 200 residents while the largest serves nearly 500,000. Across the Twin Cities metropolitan area, residential indoor water use remains relatively constant throughout the year. That average, which is represented by water use in January, is 45 to 80 gallons per person per day. Summer water use depends on temperature and precipitation, and it can cause average residential per-capita daily water use figures to vary widely from year to year. Outdoor water use can vary between 45 and 120 gallons per person per day on average, although peak use numbers for communities with large lots and new turf may rise to 200 or more gallons per person per day.	
INTERJURISDICTIONAL COOPERATION	Agreements exist today, among communities in the metropolitan area, for supplying water continuously to one another either on a wholesale or retail basis. Other arrangements are in place to share water in the event of a short-term water supply emergency. Thirty-one communities in the metropolitan area receive water from another community to meet daily demand. Twelve of those communities purchase water wholesale and distribute the water to its customers, while the other 19 communities rely on another community for billing and water distribution for at least a portion of their community. About 50% of metropolitan area communities that have public water supply systems have at least one emergency connection with a neighboring community. Most of these connections occur at relatively small-diameter pipes that are capable only of augmenting	Map of Municipal Water Supply System Interconnections (Appendix 1)

	supplies rather than completely replacing them. As the metropolitan area population grows, water demand increases, and water supply infrastructure expands, interjurisdictional cooperation may become a viable strategy. The Master Water Supply Plan identifies areas that might best resolve their issues through interjurisdictional cooperation. Differing water chemistry, pressure zones, and rate structures are common challenges associated with interjurisdictional cooperation. The plan presents water treatment for each metropolitan area community through the Make-A-Map water supply application on the Metropolitan Council website. A water supply system interconnection has been proposed by the Minneapolis Water Works and Saint Paul Regional Water Services, and state support has been recommended by the Minnesota Department of Health (MDH) and the Metropolitan Council. To date, a complete funding package for such a system has not been established. If this interconnection were to be built, it would supply sufficient water for the minimal, basic needs of either city.	Make-a-Map
SURFACE WATER SOURCES	When power generation is included, surface waters are the source of approximately 80% of the total water used each year in the metropolitan area. The Mississippi River supplies approximately 40% of the total surface water used, while the Saint Croix River supplies approximately 30%, the Minnesota River approximately 25%, and Vadnais Lake approximately 5%. Surface water is the source for approximately 30% of municipal water supplied in the region. The Minneapolis Water Works draws all its water from the Mississippi River. The Saint Paul Regional Water Services draws approximately 70% of its supply from the Mississippi River and the remainder from a combination of high-capacity wells	

and Vadnais Lake, which is connected to Centerville Lake in the Rice Creek Chain of Lakes. Together, the Minneapolis and Saint Paul systems serve their primary communities as well as 16 additional communities—a total of approximately 900,000 residents, or one-third of the region's populace.

In addition to providing water for the two major water supply systems in the metropolitan area, surface waters provide navigation access, waste assimilation, recreation, aquatic and terrestrial habitat, and cooling water for power plants. These competing uses are essential to consider when evaluating the capacity of regional surface waters to serve as sources into the future.

Currently, the flow of the Mississippi, Saint Croix, and Minnesota rivers far exceeds the volume needed to meet municipal and private demand. Severe drought or contamination, however, could limit the amount of water available for withdrawal.

If Mississippi River supplies become limited, the Saint Paul water system could use the reserves it maintains in the Rice Creek Chain of Lakes and tributaries to Vadnais Lake. These reserves can supply approximately 60 days of the system's average water demand. Because a 60-day supply may not meet system needs during an extended drought or large contamination event, Saint Paul Regional Water Services is installing wells able to supply their total average daily demand. The installation of these new wells, scheduled for completion in 2009, allows Saint Paul Regional Water Services to meet the indoor water demand with groundwater. The Minneapolis water system remains more vulnerable since it currently has no alternative water source and only one to two days of storage in its system. If Minneapolis was unable to supply water for more than one day in the absence of an alternative supply, such as an interconnection with Saint Paul Regional Water Services, a public health and public safety emergency in the region could occur.

	Widespread use of surface water is unlikely because many of the region's communities are not adjacent to a reliable surface water source. In addition, surface water suppliers are required by federal law to include filtration and disinfection in their treatment processes as a final defense against contaminants, making treatment of surface waters for potable use costly. While transportation and treatment costs may be considered minor in parts of the country where water supplies are scarce, they appear excessive where groundwater sources are viewed as plentiful. Of course, this calculation could change as growth continues to put demand on the aquifers in the region. If the demand on certain aquifers becomes too great, there may be more opportunities for interjurisdictional cooperation among communities with access to surface water sources and those that do not have access.	
GROUNDWATER SOURCES	The region's aquifers currently provide approximately two-thirds of the municipal water consumed in the metropolitan area, and they serve the needs of about 1.6 million people. There are at least two, and up to five, aquifers available throughout the region. These aquifers are generally very productive, but productivity and extent vary. Groundwater withdrawals may also have adverse impacts on surface water features and other wells, sometimes to an unacceptable degree.	Map of Metropolitan Area Bedrock Geology (Appendix 1)
	Groundwater flow through both bedrock and surficial units is controlled by the Twin Cities metropolitan area's geologic past and current hydrology. Most of the bedrock aquifers in the metropolitan area are sedimentary rocks deposited millions of years ago in shallow seas that covered the area. These bedrock formations were subsequently eroded by wind and water and buried by a complex sequence of coarse and fine grained sediments left as glaciers moved across the landscape. These geologic processes have all influenced the development of bedrock erosion surfaces, including the creation of deep bedrock valleys and the complete removal of	Map of Regional Groundwater Flow Directions (Appendix 1)

geologic units in some areas.

The Prairie du Chien-Jordan aquifer system is the most heavily used and most productive, except for a few very high-producing glacial sand and gravel wells. Glacial sand and gravel aquifers, the Franconia-Ironton-Galesville aquifer system, and the Mount Simon-Hinckley aquifer system also provide significant amounts of water to portions of the region.

MGS Report RI-65

Figure 2 presents a schematic cross section of the Twin Cities basin. A brief overview of each of the aquifers and confining units identified in the figure follows.

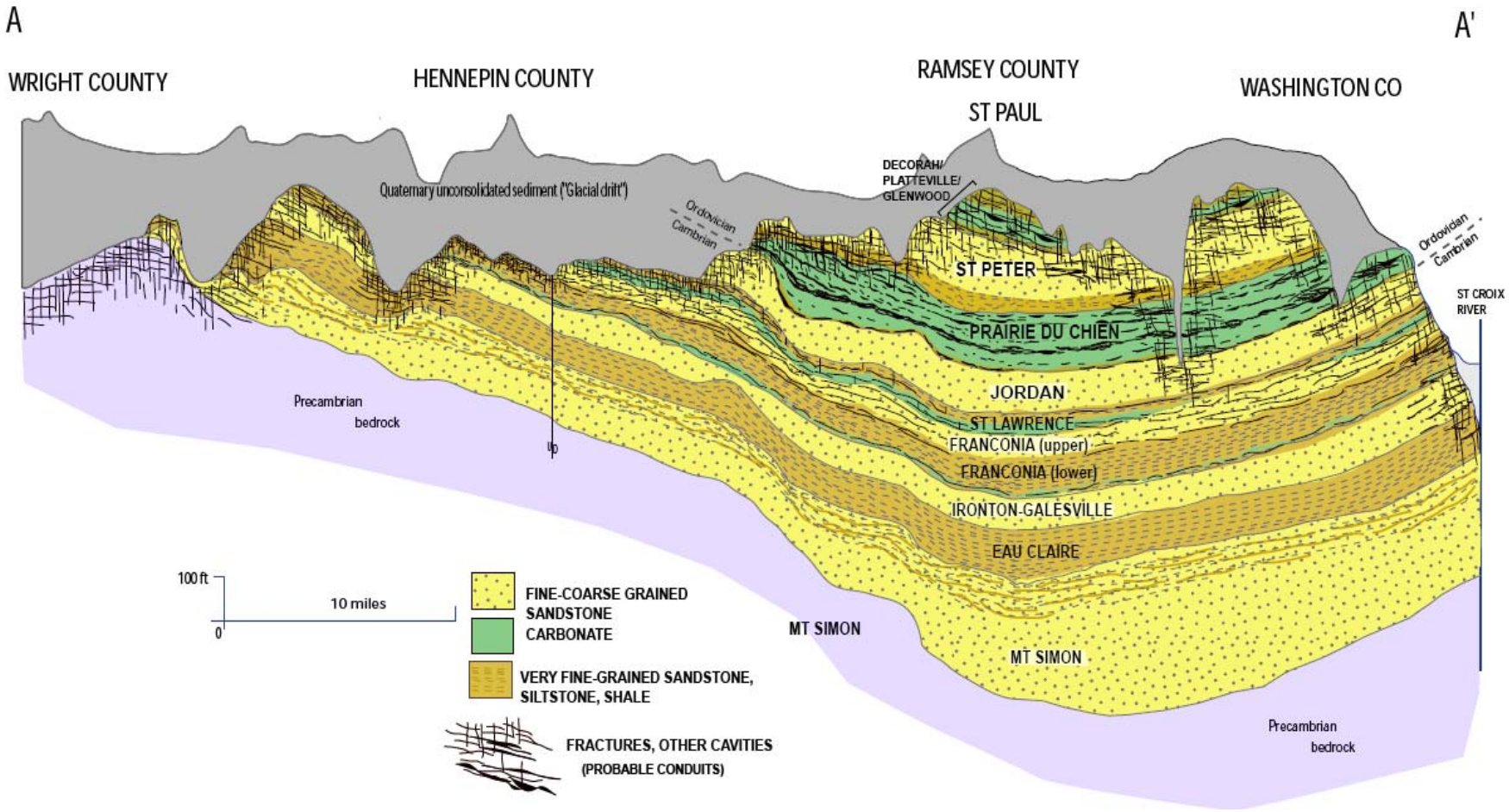


FIGURE 2: SCHEMATIC CROSS-SECTION OF THE TWIN CITIES BASIN (MODIFIED FROM MINNESOTA GEOLOGICAL SURVEY)

Quaternary Aquifer

The Quaternary aquifer is not a contiguous aquifer; it is, rather, several complex bodies of sand and gravel glacial deposits that yield moderate to large supplies of water to municipal suppliers and private wells. Precipitation infiltrates and percolates through these layers, recharging the aquifers that lie beneath them. Because it varies in extent and thickness, the Quaternary aquifer is a reliable municipal supply only in limited areas within the region and is either unreliable or unavailable in the rest.

The reported pumping capacity of metropolitan area municipal wells in the Quaternary aquifer ranges from 100 to 3,800 gallons per minute; average pumping capacity is 1,185 gallons per minute.

Decorah Shale Confining Unit

The Decorah Shale, composed of a mixture of shale and limestone, is found only in central portions of the metropolitan area—primarily in Saint Paul, Mendota Heights, West Saint Paul, Woodbury, and Oakdale. The high clay content of this geologic unit limits the vertical migration of water. The maximum reported thickness of this unit in southeastern Minnesota is 80 feet; however, it has been eroded entirely across much of the Twin Cities metropolitan area. Its limited extent negates its impact on groundwater flow across the region. No Twin Cities metropolitan area municipal wells draw water from the Decorah Shale.

Platteville and Glenwood Formations

The Platteville Formation, composed of dolostone and limestone, and the Glenwood Formation, composed of shale, are found in portions of Hennepin, Ramsey, Dakota, and Washington Counties. The maximum reported thickness of these units in southeastern Minnesota is 50 feet; however, they have been eroded away across much of the Twin Cities metropolitan area. Due to their fine-grained composition, these formations generally act as confining layers, or barriers to recharge, where they are present. Where these geologic units are fractured, however, they may act as minor aquifers supplying small-capacity wells. No Twin Cities metropolitan area municipal wells draw water

from the Platteville and Glenwood Formations.

Saint Peter Sandstone Aquifer

The Saint Peter Sandstone aquifer composed of a mixture of sandstone, shale, and siltstone, is relatively productive in parts of the Midwest outside the metropolitan area, but its limited extent and thickness within the Twin Cities basin makes it an inadequate source for municipal water in most of the region. The maximum reported thickness of this unit in the Twin Cities basin is 155 feet, although erosion has removed the Saint Peter Sandstone from much of the metropolitan area. Thickness may be as great as 190 feet in parts of southeastern Minnesota.

The reported pumping capacity of the only metropolitan area municipal well in the Saint Peter aquifer is 900 gallons per minute.

Prairie du Chien-Jordan Aquifer

Due to the well-established hydrogeologic relationship between the Prairie du Chien Group and Jordan Sandstone, the MDH and the Department of Natural Resources (DNR) regulate these units as a single aquifer and they are treated as one unit in this discussion. The Twin Cities Metropolitan Groundwater Flow Model Version 2.00 (Metro Model 2), however, treats the two units as separate layers.

