Report to the Minnesota State Legislature: Concept Cost Report for Augmentation of White Bear Lake with Surface Water

Appendices

Minnesota Department of Natural Resources

February 2016

The Minnesota Legislature in the 1st Special Session of the 2015 Minnesota Session Laws appropriated $100,000 for the Minnesota Department of Natural Resources (DNR) Commissioner "to develop cost estimates, in cooperation with the Metropolitan Council, for the augmentation of White Bear Lake with water from the Sucker Lake Chain of Lakes." (S.F. No. 5, Art. 3, Sec. 3, Subd. 3). The law further stipulated that "The commissioner must submit a report with the cost estimates developed under this paragraph to the chairs and ranking minority members of the House of Representatives and Senate committees and divisions with jurisdiction over environment and natural resources policy and finance by February 1, 2016." This report has been prepared to satisfy this law.

The DNR prepared this report with assistance and cooperation from Metropolitan Council Environmental Services (MCES). MCES retained Short Elliott Hendrickson Inc. (SEH) to develop the augmentation concept, estimate capital and annual operations and maintenance costs, and identify future considerations that may affect costs. Peer reviews of the technical work were conducted by HDR, Inc. and Wenck Associates, Inc. Zan Associates assisted with report writing, report production, and ADA compliance with the final report documents.

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Estimated cost of preparing this report (as required by Minn. Stat. § 3.197) was:

Consultants:	$120,984
Metropolitan Council:	$75,000
Department of Natural Resources:	$22,431
Total:	$218,415

Contents

Appendix A: Hydraulic and Power Analysis

TECHNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Jessica Daignault, Project Engineer

DATE: January 20, 2016

RE: Hydraulic and Power Analysis
SEH No. MCES 124593 14.00

Introduction

Metropolitan Council Environmental Services (MCES) has retained Short Elliott Hendrickson Inc. (SEH) to complete the Concept Cost Report for Augmentation of White Bear Lake with Surface Water. Included as part of this report is the development of costs for two alternative alignments for the augmentation of approximately two (2) billion gallons (BG) per year of water into White Bear Lake (WBL). This Technical Memorandum (TM) summarizes the flow assumptions, and hydraulic and power analysis for each alignment.

The preliminary route alignment selection for an augmentation system for WBL was performed with the goals of handling assumed maximum flow criteria, attaining maximum efficiency, and developing accurate and comprehensive cost estimates. Two alternative alignments were selected using the Mississippi River as a source water supply: augmentation of WBL with Sucker Lake water, also known as the Sucker Lake Alternative (Alternative 1), and augmentation of WBL with East Vadnais Lake water, also known as the East Vadnais Lake Alternative (Alternative 2). Figure 1 provides an overview of the proposed alignments.

Projected Flows

The USGS is currently preparing a groundwater model which is planned to be completed at the end of September 2016. This model will be used by engineers and scientists to more accurately evaluate the impact of various scenarios, such as augmentation, on the level of White Bear Lake and its underlying aquifers. At the time this hydraulic analysis was performed, this information was not available. For the purposes of this concept cost report the pumping rate assumed for the augmentation facilities was set to match the 2 BG/year that was used in the Metropolitan Council's December 2014 report titled, "Feasibility of Approaches to Water Sustainability in the Northeast Metro". In addition, the historic record for the previous augmentation system typically operated around 2 BG/year.

Hydraulic Analysis

Operation of the augmentation facility was assumed to operate constantly for eight (8) months of the year and shutdown for four (4) months during the winter. This equates to approximately 6,000 gpm. A hydraulic analysis was performed for both alternative alignments, to determine the total head to overcome, brake horsepower required, and cost of power at the assumed flowrate. The Hazen-Williams equation was used to calculate friction head loss through each proposed system due to pipe length, diameter and material of pipe.

$$h_L = \frac{C_f L}{C^{1.852} D^{4.87}} Q^{1.852}$$

Minor losses are the result of velocity changes and increased turbulence through fixtures such as valves, tees, bends, reducers, and other fittings in the system. Minor losses through fittings were calculated using the following equation and then added to the friction headloss as calculated using the Hazen-Williams equation:

$$h_L = \frac{kv^2}{2g} n, n\ is\ number\ of\ fittings$$

Elevation head to overcome was determined by identifying the ultimate high and ultimate low points in the system. Total head was determined by adding the friction and elevation heads.

Table 1. Hydraulic Analysis					
Alternative	**Pumping Rate (gpm)**	**Diameter (in)**	**Pumping Rate (ft3/s)**	**Velocity (ft/s)**	**Total Head (ft)**
East Vadnais Lake	6000	30	13.37	3.54	133
East Vadnais Lake	6000	24	13.37	5.55	199
Sucker Lake	6000	30	13.37	3.54	134
Sucker Lake	6000	24	13.37	5.55	196

Power Analysis

Required horsepower was calculated based on an operational efficiency of 80 percent using the following equation:

$$bhp = \frac{Qh_L}{3960}$$

The cost of operation was determined using the calculated head to overcome assuming a cost per kilowatt-hour (kwH) of $0.06. Pumping duration is assumed to be eight (8) months per year to avoid operations issues to due ice and freezing temperatures.

