FEASIBILITY ASSESSMENT OF APPROACHES TO WATER SUSTAINABILITY IN THE NORTHEAST METRO

FINAL

METROPOLITAN COUNCIL

December 2014

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About this Report

The 2005 Minnesota Legislature directed the Metropolitan Council to "carry out planning activities addressing the water supply needs of the metropolitan area," including the development of a Twin Cities Metropolitan Area Master Water Supply Plan (Minn. Stat., Sec. 473.1565). After completing that plan, the Council took on many technical and outreach projects that strengthen local and regional water supply planning efforts. These projects have also elevated the importance of water supply in local comprehensive planning, which is carried out by local communities.

This study is one of several being led by the Metropolitan Council to support an update to the Master Plan and other activities identified by the 2005 Minnesota Legislature to address the water supply needs of the seven-county metropolitan area. This study is funded from the Clean Water Legacy Fund (Minn. Laws 2013 Ch. 137, Art. 2, Sec. 9).

The Metropolitan Council retained Short Elliott Hendrickson Inc. (SEH) to complete this technical assessment of the capital and operational costs, as well as the potential benefits, of alternative approaches to water supply in the northeast metro area. The report also looks specifically at the direct augmentation of White Bear Lake with water from the major rivers in the region. This study has been carried out with input from and engagement with local stakeholders, including community public water utilities, through a water supply work group. This group continues to meet regularly to discuss the study along with other water supply topics of importance to group members.

CLEAN WATER LAND & LEGACY AMENDMENT

Recommended Citation

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Chapter 1 - Introduction

The State Fiscal Year 2014-2015 Clean Water Fund appropriation identified the Twin Cities northeast metropolitan area (northeast metro) as an area where potential solutions are needed to address emerging water supply issues. A groundwater workgroup, consisting of interested area community stakeholders, was formed to address the long-term sustainability of area water supplies. Metropolitan Council, working with communities in the northeast metro area, is leading a study to examine the feasibility of approaches to address water sustainability in the region.

1.1 Study Objectives

The primary objective of this study is to understand the relative costs and implementation considerations of different approaches to water sustainability. The northeast metro provides a study area for this evaluation. The Minnesota Legislature requested this part of the metro area to be studied specifically, given the continued concern over lake levels and the interaction of groundwater and lakes in the area, especially White Bear Lake. The study area includes 13 communities.

The results will be incorporated in the Twin Cities Metropolitan Area Master Water Supply Plan. The study will be referenced to support future planning of metro area water supplies and water sustainability practices.

This study evaluates only three approaches to water supply:

- Approach 1: Connect northeast metro communities to Saint Paul Regional Water Services to supply drinking water (Saint Paul Expansion)
- Approach 2: Develop a surface water connection to a new sub-regional surface water treatment plant (New Surface Water Treatment Plant)
- Approach 3: Continued development of groundwater sources

In addition to the water supply approaches evaluated, the Council evaluated the feasibility of direct augmentation of White Bear Lake using water from the St. Croix and Mississippi rivers. This project is evaluated separately in this study, as it does not directly involve drinking water supplies. In addition, a direct lake augmentation system would likely have different ownership with responsibility for constructing, operating, and maintaining the system.

The approaches were selected in consultation with stakeholders in the northeast metro, based on their potential to reduce impacts on surface water bodies, including White Bear Lake, from groundwater pumping activities. The Council chose the communities in the study area based on proximity to new surface water supplies, proximity to sensitive surface water bodies, as well as their inclusion in the U.S. Geological Survey (USGS) study of White Bear Lake that was published in 2013.[1]

These are not the only viable approaches to achieve water sustainability in the northeast metro. The USGS has acknowledged that the communities included in the study area are not the only water users influencing White Bear Lake. There could be many other configurations of solutions that include other municipal water systems, private water users, and other solutions in addition to the infrastructure solutions considered in this study.

The alternatives evaluated should be viewed as examples. The best option for moving forward may be a hybrid of the examples considered in this study, and could involve approaches that were not considered in this study. For example, communities in the northeast metro could utilize less expensive

[1] Jones, P.M. Trost, J.J., Rosenberry, D.O., Jackson, P.R., Bode, J.A., and O'Grady, R.M., 2013, Groundwater and Surface-Water Interactions near White Bear Lake, Minnesota, through 2011: U.S. Geological Survey Scientific Investigations Report 2013-5044.

approaches. These might include conservation or stormwater reuse to reduce groundwater pumping before making large-scale investments in alternative infrastructure solutions. Such a plan could couple these less expensive options with aggressive monitoring of groundwater and surface water, and set triggers for further action in the event these less expensive approaches are not effective.

Four ongoing activities will better inform decision-making related to water use in the northeast metro as they are completed.

1. The USGS is conducting a study, *Characterizing Groundwater and Surface Water Interaction in Northeast Metro Area Lakes, MN,* with funding from the Council through a Clean Water Fund grant. This study will provide critical information on the surface water/groundwater interaction in the area. This will allow for better understanding of how proposed approaches will mitigate low lake levels. The study is expected to be complete in 2016.

2. The Council is completing a feasibility assessment of the potential for aquifer recharge and reusing stormwater in the North and East Metro Groundwater Management Area. The study area for this feasibility assessment includes the communities in the current study area, and additional communities in Anoka, Ramsey, and Washington counties. The results of this study, expected in 2015, will evaluate the potential of using alternative approaches to reduce impacts to lakes and to address other identified water sustainability issues within the Groundwater Management Area.

3. University of Minnesota Technical Assistance Program (MnTAP) will identify opportunities for industrial water users in the North and East Metro Groundwater Management Area to reduce their water consumption as part of the Minnesota Department of Natural Resources (DNR) strategies under the Groundwater Management Area plan. The source of water in this delineated region is almost exclusively groundwater. Several approaches will be used for this effort in order to reach, inform, and interact with a broad range of industrial users. This work is expected to be completed in the summer of 2015.

4. The DNR is completing a management plan for the North and East Metro Groundwater Management Area. This plan is currently in development, and could impact future groundwater appropriations, groundwater monitoring activities, and the assessment of water use sustainability in the area.

The results of these activities will provide useful information to determine the best course to move the northeast metro in the direction of greater sustainability of water resources. In addition, communities participating in this study have noted that groundwater use could be further reduced by more active conservation programs. Further investigation is needed of the potential for conservation to both reduce future groundwater use and recharge the aquifer and connected surface water bodies.

1.2 Feasibility Assessment Process

This study defines concept level water infrastructure systems to deliver the approaches to water sustainability identified in the study objectives. The basic elements of the assessment include:

- Description of concept system alternatives
- Planning level costs
- Considerations for implementation
- Comparison of potential benefits of alternative / approach combinations to the sustainability of water resources and system reliability in the northeast metro area

The assessment for each approach followed a similar method: preliminary screening of options and then a secondary evaluation of options with a more detailed analysis. For approaches related to drinking water supplies, different alternatives were developed for sets of communities at varying scales. For the evaluation of direct augmentation of White Bear Lake, the source of river water and conveyance routes presented different system component options. Each approach is evaluated independently and considered in separate chapters as a stand-alone option.

1.3 Study Area

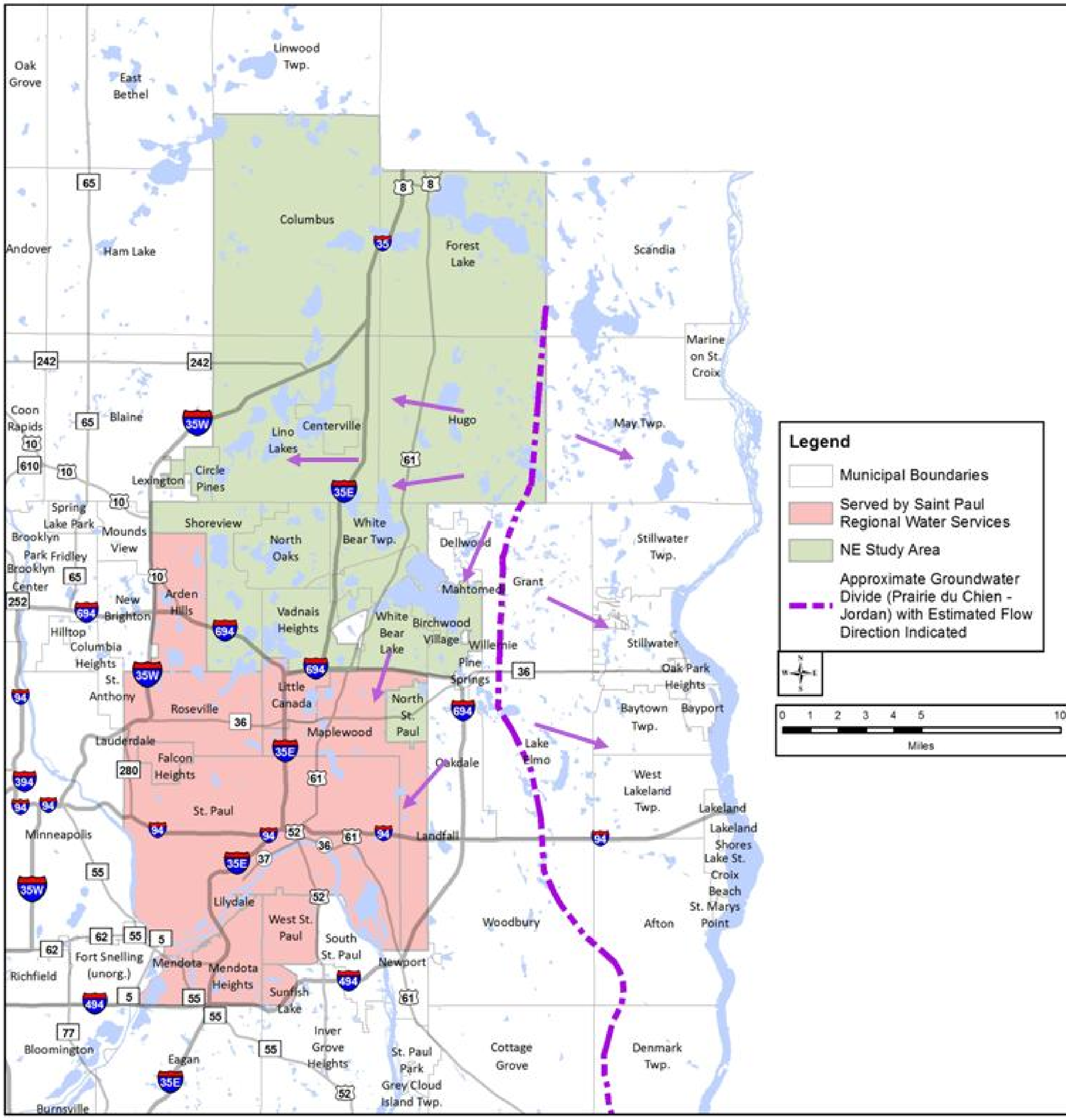


Figure 1-1. Study Area.

The northeast metro study area is delineated in Figure 1-1 in context with surface water features of interest and the St. Paul Regional Water Services (SPRWS) service area. The communities in the study area include the cities of Centerville, Circle Pines, Columbus, Forest Lake, Hugo, Lexington, Lino Lakes, Mahtomedi, North St. Paul, Shoreview, Vadnais Heights, White Bear Lake, and White Bear Township.

All of the study area communities lie within the Minnesota Department of Natural Resources' (DNR's) proposed North and East Groundwater Management Area (GWMA), and all of these communities rely on groundwater as their primary source of drinking water.

1.4 Water Demand

Current municipal well appropriations for individual cities in the study area range from 20 million gallons per year (MGY) to 1.4 billion gallons per year (BGY), and total approximately 7.1 BGY. Table 1-1 shows the relationship between groundwater withdrawals from municipal wells in each of the study cities from 2010 and associated appropriation limits.

Projected 2040 water demands for each of the study area communities are also presented in Table 1-1. Projected average daily water use by the entire study area is estimated to be 22 million gallons per day (MGD), while maximum day water demand is expected to be 64 MGD, as summarized in Table 1-2. Annual water use in 2040 is expected to be 8.3 BGY.

Total study area demand is expected to grow by about 56% from 2010 to 2040. The 2040 projected water demands for the majority of the communities exceed the 2010 permit appropriations. It is apparent that future water demands may not be met by current groundwater appropriations.

Table 1-1. Historic and Projected Population and Drinking Water Demand for Northeast Metro Communities.

City	2010 Population[1]	2040 Population[1]	2010 Municipal Water Use[2] (MGY)	2010 Municipal Well Appropriation (MGY)	2040 Demand[3] (MGY)
Centerville	2,544	2,952	96	108	110
Circle Pines	4,918	5,300	157	200	183
Columbus			16	20	376
Forest Lake	10,938	20,861	425	565.4	840
Hugo	9,588	28,756	370	650	1,205
Lexington	2,049	2,300	83	100	110
Lino Lakes	14,645	23,429	498	900	876
Mahtomedi	7,007	7,031	255	315	292
North St. Paul	13,760	15,400	424	584	548
Shoreview	25,000	27,457	1,062	1,400	1,241
Vadnais Heights	12,302	14,500	485	579	621
White Bear Lake	24,294	29,080	897	1,150	1,241
White Bear Township	11,357	12,408	532	515	621
Total	**138,400**	**189,470**	**5,300**	**7,090**	**8,264**

[1]Served by Municipal Water System (estimated) - [2]DNR - [3]Metropolitan Council, note that this projection is based on an average per capita water use from 2000-2010 for each community.

Table 1-2. Historic and Projected Total Population and Water Demand for the Northeast Metro.

Year	2010	2040
Population	138,400	189,470
Annual Water Usage (MG)	5,300	8,264
Average Day Demand (MGD)	14.5	22.6
Maximum Day Demand (MGD)	44.1	61.0

An important water infrastructure planning criteria is the ratio of maximum day water use to average day use. Peak demands occur during warmer months, and are mainly attributed to irrigation and outdoor water use needs. This ratio provides one method of assessing a community's water use efficiency. For this study, 2000 - 2010 water use data from the DNR was used to find the average maximum day to average day ratio. This ratio was applied to the average day demand projected for 2040. Table 1-3 summarizes the projected 2040 water demand and peak ratios.

Table 1-3. 2040 Average and Maximum Day Demands by Community.

City	Avg Day[1] 2040 Demand (MGD)	Max Day[2] 2040 Demand (MGD)	Peak Ratio[3]	% Total Study Area Avg Day Demand
Centerville	0.3	0.9	3.1	1%
Circle Pines	0.5	1.3	2.5	2%
Columbus	1.0	3.0	3.0	1%
Forest Lake	2.3	4.8	2.1	11%
Hugo	3.3	10.2	3.1	15%
Lexington	0.3	0.8	2.5	1%
Lino Lakes	2.4	8.4	3.5	11%
Mahtomedi	0.8	2.0	2.5	4%
North St. Paul	1.5	3.8	2.5	7%
Shoreview	3.4	8.8	2.6	16%
Vadnais Heights	1.7	4.4	2.6	8%
White Bear Lake	3.4	7.8	2.3	16%
White Bear Township	1.7	4.8	2.8	8%
Total	**22.6**	**61.0**	**2.7**	**-**

1 Average day demand is defined as the total annual water use for a system divided by 365 days, thus the annual average demand.

2 Maximum day demand is defined as the largest daily water use over the course of a calendar year. This is an important criterion for the sizing of infrastructure systems for reliable service.

3 Peak Ratio is the maximum day demand divided by the average day demand. Peak Ratios for 2040 were determined using the average Peak Ratios from 2000 to 2010 from DNR data.

1.5 Existing Water Infrastructure

Water infrastructure varies little from community to community. A water tower and/or a ground storage tank are present in all cities except for Columbus, and allow for 0.5 to 3.0 MG of storage in each community.

Pressure zones across the communities range from a low of 1,054 feet in Centerville to 1,171 feet in Mahtomedi. Most communities in the study area utilize treatment at individual wells, which typically consists of chlorination for disinfection, fluoride addition to prevent tooth decay, and the addition of polyphosphates for stabilization. Forest Lake, White Bear Lake, Circle Pines, and White Bear Township all have water treatment plants that further improve water quality. Appendix A provides a summary of each community's water supply system infrastructure.

There are 53 municipal wells listed within the study area. Of these 53 wells, 42 utilize the Prairie du Chien-Jordan aquifer, 5 in quaternary aquifers, and 6 in deeper aquifers. The sum appropriation for these wells is 7.1 BGY. Table 1-4 provides a summary of well counts and corresponding aquifers for each community.

Table 1-4. Number of Northeast Metro Municipal Wells in Area Aquifers.

City	Quaternary Wells	Prairie du Chien-Jordan Wells	Deeper Wells[1]	Total Wells
Centerville	0	2	0	2
Circle Pines	1	1	1	3
Columbus	2	0	1	3
Forest Lake	0	0	3	3
Hugo	0	5	0	5
Lexington	1	0	0	1
Lino Lakes	0	5	0	5
Mahtomedi	0	5	0	5
North St. Paul	0	5	0	5
Shoreview	1	5	0	6
Vadnais Heights	0	4	0	4
White Bear Lake	0	4	1	5
White Bear Township	0	6	0	6
Total	**5**	**42**	**6**	**53**

1 Refers to wells utilizing aquifers that are deeper than the Prairie du Chien-Jordan aquifer, including the Franconia, Ironton, Galesville and Mt. Simon aquifers.

1.6 Water Rates

Table 1-5 summarizes annual residential water bills for each community based on a typical household usage.

Table 1-5. Calculated Annual Residential Household Water Bills for Northeast Metro Communities.

City	Current Annual Cost per Household
Centerville	$216.01
Circle Pines	$202.21
Columbus	NA
Forest Lake	$217.24
Hugo	$167.91
Lexington	$162.81
Lino Lakes	$158.81
Mahtomedi	$236.54
North St. Paul	$243.85
Shoreview	$172.67
Vadnais Heights	$113.85
White Bear Lake	$86.97
White Bear Township	$181.51
St Paul	$242.49

Note: A household was defined as a family of four, with a residential water meter and an average water usage rate of 16,456 gallons per quarter. Columbus' residential water bill was not calculated as its municipal system primarily serves commercial businesses. Source: 2013/14 individual city fee schedules. NA= Not applicable.

Chapter 2 – Feasibility Assessment Overview

Preliminary screening identified a core group of alternatives for assessment. This chapter provides an overview of the alternatives selected. Separate chapters and appendices provide detail on the project components, costs, and other factors to consider for each water sustainability approach.

2.1 Assessment Methods

The development of concept water infrastructure systems for each water sustainability approach evolved from a preliminary screening phase to a group of alternatives for evaluation. The alternatives selected represent potential projects to achieve water sustainability goals. These are concept level alternatives to serve as a basis of comparison to understand the associated costs, implementation considerations, and environmental benefits of various approaches.

The summary information presented in this chapter is supported by information detailed in Appendices:

- Existing infrastructure for each of the northeast metro communities, including trunk watermain, wells, treatment facilities, and storage is identified in Appendix A.
- A methodology was developed for estimating costs of watermain, booster stations, and booster station O&M costs. A summary of the cost estimating approach is included in Appendix B. A summary of pipe segments including detailed cost tables are included in Appendix C. Groundwater modeling to predict drawdown and recovery was conducted using Metro Model 3 for each of the approaches. A description of the modeling assumptions is included in Appendix D.

2.2 Approach 1 and 2 – Groundwater to Surface Water Drinking Supplies

Approaches 1 and 2 evaluate a range of options to move communities in the northeast metro from a groundwater to a surface water drinking supply. Both approaches rely on the Mississippi River as the source of supply. In Approach 1, the Saint Paul Regional Water Service (SPRWS) would provide the drinking water using their existing treatment facilities. SPRWS would serve northeast metro communities as wholesale customers, which would own and operate their own distribution systems. In Approach 2, drinking water would be supplied from a new water treatment plant (WTP) located at Vadnais Lake, owned and operated by a new entity. This water supply would use the SPRWS raw water supply infrastructure and permitted appropriation from the Mississippi River.

The alternatives assessed for each approach are summarized in Table 2-1. Alternative numbers are based on the Approach (1 or 2) and a sub-alternative based on the communities served and supply characteristics (A, B, C, D). For example: Alternative 1A defines the system to supply water from the SPWRS (Approach "1") to North Saint Paul (sub-alternative identification letter "A"). Sub-alternatives A, B, and C correspond to different sets of communities converting from groundwater to surface water drinking water supplies. Sub-alternative D evaluates the same communities as in sub-alternative B but the supply is based on conjunctive use of ground and surface water supplies.

Table 2-1. Alternative Identification System for Approaches 1 and 2

Sub-Alternative ID	Communities Served	Approaches Analyzed (Alternative No.)
A Surface Water for North Saint Paul	North Saint Paul	1 – SPRWS Expansion (1A)
B Surface Water for Select Northeast Metro Communities	North Saint Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	1 – SPRWS Expansion (1B) 2 – New Surface WTP (2B)
C Surface Water for All Northeast Metro Communities		1 – SPRWS Expansion (1C) 2 – New Surface WTP (2C)
Phase 1	North Saint Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	
Phase 2	Lino Lakes, Centerville, Hugo	
Phase 3	Forest Lake, Columbus, Circle Pines, Lexington	
D Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities	North Saint Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	2 – New Surface WTP (2D)

2.2a Approach 1 – SPRWS Expansion

In Approach 1, northeast metro communities would be served through SPRWS as wholesale customers. The preliminary screening process identified the Hazel Park pressure zone, in proximity to North Saint Paul, as the easiest connection point for service to northeast metro communities from SPRWS' existing distribution system. However, the Hazel Park pressure zone has capacity to serve only North Saint Paul. Rather than make improvements to serve additional northeast metro communities from the Hazel Park pressure zone it is more cost-effective to provide service through a new connection. This constraint provided the basis for identifying a project with the least capital investment, defined as Alternative 1A – SPRWS Expansion to North Saint Paul. Figure 2-1 presents the concept system components for Alternative 1A.

The screening process identified a subset of study area communities for service based on capital investment in new infrastructure and upgrades to the existing SPRWS infrastructure. Alternative 1B – SPRWS Expansion to Select Northeast Metro Communities provides service to Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview through new water main connected to the core of the SPRWS system. Alternative 1B also includes service to North Saint Paul as defined in Alternative 1A. Figure 2-2 presents this concept system alternative.

Alternative 1C represents a system serving all the northeast metro communities as SPRWS wholesale customers. For this alternative, the trunk water main is sized to serve all northeast metro communities and is proposed for development in phases to meet the demand for communities considering their growth projections. In Phase 1, the communities identified for Alternatives 1A and 1B are served. In Phase 2, the communities of Lino Lakes, Centerville, and Hugo are added. In Phase 3, the system is expanded to serve Forest Lake, Columbus, Circle Pines and Lexington. Figure 2-3 presents the Alternative 1C concept system.

Table 2-2. Approach 1: SPRWS Expansion Alternatives Description Summary.

Alternative	Communities Served	Significant Features
1A SPRWS Expansion to North Saint Paul	North Saint Paul	SPRWS connection to Hazel Park pressure zone
1B SPRWS Expansion to Select Northeast Metro Communities	North Saint Paul	SPRWS connection to Hazel Park pressure zone
	Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	SPRWS connection near McCarrons WTP; system sized for only these communities
1C SPRWS Expansion to All Northeast Metro Communities		
Phase 1	North Saint Paul	SPRWS connection to Hazel Park pressure zone
	North Saint Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	Same connections as for Alternative 1B: system sized for all northeast metro communities
Phase 2	Lino Lakes, Centerville, Hugo	Water main extensions at Shoreview and White Bear Township; increase SPRWS raw water supply and treatment capacity
Phase 3	Forest Lake, Columbus, Circle Pines, Lexington	Water main extensions at Lino Lakes and Hugo

Figure 2-1. Alternative 1A - SPRWS Expansion to North St. Paul Concept System.

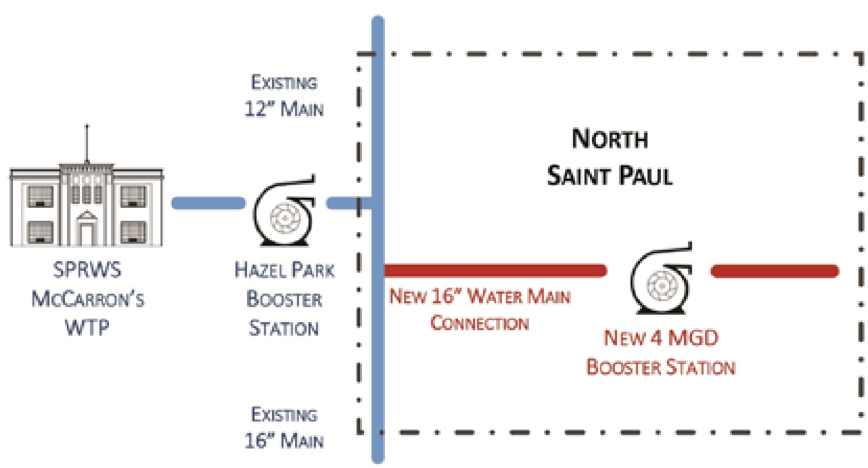


Figure 2-2. Alternative 1B - SPRWS Expansion to Select Northeast Metro Communities Concept System.

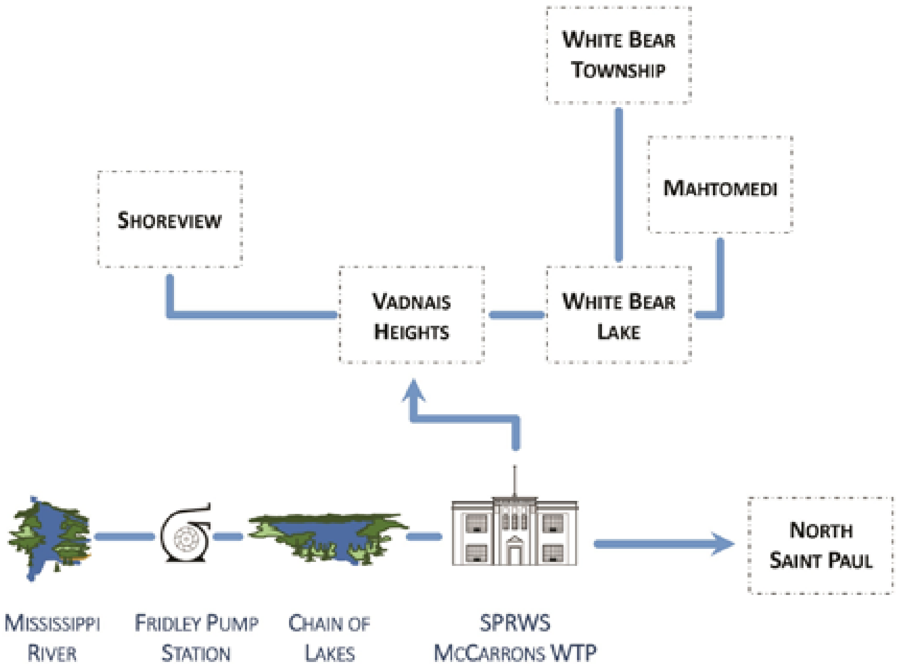
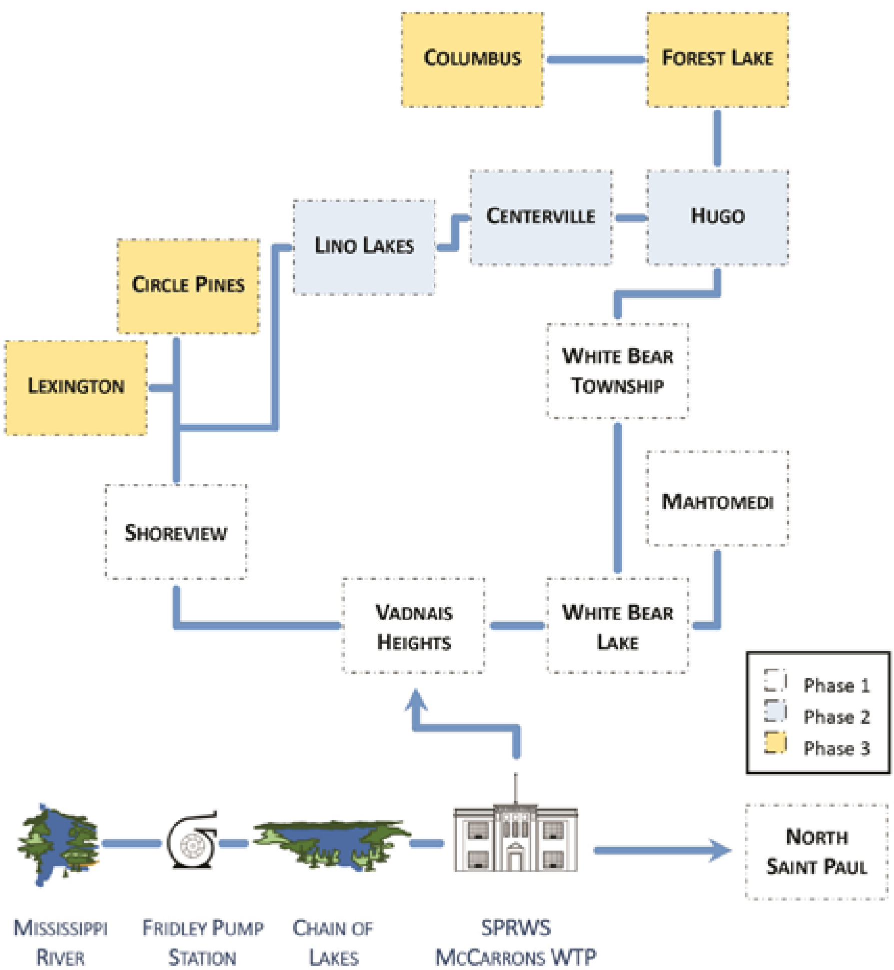


Figure 2-3. Alternative 1C - SPRWS Expansion to All Northeast Metro Communities Concept System.



2.2b Approach 2 – New Surface Water Treatment Plant

In Approach 2, the water supply source is obtained through the SPRWS appropriation of Mississippi River water, with a new WTP constructed at Vadnais Lake. For this approach there are three base alternatives that correlate to Approach 1 alternatives. Alternative 2B defines a subset of northeast metro communities served by a new surface WTP that is similar to Alternative 1B: Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview. North Saint Paul would be served as a wholesale customer of SPRWS. Figure 2-4 presents the Alternative 2B concept system. Alternative 2C defines a water supply system served by a new surface WTP for all the study area communities through a phased approach, similar to Alternative 1C. Figure 2-5 presents the Alternative 2C concept system. For Alternatives 2B and 2C, the new surface WTP and trunk watermain are sized to serve the peak demands of the communities.

Alternative 2D considers the conjunctive use of surface water and groundwater. A new surface WTP would be sized and constructed to serve the average day demands of the northeast metro communities of Shoreview, Vadnais Heights, White Bear Lake, White Bear Township, and Mahtomedi (same communities as Alternatives 1B, 2B). Existing wells in the Alternative 2D communities would be utilized to provide groundwater for peak demands. Figure 2-6 presents the Alternative 2D concept system. In Alternative 2D, North St. Paul would be served as a wholesale customer of SPRWS.

Table 2-3. Approach 2: New Surface WTP Alternatives Description Summary.

Alternative	Communities Served	Significant Features
2B New Surface WTP for Select Northeast Metro Communities	North Saint Paul	SPRWS connection to Hazel Park pressure zone
	Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	Connection to New WTP located on East Vadnais Lake
2C New Surface WTP for All Northeast Metro Communities		
Phase 1	North Saint Paul	SPRWS connection to Hazel Park pressure zone
	Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	Same connections as for Alternative 2B; system sized for all northeast metro communities
Phase 2	Lino Lakes, Centerville, Hugo	Same as Alternative 1C-Phase 2
Phase 3	Forest Lake, Columbus, Circle Pines, Lexington	Same as Alternative 1C-Phase 3
2D Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities	North Saint Paul	SPRWS connection to Hazel Park pressure zone
	Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	Connection to New WTP located on East Vadnais Lake for average day demands. Utilize existing groundwater wells for peak demands.

Figure 2-4. Alternative 2B - New Surface WTP for Select Northeast Metro Communities Concept System.

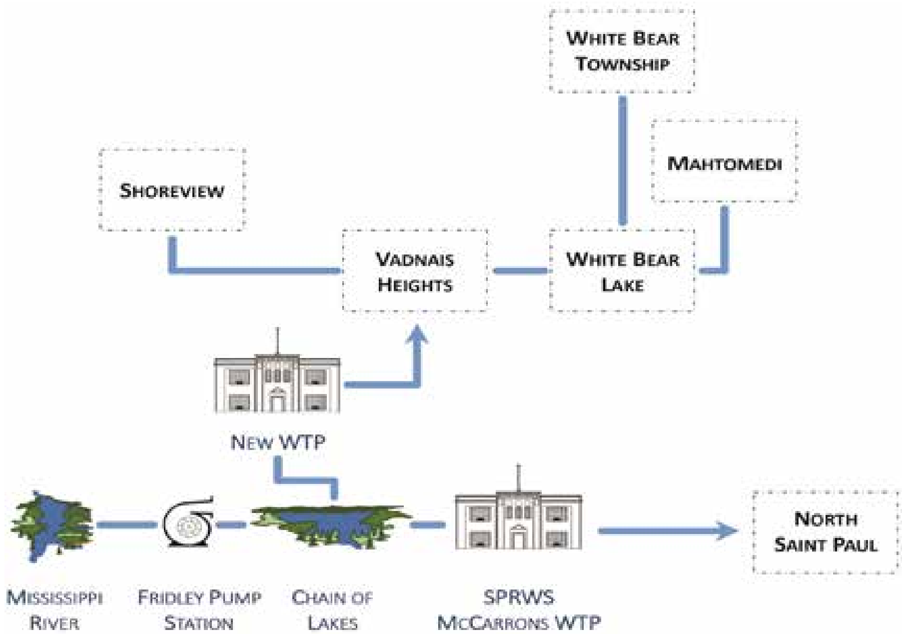


Figure 2-5. Alternative 2C - New Surface WTP for All Northeast Metro Communities Concept System.

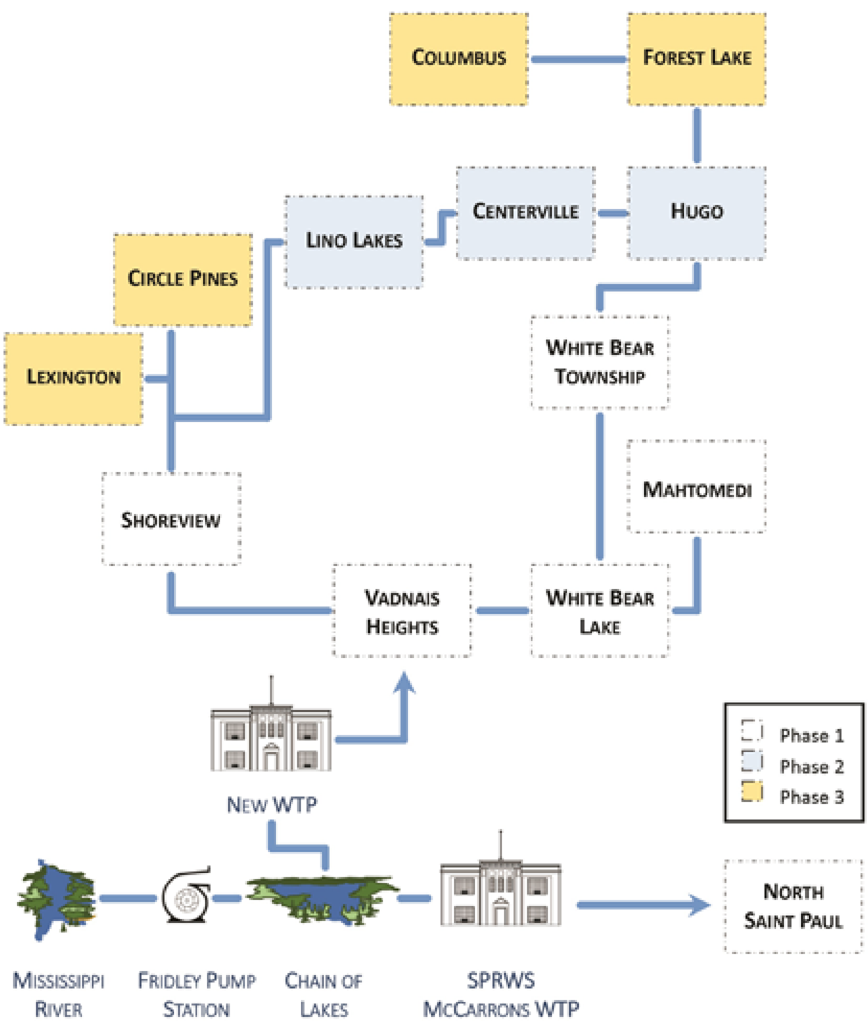
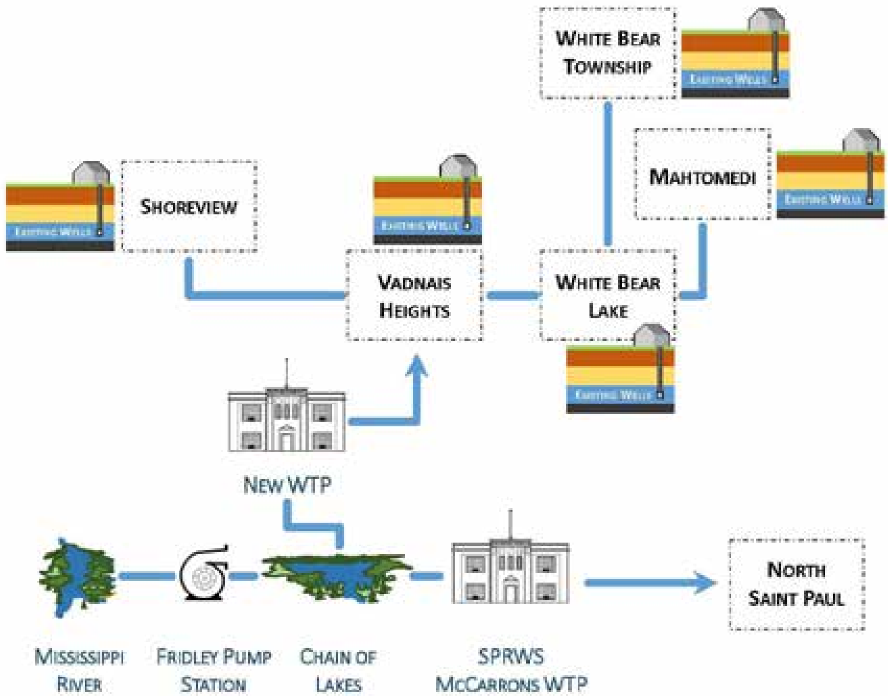


Figure 2-6. Alternative 2D – Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities



2.3 Approach 3 – Continued Development of Groundwater Sources

The northeast metro communities have relied solely on groundwater for their public water supply systems. Approach 3 evaluates the costs, increased groundwater drawdown, and identifies sensitive surface waters with continued use of groundwater supplies.