The Prairie du Chien-Jordan aquifer, composed of sandstone and dolostone, is the most heavily used aquifer in the region because of its high productivity, generally good water quality, and relatively shallow depth. The maximum reported thickness of this unit in southeastern Minnesota is 430 feet; however, the Prairie du Chien-Jordan aquifer has been almost completely eroded in the northern and western portions of the metropolitan area. As a result, this valuable aquifer is not available to communities in these areas. In addition, the relatively shallow depth and high productivity of this aquifer increase its vulnerability to contamination.

The reported pumping capacity of metropolitan area municipal wells

	in the Prairie du Chien-Jordan aquifer ranges from 120 to 4,100 gallons per minute; average pumping capacity is 1,270 gallons per minute.
Saint Lawrence Formation	The Saint Lawrence Formation, present throughout most of the region, is composed of both siltstone and dolostone. The maximum reported thickness of this unit in southeastern Minnesota is 130 feet. In general, this geologic unit acts as a confining layer between the overlying Prairie du Chien-Jordan aquifer and underlying Franconia-Ironton-Galesville aquifer. Locally, however, the Saint Lawrence Formation may serve as a minor aquifer supplying small capacity wells. The reported pumping capacity of metropolitan area municipal wells in the Saint Lawrence Formation ranges from 50 to 120 gallons per minute; average pumping capacity is 110 gallons per minute.
Franconia-Ironton-Galesville Sandstone Aquifer	Like the Prairie du Chien-Jordan aquifer, the Franconia-Ironton-Galesville aquifer (FIG) is composed of two geologic units that are well connected hydrogeologically. As with the Prairie du Chien-Jordan aquifer, the MDH and DNR regulate the Franconia Formation and Ironton-Galesville Sandstones as a single aquifer. Although they are divided in Metro Model 2, they are treated as one aquifer in this discussion. The Franconia Formation is a mixture of fine-grained sandstone and dolostone. The Ironton-Galesville Sandstones, also known as the Wonewoc Sandstone, is composed of fine-grained to coarse-grained sandstone. The maximum thickness of the Franconia-Ironton-Galesville aquifer in southeastern Minnesota is 300 feet. Its thickness across most of the metropolitan area ranges from 140 to 180 feet. The Franconia-Ironton-Galesville aquifer is the most heavily used aquifer wherever the Prairie du Chien-Jordan aquifer is not present.

	The productivity of this aquifer varies greatly throughout the metropolitan area, with its highest productivity occurring in the north and its lowest in the west-southwest. This aquifer is seldom as productive as the Prairie du Chien-Jordan, however, except in those areas where it is highly fractured or weathered. The reported pumping capacity of metropolitan area municipal wells in the Franconia-Ironton-Galesville aquifer ranges from 115 to 1,600 gallons per minute; average pumping capacity is 700 gallons per minute. The name of the Franconia-Ironton-Galesville aquifer is expected to change in the near future, per a 2008 recommendation by the Minnesota Geological Survey to improve geologic map compatibility between Minnesota and Wisconsin. The Franconia Formation will become the Tunnel City Group; the Ironton and Galesville Sandstones will become the single Wonewoc Sandstone. Today most stratigraphers prefer the name Wonewoc Sandstone because of the difficulty in distinguishing between the Ironton and Galesville Sandstones. Future updates to this plan will reflect these changes.	Minnesota Geological Survey RI 65
Eau Claire Formation	The Eau Claire Formation, composed of a mixture of fine sandstone, siltstone, and shale, acts as a regionally extensive confining layer between the overlying Franconia-Ironton-Galesville aquifer and underlying Mount Simon-Hinckley aquifer. The maximum thickness of the Eau Claire Formation in southeastern Minnesota is 250 feet. Thickness is generally less than 100 feet across most of the metropolitan area. No metropolitan area municipal wells draw water solely from the Eau Claire Formation but some multi-aquifer wells include this formation.	
Mount Simon-Hinckley Aquifer	The Mount Simon-Hinckley aquifer is made up of the Mount Simon and underlying Hinckley Sandstones. This aquifer is present throughout the metropolitan area except in limited areas of southwestern Carver and Scott counties where faults have allowed its	

	erosion. Within the Twin Cities basin, the Mount Simon Sandstone is estimated to be 200 feet thick; the thickness of the Hinckley Sandstone is uncertain. This aquifer is sometimes referred to as the Mount Simon aquifer because the extent of the Hinckley Sandstone is not well known. However, in order to be consistent with Minnesota Statute, this plan will refer to it as the Mount Simon-Hinckley aquifer. The great depth of the Mount Simon-Hinckley in the central Twin Cities basin makes it very expensive to drill wells to this aquifer in this part of the region. Additionally, very slow aquifer recharge rates and over-pumping have resulted in significant drawdown. These conditions, combined with the drought of 1988, led the Minnesota Legislature to pass legislation that limits appropriation from this aquifer in the metropolitan region to potable use and only when no other practical or feasible source is available. Use of the aquifer is also limited by high levels of naturally-occurring radium in some areas. The reported pumping capacity of metropolitan area municipal wells in the Mount Simon-Hinckley aquifer ranges from 230 to 2,300 gallons per minute; average pumping capacity is 930 gallons per minute.	Minnesota Statutes, Section 103G.271
IMPACTS ON THE WATER SUPPLY	The adequacy of the water supply in the Twin Cities metropolitan area, or in any community within its borders, is a function of several factors. The most relevant of these are: • Population growth • Aquifer distribution • Interaction between surface and groundwater • Contamination • Technology	

- Climate

Even when a community has access to surface water and groundwater within its boundaries, public water suppliers may face limitations associated with using those sources. These limitations arise because of natural and human impacts on water sources. Potential limitations for specific areas are identified using the Metro Model 2 and other methods described in Chapter 5.

Metro Model 2

The Impact of Population Growth

The Master Water Supply Plan uses Metropolitan Council and local comprehensive plan population projections to forecast future water demand. These projections show that the metropolitan area will grow by one million people between 2004 and 2030. This added population is equivalent to a city the size of Denver being dropped inside the borders of the seven-county area.

2030 Regional Development Framework

By 2030, the projected growth will increase residential demand for water by about 75 million gallons per day. Increased groundwater pumping, the preferred water source in the developing part of the region, will undoubtedly change aquifer water levels and flow directions. Although increased water demand is not projected to cause a widespread lack of water, aquifer capacity may be insufficient to meet higher demands or withdrawals may result in adverse impacts on surface water features in localized areas.

Population growth may also affect the region's aquifers by changing the location, rate, and quality of groundwater recharge. These secondary changes may, in turn, require users to either access new water supplies at higher costs or severally restrict water use. Urban land development associated with projected population growth leads to a greater number of impervious surfaces and that, in turn, may limit and redistribute aquifer recharge. Paved surfaces and compacted soils offer little opportunity for infiltration; however, there

Map of Long-term Average Annual Recharge (Appendix 1)

is some evidence indicating that some stormwater management features in urban areas increase aquifer recharge. Focused recharge can occur as infiltration in stormwater basins and rain gardens throughout the growing season, whereas areas with crops and native landscapes allow less infiltration during the growing season because of very high evapotranspiration rates.

Stormwater management is currently addressed primarily by watershed districts and local governments. Rules that require developments to meet pre-settlement runoff rates, typically for a rainfall of up to 2 inches, result in the use of onsite stormwater management strategies that include rain gardens, infiltration basins, and vegetated swales. By increasing recharge, such features provide the added benefit of offsetting the impact of impervious surfaces.

Evaluating Proposed Stormwater Infiltration Projects in Vulnerable Wellhead Protection Areas (MDH)

Another result of growth and corresponding land-use change is the potential introduction of new contaminant sources. For example, as new wells are added, changes in pumping can mobilize existing groundwater contaminants resulting from prior industrial or agricultural use, affecting existing and new wells. Anticipated population growth and development in the Saint Cloud, Twin Cities growth corridor have the potential to also adversely influence the quality of surface water that is the source of supply for Minneapolis and Saint Paul.

In some cases, the extent of existing contamination is well known. In others, uncertainty regarding the existence and extent of contamination makes it difficult to predict the effects of land-use changes on the quality of drinking water supplies. Industries may have contaminated groundwater supplies in ways that are not yet identified, or new industrial processes may create new types of contamination. Converted agricultural lands may have contaminated groundwater from agrichemicals, but the distribution of such contamination is not well documented. Recent advancements in

Drinking Water Protection Areas Map (Appendix 1)

Special Well Construction Areas (Appendix 1)

laboratory techniques has resulted the identification of very low levels of pharmaceuticals, personal care products and other compounds of emerging concern in surface and groundwater. Currently, no requirement exists to test drinking water for many of these chemicals.

With the population growth, expansion of the water supply system will become inevitable for many communities, and that expansion provides both challenges and opportunities. The installation of new municipal wells and increased pumping of existing wells may cause regional aquifer drawdown, which has several effects: well interference becomes more likely, pumping costs increase, aquifer behavior and productivity may change, and water quality may decline or become less stable. Within the challenge of infrastructure expansion, an opportunity for a more coordinated approach to the development of supply infrastructure and water supply protection activities arises.

With thoughtful and creative management, communities can locate well fields and develop distribution systems that maximize a community's ability to exchange water with neighbors and minimize the likelihood of impacting protected resources or tapping contaminated groundwater. Management of the region's water supply based on careful analysis of water sources, minimizes negative consequences and their associated mitigation costs to communities and the region, and therefore represents an economic as well as a resource net gain.

The analysis described in Chapter 5 identifies areas where projected growth may have adverse impacts on groundwater levels if traditional sources continue to be developed.

The Impact of Aquifer Distribution

While groundwater supplies are regionally abundant, the supplies are

not evenly distributed throughout the region. Due to the nature of the geology of the Twin Cities basin, the prolific Prairie du Chien-Jordan aquifer is not present in much of the north and western portions of the region. The major aquifers available in these areas are the Quaternary, the Franconia-Ironton-Galesville, and the Mount Simon-Hinckley.

In some areas, such as Maple Grove, the Quaternary aquifer produces significant quantities of water, but this productive zone occurs only locally. The Quaternary aquifer is a known good source in some other areas and may be more broadly available, but mapping is needed to determine its extent. Because of its proximity to the land surface, this aquifer is more susceptible to contamination and variations in climate. Changes in land use and weather patterns may rapidly lead to changes in aquifer productivity and quality.

The Franconia-Ironton-Galesville aquifer is used throughout the region, but its productivity varies considerably and is rarely as high as the Prairie du Chien-Jordan or Mount Simon-Hinckley aquifers. Communities in the northwestern part of the metropolitan area can pump 800-1200 gallons per minute from the Franconia-Ironton-Galesville aquifer, while communities in the west and south rarely are able to pump more than 500 gallons per minute.

As growth occurs along the Interstate 94 corridor northwest of the metropolitan area, the lingering water quality impacts of previous land uses coupled with the lower capacity of the available, unconfined aquifers may result in water supply challenges. Communities along the Interstate 35 corridor north of Hugo also suffer from low aquifer productivity. The very productive Prairie du Chien-Jordan aquifer is missing in both the I-94 corridor and the I-35 north areas. The southwest and western metropolitan areas face a similar issue. Limited access to the Prairie du Chien-Jordan aquifer, along with projected growth along Highways 169, 12, and 7 may require

creative and cooperative water supply planning and conservation to meet future demand. The issue of aquifer uncertainty was raised in this master plan for communities where knowledge of the extent and availability of aquifers is limited.

The Impact of Surface and Groundwater Interaction

While traditionally managed as separate systems, surface and groundwater resources are, in reality, dynamically linked. Management of surface water and stormwater can, therefore, impact groundwater resources. This is of particular concern in the southeastern metropolitan area, which is characterized by a karst landscape containing many sinkholes, caves, springs, and corresponding low filtration and fast response to runoff events. The impact of groundwater withdrawals on surface waters is also a concern. Most surface waters have some connection to groundwater. This is the reason streams keep flowing during very dry periods and in the winter. Many lakes and wetlands occur where the land surface intersects the water table. Groundwater withdrawals can reduce the amount of water that would have discharged to surface water features, or they can lower the water table which, in turn, lowers the levels in lakes and wetlands.

The analysis described in Chapter 5 identifies areas where future groundwater withdrawals may have an adverse impact on surface water features. Concerns over such adverse impacts have focused primarily on three areas:

- Trout streams along the Saint Croix River.
- Calcareous fens and wetlands along the Minnesota River.
- Wetlands, lakes, and streams in the northwestern metropolitan area.