The total energy cost presented in Table 2 shows an estimated annual energy cost for operation of the system for the two pipe diameters presented in this technical memorandum. Annual energy costs could vary from the costs presented in Table 2 due to differences in seasonal or time of day rates.

Table 2. Power Analysis					
Alternative	**Pumping Rate (gpm)**	**Diameter (in)**	**Horsepower (bhp)**	**Energy Cost/Hour**	**Annual Energy Cost**
East Vadnais Lake	6000	30	251.11	$11.28	$67,139
East Vadnais Lake	6000	24	376.31	$16.90	$100,589
Sucker Lake	6000	30	254.10	$11.41	$67,912
Sucker Lake	6000	24	370.95	$16.66	$99,160

Conclusion
A 30-inch pipe was selected for both alignments because the velocity was between two and five feet per second. At two feet per second or greater the water flows fast enough to scour the pipe and minimize sediment in the pipe. At velocities greater than five feet per second energy costs become unreasonable.

There is no substantial difference in total annual energy cost between the two alternative alignments.

Attachment – Figure 1

jkd

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Project: MCES 134593
Print Date: 1/6/2016

Map by: LO
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

0 900 1,800 3,600 5,400 7,200 Feet

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Concept System Alternatives

Figure 1

Appendix B: Geologic and Soils Review

MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Brent Theroux, PE

DATE: November 24, 2015

RE: Review of Surficial Geology and Organic Soils along White Bear Lake Augmentation Alternative Alignments
SEH No. 134593 14.00

This memorandum has been prepared to summarize the review of surficial geology and organic soils as it relates to the Concept Cost Report for Augmentation of White Bear Lake with Surface Water. The findings of this memorandum were used to establish more optimum alignments and identify areas with poor soils to better understand the related costs along the alignments.

Two (2) alternatives have been developed for augmentation of White Bear Lake (WBL): The Sucker Lake Alternative (Alternative 1) withdrawals water from Sucker Lake and the East Vadnais Lake Alternative (Alternative 2) withdrawals water from East Vadnais Lake. The purpose of this memorandum is provide a desktop review of the surficial geological conditions along each alternative, with a focus on areas where organic soil deposits could be encountered. Organic soils are considered to include peat, organic silt, organic clay, and other deposits of organic-based material. For the purpose of this memorandum, the nominal depth of the augmentation pipeline is assumed to be in the range of 8 to 15 feet below existing ground elevations.

The following documents were reviewed in preparing this memorandum:

- Ramsey County Geologic Atlas (Plate 3 – Surficial Geology)
- Soil boring logs prepared by American Engineering Testing for MCES (1992)
- Soil boring logs prepared by Geo Engineering Consultants for MCES (2001)
- Soil boring logs prepared by Stork Twin City Testing for MCES (2001)
- Soil boring logs prepared by GME Consultants for MCES (2004, 2005)
- Soil boring logs prepared by Braun Intertec for MCES (2005)
- Construction Plans for TH 61 between County Road E and TH 96 by MnDOT (1956)

Alignments

The Sucker Lake Alternative (Alternative 1) would connect Sucker Lake to WBL. The alignment begins on the east shore of Sucker Lake, within the Sucker Lake County Park, and runs northward to County Road 96. The alignment then follows County Road 96 eastward, crosses beneath I-35-East (I-35E), turns south along Otter Lake Road, turns east along Whitaker Street, continues east beneath Minnesota State Highway 61, turns southeast along Old White Bear Avenue, and finally terminates in Lions Park in the west bay of WBL. Figure 1 provides an overview of the proposed Sucker Lake Alternative alignment.

The East Vadnais Lake Alternative (Alternative 2) would connect East Lake Vadnais to WBL. The alignment begins at the far east shoreline of East Lake Vadnais, near the intersection of Vadnais Boulevard and Centerville Road. The alignment follows Centerville Road northeastward toward I-35E, continues beneath I-35E along Goose Lake Road, turns south and follows Otter Lake Road, turns north along Hoffman Road and west side of Goose Lake, continues east beneath Minnesota State Highway 61 and along White Bear Avenue, and finally terminates in Lions Park on the west bay of WBL. Figure 2 provides an overview of the proposed East Vadnais Lake Alternative alignment.

Sucker Lake Alternative (Alternative 1)

The beginning of Alternative 1, on the east side of Sucker Lake, is situated within coarse glacial meltwater sediments. The meltwater sediments transition to glacial till at McMenemy Street. The glacial till encompasses the alignment from McMenemy Street to approximately White Bark Parkway, which crosses County Road 96 east of I-35E. From White Bear Parkway, and extending all the way to WBL, the surficial geology is dominated by post-glacial sandy lake sediments. In Lions Park and close to WBL, the sandy lake sediments have been found by soil boring investigations to be interbedded at variable depths with buried organic soils and soft lacustrine (clay and silt) deposits.