Chapter 3 - Approach 1 - Connection to Saint Paul Regional Water Services to Supply Drinking Water (SPRWS Expansion)

To reduce reliance on groundwater, the northeast metro communities could be connected to St. Paul Regional Water Services (SPRWS) for their drinking water supply. SPRWS operates a major water utility that gets its raw water from the Mississippi River. SPRWS has excess treatment capacity and is in close proximity to the northeast metro communities.

3.1 SPRWS Existing System

SPRWS withdraws water from the Mississippi River near Fridley, Minnesota, conveys the water east to the Vadnais chain of lakes, and treats water from Vadnais Lake at the McCarrons Water Treatment Plant (WTP) as depicted in Figure 3-1. A more detailed description of the SPRWS water systems is included in the following paragraphs.

The SPRWS raw water pumping station is located on the Mississippi River in Fridley, Minnesota. The pumping station has a capacity of 80 million gallons per day (MGD). The pumping station pumps raw water into two 60-inch cast-in-place concrete pipes. The pressure inside the concrete pipes is regulated by a surge tower located at the pumping station. The overflow elevation of the surge tower is 950-ft.

The raw water conduits are routed east approximately 9 miles and discharge into Charley Lake in the City of North Oaks. Charley Lake is the first lake in a series of lakes that also includes Pleasant Lake, Sucker Lake, and Vadnais Lake. The purpose of the lakes is to act as sedimentation basins (to settle out solids) to improve the raw water quality ahead of the water treatment plant and provide storage. In addition, oxygen is added to the water in Pleasant Lake and Vadnais Lake to further improve raw water quality. The chain of lakes has an operating capacity of 3.56 billion gallons above the intakes (submerged structure where water enters pump station). A pumping station in Vadnais Lake pumps the raw water into two 90-inch conduits that deliver the water to the SPRWS McCarrons water treatment plant (WTP) located on Rice Street in St. Paul.

Figure 3-1. Schematic of SPRWS Raw Water and Treatment Infrastructure.

Along the two 90-inch conduits, SPRWS has 10 Prairie du Chien – Jordan aquifer wells with a combined capacity of 45 MGD. The wells pump directly into the 90-inch conduits. SPRWS used approximately 1.4 billion gallons of water from the wells in 2012 (3.8 MGD).

The McCarrons WTP is a conventional lime softening facility. The treatment process includes chemical addition, flocculation, clarification, recarbonation, settling, filtration, and high service pumping. The lime softening process removes hardness from the water. In 2006, granular activated carbon was added to the filters at the WTP to remove objectionable taste and odor constituents from the water. The sustainable capacity of the water treatment plant is 105 MGD with a peak capacity of 130 MGD. At peak capacity, the WTP could only sustain 130 MGD for one or two days, whereas it could sustain 105 MGD for several weeks at a time.

SPRWS serves approximately 420,000 people in 12 cities. In 2012, the average day demand for the SPRWS system was 45 MGD with a maximum day demand of 77 MGD.

SPRWS has retail customers and wholesale customers. SPRWS owns and operates the water systems of their retail customers (Maplewood, West St. Paul, Mendota Heights, Lauderdale, and Falcon Heights). SPRWS sells water to their wholesale customers, but the wholesale customers own and operate their respective water systems (Roseville and Little Canada). Table 3-1 reflects the rates charged to SPRWS retail customers.

Table 3-1. SPRWS Retail Water Rates.

Type	Retail Customer[1]
Base Rate	$9.00/quarter
Winter Rate	$3.13/1,000 gallons
Summer Rate	$3.26/1,000 gallons

[1] Based on 2013 rates.

3.2 Conjunctive Use Water Quality

In this assessment, conjunctive use is using groundwater and treated surface water in a distribution system at the same time. An initial assessment of the water quality impacts associated with delivering SPRWS potable water to the suburban communities in the northeast metro and the possibility of conjunctive use of surface water and groundwater was performed for this study.

A detailed discussion of the conjunctive use water quality is included in Appendix E. Conjunctive use water quality findings are as follows:

- Communities would need to switch disinfection methods from chlorine to chloramines with a conversion to treated surface water from SPRWS.
- Mixing groundwater and surface water from SPRWS is predicted to be feasible.
- Customers in the northeast metro could expect taste and odor properties to be different with water from SPRWS. A public education program would be recommended.
- Lead, copper, and iron solution chemistry would be different with a conversion to water from SPRWS. These constituents would need to be monitored closely.
- Prior to moving forward with any conjunctive use applications, each community water supply needs to be individually evaluated.

3.3 Development of Concept System to Serve Northeast Metro

Three alternatives were developed to serve portions or all of the northeast metro from SPRWS. Different scale alternatives were selected to determine the most cost effective option. A description of the alternatives is as follows:

- Alternative 1A – SPRWS Service Expanded to North Saint Paul
- Alternative 1B – SPRWS Service Expanded to Select Northeast Metro Communities (connect North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview to SPRWS; infrastructure sized to serve only these communities).
- Alternative 1C - SPRWS Service Expanded to All Northeast Metro Communities
    - Phase 1 will connect North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview to SPRWS.
    - Phase 2 will connect Hugo, Lino Lakes, and Centerville to SPRWS.
    - Phase 3 will connect Forest Lake, Columbus, Lexington, and Circle Pines to SPRWS.

Several design decisions/assumptions were made in developing the concept of bringing treated surface water to the northeast metro from SPRWS:

- For Alternative 1A, trunk water main would be constructed and connect to the SPRWS Hazel Park pressure zone with a hydraulic grade line (HGL) of 1098-ft. The HGL is equivalent to the water tower elevation. A booster station would be constructed in North St. Paul to boost water to their HGL of 1125. Additional communities cannot be connected to the Hazel Park pressure zone due to hydraulic limitations.
- For Alternatives 1B and 1C, trunk water main would be constructed and operated at the same HGL as SPRWS high service zone (1019-ft). Booster stations would be constructed in the individual northeast metro communities to boost water to each city's respective HGL.
- Surface water connections in the northeast metro communities are made in the vicinity of wells or treatment facilities so that mixing of surface water and groundwater would be feasible if conjunctive use were desired. Approach 1 assumes that surface water is the primary source of water and that wells are only used in the event of an emergency. Mixing facilities are not included in the estimated costs for Approach 1. For reference, mixing station costs are presented in Alternative 2D.
- Northeast metro communities would continue to utilize their elevated storage tanks at their existing HGLs.
- New trunk water main and booster stations are sized to serve the 2040 maximum day demands identified in Chapter 1. Conjunctive use of surface and groundwater is feasible, but facilities are sized to provide maximum day demands from surface water. For cost reference, Alternative 2D considers conjunctive use and facilities are sized to only meet average day demands. Alternative 1B, 2B, and 2D have similar trunk water main layouts.
- As discussed in Section 3.2, all northeast metro communities would convert disinfection methods from chlorination to chloramination.
- All costs are presented in 2014 dollars in this report, and should be adjusted for inflation.
- Trunk water mains are assumed to be in a spur configuration, unless specifically shown otherwise in an alternative. This assumes that backup groundwater supplies will be available for maintenance and emergency in the event that the surface water supply line is out of service.
- The potential for loss of chloramine disinfection is possible due to longer distances between some communities and SPRWS. Chloramine disinfection may need to be boosted which could occur in the proposed booster stations. Nitrification and disinfection byproduct formation would also need to be monitored.

3.4 Alternative 1A - SPRWS Service Expanded to North Saint Paul

SPRWS serves the City of Maplewood which is adjacent to the northeast metro community of North St. Paul. Connecting North St. Paul to SPRWS could be achieved via a 16-inch water main and booster station, as depicted in Figure 3-2. Table 3-2 summarizes the estimated construction costs to connect North St. Paul to SPRWS.

A groundwater model was utilized to predict 2040 drawdown and recovery if groundwater pumping was eliminated in North St. Paul as part of Alternative 1A. As depicted in Figure 3-3, Prairie du Chien – Jordan groundwater recovery in the North St. Paul vicinity of up to 6 feet is predicted as a result of Alternative 1A.

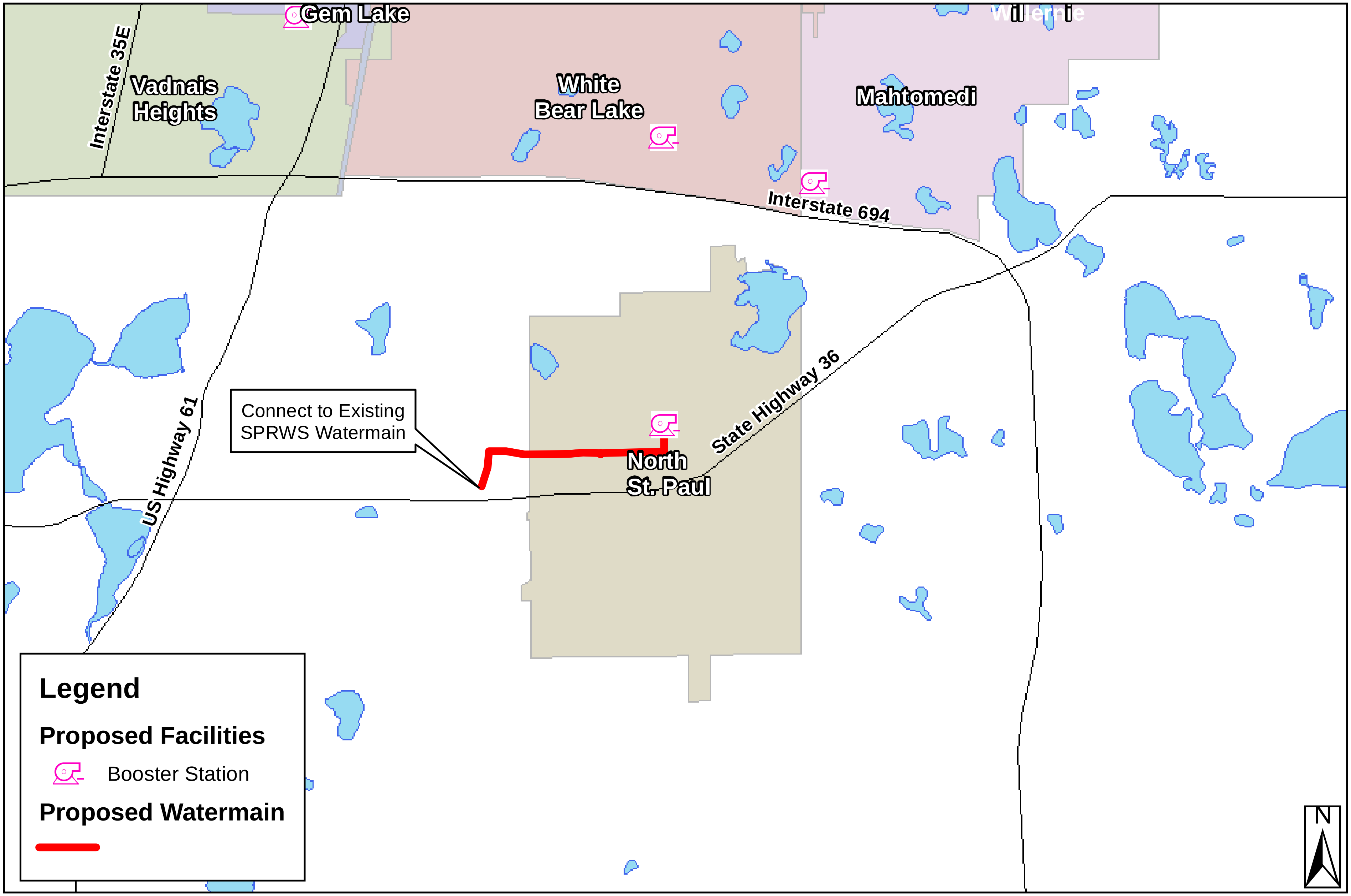
Table 3-2. Alternative 1A – SPRWS Service Expanded to North Saint Paul Capital Costs.

Item	Units	Unit Cost	Total Cost
16" Directionally Drilled HDPE	7,100 ft	$300/ft	$2,130,000
16" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	10	$15,000 ea	$150,000
Booster Stations			
North St. Paul – 4 MGD	1	$594,000 ea	$594,000
Easements/Land Acquisition	36,000 sf	$6/sf	$216,000
Environmental	1.3 miles	$50,000/mile pipe	$65,000
		Subtotal	**$3,405,000**
		Contingency (30%)	$1,022,000
		Eng/Admin/Legal (20%)	$681,000
		Total Alternative 1A	**$5,108,000**

3.5 Alternative 1B - SPRWS Service Expanded to Select NE Metro Communities

The northeast metro communities that would be connected to SPRWS in Alternative 1B are Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview. As part of Alternative 1B, North St. Paul would be connected to the SPRWS Hazel Park pressure zone. Because the combined 2040 maximum day water demands of the five communities (not including North St. Paul) is 27.8 MGD, it requires trunk water main to connect to the SPRWS system at the McCarrons WTP.

SPRWS has sufficient excess water treatment plant capacity to provide water for Alternative 1B. Although the SPRWS raw water conduits and Fridley pumping station do not have additional capacity beyond SPRWS' maximum day demand, the chain of lakes have sufficient storage to meet all demands of these communities. For Alternative 1B, it is assumed that the SPRWS raw water conduits and Fridley Pumping Station do not need to be upgraded. For Alternative 1B, the northeast metro communities will be connected to the SPRWS high service zone which operates at a HGL of approximately 1019-ft.



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Print Date: 07/11/2014

Map by:AK
Projection:WGS 1984
Source: SEH, MCES

Alternative 1A - SPRWS Expanded to North St. Paul

Figure 3-2

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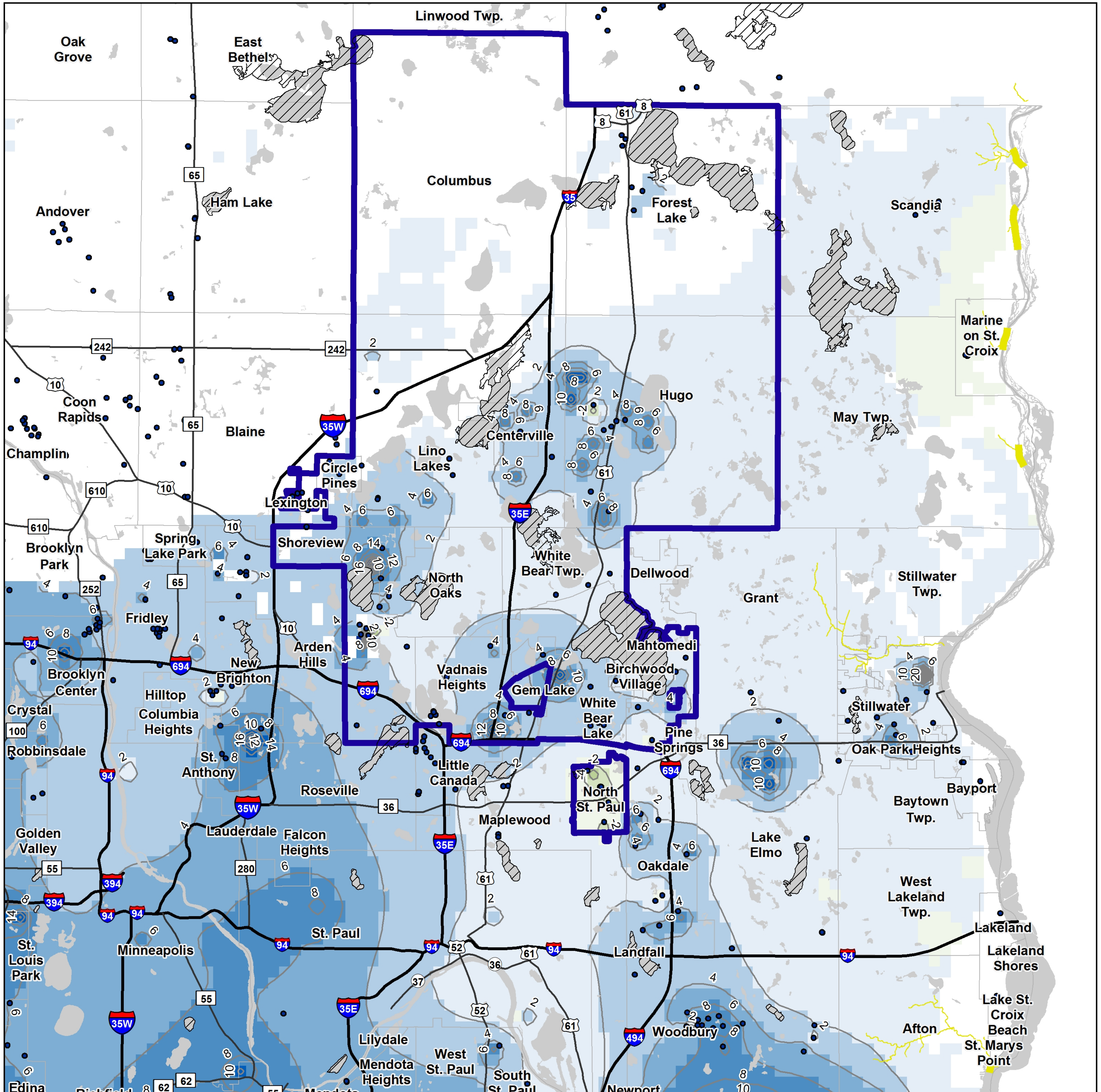
Figure 3-3: 2040 Drawdown - Prairie du Chien - Jordan Alternative 1A

Groundwater Pumping Eliminated in North St. Paul



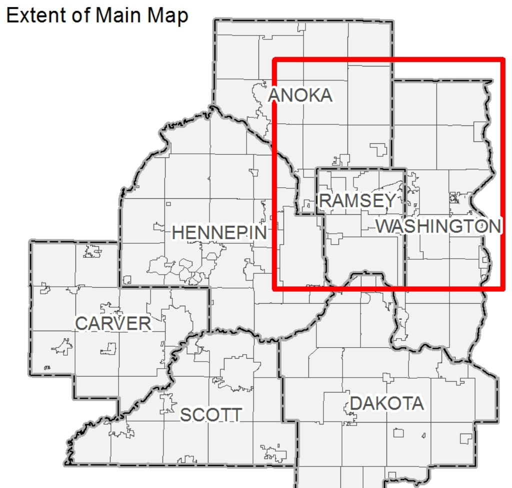
- CWI Public Community Wells
- Calcareous Fens
- Trout Streams
- Vulnerable Surface Water Features
- NE Study Area
- City and Township Boundaries
- Lakes and Rivers
- Drawdown Contours

Drawdown (ft)	Recovery (ft)
No Data	40 - 60
0 - 2	20 - 40
2 - 4	10 - 20
4 - 6	6 - 10
6 - 10	4 - 6
10 - 20	2 - 4
20 - 40	0 - 2
40 - 60	No Data

N W E S

3 1.5 0 3
Miles

Extent of Main Map



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Source(s): Groundwater drawdown / recovery from Metro Model 3; Vulnerable surface water features from "Evaluation of Groundwater and Surface-Water Interaction: Guidance for Resource Assessment", Metropolitan Council, 2010

10/15/2014

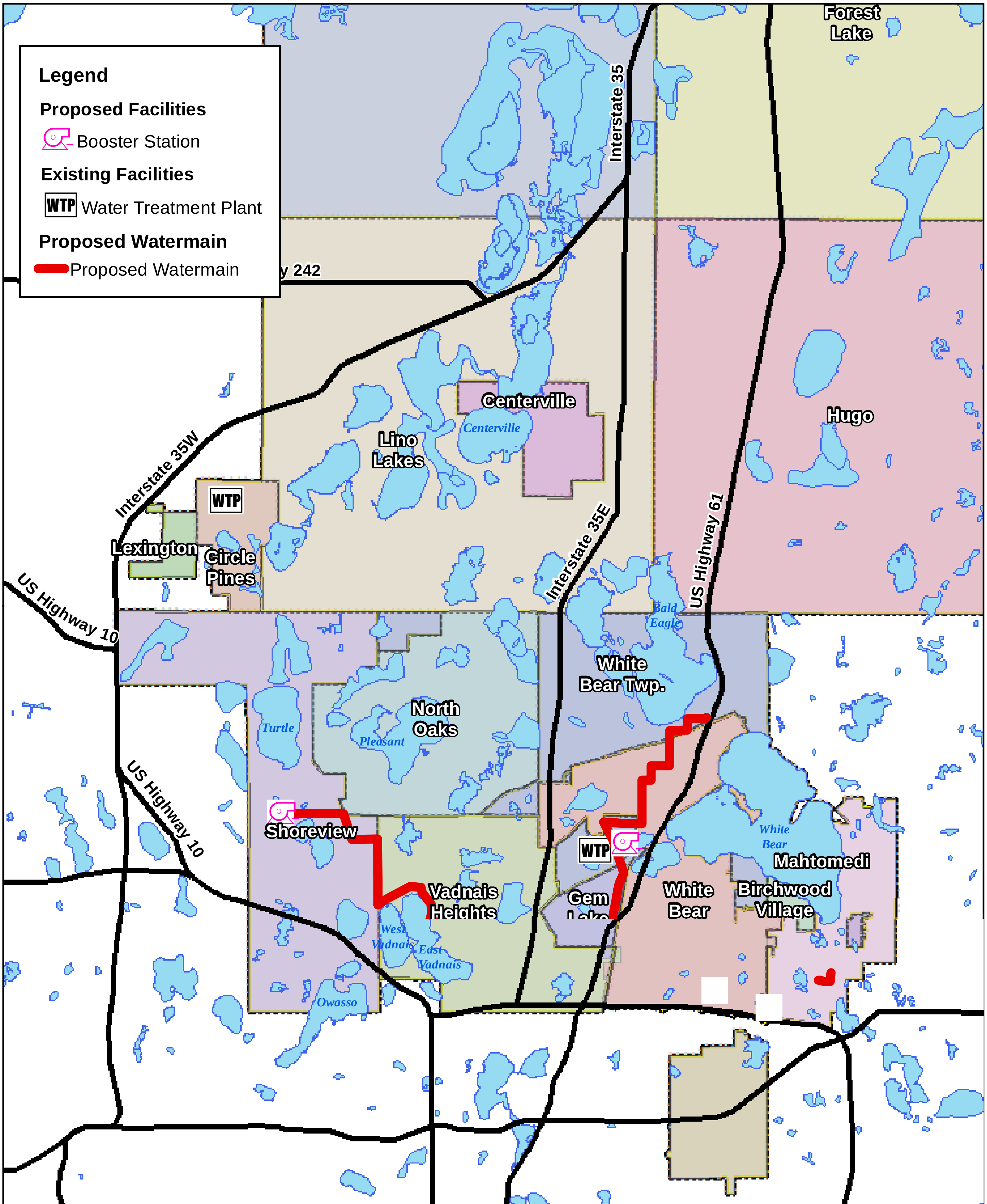
The trunk water main proposed as part of Alternative 1B is shown on Figure 3-4. The water main is sized to only serve the Alternative 1B communities and is not sized to be extended further. Because all of the northeast metro communities operate at higher HGLs than SPRWS, booster stations will be required for each community.

Table 3-3 summarizes the estimated construction costs to connect the Alternative 1B communities to SPRWS.

As depicted in Figure 3-5, groundwater recovery in the Prairie du Chien – Jordan aquifer of 8 feet or more is predicted across the Alternative 1B communities if this alternative were implemented. In addition, recovery of more than 15 feet is predicted in the aquifer for the White Bear Lake and Shoreview areas.

Table 3-3. Alternative 1B – SPRWS Service Expanded to Select Northeast Metro Communities Capital Costs.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
New Water Main			
Open Cut 48" DIP (100% in road)	22,560 ft	$1,316/ft	$29,689,000
48" Cased, tunneled pipe	1,200 ft	$4,000/ft	$4,800,000
Open Cut 36" DIP (100% in road)	12,350 ft	$1,025	$12,659,000
36" cased, tunneled pipe	400 ft	$3,000/ft	$1,200,000
Open Cut 30" DIP (100% in road)	25,500 ft	$908/ft	$23,154,000
30" cased, tunneled pipe	500 ft	$2,500/ft	$1,250,000
Open Cut 30" (0% in road)	14,140 ft	$364/ft	$5,147,000
Directionally Drilled 18" HDPE	27,330 ft	$350/ft	$9,566,000
18" cased, tunneled pipe	250 ft	$1,250/ft	$313,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	52	$15,000 ea	$780,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$599,000 ea	$599,000
Shoreview – 13 MGD	1	$900,000 ea	$900,000
Vadnais Heights – 6 MGD	1	$751,000 ea	$751,000
White Bear Lake – 10 MGD	1	$872,000 ea	$872,000
White Bear Twp – 5 MGD	1	$627,000 ea	$627,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	675,000 sf	$6/sf	$4,050,000
Environmental	21.5 miles	$50,000/mile pipe	$1,075,000
		Subtotal	**$103,626,000**
		Contingency (30%)	$31,089,000
		Eng/Admin/Legal (20%)	$20,725,000
		Total Alternative 1B	**$155,440,000**



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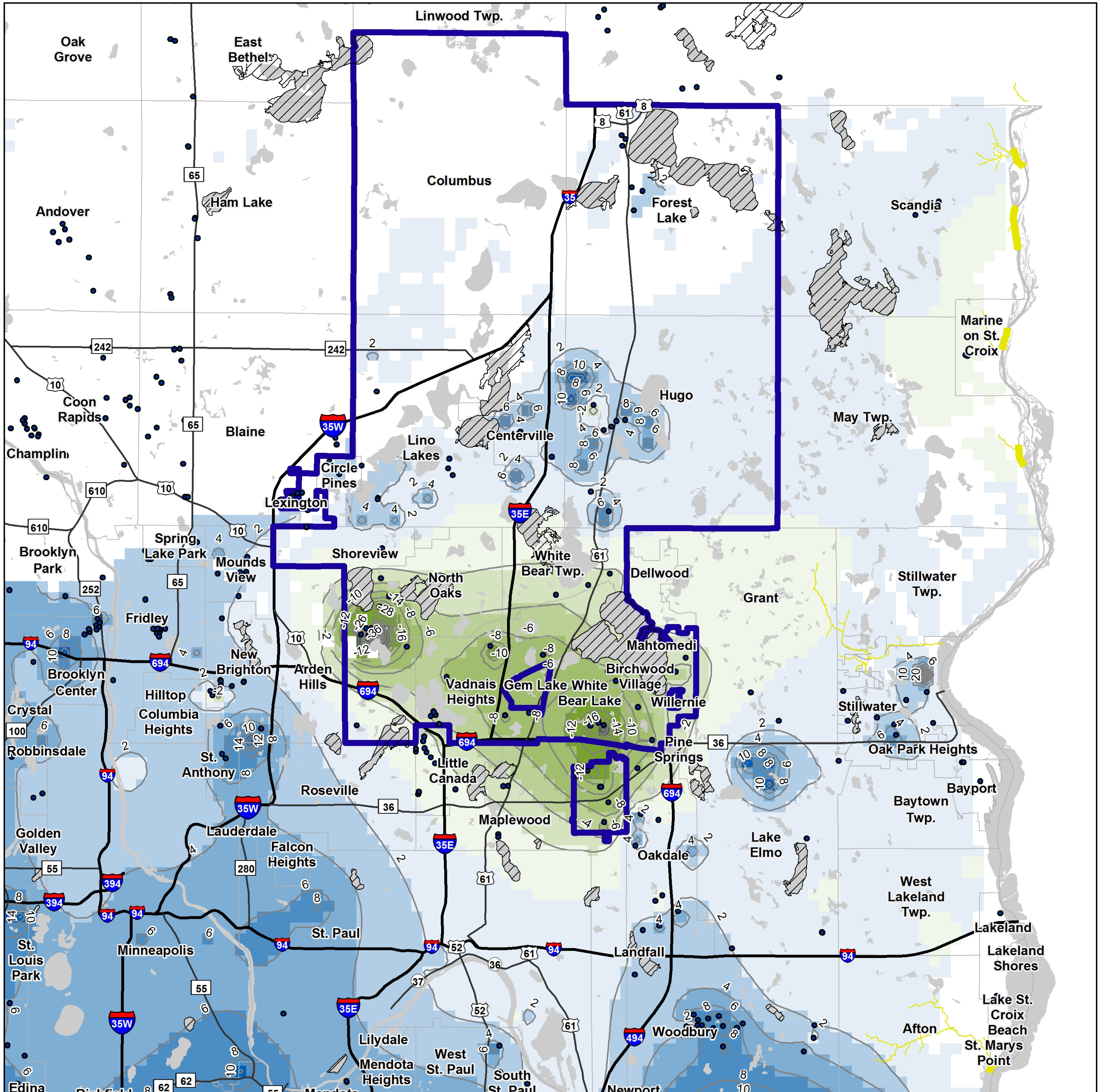
Map by: AK/SH
Projection: WGS_1984
Source: MnDOT, MnDNR, MnGEO, MCES, SEH.

Alternative 1B - SPRWS Service Expanded to Select Northeast Metro Communities

Figure 3-4

Figure 3-5: 2040 Drawdown - Prairie du Chien - Jordan Alternative 1B / 2B

Groundwater Pumping Eliminated in Shoreview, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and North St. Paul

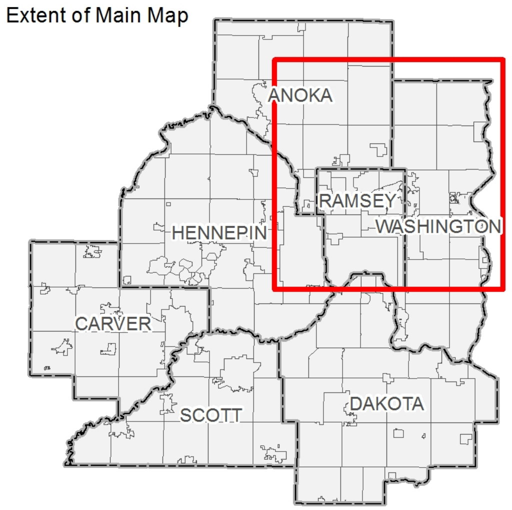


- CWI Public Community Wells
- Calcareous Fens
- Trout Streams
- Vulnerable Surface Water Features
- NE Study Area
- City and Township Boundaries
- Lakes and Rivers
- Drawdown Contours

Drawdown (ft)	Recovery (ft)
No Data	40 - 60
0 - 2	20 - 40
2 - 4	10 - 20
4 - 6	6 - 10
6 - 10	4 - 6
10 - 20	2 - 4
20 - 40	0 - 2
40 - 60	No Data

3 1.5 0 3
Miles

Extent of Main Map



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Source(s): Groundwater drawdown / recovery from Metro Model 3;
Vulnerable surface water features from "Evaluation of Groundwater and Surface-Water Interaction: Guidance for Resource Assessment", Metropolitan Council, 2010

10/15/2014

3.6 Alternative 1C - SPRWS Service Expanded to All Northeast Metro Communities

In Alternative 1C, all of the northeast metro communities would be connected to SPRWS in a phased approach. The phasing and major infrastructure improvements necessary for Alternative 1C are described below.

Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview

Phase 2 – SPRWS Connection to Hugo, Lino Lakes, and Centerville

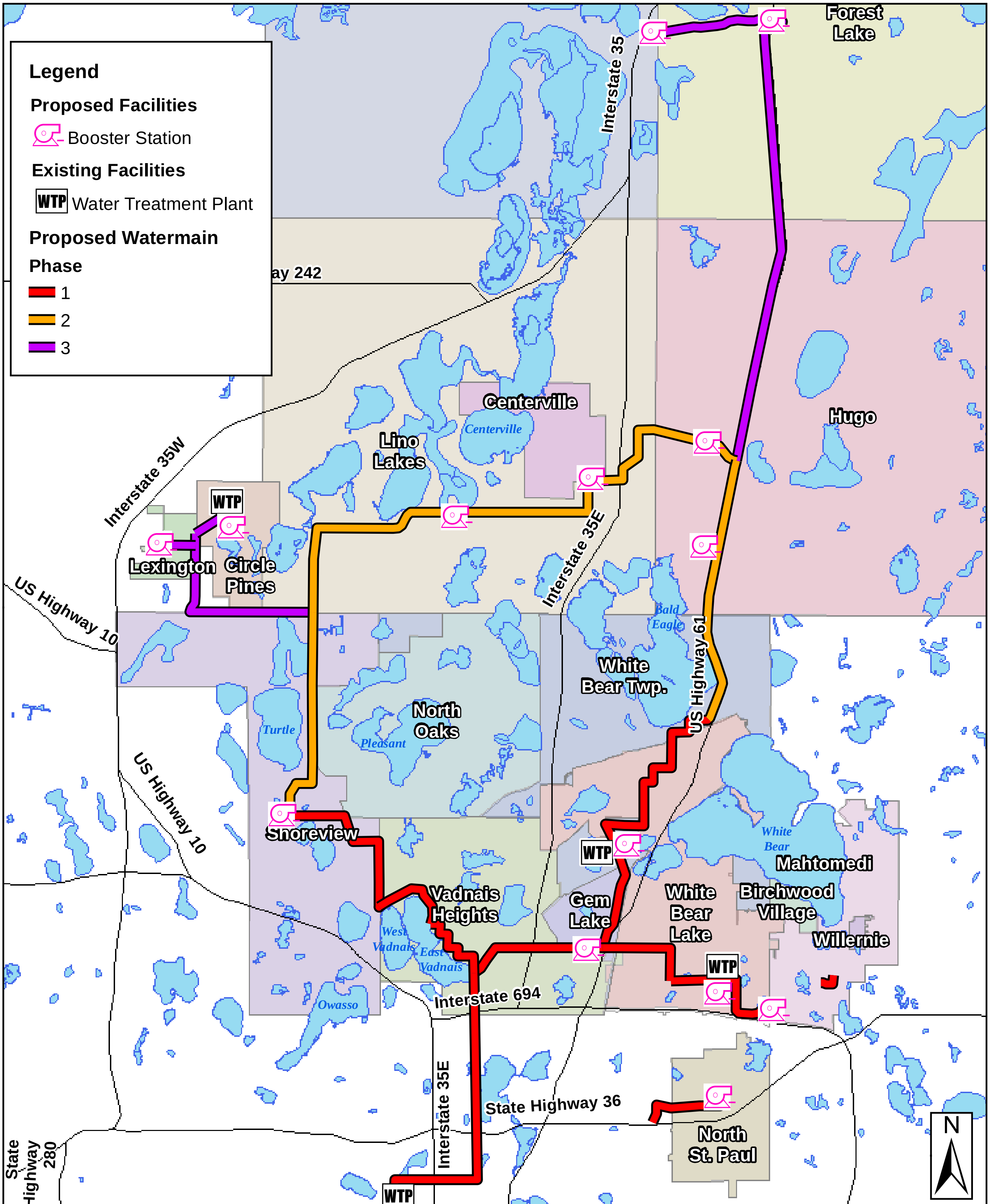
- Upgrade SPRWS Fridley raw water pumping station
- Add third 60-inch conduit to SPRWS raw water conveyance
- Add 50 MGD capacity to SPRWS McCarrons WTP

Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines, and Lexington

The trunk water main proposed as part of Alternative 1C, Phases 1-3, is shown on Figure 3-6. The trunk water main in Alternative 1C, Phases 1-3, is sized to serve the entire northeast metro.

As previously indicated, because all of the northeast metro communities operate at higher HGLs than SPRWS, booster stations will be required for each community. A description of each community's infrastructure is included in Appendix A.

Tables 3-4, 3-5, and 3-6 summarize the estimated construction costs to connect the entire northeast metro to SPRWS in a phased approach.



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Source: MnDOT, MnDNR, MnGEO, MCES, SEH.

Alternative 1C - SPRWS Service Expanded to All Northeast Metro Communities

Figure 3-6

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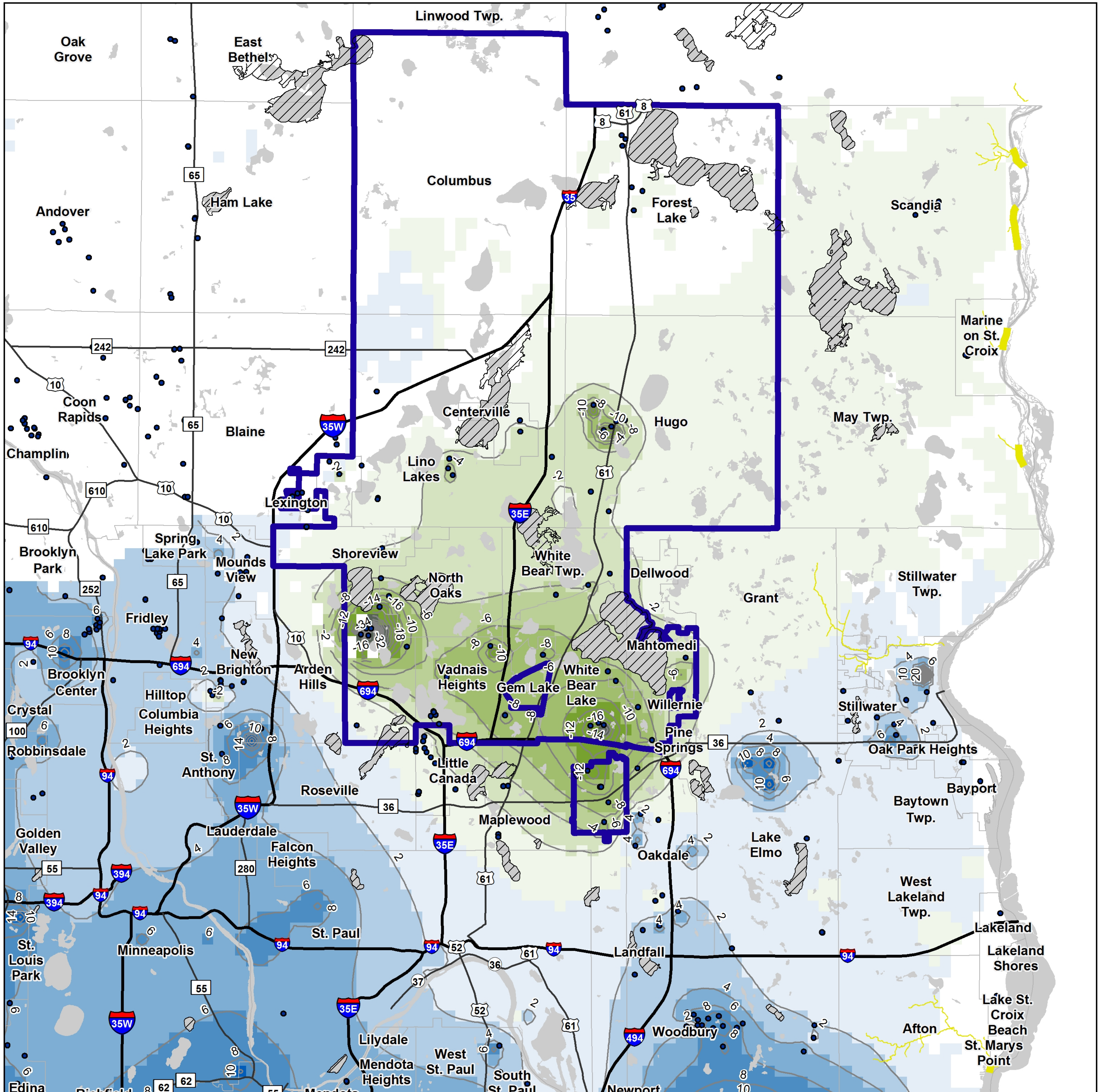
Figure 3-7: 2040 Drawdown - Prairie du Chien - Jordan Alternative 1C / 2C

Groundwater Pumping Eliminated in All Communities in Study Area



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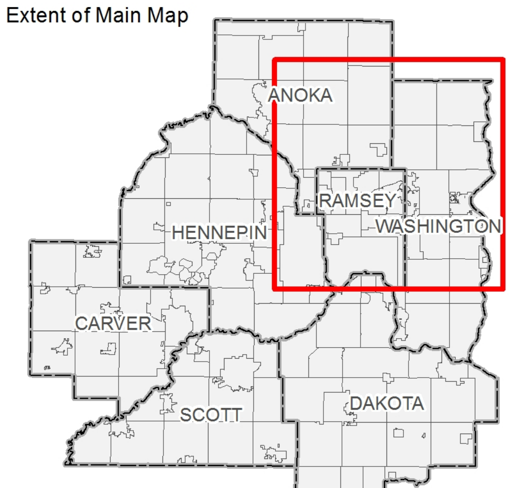
- Vulnerable Surface Water Features
- NE Study Area
- City and Township Boundaries
- Lakes and Rivers
- Drawdown Contours

Drawdown (ft)	Recovery (ft)
No Data	40 - 60
0 - 2	20 - 40
2 - 4	10 - 20
4 - 6	6 - 10
6 - 10	4 - 6
10 - 20	2 - 4
20 - 40	0 - 2
40 - 60	No Data

3 1.5 0 3

Miles

Extent of Main Map



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Source(s): Groundwater drawdown / recovery from Metro Model 3;
Vulnerable surface water features from "Evaluation of Groundwater and Surface-Water Interaction: Guidance for Resource Assessment", Metropolitan Council, 2010

10/15/2014

Table 3-4. Alternative 1C – Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, and Shoreview Capital Costs.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
Water Main			
Open cut dual 48" DIP (100% in road)	22,560 ft	$1,979/ft	$44,646,000
Open Cut 48" (0% in road)	14,140 ft	$663/ft	$9,375,000
Open Cut 48" DIP (100% in road)	54,180 ft	$1,316/ft	$71,301,000
48" Cased, tunneled pipe	3300 ft	$4,000/ft	$13,200,000
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$599,000 ea	$599,000
Shoreview – 13 MGD	1	$900,000 ea	$900,000
Vadnais Heights – 6 MGD	1	$751,000 ea	$751,000
White Bear Lake – 10 MGD	1	$872,000 ea	$872,000
White Bear Twp – 5 MGD	1	$627,000 ea	$627,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	682,000 sf	$6/sf	$4,091,000
Environmental	21.7 miles	$50,000/mile pipe	$1,085,000
		Subtotal	**$164,422,000**
		Contingency (30%)	$49,327,000
		Eng/Admin/Legal (20%)	$32,884,000
		Total Alt 1C, Phase 1	**$246,633,000**

Table 3-5. Alternative 1C – Phase 2 – SPRWS Connection to Hugo, Lino Lakes, and Centerville Capital Costs.