Map of Trout Streams and Calcareous Fens (Appendix 1)

Minnesota Statutes restrict impacts on trout streams, calcareous fens

	and environmentally sensitive areas. In areas where surface and groundwater interactions may lead to unacceptable impacts, adaptive management involving field monitoring, including analysis to determine the actual impact over time, is essential. For the Water Supply Master Plan, the presence of a trout stream or calcareous fen within a community or within one mile of a community boundary was used as a criterion for determining if this is a potential issue in water supply development. This type of adaptive management is occurring in the City of Savage, where withdrawals from the Prairie du Chien-Jordan and Quaternary aquifers have been limited due to impacts on the Savage Fen. The City of Woodbury is also conducting analyses and adapting its water supply development plans to avoid potential impacts on the Valley Creek trout stream. As an aspect of their DNR appropriation permits, communities in the northwest metropolitan area have been required to install monitoring wells to evaluate the impact of their withdrawals on surface water features.	Minnesota Statutes, Section 103G.285 Minnesota Statutes, Section 103G.223
The Impact of Water Quality	Surface water and groundwater supplies are susceptible both to chronic and acute contamination from natural and manmade sources. An acute release of a contaminant—a release, which is both serious and sudden—can pose a problem for both surface water and groundwater, although surface water is the most susceptible. Water suppliers who depend on surface water sources face the challenge of attempting to implement resource protection measures in the upstream area that supplies water to their systems, which is almost entirely outside their jurisdictions. To address this challenge, the Minneapolis Water Works, the City of Saint Cloud, and the Saint Paul Regional Water Services have voluntarily joined forces to prepare source water protection plans for the Upper Mississippi River basin. The Clean Water Legacy Act, passed in 2006, is intended to improve water quality statewide and	Statewide contamination susceptibility Upper Mississippi River Source Water Protection Planning Minnesota Statutes, Section 114D

supports water quality programs that protect water supplies for these three surface water suppliers as well as others. The efforts of the three water suppliers have already established a clear connection between drinking water supply, stormwater management, shoreline protection, and other water quality programs.

Short-term, small contaminant releases have occurred in the Mississippi River upstream of the Minneapolis and Saint Paul intakes in the past, and they are likely to occur in the future. Thus far, immediate and appropriate action by emergency responders and public utilities has protected drinking water quality in the region. Nevertheless, the need for constant vigilance is illustrated by contamination events in other parts of the country. For example, a series of events during 1993 in Milwaukee, Wisconsin, caused contamination of its water supply with cryptosporidium, resulting in over 400,000 illnesses and 100 deaths.

Groundwater suppliers may be less affected by instantaneous contaminations, but they face the challenge of chronic contamination. Once an aquifer is contaminated, it is often very difficult to remove the contamination or predict where it will spread. Petroleum compounds, solvents, nitrates, fertilizers, pesticides, and other manmade products, as well as radioactive compounds and other naturally occurring contaminants, have been found in various portions of the region's groundwater. Multi-aquifer wells, like karst features and faults, allow contamination to move between aquifers and complicate water supply protection strategies.

Chronic contamination in both surface water and groundwater can have long-term public health and economic consequences. While chronic contamination of municipal supplies can often be treated once it is discovered, treatment costs may cause significant price increases for consumers and may, in severe cases, limit use of the water source.

Metropolitan Council Urban Stormwater BMPs

Evaluating Proposed Stormwater Infiltration Projects in Vulnerable Wellhead Protection Areas (MDH)

The difficulty and cost of identifying and removing contaminants from groundwater was a key driver in the establishment of Minnesota's source water protection program. After 2006, each public supply system that uses groundwater in Minnesota is required to at least begin to prepare and implement a wellhead protection plan to safeguard the source of its supplies from contamination. This wellhead protection plan is also a required element of each metropolitan area community's local comprehensive plan. The wellhead protection program, administered by the MDH, requires all public water suppliers to describe their supply source and its vulnerability to contamination. The MDH also requires public water suppliers to develop plans addressing potential sources and pathways of pollutants. The community profiles in Appendix 2 note communities with areas of high aquifer vulnerability.

Wellhead Protection Program (MDH)

Map of Drinking Water Protection Areas (Appendix 1)

Several communities in the region are in the implementation phase of their wellhead protection, and a significant challenge they face is that their wellhead protection areas often extend beyond their borders. The MDH works closely with communities to coordinate protection efforts among multiple jurisdictions.

This plan supports interjurisdictional cooperation by providing regionally consistent datasets and water supply guidance to communities and environmental reviewers. That guidance appears in the community profiles found in Appendix 2 and is linked to this document. The information regarding options for future development that is included in each community's profile is useful for implementing wellhead protection plans as well as making other sourcing decisions. The MDH has designated eight Special Well Construction Areas within the metropolitan area in recognition of the fact that contaminated groundwater in these areas poses potential health risks (See Table 1, below). The additional scrutiny required in using supplies from these areas is intended to prevent the spread of contamination that can result from improper drilling or placement of wells. While the

MDH Special Well Construction Areas

Map of Special Well Construction Areas (Appendix 1)

designation of Special Well Construction Areas does not prevent development of municipal water systems, the designation has, in some areas, led both to limitations on withdrawals and to increased production costs for municipal systems. The community profiles note communities that have a Special Well Construction Area within their boundaries.

The Metropolitan Council is currently working with the MDH, Minnesota Pollution Control Agency (PCA) and other stakeholders to improve mapping and management of known groundwater contamination throughout the region. The result of these efforts is a better assessment of the impact of proposed withdrawals on contaminant extent and treatment costs.

The Impact of Technology

Technological advances regularly provide opportunities and challenges for water supply planning, and the effects are often difficult to predict. For the region's water suppliers, technological advances mean that they may be able to provide additional supply without seeking new groundwater or surface water sources. New treatment technologies may make it cost effective to use water with undesirable constituents. Advances in directional drilling will soon allow access to sites and right-of-ways that would have been difficult or impossible to reach. Materials science holds much promise for applications requiring piping. More durable and less expensive pipe materials may result in greater opportunity for moving water long distances.

Improved water treatment methods have already increased the volume of available supply in other parts of the country. Both stormwater and wastewater that was previously discharged can now be treated to meet drinking water standards. This recycled water may then be used for non-potable and potable purposes, relieving the pressure on natural water sources considerably.

	The Metropolitan Council, with its responsibility for wastewater treatment, is constantly exploring new treatment methods to address emerging contaminants and changing water quality standards. Improvements in treated wastewater quality may, in turn, lead to more opportunities for recycling treated wastewater.	Recycling Treated Municipal Wastewater for Industrial Water Use (Metropolitan Council)

TABLE 1: SPECIAL WELL CONSTRUCTION AREAS IN THE METROPOLITAN AREA

Special Well Construction Area	Established	Primary Contaminant(s)	Aquifers Impacted	County(s)
Baytown/West Lakeland Townships	1988	VOCs, primarily TCE	Glacial deposits, Prairie du Chien dolomite, Jordan Sandstone, Franconia Sandstone	Washington
East Bethel Sanitary Landfill	1998	VOCs	Surficial and buried sand deposits above Superior till	Anoka
Lakeland/Lakeland Shores	1987	VOCs	Not available on MDH website	Washington
St Paul Park and Newport	1997	VOCs, petroleum products, pentachlorophenol	Prairie du Chien dolomite Jordan Sandstone	Washington
Twin Cities Army Ammunition Plant	1996, 1999	VOCs, primarily TCE	Surficial deposits, Prairie du Chien dolomite, Jordan Sandstone	Anoka, Hennepin, Ramsey
Inver Grove Heights (Pine Bend Area)	1973	VOCs, metals, phenols, ammonia, lowered pH	Surficial deposits, Prairie du Chien dolomite, Jordan Sandstone, Franconia Sandstone	Dakota
CMC Heartland Lite Yard Site	2005	Arsenic	Terrace deposits and glacial till	Hennepin
Lake Elmo/Oakdale (expansion of Washington County Landfill SWCA)	2007	VOCs, PFCs, metals	All aquifers above the St. Lawrence Formation	Washington

The Impact of Climate

During hot, dry periods, demand for water increases and, simultaneously, availability and replenishment decrease. Hence, climate affects both the demand for and the availability of water. When surface water supplies a community's needs, even a brief drought can result in lower flow or levels and can impact supply availability. Confined aquifers, such as the bedrock aquifers that supply the core of the metropolitan area, are less immediately responsive to the short-term effects of weather because, even in periods of normal precipitation, it typically takes many years for rainfall to percolate through the layers of soil and rock to recharge aquifers. Unconfined aquifers, such as those in the northern and northwestern portions of the region, are more susceptible to drought, reacting similar to surface water.

Extremely dry conditions occurred regionally in the 1910s, 1930s, 1950s, 1970s, and 1980s. More recently, drought conditions occurred during parts of the summers of 2006 and 2007. The 1988 drought raised public awareness about the recurring nature of drought and its impacts on water availability, especially for communities that depend on the Mississippi River for drinking water.

Following the 1988 drought, the state recognized the need for an action plan to address water supply shortages during Mississippi River low-flow periods. As a result, the 1990 Metropolitan Council's *Metropolitan Area Short-Term Water Supply Plan* establishes a critical flow rate of 554 cubic feet per second (cfs), equivalent to 358 million gallons per day of flow in the Mississippi River, as measured at Anoka. That level of flow, with the quantities shown in the accompanying table, can supply municipal water systems, generate power, and allow navigation.

Metropolitan Area Short-term Water Supply Plan

As part of this water supply planning effort, the region is currently conducting an assessment of low-flow probability in the Mississippi River. Meanwhile, the DNR is in the process of updating the *Drought*

Drought Information (DNR)

Response Plan, which was first published in 1993. The updated *Drought Response Plan* will clarify responsibilities, expectations, and triggers for various levels of government at each stage of a worsening drought. This update will include the stages at which conservation measures should be taken and the Army Corps of Engineers should be consulted regarding the release of water from the headwaters reservoir.

Any changes in climate patterns have the potential to significantly impact the region's water supplies in the future. Given the wide variety of factors that must be taken into account, it is difficult to predict how climate change will ultimately affect water supplies in Minnesota and the Twin Cities metropolitan area. However, enough historical evidence exists to suggest the importance of re-evaluating the validity of planning based on assumptions of long-term average climate conditions. During the last century, the average temperature in Minneapolis, as reported by the PCA, has increased one degree Fahrenheit, and precipitation has increased by up to 20% in the southern half of the state. Data and modeling referenced by the PCA suggest that temperature will continue to rise and precipitation will slightly increase, mainly in the fall, winter and spring months.

Minnesota Pollution Control Agency: Global Climate Change & Its Impact on Minnesota

Regardless of whether Minnesota's future climate is exactly as predicted by current climate models, the region needs mechanisms in place to track and adapt to changes. Through the ongoing data collection and analysis identified in this plan, trends in climate conditions and resulting impacts on water resources will be periodically evaluated. With this information, water supply development decisions can be based on the best available estimation of current and future conditions to ensure supplies are developed sustainably.

CHAPTER 4. COMPONENTS AND IMPLEMENTATION OF THE PLAN

OVERVIEW

As Minnesota law directs, the Metropolitan Area Master Water Supply Plan, drawing on existing state, regional, and local water supply programs, creates an integrated base of technical information needed for sound water supply management. An array of datasets, applications, analyses, maps, and community profiles, along with this report, constitute the plan. These elements are available electronically and are hyperlinked to this document; where feasible, they also appear in the Appendices. Presentation of the plan's complex information in electronic format allows users easy access and facilitates timely updates.

The plan provides analyses based on the best available and widely applicable information regarding the characteristics of the region's water resources and the estimates of water demand. More detail about these analyses is presented in Chapter 5. Recognizing that the region's water supplies are part of a dynamic system, which includes climatic variation, unique natural resource demands, complex geologic systems, increasing water demand, and land-use changes, the plan provides an adaptable mechanism for management, as well as the data and tools needed to ensure that analyses performed in the future are accurate and relevant.

Although the plan is designed for immediate and widespread use for water supply planning, its data and tools are available for a variety of applications. Geographical information, because it is systematically organized and electronically stored, may be used to evaluate, prioritize, and answer a number of water resource and planning questions.

The analyses conducted in developing this plan, while robust, are limited by the incomplete understanding of the complex natural

systems from which we extract our water supplies. The understanding of these resources will continue to improve as information is collected through additional studies, well installations, and withdrawal and use tracking. Similarly, as the tools used to evaluate the data improve, the ability to more accurately estimate the impact of proposed withdrawals will improve. A strategy for maintenance and refinement of the plan's analytical tools and information is presented in Chapter 6.

The Department of Natural Resources (DNR), Department of Health (MDH), and the Metropolitan Council will use the mechanisms and framework of this plan to implement an ongoing assessment of the adequacy and safety of the water supply. Future revisions of the Metropolitan Council's Development Guide will consider the Master Water Supply Plan to ensure water supply issues are addressed prior to growth.

COMPONENTS OF THE MASTER WATER SUPPLY PLAN

Components of the Master Water Supply Plan serve to assess the region's water availability, provide guidance for addressing specific issues, inform users and suppliers of the latest conservation measures, and provide support to agencies involved in managing water resources. The plan uses regionally accepted data and methodology and thus serves as a common framework for regional and local water supply planning.

Make-a-Map Tool

Throughout the development of the plan, the Metropolitan Council collected and analyzed water use, supply system, and water resource information from the MDH, DNR, U.S. Minnesota Geological Survey, Minnesota Geological Survey, and metropolitan area counties and communities. These data are available through the Metropolitan Council's Make-a-Map application. Make-a-Map is an interactive web application that provides users access to GIS datasets and offers the ability to create customized maps.