From	To	Surficial Geology Unit	Estimated Soil Conditions
Sucker Lake	McMenemy St.	Coarse Glacial Meltwater Sediment	coarse sand, in some areas covered by glacial till of variable thickness
McMenemy St.	White Bear Pkwy	Glacial Till	sandy loam, some clay loam and silty clay
White Bear Pkwy	Lions Park (WBL)	Post-Glacial Sandy Lake Sediment	fine to medium sand, in some areas may be underlain and interbedded with deposits of organic soils and soft clay and silt

Plate 3 of the Ramsey County Geologic Atlas identifies isolated deposits organic soils at the following locations along the Alternative 1 alignment:

- Eastern shoreline of Sucker Lake
- South side of County Road 96, approximately between East Gilfillan Road and the Burlington Northern Santa Fe (BNSF) railroad tracks
- South side of County Road 96, approximately between Bramblewood Avenue and Birch Ridge Road
- Along Whitaker Street, approximately between Margaret Street and Minnesota State Highway 61
- Lions Park on WBL

East Vadnais Lake Alternative (Alternative 2)

The beginning of Alternative 2, at the east tip of East Vadnais Lake, lies within a large lacustrine deposit of varved silt and clay. The lacustrine deposit extends from East Vadnais Lake to approximately County Road E. The Atlas indicates a long, thin band of sandy lake sediment (possibly an old beach remnant), striking southwest-northeast that cuts through the lacustrine deposit; Centerville Road approximately follows this band of sandy lake sediment. The sandy lake sediment persists along the alignment from north of County Road E to the intersection of Goose Lake Road and Labore Road. East of Labore Road and extending to roughly Otter Lake Road, the soils transition to meltwater sediments consisting of medium to coarse sand. From the Goose Lake Road/Otter Lake Road intersection, and extending all the way to WBL, the surficial geology is dominated by old sandy lake sediments. In Lions Park and close to

WBL, the sandy lake sediments have been found by soil boring investigations to be interbedded at variable depths with buried organic soils and soft lacustrine (clay and silt) deposits.

From	To	Surficial Geology Unit	Estimated Soil Conditions
Lake Vadnais	County Road E	Lacustrine with Sandy Lake Sediment	varved silt and clay, with fine sand
County Road E	Labore Road	Post-Glacial Sandy Lake Sediment	fine to medium sand, with silt and clay
Labore Road	Otter Lake Road	Glacial Meltwater Sediments	medium to coarse sand, some cobbles and boulders
Otter Lake Road	Lions Park (WBL)	Post-Glacial Sandy Lake Sediment	fine to medium sand, in some areas may be underlain and interbedded with deposits of organic soils and soft clay and silt

Plate 3 of the Ramsey County Geologic Atlas identifies isolated deposits of organic soils at the following locations along the Alternative Two alignment:

- West of the Centerville Road/Goose Lake Road intersection along the west side of I-35E
- East side of Hoffman Road, from approximately 100 feet to 1000 feet north of Scheuneman Road
- West side of Hoffman Road, from approximately White Bear Avenue to 800 feet south of White Bear Avenue
- Lions Park on WBL

Summary

The published surficial geologic conditions along both alternatives identify a mix of soil conditions. Alternative 1 passes through areas of coarse meltwater sediment, glacial till, and generally sandy lake-deposited soils. Alternative 2 passes through lacustrine soils, coarse meltwater sediment, and generally sandy lake-deposited soils. Isolated areas of organic soils also exist along both alignments. Closer to the proposed augmentation point at Lions Park along WBL, the surficial sandy lake-deposited soils have been found by previous investigations to be interbedded with buried organic soils and soft lacustrine clay and silt. The investigations indicate these conditions to exist as far west as the intersection of Hoffman Road/White Bear Avenue and Minnesota State Highway 61, as far northwest as the intersection of Whitaker Street and Lincoln Avenue, and as far south east as the intersection of White Bear Avenue and South Shore Boulevard.

The limits of surficial geology conditions presented in this memorandum are approximate and based on our review of the referenced documents. The actual subsurface conditions encountered along either alternative alignment may vary from those described herein.