Item	Units	Unit Cost	Total Cost
Fridley Pumping Station Upgrades	1	$10,000,000 ea	$10,000,000
Additional 60" Raw Water Conduit (50% in road)	42,000 ft	$1,196/ft	$50,232,000
50 MGD SPRWS Treatment Plant Expansion	1	$65,000,000 ea	$65,000,000
Water Main			
Open Cut 48" DIP (50% in road)	71,030 ft	$910/ft	$64,637,000
Open Cut 48" DIP (100% in road)	16,000 ft	$1,316/ft	$21,056,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Booster Stations			
Centerville – 2 MGD	1	$544,000 ea	$544,000
Hugo – 7 MGD	1	$769,000 ea	$769,000
Hugo – 5 MGD	1	$727,000 ea	$727,000
Lino Lakes – 8 MGD	1	$751,000 ea	$751,000
Easements/Land Acquisition	524,000 sf	$6/sf	$3,144,000
Environmental	24.5 miles	$50,000/mile pipe	$1,225,000
		Subtotal	**$219,686,000**
		Contingency (30%)	$65,906,000
		Eng/Admin/Legal (20%)	$43,937,000
		Total Alt 1C, Phase 2	**$329,529,000**

As depicted in Figure 3-7, groundwater recovery in the Prairie du Chien – Jordan aquifer is predicted across most of the Alternative 1C communities with the exception of Forest Lake and Columbus areas if this alternative were implemented.

Table 3-6. Alternative 1C – Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines, and Lexington Capital Costs.

Item	Units	Unit Cost	Total Cost
Water Main			
20" Directionally drilled HDPE (or open cut under trail)	37,900 ft	$400/ft	$15,160,000
12" Directionally drilled HDPE	24,325 ft	$250/ft	$6,081,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally drilled HDPE	9,500 ft	$225/ft	$2,138,000
10" cased, tunneled pipe	250 ft	$900/ft	$225,000
Fusing Pits	121	$15,000 ea	$1,815,000
Booster Stations			
Circle Pines – 2 MGD	1	$570,000 ea	$570,000
Columbus – 1 MGD	1	$577,000 ea	$577,000
Forest Lake – 5 MGD	1	$748,000 ea	$748,000
Lexington – 2 MGD	1	$577,000 ea	$577,000
Easements/Land Acquisition	449,000 sf	$6/sf	$2,694,000
Environmental	13.7 miles	$50,000/mile pipe	$685,000
		Subtotal	**$31,520,000**
		Contingency (30%)	$9,456,000
		Eng/Admin/Legal (20%)	$6,304,000
		Total Alt 1C, Phase 3	**$47,280,000**

3.7 Cost Summary - Alternatives 1A, 1B and 1C

Table 3-7 provides a cost summary of Alternatives 1A, 1B, and 1C. These represent project cost estimates; including contingencies, engineering, administration, and legal costs in addition to construction costs. Detailed cost tables by alternative and pipe segment are included in Appendix C.

Table 3-7 Capital Costs to Connect Northeast Metro Communities to SPRWS

	Capital Cost
Alternative 1A – SPRWS Connection to North St. Paul	**$5,108,000**
Alternative 1B – SPRWS Connection to Select Northeast Metro Communities	**$155,440,000**
Alternative 1C – SPRWS Connection to All Northeast Metro Communities	
Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview	$246,633,000
Phase 2 – SPRWS Connection to Hugo, Lino Lakes, and Centerville	$329,529,000
Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines, and Lexington	$47,280,000
Total Alternative 1C	**$623,442,000**

3.8 Operation and Maintenance Costs

Operation and maintenance (O&M) costs for communities connected to SPRWS are included in the water rates charged by SPRWS. To determine the rate, SPRWS would conduct a "Cost of Service" study. Roseville, a wholesale customer of SPRWS, currently pays approximately 70% of SPRWS retail rate (plus a base charge). This works out to be approximately $2.19/1,000 gallons in the winter and $2.28/1,000 gallons in the summer, plus a quarterly base rate of $9, for each connection. The total cost for Roseville customers includes this wholesale cost charged by SPRWS plus a City charge for their system infrastructure costs.

According to SPRWS, the water coming from the Hazel Park pressure zone would likely be charged more than 70% of the SPRWS retail rate because it is provided at a higher pressure and goes through more SPRWS distribution piping. For Alternative 1A, it is assumed that the wholesale rate from SPRWS would be 75% of the average retail rate ($2.40 per 1,000 gal).

Because major water infrastructure is being constructed in the SPRWS system as part of Alternatives 1B and 1C and assumes a lower delivery pressure, it is assumed that the wholesale rate from SPRWS would be 65% of the average retail rate ($2.08 per 1,000 gal). This rate is only for alternative comparison purposes in this report and has not been negotiated with SPRWS.

3.9 Booster Station O&M Costs

O&M costs for the booster stations needed to connect northeast metro communities to SPRWS were developed based on pumping energy, equipment maintenance, labor costs, building heat, and other miscellaneous costs. The booster station operation and maintenance costs are presented in detail in Appendix B.

3.10 Annual Costs

Annual costs to connect northeast metro communities to SPRWS include annualized payments on capital infrastructure, repair and replacement on capital infrastructure, cost of water from SPRWS, and booster station O&M. The annual costs for each alternative are included in Table 3-8.

Cost assumptions include:

- 20 year annualized payment, 4% interest
- 1% annual repair and replacement for new water main
- 2% annual repair and replacement for booster stations
- Repair and replacement for new SPRWS infrastructure and treatment plant is included in cost of water
- O&M and repair and replacement for existing northeast metro infrastructure is not included

Table 3-8. Annual Costs for Approach 1 - Connection to SPRWS to Supply Drinking Water (SPRWS Expansion).

	2040 Annual Water Demand (MG)	Annualized Payment	Repair & Replacement	Cost of Water	Booster Station O&M	Total Annual Cost
Alternative 1A	548	$371,000	$36,800	$1,315,000	$27,000	**$1,750,800**
Alternative 1B	4,564	$11,303,000	$980,000	$9,493,000	$284,000	**$22,060,000**
Alternative 1C						
Phase 1	4,564	$17,937,000	$1,584,000	$9,493,000	$284,000	$29,298,000
Phase 2	2,191	$23,963,000	$927,000	$4,557,000	$130,000	$29,577,000
Phase 3	1,509	$3,438,000	$307,000	$3,139,000	$110,000	$6,994,000
Total Alternative 1C						**$65,869,000**

Chapter 4 - Approach 2 - Development of a Surface Water Connection to a New Subregional Water Treatment Plant (New Surface Water Treatment Plant)

A second option for reducing reliance on groundwater for northeast metro communities is to build a new water treatment plant (WTP) with a surface water source. Although the northeast metro communities are not in the immediate vicinity of a major river, the raw water supply for SPRWS does come through the northeast metro area.

4.1 New Water Treatment Plant Location

Two locations were identified as possible sites for a new WTP. These sites include the former Twin Cities Army Ammunition Plant (TCAAP), and a second potential site on the east side of Vadnais Lake owned by SPRWS.

4.1a TCAAP Site

The TCAAP site is currently vacant land owned by the United States Army. The SPRWS raw water conduits run adjacent to the site along County Road I. Advantages of the TCAAP site are the site is at a higher elevation than Vadnais Lake and would allow for easier elevated storage of treated water and it is adjacent to the SPRWS raw water conduits. Disadvantages of the TCAAP site are that it would require additional trunk water main to serve the northeast metro and the raw water quality requires more treatment than at Vadnais Lake. The chain of lakes provides a water supply with lower turbidity and suspended solids than a supply directly from the river. In addition, portions of the TCAAP site have environmental contamination (TCAAP is a superfund site) which could impact construction activities.

4.1b Vadnais Lake Site

A potential Vadnais Lake water treatment plant site is on the east side of Vadnais Lake on wooded property currently owned by SPRWS. Advantages of the Vadnais Lake site are that it would require less trunk water main and the water quality is better than the TCAAP site. The disadvantage is that the site is lower in elevation and elevated storage would be more expensive.

Because the water quality is better at the Vadnais Lake site and it would be less expensive overall (due to less trunk water main), this report assumes that the treatment plant would be constructed at Vadnais Lake.

4.2 New Water Treatment Plant Regulatory Requirements

A new surface WTP would need to adhere to the United States Environmental Protection Agency's Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). A discussion of the LT2ESWTR and potential treatment processes is included in Appendix F.

4.3 Conjunctive Use Water Quality

As discussed in Section 3.2 and Appendix E, conjunctive use of surface water and groundwater is predicted to be feasible. It will require northeast metro communities to switch their disinfection method from chlorination to chloramination.

4.4 Development of Concept System to Serve the Northeast Metro

Several design decisions and assumptions were made in developing the concept of bringing treated surface water to the northeast metro from a new surface WTP as follows:

- Due to its proximity, the City of North St. Paul would be served by SPRWS and not from a new WTP.
- A new surface WTP would be constructed at Vadnais Lake.
- New trunk watermain and booster stations are sized to serve the 2040 maximum day demands identified in Chapter 1. While conjunctive use of surface and groundwater is considered feasible, the groundwater supply is only necessary as an emergency backup supply in Alternatives 2B & 2C providing a new surface WTP and distribution system for select (2B) and all (2C) northeast communities. In Alternative 2D, conjunctive use is considered and new facilities are sized to meet average day demands.

- A trunk water main loop and spurs would be constructed and operated at the same hydraulic grade line. Hydraulic grade lines (HGLs) of 1100’ for Alternative 2B and 1054’ for Alternative 2C were selected because they are the lowest HGLs common to the existing HGLs for those alternatives.
- Booster stations would be constructed in some of the individual northeast metro communities as necessary to boost water from the trunk water main to each city’s respective HGL.
- Northeast metro communities would continue to utilize their elevated storage tanks at their existing HGLs.
- As discussed in Section 3.2, it is assumed that all northeast metro communities would convert disinfection methods from chlorination to chloramination.

4.5 Alternative 2B - New Surface WTP for Select Northeast Metro Communities

The northeast metro communities that would be connected to a new surface WTP in Alternative 2B are Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview. As part of Alternative 2B, North St. Paul would be connected to the SPRWS Hazel Park pressure zone.

The proposed surface WTP for Alternative 2B would be constructed with a capacity of 40 MGD.

Although the SPRWS raw water conduits and Fridley pumping station do not have additional capacity beyond SPRWS’ maximum day demand, the chain of lakes have sufficient storage to meet all demands of the communities. For Alternative 2B, it is assumed that the SPRWS raw water conduits and Fridley Pumping Station do not need to be upgraded.

The trunk water main proposed as part of Alternative 2B is shown on Figure 4-1. The water main is sized to only serve the Alternative 2B communities and is not sized to be extended further.

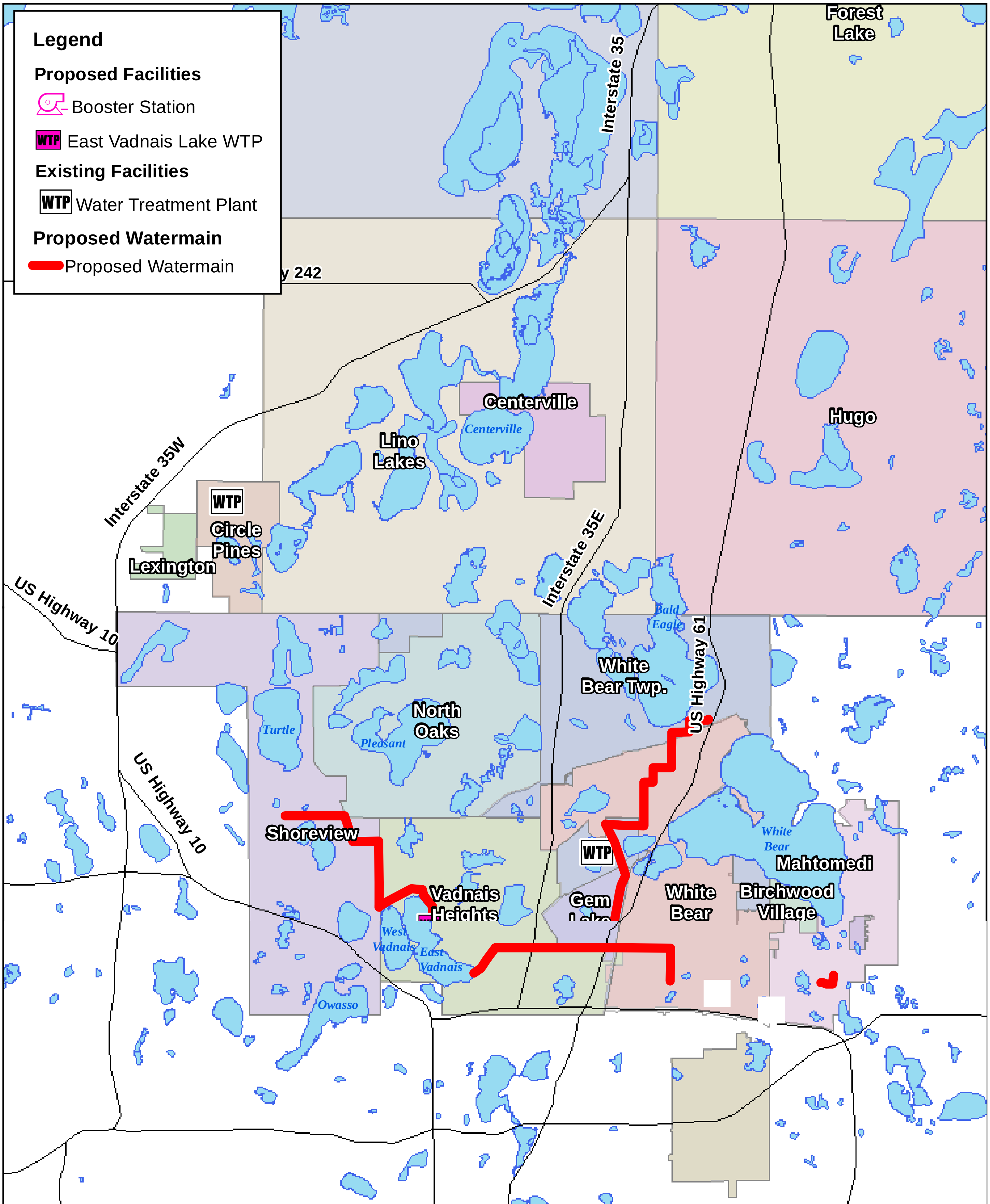
Because the new trunk distribution system is proposed to operate at a HGL of 1100’, booster stations will be required for White Bear Lake and Mahtomedi.

Table 4-1 summarizes the estimated construction costs to connect the Alternative 2B communities to a new surface WTP.

A groundwater model was utilized to predict 2040 drawdown and recovery if groundwater pumping was eliminated in the Alternative 2B communities. As depicted in Figure 3-5 (see Chapter 3), groundwater recovery in the Prairie du Chien – Jordan aquifer of 8 feet or more is predicted across the Alternative 2B communities. In addition, recovery of more than 15 feet is predicted in the aquifer for White Bear Lake and Shoreview areas.

Table 4-1. Alternative 2B – New Surface WTP for Select Northeast Metro Communities Capital Costs.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000 ea	$3,461,000
40 MGD Surface Water Treatment Plant	1	$85,000,000 ea	$85,000,000
Open Cut 36" DIP (100% in road)	12,350 ft	$1,025/ft	$12,659,000
36" cased, tunneled pipe	400 ft	$3,000/ft	$1,200,000
Open Cut 30" (0% in road)	14,140 ft	$364/ft	$5,147,000
Open Cut 30" DIP (100% in road)	25,500 ft	$908/ft	$23,154,000
30" cased, tunneled pipe	500 ft	$2,500/ft	$1,250,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Directionally Drilled 18" HDPE	27,330 ft	$350/ft	$9,566,000
18" cased, tunneled pipe	250 ft	$1,250/ft	$313,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	52	$15,000 ea	$780,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$591,000 ea	$591,000
White Bear Lake – 10 MGD	1	$801,000 ea	$801,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	493,000 sf	$6/sf	$2,958,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$151,088,000**
		Contingency (30%)	$45,326,000
		Eng/Admin/Legal (20%)	$30,218,000
		Total Alternative 2B	**$226,632,000**



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Alternative 2B - New Surface WTP for Select Northeast Metro Communities

Figure 4-1

4.6 Alternative 2C - New Surface WTP for All Northeast Metro Communities

In Alternative 2C, all of the northeast metro communities will be connected to a new surface WTP in a phased approach. The phasing and major infrastructure improvements necessary for Alternative 2C are described below. For comparison purposes, Alternative 2C phasing is the same as Alternative 1C.

Phase 1 – New surface WTP connected to Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview. North St. Paul connected to SPRWS.

- 40 MGD surface WTP constructed
- Trunk water main sixed for maximum day demand of 60 mgd

Phase 2 – New surface WTP connected to Hugo, Lino Lakes, and Centerville

- Upgrade SPRWS Fridley raw water pumping station
- Add third 60” conduit to SPRWS raw water conveyance
- 20 MGD Expansion of surface WTP
- Extend trunk water main to Hugo, Lino Lakes and Centerville

Phase 3 – New surface WTP connected to Forest Lake, Columbus, Circle Pines, and Lexington

- Extend trunk water main to remainder of study area communities

The trunk water main proposed as part of Alternative 2C, Phases 1-3, is shown on Figure 4-2. The trunk water main in Alternative 2C, Phases 1-3, is sized to serve the entire northeast metro.

As previously indicated, some of the northeast metro communities operate at higher HGLs than the proposed trunk water main, booster stations will be required for some of the communities.

Tables 4-2, 4-3, and 4-4 summarize the estimated construction costs to connect the entire northeast metro to a new surface WTP in a phased approach.

A groundwater model was utilized to predict 2040 drawdown and recovery if groundwater pumping was eliminated in the Alternative 2C communities. As depicted previously in Figure 3-7 for Alternative 1C (see Chapter 3), groundwater recovery in the Prairie du Chien – Jordan aquifer is predicted across most of the Alternative 2C communities with the exception of Forest Lake and Columbus. In addition, recovery of more than 15 feet is predicted in the aquifer for White Bear Lake and Shoreview areas.

Table 4-2. Alternate 2C – Phase 1 – New Surface WTP for Vadnais Heights, White Bear Lake, White Bear Township, and Shoreview (North St. Paul to SPRWS) Capital Costs.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
New 40 MGD Surface Water Treatment Plant	1	$85,000,000	$85,000,000
Water Main			
Open Cut 48” (0% in road)	14,140 ft	$663	$9,375,000
Open Cut 48” DIP (100% in road)	54,180 ft	$1,316	$71,301,000
48” cased, tunneled pipe	900 ft	$4,000	$3,600,000
Open Cut 30” DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30” cased, tunneled pipe	250 ft	$2,500/ft	$625,000
12” Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12” cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10” Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$592,000 ea	$592,000
Shoreview – 13 MGD	1	$868,000 ea	$868,000
Vadnais Heights – 6 MGD	1	$727,000 ea	$727,000

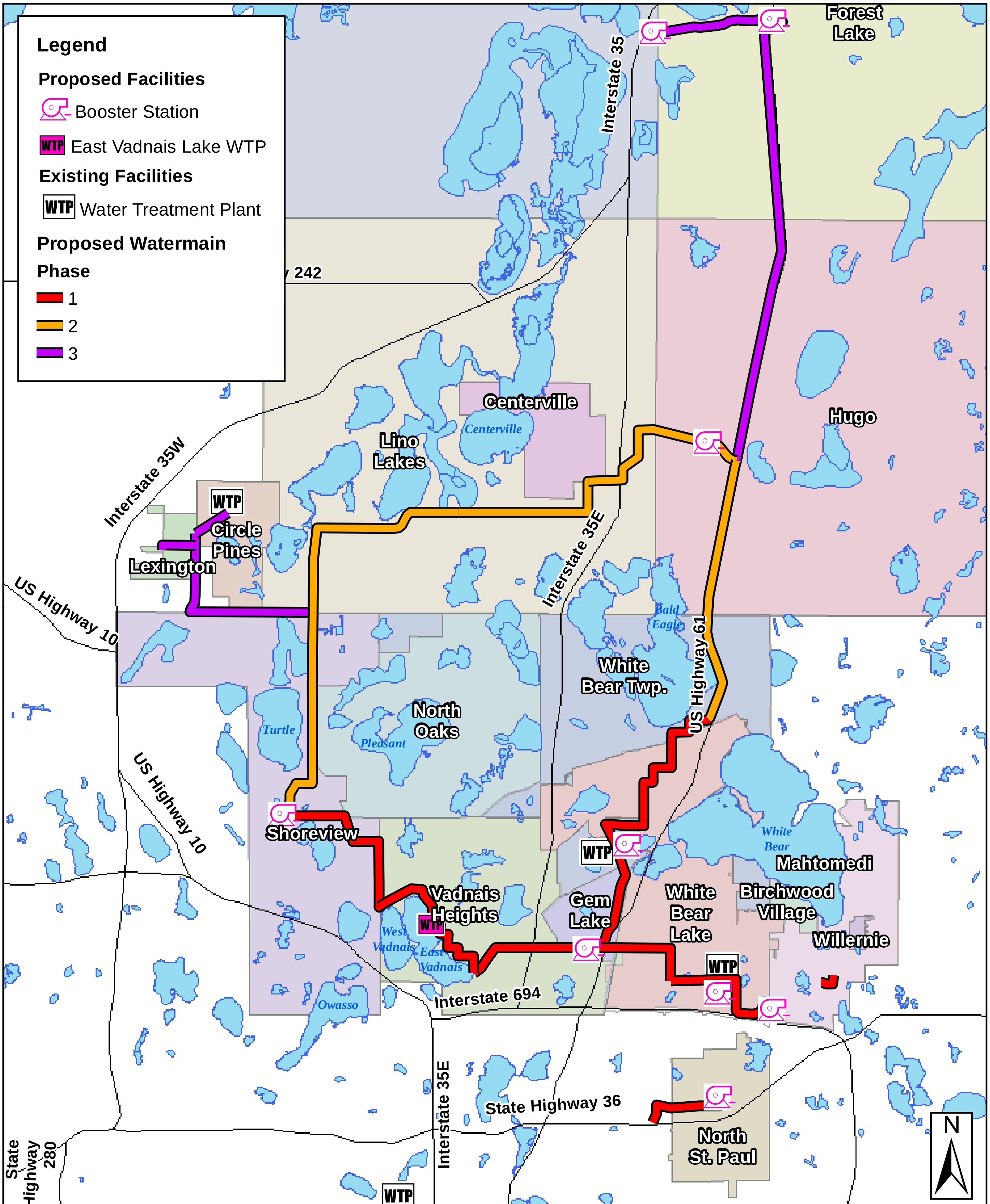
Item	Units	Unit Cost	Total Cost
White Bear Lake – 10 MGD	1	$801,000 ea	$801,000
White Bear Twp – 5 MGD	1	$606,000 ea	$606,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$194,070,000**
		Contingency (30%)	$58,221,000
		Eng/Admin/Legal (20%)	$38,814,000
		Total Alt 2C, Phase 1	**$291,105,000**

Table 4-3. Alternate 2C – Phase 2 – New Surface WTP for Hugo, Lino Lakes, and Centerville Capital Costs.

Item	Units	Unit Cost	Total Cost
Fridley Pumping Station Upgrades	1	$10,000,000 ea	$10,000,000
Additional 60" Raw Water Conduit (50% in road)	42,000 ft	$1,196/ft	$50,232,000
20 MGD Lime Softening Water Treatment Plant Expansion	1	$30,000,000 ea	$30,000,000
Water Main			
Open Cut 48" DIP (50% in road)	71,030 ft	$910/ft	$64,637,000
Open Cut 48" DIP (100% in road)	16,000 ft	$1,316/ft	$21,056,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Booster Stations			
Hugo – 7 MGD	1	$741,000 ea	$751,000
Easements/Land Acquisition	458,000 sf	$6/sf	$2,748,000
Environmental	24.5 miles	$50,000/mile pipe	$1,225,000
		Subtotal	**$182,249,000**
		Contingency (30%)	$54,675,000
		Eng/Admin/Legal (20%)	$36,450,000
		Total Alt 2C, Phase 2	**$273,374,000**

Table 4-4. Alternate 2C – Phase 3 – New Surface WTP for Forest Lake, Columbus, Circle Pines, and Lexington Capital Costs.

Item	Units	Unit Cost	Total Cost
Water Main			
20" Directionally drilled HDPE (or open cut under trail)	37,900 ft	$400/ft	$15,160,000
12" Directionally drilled HDPE	24,325 ft	$250/ft	$6,081,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally drilled HDPE	9,500 ft	$225/ft	$2,138,000
10" cased, tunneled pipe	250 ft	$900/ft	$225,000
Fusing Pits	121	$15,000 ea	$1,815,000
Booster Stations			
Columbus – 1 MGD	1	$497,000 ea	$497,000
Forest Lake – 5 MGD	1	$727,000 ea	$727,000
Easements/Land Acquisition	403,000 sf	$6/sf	$2,418,000
Environmental	13.7 miles	$50,000/mile pipe	$685,000
		Subtotal	**$29,996,000**
		Contingency (30%)	$8,999,000
		Eng/Admin/Legal (20%)	$5,999,000
		Total Alt 2C, Phase 3	**$44,994,000**



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Map by: AK/SH
Projection: WGS_1984
Source: MnDOT, MnDNR, MnGEO, MCES, SEH.

Alternative 2C - New Surface WTP for All Northeast Metro Communities

Figure 4-2

4.7 Alternative 2D – Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities

A preliminary analysis of water quality for the northeast communities and the SPRWS indicates conjunctive use of treated surface water and groundwater is feasible. The conjunctive use scenario evaluated for this study is based on northeast metro community average day water demands being met by a new surface water treatment plant, and groundwater wells being maintained to supply peak water demands.

As part of Alternative 2D, the northeast metro communities that would utilize conjunctive use of a new surface WTP and groundwater are the same as Alternatives 1B and 2B and include Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview. As part of Alternative 2D, North St. Paul would be connected to the SPRWS Hazel Park pressure zone.

The proposed surface WTP for Alternative 2D would be constructed with a capacity of 15 MGD and would serve the 2040 average day water demands of the select northeast metro communities. These communities would continue to operate and maintain some of their existing wells.

For Alternative 2D, it is assumed that the SPRWS raw water conduits and Fridley Pumping Station do not need to be upgraded.

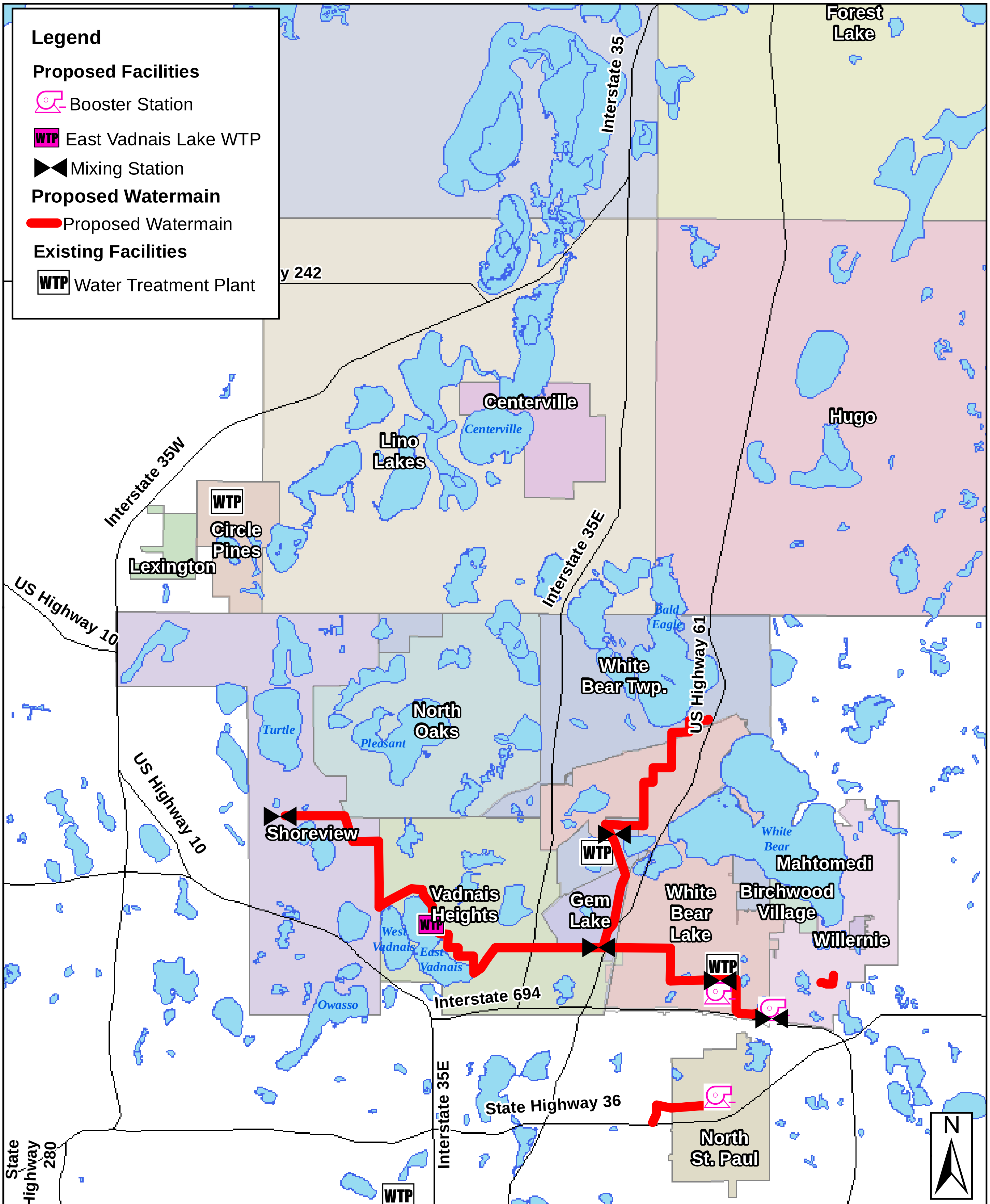
The trunk water main proposed as part of Alternative 2D is shown on Figure 4-3. The water main is sized to only serve the Alternative 2D communities and is not sized to be extended further.

The trunk distribution system for Alternative 2D is proposed to operate at a HGL of 1100'. At this HGL, White Bear Lake and Mahtomedi would require booster stations.

In addition to booster stations, mixing stations would also be constructed in each community to ensure uniform water quality between the surface water and groundwater. The proposed mixing stations would include raw water main from existing wells and be the connection point from the new surface WTP. A blending valve and static mixer would be used to mix the surface water and groundwater. For communities that require booster stations, the mixing station would be part of the booster station.

Table 4-5 summarizes the estimated construction costs to connect the Alternative 2D communities to a new surface WTP to meet average day (base) water demands and use existing wells to help meet peak demands.

Potential groundwater recovery in the Prairie du Chien – Jordan aquifer as a result of Alternative 2D is represented in Figure 4-4. The predicted groundwater recovery is similar to results from Alternatives 1B and 2B with 6-8 feet of recovery across the Alternative 2D communities. In addition, recovery of more than 15 feet is predicted in the aquifer for White Bear Lake and Shoreview areas.



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Alternative 2D - Conjunctive Use of SurfaceWater and Groundwater for Select Northeast Metro Communities

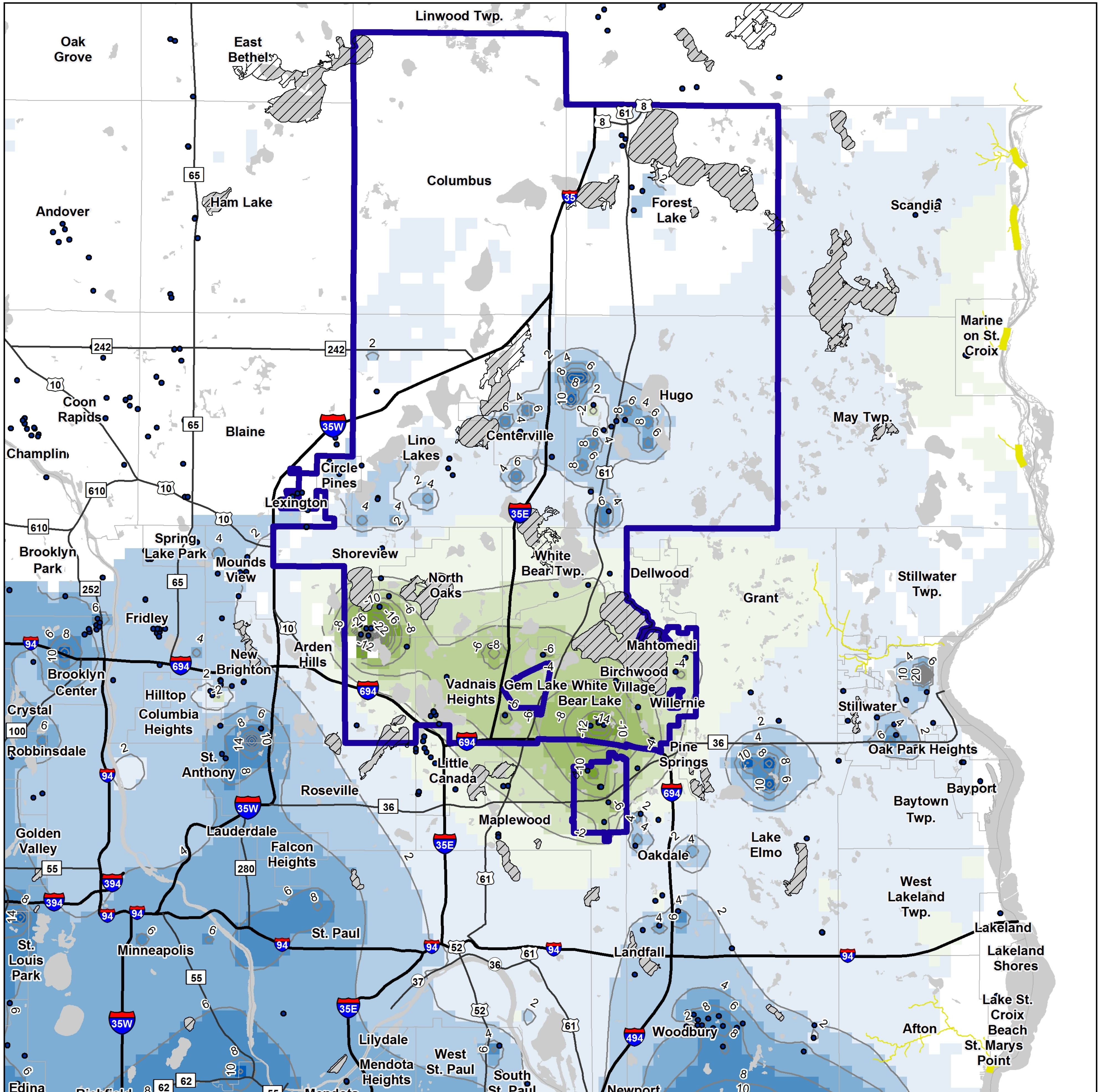
Figure 4-3

Table 4-5. Alternative 2D – Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000 ea	$3,461,000
15 MGD Surface Water Treatment Plant	1	$45,000,000 ea	$45,000,000
Open Cut 30” DIP (100% in road)	12,350 ft	$908/ft	$11,214,000
30” cased, tunneled pipe	400 ft	$2,500/ft	$1,000,000
Open Cut 24” (0% in road)	14,140 ft	$304/ft	$4,299,000
Open Cut 24” DIP (100% in road)	25,500 ft	$811/ft	$20,681,000
24” cased, tunneled pipe	500 ft	$2,250/ft	$1,125,000
18” Directionally Drilled HDPE	27,330 ft	$350/ft	$9,566,000
18” cased, tunneled pipe	250 ft	$1,250/ft	$313,000
12” Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12” cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10” Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	52	$15,000 ea	$780,000
Booster/Mixing Stations			
Mahtomedi Booster/Mixing Station – 2.5 MGD	1	$1,100,000 ea	$1,100,000
Shoreview Mixing Station	1	$1,000,000 ea	$1,000,000
Vadnais Heights Mixing Station	1	$750,000 ea	$750,000
White Bear Lake Booster/Mixing Station – 10 MGD	1	$1,300,000 ea	$1,300,000
White Bear Twp Mixing Station	1	$750,000 ea	$750,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$109,271,000**
		Contingency (30%)	$32,781,000
		Eng/Admin/Legal (20%)	$21,854,000
		Total Alternative 2B	**$163,906,000**

Figure 4-4: 2040 Drawdown - Prairie du Chien - Jordan Alternative 2D

Groundwater Pumping for Peak Use Only in Shoreview, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and North St. Paul

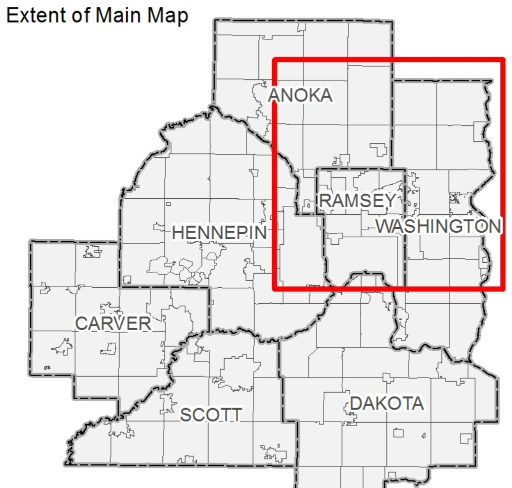


- CWI Public Community Wells
- Calcareous Fens
- Trout Streams
- Vulnerable Surface Water Features
- NE Study Area
- City and Township Boundaries
- Lakes and Rivers
- Drawdown Contours

Drawdown (ft)	Recovery (ft)
No Data	40 - 60
0 - 2	20 - 40
2 - 4	10 - 20
4 - 6	6 - 10
6 - 10	4 - 6
10 - 20	2 - 4
20 - 40	0 - 2
40 - 60	No Data

3 1.5 0 3
Miles

Extent of Main Map



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Source(s): Groundwater drawdown / recovery from Metro Model 3; Vulnerable surface water features from "Evaluation of Groundwater and Surface-Water Interaction: Guidance for Resource Assessment", Metropolitan Council, 2010

10/15/2014

4.8 Cost Summary – Alternatives 2B, 2C, and 2D

Table 4-6 provides a cost summary of Alternatives 2B and 2C to connect northeast metro communities to a new surface WTP. These represent project cost estimates; including contingencies, engineering, administration, and legal costs in addition to construction costs. Detailed cost tables by alternative and pipe segment are included in Appendix C.