Make-a-Map

	Maps and data found on Make-a-Map are divided into the following themes: community planning; natural resources; past and projected population, household, and employment numbers; regional systems; transit; transportation planning; and water supply planning. The water supply planning theme contains the maps and associated data generated as a part of this plan. Along with the other themes, the water supply information is intended to provide the best available data to inform local and regional water supply planning decisions. The Make-a-Map application will be of particular use to local planners as they amend and update their comprehensive plans. The Metropolitan Council continually updates the Make-a-Map application with data from state, regional, and local organizations.	
Twin Cities Metropolitan Groundwater Flow Model Version 2.00 (Metro Model 2)	Metro Model 2 is a numerical groundwater flow model designed to correlate regional water supplies with current and projected demand, and thus to identify potential problems associated with using specific sources. The model provides analyses that identify where in the region issues are likely to emerge so that adaptive measures may be taken long before additional water is needed. Metro Model 2 results inform community and county profiles. To ensure its accuracy and usability, the model was designed on the basis of input from potential users and stakeholders. The model is scaleable, allowing for water availability assessments to be performed on a local, sub-regional, and regional level. The Metropolitan Council will periodically update and recalibrate Metro Model 2 with current and relevant data.	Metro Model 2 Twin Cities Metropolitan Groundwater Flow Model Version 2.00 Technical Report Technical Advisory Group
Community Water Supply Profiles and Appropriation Permit and Water Quality Guidance	The plan provides a specific water profile for each community in the metropolitan area. These profiles are linked to this document and also appear in Appendix 2. Each community's profile includes demographic and hydrological information as well as potential water supply issues	Community Profiles (Appendix 2)

resulting from the community's continued use of its traditional water source.

Information contained in these profiles was identified through the planning process as the most relevant to regional and local water supply management and appropriation permitting. To ensure congruity, the profiles employ the assumptions and same forecasts used in the Metropolitan Council's Development Framework and local comprehensive plans. Hence, the evaluation of water supply availability is based on the best estimates of growth through 2030 and beyond. An extensive analysis of water demand projections and water resource availability underlies the guidance found in the profiles. Water demand projections are included in the community profiles to facilitate long-range planning beyond the 10-year planning horizon for existing water supply and comprehensive plans. This information is intended to benefit both water utilities and regional planning staff. This plan recognizes uncertainty in long-term water demand projections, but the link between water demand and population growth ensures that water demand projections are reasonable and consistent with regional system planning (such as wastewater service).

In the profiles, current water supply sources are summarized along with the total 2008 permitted appropriation and the 2008 water demand by source. This information is primarily intended to assist stakeholders unfamiliar with the details of a community's water supply system to better understand existing water supply infrastructure. Available future water supply sources are identified on each community's water supply profile. Identified sources include *all* sources available to meet future water demand, even if that source is not currently utilized or is only capable of meeting a portion of the community's total demand. Interjurisdictional cooperation was suggested for all communities with anticipated growth large enough to require significant water supply infrastructure investment, such as

drilling a new well. The Mount Simon-Hinckley aquifer is not included as an available future source for any community, as Minnesota Statutes, Section 103G.271, limits new use of that aquifer. This information is intended to guide water utilities and water supply plan and permit review staff toward alternative sources, should traditional sources become limited in the community. It is important to note that not all available sources were evaluated as part of the analysis conducted for this plan. If alternative sources are considered, analyses may be necessary to evaluate potential impacts.

Finally, the community water supply profiles list all water supply issues identified through the analysis outlined in Chapter 5. Specific details are included, such as the water resource likely to be impacted, whether the water supply availability issue has already occurred and is documented, or whether it is predicted to become a problem in the future.

Appendix 3 provides guidance to communities as they plan for future appropriations. The guidance includes information on the type of information communities should submit as part of their appropriation requests and the type of permit conditions they may expect to receive associated with specific water supply issues. Appendix 3 outlines additional monitoring and data collection that will be required of communities to ensure that the necessary information is being collected to evaluate resource sustainability. As described later in this chapter, communities who select to use an alternative source may not have to take the required actions if they select to use a source not identified for a specific issue. Communities that have already performed local studies sufficient to meet the intentions outlined in Appendix 3 will not be asked to do additional work.

Appropriation Permit Guidance (Appendix 3)

Appendix 4 provides guidance to communities on their regulatory requirements to protect the quality of their water supply. MDH played a key role in the development of Appendix 4.

Water Quality Issue Guidance (Appendix 4)

	When new or updated data and information results in a better understanding of issues and steps to address them, an update to the community profiles and appropriation permit guidance may be warranted. If needed, an annual review of updated technical information, profiles and guidance will be conducted.	
Conservation Toolbox	Early in the development of the plan, state, regional, and local stakeholders voiced a need for better water conservation guidance. The online water conservation toolbox is the plan's response to that need. One section of the Toolbox addresses water-conserving practices and water use benchmarks for customers while another presents program ideas and tools, such as sample ordinances, for water suppliers. Information is selected on the basis of its appropriateness to the region's water use trends, development patterns, and climate. Links to the websites of reputable organizations lead the user deeper into subjects related to conservation and regulation. Contents of the conservation toolbox are updated as new information appears on the internet and as stakeholders make recommendations.	Conservation toolbox
IMPLEMENTATION OF THE MASTER PLAN THROUGH LOCAL, REGIONAL, AND STATE PLANNING AND REGULATION	Several state, regional, and local entities and programs exist to regulate and guide aspects of water supply development, use, and protection. Each plays a unique role in the network of functions that, together, ensure water supplies are developed sustainably and delivered safely. Cooperation among these groups results in an efficient planning and permitting process that does not compromise the quality and quantity of water delivered to the region's residents, businesses, utilities, and institutions. The Metropolitan Area Master Water Supply Plan is intended to provide guidance to water appropriators and the agencies which regulate water withdrawals and water system development. This plan does not introduce new requirements but rather brings to light existing appropriation request requirements and permit conditions, under existing agency authorities. This will avoid the unwelcome last-minute surprises that	

communities have faced in the past during water appropriation permitting process. The plan will also be used by the Metropolitan Council to consider water supply availability in the preparation of future development guides.

Local Water Suppliers

Local water suppliers are responsible for owning and operating water supply systems. Associated with this responsibility is planning for future water supply needs. Suppliers make critical decisions about where to site their facilities, how many new wells or surface water intakes to construct, how much storage they will require, and what kind of treatment they will need. This plan does not change this responsibility. Rather, through the community profiles (Appendix 2), appropriation permit guidance (Appendix 3), and water quality issue guidance (Appendix 4) this plan integrates local water supply system planning with regional comprehensive planning and water appropriation permitting decisions.

Minnesota Statutes, Section 103G.291

Minnesota Statutes, Section 473.859

Local Planning Handbook (Council)
Local water supply plans

Prior to requesting additional appropriations or as part of future updates to local water supply plans, communities will need to outline the actions to address issues identified in the community profiles based on the guidance provided in Appendix 3. Alternative sources to meet projected demand should also be identified if the preferred source is unable to meet future demands without adverse impacts.

Community Profiles (Appendix 2)

Appropriation Permit Guidance (Appendix 3)

Several appropriate responses to the issues identified in a community's water supply profile exist, depending upon the severity and location. In some cases, issues identified in a profile could limit the use of a particular water supply source. The City of Savage is an example of a location where Prairie du Chien-Jordan aquifer withdrawals have been limited due to potential impacts on a calcareous fen. Most water supply availability issues, however, may be appropriately addressed by one of the following responses:

1. Plan to use sources without identified issues to meet projected demands.
Local water supply plans that propose the development of a water supply source *without* any identified water availability issues may be considered an appropriate response to the issues identified on a community's profile. The analysis conducted for the development of this plan only evaluated impacts resulting from continued use of traditional sources. Therefore, analysis of impacts resulting from use of alternative sources may be necessary prior to use.

2. Demonstrate that use of the water supply source will not result in the issue identified in the community profile.
If accepted by the DNR, communities may address the issue identified on their profile through a local study, past or present, that demonstrates the use of a particular source will not result in the issue identified. The Metropolitan Council will incorporate study results, as they are available, into the regional availability analysis and in updates to the Master Plan.

3. Develop a management plan as described in this appendix.
Communities that intend to use a supply source with an identified issue should develop and submit a management plan that incorporates the elements described in this appendix, to the DNR prior to issuance of or amendment to an appropriation permit. The development of a management plan should be done *early in the well siting process in consultation with the DNR* to ensure the plan is appropriately tailored to local needs and that the necessary information is collected and evaluated prior to well construction. The management plan should be incorporated into future revisions of the community water supply plans.

Several communities are already addressing issues identified in their profiles as part of existing water appropriation permits. These efforts may already meet the actions listed above and in Appendix 3, and will

	be considered an acceptable approach where deemed so by the DNR. Most communities are also already addressing the water quality issues identified in their profiles through actions listed in Appendix 4. Communities are encouraged to work with MDH to ensure that water quality issues are addressed. Consistency with the community profile, appropriation permit guidance, and water quality guidance demonstrates that the community is taking steps to ensure that supplies are developed sustainably. Since water supply availability is addressed as part of the planning process and before water is needed, the community is forewarned of issues that need to be addressed for future water appropriations. Increases in permitted water appropriation depend on evidence that a community has taken one of actions outlined above and in Appendix 3 to address the issues identified in its profile.	
Minnesota Department of Natural Resources	The DNR manages the state's water resources to ensure adequate supply to meet long-range seasonal requirements for domestic, agricultural, fish and wildlife, recreational, power, navigation, and quality-control purposes. Associated with this directive, the DNR administers water supply-related programs such as permitting water appropriations and monitoring groundwater levels, lake levels and stream flows. The DNR, which by law must approve the Metropolitan Area Master Water Supply Plan, has been integrally involved with its development. Once this plan is adopted, the DNR will use the water supply source options, issues and responses identified in the Plan as guidance in its review of water supply plans and appropriation permits. The DNR will also review non-municipal water appropriation permit requests using the community water supply profiles to ensure that the appropriate actions are being taken to address potential impacts of	Minnesota Statutes, Section 103A.204 Department of Natural Resources Waters Division

non-municipal withdrawals.

Minnesota Department of Health

The MDH collaborates with other agencies and programs responsible for monitoring and protecting groundwater quality and quantity in Minnesota. Through its Drinking Water Protection Program, it ensures a safe and adequate supply of drinking water is provided by all public water systems. Through its Source Water Protection Program, the MDH works with local water suppliers to develop wellhead protection plans that safeguard drinking water supplies. The MDH also regulates well construction in the state and is involved in compliance monitoring and review of water system designs.

The MDH also produces Source Water Assessments to provide basic water supply information to public water suppliers and the general public. These assessments include information regarding where drinking water comes from and the degree to which the water source may be impacted by potential sources of contamination. Beyond the general public and public water suppliers, these assessments are also used in permitting decisions to determine if a proposed land use has the potential to adversely affect a public water supply.

Under this Master Water Supply Plan, the MDH will continue to coordinate well permitting and source water assessment efforts with DNR and the Metropolitan Council. The MDH provides the information regarding aquifer vulnerability and water quality that is included in the community profiles. They also use the tools and information generated through this plan to assist in the development of wellhead protection plans and to guide well installation to appropriate aquifers and locations. The MDH currently consults with the DNR during the review of proposed municipal wells so that potential issues that need to be addressed as part of an appropriation permit can be identified.

Department of Health groundwater related programs

Metropolitan Council	The Metropolitan Council is required to prepare a comprehensive development guide to ensure the orderly and economic growth of the metropolitan area and the efficient use of the four regional systems: transportation, aviation, water resources, and regional parks and open space. Associated with this directive, the Council reviews and approves local comprehensive plans to ensure the plans are consistent with the Council's regional development guide. With the cooperation of state, regional and local partners, the Council will ensure that this master plan is updated as new information becomes available. The Council will consider this Master Water Supply Plan in the development of subsequent regional comprehensive development guides. In addition, the Council will review future local comprehensive plan updates for consistency with this Master Plan.	Metropolitan Council Water Supply Planning
Interjurisdictional Cooperation	Effective implementation of the Master Water Supply Plan depends on cooperation among state, regional, county, and local decision-makers. With this plan, local water suppliers rely on regional and statewide analyses when planning future water supplies. Similarly, state and regional planners and regulators rely on public water suppliers for site-specific analyses and data collected through monitoring activities. While the DNR, MDH, and Metropolitan Council each have a unique role in water supply planning and decision-making, strong coordination among them minimizes redundancies and ensures that the planning process is seamless and efficient. Under this Master Water Supply Plan, the Council and DNR will coordinate their review of local water supply plans. Recent changes in the DNR water appropriation process allow conditional permit approval within the same timeframe as the MDH public water system design review. Because of these changes, a final appropriation permit can be issued without delay if well construction is completed as anticipated. As the region continues to grow and demand on the water resources	

increases, cooperation among communities to develop supplies will likely become a more cost-effective option. In anticipation of this reality, this plan identifies areas in the region where interjurisdictional cooperation may prove a feasible and perhaps optimal option.

CHAPTER 5. ASSESSMENT OF SUPPLY ACROSS THE REGION AND OVER TIME

ASSESSMENT OVERVIEW

The foundation of the Metropolitan Area Master Water Supply Plan is a region-wide assessment of current and future water availability that integrates existing information and analyses with groundwater flow model results. This chapter describes the data and analyses that were used to evaluate supply availability and develop the community water supply profiles and issue responses discussed in Chapter 4.