Attachments – Figures 1 and 2

c: Don Lutch
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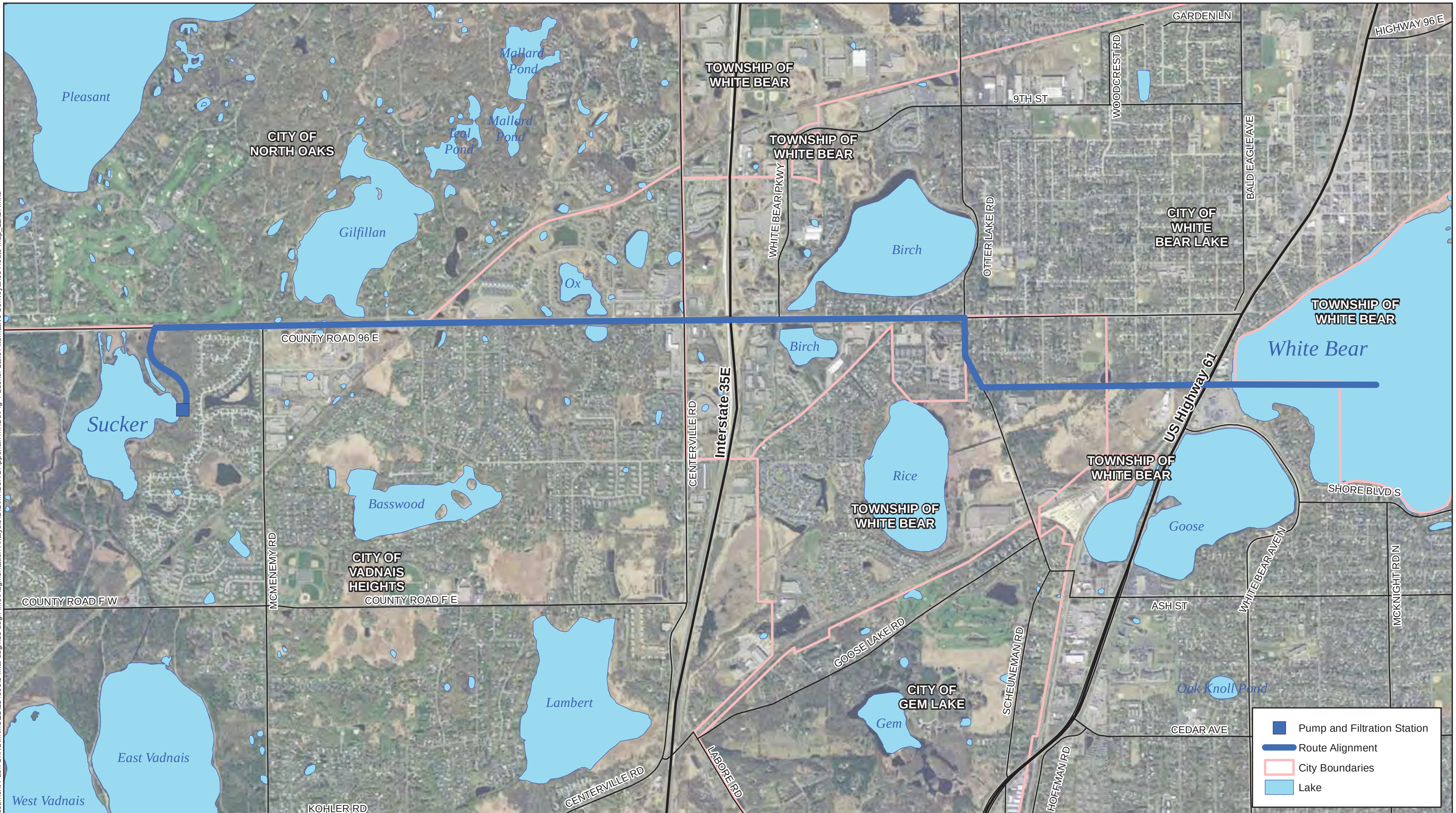

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Map by: LO
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

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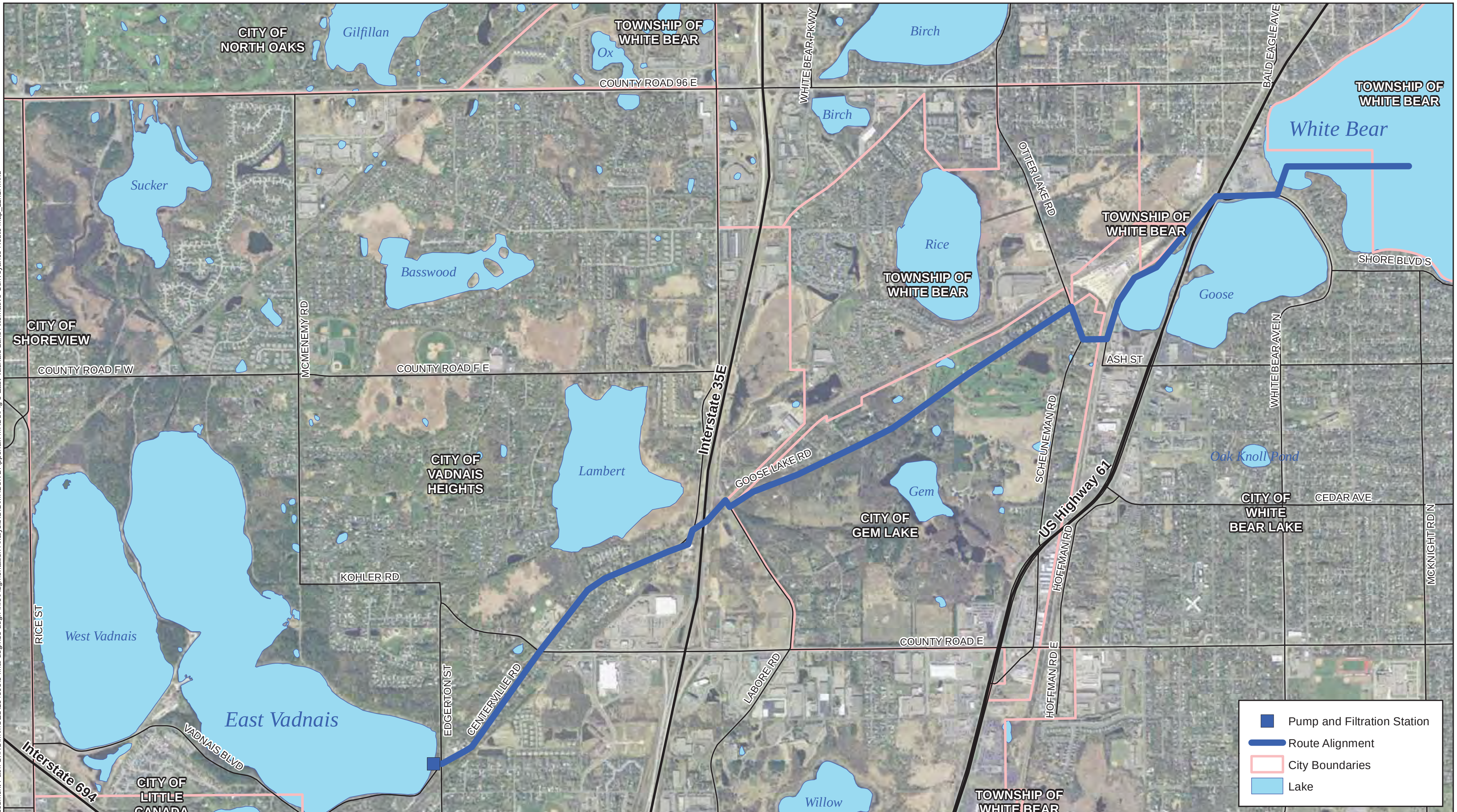
Sucker Lake Alternative Conveyance Route