Table 4-6. Costs to Connect Northeast Metro to New Surface WTP.

	Capital Cost
Alternative 2B – New Surface WTP for Select Northeast Metro Communities	**$226,632,000**
Alternative 2C – New Surface WTP for All Northeast Metro Communities	
Phase 1 – New Surface WTP for Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi & Shoreview (North St. Paul connection to SPRWS)	$291,105,000
Phase 2 – New Surface WTP for Hugo, Lino Lakes, and Centerville	$273,374,000
Phase 3 – New Surface WTP for Forest Lake, Columbus, Circle Pines & Lexington	$44,994,000
Total Alternative 2C	**$609,473,000**
Alternative 2D – Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities	**$163,906,000**

4.9 Operations and Maintenance Costs

The O&M costs for various sized lime softening, surface water treatment facilities are included in Table 4-7. The O&M costs presented were proportioned based on relevant SPRWS O&M costs. These costs do not include O&M costs for distribution systems or booster stations.

Table 4-7. Annual Operation and Maintenance Costs.

Average Demand	Annual O&M[1]
9.3 MGD (Alt. 2D)	$4,075,000
11.0 MGD (Alt. 2B, 2C Phase 1)	$4,841,000
17.0 MGD (Alt. 2C Phase 2)	$7,482,000
21.1 MGD (Alt. 2C Phase 3)	$9,286,000

1 – O&M Costs proportioned from SPRWS costs included in *Cost of Service Study to Serve Wholesale Customers, SPRWS, prepared by Progressive Consulting Engineers, February 2013*

4.10 Booster Station O&M Costs

O&M costs for the booster stations needed to connect northeast metro communities to a new surface WTP were developed based on pumping energy, equipment maintenance, labor costs, building heat, and other miscellaneous costs. The booster station operation and maintenance costs are presented in detail in Appendix B.

4.11 Annual Costs

Annual costs to connect northeast metro communities to a new surface WTP include annualized payments on capital infrastructure, repair and replacement on capital infrastructure, cost of raw water from SPRWS ($100 per million gallons), WTP O&M, and booster station O&M. The annual costs for each alternative are included in Table 4-8.

Cost assumptions include:

- 20 year annualized payment, 4% interest
- 1% annual repair and replacement for new water main
- 2% annual repair and replacement for WTP and booster stations
- O&M and repair and replacement for existing northeast metro infrastructure is <u>not included</u>

Table 4-8. Annual Costs for Alternatives to Connect Northeast Metro to a New Surface WTP.

	2040 Annual Water Demand (MG)	Annualized Payment	Repair and Replacement	Cost of Water	WTP and Booster Station O&M	Total Annual Cost
Alternative 2B	4,564	$16,480,000	$2,340,000	$1,717,000[1]	$5,080,000	**$25,617,000**
Alternative 2C						
Phase 1	4,564	$21,168,000	$2,755,000	$1,717,000[1]	$5,080,000	$30,720,000
Phase 2	2,191	$19,879,000	$1,488,000	$219,000	$2,676,000	$24,262,000
Phase 3	1,509	$3,272,000	$283,000	$151,000	$1,858,000	$5,564,000
Total Alternative 2C	**8,264**					**$60,546,000**
Alternative 2D	3,928	$11,919,000	$1,555,000	$1,653,000[1]	$4,331,000	**$19,458,000**

1 Includes North St. Paul purchasing water from SPRWS at wholesale rate of $2.40/1,000 gal.

Chapter 5 – Approach 3 – Continued Development of Groundwater Sources

5.1 Groundwater Infrastructure Projects

The costs to convert northeast metro public water supplies from groundwater sources to a surface water source are significant. There are, however, costs and potential environmental impacts that are inherent in continuing on the current path of relying on groundwater. The costs that need to be considered include infrastructure that would need to be constructed and operated over the same planning horizon to provide drinking water sourced from groundwater. These costs include new treatment facilities, rehabilitation of existing treatment facilities, and new groundwater supply wells. Approach 3 considers all 13 of the northeast metro communities similar to Alternatives 1C and 2C.

Several northeast metro groundwater-related capital projects are known to be planned or will be needed in the future, including:

- A new groundwater treatment plant in Shoreview in 2015 (estimated cost $10,000,000).
- A new groundwater treatment plant in Lino Lakes in approximately 2020 (estimated cost $20,000,000).
- Nine new wells and well houses as follows ($1,000,000 each):
    - Hugo – 3 new wells
    - Lino Lakes – 3 new wells
    - Centerville – 1 new well
    - Forest Lake – 1 new well
    - White Bear Township – 1 new well
- Water treatment plant maintenance, rehabilitation, and upgrade costs in White Bear Lake, White Bear Township, Circle Pines, and Forest Lake. Water treatment plant rehabilitation projects are typically done approximately every 20 years (assume 5 rehabilitation projects that cost $2,000,000 each).
- Wellhouse rehabilitation projects. It is assumed that each wellhouse will be rehabilitated once over the planning period at a cost of $100,000.
- Well pumps and motors need to be pulled and repaired approximately every 7 years. The cost per well is approximately $40,000. The typical life expectancy of a well is approximately 80 years.

The capital costs of continued development of groundwater sources are summarized in Table 5-1

Table 5-1. Approach 3 Continued Development of Groundwater Sources Capital Costs.

Item	Units	Unit Cost	Total Cost
Shoreview Groundwater WTP	1	$10,000,000 ea	$10,000,000
Lino Lakes Groundwater WTP	1	$20,000,000 ea	$20,000,000
New Wells and Wellhouses	9	$1,000,000 ea	$9,000,000
WTP Rehabilitation Projects	5	$2,000,000 ea	$10,000,000
Wellhouse Rehabilitation Projects	53	$100,000 ea	$5,300,000
Well Rehabilitation Projects	159	$40,000 ea	$6,360,000
		Subtotal	**$60,660,000**
		Contingency (30%)	$18,198,000
		Eng/Admin/Legal (20%)	$12,132,000
		Total Approach 3	**$90,990,000**

The costs in Table 5-1 represent projects for the entire northeast metro and should not be compared to alternatives that are a smaller subset of the northeast metro.

5.2 Life Cycle Costs

The monetary costs to continue relying on groundwater are identified by the existing water rates charged by the northeast metro communities. The existing water rates are presented in Section 1.6 and Appendix A. The existing water rates include repair and replacements costs.

Even though significant water treatment plant projects are planned in Shoreview and Lino Lakes; these costs are anticipated and worked into the water rates long before the capital projects are undertaken.

The cost of water for the northeast communities ranges from $1.34/1,000 gallons in White Bear Lake to $3.69/1,000 gallons in North St. Paul. Table 1-5 presented previously provides the water rates. These costs include base costs and cost of water and can vary by the amount of water used. The cost of water for SPRWS customers is approximately $3.70/1,000 gallons for treated surface water (includes quarterly base rate).

5.3 Aquifer Impacts with Continued Development of Groundwater Sources

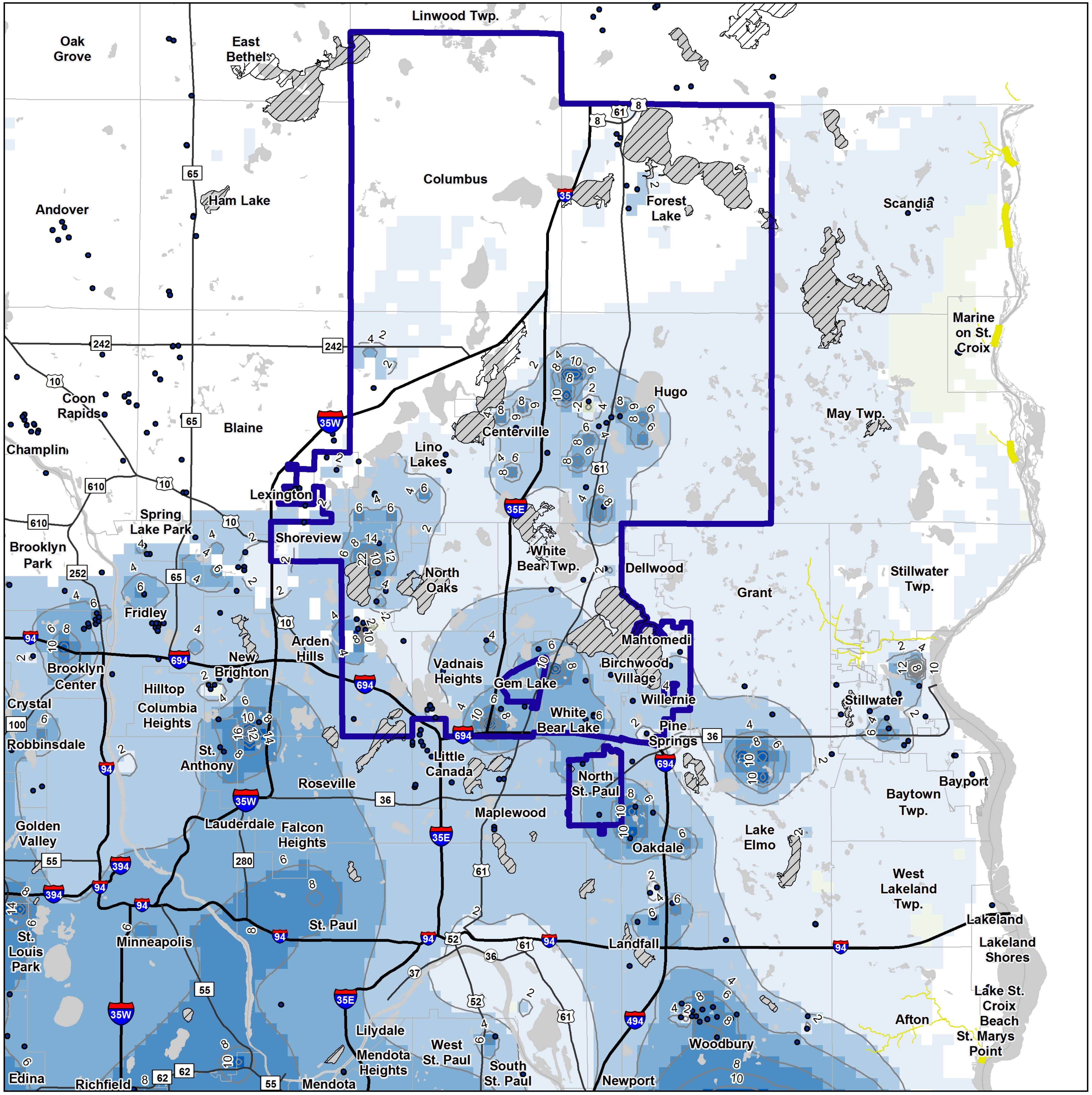
Figure 5-1 shows the predicted drawdown in the Prairie du Chien-Jordan aquifer if all the northeast metro communities continue to rely on groundwater. This represents predicted drawdown from current conditions to 2040 predicted conditions. In comparison, Figures 3-3, 3-5, and 3-7 show the predicted recovery in aquifer levels if groundwater pumping was eliminated in select or all northeast metro communities.

As Figure 5-1 demonstrates, if groundwater continues to be developed, the aquifer levels are predicted to decrease more than an additional 10 feet in areas of Shoreview, Vadnais Heights, White Bear Lake, and Hugo. If groundwater pumping were eliminated in selected northeast metro communities as shown on Figure 3-5, significant aquifer recovery (greater than 10 feet) is predicted in all of the selected northeast metro communities (Alternatives 1B, 2B, 2D) . If groundwater pumping were eliminated in all of the northeast metro communities, significant additional aquifer recovery (greater than 10 feet) is also predicted in Hugo (Figure 3-6). Little or no aquifer drawdown or recovery is predicted in Lino Lakes, Lexington, or Circle Pines. Columbus and Forest Lake are not using the Prairie du Chien-Jordan aquifer and therefore will not influence conditions depicted on the drawdown maps.

Figure 5-1 also identifies several vulnerable surface water features in the northeast metro area including White Bear Lake, Turtle Lake, Pleasant Lake, Otter Lake, Centerville Lake, Peltier Lake, Forest Lake, and Clear Lake. Concerns about water levels have already been expressed for White Bear Lake and Turtle Lake. If the vulnerable surface water features are hydraulically connected to the Prairie du Chien-Jordan aquifer and aquifer levels decline, the lake levels are also likely to decline.

Figure 5-1: 2040 Drawdown - Prairie du Chien - Jordan Approach 3

All Communities in Study Area Continue to Develop Groundwater Supplies

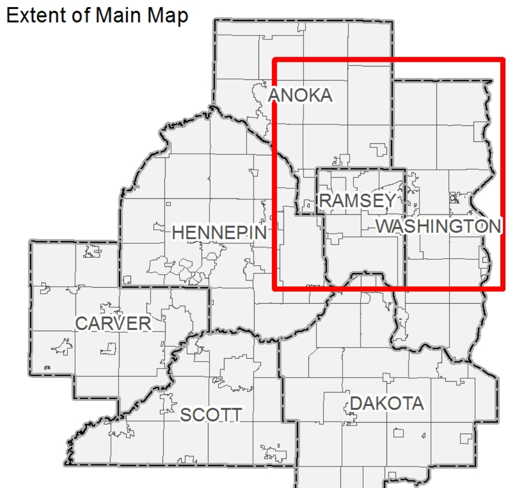


- CWI Public Community Wells
- Calcareous Fens
- Trout Streams
- Vulnerable Surface Water Features
- NE Study Area
- City and Township Boundaries
- Lakes and Rivers
- Drawdown Contours

Drawdown (ft)	Recovery (ft)
No Data	40 - 60
0 - 2	20 - 40
2 - 4	10 - 20
4 - 6	6 - 10
6 - 10	4 - 6
10 - 20	2 - 4
20 - 40	0 - 2
40 - 60	No Data

3 1.5 0 3
Miles

Extent of Main Map



METROPOLITAN COUNCIL

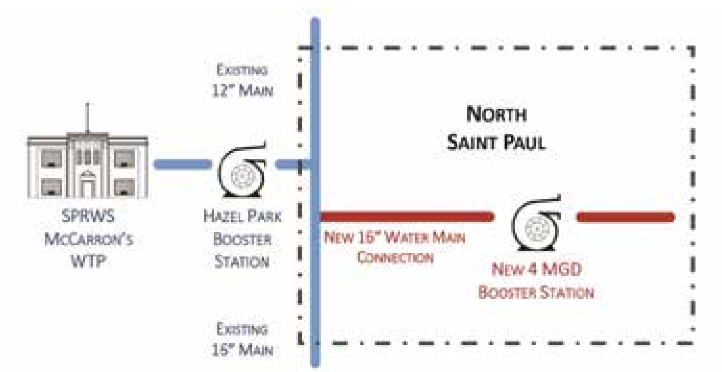
Source(s): Groundwater drawdown / recovery from Metro Model 3;
Vulnerable surface water features from "Evaluation of Groundwater and Surface-Water Interaction: Guidance for Resource Assessment", Metropolitan Council, 2010

Chapter 6 – Evaluation of Alternatives

The Council analyzed the alternatives and estimated the capital, operational, and maintenance costs of each. In addition, a qualitative evaluation of other advantages and disadvantages was completed for each alternative, including water source reliability, potential to impact lake levels, implementation obstacles, and water rate impacts. The results are summarized in Figures 6-1 through 6-7. The monetary evaluation presents total and unit costs for both capital and operations and maintenance costs.

Figure 6-1. Approach 1 – Alternative 1A – Saint Paul Service Expanded to North Saint Paul

Approach 1 - Alternative 1A – Saint Paul Service Expanded to North Saint Paul



Description

Alternative 1A would provide service from Saint Paul Regional Water Services to North Saint Paul by extending water main from the Saint Paul Regional Water Services Hazel Park pressure zone in Maplewood and building a booster station.

People Served by System in 2040: 15,400

Total Reduction in Groundwater Pumping: 548 million gallons per year (7% of total water use in study area)

Cost Summary Table

Capital Cost[1]	$5,108,000
Capital Cost per Million Gallons of Capacity	$9,300
Annual Operations and Maintenance Cost	$1,380,000
Operations and Maintenance Cost per Million Gallons of Capacity	$2,500

[1]Based on April 2014, no escalation to date of construction

Evaluation of Alternative

Advantages

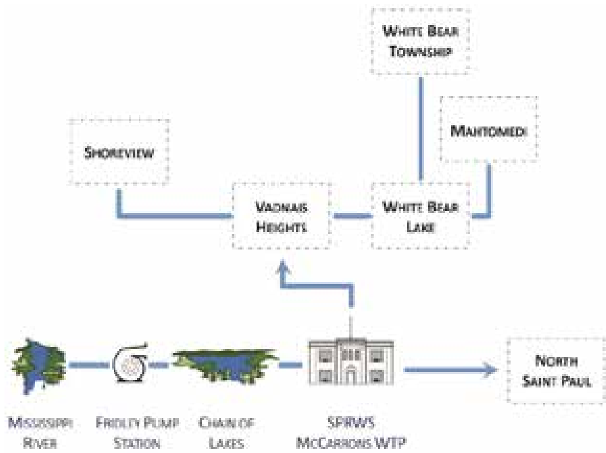
- Low capital cost
- Ease of implementation

Disadvantages

- Very small expected benefit to aquifer levels or lake levels as a stand-alone option
- Study area communities could have less control over operation of water supply and treatment system

Figure 6-2. Approach 1 – Alternative 1B – Saint Paul Service Expanded to Select Northeast Metro Communities

Approach 1 - Alternative 1B – Saint Paul Service Expanded to Select Northeast Metro Communities



Description
Alternative 1B would provide service from Saint Paul Regional Water Services to Mahtomedi, North Saint Paul, Shoreview, Vadnais Heights, White Bear Lake, and White Bear Township by extending water main and building booster stations. Alternative 1B requires major trunk water main, but does not add capacity to the Saint Paul Regional Water Services McCarrons water treatment plant (WTP) or raw water pumping or conveyance.

People Served by System in 2040: 105,876

Total Reduction in Groundwater Pumping: 4,564 million gallons per year (57% of total water use in study area)

Cost Summary Table

Capital Cost[1]	$155,440,000
Capital Cost per Million Gallons of Capacity	$34,000
Annual Operations and Maintenance Cost	$10,757,000
Operations and Maintenance Cost per Million Gallons of Capacity	$2,400

[1]Based on April 2014, no escalation to date of construction

Evaluation of Alternative

Advantages

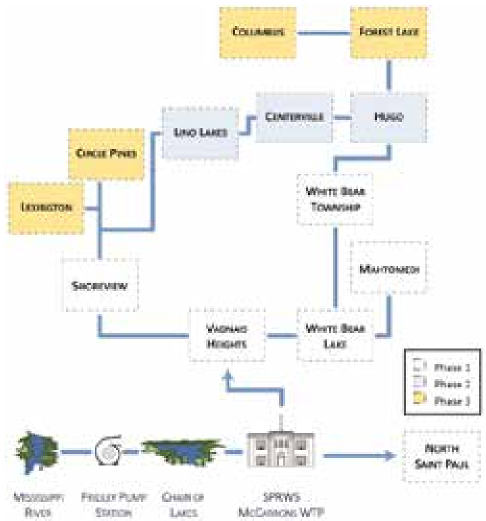
- Maximizes use of existing infrastructure, and does not require significant improvements in current SPRWS supply and treatment infrastructure
- Would increase water supply reliability by creating multiple sources for northeast metro communities
- Aquifer recovery expected
- Existing organizational structure to own and operate system

Disadvantages

- Uncertainty in response of lakes to changes in groundwater level
- Increase in operational costs for water supplies of northeast metro communities, and higher water rates for residents and businesses
- Large capital cost
- Study area communities could have less control over operation of water supply and treatment system

Figure 6-3. Approach 1 – Alternative 1C – Saint Paul Service Expanded to All Northeast Metro Communities

Approach 1 - Alternative 1C – Saint Paul Service Expanded to All Northeast Metro Communities



Description

Alternative 1C would provide service from Saint Paul Regional Water Services to all 13 of the northeast metro communities by extending water main and building booster stations. Alternative 1C requires major trunk water main and booster stations, expansion of Saint Paul Regional Water Services raw water pumping and conveyance systems, and expansion of the Saint Paul Regional Water Services McCarrons water treatment plant.

People Served by System in 2040: 191,050

Total Reduction in Groundwater Pumping: 8,264 million gallons per year (100% of total water use in study area)

Cost Summary Table

Capital Cost[1]	$623,442,000
Capital Cost per Million Gallons of Capacity	$78,000
Annual Operations and Maintenance Cost	$20,000,000
Operations and Maintenance Cost per Million Gallons of Capacity	$2,500

[1]Based on April 2014, no escalation to date of construction

Evaluation of Alternative

Advantages

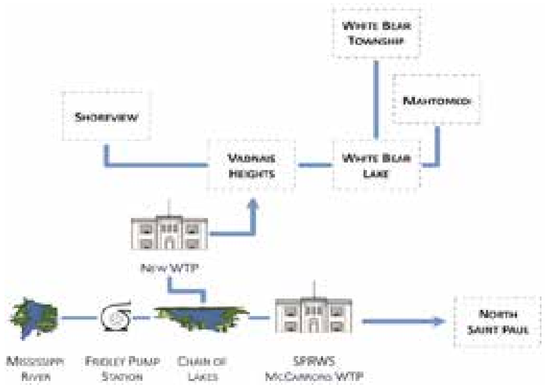
- Would increase water supply reliability by creating multiple sources for northeast metro communities
- Aquifer recovery expected
- Existing organizational structure to own and operate system

Disadvantages

- Large investment in expansion of existing supply and treatment infrastructure required
- Uncertainty in response of lakes to changes in groundwater level
- Increase in operational costs for water supplies of northeast metro communities, and higher water rates for residents and businesses
- Very large capital cost, and less benefit per dollar invested compared with Alternative 1B
- Study area communities could have less control over operation of water supply and treatment system

Figure 6-4. Approach 2 – Alternative 2B – New Surface Water Treatment Plant Service to Select Northeast Metro Communities

Approach 2 - Alternative 2B – New Surface Water Treatment Plant Service to Select Northeast Metro Communities



Description

Alternative 2B would provide water from a new surface water treatment plant to Mahtomedi, Shoreview, Vadnais Heights, White Bear Lake, and White Bear Township. North Saint Paul would be served by Saint Paul Regional Water Services. Alternative 2B requires major trunk water main and a new surface water treatment plant with capacity of 40 million gallons per day (MGD). Alternative 2B does not upgrade the Saint Paul Regional Water Services raw water pumping or conveyance systems.

People Served by System in 2040: 105,876

Total Reduction in Groundwater Pumping: 4,564 million gallons per year (57% of total water use in study area)

Cost Summary Table

Capital Cost[1]	$226,632,000
Capital Cost per Million Gallons of Capacity	$50,000
Annual Operations and Maintenance Cost	$9,137,000
Operations and Maintenance Cost per Million Gallons of Capacity	$2,000

[1]Based on April 2014, no escalation to date of construction

Evaluation of Alternative

Advantages

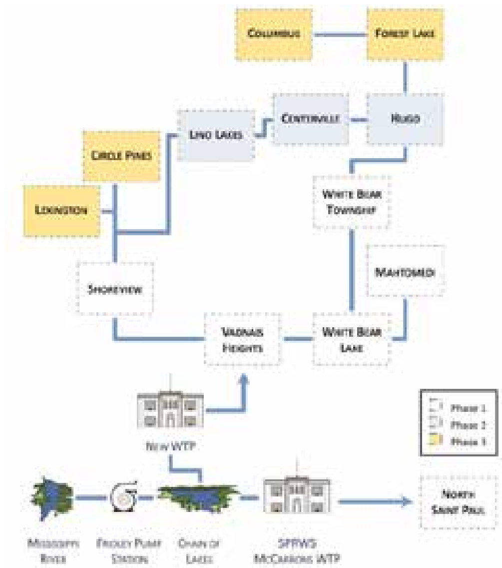
- Would increase water supply reliability by creating multiple sources for northeast metro communities
- Aquifer recovery expected
- Study area communities could retain greater control over operation of water supply and treatment system

Disadvantages

- Uncertainty in response of lakes to changes in groundwater level
- Increase in operational costs for water supplies of northeast metro communities, and higher water rates for residents and businesses
- Higher capital cost than equivalent option to provide service from Saint Paul system (Alternative 1B)
- There is not currently an organizational structure to own and operate the system

Figure 6-5. Approach 2 – Alternative 2C – New Surface Water Treatment Plant Service to All Northeast Metro Communities

Approach 2 - Alternative 2C – New Surface Water Treatment Plant Service to All Northeast Metro Communities



Description

Alternative 2C would provide water from a new surface water treatment plant to all 13 of the northeast metro communities. North Saint Paul would be served by Saint Paul Regional Water Services. Alternative 2C requires major trunk water main, booster stations, and a new surface water treatment plant with capacity of 60 MGD. Alternative 2C upgrades the Saint Paul Regional Water Services raw water pumping and conveyance systems.

People Served by System in 2040: 191,050

Total Reduction in Groundwater Pumping: 8,264 million gallons per year (100% of total water use in study area)

Cost Summary Table

Capital Cost[1]	$609,473,000
Capital Cost per Million Gallons of Capacity	$76,000
Annual Operations and Maintenance Cost	$15,909,000
Operations and Maintenance Cost per Million Gallons of Capacity	$2,000

[1]Based on April 2014, no escalation to date of construction

Evaluation of Alternative

Advantages

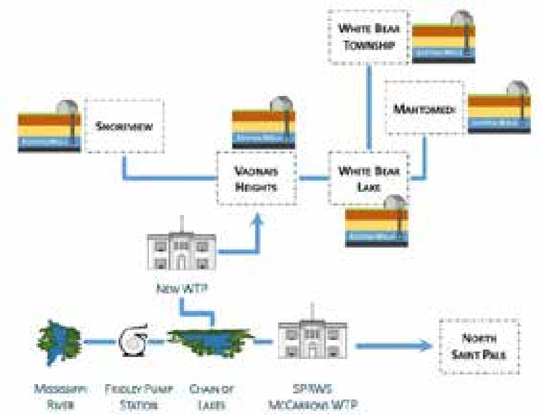
- Would increase water supply reliability by creating multiple sources for northeast metro communities
- Significant aquifer recovery expected
- Study area communities could retain greater control over operation of water supply and treatment system

Disadvantages

- Large investment in new infrastructure
- Very large capital cost, and less benefit per dollar invested compared with Alternative 2B
- Uncertainty in response of lakes to changes in groundwater level
- Increase in operational costs for water supplies of northeast metro communities, and higher water rates for residents and businesses
- There is not currently an organizational structure to own and operate the system

Figure 6-6. Approach 2 – Alternative 2D – Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities

Approach 2 - Alternative 2D – Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities



Description

Alternative 2D would provide water from a new surface water treatment plant to Mahtomedi, Shoreview, Vadnais Heights, White Bear Lake, and White Bear Township for average day use. Existing wells would be utilized to help meet peak demands. North Saint Paul would be served by Saint Paul Regional Water Services. Alternative 2D requires major trunk water main and a new surface water treatment plant with capacity of 15 MGD. Alternative 2D does not upgrade the Saint Paul Regional Water Services raw water pumping or conveyance systems.

People Served by System in 2040: 105,876

Total Reduction in Groundwater Pumping: 3,928 million gallons per year (49% of total water use in study area)

Cost Summary Table

Capital Cost[1]	$163,906,000
Capital Cost per Million Gallons of Capacity	$41,000
Annual Operations and Maintenance Cost	$7,539,000
Operations and Maintenance Cost per Million Gallons of Capacity	$1,900

[1]Based on April 2014, no escalation to date of construction

Evaluation of Alternative

Advantages

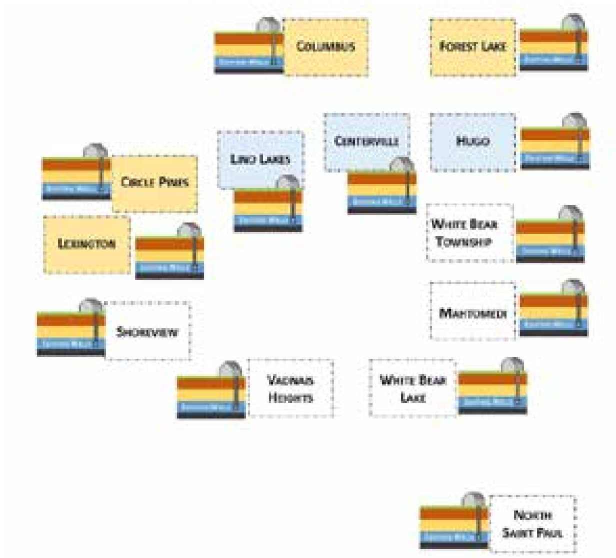
- Study area communities could use surface water or groundwater as needed, with greater management flexibility to respond to supply constraints
- Would increase water supply reliability by creating multiple sources for northeast metro communities
- Significant aquifer recovery expected, similar in magnitude to system that is designed to meet peak demands of study area communities
- Significantly lower cost than system that is designed to meet peak demands of study area communities
- Study area communities could retain greater control over operation of water supply and treatment system

Disadvantages

- Need to maintain two water supply systems
- Uncertainty in response of lakes to changes in groundwater level
- Increase in operational costs for water supplies of northeast metro communities, and higher water rates for residents and businesses
- Could likely be accomplished less expensively using existing supply and treatment infrastructure in the Saint Paul system
- There is not currently an organizational structure to own and operate the system

Figure 6-7. Approach 3 – Continued Development of Groundwater Sources

Approach 3 – Continued Development of Groundwater Sources



Description

Approach 3 characterizes a system with continued use of groundwater. Existing community water supply systems will be upgraded with in-kind replacement of aging infrastructure. When additional supply is needed, new wells would be drilled. Community comprehensive plans for new wells and future treatment plants serve as the basis for new infrastructure.

People Served by System in 2040: 191,050

Total Reduction in Groundwater Pumping: 0

Cost Summary Table

Capital Cost[1]	$90,990,000
Capital Cost per Million Gallons of Capacity	$11,400
Annual Operations and Maintenance Cost	No Additional
Operations and Maintenance Cost per Million Gallons of Capacity	No Additional Cost[2]

[1]Based on April 2014, no escalation to date of construction

[2]Current water rates assumed to be representative of future operational costs for each community

Evaluation of Alternative

Advantages

- Lowest capital cost of options considered
- Ease of implementation
- Study area communities retain control over operation of water supply and treatment systems

Disadvantages

- Potential for continued decline in aquifer and lake levels

Chapter 7 – Cost Sharing

7.1 Cost Sharing Models

Because the costs would be significantly higher to develop a surface water source for water supply to northeast metro communities than traditional groundwater sources, implementation is not likely to occur without incentive, and a mechanism to share the costs amongst a broad range of beneficiaries. The motivation for the reduction in groundwater use is regional in nature – to protect natural resources from the cumulative effects of groundwater use. A single community or a small subset of communities should not bear the cost of regional water sustainability needs. This analysis will consider cost sharing from two perspectives:

- A scenario where only the communities served by the hypothetical surface water system would pay for the system. This scenario will consider the cost impacts to those communities, and also the degree of outside funding that would be necessary to bring the costs to the individual communities in line with other water systems in the region.
- A scenario where the costs are shared amongst all of the communities in the DNR North and East Metro Groundwater Management Area (GWMA). In this case, the model for ownership and cost sharing will include the creation of a district that would own and operate the surface water delivery system, with fees paid by all communities within the Groundwater Management Area to promote equity amongst users of the groundwater resource.

There are many examples of similar cost sharing arrangements for water supply across the country. The Metropolitan Council has collected information on case studies as part of its ongoing study, "Regional Feasibility of Alternative Approaches to Water Sustainability." This study, being conducted by HDR Engineering on behalf of the Metropolitan Council, has reviewed three regional water system cost-sharing models. The cost sharing models included the San Jacinto River Authority, Conroe, Texas; West Harris County Regional Water Authority, Houston, Texas; and Woodland-Davis Clean Water Agency, Woodland and Davis, California. The cost-sharing models are summarized below.

San Jacinto River Authority, Conroe, Texas

The San Jacinto River Authority, Conroe, Texas (SJRA) watershed includes approximately 3,200 square miles of land north of the City of Houston. In 2001, the Lone Star Groundwater Conservation District (LSGCD) was created to help Montgomery County manage its dependence on the Gulf Coast Aquifer. The LSGCD studied the aquifer and confirmed that the water levels were declining at an unsustainable rate. The LSGCD calculated the amount of water that the aquifer could yield on a sustainable basis.

To address deficit pumping, the LSGCD required all large-volume groundwater users (LVGUs) to reduce groundwater pumping by 30 percent. In response to this directive, the SJRA created the Groundwater Reduction Plan Division (GRP) to implement a county-wide program to meet the requirements of the LSGCD.

Participation in the GRP was opened to all of the LVGUs that included approximately 200 cities, utilities, and other water users. Of these, 140 water systems joined the GRP. By joining the GRP, the participants are able to achieve cost savings by utilizing a "group compliance" concept in which some of the participants are converted to surface water while other participants continued to use groundwater, while meeting the overall groundwater reduction goal of 30 percent. Cost, proximity to surface water, and demands were used to determine which participants would be converted to surface water. Any LVGUs that did not join the GRP were still required to meet the 30 percent groundwater reduction goal.

The SJRA issued approximately $552 million in bonds between 2009 and 2013 to construct Phase 1 of the project, which included building a surface water treatment plant and transmission system.

One of the challenges in implementing the groundwater reduction plan was defining a rate system that balanced costs between participants, including those that would continue to rely solely on groundwater and those that would be converted to surface water. To balance revenue between the two groups, a groundwater pumpage fee and a surface water rate were calculated. The groundwater pumpage fee and surface water rate developed are $2.25 and $2.44 per 1,000 gallons, respectively.

West Harris County Regional Water Authority, Houston, Texas

In the early 1940s, studies of the Houston/Galveston area located in southeast Texas showed increasing problems due to groundwater extraction from the Chico and Evangeline aquifers causing land subsidence (sinking). In 1975, the Harris Galveston Subsidence District (HGSD) was created to address the impacts of groundwater pumping on land subsidence. In response to the regulatory plans of the HGSD, the West Harris County Regional Water Authority (Authority) was created to transition the area to surface water within a set timeframe.

There are currently 120 municipal water providers within the boundary of the Authority which is managed by a nine-member Board of Directors. The Authority's Groundwater Reduction Plan (GRP) requirements include a 30 percent reduction in groundwater use in 2010, a 60 percent reduction by 2025, and an 80 percent reduction by 2035.

The initial phase of the plan included negotiating a long-term contract with the City of Houston and the construction of numerous transmission projects to supply treated surface water to utility districts within the GRP.

Like SJRA, the Authority has developed a similar rate structure where all water users within the area will pay a share of the costs to build and maintain water delivery infrastructure and for the supply of surface water from the City of Houston system. As of 2014, the groundwater and surface water rates charged to the water providers are $1.90/1,000 gallons and $2.30/1,000 gallons, respectively.

Woodland-Davis Clean Water Agency, Woodland and Davis, California

In September 2009, the neighboring cities of Woodland and Davis, California created the Woodland-Davis Clean Water Agency (WDCWA), a joint powers authority to implement and oversee a regional surface water supply project. Both cities have been dealing with water supply and wastewater discharge issues related to degrading groundwater quality and concluded that a jointly-owned and operated surface water system was the best overall solution.

The Cities of Woodland and Davis have depended on groundwater for water supply since the 1950s. Over time, the quality of the groundwater has declined to the point where the water supply system will not be able to meet state and federal drinking water standards, and the wastewater will not meet anticipated discharge regulations.

The cities identified two possible solutions to address the water quality issues, including developing a higher quality water supply or installing a new wastewater treatment process. It was determined that building a new surface water treatment plant was the most cost effective solution. The system, which will be put into service in 2016, will provide treated surface water from the Sacramento River to the Cities through dedicated service lines. The total capital cost estimate for the project is $228 million. According to the joint powers agreement, the costs to cover the debt service and O&M costs will be divided between the cities based on demand.

7.2 Cost Sharing Examples

For the purposes of demonstrating a potential equitable cost sharing structure, Alternative 2B – New Surface WTP for Select Northeast Metro Communities will be used as an example. In Alternative 2B, the communities that switch to surface water are Mahtomedi, North St. Paul, Shoreview, Vadnais Heights, White Bear Lake, and White Bear Township. Because North St. Paul connects to SPRWS and not a new surface WTP as part of Alternative 2B, they will not be included in the example.