The plan's regional water availability assessment was designed to evaluate water sources and identify water resource issues that must be addressed to ensure that water supplies are used sustainably. As noted in Chapter 3, the adequacy of water supply in the Twin Cities metropolitan area is a function of several factors. The most relevant of these are population growth, aquifer characteristics and distribution, interaction between surface and groundwater, contamination, technology, and climate. Analyses supporting this plan incorporate these factors in a variety of ways.

A key component of the availability assessment is the Twin Cities Metropolitan Groundwater Flow Model Version 2.00, Metro Model 2, developed as part of the preparation of this plan. This numerical groundwater flow model correlates water supply availability with projected demand across the region over time. Several other analytical methods were also employed to complement the Metro Model 2. They range from simple mapping exercises to relatively complex drinking water vulnerability assessments.

Metro Model 2

For this plan, future water availability was assessed assuming expanded use of current sources at historical per capita use rates. Water demand and withdrawal projections were developed for each community based on past demands and demographic forecasts, and the impact of these withdrawals on water resources was evaluated

through the technical analysis described in this chapter.

Based on the analysis, the Twin Cities metropolitan area water supplies appear adequate to sustain projected demands without unacceptable consequences. Supplies, however, are not evenly distributed throughout the region; therefore, some communities will need to take actions to ensure their supplies are developed sustainably. The regional assessment identified issues that may not result in a limitation but local information is needed to make this assessment. In some cases communities may be unable to continue to rely on their traditional water supply sources and will need to seek other sources to meet future demand. Information on the issues identified and guidance for addressing them is provided through the community profiles (Appendix 2), appropriation permit guidance (Appendix 3), and water quality issue guidance (Appendix 4).

Improved predictions of supply availability and impacts will be made as more information and improved tools to evaluate the information become available. Chapter 6 describes the ongoing assessment process and how the Plan will be updated including recommendations for future data collection and analyses.

SUPPORTING DATA

Data used in the water supply assessment were collected from state, regional, and local governments as well as public utilities, private-sector consultants, and representatives from academia. These data included demographic projections, land-use figures and projections, surface and groundwater levels and pumping figures, geologic studies and maps, well information, climate figures and projections, and soil analyses (Table 2). In order to be used, these data were standardized and normalized into datasets that are consistent across the region. Most of these datasets are now available to the public as regional map themes through the Metropolitan Council's online Make-a-Map application. The Metro Model 2 Technical Report contains detailed information about how data were used to develop

Make-A-Map

Metro Model 2

Twin Cities Metropolitan Groundwater Flow Model Version 2.00 Technical Report

	the regional groundwater flow model.	
POPULATION AND WATER USE FORECASTS	The Master Plan uses population and water use forecasts for 2010, 2020, and 2030 from local water supply plans. When these forecasts were not available, the Council used the water demand projection method outlined in the 2007 Water Supply Planning in the Twin Cities Metropolitan Area Technical Report to forecast water use. While the Council does not have official 2040 and 2050 population forecasts for each community in the metropolitan area, population forecasts, for these years, were projected based on amount of remaining developable land and predicted population growth trends between 2000 and 2030. The 2040 and 2050 water use forecasts use the same rate of water use for 2030 multiplied by the forecasted population for 2040 and 2050 for each community.	Water Supply Planning in the Twin Cities Metropolitan Area Technical Report

TABLE 2: DATA SUPPORTING THE TWIN CITIES METROPOLITAN AREA WATER SUPPLY AVAILABILITY ASSESSMENT

Organization	Data Set
Cannon River Watershed Partnership	Stream Discharge (table)
Metropolitan Council	Surface Water Under the Influence of Groundwater (map) Population & Water Demand Projections (tables)
Minnesota Department of Health	Minnesota County Well Index (CWI) (map and tables) Special Well Construction Areas (maps) Drinking Water Supply Management Area Vulnerability (maps) Nitrate Probability (maps) Minnesota Drinking Water Information System (MNDWIS) (database) Aquifer Test Data (database)

Organization	Data Set
Minnesota Department of Natural Resources	Minnesota Trout Streams (map) Calcareous Fens (table) Stream Discharge & Lake Level (tables) State Water Use Database System (SWUDS) (tables) Water Appropriations Permit Program (water supply plans) Observation Well Program (graphs) Surface Water-Groundwater Exchange Rates (report)
Minnesota Geological Survey	Bedrock Geology & Structure of the Seven-county Twin Cities Metropolitan Area, Minnesota (map) Surficial Geology of the Twin Cities Metropolitan Area, Minnesota (map) Geologic Atlas of Scott County, Minnesota (map)
Minnesota Pollution Control Agency	Metro Model Database (files and maps)
National Resources Conservation Service	Soil Survey Geographic Database (SSURGO) (maps and tables)
Shakopee Mdewakanton Sioux Community	Stream Discharge (table)
United States Geological Survey	Surface-Water Data for Minnesota (tables) 2001 National Land Cover Dataset (map and tables) US GeoData Digital Elevation Models (DEMs) (map) Surface Water-Groundwater Exchange Rates (report)
University of Minnesota & Land Management Information Center	Minnesota State Soil Atlas (map and tables)
United States National Weather Service	1975-2003 Climate Data: Downtown St. Paul Holman field Airport station
Watershed & Conservation Districts	Stream Discharge (table)

METRO MODEL 2

In addition to the assessments described above, a regional groundwater model, Metro Model 2, was developed to evaluate the relationship between the factors affecting water sources and projected demands.

Metro Model 2

Origins

Metro Model 2 builds on the foundation of the Minnesota Pollution Control Agency's *Twin Cities Metropolitan Groundwater Model Version 1.00*, known as the Metro Model (Seaberg, 2000). The Metro Model was successful in compiling hydrogeologic data into a single data repository and included calculations of the base elevations of key bedrock aquifers. Recent developments in modeling code and computing power opened the possibility of improvements that were beyond the capacity of the Metro Model. For example, the original Metro Model was unable to accommodate variable pumping conditions or to model substantial changes in the base elevation of aquifers. Metro Model 2 is designed to overcome these limitations. In addition, Metro Model 2 is compatible with regional geographic information system (GIS) datasets. Because of this, and the fact that Metro Model 2 uses the U.S. Geological Survey's MODFLOW code, makes the model and supporting datasets more accessible to a wide variety of potential users in both the public and private sectors—a feature that furthers usability of Metro Model 2.

Twin Cities Metropolitan Groundwater Model Version 1.00

Twin Cities Metropolitan Groundwater Flow Model Version 2.00 Technical Report

U.S. Geological Survey MODFLOW

Development and Description

Because the model was a key element of the plan and would potentially be used for a wide variety of applications in the region, it made sense to convene a technical advisory work group of potential users. This group, which included government scientists, private-sector consultants and representatives from academia, provided valuable guidance and feedback throughout the process of developing Metro Model 2 and ensuring its technical soundness.

Technical Advisory Group

	Metro Model 2 encompasses the entire seven-county Twin Cities metropolitan area and portions of adjacent counties. The model simulates flow through nine geologic units: Quaternary unconsolidated sediments, Saint Peter Sandstone, Prairie du Chien Group, Jordan Sandstone, Saint Lawrence Formation, Franconia Formation, Ironton-Galesville Formation, Eau Claire Formation, and Mount Simon-Hinckley Sandstone. Metro Model 2 incorporates available local and regional climatic, land use, soil, geologic, withdrawal and hydrogeologic data. Water Demand data collected between 1988 and 2006, as well as demand projections through 2050, were considered in order to evaluate long-term average or 'steady-state' conditions in support of long-term water supply planning horizons. This was considered an appropriate approach to assessing long-term effects (greater than a year) of projected demand on a regional scale. To estimate groundwater recharge, a modified version of the soil-water balance model developed by the Wisconsin Geological and Natural History Survey and the United States Geological Survey was used. This method takes land use, topography, soils and climate into consideration to arrive at groundwater recharge values which were used as the input for Metro Model 2. Although Metro Model 2 focuses on groundwater flow, surface water measurements are included to allow assessment of the affect of groundwater pumping on the lakes, rivers, streams, fens, and wetlands of the region. The model is calibrated to three kinds of water resource measurements. The first set of measurements is water levels recorded at thousands of wells from the MDH Minnesota County Well Index and the DNR observation well network. The second set is measured stream flows collected from monitoring and	Soil-Water Balance Technical Report

measurement sites around the region. The third is aquifer test data collected from wellhead protection plans and other sources. During calibration, various model parameters - such as aquifer hydraulic conductivity - were adjusted until the model's predicted water levels and stream flows were equivalent to actual measured values. Once that calibration was achieved, the model was ready for use.

Because the model is scaleable and flexible, impacts that may result from proposed withdrawals can be assessed on a local, sub-regional and regional level. These features also make it straight-forward to evaluate different development patterns, water use trends, or climate changes. In other words, any number of scenarios using multiple variables may be run using Metro Model 2, and questions that are outside current interests or attention may eventually be asked and answered.

Objectives and Applications

A series of specific questions regarding water supply availability were identified from previous experiences, stakeholder input and from groundwater plans, local water supply plans, and appropriation permits issued by the DNR. These are the critical questions that Metro Model 2 is designed to answer:

- How will projected water demand affect groundwater levels in each aquifer across the metropolitan area?
- Will projected water demand cause water levels to decline in water table aquifers that support lakes and wetlands?
- How might land use and development patterns affect recharge and thereby alter groundwater levels?
- What is the likely maximum pumping capacity of a proposed well field, and where might withdrawals increase the

likelihood of well interference?

In its current design, Metro Model 2 successfully answers these questions. However, interpretation of model results must recognize that any model is a simplification of a complex system and that accuracy is limited by naturally variable geologic conditions, imprecise field measurements, inclusion of field measurements that may not best represent local conditions, and inaccurate interpolation between sparse data points. The reader is encouraged to review the Twin Cities Metropolitan Groundwater Flow Model Version 2.00 Technical Report for more information.

Twin Cities Metropolitan Groundwater Flow Model Version 2.00 Technical Report

Interpretation of the model must also recognize that predictive accuracy is shaped by assumptions of future demand and aquifer withdrawals. For this plan, water supply availability was assessed assuming that communities will expand their current water sources (aquifers) to supply projected demands. This method was employed to test the assumption that metropolitan area communities can continue to use water at their current rates and develop supplies using their traditional sources. The potential issues identified in this plan will need to be reevaluated if communities develop water supply alternatives to their traditional supplies. Chapter 6 describes the process for ongoing supply assessment to evaluate impacts under a variety of conditions and to provide up to date information on the potential impacts from the inevitable changes in understanding of demands and sources.

The value of Metro Model 2 and supporting datasets extends beyond the support of this plan. These tools can also be used and adapted by a variety of parties to answer local or regional questions or to evaluate decisions. For instance, a community might use the model as a starting point for developing their wellhead protection plan or evaluating the most sustainable location for a future well field. The model must be modified if it is

to be used to resolve site-specific problems, such as single well siting, or to analyze problems other than those listed above, such as contaminant transport, but it does provide a good starting point for more specific assessments. Sufficient data must be available for local areas if such a model is to be successfully employed.

2030 and 2050 Regional Scenarios

Regional scenarios were run using the model to evaluate the effects of forecasted groundwater withdrawals on the region's aquifer system. The scenarios were designed to test the hypothesis that, given projected demands, metropolitan area communities can continue to use water and develop supplies using their traditional assumption of aquifer availability. In other words, the scenarios assumed that communities would expand their most-relied-upon current water source to meet projected demands.

Two groundwater withdrawal scenarios were evaluated corresponding to projected 2030 and 2050 increases in municipal groundwater withdrawals from the primary aquifer currently utilized by each community. These projection years correspond to an increase in metropolitan area municipal demand from 2008 rates of approximately 33% and 66% respectively. Because projected withdrawal rates will not necessarily match actual rates in these particular years due to uncertainty in demand projections, it is more appropriate to consider the scenarios as simulations of aquifer response to groundwater withdrawal rates rather than projected responses for specific years.

A maximum day demand scenario could not be run on the regional scale because Metro Model 2 is currently a steady-state model. Rather the results reflect long-term impacts of projected withdrawals. As part of ongoing planning the model will be adapted to evaluate potential impacts from short-term, high demand periods. This will be done for both a seasonal and multi-

year drought scenario.

Ultimate Demand Regional Scenario

In order to estimate adequacy of water supplies to meet ultimate demand, the Metropolitan Council used Metro Model 2 to evaluate the adequacy of the region's groundwater supplies assuming that the entire developable area of the region is developed at urban densities and that groundwater will be the water source used to meet all new demand in the region.

Based on existing per capita water demand rates, the groundwater system of the Twin Cities metropolitan area appears to be capable of sustaining a population three times larger than the current population (estimated ultimate population). Although there will be declines in aquifer water levels, as there are with any increase in withdrawal, long-term average recharge rates are high enough to keep aquifers from "drying out" under the ultimate demand scenario.