Figure 1



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0 850 1,700 3,400 5,100 6,800 Feet

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East Vadnais Lake Alternative Conveyance Route

Figure 2

Appendix C: Contaminant Site Inventory Review Summary

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MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Jessica Daignault, Project Engineer

DATE: January 5, 2016

RE: Contaminant Site Inventory Review Summary
SEH No. MCES 124593 14.00

The following summary provides an abridged version of the Contaminant Site Inventory Technical Memorandum which is presented in its entirety in Appendix D.

Overview

A contaminated site inventory was conducted to determine the potential contaminated materials issues that may be encountered during construction activities along each alignment and how that would impact costs. The research targets identifying potential soil, groundwater, and soil vapor contaminated sites within the “project corridors.” The project corridors include parcels partially or wholly included in a buffer area that extends 500 feet from the two alignment options.

This Contaminant Site Inventory Review included a desktop review of the project area and a site reconnaissance. The analysis was limited to the following research tasks listed below:

- Review of contaminated site information available from the MPCA What’s in my Neighborhood (WIMN), Minnesota Department of Agriculture (MDA) WIMN and Petroleum Remediation Program (PRP) websites
- Limited review of the MPCA Spill sites
- Historic aerial photograph review (1947, 1957, 1966, 1980, 1991, 2003, 2004, 2008, 2009, 2011)
- Historic topographic map review (1902, 1910, 1918, 1943, 1954, 1959, 1965, 1969, 1973, 1981, 1987, 1993)
- Review of available Solid Waste, Voluntary Investigation and Cleanup (VIC), Petroleum Brownfield, and Leak Files.
- Review of located monitoring and abandoned wells available on the Minnesota Department of Health (MDH) County Well Index (CWI) website.
- Site reconnaissance to identify suspect existing conditions and observable past uses that may impact the project.

The following categories of “low,” “medium,” and “high” risk were used to rank sites within the alignment corridors. Rankings may not adhere directly to the definitions below if information obtained during the review justified lowering or raising the rank level.

- Low Risk – Hazardous and/or petroleum substances are known or inferred to have been, or are being used, stored or generated on these sites; however, there appear to be “good housekeeping” practices conducted on the site. Good housekeeping practices are defined as proper handling and/or storage of hazardous or petroleum substances. There is also no record or evidence of spills, releases, surface contamination and/or subsurface contamination at the site.
- Medium Risk – Hazardous substances are known or inferred to have been, or are being used, stored, or generated on these sites, and there appears to be “poor housekeeping” practices conducted at the site. Poor housekeeping practices are defined as improper handling and/or storage of hazardous or petroleum substances. All properties that have underground storage tanks (USTs) or above ground storage tanks (ASTs) and leaking underground storage tank (Leak) sites that have received closure from the Minnesota Pollution Control Agency (MPCA), and vehicle repair and maintenance facilities are also considered medium risks.
- High Risk – These are sites where hazardous and/or petroleum substances are known or inferred to have been, or are being used, stored, or generated, and there is a record or evidence that a spill, release, surface contamination and/or subsurface contamination has occurred. These sites include all active Voluntary Investigative and Cleanup (VIC), Minnesota Environmental Response & Liability Act (MERLA), active Leak sites and all active and inactive dump sites.

Sucker Lake Alternative (Alternative 1)

The Sucker Lake Alternative (Alternative 1) project corridor extends from Sucker Lake to White Bear Lake along CSAH 96 with mostly undeveloped, residential, and commercial properties. The contaminant site inventory review identified 6 high risk, 23 medium risk, and 20 low risk sites within the alignment buffer area for Alternative 1. High, medium, and low risk sites are shown on Figure 1.
Historically, fill of unknown origin was commonly placed in low lying areas along this transect throughout the mid-century. Significant filling of low-lying marshy areas and ponds was completed during this time prior to the construction of Highway 96. There are eight (8) sites that had historic fill of unknown origin. Site contamination summaries and detailed map books with labeled parcels are provided in Appendix D.