7.2a Existing Water Infrastructure

A new water utility would need to purchase the existing water supply and treatment facilities that would be decommissioned or used as emergency backup as a result of switching to surface water. This includes 26 wells and well houses in the five communities and water treatment plants in White Bear Lake and White Bear Township. Some wells would be maintained as an emergency backup, but would still be purchased by the proposed utility. For purposes of this cost sharing example, the wells will be valued at $800,000 each and the combined value of the treatment plants is $18 million (WBL - $10 million, WBT - $8 million). Some depreciation was assumed in the existing infrastructure values. The total value of the existing utility infrastructure to be decommissioned with a new surface WTP is estimated to be $38,000,000.

In addition to existing wells and treatment infrastructure, the communities have costs associated with their existing distribution and storage facilities. These costs include operation and maintenance, repair and replacement, and existing debt service. For the purposes of the cost sharing example, it is assumed that the existing storage and distribution O&M cost is $1.50/1,000 gallons of water. This assumes that approximately half of the existing rates are utilized for water supply and treatment and half are utilized for storage and distribution.

7.2b Cost Sharing Assumptions and Basis

The assumptions used for preparing the cost sharing examples are as follows:

- All costs in 2014 dollars
- Capital cost: $221,524,000 (new facilities) + $38,800,000 (existing utilities) = $260,324,000
- Capital costs amortized over 20 years, 4% interest
- Annual Operation and Maintenance Cost: $5,080,000
- Annual Repair and Replacement Cost: $2,340,000
- Cost of Raw Surface Water from SPRWS: $100/1,000,000 gallons
- Existing Operation and Maintenance: $1.50/1,000 gallons
- 2025 estimated water demands used to project average unit cost over next 25 years
- Selected communities use 3.5 billion gallons of water per year in 2025 (9.6 MGD average day)
- The North and East GWMA will use 31 billion gallons of groundwater in 2025 (after Alternative 2B communities convert to surface water). This estimate includes municipal, non-municipal, and private wells.
- The new facilities include a new 40 MGD surface WTP, 17 miles of trunk watermain and booster stations

7.2c Cost Sharing as Water Utility

In a typical water utility, the costs are shared among the member communities based on water usage. Table 7-1 identifies the costs for a potential water utility.

Table 7-1. Potential Water Utility Costs

Item	Annual Cost	Water Used (thousand gallons)	Cost/1,000 gallons[1]
Annualized Payment	$18,930,000	3,500,000	$5.41
Joint Utility O&M Costs	$5,080,000	3,500,000	$1.45
Repair and Replacement	$2,340,000	3,500,000	$0.67
Cost of Raw Water	$100/1,000,000 gal	3,500,000	$0.10
Cities Existing O&M	$1.50/1,000 gal	3,500,000	$1.50
		Total	**$9.13**

1- Cost per 1,000 gallons are an estimate for example purposes only and would vary based on cost and water used.

A cost of $9.13 per 1,000 gallons of water would be nearly three times what SPRWS retail customers currently pay at $3.20 per 1,000 gallons. To bring the costs for the Alternative 2B communities down to $3.20 per 1,000 gallons, the utility would need to be subsidized by $5.93 per 1,000 gallons (approximately $21 million per year). If the capital cost of the project ($265,543,000) were covered by another funding source, the estimated cost of water from the new utility would be close to SPRWS' rates.

7.2d Cost Sharing Across North and East GWMA

Instead of sharing costs as a utility, it would be reasonable to share costs across the North and East GWMA. Some communities would continue to use groundwater while other communities would be converted to surface water. The communities that would convert to surface water could be determined based on economic feasibility or effects of groundwater use on surface water features. Similar to the water utility cost sharing example, it will be assumed that the Alternative 2B communities will be converted to surface water. As demonstrated in Section 7.2c, if the Alternative 2B communities are charged the same rate as SPRWS customers, it requires that $21 million per year be covered by other funding. If the remaining groundwater users (all municipal, industrial, and private) in the North and East GWMA paid a ***groundwater usage fee*** **of $0.68 per 1,000** gallons, this would subsidize the 40 MGD regional surface water supply system, so that the five northeast communities have rates equal to other surface water supply communities.

7.2e Summary of Cost Sharing Examples

The cost sharing example evaluated the potential rates to transition five northeast metro communities from a groundwater to a surface water supply system. These communities have a 2040 projected annual average demand of 11 MGD with maximum day demand of 32 MGD. The groundwater modeling predicts the groundwater levels in the area to recover without this aquifer withdrawal, in some areas more than 20 ft.

The projected demand for 2025 was used in the cost sharing examples as an average demand over the planning period. If earlier demand projections are used, it will increase the unit cost. If later demands are used, it will decrease the unit cost.

Chapter 8 – Summary of Findings and Implementation Considerations

8.1 SPRWS Expansion (Approach 1)

The feasibility of connecting northeast metro communities to Saint Paul Regional Water Services (SPWRS) was evaluated. Key findings are as follows:

- The SPRWS raw water main and pumping are essentially at capacity with existing SPRWS maximum day demands (approximately 80 MGD); however, significant storage exists in the chain of lakes (3.5 BG) to provide additional water to the northeast metro.
- The SPRWS McCarrons Water Treatment Plant currently has approximately 30 MGD of excess capacity.
- The six communities nearest to the SPRWS system (Shoreview, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and North Saint Paul) could be served by SPRWS without expanding its major water treatment facility or improving its raw water delivery system to the plant. To expand service beyond these six communities, additional large-scale infrastructure improvements would be needed. This would significantly increase the capital costs of the system.
- The SPRWS Hazel Park pressure zone which is adjacent to North Saint Paul and White Bear Lake has limited capacity to provide water to the northeast metro. Only North Saint Paul can be served from the Hazel Park pressure zone without large-scale infrastructure improvements.
- A new trunk water main that connects to the SPRWS McCarrons Water Treatment Plant is necessary to bring water to the majority of the northeast metro.

A cost summary to connect the northeast metro to SPRWS is included in Table 8-1.

Table 8-1. Approach 1 - Costs Connect Northeast Metro Communities to SPRWS.

	Annual Groundwater Offset (Millions of Gallons)	Capital Cost[1,2]	Annual Operations & Maintenance Cost for Water Service
Alternative 1A – Saint Paul Connection to North Saint Paul	**548**	**$5,108,000**	**$1,380,000**
Alternative 1B – Saint Paul Connection to Select NE Metro Communities *(Mahtomedi, North Saint Paul, Shoreview, Vadnais Heights, White Bear Lake, White Bear Township)*	**4,564**	**$155,440,000**	**$10,757,000**
Alternative 1C – Saint Paul Connection to All NE Metro Communities			
Phase 1		*$246,633,000*	
Phase 2		*$329,529,000*	
Phase 3		*$47,280,000*	
Total Alternative 1C	**8,264**	**$623,442,000**	**$20,000,000**

1 Based on April 2014; no escalation to date of construction.

2 Capital cost estimates for Approach 1 include distribution facilities. Alternative 1C also includes improvements to the McCarrons WTP and the raw water delivery system from the Mississippi River.

As Table 8-1 indicates, Alternative 1A, which would bring water from SPRWS to North Saint Paul, has the lowest cost of the alternatives considered. This is due to North Saint Paul's proximity to SPRWS and relatively little infrastructure being necessary to implement the alternative.

Alternative 1B and Alternative 1C – Phase 1 connect the same select northeast metro communities to SPRWS, with the difference being that Alternative 1C infrastructure is sized to ultimately connect all northeast metro communities. The cost difference is primarily due to larger pipes in Alternative 1C requiring different construction methods (directional drilling versus open cut in roads).

The large jump in cost for a relatively small increase in system capacity between Alternative 1C – Phase 1 and Phase 2 is due in part to capacity improvements needed to the SPRWS raw water conveyance system and an expansion of capacity at the McCarrons WTP. The analysis assumes SPRWS will pass on the annualized capital costs similar to the costs for water infrastructure owned by others.

8.2 New Surface Water Treatment Plant (Approach 2)

The feasibility of constructing a new Water Treatment Plant (WTP) with a surface water source was evaluated. Key findings are as follows:

- SPRWS owns land on Vadnais Lake, the final lake in the SPRWS chain of lakes, which could serve as a location for a new WTP.
- The water quality in Vadnais Lake is better than the Mississippi River due to chemical treatment, oxygen being added, and settling of solids. Preliminary screening of potential WTP sites based on water quality and location resulted in the identification of Vadnais Lake as the preferred site for a new WTP at this concept level.

A cost summary to connect the northeast metro communities to a new WTP is included in Table 8-2.

Table 8-2. Approach 2 - Costs to Connect Northeast Metro to New Surface WTP

	Annual Groundwater Offset (Millions of Gallons)	Capital Cost[1]	Annual Operations & Maintenance Cost for Water Service
Alternative 2B – New Surface WTP for Select NE Metro Communities *(Mahtomedi, North Saint Paul, Shoreview, Vadnais Heights, White Bear Lake, White Bear Township)*	**4,564**	**$226,632,000**	**$9,137,000**
Alternative 2C – New Surface WTP for All NE Metro Communities			
Phase 1		*$291,105,000*	**$9,552,000**
Phase 2		*$273,374,000*	**$4,383,000**
Phase 3		*$44,994,000*	**$2,292,000**
Total Alternative 2C	**8,264**	**$609,473,000**	**$16,227,000**
Alternative 2D – Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities *(Mahtomedi, North Saint Paul, Shoreview, Vadnais Heights, White Bear Lake, White Bear Township)*	**3,928**	**$163,906,000**	**$7,539,000**

[1] Based on April 2014; no escalation to date of construction.

Alternative 2B and Alternative 2C – Phase 1 connect the same select northeast metro communities to a new surface WTP, with the difference being that Alternative 2C infrastructure is sized to ultimately connect all northeast metro communities. The cost difference is primarily due to larger pipes in Alternative 2C requiring different construction methods (directional drilling versus open cut in roads).

The large jump in cost for a relatively small increase in system capacity between Alternative 2C – Phase 1 and Phase 2 is due in part to capacity improvements needed to the SPRWS raw water conveyance system.

Alternative 2D connects the same northeast metro communities to a new WTP as Alternatives 2B and 2C – Phase 1, with the difference being that the WTP is only sized to meet average day demands. The Alternative 2D communities would utilize existing wells to serve demand that exceeds average day demands.

8.3 Continued Development of Groundwater Sources (Approach 3)

The costs and impacts of continuing to use groundwater were evaluated. Key findings are as follows:

- Although much less costly than other alternatives, the continued use of groundwater still has significant capital costs (greater than $90 million).
- If the region continues to rely solely on groundwater, the projected annual groundwater withdrawal for the northeast metro in 2040 is 8,264 million gallons.
- The Prairie du Chien-Jordan aquifer levels will continue to go down if groundwater pumping is continued.

8.4 Implementation Timeframes

The projects included in Approaches 1-2 are significant and would involve lengthy planning, design, and construction timeframes. Potential implementation timeframes for each approach are provided in Table 8-3. The timeframes presented assume that a specific project has been selected and approved by participating municipalities and regulatory agencies, the public involvement and environmental review process has been completed, and all required legislation, community agreements, and funding is in place.

Table 8-3 Implementation Timeframes

	Planning	Design/Permitting	Construction	Total
Approach 1 – SPRWS Expansion				
Alternative 1A	1 year	1 year	1 year	3 years
Alternative 1B	1 year	1 year	3-4 years	5-6 years
Alternative 1C				
Phase 1	1 year	1 year	3-4 years	5-6 years
Phase 2	1 year	2 years	3-4 years	6-7 years
Phase 3	1 year	1 year	2 years	4 years
Approach 2 – New Surface WTP				
Alternative 2B	1 year	1 year	3-4 years	5-6 years
Alternative 2C				
Phase 1	1 year	1 year	3-4 years	5-6 years
Phase 2	1 year	2 years	3-4 years	6-7 years
Phase 3	1 year	1 year	2 years	4 years
Alternative 2D - Conjunctive Use	1 year	2 years	3 years	6 years

Significant projects can trigger mandatory Environmental Impact Statements (EIS) that can take a year or more to complete. The potential projects in Approaches 1 and 2 do not appear to trigger a mandatory EIS; however, some form of environmental review would be required.

8.5 Potential Funding Sources

Potential funding sources for the approaches discussed in this report include user rates, State bond money, Drinking Water Revolving Fund (DWRF), or new sources of revenue. These options are discussed below.

User Rates

User rates are the costs paid by the residents for their water. User rates are how most municipalities and water utilities fund projects. As demonstrated in Chapter 7, it would not be equitable to the northeast metro communities to fund the projects identified in this report strictly by user rates.

State Bond Money

State bonds are general obligation bonds issued by the State of Minnesota. Projects that benefit more than one community and are environmentally responsible have received State bond money in the past. It is likely that State bond money would be needed to make one of the approaches identified in this report feasible.

Drinking Water Revolving Fund (DWRF)

The DWRF is a federally funded program used to provide below market-rate loans to municipalities. The DWRF is administered by the Minnesota Public Facilities Authority. The loan rate is based on the financial capability of the municipality. Priority for DWRF loans is based on elements of the project. The criteria for project selection have changed over the years to provide assistance to higher priority needs. The weighting of water sustainability criteria could be modified to provide more incentive for projects that reduce groundwater use. It is important to note that DWRF provides loans that need to be paid back (not grants).

New Sources of Revenue

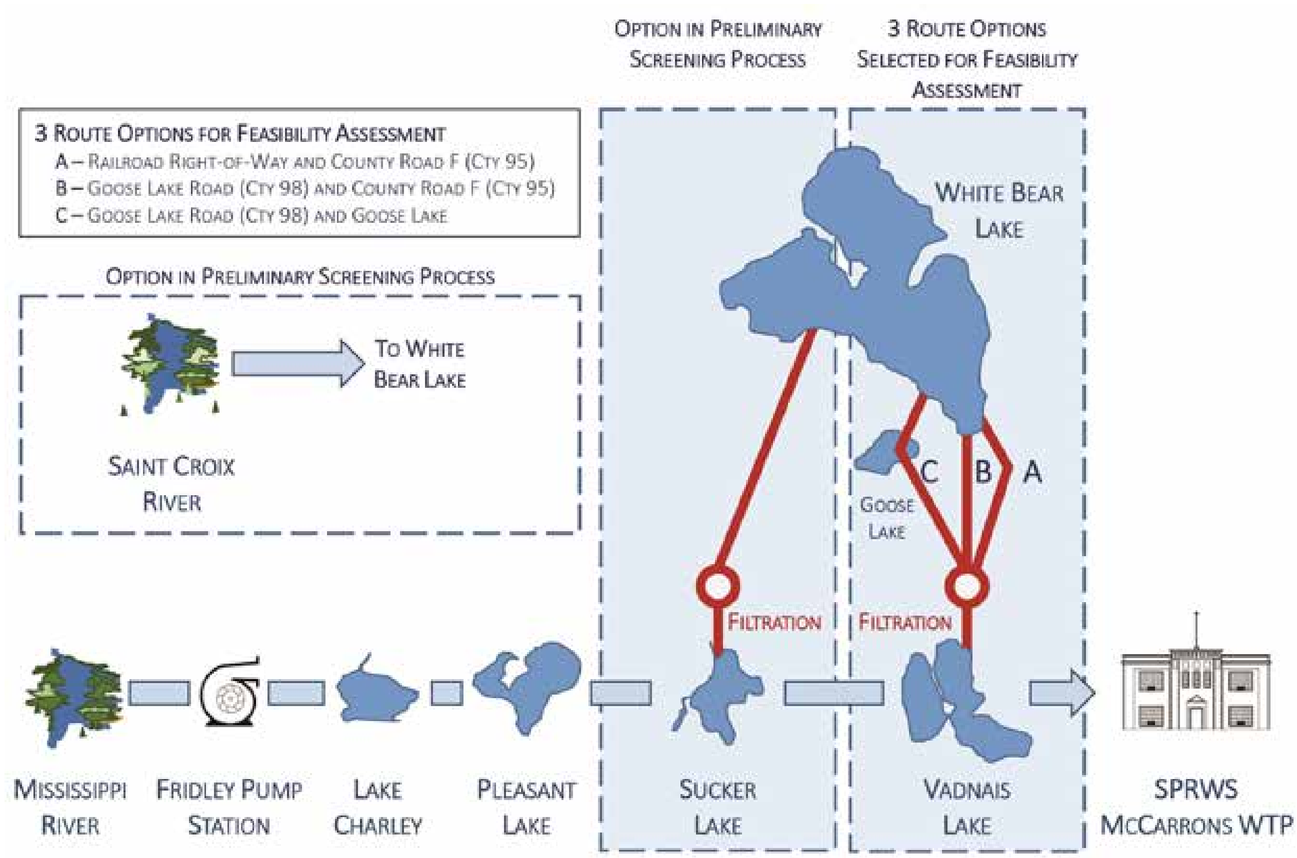
A new source of revenue could include a groundwater usage fee and be spread across an entire area or region benefitting from the resource (i.e. Prairie du Chien – Jordan aquifer). This could be the North and East GWMA or possibly even the entire Metro area. Another source would be specially appropriated grant programs focused on groundwater withdrawal reduction.

Chapter 9 - Direct Augmentation of White Bear Lake

9.1 Lake Augmentation

This Chapter examines the feasibility of augmentation of White Bear Lake with river water. The screening process for direct augmentation of White Bear Lake involved selection of the river water source and then options were considered for the preferred conveyance route. The Mississippi River and St. Croix were evaluated as source waters with preliminary conveyance routes. Screening criteria identified the Mississippi River with withdrawal from Vadnais Lake as the optimum source for river water. Options were evaluated for different conveyance routes from Vadnais Lake to White Bear Lake as depicted in Figure 9-1.

Figure 9-1. Lake Augmentation Concept System Options.



9.2 Development of Concept System

Concept Description

Two raw water sources have been considered for augmentation of water into White Bear Lake: the St. Croix River and the Mississippi River. The following sections of this chapter and Appendices G-L, outline study area characteristics, environmental considerations, water quality considerations, flow projections, alignment characteristics and infrastructure, as well as cost estimates for multiple potential project routes.

Planning Approach

The design of an augmentation system for White Bear Lake took many factors into account. Design was performed with the goals of increasing lake levels, handling maximum flow criteria, attaining maximum efficiency, utilizing gravity flow when possible, and keeping costs at a minimum.

The concept system was developed in two phases, as depicted in Figure 9-1. The preliminary analysis included assessing three options: 1. Augmentation of White Bear Lake using Mississippi River water via Sucker Lake, 2. Augmentation of White Bear Lake using Mississippi River water via Vadnais Lake and

3. Augmentation of White Bear Lake using St. Croix River water. These options were screened to advance the most feasible options for further development.

Pumping water from the St. Croix River would require construction of 60,000 linear feet of forcemain, with a total head of 324 feet to overcome. As a result, it was determined that the expense of installing such a length of forcemain, as well as purchasing and operating multiple pumps, makes this option less cost effective as well as requires an increased construction duration. In addition, the St. Croix River is a protected waterway and construction of a pump station on its shore would require extensive permitting.

Alignments that considered pumping Mississippi River water (Sucker Lake to White Bear Lake and Vadnais Lake to White Bear Lake) were more comparable in cost and feasibility. Vadnais Lake has a higher quality water due to its location at the end of a chain of lakes, as well as an existing lake oxygenation system. Preliminary routing estimates identified the Vadnais Lake option as more cost-effective than the Sucker Lake option. With water quality considerations, Vadnais Lake was moved forward as the most feasible option.

Three alignment alternatives have been developed that connect Vadnais Lake to White Bear Lake with a 30-inch High Density Polyethylene (HDPE) forcemain. Each alignment includes a lake intake and filtration structure, 30" HDPE forcemain, as well as an outlet structure for discharge of water into White Bear Lake. These alignments are described in more detail below.

9.3 Study Area Characteristics

White Bear Lake

White Bear Lake (WBL) is located in Washington County, Minnesota. WBL has an area of 2127 acres with a maximum depth of 83 feet. WBL has a record high water level of 926.7 feet as measured in 1943. The record low water level is 918 feet as measured in 2013. The ordinary high water level and outlet elevation is 924 feet. White Bear Lake is used heavily for recreation by a variety of user groups. Further detail regarding study area characteristics are included in Appendix G.

White Bear Lake is part of a chain of lakes that were created by glacial scouring of bedrock and subsequent melting. Groundwater in the water table aquifer flows toward White Bear Lake on all sides except from the northwest corner of the lake, where the flow path is routed northwest. Groundwater within the Prairie du Chien-Jordan aquifer lies at a regional elevation high northeast of White Bear Lake, centered approximately at School Section Lake. Groundwater flows outward from this point, flowing southwest past White Bear Lake. Groundwater within the Franconia Ironton Galesville and Mount Simon-Hinckley aquifers follows similar paths to that in the Prairie du Chien-Jordan aquifer.

9.4 Environmental Considerations

A search of the Minnesota Pollution Control Agency (MPCA) "What's In My Neighborhood" (WIMN) database was conducted to identify potential environmental concerns related to White Bear Lake augmentation pipeline route alternatives. Environmental database listings indicate environmental conditions which may negatively impact the construction of augmentation pipeline for portions of several route alternatives.

The MPCA database was searched with a ¼ mile radius from each of the augmentation routes. The descriptions for the environmental conditions, as well as the frequency of occurrence, are summarized in Appendix H.

In addition, an environmental consideration that needs to be accounted for is the presence of invasive species in the Mississippi River water. Zebra mussels of various stages of life grow and reproduce in the Mississippi River, which is considered as a raw water source for augmentation of White Bear Lake. These zebra mussels can cause damage to facilities and infrastructure. It reduces the amount of intake head and incapacitates the system. Zebra mussels will colonize on hard surfaces and are costly to eradicate once populations have been established. The Minnesota DNR restricts the transfer of infested waters from water body to water body unless treatment is provided.

9.5 Water Quality Considerations

White Bear Lake is a moderately clear lake in which nutrient levels (nitrogen and phosphorus) are low. The only indication of anthropogenic influences on WBL is a steady increase in chloride concentrations. SPRWS pumps Mississippi River water to their chain of lakes. The chain of lakes acts as a clarification process for the intake at SPRWS. The turbidity and solids concentrations in the Mississippi River are significantly higher than those in White Bear Lake. Ammonia and Phosphorus levels in the Mississippi River or chain of lakes are not significantly elevated compared to White Bear Lake, and nitrite/nitrate concentrations are slightly elevated in the chain of lakes as compared to White Bear Lake.

If no filtration occurs prior to augmentation, White Bear Lake would likely experience an increase in turbidity and total suspended solids (TSS) concentrations. While the nutrient concentrations in the augmentation water are not elevated to a point of concern, the potential for an increased rate of eutrophication of White Bear Lake is possible. Water quality data for White Bear Lake indicate that the lake is a phosphorus limited system, as is common in Minnesota Lakes. Small additions of the nutrient may cause increases in plant and algae growth, phosphorus should therefore be the focus of management efforts. The effects of the additional nutrient load from augmentation have been simulated with the Wisconsin Lake Modeling Suite (WiLMS) program. The results of the WiLMS, and other water quality details are included in Appendix I. The results indicate that the augmentation water should not have a significant impact on WBL water quality, but should be closely monitored. Based on the screening analysis performed using WiLMS, treatment of the augmentation water will not be necessary. It is likely that phosphorus will be further reduced in the augmentation water during filtration. Future regulations could necessitate additional nutrient removal.

9.6 Permitting Requirements

Multiple permits need to be considered for augmentation. They are as follows:

- DNR Invasive Species Permit
- Army Corps 404 for structures
- Wetland Conservation Act
- Public Water Work Permit (DNR)
- Saint Paul Regional Water Reservoir Permit
- MNDOT and County permits for any roadway crossings
- Vadnais Lake Area Water Management Organization (VLAWMO)
- Rice Creek Watershed District (RCWD)
- NPDES and SWPPP
- MCES Crossings permit

Significant projects can trigger mandatory Environmental Impact Statements (EIS) that can take a year or more to complete. Augmentation of White Bear Lake does not appear to trigger a mandatory EIS; however, some form of environmental review would be required.

In addition, there is a possibility that wetlands may need to be mitigated as part of construction. Utilities are exempt from this mitigation under the Wetlands Conservation Act, however a permit is still required.

9.7 Augmentation Pumping Rate

The augmentation pumping rate was selected based upon practical limitations. As discussed in Chapter 3, SPRWS raw water conduits and Fridley Pumping Station have limited capacity (80 million gallons per day [MGD]). In addition, SPRWS only has approximately 7 billion gallons per year (BGY) of excess appropriation from the Mississippi River.

The augmentation flow rate selected is 2 BGY pumped over 8 months (approximately 6,000 gallons per minute [gpm] or 8.6 MGD). Augmentation is not anticipated to occur over the winter months due to ice plugging the filters.

If there were no losses (i.e. evaporation, groundwater exchange), a volume of 2 billion gallons would likely raise the level of White Bear Lake by approximately 2.5 feet.

If augmentation were able to raise water levels to the normal high water level (924 feet amsl), maintenance pumping would need to be performed. The rate of maintenance pumping will depend on multiple factors such as inputs and outlets to and from WBL, and will take place over a long-term duration. It is not known if augmenting White Bear Lake by 2 billion gallons per year would cause lake levels to reach 924'.

9.8 White Bear Lake Water Budget

A water budget model of White Bear Lake was created with Microsoft Excel in order to aid in selecting an augmentation flow rate and gauge its potential effects on lake levels. The development of the model's methods were pulled heavily from two previously published works, the DNR's "Lake-Ground Water Interaction Study at White Bear Lake, Minnesota" report published in 1998, and the USGS's "Groundwater and Surface-Water Interactions Near White Bear Lake, Minnesota, through 2011" report published in 2013. The model was created based on a water balance equation provided in the DNR 1998 report on historical augmentation of White Bear Lake:

DL = P + RO – SO – E + GWex + PA

DL = change in water level
P = direct precipitation
RO = runoff volume from drainage area
SO = volume of outflow surface outlet
E = evaporation
GWex = groundwater exchange
PA = volume of pumped augmentation

The model generated expected water levels on a monthly basis given over a three year period, starting at the 2012 and 2013 average lake level elevation of 920 feet above mean sea level (amsl) and assuming variable values based on past trends. The above equation was also assessed using the ten year averages of each of the parameters. A description of each variable's estimation, as well as more detailed information on the water budget is provided in Appendix J.

Results of the model should be interpreted with caution and not used for any purpose other than developing a starting point for assessing the effects of lake augmentation. Table 9-1 summarizes the time required to bring current lake levels up to 924 feet amsl given the varying groundwater exchange scenarios. Assuming augmentation with surface water would result in the same groundwater exchange parameter as augmentation using groundwater in the 1930s did, augmenting by 2 BGY, it would take approximately 4.5 years to restore White Bear Lake water levels. If the groundwater exchange parameter is unaffected by surface water augmentation, the same pumping scenario could result in restored lake levels as quickly as 1.9 years.

Table 9-1. White Bear Lake Augmentation Water Budget.

Groundwater Exchange (inches/year)	11	18.5	33
Time to fill with no augmentation (years)	>10 years	continued decrease	continued decrease
Time to fill with 2BG/yr (years)	1.7	1.9	4.5

It should be noted that White Bear Lake was augmented with approximately 2 billion gallons per year of groundwater in the 1930's and the water level never reached an elevation of 923 feet amsl (below current outlet level). There was potential short circuiting due to a connection with the aquifer; however current groundwater pumping rates by cities adjacent to White Bear Lake equal approximately 2 billion gallons per year. It is possible that augmenting White Bear Lake with 2 billion gallons per year of water would cause water levels to rise and reach an equilibrium below the current overflow elevation of 924 feet amsl.

9.9 Concept 1 – Mississippi River Water via Vadnais Lake

Description

Raw water would be pumped from the southeastern shore of Vadnais Lake to augment White Bear Lake. A filtration system would be installed on the shoreline of Vadnais Lake and filtered water would flow through a 30-inch HDPE pipe to an outlet structure located in White Bear Lake. The filtration system will prevent the transfer of zebra mussels from the infested waters of Vadnais Lake and improve the water quality by reduction of solids and nutrients.

System Components

Augmentation of White Bear Lake from Vadnais Lake will require both an intake structure with a filtration facility located in Vadnais Lake and an outlet structure located on the bottom of White Bear Lake (Figure 9-2). The intake and outlet structures would be the same for all of the proposed routes. The intake and outlet structures are described below.

Intake

The intake structure would be constructed approximately 20 feet deep in Vadnais Lake with a filtration housing structure located on-shore. The facility would include the intake structure with intake portals, 30” HDPE intake pipe with concrete armor mat to minimize bottom disturbance, a well pump, primary filters, secondary filters, a magnetic flow meter, an overhead service crane, and a filter house. The intake structure is shown in Appendix K.

Outlet

The outlet structure would be constructed on the bottom of WBL in approximately 15 feet of water. Water will exit the structure at a velocity that ensures complete mixing and protects both fish and plant life. Components of the outlet structure include 6” diameter ports spaced 6 feet apart. There will be three ports on each side of the structure. The structure will be made of 30” capped HDPE with concrete armor mat. Appendix K shows the layout of the structure.

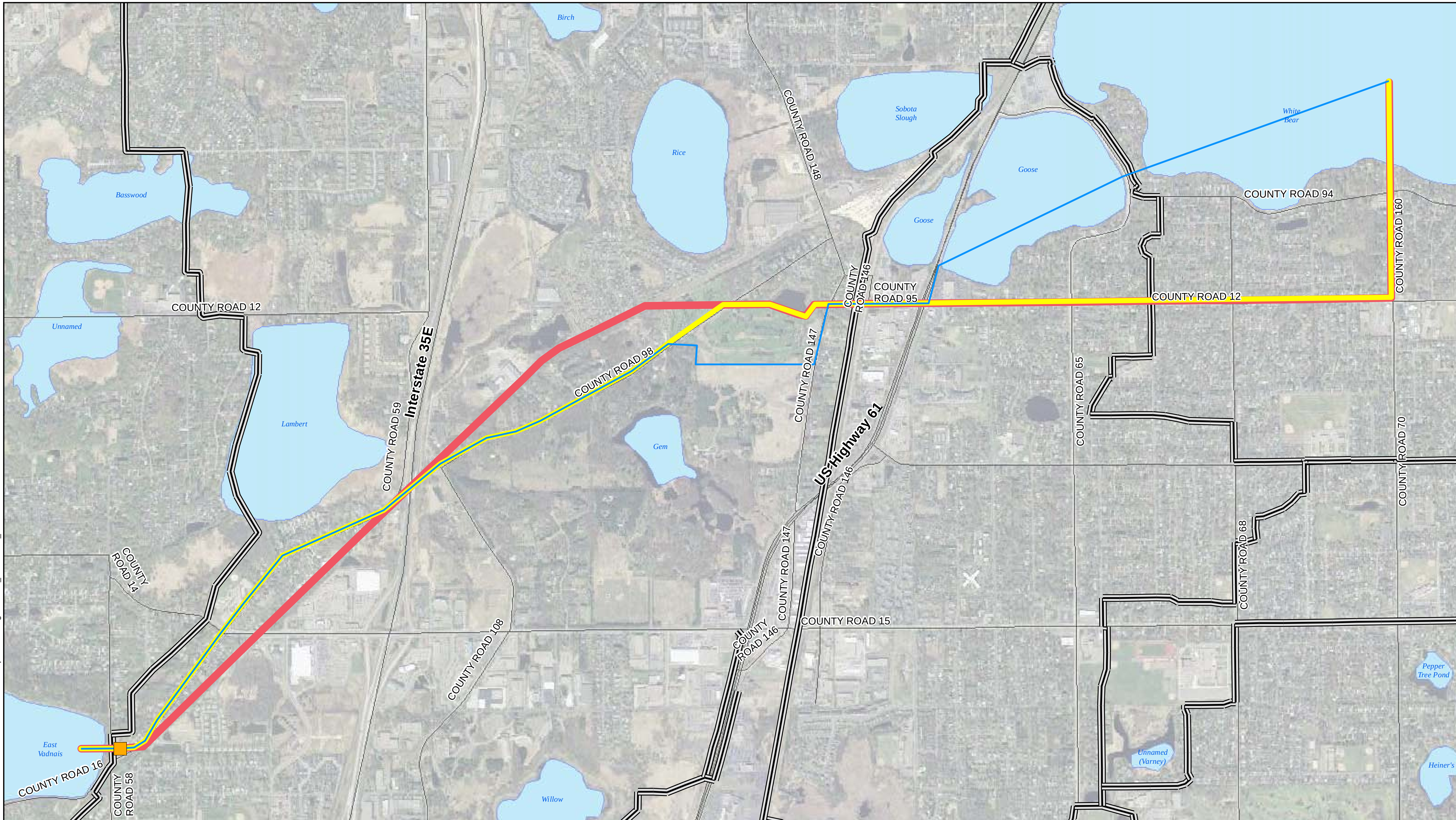
9.10 Route 1A – Vadnais Lake to White Bear Lake via BNSF Railroad Right-of-Way and County Road F (Cty 95)

This route includes pumping water from East Vadnais Lake to White Bear Lake via the Burlington Northern Santa Fe (BNSF) Railroad Right of Way and County Road F (Cty 95). Route description details are shown in Appendix L.

The preliminary costs are listed in Table 9-2.

Table 9-2. Route 1A - Railroad and County Road F Cost Breakdown.

Item	Unit	Unit Cost	Cost
Pumping Station, Intake, Outfall	1	$9,340,000	$9,340,000
Pumping Station Land	4 acres	$435,600/acre	$1,742,000
30" HDPE Forcemain in Road	12,242 ft	$908	$11,116,000
Tunneled Forcemain	600 ft	$2500/ft	$1,500,000
30" HDPE Forcemain in Railroad	11,158 ft	$700/ft	$7,810,000
Steel Casing	11,158 ft	$400/ft	$4,463,000
Railroad Easement	223,160 sf	$3/sf	$670,000
Private Easement	100,000 sf	$6/sf	$600,000
		Subtotal	$37,241,000
		Contingency (20%)	$7,448,000
		Eng/Legal/Adm (20%)	$7,448,000
		Total	**$52,137,000**



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Project: MCES 126394
Print Date: 04/28/2014

Map by: AK
Projection: MN State Plane South FT

Pump Station
MCES Interceptor

Augmentation Alternative
1-A
1-B
1-C

1,500 750 0 1,500 Feet

Augmentation Alternative
Vadnais Lake to White Bear Lake
1 inch = 1,500 feet

Figure
9-2

9.11 Route 1B – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95)

This route includes pumping water from East Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95). The alignment is similar to that outlined in Route 1A, however, this alignment does not include installing forcemain in the railroad right-of-way. Route description details are shown in Appendix L. The preliminary costs are listed in Table 9-3.

Table 9-3. Route 1B - Goose Lake Road and County Road F Cost Breakdown.

Item	Unit	Unit Price	Cost
Pumping Facility, Intake, Outfall	1	$9,340,000	$9,340,000
Pumping Station Land	4 acres	$435,600/acre	$1,742,000
30” HDPE Forcemain in Road	24609 ft	$908	$22,345,000
Tunneled Forcemain	600 ft	$2500/ft	$1,500,000
Private Easement	100,000 sf	$6/sf	$600,000
		Subtotal	**$35,527,000**
		Contingency (20%)	$7,105,000
		Eng/Legal/Adm (20%)	$7,105,000
		Total	**$49,737,000**

9.12 Route 1C – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and Goose Lake

Description

This route includes pumping water from East Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) as described above. However, rather than the alignment running through the Gem Lake Hills Golf Course by permanent easement and meeting up with County Road F, this alignment runs south of the golf course, crosses US Highway 61, and then traverses along the bottom of Goose Lake east of US Highway 61 before discharging into White Bear Lake through an outlet structure as detailed in Appendix K. Route description details are shown in Appendix L. The preliminary costs are listed in Table 9-4.

Table 9-4. Route 1C - Goose Lake Road and Goose Lake Cost Breakdown.

Item	Unit	Unit Price	Cost
Pumping Facility, Intake, Outfall	1	$9,225,000	$9,225,000
Pumping Station Land	4 acres	$435,600/acre	$1,742,000
30” HDPE Forcemain in Road	21,267 ft	$908	$19,310,000
30” HDPE Forcemain in Goose Lake	3,340 ft	$700/ft	$2,338,000
Tunneled Forcemain	300 ft	$2500/ft	$750,000
Private Easement	200,000 sf	$6/sf	$1,200,000
		Subtotal	**$34,565,000**
		Contingency (20%)	$6,913,000
		Eng/Legal/Admin (20%)	$6,913,000
		Total	**$48,391,000**

9.13 Operations and Maintenance

Equipment installed as part of the intake structure would need to be operated and maintained throughout the duration of augmentation. Preliminary costs associated with operations are listed in Table 9-5.

Vertical turbine pumps with vertical high-thrust motors were assumed for the project. Components need to be installed and routinely maintained per manufacturers' instructions.

Finally, an automatic self-cleaning strainer assembly would be used to filter water before it enters White Bear Lake. The strainer should be disassembled for internal inspection annually. The straining element should be checked for mechanical damage or binding. In addition, the straining element should be cleaned thoroughly.

As the filter system is very large and heavy, servicing of the individual components would require the use of an overhead hoisting bridge crane.

Table 9-5. Estimated Augmentation Operation and Maintenance Costs.

Item	Quantity	Unit Cost	Cost/Month	Cost/Year
Energy	720 Hours	$11.19/Hour	$8,056	$64,448
Water	260 MG	$100/MG	$26,000	$208,000
Operator	1 Operator	$50/hour	$2,000	$16,000
Total			$36,056	$288,448
**Yearly costs are based on an 8 month augmentation period*				
**Water use is based on a 6,000 gpm pumping rate*				

9.14 Estimated Costs

The total cost for implementation of an augmentation system from Vadnais Lake to White Bear Lake is estimated to range between $48-$52 million dollars as shown in Table 9-6.

All of the alignments contain the following components with costs that will remain consistent: sitework, screening facility structure, backwash system, and electrical controls. Facility estimates at the concept level have uncertainty related to several factors including various permits, linear footage of forcemain, right-of-way acquisition and forcemain casing requirements.

Table 9-6. White Bear Lake Augmentation Cost Estimate Summary – Mississippi River.

Concept	Route Description	Cost
1A	Railroad Right-of-Way and County Road F (Cty 95)	$ 52,137,000
1B	Goose Lake Road (Cty 98) and County Road F (Cty 95)	$ 49,737,000
1C	Goose Lake Road (Cty 98) and Goose Lake	$ 48,391,000

9.15 St. Croix River

The raw water would be pumped from the St. Croix River from a location north of the City of Stillwater. High density polyethylene pipe (HDPE) would be laid along the route as described below.

This option assumes high density polyethylene pipe (HDPE) would run from the St. Croix River south along Highway 95. The pipe would then run west along Highway 96 to the north side of White Bear Lake. This alignment for the pipe is shown on Figure 9-3.

The total cost for implementation of an augmentation system from the St. Croix River to White Bear Lake is estimated to be nearly $67 million. This alternative is estimated to be significantly higher primarily due to the increase in linear footage of forcemain. Pumping water from Vadnais Lake will require approximately 23,000-25,000 LF of forcemain, while pumping water from the St. Croix River will require approximately 60,000 LF of forcemain.