The model predicts that the magnitude of aquifer declines will vary across the metropolitan area. In the developed central cities and inner ring suburbs, aquifer decline is expected to be minimal. In outer-ring suburbs and rural areas, particularly in the southern metropolitan area, aquifer decline on the order of 100 feet, may occur. This level of decline is predicted for all major aquifers, although the ramifications of this decline vary from aquifer to aquifer and from place to place. In some areas the projected decline will have little impact on natural resources and in others could adversely affect aquifer productivity and/or surface water features. In areas where adverse impacts from use of traditional sources are predicted, communities will be able to meet projected demands through development of options including use of other aquifers, surface waters, conservation and cooperation with neighboring communities, avoiding the adverse impact.

The analysis suggests that regionally, supplies are available to meet demands for an 'ultimate' population. The planning framework put forth in this plan is intended to prevent exactly the types of issues identified in this analysis – and long before urban planning for the development of currently rural areas. As the data and tools improve, increasingly accurate predictions of future demands and potential impacts as well as creative solutions to avoid the impacts can be developed.

Three Sub- Regional Scenarios

Two sub-regional scenarios were run that illustrate how Metro Model 2 may be refined to answer questions at the local level. A third sub-regional scenario, modeled in a previous effort, illustrates how this approach can help address difficult water availability issues. The three scenarios address the following areas of interest:

- Assessment of groundwater productivity and interaction between groundwater withdrawal and surface water levels in the city of Ramsey.
- Assessment of the impact of pumping on aquifers in the Lakeville-Farmington area.
- Assessment of groundwater productivity and impacts to Valley Creek trout stream in Woodbury.

Ramsey

In the Ramsey area, results of the model simulation show that the Franconia-Ironton-Galesville aquifer should be able to meet projected demands. However, potential drawdown in the water table may have detrimental effects on surface water bodies in the area. As additional wells are added, vigilant monitoring of both the surficial aquifer and the Franconia-Ironton-Galesville aquifer will be necessary. Resource protection thresholds could be set to limit pumping from nearby wells when groundwater levels, wetlands or

Model Results: Evaluation of Groundwater Sustainability in the Ramsey Area (Appendix 3)

	lakes approach critical levels.	
Lakeville-Farmington	The local groundwater modeling conducted in the Lakeville-Farmington area indicates that pumping to meet average conditions in 2030 may cause groundwater levels to decline in the area by about 20 feet in the Prairie du Chien-Jordan aquifer and by 10 feet in the water table. These projected declines in the water table may reduce base flows to portions of the Vermillion River. Under a projected 2030-summer peak condition scenario, groundwater declines of approximately 35 feet in the Prairie du Chien-Jordan aquifer and 15 feet in the water table may occur. Most of the summer peak drawdown will occur in, and east of, Lakeville; only small declines are predicted for undeveloped areas west of Lakeville. By 2050, the water levels in the Prairie du Chien-Jordan and water table aquifers are expected to decline even more due to average and summer peak pumping; 20 to 25 feet of decline under average pumping conditions and 50 feet under summer peak conditions. Demand in 2050 may, therefore, reduce base flows to portions of the Vermillion River and cause about 15 to 20 feet of decline in the Prairie du Chien-Jordan aquifer in the undeveloped area west of Lakeville during maximum pumping conditions. Monitoring of water level trends in the Prairie du Chien-Jordan and Quaternary aquifers is necessary to assess actual conditions. Resource protection thresholds could be set to limit pumping from nearby wells when groundwater levels, or stream flows approach critical levels.	Model Results: Evaluation of Future Drawdown Conditions in the Lakeville/Farmington Area (Appendix 5)
Woodbury	An earlier modeling effort in the Woodbury area was used to evaluate potential impacts on the Valley Creek trout stream from a proposed municipal well field. The preliminary results of this	Model Results: Evaluation of Groundwater Sustainability in

	modeling indicate that pumping of Well 17, along with additional water demands through 2010, may cause small reductions in base flows to Valley Creek (about 0.13 cubic feet per second, or three percent of the base flow of the headwaters portion of Valley Creek). This suggests that groundwater withdrawal in the area could have an impact on the flow in the trout stream and that plans to develop future wells will require careful assessment. A monitoring network is in place to evaluate actual impacts of withdrawals.	the Woodbury Area (Appendix 5)
ANALYTICAL RESULTS: COMMUNITY PROFILES	As described in Chapter 4, this water supply availability analysis was used to develop community-specific water supply profiles for each community in the Twin Cities metropolitan area in consultation with state, regional, and local agencies (Appendix 2). The profiles serve as both a summary of existing municipal water supply system conditions and as guidance for avoiding or mitigating future water availability issues. They bring to light issues that need to be addressed and Appendix 3 outlines steps to address them to avoid unwanted, last-minute delays in water appropriation permit approvals. This information will also be considered in the development of regional plans for sewers and transportation. Another benefit is that this base of technical water supply information will be available to a broad audience for land use and water appropriation decisions, regardless of internal staffing or program changes. The information presented in the community profiles is based on a robust blend of existing data and new regional modeling. As such, users are assured that long-term water supply issues have been identified to the extent possible at the time on the regional scale. Use of these community water supply profiles should, however, recognize the regional nature of the underlying analyses. Local studies and new information may show somewhat different results due to inclusion of small features and different time horizons. This	Community Profiles (Appendix 2)

	local information should be considered in the development of specific issue responses to ensure that recommended responses are reasonable and appropriate for the identified issue. Local information will also be used to update the plan as described in Chapter 6.	
DEFINING WATER SUPPLY AVAILABILITY ISSUES AND RESPONSES	The Metropolitan Council, the DNR, and the MDH worked together to define water supply availability issues at both the regional and community level for development of this plan. Existing Minnesota Statutes and DNR and MDH guidelines were the starting point for this effort. Regional and local information gathered during public outreach events, through formal and informal meetings, and from past reports documenting state and regional water resource research and policy, were also considered. Minnesota Statutes, existing DNR, and MDH guidelines, were also examined to provide guidance on information communities must submit with appropriation requests and permit conditions to expect for specific water supply issues. The guidance presented in the plan, therefore, is based primarily on existing permit and plan conditions used to address similar water supply issues. The particular response a community implements depends upon the severity or immediacy of the issue it is addressing as described in chapter 4.	Department of Natural Resources Ground Water Technical Analysis Program Department of Health Wellhead Protection Program Department of Health Well Management Program Appropriation Permit Guidance (Appendix 3) Water Quality Issue Guidance (Appendix 4)
Potential for well interference	Water use conflict is defined in Minnesota Rules (6115.0740) as a condition where the available supply of waters of the state in a given area is limited to the extent to which there are competing demands among existing and proposed users that exceed the reasonably available waters. Complaints about the impact of others' use of groundwater are first reported to the DNR who then works to resolve the issue(s) through a process set forth in Minnesota Rules (6115.0730).	Minnesota Rules (6115.0740) Minnesota Rules (6115.0730) Minnesota Department of

	For this plan it was determined that due to the pervasiveness of private wells in the metro area, there exists a potential for well interference for all appropriators. Therefore, as described in Appendix 3, all supplies requesting water appropriations will need to undertake at least a minimal screening effort to determine if additional analysis is necessary.	Health County Well Index Minnesota Department of Natural Resources Water Appropriations Permit Program
Potential for significant decline in aquifer water levels	Minnesota Rules (6115.0670) specify that the amounts and timing of water appropriated from groundwater shall be limited to the safe yield of the aquifer to the maximum extent feasible and practical. As defined by Minnesota Rules (6115.0630), under water table or unconfined conditions, "safe yield" means the amount of groundwater that can be withdrawn from an aquifer system without degrading the quality of the aquifer and without allowing the long-term average withdrawal to exceed the available long-term average recharge to the aquifer system based on representative climatic conditions. Under artesian, or confined, conditions, "safe yield" means the amount of groundwater that can be withdrawn from an aquifer system without degrading the quality of water in the aquifer and without the progressive decline in water pressures and levels that will result in a change from artesian condition to water table condition. "Available head" is an informal term to specify the amount of decline in water level that can occur in a confined aquifer before artesian conditions change to water table conditions. For the purposes of this plan "available head" is defined as the difference in elevation between an aquifer's long-term average water level, as predicted by the Metropolitan Council's groundwater flow model, and the upper bedrock surface of that aquifer. The Metropolitan Council's groundwater flow model was used to	

	calculate changes in available head in confined portions of aquifers under projected demand conditions. The DNR observation well network was used to determine if ongoing decline is occurring in unconfined portions of aquifers; unconfined areas were defined as having less than 10 feet of available head. The following criteria were used for this plan to determine when the potential for significant decline in aquifer levels should be addressed in water supply planning and development: ▪ 2030 and 2050 model-predicted decline in available head greater than 50% in a confined aquifer, where available head is more than 10 feet ▪ Measured decline in available head greater than 50% and 75% in a confined aquifer ▪ Measured continuing decline in unconfined aquifers The DNR has used the 50% reduction in pre-pumping available head as a management threshold in several areas across the state. Fifty-percent reduction in pre-pumping available head is meant to act as a warning that declines are heading toward a breach of the safe-yield condition. A 75% reduction in available head is meant to trigger corrective action, including reduced pumping to ensure that the safe-yield condition is not breached. Appropriation permit guidance for significant aquifer decline was developed in cooperation with the DNR and is outlined in Appendix 3.	Minnesota Department of Natural Resources Groundwater Level Monitoring Program
Potential for impacts of groundwater pumping on surface water features	Minnesota Rules (6115.0670) specify that, if the commissioner [of natural resources] determines, based on substantial evidence, that appropriation from groundwater shall be limited if a direct relationship of groundwater and surface waters exists such that there would be adverse impact on the surface waters.	Minnesota Rules (6115.0670)

An assessment was made to determine where groundwater aquifers and surface water features are in close connection. Groundwater flow modeling was then conducted for this plan to evaluate where groundwater withdrawals might cause drawdown in these areas to a degree, which could result in impacts to surface water features. In addition, known existing impacts to surface water features from groundwater withdrawals was also considered when determining which communities should be noted for this issue.

The criteria used for this plan to determine when potential impact of groundwater withdrawal on surface water features should be addressed in water supply planning and development were as follows:

- 2030 and 2050 model-predicted decline in surficial aquifer water levels greater than one meter in areas where a connection between groundwater and surface water is suspected.

- Exceedance of resource protection thresholds developed cooperatively by community and the DNR

These thresholds were selected based on the understanding that shallow aquifer decline may directly affect surface water features where no confining units separate surface water and ground water systems.

Appropriation permit guidance for groundwater pumping impacts on surface water features was developed in cooperation with the DNR and is outlined in Appendix 3.

Map of Areas where Groundwater Pumping is Likely to Directly Impact Surface Water Features (Appendix 1)

Potential for impacts to state-protected trout habitat or calcareous fen	Minnesota Statutes, Section 103G.223, specifies that calcareous fens, as identified by the commissioner [of natural resources] by written order published in the State Register, may not be filled, drained, or otherwise degraded, wholly or partially, by any activity, unless the commissioner, under an approved management plan, decides some alteration is necessary. Minnesota Statutes, Section 103G.285, limits withdrawals from designated trout streams to temporary appropriations. The DNR maintains a database of designated trout streams and calcareous fens, and these data were reviewed to determine proximity of these features to each community in the Twin Cities metropolitan area. The criteria used for this plan to determine when potential impact of groundwater withdrawal on trout streams or calcareous fens should be addressed in water supply planning and development were as follows: ▪ A trout stream or calcareous fen is located within one mile of the community ▪ Measured decline greater than one meter in an observation well (correlated to pumping) between a production well and the trout stream or calcareous fen ▪ Measured decline in an observation well adjacent to a trout stream or calcareous fen and/or the feature itself These thresholds were selected based on the understanding that that both trout streams and calcareous fens rely on groundwater discharge to support the unique biotic communities and are sensitive to fluctuations in this discharge. They are also based on existing water appropriation permit conditions established by the	Minnesota Statutes, Section 103G.223 Minnesota Statutes, Section 103G.285 Minnesota Department of Natural Resources GIS Data Deli Minnesota Department of Natural Resources Water Appropriations Permit Program