East Vadnais Lake Alternative (Alternative 2)

The East Vadnais Lake Alternative project corridor extends from the south east corner of the East Vadnais Lake near Centerville Road and is generally aligned along the BNSF Railroad on Centerville Rd (County Road) and crossing under the railroad and going northeast on Goose Lake Road (County Road) and extends toward Goose and White Bear Lakes. In this area the railroad has been active since at least 1902 and a former rail yard was located along White Bear Parkway. Historically, more industrial activity has occurred along this alignment. There are 8 high risk, 16 medium risk, and 17 low risk sites identified. High, medium, and low risk sites are shown on Figure 2. Site contamination summaries and detailed map books with labeled parcels are provided in Appendix D.

jkd
Attachments- Figures 1 and 2

c: Don Lutch, SEH

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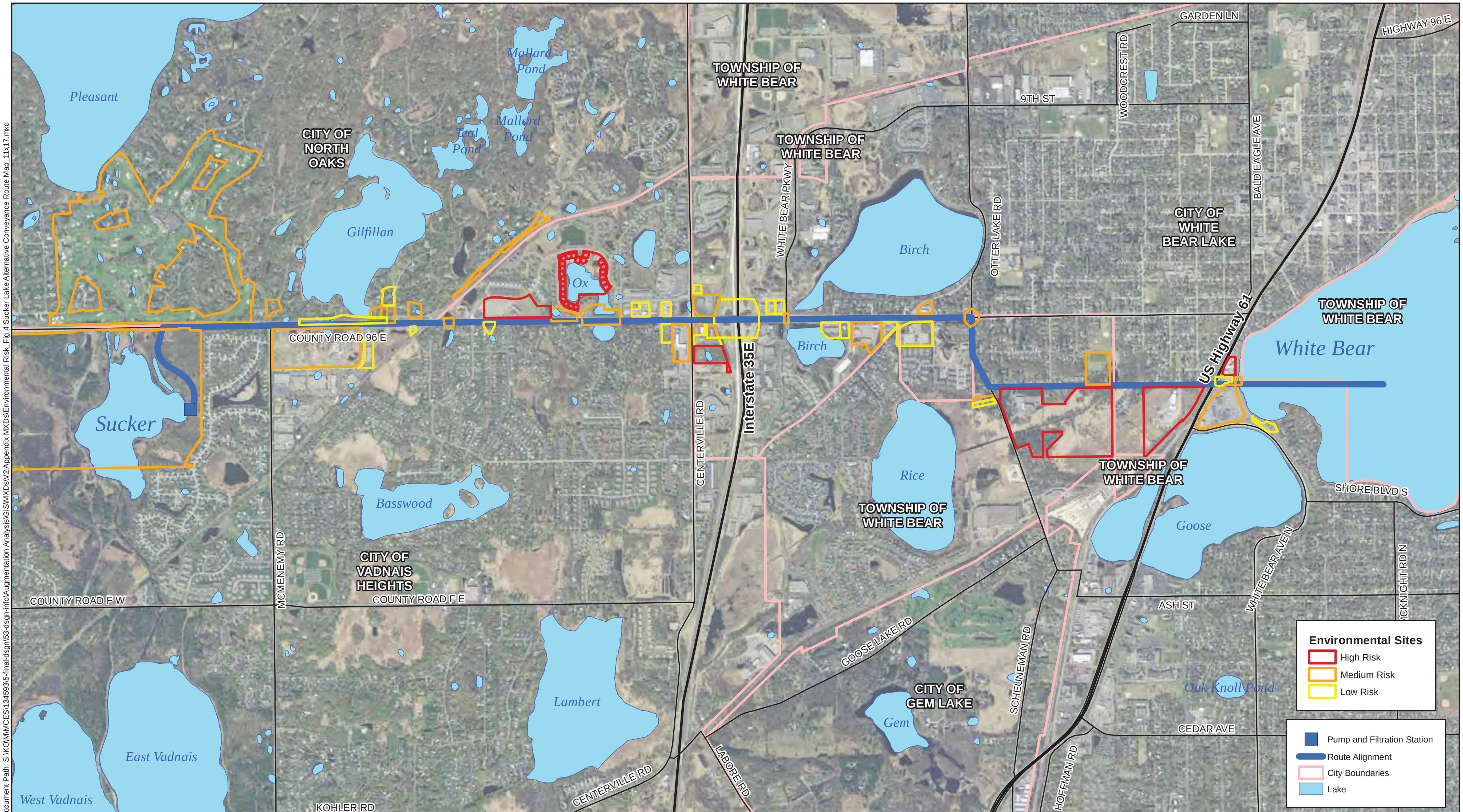

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Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