In addition, there is a much greater head to overcome during pumping with this alignment. The costs of pumps as well as electricity required to perform the pumping will increase operational costs by approximately 60 percent.

Table 9-7. Concept 2 - White Bear Lake Augmentation Cost Estimate Summary - St. Croix River.

Item	Units	Unit Cost	Cost
Pump Station, Intake, Outfall	1	$12,500,000 ea	$12,500,000
30" HDPE Forcemain (50% in road)	60,000 ft	$575	$ 34,500,000
Private Easement	100,000 sf	$6/sf	$600,000
		Subtotal	**$47,600,000**
		Contingency (20%)	$9,520,000
		Eng/Legal/Adm (20%)	$9,520,000
		Total	**$66,640,000**

9.16 Direct Augmentation of White Bear Lake

The feasibility of augmenting White Bear Lake water levels with water from the Mississippi River and St. Croix River was evaluated. Key findings are as follows:

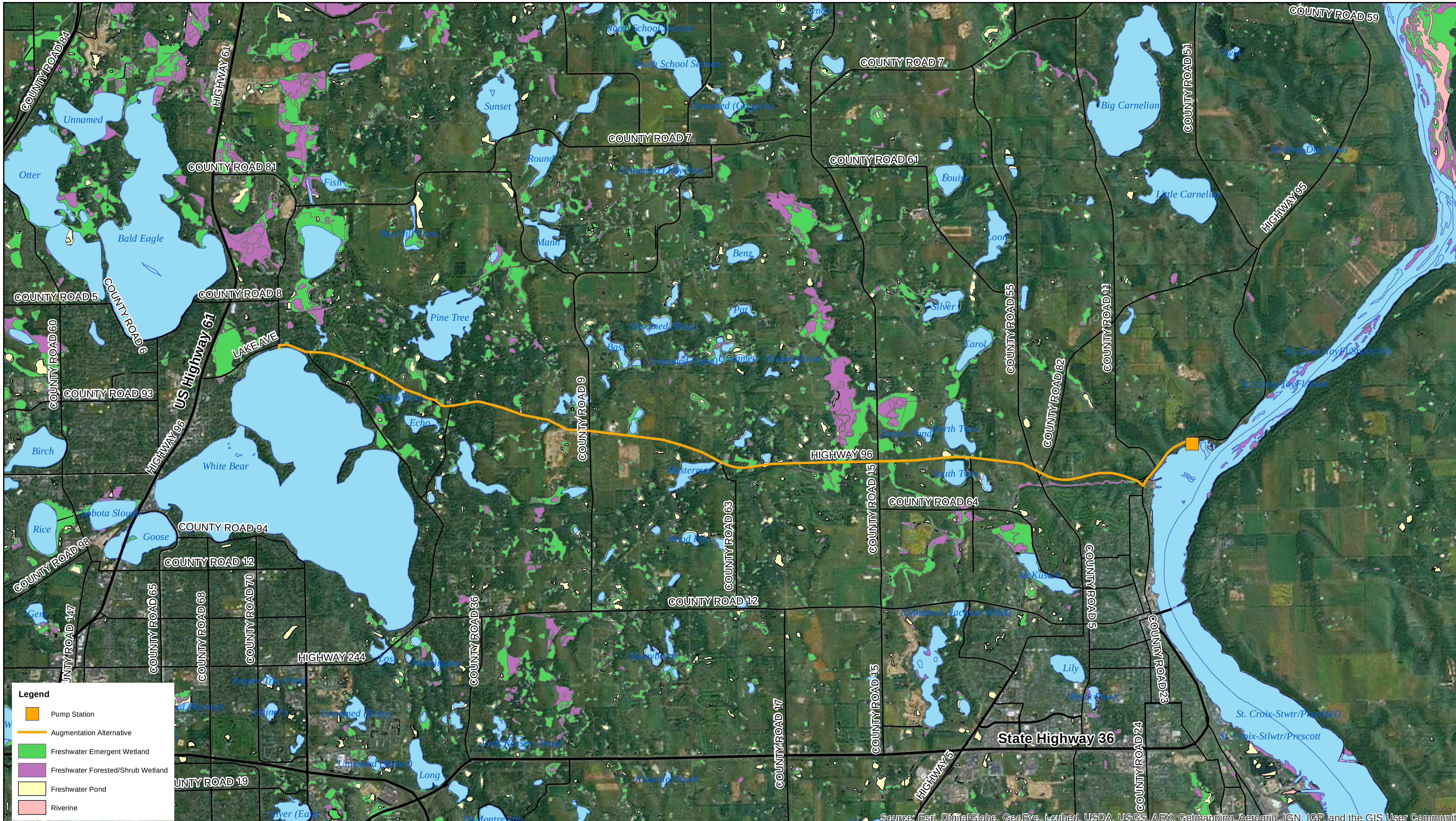
- The St. Croix River is significantly further away and has significantly higher pumping pressure required than water from the Mississippi River for augmentation. The potential route identified for the pipeline from the St. Croix River is approximately 11 miles. This compares to 4 – 5 miles for the options that evaluated service from Vadnais Lake. The pumping head needed to pump from the St. Croix River is calculated to be 324 feet, compared to 70 feet in pumping head needed to transfer water from Vadnais Lake to White Bear Lake. In addition, the St. Croix River is a National Scenic Riverway, making construction in or near the river difficult from a regulatory standpoint.
- The Mississippi River is impaired with zebra mussels, as is Vadnais Lake. Augmentation from this source will require filtration.
- With filtration, augmentation with water from Vadnais Lake is not anticipated to degrade White Bear Lake water quality. The primary concerns based on analysis of water quality differences between Vadnais Lake and White Bear Lake are increased eutrophication, turbidity, and total coliform levels. The water from Vadnais Lake has higher nitrate levels than White Bear Lake. White Bear Lake is a phosphorous-limited lake and elevated nitrogen levels are not expected to increase eutrophication. Modeling indicates that augmentation should not increase phosphorous levels in the lake.
- SPRWS has sufficient capacity to draw and convey 2 billion gallons of water annually (2 BGY) for augmentation.
- It is not certain if augmentation of 2 BGY will raise the water level of White Bear Lake to the ordinary high water level.
- It is unlikely that augmenting White Bear Lake will provide benefit to other lakes.

Table 9-8 shows a cost summary for augmenting White Bear Lake.

Table 9-8. - Costs for Augmenting White Bear Lake

	Capital Cost[1]	Annual Operations & Maintenance Cost
White Bear Lake Augmentation System (2 Billion Gallons per Year)	**$50,000,000**	**$300,000**

[1] Based on April 2014; no escalation to date of construction.



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Print Date: 12/23/2014

Map by: AK
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Source: MnGeo, SEH, Ramsey County

N

0 3,500 7,000 Feet

Augmentation Alternative
Raw Water Source: St. Croix River
White Bear Lake, Minnesota

Figure 9-3

9.17 Summary

Results of the preliminary feasibility analysis show that Concept 1C, Goose Lake Road (Cty 98) and Goose Lake, is the most cost effective alignment with an estimated cost of $ 48,391,000. Special consideration will need to be taken for construction of forcemain on the bottom of Goose Lake. Necessary permits will need to be acquired from the DNR and other agencies as summarized in Section 9.6.

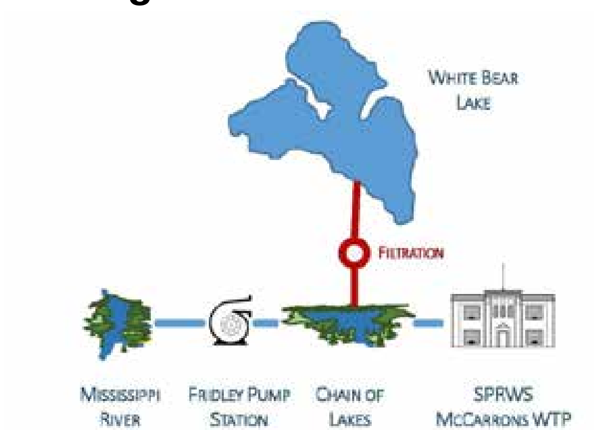
The augmentation pumping facilities were sized for 6,000 gpm. The intake structure would be located approximately 20 feet deep in Vadnais Lake. It would flow through a filtration system before entering White Bear Lake, and exit through an outlet structure with 6" diameter portals.

Chemical treatment of the augmentation water is not expected to be necessary. It is likely that phosphorus will be further reduced in the augmentation water during filtration. Invasive species will be controlled from the Mississippi River water during filtration. While the temperature in the augmentation water is slightly higher than that of White Bear Lake, significant impacts are not expected.

Further investigation is required before any alignment can be selected for construction. Utility locates, geotechnical exploration, right-of-ways, easements, permitting, constructability, and community consent will all need to be considered.

Figure 9-4. Direct Augmentation of White Bear Lake

Direct Augmentation of White Bear Lake



Description

Direct augmentation of White Bear Lake with two billion gallons per year of water from the Mississippi River. A pumping and filtration facility would be constructed near Vadnais Lake with water main to convey water to White Bear Lake.

People Served by System in 2040: N/A

Total Reduction in Groundwater Pumping: N/A

Cost Summary Table

Capital Cost[1]	$50,000,000
Capital Cost per Million Gallons of Capacity	N/A[2]
Annual Operations and Maintenance Cost	$300,000
Operations and Maintenance Cost per Million Gallons of	N/A[2]

[1]Based on April 2014, no escalation to date of construction
[2]N/A – not applicable: this alternative does not provide a drinking water supply

Evaluation of Direct Augmentation of White Bear Lake

Advantages

- Would provide immediate benefit to White Bear Lake

Disadvantages

- Uncertainty in response of lake to additional volume added by augmentation (correct design capacity uncertain at this time)
- High capital cost
- Unlikely to provide benefit to water supply reliability or other regional surface water bodies

Chapter 10 – Conclusions

The analyses conducted for this feasibility assessment yielded previously unknown information about potential approaches to improve the sustainability and reliability of groundwater in the northeast metro area and the Twin Cities region. Importantly, this includes information about the necessary infrastructure components and costs of some of the infrastructure solutions that have been proposed.

Groundwater flow modeling was also used to estimate the potential benefit to the Prairie du Chien – Jordan aquifer due to reduced groundwater pumping that would result from the alternatives evaluated in this study. Given the relationship between water levels in White Bear Lake and water levels in the aquifer, it is reasonable to extrapolate that an increase in aquifer level would over time cause the lake level to increase. Where aquifer levels are estimated to increase over a broader area, it is likely that other lakes that have similar connectivity to the aquifer would also receive some benefit. The magnitude of benefit is difficult to assess with our current understanding of the hydrogeologic system. This understanding is expected to increase with the current investigation of the USGS, which is scheduled to be completed in 2016.

The use of surface water to replace groundwater use for municipal supplies was evaluated at multiple scales to estimate how the costs and benefits of such approaches change as a greater number of communities are included. It is clear from the analysis at multiple system scales that there is less benefit obtained at greater marginal cost as the system is expanded outward toward less densely developed communities. This is in part due to the proximity of the source of water. Therefore, if a surface water supply is implemented in the future, it would be sensible to target it to a geographic area that has greater density, is as close to the source of water as possible, and reduces pumping in proximity to sensitive surface water features.

Direct augmentation of White Bear Lake with Mississippi River water via Vadnais Lake was found to be feasible, though the system required would need to be very large in scale in order to overcome the historically documented seepage rates from the lake to the aquifer below.[2] In addition, if future groundwater pumping or climate conditions cause further reductions in the underlying aquifer system, the rate of seepage from the lake could increase over time. The benefits of a lake augmentation system would be exclusive to the lake water levels, not likely providing any broader benefit to other lakes or to water source reliability.

None of the proposed approaches would be easy to implement. All have significant capital and operational costs, and additional discussion is needed to determine who should be responsible for those costs if any of these approaches were implemented. There are, however, models for cost sharing that have been implemented in other locations in the United States that could be used as a starting point for discussion. Two of these models have been applied to the northeast metro in this report to illustrate the potential impacts to rate payers with implementation.

Communities in the study area have expressed a desire to explore the potential to use conservation, stormwater capture for irrigation, aquifer recharge, or other less expensive methods to reduce groundwater use before switching their supply source to surface water at significant expense. However, such approaches could take longer and would result in less aquifer recovery than elimination of groundwater use through a switch to surface water. Decision makers and the DNR will need to decide whether this approach is acceptable given the risk of additional declines in lake level or of slower recovery of lake level.

[2] Minnesota Department of Natural Resources, 1998, Lake-Ground Water Interaction: Report to the Legislative Committee on Minnesota Resources.

Additional Work is in Progress

Several pieces of information not found in this investigation could be important considerations in water supply planning decisions for the northeast metro area. This evaluation of alternatives stops short of identifying the best way forward. Local government units, state lawmakers, the DNR, and other stakeholders should all be part of the discussion in developing a plan for water supply for the region that protects our natural resources in the most cost-effective manner. This future plan could include one or more of the options investigated in this study, and could also include other approaches not evaluated here.

Currently unanswered questions include:

- **What is the potential to use conservation, aquifer recharge, or stormwater reuse to reduce aquifer impacts from pumping activities?** The Council is leading an ongoing study to look at aquifer recharge and stormwater reuse for the North and East Metro Groundwater Management Area, which is expected to be completed in 2015. Additional evaluation of conservation potential is recommended.
- **How much will changes in pumping impact the water levels in White Bear Lake, and how long will those changes take?** The current USGS study in the northeast metro, to be completed in 2016, will develop a localized groundwater model that will consider groundwater-surface water interactions, and will incorporate a significant amount of new data currently being collected from lakes in the northeast metro.
- **What is the sustainable limit for groundwater withdrawals in the northeast metro?** The Council, in coordination with the DNR, is trying to make an initial assessment of sustainable levels of groundwater use in sub-regional areas across the metro area that would prevent future problems with water use. This is a complex problem, due to the complexity of the physical systems involved. There is not currently a timeline for completion of this activity, though it is acknowledged that identifying sustainable limits on water use is essential for future planning.

Appendix A: Study Area Existing Water Infrastructure

Appendix A has been excluded from the online version of this report. Please contact Metropolitan Council Environmental Services to obtain a copy.

Appendix B: Cost Estimating Methodology

Building a Better World for All of Us®

TECHNICAL MEMORANDUM

TO: Chris Larson

FROM: Noah Johnson

DATE: September 29, 2014

RE: Unit Cost Development for the Feasibility Assessment of Approaches to Water Sustainability in the Northeast Metro
SEH No. MCES 126394 14.00

Cost estimating for projects under an urban roadway are difficult to estimate at a study phase level, for the purpose of this study several assumptions are needed. A tool was developed to calculate these costs, titled “MCES_NE_FeasibilityStudy_UnitPrices”. The easily definable cost estimates for pavement removal, trench excavation and backfill, pipe and installing costs, and pavement replacement are quantifiable based on 2014 MNDOT published costs. These costs are developed on sheet “Piping and Pavement” of the tool. These cost typically represent 25-35% of a project. The general assumptions that were used to determine the defined costs are:

- A 40 foot wide section of roadway would be removed and replaced
- The curb, gutter and sidewalks would also be removed and replaced
- Some of the pipe would not be under the roadway and a portion of the pavement costs were not included based on the proposed alignments
- The pipe would be buried 8 feet deep and the excavation would have a side slope of 1:1
- No excavation protection was assumed

Several other undefined costs associated with working in the roadway exist and are not easily determined. These costs include watermain structures and pipe fittings, other trenching or dewatering costs, other pavement removal and replacement costs, conflicts with the proposed alignments, allowances, and construction activity costs. These costs make up the majority of the project costs and are unknown without a significant effort. In order to estimate these costs a similar project that was just bid in 2014 was reviewed, sheet “SLP” of the tool. Each item was reviewed and the prices were removed from the project if they were accounted for in the defined costs listed above. The remaining bid items were grouped based on the cost item in the following groups:

- Pipe Fittings
- Other Trenching Costs
- Watermain Structures
- Other Pavement Costs
- Allowances
- Construction Costs

- Stormwater Protection
- Utility Conflicts

These undefined costs were then divided by the total amount of roadway that was removed and replaced in the similar project. This method provided a unit price per foot for each group of undefined cost. These costs are totaled in the “Undefined Costs” sheet in the tool.
To determine the basis for the final projected unit costs, the proposed alignments were considered. Three unit costs for each pipe diameter were developed based on the percentage of the pipe alignment under the roadway. The pavement costs were adjusted based directly on the amount of pavement that would be removed and replaced, identified in the “Percent Under Road” column of the “Piping and Pavement” sheet. The undefined costs were not directly adjusted by the same amounts, these were adjusted based on the potential to encounter the undefined costs identified in the “Multiplier” cells of the “Undefined Costs” sheet. The undefined costs were further refined based on the diameter of the pipe to be installed. The undefined costs were scaled down linearly based on pipe diameter, 60” pipe assumed 100% of the undefined costs down to 24” pipe which assumed 60% of these costs. With a range of unit prices, the final proposed alignments can be evaluated and a final total cost can be calculated. The following tables outline the assumptions made to determine the unit costs and the final unit costs for each pipe diameter.

Table 1.
Unit Cost Adjustments Based on the Proposed Alignments

Percentage of the alignment under the roadway	Percentage of pavement costs included in the unit cost	Percentage of undefined costs included in the unit cost
100%	100%	100%
50%	50%	50%
0%	0%	25%

Table 2.
Northeast Metro Water Supply Feasibility Study Unit Cost Summary

Pipe Diameter (in)	Percent in Roadway	Defined Costs per Foot	Undefined Costs per Foot	Total Costs per Foot
24	0%	$194	$110	$304
24	50%	$283	$219	$503
24	100%	$372	$439	$811
30	0%	$242	$122	$364
30	50%	$331	$244	$575
30	100%	$420	$487	$908
36	0%	$311	$134	$445
36	50%	$400	$268	$668
36	100%	$489	$536	$1,025
42	0%	$371	$146	$518
42	50%	$460	$292	$753
42	100%	$549	$585	$1,134
48	0%	$505	$158	$663
48	50%	$594	$317	$910
48	100%	$683	$634	$1,316
54	0%	$592	$171	$762
54	50%	$681	$341	$1,022
54	100%	$770	$682	$1,452

60	0%	$741	$183	$924
60	50%	$830	$365	$1,196
60	100%	$919	$731	$1,650

Each township provided with water will utilize a booster station to provide the required system water pressure. It is more cost effective to transport water at low pressure and boost the pressure at each township. In order to estimate the costs of each of the needed booster stations a cost development tool was created titled “MCES_NE_FeasibilityStudy_BoosterStationEstimate”. Before the tool can be used, the demand and pressure zones of each township and the pressure zone at which the water will be delivered to each booster station must be known. The “Demand Summary” sheet is used for these inputs. Alternative 2 and 3 assumed the booster stations would need to boost from elevation 1019, this is the St. Paul Regional Water Service pressure zone. North Saint Paul would be supplied by SPRWS Hazel Park Pressure Zone at an elevation of 1098. With the flow and head of each booster station determined, several pump curves were evaluated. The “Motor Hp” and “# of Duty Pumps” are direct inputs based on the review of possible pump curves and horsepower that may be used for each application. These direct inputs are used for the basis of each booster station cost estimate.

It is assumed vertical turbine pumps will be used at each booster station. These costs are determined on sheet “Pumps Pipes and Valves” of the tool. Factors were applied to the pump costs for piping, valves and installation costs based on similar projects and design experience. A stand-by pump was included in order to determine the total costs for the pumps detailed in the following table.

Table 3.
Alternative 1A, 1B, and 1C Booster Pump Size and Costs

Township	Flow (MGD)	Head (Ft)	Total Number of Pumps	Hp	Cost per Pump	Total
Centerville	0.8	35	2	7.5	$63,000.00	$126,000.00
Circle Pines	1.7	35	2	10	$74,000.00	$148,000.00
Columbus	0.8	70	2	15	$77,000.00	$154,000.00
Forest Lake	3.9	71	3	25	$83,000.00	$249,000.00
Hugo	7.0	66	3	50	$89,000.00	$267,000.00
Hugo 2	5.0	36	3	20	$77,000.00	$231,000.00
Lexington	1.8	35	2	15	$77,000.00	$154,000.00
Lino Lakes	7.9	35.5	3	30	$84,000.00	$252,000.00
Mahtomedi	2.0	119	2	40	$86,000.00	$172,000.00
North St. Paul	4.5	27	2	30	$84,000.00	$168,000.00
Shoreview	10.9	73.5	3	75	$98,000.00	$294,000.00
Vadnais Heights	4.1	81	3	30	$84,000.00	$252,000.00
White Bear Lake	9.5	106	3	100	$118,000.00	$354,000.00
White Bear Township	4.4	84	2	75	$98,000.00	$196,000.00

The booster stations will range between a total of 2 or 3 pumps based on water demand. Structure costs were then developed which provided an appropriate footprint and building size for each station. General structural costs and installation multipliers are develop for the 2 or 3 pump stations in sheets “2 Pump Bldg” and “3 Pump Bldg”. Building mechanical estimated costs are based on similar projects and detailed in sheet “Mechanicals” of the tool. The “Yard Piping” sheet details costs for various diameters of pipe, these costs are based on 200 feet of pipe, and fittings needed to bring water into the booster station and to connect to the service line or water tower. The summary sheet tabulates the costs developed in the tool sheets plus electrical and generator costs. The electrical cost is an estimate based on experience and current costs. This estimate is 13% of the pump, structure and mechanical costs. The generator cost is developed based on the size and number of duty pumps needed for each station. It is assumed natural gas generators will be used. The following table outlines the total estimated cost for each booster station in year 2014 dollars, ENR 9800.

Table 4.
Alternative 1A, 1B, and 1C Booster Station Total Costs

Township	Pumps, Pipes, Valves Cost	Bldg	Mechanical	Electrical	Generator	Yard Piping	Total Cost
Centerville	$126,000	$199,442	$45,600	$66,788	$80,000	$26,499	$544,328
Circle Pines	$148,000	$199,442	$45,600	$70,748	$80,000	$26,499	$570,288
Columbus	$154,000	$199,442	$45,600	$71,828	$80,000	$26,499	$577,368
Forest Lake	$249,000	$249,007	$45,600	$97,849	$80,000	$26,499	$747,955
Hugo	$267,000	$249,007	$45,600	$101,089	$80,000	$26,499	$769,195
Hugo 2	$231,000	$249,007	$45,600	$94,609	$80,000	$26,499	$726,715
Lexington	$154,000	$199,442	$45,600	$71,828	$80,000	$26,499	$577,368
Lino Lakes	$252,000	$249,007	$45,600	$98,389	$80,000	$26,499	$751,495
Mahtomedi	$172,000	$199,442	$45,600	$75,068	$80,000	$26,499	$598,608
North St. Paul	$168,000	$199,442	$45,600	$74,348	$80,000	$26,499	$593,888
Shoreview	$294,000	$249,007	$45,600	$105,949	$170,000	$35,251	$899,807
Vadnais Heights	$252,000	$249,007	$45,600	$98,389	$80,000	$26,499	$751,495
White Bear Lake	$354,000	$249,007	$45,600	$116,749	$80,000	$26,499	$871,855
White Bear Township	$196,000	$199,442	$45,600	$79,388	$80,000	$26,499	$626,928

Yearly operation and maintenance costs are determined on tab “O&M Costs”. Based on previous project experience, 3% of the capital costs for the pumping equipment is used to determine the costs in the “Equipment Maintenance” totals to cover items such as pump seal replacement or other typical equipment upkeep costs. A general amount of $2,000 was assumed for heating the building and another $2000 was identified for other miscellaneous building costs. The “Operator Costs” are based on an assumed 4 hours per week of time and an hourly cost of $50. The pumping energy costs assumed the pumps were 60% efficient at pumping the average daily flow and a KW-hr cost of $0.072. The following table outlines the probable costs of operation and maintenance in 2014 dollars.

Table 5.
Alternative 1A, 1B, and 1C Booster Station Yearly Operation and Maintenance Costs

Township	Equipment Maintenance	Operator Costs	Pumping Energy Costs	Building Heating	Misc Bldg Costs	Total
Centerville	$3,780.00	$10,400.00	$2,287.24	$2,000.00	$2,000.00	$20,467.24
Circle Pines	$4,440.00	$10,400.00	$2,400.60	$2,000.00	$2,000.00	$21,240.60
Columbus	$4,620.00	$10,400.00	$4,705.17	$2,000.00	$2,000.00	$23,725.17
Forest Lake	$7,470.00	$10,400.00	$22,434.45	$2,000.00	$2,000.00	$44,304.45
Hugo	$8,010.00	$10,400.00	$21,776.40	$2,000.00	$2,000.00	$44,186.40

Hugo 2	$6,930.00	$10,400.00	$8,710.56	$2,000.00	$2,000.00	$30,040.56
Lexington	$4,620.00	$10,400.00	$1,985.95	$2,000.00	$2,000.00	$21,005.95
Lino Lakes	$7,560.00	$10,400.00	$14,115.51	$2,000.00	$2,000.00	$36,075.51
Mahtomedi	$5,160.00	$10,400.00	$12,547.12	$2,000.00	$2,000.00	$32,107.12
North St. Paul	$5,040.00	$10,400.00	$7,841.95	$2,000.00	$2,000.00	$27,281.95
Shoreview	$8,820.00	$10,400.00	$36,364.19	$2,000.00	$2,000.00	$59,584.19
Vadnais Heights	$7,560.00	$10,400.00	$19,303.27	$2,000.00	$2,000.00	$41,263.27
White Bear Lake	$10,620.00	$10,400.00	$56,152.25	$2,000.00	$2,000.00	$81,172.25
White Bear Township	$5,880.00	$10,400.00	$22,610.96	$2,000.00	$2,000.00	$42,890.96

Alternatives 4 and 5 assume the booster stations would boost from the trunk water main from the water pant at an elevation of 1055. North Saint Paul would still be supplied by SPRWS Hazel Park Pressure Zone at an elevation of 1098. The size of the pumps are reduced and stations located in Centerville, Circle Pines, Lexington, Lino Lakes and the station in the second pressure zone in Hugo would be eliminated. The following tables outline the results of the alternative 4 and 5 booster station cost analysis.

Table 6.
Alternative 2B, 2C, and 2D Booster Pump Size and Costs

Township	Flow (MGD)	Head (Ft)	Total Number of Pumps	Hp	Cost per Pump	Total
Centerville	--	--	--	--	--	--
Circle Pines	--	--	--	--	--	--
Columbus	0.8	35	2	7.5	$43,000.00	$86,000.00
Forest Lake	3.9	35	3	15	$77,000.00	$231,000.00
Hugo	7.0	30	3	30	$84,000.00	$252,000.00
Hugo 2	--	--	--	--	--	--
Lexington	--	--	--	--	--	--
Lino Lakes	--	--	--	--	--	--
Mahtomedi	2.0	83	2	25	$83,000.00	$166,000.00
North St. Paul	4.5	27	2	25	$83,000.00	$166,000.00
Shoreview	10.9	37.5	3	60	$89,000.00	$267,000.00
Vadnais Heights	4.1	45	3	20	$77,000.00	$231,000.00
White Bear Lake	9.5	70	3	75	$98,000.00	$294,000.00
White Bear Township	4.4	48	2	50	$89,000.00	$178,000.00

Table 7.
Alternative 2B, 2C, and 2D Booster Station Total Costs

Township	Pumps, Pipes, Valves Cost	Bldg	Mechanical	Electrical	Generator	Yard Piping	Total Cost
Centerville	--	--	--	--	--	--	--

Circle Pines	--	--	--	--	--	--	--
Columbus	$86,000	$199,442	$45,600	$59,588	$80,000	$26,499	$497,128
Forest Lake	$231,000	$249,007	$45,600	$94,609	$80,000	$26,499	$726,715
Hugo	$252,000	$249,007	$45,600	$98,389	$80,000	$26,499	$751,495
Hugo 2	--	--	--	--	--	--	--
Lexington	--	--	--	--	--	--	--
Lino Lakes	--	--	--	--	--	--	--
Mahtomedi	$166,000	$199,442	$45,600	$73,988	$80,000	$26,499	$591,528
North St. Paul	$166,000	$199,442	$45,600	$73,988	$80,000	$26,499	$591,528
Shoreview	$267,000	$249,007	$45,600	$101,089	$170,000	$35,251	$867,947
Vadnais Heights	$231,000	$249,007	$45,600	$94,609	$80,000	$26,499	$726,715
White Bear Lake	$294,000	$249,007	$45,600	$105,949	$80,000	$26,499	$801,055
White Bear Township	$178,000	$199,442	$45,600	$76,148	$80,000	$26,499	$605,688

Table 8.
Alternative 2B, 2C, and 2D Booster Station Yearly Operation and Maintenance Costs

Township	Equipment Maintenance	Operator Costs	Pumping Energy Costs	Building Heating	Misc Bldg Costs	Total
Centerville	--	--	--	--	--	--
Circle Pines	--	--	--	--	--	--
Columbus	$2,580.00	$10,400.00	$2,352.59	$2,000.00	$2,000.00	$19,332.59
Forest Lake	$6,930.00	$10,400.00	$13,460.67	$2,000.00	$2,000.00	$34,790.67
Hugo	$7,560.00	$10,400.00	$13,065.84	$2,000.00	$2,000.00	$35,025.84
Hugo 2	--	--	--	--	--	--
Lexington	--	--	--	--	--	--
Lino Lakes	--	--	--	--	--	--
Mahtomedi	$4,980.00	$10,400.00	$7,841.95	$2,000.00	$2,000.00	$27,221.95
North St. Paul	$4,980.00	$10,400.00	$6,534.96	$2,000.00	$2,000.00	$25,914.96
Shoreview	$8,010.00	$10,400.00	$29,091.35	$2,000.00	$2,000.00	$51,501.35
Vadnais Heights	$6,930.00	$10,400.00	$12,868.84	$2,000.00	$2,000.00	$34,198.84
White Bear Lake	$8,820.00	$10,400.00	$42,114.19	$2,000.00	$2,000.00	$65,334.19
White Bear Township	$5,340.00	$10,400.00	$15,073.97	$2,000.00	$2,000.00	$34,813.97

Appendix C: Pipe Segment Descriptions

Pipe Segment Descriptions

The sizes of the water mains may vary depending on alternative. Where water main sizes are not listed, refer to tables in this appendix for pipe sizes.

Segment 1 (7,420 ft) A proposed water main is connected to an existing SPRWS 16” water main in the northeast corner of State Highway 36 and White Bear Avenue. The proposed water main is routed north along the east side of White Bear Avenue to 11th Avenue, and east along 11th Avenue to 2nd Street in North St. Paul. The proposed water main is routed north on 2nd Street to the North St. Paul water tower in the City park at 13th Avenue.

Segment 2 (22,560 ft) – Water main(s) are proposed from the SPRWS McCarron’s water treatment facility in St. Paul. The proposed water main(s) are routed north from the water treatment facility to Roselawn Avenue. The water mains are routed east along Roselawn Avenue, tunnel under Interstate 35, to Edgerton Street. The proposed water main(s) are routed north on Edgerton Street, tunnel under State Highway 36, continue north on Edgerton, tunnel under Interstate 694, and continue north to Centerville Road in Vadnais Heights.

Segment 3 (14,140 ft) – A proposed water main continues north along Edgerton Street to the Oak Creek Park. The proposed water main is routed west and north along Vadnais Lake in the property owned by SPRWS. At the north end of Vadnais Lake, the proposed water main is routed west, goes under the SPRWS raw water conduits, to Rice Street.

Segment 4 (14,500 ft) – A proposed water main is routed north on Rice Street to Snail Lake Road, west on Snail Lake Road to Hodgson Road, and northwest on Hodgson Road to County Road 96. The proposed water main is tunneled under Highway 96 and routed west to Victoria Street.

Segment 5 (12,350 ft) – A single water main is routed from the intersection of Edgerton Street and Centerville Road northeast along Centerville Road to County Road E. The water main is routed east along County Road E, tunnels under Interstate 35E, and continues east to State Highway 61.

Segment 6 (27,330 ft) **-** A proposed water main is routed north along the west side of State Highway 61 from County Road E to Scheuneman Road. The proposed water main is routed north on Sheuneman Road to Otter Lake Road, north on Otter Lake Road to Park Street. The proposed water main is routed east on Park Avenue, across Columbia Park, to 4th Avenue. The proposed water main is routed north on 4th Avenue, tunnels under Highway 96, and continues north to 5th Street. The proposed water main is routed east on 5th Street to Wood Avenue, north on Wood Avenue to 9th Street, east on 9th Street to Bald Eagle Avenue, and north on Bald Eagle Avenue to Stillwater Street. The proposed water main is routed east on Stillwater Street to Division Street, north on Division Street to Park Avenue, and east on Park Avenue to Highway 61.

Segment 7 (11,000 ft) – A 30” water main is routed from the water main at State Highway 61, tunnels under Highway 61, and continues along County Road E to White Bear Avenue. The 30” water main is routed south along White Bear Avenue to Orchard Lane. The 30” water main is routed east along Orchard Lane to the White Bear Lake water treatment facility.

Segment 8-1 (7,200 ft) To provide water to Mahtomedi, a proposed 12” water main is connected to the 30” water main in Orchard Lane. The proposed 12” water main is routed east on Orchard Avenue to Bellaire Avenue. The proposed 12” water main is routed along Bellaire Avenue to the south and east and crosses Century Avenue.

Segment 8-2 (1,700 ft) **-** To provide water to Mahtomedi’s low pressure zone, a new section of 10” water main is proposed. The proposed 10” water main connects to existing 12” water main in Dunbar Avenue and is routed east to Lincolntown Avenue and north on Lincolntown Avenue where it connects to an existing 10” water main.

Segment 9 (21,400 ft) – A proposed 48” water main is routed south on the west side of State Highway 61 from County Road 8 to Park Avenue in White Bear Township, where the proposed 48” water main connects to the proposed 48” water main Segment 2F. This completes the trunk water main loop.

Segment 10 (16,000 ft) – A proposed 48” water main is routed east on West Cedar Street from 20th Avenue South, tunneled under Interstate Highway 35E to Otter Lake Road, and north on Otter Lake Road to County Road 14. At County Road 14, the proposed 48” water main is routed east to State Highway 61.

Segment 11 (12,880 ft) – A proposed 48” water main is routed east on Hodgson Road from Pheasant Run South to 20th Avenue South and north on 20th Avenue South to the Centerville border at West Cedar Street.

Segment 12 (18,900 ft) – A proposed 48” water main is routed north on Hodgson Road to Birch Street, east on Birch Street to Pheasant Run South.

Segment 13 (17,850 ft) – A proposed 48” water main is routed north on Victoria Street (turns into Larson Road), east on Mercury Drive West to Hodgson Connection, north on Hodgson Connection to Hodgson Road. The proposed 48” water main is routed north on Hodgson Road to County Road J.

Segment 14 (37,900 ft) – A proposed 20” water main is routed north along State Highway 61 underneath the existing trail from County Road 8 in Hugo to Highway 97 in Forest Lake.

Segment 15 (9,500 ft) – A proposed 10” water main is routed west from the intersection of Highway 97 and State Highway 61 to Hornsby Street in Columbus.

Segment 16 (16,305 ft) – A proposed 12” water main is routed west from the intersection of County Road J and Hodgson Road. The proposed 12” water main is routed west on County Road J to Lexington Avenue, north on Lexington Avenue to Woodland Road.

Segment 17 – (3,020 ft) - A proposed 12” water main is routed west on Woodland Road, jacked and cased under Lexington Avenue, jacked and cased under Lake Drive, to Hamline Avenue. The proposed 12” water main is routed north on Hamline Avenue to the Lexington water tower.

Segment 18 – (5,000 ft) - A proposed 12” water main is routed north on Lexington Avenue from Woodland Road, northeast on Lake Drive to the Circle Pines WTP.