	DNR. Appropriation permit guidance for potential trout habitat and calcareous fen impact were developed in cooperation with the DNR and are outlined in Appendix 3 of this plan.	
Significant uncertainty regarding aquifer extent and productivity	Groundwater and surface water supply sources are not evenly distributed nor are they equally productive throughout the region. Minnesota Rules (6115.0670) specify that appropriation of groundwater shall not be approved or shall be issued on a conditional basis in those instances where sufficient hydrologic data are not available to allow the commissioner to adequately determine the effects of the proposed appropriation. A review of the Minnesota County Well Index and municipal Wellhead Protection Plans highlighted a lack of hydrologic data, particularly for the Quaternary and Franconia-Ironton-Galesville aquifers. In addition, calibration of the Metropolitan Council's groundwater flow model illustrated areas of uncertainty in those aquifers' properties. Many communities where the Prairie du Chien-Jordan aquifer is absent were identified has having significant uncertainty for water supply decision-making. This uncertainty increases the risk of developing supplies with low yields. The criteria used for this plan to determine when significant uncertainty should be addressed in water supply planning and development were as follows: ▪ No local aquifer tests, as reported in community wellhead protection plans, have been conducted in one or more of the community's available aquifers ▪ The Quaternary and Franconia-Ironton-Galesville aquifers	Minnesota Rules (6115.0670)

	are the only regionally productive aquifers available in the community (not including the Mt. Simon-Hinkley aquifer) These thresholds were selected in part to provide additional information for updates to Metro Model 2 and geologic mapping conducted by the DNR and the Minnesota Geological Survey. Appropriation permit guidance for aquifer uncertainty is outlined in Appendix 3 of this plan.	
Known groundwater contamination	For obvious reasons sourcewater quality needs to be considered as part of water supply planning and development. The MDH establishes and documents Special Well Construction Areas, and these data were reviewed for each community in the Twin Cities metropolitan area to determine areas where water supply development may be impacted due to poor water quality. Known groundwater contamination should be explicitly addressed in water supply planning and development when conditions exceed the following thresholds: ▪ Contamination has been detected in the community water supply system or locally in the aquifer serving the community water supply system ▪ The MDH has established a Special Well Construction Area These thresholds were selected to provide suppliers more information about known sources of contamination and to support existing MDH programs. Responses to the issue of known groundwater contamination were developed in cooperation with the MDH and are outlined in Appendix 4 of this plan.	Minnesota Rules (4725.1845) County Atlas, DNR
Vulnerability to contamination	The MDH Drinking Water Protection Program works with public water suppliers to delineate Drinking Water Supply Management	Minnesota Department of Health Well Management

	Areas and determine their vulnerability to potential contaminant sources. Documented vulnerable and highly vulnerable Drinking Water Supply Management Areas were reviewed for each community in the Twin Cities metropolitan area to determine where water supply source waters may be impacted by potential contaminant sources. Vulnerability to contamination should be explicitly addressed in water supply planning and development when conditions exceed the following thresholds: ▪ The MDH has designated all or part of a wellhead protection area as vulnerable to potential sources of contamination ▪ The MDH has designated all or part of the community as exhibiting a high potential for nitrate nitrogen contamination ▪ The MDH has designated the aquifer as a likely source of arsenic, radium, or other naturally occurring contaminants These thresholds were selected to support existing MDH programs. Responses to the issue of aquifer vulnerability to contamination were developed in cooperation with the MDH and are outlined in Appendix 4 of this plan.	Unit Minnesota Department of Health Community Public Water Supply Unit
ANALYTICAL RESULTS: REGIONAL PERSPECTIVE	Based on the analysis conducted for this planning effort, water resources in the Twin Cities metropolitan area appear adequate to supply projected demands on a regional basis. As with any increase in groundwater withdrawals, there will be additional lowering of water levels in aquifers. The drawdown is likely to be most pronounced primarily in the outer-ring suburbs where high growth is projected. In some areas the drawdown will have little impact on the resource. In others, communities will need to address issues and potentially develop alternative sources to meet future demands.	

	The analysis conducted assumed that communities would continue to use their traditional source to supply existing demands and expand these same water supply sources to supply additional demands. Any changes in projected water demand or water supply sources will affect the predictions of water availability presented here. Unforeseen issues may arise if communities begin developing alternative sources. However, the datasets and tools developed for this plan allow a variety of supply scenarios to be evaluated as part of ongoing planning. Chapter 6 presents a process to incorporate updated information on demand forecasts as well as natural resource information to evaluate impacts under a variety of conditions. This information will be incorporated into updates of this plan. Significant aquifer decline is expected to occur in approximately 16% of metropolitan area communities under projected 2050 demand conditions. This issue is anticipated to arise in much of Dakota County and other areas where water levels are not very high above the top of the aquifer to begin with. Groundwater withdrawal in at least 35% of metropolitan area communities has the potential for impact on surface water features under projected 2050 demand conditions, particularly along the Minnesota, Mississippi, and Saint Croix river valleys where trout streams and calcareous fens are prevalent. Surface waters located in areas where shallow water tables are in direct connection to bedrock aquifers, such as the Anoka Sand Plain, may also be impacted.	Maps of 2030 and 2050 Model Projected Drawdown in the Prairie du Chien-Jordan and Franconia-Ironton-Galesville Aquifers (Appendix 1)
	Uncertainty regarding aquifer properties is particularly prevalent in Anoka and Carver and western Hennepin and Scott counties where the Prairie du Chien-Jordan aquifer is absent and fewer municipal have been drilled. High growth communities such as Rogers and Dayton will need to evaluate the capacities of the Franconia-Ironton-Galesville and Quaternary aquifers to serve the growing	Maps of 2030 and 2050 Model-Projected Drawdown in Areas where Groundwater Pumping is Likely to Directly Impact Surface Waters

	demands due to the lack of Prairie du Chien-Jordan aquifer.	(Appendix 1)
	Sixty-two communities in the Twin Cities metropolitan area currently have some portion designated as vulnerable or highly-vulnerable Drinking Water Supply Management Areas, and 22 currently contain all or part of a Special Well Construction Areas. Several programs exist to address water supply contamination. Chapter 6 provides more information about a groundwater contaminant investigation database that can be expanded to document contaminant investigations across the Twin Cities metropolitan area.	Maps of Vulnerable Drinking Water Supply Management Areas and Special Well Construction Areas (Appendix 1)
	Expanded use of an aquifer may impact other, relatively unused aquifers, too. For instance, Metro Model 2 results suggest that already low Mount Simon-Hinckley aquifer recharge rates will be reduced even further by pumping overlying aquifers. Low recharge, in combination with its continued use for water supply in only a few locations, will exacerbate existing cones of depression in this protected resource. This will need to be evaluated as part of the ongoing planning process described in chapter 6.	Maps of the 2030 and 2050 Model-Projected Drawdown in the Mt. Simon-Hinckley (Appendix 1)

CHAPTER 6. NEXT STEPS: MAINTAINING AND REFINING THE SUPPLY ASSESSMENTS

PURPOSE AND SCOPE OF CONTINUING ACTIVITIES

In order to evaluate water demands and supply availability for the Master Water Supply Plan, existing datasets were assembled and new datasets were created from numerous sources and organizations. In addition, tools were developed and analyses conducted to analyze both the impacts on and demand for the region's water supply. Such systematic analyses serve as a logical foundation for future planning decisions.

The work that has been done, however, is just the first step. It is the actions that follow that will determine the ongoing viability and usability of this plan. This chapter describes the actions that will be taken to ensure that current and future decisions are based on the best available information and analyses. These actions include:

- Continue collaboration with stakeholders
- Improve data sharing and management
- Collect additional data and information and update existing datasets and analytical tools
- Ongoing availability analysis

ONGOING STAKEHOLDER INVOLVEMENT

Keeping in mind that the ultimate purpose for the ongoing activities discussed in this chapter is to provide the best information to guide water supply decision-making, stakeholder input is needed to ensure that data collection, analyses, and subsequent conclusions accurately characterize the resources being managed. Stakeholders representing technical, policy, and planning perspectives must periodically review what data, existing and proposed, should be used as indicators of sustainable water use. They should also develop consensus on how these data should be collected. The results of analyses based on existing data

	need to be verified as well. If they are not verifiable, either new data or a new analysis method may be needed. Stakeholders will be relied upon to review and verify the results of analyses and suggest additional data collection or new analysis methods. To ensure that stakeholders are involved at the necessary level, the plan's data and analyses will be periodically presented for review to the Interagency Monitoring Technical Workgroup, the Master Water Supply Plan Technical Advisory Workgroup, and the Southwest East and Northwest Metro Water Supply Workgroups. In the future, the data and analyses will be reviewed by other water supply technical, policy, and planning workgroups as those groups are established.	
Interagency Monitoring Technical Workgroup	The mission of the Interagency Monitoring Technical Workgroup, led by the Pollution Control Agency and Department of Natural Resources (DNR), is to support data sharing and analysis, improved coordination, elimination of redundancy, and identification of future monitoring needs among regional, state, and federal water monitoring agencies in Minnesota. This group provides recommendations for formats that will ensure data are easily transferable and useable by others and its members are directly involved in the development of web services and other data-sharing technology. Updates to this Master Water Supply Plan will incorporate data standards identified by this workgroup.	
Master Water Supply Plan Technical Advisory Workgroup	The Master Water Supply Plan Technical Advisory Workgroup, established by the Metropolitan Council to support the development of Metro Model 2, will meet annually to review Metro Model 2 applications and datasets used to assess water availability. The continued involvement of this group will ensure that the Master Water Supply Plan is a trusted instrument whose analyses are based on the best available water supply data and analysis.	Master Water Supply Plan Technical Advisory Workgroup

Southwest, East and Northwest Metro Water Supply Workgroups	The Southwest, East and Northwest Metro Water Supply Workgroups currently provide a venue for communities in these regions to share water supply development information and to coordinate water resource protection activities. They provide additional opportunities for identifying potential local water supply challenges and solutions. Similar work groups will be established for other areas around the region to foster a collaborative approach to addressing issues.	Southwest Metro Water Supply Workgroup East Metro Water Supply Workgroup
DATA FORMAT AND MANAGEMENT	When designing datasets, choosing the appropriate format and ensuring that new data is entered in that format is as important as ensuring the accuracy of the content. Inappropriate formats or applications can make the data unusable or inaccessible. This fact becomes a serious stumbling block when the data in question is both entered and used by multiple organizations across a wide geographical area. A regionally-packaged electronic format, compatible with Geographic Information System software, maximizes the value of water supply-related data for regional planning purposes. The ongoing planning effort will continue to promote efforts to further the standardization of data formats and applications.	
CONTINUING AND REFINING DATA COLLECTION AND ANALYSIS	Water supply planning and management in the region depends on the decisions of regional and local water supply planners and regulators. Since these decision-makers access and use Metro Model 2 and its supporting datasets, ongoing updating of the information and periodic recalibration is necessary to ensure the tools and data remain relevant and useful. As additional information is collected, datasets will be updated and made available. In addition, the model will be updated and recalibrated periodically to reflect new demand conditions and other calibration data. More detail regarding this process is included in the Metro Model 2 technical report.	Twin Cities Metropolitan Groundwater Flow Model Version 2.00 Technical Report Metro Model 2

In the development and application of Metro Model 2, it became clear that certain data would significantly improve the predictive ability of the model. The list of these data types, and a discussion of collection processes, follow. Some of these collection efforts have already occurred, while others are at the beginning stages of development. Ensuring that these activities continue is essential. The following is a list of datasets that were identified as important in ensuring the ongoing usefulness of the plan. Some of these databases exist but need expansion; others must be developed. All should be regionally packaged, and recorded in a format that is usable by the majority of interested parties.

- Water-level measurements at existing municipal production and observation wells
- Water-level measurements at state observation wells
- Synoptic groundwater-level measurements
- Aquifer test data
- Surface water base-flow data
- Lake- and stream-bed hydraulic properties
- Groundwater quality data
- Groundwater vulnerability information
- Hydrogeologic data
- Recharge measurements

Water Level Measurements at Municipal Production and Observation Wells

As part of the ongoing planning effort, municipal suppliers will be encouraged to collect water-level measurements taken at production wells and any observation wells they are responsible for monitoring, on a minimum monthly basis and submit the data to the DNR. This information will be used to recalibrate Metro Model 2 and will provide information on long-term trends in aquifer levels in the region.

Many communities already monitor production well water levels,

	and in some cases, observation wells, on a much more frequent than monthly basis using Supervisory Control and Data Acquisition (SCADA) systems. Suppliers using continuous water level recorders should take hand measurement readings in production and observation wells monthly to calibrate the recorders. Public water suppliers without an automated monitoring system can collect monthly measurements manually and submit them to the DNR with the required annual report of monthly water usage measurements. In either case, automated or manually submitted, it is important that the pumping conditions at the time of measurement are reported to ensure they can be accounted for in the interpretation of the information. Water-level measurements in wells open to the Franconia Formation and the Ironton and Galesville Sandstones are particularly needed in the central metropolitan area, where most wells utilize the Prairie du Chien-Jordan aquifer.	Minnesota Department of Natural Resources Water Level Monitoring Data Submittal
Water Level Measurements at State Observation Wells	Various water resource managers use water-level data collected at DNR observation wells to assess impacts of climate and water demand on groundwater and surface water resources. Currently, these data are available only online on a well-by-well basis. Planned data-access improvements will allow external users to perform multi-well aquifer assessments more easily, and the Metropolitan Council will be able to respond more quickly to requests for water resource assessments. Because this is high-quality data and in many cases has been collected for several years, it is particularly valuable for use as Metro Model 2 calibration targets and to assess long-term trends in water levels. The DNR observation well network has many recognized gaps, both in coverage of the region and its aquifers and in the frequency of data gathered. Water-level data is needed to develop a better understanding of aquifer characteristics,	

interactions between bedrock aquifers, and surface water features, the relationship of buried bedrock valleys and aquifers, aquifer recharge, aquifer productivity, and contaminant transport. Information from this regional planning effort has already been used to help pinpoint where limited resources can be used to most effectively develop new monitoring locations.