0 850 1,700 3,400 5,100 6,800 Feet

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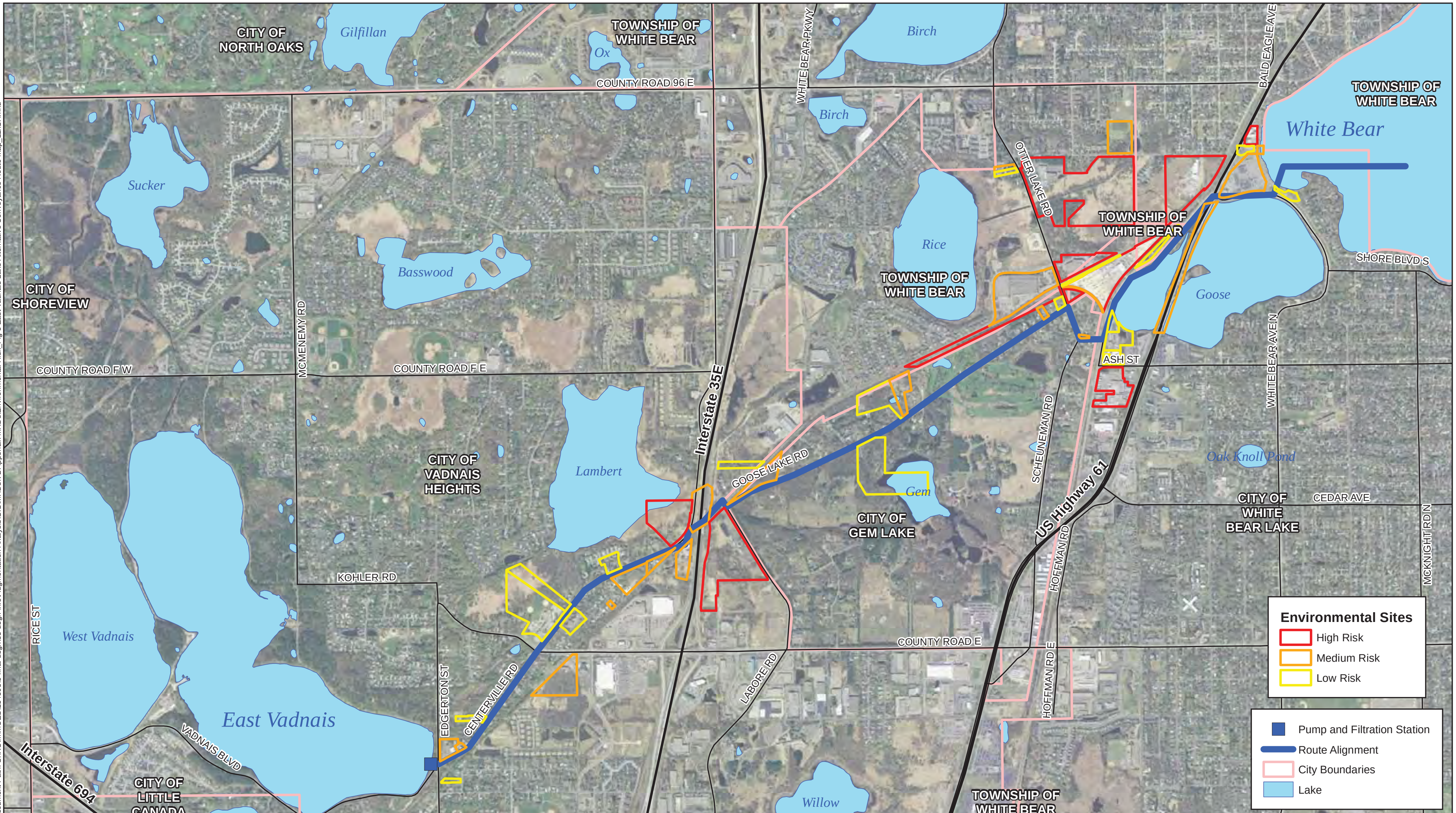
Sucker Lake Alternative Environmental Risk Summary

Figure 1



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0 850 1,700 3,400 5,100 6,800 Feet

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East Vadnais Lake Alternative Environmental Risk Summary

Figure 2

Appendix D: Contaminant Site Inventory Review

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MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Erin Borgschatz and Christine Carlson

DATE: November 20, 2015

RE: Contaminated Site Inventory Review
White Bear Lake Augmentation Concept Report
Sucker Lake and Vadnais Lake Alternatives
SEH No. MCES0 134593 14.00

INTRODUCTION

SEH has completed a Contaminated Site Inventory Review for the Concept Cost Report for Augmentation of White Bear Lake with Surface Water on the Sucker Lake Alternative (Alternative 1) and East Vadnais Lake Alternative (Alternative 2) in the city of White Bear Lake, Minnesota. The purpose of this study was to determine the potential contaminated materials issues that may be encountered during construction activities along each alignment. The research targets identifying potential soil, groundwater, and soil vapor contaminated sites within the "alignment corridors." The alignment corridors include parcels partially or wholly included in a buffer area that extends 500 feet from the two alignment alternatives. Alternative 1 extends east from Sucker Lake and Alternative 2 extends northeast from East Vadnais Lake to Goose Lake and Vadnais Lake, where the corridors overlap. The alignments are depicted on the attached Figure 1.

It was not within the scope of this Contaminated Site Inventory Review to evaluate the level, extent, or confirm contamination. Additionally, the scope of this work is not considered a Phase I Environmental Assessment (ESA). Summary information and conclusions from this report may be used to improve cost estimates.

RESEARCH SUMMARY

This Contaminated Site Inventory included a desktop review of the alignment areas and a site reconnaissance. The analysis was limited to the following research tasks listed below:

- Review of contaminated site information available from the MPCA What's in my Neighborhood (WIMN), Minnesota Department of Agriculture (MDA) WIMN and Petroleum Remediation Program (PRP) websites
- Limited review of the MPCA Spill sites
- Historic aerial photograph review (1947, 1957, 1966, 1980, 1991, 2003, 2004, 2008, 2009, 2011)
- Historic topographic map review (1902, 1910, 1918, 1943, 1954, 1959, 1965, 1969, 1973, 1981, 1987, 1993)
- Review of available Solid Waste, Voluntary Investigation and Cleanup (VIC), Petroleum Brownfield, and Leak Files.