Table 3-2
Alternative 1A – SPRWS Connection to North St. Paul

Item	**Units**	**Unit Cost**	**Total Cost**
16” Directionally Drilled HDPE	7,100 ft	$300/ft	$2,130,000
16” cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	10	$15,000 ea	$150,000
Booster Stations			
North St. Paul – 4 MGD	1	$594,000 ea	$594,000
Easements/Land Acquisition	36,000 sf	$6/sf	$216,000
Environmental	1.3 miles	$50,000/mile pipe	$65,000
		Subtotal	**$3,405,000**
		Contingency (30%)	$1,022,000
		Eng/Admin/Legal (20%)	$681,000
		Total Alternative 1A	**$5,108,000**

Table 3-3 Alternative 1B – SPRWS Connection to Select NE Metro Communities			
Item	**Units**	**Unit Cost**	**Total Cost**
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
Segment 2			
Open Cut 48" DIP (100% in road)	22,560 ft	$1,316/ft	$29,689,000
48" Cased, tunneled pipe	1,200 ft	$4,000/ft	$4,800,000
Segment 3			
Open Cut 30" (0% in road)	14,140 ft	$364/ft	$5,147,000
Segment 4			
Open Cut 30" DIP (100% in road)	14,500 ft	$908/ft	$13,166,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segment 5			
Open Cut 36" DIP (100% in road)	12,350 ft	$1,025	$12,659,000
36" cased, tunneled pipe	400 ft	$3,000/ft	$1,200,000
Segment 6			
Directionally Drilled 18" HDPE	27,330 ft	$350/ft	$9,566,000
18" cased, tunneled pipe	250 ft	$1,250/ft	$313,000
Fusing Pits	39	$15,000 ea	$585,000
Segment 7			
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segments 8-1, 8-2			
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$599,000 ea	$599,000
Shoreview – 13 MGD	1	$900,000 ea	$900,000
Vadnais Heights – 6 MGD	1	$751,000 ea	$751,000
White Bear Lake – 10 MGD	1	$872,000 ea	$872,000
White Bear Twp – 5 MGD	1	$627,000 ea	$627,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	675,000 sf	$6/sf	$4,050,000
Environmental	21.5 miles	$50,000/mile pipe	$1,075,000
		Subtotal	**$103,626,000**
		Contingency (30%)	$31,089,000
		Eng/Admin/Legal (20%)	$20,725,000
		Total Alternative 1B	**$155,440,000**

Table 3-4
Alternative 1C – Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, and Shoreview

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
Segment 2			
Open cut dual 48" DIP (100% in road)	22,560 ft	$1,979/ft	$44,646,000
48" Cased, tunneled pipe	2,400 ft	$4,000/ft	$9,600,000
Segment 3			
Open Cut 48" (0% in road)	14,140 ft	$663/ft	$9,375,000
Segment 4			
Open Cut 48" DIP (100% in road)	14,500 ft	$1,316/ft	$19,082,000
48" cased, tunneled pipe	250 ft	$4,000/ft	$1,000,000
Segment 5			
Open Cut 48" DIP (100% in road)	12,350 ft	$1,316/ft	$16,253,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Segment 6			
Open Cut 48" DIP (100% in road)	27,330 ft	$1,316/ft	$35,966,000
48" cased, tunneled pipe	250 ft	$4,000/ft	$1,000,000
Segment 7			
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segments 8-1, 8-2			
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$599,000 ea	$599,000
Shoreview – 13 MGD	1	$900,000 ea	$900,000
Vadnais Heights – 6 MGD	1	$751,000 ea	$751,000
White Bear Lake – 10 MGD	1	$872,000 ea	$872,000
White Bear Twp – 5 MGD	1	$627,000 ea	$627,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	682,000 sf	$6/sf	$4,091,000
Environmental	21.7 miles	$50,000/mile pipe	$1,085,000
		Subtotal	**$164,422,000**
		Contingency (30%)	$49,327,000
		Eng/Admin/Legal (20%)	$32,884,000
		Total Alt 1C, Phase 1	**$246,633,000**

Table 3-5 Alternative 1C – Phase 2 – SPRWS Connection to Hugo, Lino Lakes, and Centerville			
Item	**Units**	**Unit Cost**	**Total Cost**
Fridley Pumping Station Upgrades	1	$10,000,000 ea	$10,000,000
Additional 60" Raw Water Conduit (50% in road)	42,000 ft	$1,196/ft	$50,232,000
50 MGD SPRWS Treatment Plant Expansion	1	$65,000,000 ea	$65,000,000
Segment 9			
Open Cut 48" DIP (50% in road)	21,400 ft	$910/ft	$19,474,000
Segment 10			
Open Cut 48" DIP (100% in road)	16,000 ft	$1,316/ft	$21,056,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Segment 11			
Open Cut 48" DIP (50% in road)	12,880 ft	$910/ft	$11,721,000
Segment 12			
Open Cut 48" DIP (50% in road)	18,900 ft	$910/ft	$17,199,000
Segment 13			
Open Cut 48" DIP (50% in road)	17,850 ft	$910/ft	$16,244,000
Booster Stations			
Centerville – 2 MGD	1	$544,000 ea	$544,000
Hugo – 7 MGD	1	$769,000 ea	$769,000
Hugo – 5 MGD	1	$727,000 ea	$727,000
Lino Lakes – 8 MGD	1	$751,000 ea	$751,000
Easements/Land Acquisition	524,000 sf	$6/sf	$3,144,000
Environmental	24.5 miles	$50,000/mile pipe	$1,225,000
		Subtotal	**$219,686,000**
		Contingency (30%)	$65,906,000
		Eng/Admin/Legal (20%)	$43,937,000
		Total Alt 1C, Phase 2	**$329,529,000**

Table 3-6 Alternative 1C – Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines, and Lexington			
Item	**Units**	**Unit Cost**	**Total Cost**
Segment 14			
20" Directionally drilled HDPE (or open cut under trail)	37,900 ft	$400/ft	$15,160,000
Fusing Pits	54	$15,000 ea	$810,000
Segment 15			
10" Directionally drilled HDPE	9,500 ft	$225/ft	$2,138,000
Fusing Pits	14	$15,000 ea	$210,000
10" cased, tunneled pipe	250 ft	$900/ft	$225,000
Segment 16			
12" Directionally drilled HDPE	16,305 ft	$250/ft	$4,076,000
Fusing Pits	23	$15,000 ea	$345,000
Segment 17			
12" Directionally drilled HDPE	3,020 ft	$250/ft	$755,000
Fusing Pits	23	$15,000 ea	$345,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Segment 18			
12" Directionally drilled HDPE	5,000 ft	$250/ft	$1,250,000
Fusing Pits	7	$15,000 ea	$105,000
Booster Stations			
Circle Pines – 2 MGD	1	$570,000 ea	$570,000
Columbus – 1 MGD	1	$577,000 ea	$577,000
Forest Lake – 5 MGD	1	$748,000 ea	$748,000
Lexington – 2 MGD	1	$577,000 ea	$577,000
Easements/Land Acquisition	449,000 sf	$6/sf	$2,694,000
Environmental	13.7 miles	$50,000/mile pipe	$685,000
		Subtotal	**$31,520,000**
		Contingency (30%)	$9,456,000
		Eng/Admin/Legal (20%)	$6,304,000
		Total Alt 1C, Phase 3	**$47,280,000**

Table 4-1
Alternative 2B – New Surface WTP for Select NE Metro Communities

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000 ea	$3,461,000
40 MGD Surface Water Treatment Plant	1	$85,000,000 ea	$85,000,000
Segment 3			
Open Cut 30" (0% in road)	14,140 ft	$364/ft	$5,147,000
Segment 4			
Open Cut 30" DIP (100% in road)	14,500 ft	$908/ft	$13,166,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segment 5			
Open Cut 36" DIP (100% in road)	12,350 ft	$1,025/ft	$12,659,000
36" cased, tunneled pipe	400 ft	$3,000/ft	$1,200,000
Segment 6			
Directionally Drilled 18" HDPE	27,330 ft	$350/ft	$9,566,000
18" cased, tunneled pipe	250 ft	$1,250/ft	$313,000
Fusing Pits	39	$15,000 ea	$585,000
Segment 7			
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segments 8-1, 8-2			
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$591,000 ea	$591,000
White Bear Lake – 10 MGD	1	$801,000 ea	$801,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$151,088,000**
		Contingency (30%)	$45,326,000
		Eng/Admin/Legal (20%)	$30,218,000
		Total Alternative 2B	**$226,632,000**

Table 4-2
Alternative 2C – Phase 1 – New Surface WTP for Vadnais Heights, White Bear Lake, White Bear Township, and Shoreview (North St. Paul to SPRWS)

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
New 40 MGD Surface Water Treatment Plant	1	$85,000,000	$85,000,000
Segment 3			
Open Cut 48" (0% in road)	14,140 ft	$663	$9,375,000
Segment 4			
Open Cut 48" DIP (100% in road)	14,500 ft	$1,316	$19,082,000
48" cased, tunneled pipe	250 ft	$4,000	$1,000,000
Segment 5			
Open Cut 48" DIP (100% in road)	12,350 ft	$1,316	$16,253,000
48" cased, tunneled pipe	400 ft	$4,000	$1,600,000
Segment 6			
Open Cut 48" DIP (100% in road)	27,330 ft	$1,316	$35,966,000
48" cased, tunneled pipe	250 ft	$4,000	$1,000,000
Segment 7			
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segments 8-1, 8-2			
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$592,000 ea	$592,000
Shoreview – 13 MGD	1	$868,000 ea	$868,000
Vadnais Heights – 6 MGD	1	$727,000 ea	$727,000
White Bear Lake – 10 MGD	1	$801,000 ea	$801,000
White Bear Twp – 5 MGD	1	$606,000 ea	$606,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$194,070,000**
		Contingency (30%)	$58,221,000
		Eng/Admin/Legal (20%)	$38,814,000
		Total Alt 2C, Phase 1	**$291,105,000**

Table 4-3
Alternative 2C – Phase 2 – New Surface WTP for Hugo, Lino Lakes, and Centerville

Item	Units	Unit Cost	Total Cost
Fridley Pumping Station Upgrades	1	$10,000,000 ea	$10,000,000
Additional 60" Raw Water Conduit (50% in road)	42,000 ft	$1,196/ft	$50,232,000
20 MGD Lime Softening Water Treatment Plant Expansion	1	$30,000,000 ea	$30,000,000
Segment 9			
Open Cut 48" DIP (50% in road)	21,400 ft	$910/ft	$19,474,000
Segment 10			
Open Cut 48" DIP (100% in road)	16,000 ft	$1,316/ft	$21,056,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Segment 11			
Open Cut 48" DIP (50% in road)	12,880 ft	$910/ft	$11,721,000
Segment 12			
Open Cut 48" DIP (50% in road)	18,900 ft	$910/ft	$17,199,000
Segment 13			
Open Cut 48" DIP (50% in road)	17,850 ft	$910/ft	$16,244,000
Booster Stations			
Hugo – 7 MGD	1	$751,000 ea	$751,000
Easements/Land Acquisition	458,000 sf	$6/sf	$2,748,000
Environmental	24.5 miles	$50,000/mile pipe	$1,225,000
		Subtotal	**$182,249,000**
		Contingency (30%)	$54,675,000
		Eng/Admin/Legal (20%)	$36,450,000
		Total Alt 2C, Phase 2	**$273,374,000**

Table 4-4
Alternative 2C – Phase 3 – New Surface WTP for Forest Lake, Columbus, Circle Pines, and Lexington

Item	Units	Unit Cost	Total Cost
Segment 14			
20" Directionally drilled HDPE (or open cut under trail)	37,900 ft	$400/ft	$15,160,000
Fusing Pits	54	$15,000 ea	$810,000
Segment 15			
10" Directionally drilled HDPE	9,500 ft	$225/ft	$2,138,000
Fusing Pits	14	$15,000 ea	$210,000
10" cased, tunneled pipe	250 ft	$900/ft	$225,000
Segment 16			
12" Directionally drilled HDPE	16,305 ft	$250/ft	$4,076,000
Fusing Pits	23	$15,000 ea	$345,000
Segment 17			
12" Directionally drilled HDPE	3,020 ft	$250/ft	$755,000
Fusing Pits	23	$15,000 ea	$345,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Segment 18			
12" Directionally drilled HDPE	5,000 ft	$250/ft	$1,250,000
Fusing Pits	7	$15,000 ea	$105,000
Booster Stations			
Columbus – 1 MGD	1	$497,000 ea	$497,000
Forest Lake – 5 MGD	1	$727,000 ea	$727,000
Easements/Land Acquisition	403,000 sf	$6/sf	$2,418,000
Environmental	13.7 miles	$50,000/mile pipe	$685,000
		Subtotal	**$29,996,000**
		Contingency (30%)	$8,999,000
		Eng/Admin/Legal (20%)	$5,999,000
		Total Alt 2C, Phase 3	**$44,994,000**

Table 4-5
Alternative 2D – Conjunctive Use of Surface Water and Groundwater for Select Northeast Metro Communities

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000 ea	$3,461,000
15 MGD Surface Water Treatment Plant	1	$45,000,000 ea	$45,000,000
Segment 3			
Open Cut 24” (0% in road)	14,140 ft	$304/ft	$4,299,000
Segment 4			
Open Cut 24” DIP (100% in road)	14,500 ft	$811/ft	$11,760,000
24” cased, tunneled pipe	250 ft	$2,250/ft	$563,000
Segment 5			
Open Cut 30” DIP (100% in road)	12,350 ft	$908/ft	$11,214,000
30” cased, tunneled pipe	400 ft	$2,500/ft	$1,000,000
Segment 6			**$77,297,000**
Directionally Drilled 18” HDPE	27,330 ft	$350/ft	$9,566,000
18” cased, tunneled pipe	250 ft	$1,250/ft	$313,000
Fusing Pits	39	$15,000 ea	$585,000
Segment 7			
Open Cut 24” DIP (100% in road)	11,000 ft	$811/ft	$8,921,000
24” cased, tunneled pipe	250 ft	$2,250/ft	$563,000
Segments 8-1, 8-2			
10” Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12” Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12” cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			**$22,576,000**
Mahtomedi Booster/Mixing Station – 2.5 MGD	1	$1,100,000 ea	$1,100,000
Shoreview Mixing Station	1	$1,000,000 ea	$1,000,000
Vadnais Heights Mixing Station	1	$750,000 ea	$750,000
White Bear Lake Booster/Mixing Station – 10 MGD	1	$1,300,000 ea	$1,300,000
White Bear Twp Mixing Station	1	$750,000 ea	$750,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$109,271,000**
		Contingency (30%)	$32,781,000
		Eng/Admin/Legal (20%)	$21,854,000
		Total Alternative 2D	**$163,906,000**

Appendix D: Groundwater Modeling Methodology

Groundwater Modeling Methodology

All of the groundwater modeling results presented in this study were generated by the Twin Cities Metropolitan Area Groundwater Flow Model Version 3.0 (Metro Model 3). The model and documentation are available on the Metropolitan Council's website: *http://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Metro-Model-3.aspx*. The results represent steady-state analysis of the Prairie du Chien-Jordan aquifer, and are presented in terms of drawdown or recovery of the aquifer potentiometric head from a baseline condition.

The following paragraphs provide a summary of the primary modeling assumptions used to produce the results presented in this report.

Drawdown Calculations

- Modeling results used in this study represent drawdown from a baseline condition to a future scenario condition. The model was run in steady-state for each pumping scenario, as well as the baseline condition. The model output of aquifer potentiometric head for each scenario was subtracted from the aquifer potentiometric head resulting from the baseline pumping condition.
- The baseline pumping condition has been set at 2010 pumping, as recorded in the State Water Use Data System (SWUDS), which is maintained by the MN Department of Natural Resources. This baseline condition is similar in pumping intensity to that used in Metro Model 2 for modeling drawdowns presented in the 2010 Master Water Supply Plan, but sets the baseline pumping condition to a specific year.

Water Demand

- 2040 municipal average daily water demands were used for all future scenarios analyzed in this study. These projected values were calculated based on a per capita unit use coefficient method. The projection method used an average of per capita water use values for each municipal water system between 2000 and 2010. This average per capita value was multiplied by the projected population to be served by the water system in 2040 to calculate a projected average daily water use rate.
- 2040 non-municipal water use was assumed to remain constant at rates already represented in the calibrated steady-state Metro Model 3. The pumping rates in the calibrated stead-state Metro Model 3 are representative of the average pumping condition from 2003 - 2011. Additional information on the model calibration can be found in the Metro Model 3 report (*http://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Metro-Model-3.aspx*).

Well Locations & Sources

- Future municipal water supply source information was developed by Metropolitan Council based on information provided by communities in their local water supply plans. It was generally assumed that communities will install new wells in the most productive aquifer(s) currently used by that community but that no new wells will be constructed in the Mt. Simon-Hinckley aquifer.
- Future well locations were delineated by Metropolitan Council in cooperation with water supply work groups during the development of the Master Water Supply Plan in 2005-2010. Where the number and location of future wells was known by water supply utility staff, that information was included in the model. Where the number and location of future wells was unknown, the number of new wells was estimated based on projected demand and the average reported metro area pumping rate for each community's likely future source. The location of new wells was randomly distributed within a restricted area in each community.
- Projected 2040 municipal water use was assumed to be evenly distributed among all of the existing and future wells in each city.

Appendix E: Conjunctive Use Water Quality Memo

Date: June 6, 2014

To: Chris Larson - SEH
Colin Fitzgerald - SEH

From: Greg Harrington

Re: Evaluation of water quality issues for the Northeast Metro Water Supply Feasibility Assessment

The purpose of this memo is to provide you with my conclusions on the water quality aspects of delivering water from St. Paul Regional Water Services to the suburban communities in the northeast Twin Cities metro area. This is qualitative in nature.

Water quality issues will be driven by a number of factors, including the manner in which SPRWS water is delivered to the communities. The following are possible alternatives

- Abandonment of existing wells with complete conversion to water from SPRWS, or placement of existing wells onto a status of emergency use only.
- Mixing of existing well water with water from SPRWS prior to delivering SPRWS water into the distribution system. This memo only focuses on the water quality aspects of this approach, without covering how this would be done from a hydraulics or construction perspective, and without quantifying costs.
- Retaining existing wells and their entry points while introducing SPRWS water into the distribution system at a separate entry point. This memo does not attempt to identify the most plausible entry point of SPRWS water to each community's distribution system.

As noted later, the communities are strongly encouraged to implement the same distribution system disinfection strategy as SPRWS, which is likely to be chloramination for an extended period of time. For communities that switch from chlorination to chloramination, all three of these alternatives are technically feasible for reaching acceptable water quality targets and the best approach can be decided on a community-by-community basis. For example, those communities with existing treatment facilities for their groundwater sources may find the second option more feasible because they would give up a substantial capital investment to implement the first and third of the above alternatives and they have a potential centralized location to implement the second of the above alternatives. The distance of the community treatment plant from the SPRWS system may influence the decision as well. Those communities without existing treatment facilities may find the first and third options more feasible, due to the cost of reaching a centralized location for the second option.

All of the above could be performed by purchasing treated water from SPRWS or by purchasing untreated water from SPRWS and building a new water treatment plant. For purposes of this assessment, it was assumed that a new water treatment plant would have a similar set of treatment processes as the current SPRWS facility and, therefore, would produce water of similar quality to the existing treatment plant. Thus, this memo assumes that the water quality issues will be independent of the entity providing treated water from the chain of lakes. There are some implications to this assumption. For example, it assumes that SPRWS' ten wells, which are fed into the raw water pipeline between Vadnais Lake and the McCarron WTP, are included in both scenarios.

The remainder of this memo will cover water quality issues on a parameter-specific basis, giving consideration to the three alternative approaches noted above.

Waterborne Pathogens, Disinfection Byproducts and Disinfection

For all three alternatives noted above, the northeast metro communities will transition from rules focused on enteric viruses to rules focused on *Cryptosporidium*, *Giardia*, *Legionella*, *E. coli*, and enteric viruses. Most of the effort needed to manage these water quality concerns is done at the surface water treatment plant, so it is unlikely that the northeast metro communities will be directly involved in this aspect of regulatory compliance. However, the northeast metro communities will transition to a new water supply that has significant potential to form trihalomethanes (THMs) and haloacetic acids (HAAs) when free chlorine is used as a disinfectant. The northeast metro communities will need to continue the maintenance of a disinfectant residual in the distribution system. However, SPRWS meets these standards with chloramines as their distribution system disinfectant while the northeast metro communities currently use free chlorine as their distribution system disinfectant.

The difference in disinfectant raises a number of potential issues for the northeast metro communities. The first of these to consider is breakpoint chemistry, which accounts for the interaction between free chlorine, free ammonia, and chloramines. This chemistry will be explained in more detail in a follow-up report. For the purposes of this memo, this chemistry has implications for the blending of chloraminated SPRWS water with chlorinated water and the implications depend on the approach used to incorporate SPRWS water into the water supply:

- If the wells are abandoned or placed off-line for emergency purposes only, then the northeast metro communities are committing to a conversion from free chlorine to chloramines. With respect to breakpoint chemistry, there will be a short and temporary loss of disinfectant residual at locations in the distribution system. For a location that is one day of residence time downstream of the SPRWS entry point, this loss of residual would likely occur at approximately one day after the SPRWS water is turned on.
- If chloraminated SPRWS water is blended with chlorinated well water prior to distribution system, some loss of disinfectant will occur in the blending tank. To avoid this, it is strongly recommended that well water be introduced to the blending tank with no disinfectant applied upstream of the blending tank. Chlorine and ammonia should be added to the blending tank at a ratio needed to achieve a chloramine residual sufficient to survive the entire residence time of the distribution system.
- If chloraminated SPRWS water is introduced via a separate entry point from chlorinated well water, then there will be areas of the distribution system with little to no disinfectant residual. This will be a permanent issue, unlike the temporary issue associated with the first alternative. Although there are some utilities, notably in southern California, that follow this approach while complying with regulatory standards, it is strongly recommended that the northeast metro communities avoid this by converting to chloramines at the wells. Compliance monitoring for disinfectant residuals and coliform presence does not produce a sufficient number of samples to adequately capture the nature of the problem. Conversion to chloramines would require the installation of an ammonia feed system at each entry point to the distribution system.

As noted above, the northeast metro communities are advised to switch to chloramine disinfection once SPRWS water is introduced to the distribution system, regardless of approach used to implement SPRWS water. Of the three alternatives, the first would require less monitoring, offer easier control of chloramine residuals, and require the operation and maintenance of fewer chemical feed systems. However, all three are technically feasible and the best approach can be decided on a community-by-community basis.

Conversion to chloramines raises some additional water quality issues, to include but not be limited to the following:

- **Nitrification.** Nitrification is the conversion of free ammonia to nitrite by ammonia oxidizing bacteria (AOB). Although AOB are not pathogenic, the nitrite they produce can deplete the chloramine residual. This requires careful monitoring of disinfectant residuals, free ammonia residuals, and areas of the distribution system with long residence times. Data from SPRWS suggest that residence times of 10 days or longer are a significant concern. Implementation of distribution system hydraulic models can help identify areas of concern. Minimizing thermal stratification in storage tanks is an important strategy for managing nitrification events, and the communities will want to consider alternatives for doing this.
- **Microbial counts.** Conversion to chloramines can potentially introduce relatively high disinfectant residuals to areas of the distribution system having historically low disinfectant residuals. This may produce a temporary increase in microorganism counts as the system re-equilibrates to the new disinfectant. Again, careful monitoring is needed to manage this issue.
- **Corrosion chemistry.** The pipe surfaces in the distribution system will need to re-equilibrate to the new redox potential and this could lead to changes in corrosion of lead, copper, and iron pipe materials. Changes are difficult to predict. Although Washington DC was infamous for an increase in lead concentrations after converting from chlorine to chloramines, other utilities have made the conversion without such an issue. Careful monitoring will be needed to understand what changes take place and what control strategies are best implemented, with the understanding that time to equilibration may be more than a year.

- **Toxicity to fish.** The free ammonia present in chloraminated systems is of concern for residents with aquariums containing fish that are sensitive to free ammonia. The communities will need to implement a public education campaign to manage this concern.

Chloramination can be avoided if steps are taken at the treatment plant to remove more natural organic matter (NOM) that is present in the surface water. A sufficient amount of removal would be needed to keep THMs and HAAs below regulatory limits while using free chlorine as the distribution system disinfectant. This would require technologies at a significantly higher cost than currently used to achieve THM and HAA compliance. Implementation of this alternative would require regional cooperation on expectations for water quality and willingness to pay for that water quality.

Lead, Copper and Iron from Pipe Corrosion

As noted above, conversion from free chlorine to chloramines is expected to have some impact on lead, copper, and iron release from pipe corrosion. The concentration of these metals is also dependent on pH, alkalinity, hardness, sulfate concentration, and chloride concentration. For the northeast metro communities, a switch to water from SPRWS will come with a reduction in alkalinity and hardness, but with increased pH as well as increased sulfate and chloride concentrations.

As with the change in disinfectant, changes in these parameters are likely to have site-specific effects on the concentrations of lead, copper, and iron. A study in the Tampa Bay area showed that decreased alkalinity was associated with more iron release but with less lead and copper release. The same study showed that increased sulfate concentration was associated with increased iron release but decreased lead release.

These conflicting concerns suggest that utilities serving the northeast metro communities may wish to participate in some water quality monitoring and testing projects prior to implementation of SPRWS water. This could help utilities anticipate needed changes to corrosion control programs, especially the polyphosphate approach used by ten of the communities. It is important to note that equilibration may take more than a year for precipitation/dissolution processes like those encountered in metals release from pipe surfaces.

As noted earlier, the strategy employed for implementation of SPRWS water will influence changes in water quality. For example, abandonment of existing wells or blending of groundwater with surface water at the entry point to the distribution system will produce a change in water chemistry throughout the distribution system. Using separate entry points for surface water and groundwater will mitigate the widespread nature of the change, but will make changes more difficult to monitor and predict.

Hardness, Iron and Manganese from Source

At the present time, four communities provide oxidation and filtration for iron and manganese removal from their groundwater source and two of these also provide facilities for hardness removal. Eight communities use sequestration to limit iron and manganese precipitation in the distribution system. SPRWS water contains less hardness, iron and manganese than the groundwater sources at the northeast metro communities, which should benefit from this change.

Abandonment of existing wells or blending of groundwater with surface water at the entry point to the distribution system will allow communities using sequestration to abandon or reduce the need for that treatment strategy. A similar statement can be made for those communities using oxidation and filtration, although the costs of doing so may not be practical. Using separate entry points for surface water and groundwater will also reduce the costs of treating the groundwater source by oxidation/filtration or by sequestration.

Taste and Odor

Customers in the northeast metro communities can expect taste and odor properties to change for two reasons. First, many customers will detect a change in taste and odor due to the change in disinfection strategy. Second, there is a possibility that customers will notice the naturally-occurring tastes and odors associated with the surface water supply. The primary culprits for the latter are geosmin and methylisoborneol (MIB). SPRWS has done an extensive amount of work to reduce complaints associated with geosmin and MIB, with granular activated carbon as a key component of the treatment plant. Nevertheless, the communities will likely need to invest in a public education campaign to educate their customers about the change.

Conclusions and Recommendations

At this time, the primary conclusions and recommendations for implementing SPRWS water in the northeast metro communities are as follows:

- Blending chloraminated SPRWS water with chlorinated groundwater will create loss of total chlorine residual. The northeast metro communities are strongly encouraged to switch to chloramination for distribution system disinfection. Public education programs should be implemented to manage concerns with changing taste and odor properties of the water and with aquarium owners.
- Blending SPRWS water with groundwater will change the chemistry of the bulk water in the distribution system, and is expected to change release of lead, copper, and iron from pipe materials. The northeast metro communities are encouraged to participate in treatment studies that elucidate potential changes prior to implementation of SPRWS water.
- There are several alternatives for incorporating SPRWS water at each community:
    - Complete switch to SPRWS water
    - Blending groundwater with SPRWS water prior to the distribution system entry point.
    - Introducing SPRWS water and groundwater at separate entry points to the distribution system.
- The above alternatives should be considered on a case-by-case basis for each community, taking costs into consideration. All are capable of meeting accepted water quality targets, provided that the communities convert to chloramines.

Appendix F: Surface Water Treatment Rule & Process Train Description

Appendix F – Surface Water Treatment Rule and Process Train

The purpose of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is to reduce illness associated with the contaminant *Cryptosporidium* and other disease-causing microorganisms in drinking water. Pathogens, such as *Giardia* and C*ryptosporidium*, are often found in water, and can cause gastrointestinal illness (e.g., diarrhea, vomiting, cramps) and other health risks. In many cases, this water needs to be disinfected through the use of additives such as chlorine to inactivate (or kill) microbial pathogens.

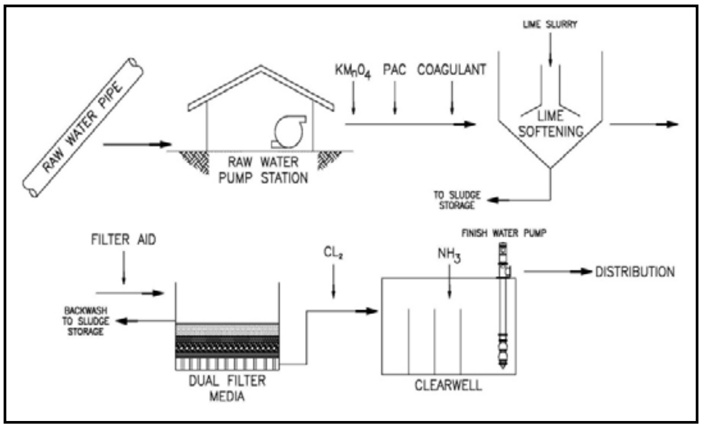
Cryptosporidium is a significant concern in drinking water because it contaminates surface waters used as drinking water sources, it is resistant to chlorine and other disinfectants, and it has caused waterborne disease outbreaks. Consuming water with *Cryptosporidium,* a contaminant in drinking water sources, can cause gastrointestinal illness, which may be severe in people with weakened immune systems (e.g., infants and the elderly) and sometimes fatal in people with severely compromised immune systems (e.g., cancer and AIDS patients).

The rule is intended to supplement existing regulations by targeting additional *Cryptosporidium* concentrations treatment requirements to higher risk systems. LT2ESWTR has the following major components:

- Source water characterization of *Cryptosporidium* concentrations based on a two-year long, monthly source water monitoring program for *Cryptosporidium,* E-Coli, and turbidity. The highest running annual average of the monitoring data will determine the bin classification for compliance.
- Bin classification for treatment requirements are shown in the Table below.
- Requirements presume that conventional treatment obtains 3.0 log removal and direct filtration obtains 2.0 log removal/inactivation of *Cryptosporidium.*
- Treatment requirements range from 0 to 2.5 log additional removal/inactivation of *Cryptosporidium* for systems utilizing conventional treatment resulting in 3.0 to 5.5 log total removal/inactivation of *Cryptosporidium.*
- Additional log removal credits may be achieved by utilizing multiple tools. The following list summarizes alternatives that may be implemented:
    - Watershed Control
    - Alternative Source
    - Pretreatment
    - Improved Treatment
    - Improved disinfection: Chlorine dioxide, ozone, UV
    - Peer review validation of system performance

Bin Classification	Crypto Concentration (oocysts/L)	Additional Treatment Requirements for Systems with Conventional Treatment
1	< 0.075	No Additional Treatment
2	From 0.075 - < 1.0	1 log of Additional Treatment (90%)
3	From 1.0 - < 3.0	2 log of Additional Treatment (99%)
4	≥ 3.0	2.5 log of Additional Treatment (99.7%)

The preliminary treatment process proposed for NE Metro assumes that the surface water supply will be classified as Bin 1. If additional treatment is required, a future UV and potential for chlorine dioxide addition can be implemented to assist in meeting additional treatment requirements.



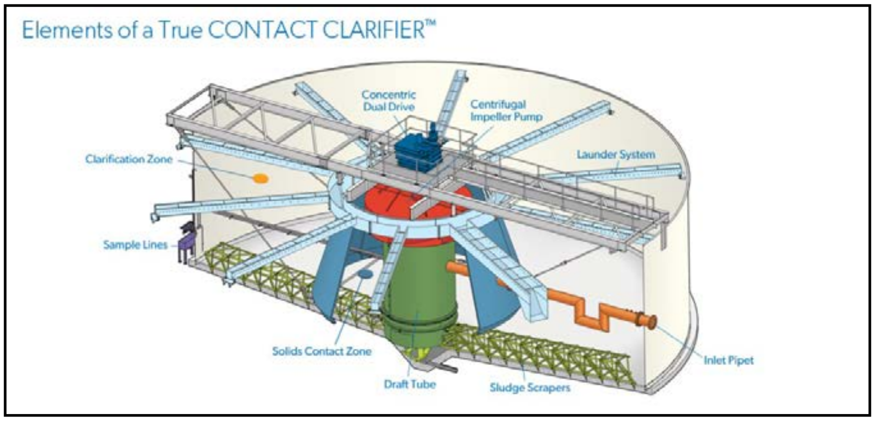
Process Train

As depicted in the process diagram, a potential process train to treat raw surface water from SPRWS includes raw water pumping, chemical addition, lime softening, filtration, and finished water pumping.

This process is very similar to other major surface water treatment plants in Minnesota including SPRWS, the City of Minneapolis, and the City of St. Cloud.

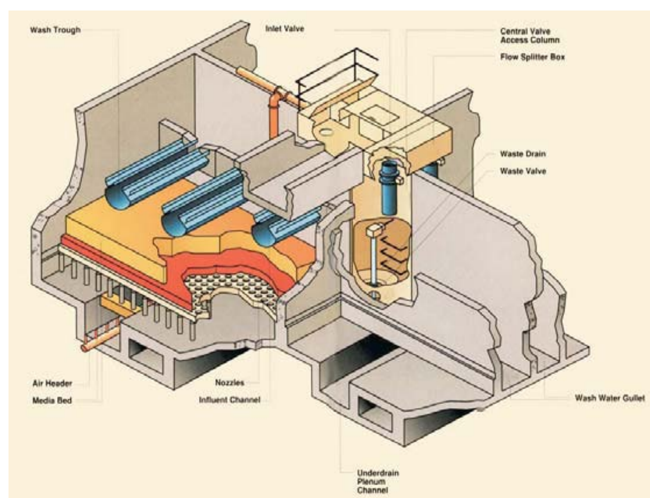
The chemical addition includes potassium permanganate (KMnO4) for oxidation, powdered activated carbon (PAC) for taste and odor, and coagulant to help with floc production.

Lime Softening



Lime softening is used to reduce hardness of water prior to filtration. In addition to removal of hardness from a drinking water supply, lime softening can also remove the following constituents including arsenic, barium, beryllium, chromium III, copper, fluoride, lead, mercury, cadmium, nickel and radionuclides. The softening step includes the addition of quick lime (CaO) which combined with water forms hydrated lime slurry ($Ca(OH)_2$) typically in the 5%-10% lime slurry. Hydrated lime can also be used if desired. The lime slurry reacts with CO_2 to form a calcium carbonate ($CaCO_3$) precipitate. The optimum pH is around 10.3. Magnesium precipitation in the form of magnesium hydroxide ($Mg(OH)_2$) requires a pH of 11-11.3. The solids contact clarifiers (SCC) combine mixing, flocculation and sedimentation in a single basin and is typically used for lime softening. The rapid mix time and surface overflow rate will typically govern the sizing of the Raw water and lime is mixed with previously formed lime slurry in a centrally located draft tube with impeller. The water then passes through zones where flocculation occurs followed by clarification. Clarified water is collected in radial effluent launders which direct flow to an effluent discharge pipe. After softening, water is recarbonated to "stabilize" the water. A portion of the solids collected at the bottom of the clarifier is recirculated and serves as a seed for coagulation/precipitation process with the raw water in the contact zone.

Conventional Filtration (Conv)



Conventional filtration is considered for its benefits in reduction of suspended particulates. Typical conventional filters used in water treatment are rapid, deep bed, dual media, gravity filters that utilize layers of both sand and anthracite for media. Typical depths are 12" sand and 24"-36" anthracite. Underdrains and or gravel provide the support necessary for the media. Some particles are removed simply by the mechanical process of interstitial straining. However, the filters are capable of removing particulates smaller than the interstices between filter particles. These particles are brought close enough to the surface of the media grains that inter-particle forces attach them to the media. The filter media arrangement allows for the larger particulates to be removed near the top of the media bed with the smaller particulates being retained deeper within the media bed. Typical loading rates range from 2 gpm/ft^2 to 4 gpm/ft^2. Gravity media filters require periodic backwashing depending on the pressure differential across the media. Typical backwash rates range from 12 gpm/ft^2 to 15 gpm/ft^2. The particulates removed in conventional filtration include microbial contaminants, turbidity, THM precursors, as well as those precipitates formed in pretreatment processes.

Appendix G: Study Area Characteristics

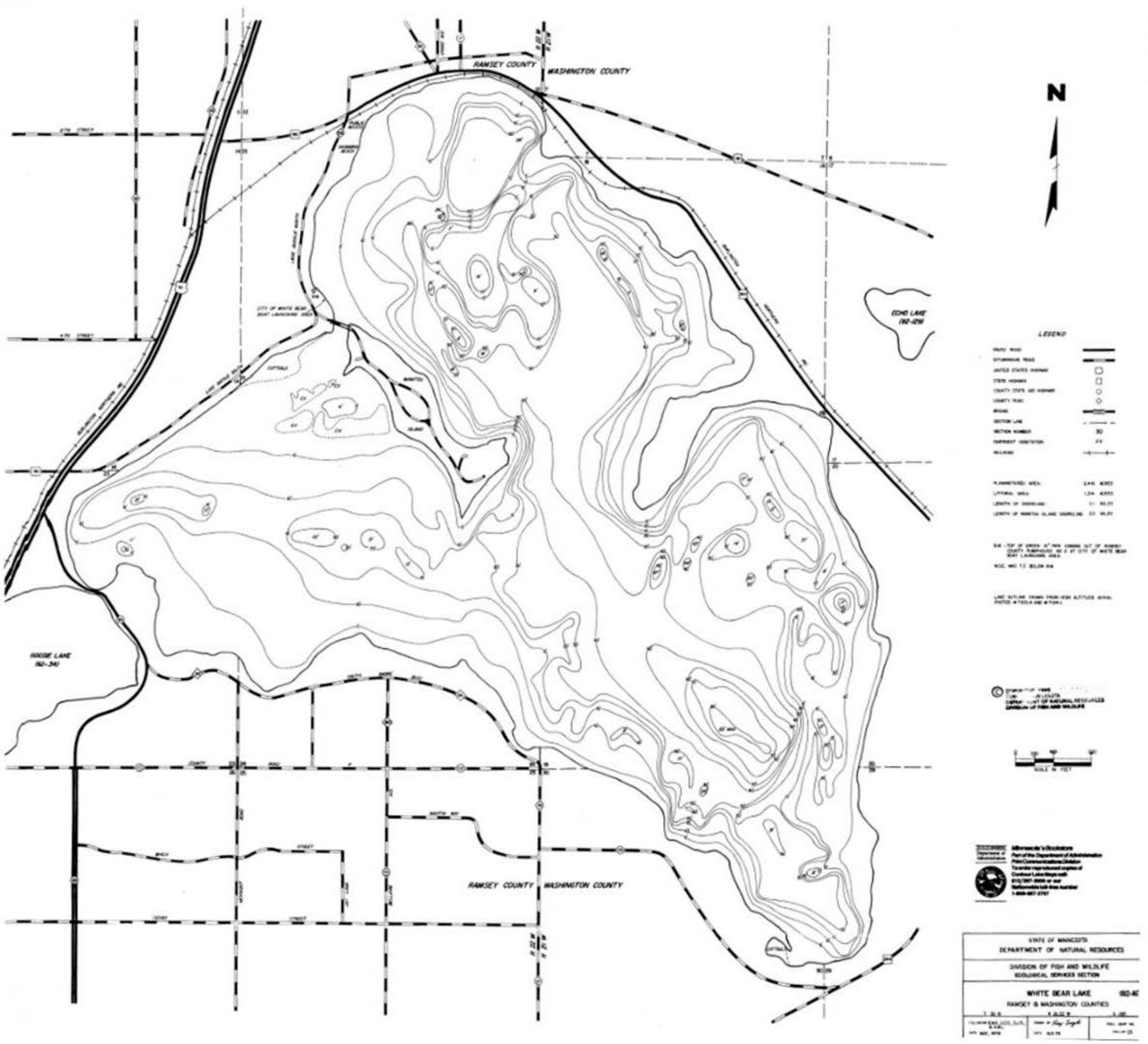
White Bear Lake Study Area Characteristics

White Bear Lake

The lake of interest, White Bear Lake (WBL), is located in Washington County, Minn. WBL has an area of 2127 acres with a maximum depth of 83 feet. An aerial map of WBL is shown below in Figure 1.

WBL has a record high water level of 926.7 feet as measured in 1943. The record low water level is 918 feet as measured in 2013. The ordinary high water level is 924 feet. The lake has a primarily sandy bottom and supports various plant and fish life.

Figure 1. White Bear Lake.