Communities have an opportunity to assist in the statewide and local assessment of water resources by volunteering any municipal wells they plan to abandon to the DNR observation well program. Each municipal well that is taken out of service represents an opportunity to establish a monitoring point near a pumping center. This information is valuable for assessing ongoing trends in water levels related to withdrawals.
Prior to abandonment, communities may notify the DNR, which will then determine whether the site represents a useful monitoring location. The Minnesota Geological Survey is often able to geophysically log these wells, providing even more information about local groundwater conditions. Use of abandoned wells as observation wells is a cost-effective way to expand the water supply monitoring program.

Again, static water-level measurements in wells open to the Franconia Formation and the Ironton and Galesville Sandstones are particularly needed in the central metropolitan area, where most wells utilize the Prairie du Chien-Jordan aquifer. Nested observation wells, which monitor water levels in multiple aquifers at one location, provide valuable information about interaction between aquifers and vertical rates of flow through the groundwater flow system.

Synoptic Measurements

Synoptic water-level measurements are measurements that are both simultaneous and widespread. In the region, synoptic data have been collected sporadically for several decades. Such

measurements provide insight into the aquifer response to various climate changes and pumping regimens over a large area. When compared to previous synoptic measurements, they can provide valuable information about water-level trends over time across the region.

The Metropolitan Council will work with stakeholders to conduct synoptic measurements, preferably on a three- to five-year timeframe. This timeframe is preferred, because frequent measurements reduce the likelihood that wells will be lost due to property transfers. Replacing lost wells is a time-consuming and costly effort.

As part of ongoing planning, synoptic measurements will be compared to historical data to provide necessary information on water supply trends. These measurements will also help evaluate natural variability in aquifer water levels and to distinguish it from variability induced by human activity.

The Metropolitan Council will use the synoptic water-level measurement data to improve the regional assessment of water availability. The DNR will continue to use the same data to help with its management of water resources, including water appropriation determinations.

Performing these synoptic measurements will contribute to the understanding of water levels not only across the region, but even across the nation. The United States Geological Survey stores synoptic water level measurement data and provides it online through their National Water Information System and as published reports.

Aquifer Test Data

Development of the Metro Model 2 highlighted the need for electronic sharing of aquifer test data. Such sharing is essential to

ensure the accuracy of the model's predictive responses to seasonal stresses. Collecting the aquifer test data electronically will allow the Minnesota Department of Health (MDH) to more easily store and access these data in a format compatible with other state, regional, and local governments as well as other water supply planners.

The MDH is developing the capability to electronically store aquifer test data, including both monitoring data and results that have been collected by public water suppliers during pump tests. The DNR, which collects aquifer test data from large water appropriators, is also developing the capability to store aquifer test data electronically. The combined efforts of these two agencies will create a statewide database of easily accessible aquifer test data. These data will be used during annual model recalibration to improve the model's predictive capabilities.

In areas where aquifer tests have not been conducted, communities should conduct these tests and submit the information as part of their wellhead protection plan or water appropriation permit request. There is a particular need for aquifer test data in the Franconia-Ironton-Galesville aquifer in the southwestern and west-central part of the Twin Cities metropolitan area.

Surface Water Base Flow Data

A regionally consistent set of base-flow data, also known as low-flow data, collected at streams and springs will provide widespread information about surface water-groundwater interaction. These data will significantly improve the ability of Metro Model 2 to predict impacts of projected pumping on surface water features, which will help refine recommendations to communities regarding proposed water withdrawals. The DNR will also use these data to assess the natural variability and sustainability of water resources and to improve groundwater

discharge estimations.

The Metropolitan Council, the United States Geological Survey, watershed districts, and the DNR all conduct surface water monitoring in the metropolitan area. Nevertheless, gaps in base-flow data are particularly large, as base flow is most accurately measured in the winter when most stream-flow gauges are not in service. The handful of site-specific base-flow assessments does not offset this lack of data. Documentation of flow from streams is even more limited, and initiating a program for regular spring-flow-data collection offers great opportunity to improve understanding of the interaction between aquifers and surface water features. Camp Coldwater Spring and Boiling Springs are two sites that require regular monitoring due to their documented cultural value.

Map of Existing and Recommended Baseflow Measurement Sites (Appendix 1)

The following efforts are needed to improve the understanding of groundwater contribution to surface water features in the metropolitan area:

1. Establish a regionally consistent data reporting format.

2. Create a centralized database to store regional surface water data.

3. Take measurements between November and February to collect base-flow data at existing surface water flow measurement locations.

4. Establish new spring-flow-monitoring sites at Camp Coldwater Spring, Boiling Springs, identified calcareous fens, and other identified seep and spring locations.

With a regionally-consistent reporting format, information from

	organizations that prefer to maintain their own databases can be easily shared through web-based services. For those who do not wish to develop a database, the Metropolitan Council is capable of storing regional stream-flow data through its Environmental Information Management System. This system currently houses only data collected by the Council and its volunteer partners. There is potential, however, to accept and manage data submitted electronically by watershed districts and water and soil conservation districts. Allowing watershed districts to add their data to the Environmental Information Management System provides regional planners, such as those whose territory spans multiple watershed districts, a more complete understanding of the systems they manage. Environmental Information Management System is heavily used by surface water resource managers. Allowing the Metropolitan Council to take on the responsibility of managing watershed district data shifts some costs of data management from watershed districts to the Council, and storing the data electronically ensures that it is not lost due to staff or other physical changes.	
Surface Water Level Data	Periodic water-level measurements taken at surface water monitoring stations (lakes, streams, wetlands) will be used to recalibrate Metro Model 2. Besides improving the predictive accuracy of the model, this effort will provide information on long-term trends in shallow aquifer levels in the region. Many organizations already monitor surface water levels as part of resource assessment programs or permit requirements. Public water suppliers monitoring surface water levels in at-risk resources can submit the data electronically to the DNR.	Minnesota Department of Natural Resources Water Level Monitoring Data Submittal

Lake and Stream Bed Hydraulic Properties	The sediments on the bottom of lakes and streams influence the interaction between shallow groundwater and surface water. Assessing the hydraulic properties of the region's lake and stream beds, especially in areas of potential surface and groundwater interaction, will improve Metro Model 2 by ensuring that lake-bed conductance parameters correlate with real measured values. As the opportunity and need arises, information on surface-water-bed hydraulic properties should be collected.	
Groundwater Quality Data	Potential sources of water supply contamination are ubiquitous throughout the Twin Cities metropolitan area. Both naturally occurring contaminants, such as arsenic and radium, and manmade contaminants, such as solvents, perfluorochemicals, and nitrates, have resulted in increased costs for treatment or in withdrawal limitations. Limited access to information about contaminant extent makes it difficult for communities to predict where and when a new well might encounter a source of contamination that renders the well unusable. During the regional planning effort the Council collaborated with the MDH and Dakota County to develop a map of groundwater contamination in Dakota County. In addition to the map itself, a contaminant mapping and documentation process was developed that can be utilized in other metro area counties, which will be part of the ongoing planning efforts. A regionally consistent map of groundwater contamination will be an asset to development of water supplies across the region. Access to such a map will assist communities with well siting and wellhead protection plan development and implementation. It will also benefit the MDH in its permitting of well sites and engineering designs. The Minnesota Pollution Control Agency, which is responsible for addressing most point-source groundwater	Map of the Minnesota Department of Health Special Well Construction Areas (Appendix 1) Mapping Groundwater Contaminant Investigations: Database Template

	contamination sites, will also benefit from a comprehensive map of known groundwater contamination. The MDH has developed maps for the naturally occurring compounds radium and arsenic in portions of the region and in select aquifers. A continuation of this effort is necessary to provide a complete picture of where these naturally occurring groundwater contaminant sources might be encountered. The MDH has also developed nitrate probability maps, which can be used to predict where wells might encounter unacceptable levels of this compound. A complete map showing coverage of nitrate probability in the metropolitan area has not been completed. This mapping effort will continue as part of ongoing planning to guide the development of both public and private water supplies.	
Groundwater Vulnerability Information	As part of the wellhead protection program, communities determine the vulnerability of the aquifer area that contributes to their municipal wells. Groundwater pollution sensitivity is also mapped as one element in the development of county geologic atlases. Through 2007, wellhead protection activities resulted in designating 14% of the municipal drinking water supply management areas (407 square miles) in the vulnerable or highly vulnerable designation. Municipal water suppliers are responsible for managing potential contaminant sources in these areas even when the areas extend beyond their community boundaries or overlap with a neighbor's source water protection area. This overlap of boundaries occurs in at least 10% of the management areas. A consistent approach to interjurisdictional management would help to address the need for source water protection of areas outside a community's boundaries.	DNR Pollution Sensitivity Mapping

As additional wellhead protection areas and their groundwater are delineated, the information will be added to a composite dataset and made available through the Metropolitan Council's Make-a-Map application for use in land-use and other planning decisions.

Hydrogeologic Data

The Prairie du Chien-Jordan aquifer is not present in much of Carver or western Hennepin counties. The Franconia-Ironton-Galesville aquifer is used in the area but many of the municipal wells in that aquifer are relatively low producers. The Quaternary aquifer is also present in this area but its extent and capacity are not well known. Assuming withdrawals from the Mt. Simon aquifer remains limited due to statutory limitations, better information about the productivity of the Franconia-Ironton-Galesville aquifer and the productivity and extent of the Quaternary aquifer is necessary to identify water supply sources adequate to meet future demand. Better hydrological data on the Quaternary aquifer will also provide greater insight into its vulnerability to contamination and connection to surface water features.

Currently, a geologic atlas for Carver County is being developed. When completed, it will provide significant information about the extent of the Quaternary aquifer. This information should be combined with additional mapping of the Quaternary in Hennepin County and the recently updated geologic mapping in Scott County to assess aquifer availability in the western metropolitan area.

The Prairie du Chien-Jordan is also not present in the northern portion of the metropolitan area. Additional mapping of the Quaternary aquifer and assessment of the capacity of the Franconia-Ironton-Galesville aquifer are also necessary in this area to determine the adequacy of these supplies to meet future demand.

	In much of Dakota County and southern Washington County, potential limitations on the use of the Prairie du Chien-Jordan combined with significant projected demands may force communities to rely more heavily on the Quaternary or Franconia-Ironton-Galesville aquifers. Additional assessment of the potential capacity and limitations of these sources is necessary to assist decision-makers as they develop plans for long-term demands in these areas.	
Recharge Measurements	The analysis conducted using Metro Model 2 provides an estimate of aquifer recharge based on the soil-water balance model as described in the Metro Model 2 Technical Report. The analysis, however, also identifies the need for field verification and additional aquifer recharge data. While accurate estimates of recharge are difficult to obtain, continuous collection of ample and accurate data regarding aquifer levels is essential because such measurements and resulting estimates of recharge are the foundation for evaluating the limit on groundwater supplies. Nested observation wells provide the most complete understanding of vertical groundwater flow rates through the region's layered aquifer system. As opportunities arise for the installation of well nests, the Metropolitan Council, DNR, Pollution Control Agency, Minnesota Geological Survey, and United States Geological Survey should coordinate efforts to collect hydrogeologic information and make data available to stakeholders. These data will be used to determine the response time, as well as the magnitude of response, to recharge events and land use changes. As additional well nests are installed and more information on the Quaternary aquifer is collected, the understanding of groundwater recharge pathways will improve. Combined with other types of information such as land use and stream base flow, estimates	Metro Model 2 Technical Report

using methods similar to the soil-water balance model used for this Master Plan can be improved.

UPDATING THE PLAN

The analyses conducted for this plan incorporates the best available data to answer questions of water supply availability. Uncertainty remains and several questions remain unanswered, however, and other questions will inevitably emerge over time. As information on the hydrologic system, water use, withdrawals, climate, and land use is collected, it will be incorporated into relevant databases and the tools, specifically Metro Model 2, will be updated.

Evaluation of new information will improve the evaluation of potential pumping sources, locations, and pumping rates to determine regionally optimal withdrawal scenarios. Through this iterative process, predictions about the long-term sustainability of water supplies within communities and across the region will continuously improve.

The plan will be updated in two ways. One is ongoing. If the data collection and analysis efforts result in a change to the understanding of potential impacts from proposed withdrawals and resulting appropriation permit requirements, this information will be shared with local suppliers as well as regulatory agencies so that appropriate responses can be made. In addition, the Master Water Supply Plan will be formally updated as part of the State Water Plan and when the Council updates the comprehensive development guide for the metropolitan area and when the Council amends or modifies a community system statement.

DEVELOPING GROUNDWATER MANAGEMENT AREAS: A NEW MANAGEMENT APPROACH

It has been widely recognized that, from a hydrologic perspective, surface waters are logically monitored and managed on a watershed basis. The most effective way to ensure the sustainability of groundwater resources may well be to base data collection, monitoring and management on discrete groundwater management areas. This model for monitoring and management has been used in other parts of the country, such as the State of Texas Groundwater Management Areas, and could also be applied to groundwater resources in the metropolitan area. Minnesota Rules (6115.0810) establish a process for the preparation and implementation of plans relating to water appropriation and use. This rule could be the basis for the development of groundwater management areas. The potential for implementing aquifer-based monitoring and management will be evaluated as part of the ongoing water supply planning effort.