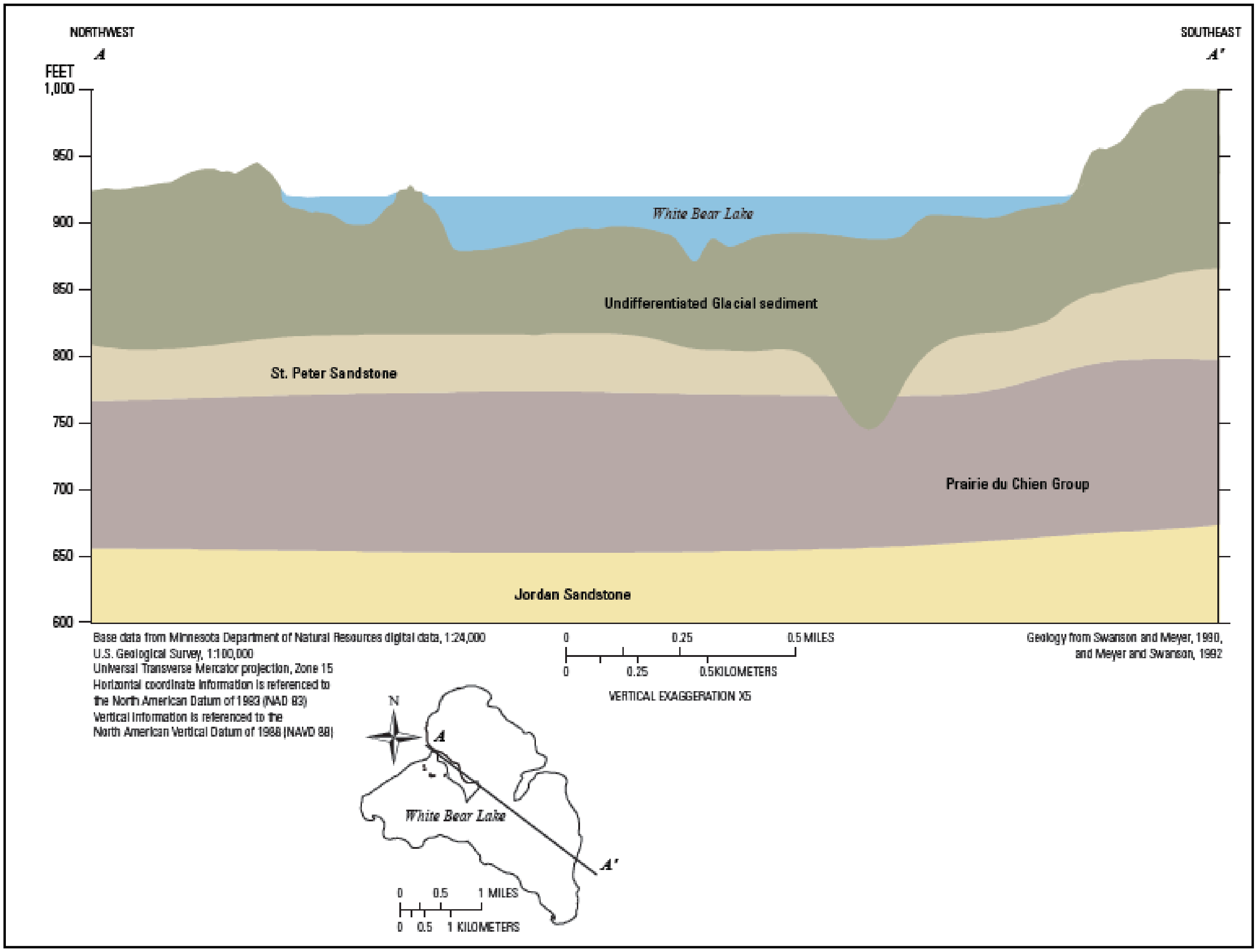
Parks and Recreation

White Bear Lake is used heavily for recreation by a variety of user groups. WBL offers opportunities for boating, fishing, paddling, swimming, and more. Multiple parks surround WBL and offer public swimming areas in the form of public beaches. These include: Memorial Beach Park, Bellaire Beach, Mahtomedi Beach, and other private beaches.

Geotechnical

White Bear Lake is part of a Chain of Lakes that were created by glacial scouring of bedrock and subsequent melting. Shallow geology about White Bear Lake consists of glacial till and outwash deposits. Regional bedrock units include the Glenwood Formation, St. Peter Sandstone, Prairie du Chien group, Jordan Sandstone, St. Lawrence Formation, Franconia Formation, Ironton and Galesville Sandstones, Eau Claire Formation, and Mt. Simon Sandstone. White Bear Lake lies in a bedrock basin that is overlain by glacial deposits. Immediately underlying the deposits are St. Peter Sandstone and the Prairie du Chien Group as shown in Figure 2.

Figure 2. Immediately underlying the deposits are St. Peter Sandstone and the Prairie du Chien Group.



Soils

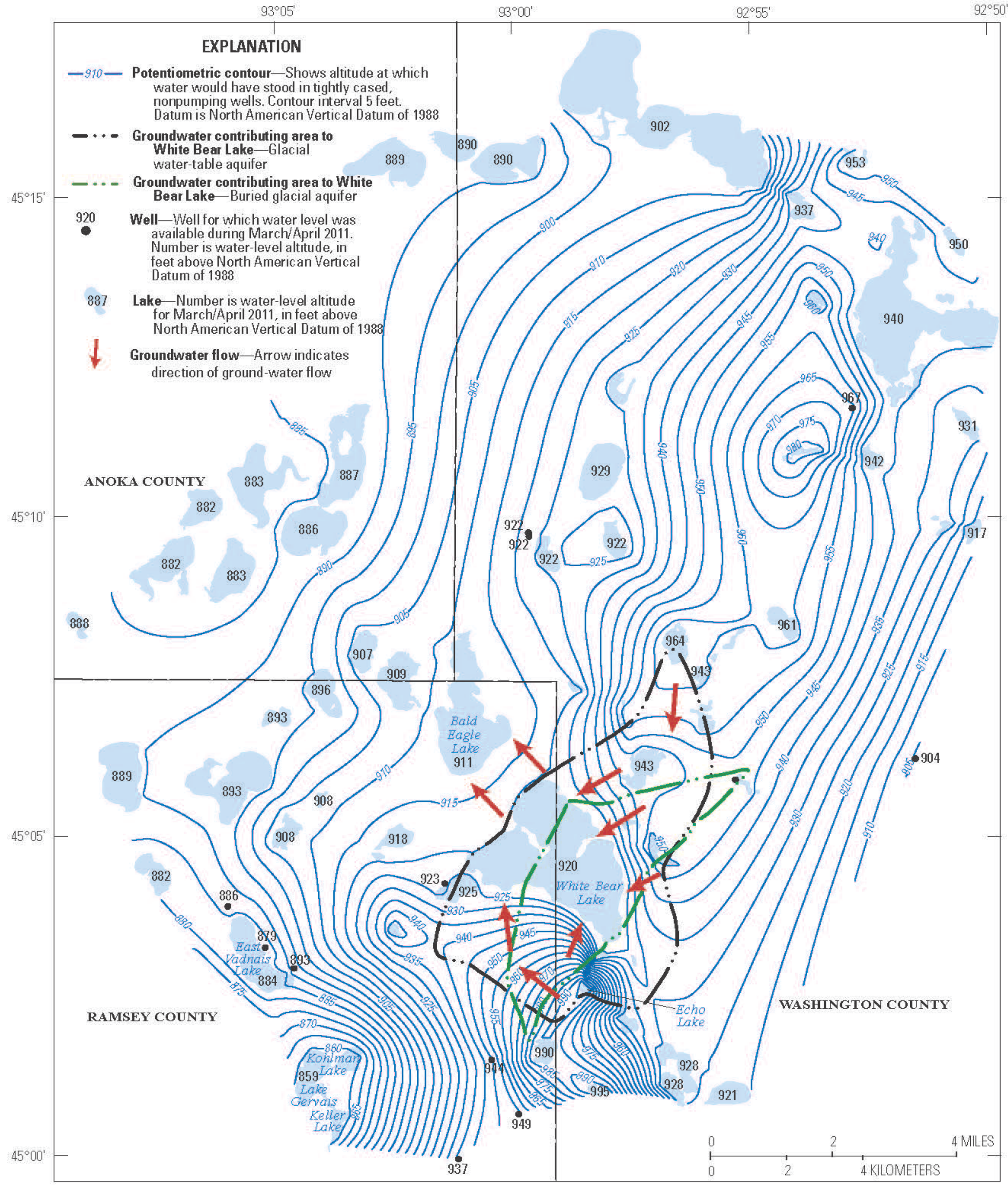
As part of construction of this project, a determination of soil types will need to be performed along the selected route. Water lines, sanitary sewer lines, railroad routes and highway routes are all affected by soil type. The following need to be performed as part of a preliminary geotechnical investigation:

1. Soil borings
2. Geotechnical laboratory testing
3. Report with foundation and other geotechnical recommendations for the facility footprint

Groundwater Resources

The St. Peter Aquifer is utilized to a minor degree for domestic water supply. Groundwater present in glacial till deposits flows toward White Bear Lake on all sides except for the northwest corner of the lake, where the flow path is routed northwest. Groundwater within the Prairie du Chien-Jordan lies at a regional elevation high northeast of White Bear Lake, centered approximately at School Section Lake. Groundwater flows outward from this point, flowing southwest past White Bear Lake. Groundwater within the Franconia Ironton Galesville and Mount Simon-Hinckley aquifers follows similar paths to that in the Prairie du Chien-Jordan aquifer. Figure 3, from the USGS Scientific Investigation report titled “Groundwater and Surface Water Interactions near White Bear Lake, Minnesota, through 2011”, shows the groundwater flow around the lake as well as local well sites.

Figure 3. Potentiometric surface of the glacial water-table aquifer and lake levels in the northeast Twin Cities Metropolitan Area, Minnesota. March/April 2011.



Base data from Minnesota Department of Natural Resources digital data, 1:24,000 and U.S. Geological Survey, 1:100,000
Universal Transverse Mercator projection, Zone 15
Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83)

Appendix H: Environmental Considerations

Environmental Considerations

A search of the Minnesota Pollution Control Agency's (MPCA) "What's In My Neighborhood" (WIMN) database was conducted to identify potential environmental concerns related to White Bear Lake augmentation pipeline route alternatives. Environmental database listings indicate environmental conditions which may negatively impact the construction of augmentation pipeline for portions of several route alternatives.

The MPCA's database was searched with a ¼ mile radius from each of the augmentation routes. The descriptions for the environmental conditions found at the sites are summarized below:

1. Petroleum Brownfield – Petroleum Brownfields are sites potentially contaminated with petroleum where the MPCA is helping buyers, sellers, developers or local governments to voluntarily investigate and clean up land for sale, financing or redevelopment.
2. Voluntary Investigation & Cleanup (VIC) – VIC sites are non-petroleum brownfields where the MPCA is helping buyers, sellers, developers or local governments to voluntarily investigate and clean up land for sale, financing or redevelopment.
3. Leak Site – Leak sites are locations where a release of petroleum products has occurred from a tank system. Leak sites can occur from above ground or underground tank systems as well as from spills at tank facilities.
4. State Assessment Site/Unpermitted Dumpsite – State Assessment sites are places the MPCA has investigated due to suspected contamination. They are assessed to determine if they pose a risk to human health or the environment. If so, they are referred to a cleanup program. Unpermitted dumps are landfills that were never permitted. Generally, they existed before the creation of the MPCA. They were not restricted to any type of waste but were often farm or municipal disposal sites that accepted household waste.
5. CERCLIS Site – A Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) site is a place suspected of being contaminated. Each site is investigated to determine if it needs to be elevated to a state/federal Superfund list.
6. RCRA Cleanup – A Resource Conservation and Recovery Act Cleanup (RCRA) site is a place where a business with a hazardous waste license or permit may have released hazardous waste to the environment. These sites are investigated to decide if cleanup is needed.

Solid Waste, Permit by Rule Landfill – A Permit-by-Rule landfill does not need to obtain a solid waste permit since it meets certain eligibility criteria. It must comply with waste management regulations. It is small and/or operates for a short time (<15,000 cubic yards/1 year).

Concept 1 – Mississippi River

All three Concept 1 alignments share a leak site in common. The leak site is located at Vadnais Heights Service, the proposed site for the intake structure.

Table 1. Concept 1-A Environmental Conditions Review.

Condition	No. of Occurrences
Leak Site	1
Multiple Activities	6
Petroleum Brownfield	0
Solid Wate, Permit By Rule	1
Voluntary Investigation & Cleanup (VIC)	2

Table 2. Concept 1-B Environmental Conditions Review.

Condition	No. of Occurrences
Leak Site	1
Multiple Activities	8
Petroleum Brownfield	0
Solid Waste, Permit By Rule	1
Voluntary Investigation & Cleanup (VIC)	4

Table 3. Concept 1-C Environmental Conditions Review.

Condition	No. of Occurrences
Leak Site	2
Multiple Activities	8
Petroleum Brownfield	1
Solid Waste, Permit By Rule	1
Voluntary Investigation & Cleanup (VIC)	4

Concept 2 – St. Croix River

There are two leak sites located along the proposed conveyance route from the St. Croix River intake at Marine on St. Croix to the outlet at White Bear Lake.

The first leak site is located just north of White Bear Lake at Bartylla Landscaping, Inc. The second is located east of Round Lake at Withrow Elementary School. Leak sites can lead to contaminated soil which increases the cost of construction for contaminated soil excavation and disposal. Further investigation of the constituents present in this soil would be required.

In addition, wetlands as described above in the “Route constraints” section need to be considered. Any wetlands that are disturbed as part of the construction of this project need to be protected during construction or mitigated.

Appendix I: Water Quality

Water Quality Considerations

The Minnesota Pollution Control Agency, Minnesota DNR, Ramsey County Public Works, the Citizen Lake Monitoring Program and MCES have monitored the water quality characteristics of White Bear Lake dating back to 1954. From the data available, the following conclusions can be made about the water quality in White Bear Lake: 1. White Bear Lake is a moderately clear lake (mesotrophic), indicating that WBL has not seen increased aging due to anthropogenic activity, 2. Nutrient levels (nitrogen and phosphorus) are low in WBL indicating there is no excess inflow of nutrients from agricultural or residential properties. This also indicates that WBL does not likely experience significant algal blooms in the summer months, and 3. The only indication of anthropogenic influences on WBL is a steady increase in chloride concentrations.

Saint Paul Regional Water Supply (SPRWS) pumps Mississippi River Water to the water supply's Chain of Lakes, which serve as raw water storage for SPRWS. Water quality characteristics of the river water through the Chain of Lakes and into the McCarron's treatment plant are monitored by SPRWS. The following conclusions can be made about the Mississippi River water, and subsequently, the water in the Chain of Lakes:

1. The Chain of Lakes acts as a clarification process for the intake at SPRWS, reducing turbidity, solids and coliform bacteria

2. The turbidity and solids concentrations in the Mississippi River are significantly higher than those in White Bear Lake, and less as the water moves through the Chain of Lakes.

3. Ammonia and Phosphorus levels in the Mississippi River or Chain of Lakes are not significantly elevated compared to White Bear Lake.

4. Nitrite/Nitrate concentrations are slightly elevated in the Chain of Lakes as compared to White Bear Lake.

Table 1. Constituent Concentrations in River & Lake Water.

Constituent	River Water	Raw WTP Water	White Bear Lake
Temperature °C	NA	20.11±4.38	17.88±4.71
Turbidity(NTU)	9.24±6.18	0.85±0.45	2.03±1.29
pH	8.17±0.25	8.11±0.12	8.24±0.2
Dissolved Oxygen (mg/L)	9.59±1.49	9.77±1.3	7.24±1.82
Total Phosphorus (mg-P/L)	0.06±0.04	0.02±0.01	0.03±0.02
Ammonia (mg-N/L)	0.12±0.03	0.07±0.12	0.06±0.16
Nitrate/Nitrite (mg-N/L)	0.47±0.14	0.26±0.12	0.02±0.01
Total Nitrogen (mg-N/L)	1.08±0.24	0.72±0.21	0.86±0.23
Total Coliform MPN Count/100 ml	1855.67±977.45	995.5±1154.71	211.78±341.21
E.Coli MPN Count/100 ml	42.5±20.76	0.5±0.71	46.55±229.43

If no filtration occurs prior to augmentation, White Bear Lake will likely experience an increase in turbidity and total suspended solids (TSS) concentrations due to the relatively high turbidity and TSS concentrations in the river water.

More complex interactions that could occur include the potential increased rate of eutrophication of White Bear Lake due to increased nutrient concentrations. While the nutrient concentrations in the augmentation water are not elevated to an extreme point of concern, it has been demonstrated that minor, seemingly meaningless increases in phosphorus and nitrogen or changes in the nitrogen to phosphorus ratio can lead to algal/cyanobaterial blooms (SITE). However, the relationship between nitrogen and phosphorus ratios and algal/ cyanobaterial growth is not linear and varies significantly by the lake being examined. Furthermore, while the Mississippi River does not typically experience excessive algal/cyanobacterial growth in the summer, the increased stagnation of the water in White Bear Lake may further support algal/cyanobacterial growth in White Bear Lake.

The biological diversity (both macro and micro) between the augmentation water and White Bear Lake is most likely very different. To date, little work has been done to determine the potential impacts. In this situation we can predict that Total Coliform bacteria will likely increase in White Bear Lake, as the augmentation water has a significantly higher concentration of Total Coliform counts. The filtration facility final design will consider the potential reduction of Total Coliform levels in the augmentation supply.

A screening model prepared by SEH, further demonstrated the effects of mixing augmentation water with White Bear Lake water. The total phosphorus to total nitrogen ratio (N:P) is used to determine which nutrient likely limits aquatic plant and algae growth in a water body. Phosphorus is the limiting nutrient when the ratio is greater than 16:1 and nitrogen is limiting when the ratio is less than 10:1. Water quality data for White Bear Lake indicate that the lake is a phosphorus limited system, as is common in Minnesota Lakes, with an N:P averaging about 46:1. When phosphorus is limiting production, small additions of the nutrient may cause dramatic increases in plant and algae growth and phosphorus should therefore be the focus of management efforts to control plant and algae growth.

The effects of the additional nutrient load from augmentation were simulated with the Wisconsin Lake Modeling Suite (WiLMS) program. The WiLMS is a collection of empirical lake models developed from statistical analyses of lake and reservoir systems and as such the results of the models more accurately predict the percentage of change rather than absolute values. Three of the models in WiLMS were a good fit to White Bear Lake: Canfield-Bachmann (1981) Natural Lake, Canfield-Bachmann (1981) Artificial Lake, and Rechow (1977) Water Load <50 m/yr.

Two augmentation scenarios were evaluated: the first was 2 billion gallons (Bgal) of water and the second was 4 Bgal of water, both sourced from Vadnais Lake in Ramsey County, MN. It was assumed that augmentation would occur from April through November. The growing season for phosphorus was assumed to be April through October. Results of the scenarios for both models are summarized in Table 2.

Table 2. Change in WBL Phosphorus Concentration with Addition of Augmentation Water.

Model Type	2 Bgal				4 Bgal			
	Conc. Before (ug/L)	Conc. After (ug/L)	% Change	Net Change (ug/L)	Conc. Before (ug/L)	Conc. After (ug/L)	% Change	Net Change (ug/L)
Canfield-Bachmann Natural Lake	24	22	6.9	2	24	21	13.8	3
Canfield-Bachmann Artificial Lake	24	21	13.8	3	24	21	13.8	3
Rechow Water Load <50 m/yr	24	25	5.7	1	24	25	5.7	1

The results of the WiLMS indicate that the augmentation water can be a net neutral impact on WBL, but should be closely monitored.

The augmentation system will include a filtration component to reduce the impact of solids and turbidity on the water quality of White Bear Lake. In addition, the filtration system will prevent the transfer of invasive species.

Based on the screening analysis performed as described above, treatment of the augmentation water will not be necessary. It is likely that phosphorus will be further reduced in the augmentation water during filtration.

While the temperature in the augmentation water is slightly higher than that of White Bear Lake, significant impacts are not expected.

Appendix J: Water Budget

White Bear Lake Water Budget

Model Development

A simple water budget model of White Bear Lake was created with Microsoft Excel in order to aid in selecting an augmentation flow rate and gauge its potential effects on lake levels. The development of the model's methods pulled heavily from two previously published works, the Minnesota DNR's "Lake-Ground Water Interaction Study at White Bear Lake, Minnesota" report published in 1998, and the USGS's "Groundwater and Surface-Water Interactions Near White Bear Lake, Minnesota, through 2011" report published in 2013. The model was created based on a water balance equation provided in the MnDNR's 1998 report on historical augmentation of White Bear Lake:

DL	**= P + RO – SO – E + GWex + PA**
DL	= change in water level
P	= direct precipitation
RO	= runoff volume from drainage area
SO	= volume of outflow surface outlet
E	= evaporation
GWex	= groundwater exchange
PA	= volume of pumped augmentation

The model generated expected water levels on a monthly basis given over a three year period, starting at the 2012 and 2013 average lake level elevation of 920 feet amsl and assuming variable values based on past trends. The above equation was also assessed using average the ten year averages of each of the parameters. A description of each variable's estimation is provided below.

<u>Direct Precipitation</u>

Monthly precipitation data recorded at the National Weather Service (NWS) station VADM5-218477 from 2003-2013 was averaged to provide an average precipitation rate for each month. Station 218477 lies approximately three miles from White Bear Lake, and is the closest station to the lake. The volume of precipitation added to the lake was calculated as the precipitation amount multiplied by the area of the lake at the current depth. Lake area was calculated as a function of lake storage, as described in the Stage Storage section below. Monthly precipitation values used are shown in Table 1. Data was obtained from the Minnesota Climatology Working Group's "Nearest Station Precipitation Data Retrieval" website (*http://climate.umn.edu/HIDradius/radius_new.asp*).

<u>Runoff</u>

Using the same method as the USGS's 2013 report, runoff was estimated based on a coefficient determined from the ratio of historical runoff to precipitation stated in the 1998 MnDNR's report. This coefficient, 0.19, was calculated based on the MnDNR's 1981-1990 runoff and precipitation data. This coefficient was multiplied by the area contributing surface water runoff to the lake, 3,087 acres, and the average monthly precipitation values.

<u>Surface Outlet</u>

A culvert with an invert elevation of 924.3 feet amsl is the only outlet from White Bear Lake. If the lake's water level were to rise above this elevation, a negative value proportional to the water level and the culvert's capacity would result; however, this variable was not included because the intention of the model was to determine the time at which augmentation would result in lake levels returning to this elevation.

Table 1. Average Monthly Evaporation Summary.

Month	Precipitation, in
January	0.71
February	1.19
March	2.06
April	3.10
May	4.62
June	4.62
July	3.70
August	3.89
September	3.24
October	2.86
November	0.99
December	1.73
Annual	**32.7**

Source: *http://climate.umn.edu/HIDradius/radius_new.asp*

Evaporation

Similar to precipitation data, pan evaporation data was obtained on a monthly basis from 2003-2013 and averaged by month. A pan evaporation coefficient of 0.75, which was provided in the USGS's 2013 report, was applied to the values. The volume of loss from the lake was taken as the pan evaporation multiplied by the pan coefficient and by the area of the lake at the current depth. Lake area was calculated as a function of lake storage, as described in the Stage Storage section below. Monthly evaporation values used are shown in Table 2. Evaporation data was obtained from the same source as the USGS's 2013 report, which was the Minnesota Climatology Working Group's St. Paul Campus Climatological Observatory (Cooperative station ID 21–8450–6) monthly pan evaporation database, located at *http://climate.umn.edu/img/wxsta/pan-evaporation.htm*.

Groundwater Exchange

Two groundwater exchange values were considered in this analysis. The MnDNR's WATBUD analysis in their 1998 report found that average groundwater loss in the 1930s when lake level augmentation was occurring was 33 inches per year. The other seepage value assessed was 19.2 inches, which was the groundwater exchange parameter calculated based on averaging White Bear Lake's water budget values over the last ten years. The volume of loss from the lake was calculated by multiplying the monthly groundwater loss rate by the area of the lake at the current depth. Lake area was calculated as a function of lake storage, as described in the Stage Storage section below.

Pumped Augmentation

Augmentation scenarios of pumping 6,000 gpm continuously for 8 months for a total of 2 BGY and 12,000 gpm for a total of 4 BGY were assessed. Pumping was not included for the four months between December and March to avoid ice issues.

Table 2. Average monthly evaporation summary.

Month	Evaporation, In
January	0.00
February	0.00
March	0.00
April	1.31
May	4.68
June	5.33
July	6.01
August	4.97
September	3.63
October	1.03
November	0.00
December	0.00
Annual	27.0

Months with "0" values did not have data provided for them; they were assumed to be zero since they represent winter months. Source: *http://www.dnr.state.mn.us/climate/wxsta/pan-evaporation.html*.

Stage Storage

Each of the variables described above was calculated as a volume contribution in acre-feet for each month. A stage storage analysis was provided in the MnDNR's 1998 report, and when fit with a second order polynomial trend line, resulted in a relationship of:

$Y = -7.6E\text{-}09*X^2 + 1.0E\text{-}2*X+892.5$

Y= lake elevation, feet

X= lake volume, acre-ft

Change in Water Level

The effect of each of the above parameters on White Bear Lake's water levels was assessed in two ways. First, a simplified water budget using the ten year averages for each of the variables was solved for the ten year average groundwater exchange parameter. This equation took the following form:

DL = P + RO – SO – E + GWex + PA

-5.3 inches/year = 32.7 inches/year + 8.2 inches/year – 0.7 inches/year – 26.97 inches/year + GWex

GWex= -18.5 inches/year

The results of the temporal water budget model are discussed in the below section.

Results of the Model

Results of the model should be interpreted with caution, and not used for any purpose other than developing a starting point for assessing the effects of lake augmentation.

Table 3 summarizes the time required to bring current lake levels up to 924 feet amsl given the varying pumping rates and seepage scenarios. Assuming augmentation with surface water would result in the same groundwater exchange parameter as augmentation using groundwater in the 1930s did, the low flow 2 BGY option would take approximately 4.5 years to restore White Bear Lake water levels. If the groundwater exchange parameter is unaffected by surface water augmentation, the same pumping scenario could result in restored lake levels as quickly as 1.9 years. A 4 BGY pumping scenario could have similar results in 1.4 years and 11 months respectively.

Table 3. Summary of White Bear Lake water budget findings.

Seepage Scenario (inches/year)	11	18.5	33
Time to fill with no augmentation (years)	>10 years	continued decrease	continued decrease
Time to fill with 4BG/yr (years)	0.8	0.9	1.4
Time to fill with 2BG/yr (years)	1.7	1.9	4.5

Appendix K: System Components

Lake Augmentation System Components

Figure 1. White Bear Lake Augmentation – Intake and Filtration at Vadnais Lake, Profile.

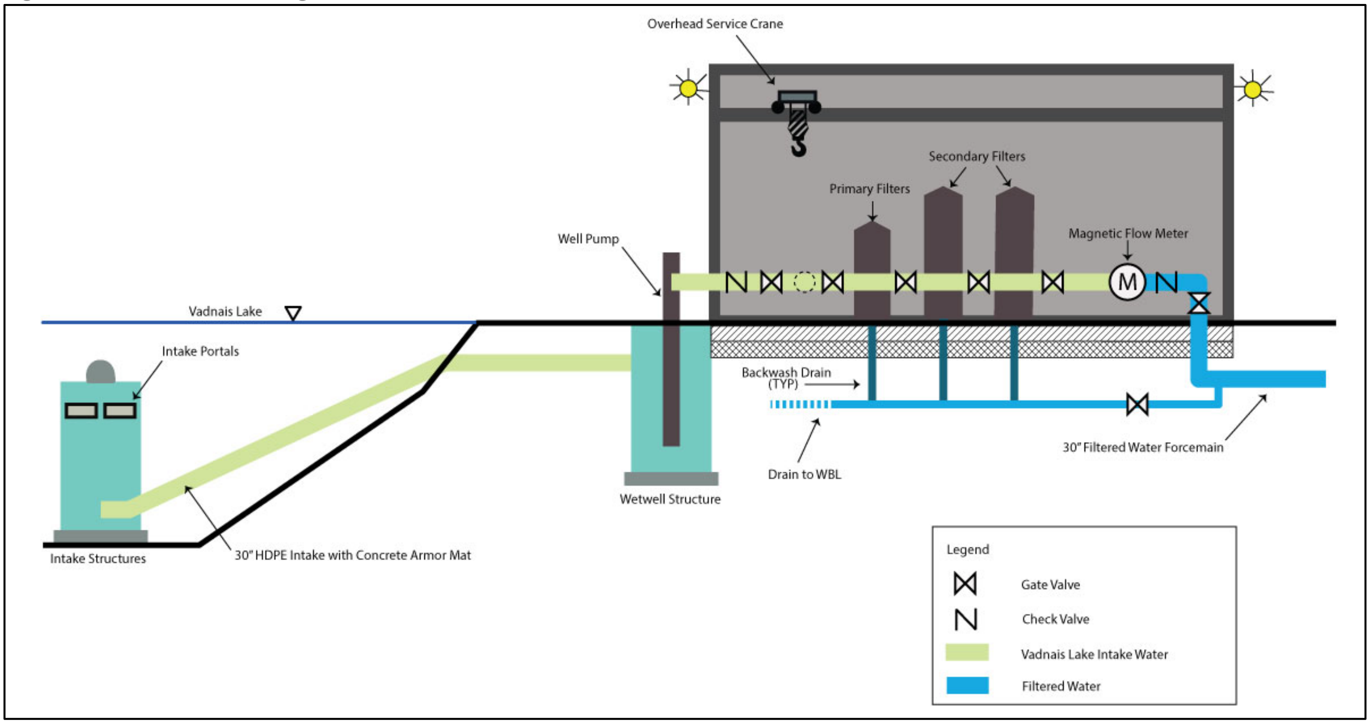


Figure 5-2. White Bear Lake Augmentation – Intake and Filtration at Vadnais Lake, Plan.

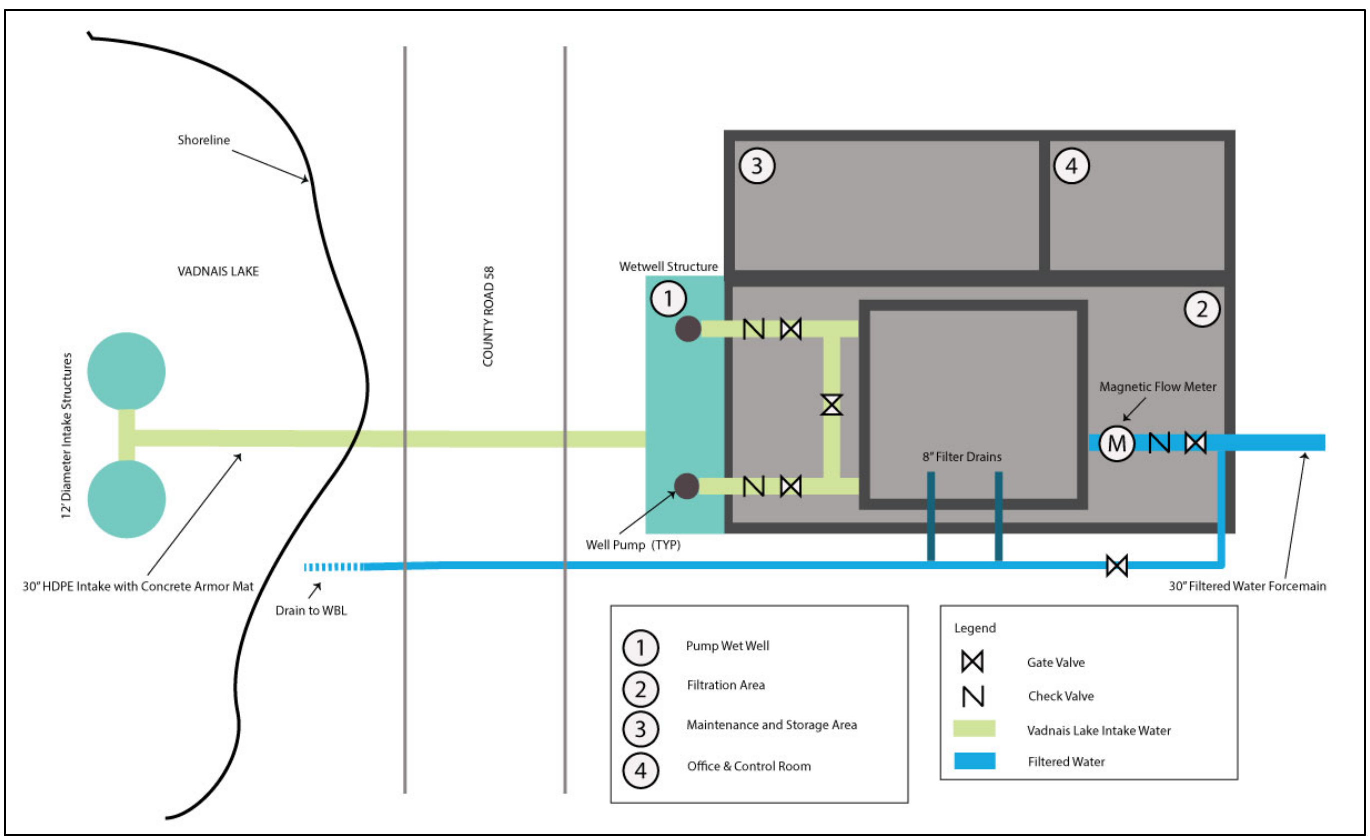
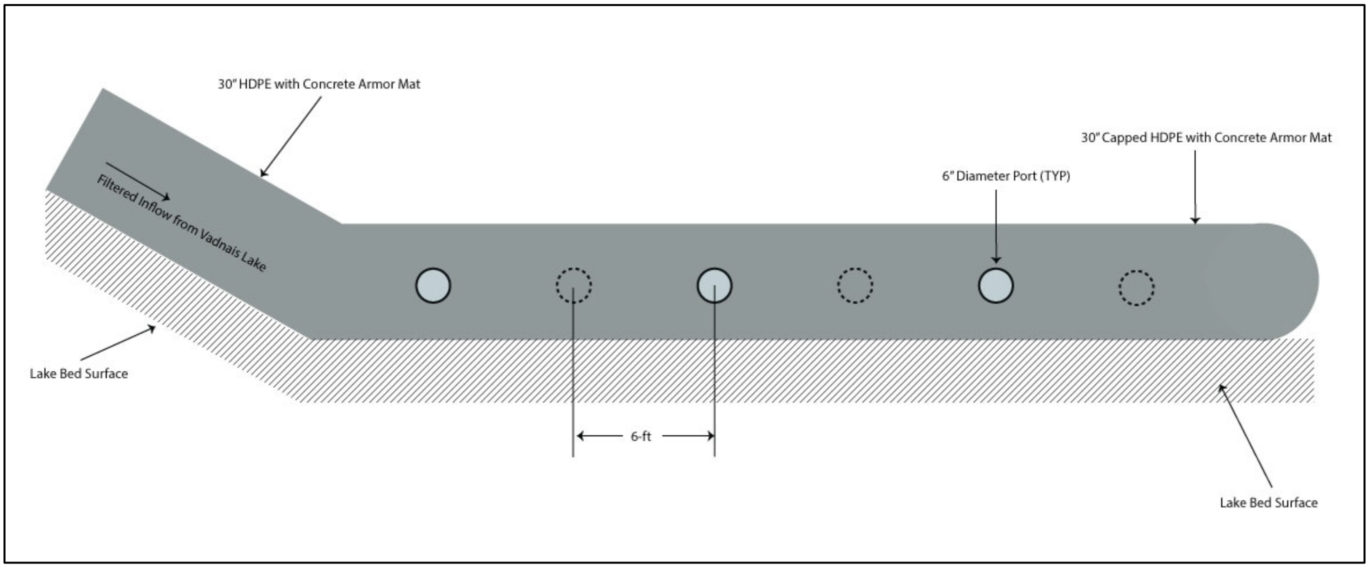


Figure 2. Outlet Structure at White Bear Lake, Profile



Appendix L: Route Characteristics

Lake Augmentation Route Characteristics and Route Constraints

Concept 1A – Vadnais Lake to White Bear Lake via BNSF Railroad Right-of-Way and County Road F (Cty 95)

Route Characteristics

This route includes pumping water from East Vadnais Lake to White Bear Lake via the Burlington Northern Santa Fe (BNSF) Railroad Right of Way and County Road F (Cty 95).

Raw water will be pumped from East Vadnais Lake using an intake structure that includes an intake, pumps, and filtration system as shown in Appendix J figures. The proposed 30-inch HDPE pipe would follow in the railroad right-of-way adjacent to Goose Lake Road (Cty 98) and cross under Interstate 35E under the existing I-35 bridge. Once it passes under the interstate, the alignment would continue in the BNSF Railroad Right-of-Way adjacent to Goose Lake Road (Cty 98).

The Route turns east to cross the Gem Lake Hills Golf Course and follows County Road F (Cty 95), crossing County Road 147, County Road 146, and US Highway 61 by means of tunneling. The alignment turns again to continue north along County Road 160, also known as Bellaire Avenue, through Bellaire Beach Park, and would discharge into White Bear Lake through the outlet structure shown in Appendix J.

Route Constraints

Permission will need to be granted by the Gem Lake Hills Golf Course by permanent easement to install pipe through the golf course. In addition, permission will need to be granted by the City of White Bear Lake to install pipe through the park at Bellaire Beach. Tunneling will need to be coordinated for the crossings of County Road 147, County Road 146 and US Highway 61.

Route constraints stem primarily from the easement use of the Railroad Right-of-Way. BNSF Rail is requiring that all forcemain installed in the Railroad Right-of-Way be installed in a steel casing. In addition, each square foot of land acquired in the right-of-way will add additional cost.

Concept 1B – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95)

Route Characteristics

This route includes pumping water from East Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95). The alignment is similar to that outlined in Concept 1A, however, this alignment does not include installing forcemain in the Railroad Right-of-Way.

Raw water will be pumped from East Vadnais Lake using an intake structure that includes pumps and a filtration system as shown in Appendix J. The proposed 30-inch HDPE pipe would follow the highway Right-of-Way of Goose Lake Road (Cty 98) and cross under Interstate 35E under the existing bridge. Once it passes under the interstate, the alignment would continue in the highway right-of-way of Goose Lake Road (Cty 98).

The Route turns east to cross the Gem Lake Hills Golf Course by permanent easement and follows County Road F (Cty 95), crossing County Road 147, County Road 146, and US Highway 61 by means of tunneling. The alignment turns again to continue north along County Road 160, also known as Bellaire Avenue, through Bellaire Beach Park, and would discharge into White Bear Lake through the outlet structure shown in Appendix J.

Route Constraints

Permission will need to be granted by the Gem Lake Hills Golf Course by permanent easement to install pipe through the golf course. In addition, permission will need to be granted by the City of White Bear Lake to install pipe through the park at Bellaire Beach. Tunneling will need to be coordinated for the crossings of County Road 147, County Road 146 and US Highway 61.

Concept 1C – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and Goose Lake

Route Characteristics

This route includes pumping water from East Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98), also known as Goose Lake Road, as described above. However, rather than the alignment running through the Gem Lake Hills Golf Course by permanent easement and meeting up with Highway 95, this alignment runs south of the Golf Course, crosses US Highway 61, and then traverses along the bottom of Goose Lake east of US Highway 61 before discharging into White Bear Lake through an outlet structure as described above.

Raw water will be pumped from East Vadnais Lake via an intake structure that includes pumps and a filtration system as shown in Appendix J. The proposed 30-inch HDPE pipe would follow the highway Right-of-Way of Goose Lake Road (Cty 98) and cross under Interstate 35E under the existing bridge. Once it passes under the interstate, the alignment would continue in the highway right-of-way of Goose Lake Road (Cty 98).

The route continues along the south side of the Gem Lake Hills Golf Course before turning north to follow County Road 147. The alignment runs north until County Road 147 meets County Road F (Cty 95), and then it runs east until it meets up with US Highway 61.

Route Constraints

This alignment offers a few constraints in addition to concept 1-B due to the construction of the alignment on the bottom of Goose Lake, as well as the US Highway 61 crossing. Construction of the forcemain pipe along the bottom of Goose Lake will require the issue of a DNR approved permit. An acceptable location will need to be determined for the pipe to be tunneled under US Highway 61 to reach White Bear Lake from Goose Lake.

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