- Review of located monitoring and abandoned wells available on the Minnesota Department of Health (MDH) County Well Index (CWI) website.
- Site reconnaissance to identify suspect existing conditions and observable past uses that may impact the cost estimates.

SEH used the following categories of "low," "medium," and "high" risk to rank sites within both alternative corridors. Rankings may not adhere directly to the definitions below if information obtained during the review justified lowering or raising the rank level.

- **Low Risk** – Hazardous and/or petroleum substances are known or inferred to have been, or are being used, stored or generate on these sites; however, there appear to be "good housekeeping" practices conducted on the site. Good housekeeping practices are defined as proper handling and/or storage of hazardous or petroleum substances. There is also no record or evidence of spills, releases, surface contamination and/or subsurface contamination at the site.
- **Medium Risk** – Hazardous substances are known or inferred to have been, or are being used, stored, or generated on these sites, and there appears to be "poor housekeeping" practices conducted at the site. Poor housekeeping practices are defined as improper handling and/or storage of hazardous or petroleum substances. All properties that have underground storage tanks (USTs) or above ground storage tanks (ASTs) and leaking underground storage tank (Leak) sites that have received closure from the Minnesota Pollution Control Agency (MPCA), and vehicle repair and maintenance facilities are also considered medium risks.
- **High Risk** – These are sites where hazardous and/or petroleum substances are known or inferred to have been, or are being used, stored, or generated, and there is a record or evidence that a spill, release, surface contamination and/or subsurface contamination has occurred. These sites include all active Voluntary Investigative and Cleanup (VIC), Minnesota Environmental Response & Liability Act (MERLA), active Leak sites and all active and inactive dump sites.

DISCUSSION

SEH identified the following general concerns for the alignment corridors. Railroad corridors intersect both alignment alternatives. Alternative 2 includes significantly more railroad property than Alternative 1. Railroad corridors present contaminant concerns from property uses directly associated with railroad activities and surrounding industry. Historically, railroad property is known for heavy metals and polycyclic aromatic hydrocarbons (PAHs) associated with transport of coal and other industrial products. Fill material is likely present below the railroad corridor in portions of both alignment corridors. Additionally, railroads are known to sometimes use chemicals associated with controlling encroaching vegetation along the railroad. Railroads are depicted on the attached figures.

Sites with farm structures, such as residences and barns, formerly located within the alignment corridors have been demolished. For that reason alone, these sites do not qualify as low, medium or high risk sites by definition. It is unknown if all of the demolition debris or foundations associated with the buildings were removed from within the alignment corridors. The potential exists that buried materials are present within the alignment corridors that require management as solid waste or waste with hazardous materials or regulated substances. Areas with historic removed structures that are within the alignment corridors have been identified and are included in the site ranking rationale descriptions.

SUCKER LAKE ALTERNATIVE (ALTERNATIVE 1):

The Alternative 1 alignment corridor extends from Sucker Lake to Goose and White Bear Lakes. It is located along CSAH 96 with mostly undeveloped, residential, and commercial properties. Sites 01 through 49 (6 high, 23 medium, and 20 low) were identified within the Alternative 1 alignment buffer for potential environmental risk and are summarized on the attached Table 1 and Figure 2 (multiple maps). Historically fill of unknown origin was commonly placed in low lying areas along this transect throughout the mid-century. Significant filling of low-lying marshy areas and ponds was completed during this time prior to the construction of Highway 96. Example of sites that had historic fill of unknown origin include Sites 07, 09, 10, 12, 16, 18, 24, and 27. Filling of dump material also occurred historically on this alignment. The summaries in this section are presented generally from west to east along the alignment corridor.

The Highway 96 Dump (White Bear Township Dump) Superfund Site, located north of Highway 96 and west of Allendale Drive in White Bear Township, was operated as a small burning dump from the 1920s to 1973. The investigations identified waste in two areas: the North Disposal Area (NDA) located in the northwest portion of the current development referred to as Weston Woods. Town house development has occurred in the South Disposal Area (SDA). During the late 1980s and into the 1990s remediation efforts began on the site. Waste material was removed from the NDA and SDA. All waste and soil contamination was removed from the SDA. The NDA was consolidated and capped. Groundwater at the site is impacted and a groundwater extraction system is in place. Site 15, located adjacent to the alignment alignment received an off-site source determination from the MPCA for groundwater impacts associated with the dump.

Additional areas along the Alternative 1 alignment include petroleum leak sites and other commercial properties with hazardous property uses. Multiple Leak sites are located at the intersection of CSAH 96 and CR 59. Sites 23, 26, and 29 have significant petroleum impacts documented for soil and groundwater associated with former and active petroleum tanks. Soil gas results for petroleum were above action levels at Site 23, which also has a dry cleaners on-site. Several properties adjacent to this intersection have historically been used for auto fueling, repair, and service.

Two additional Leak sites, former fuel station at site 36 and active fuel station at site 39, are located on CSAH 96 east of I-35E near Birch Lake Road. The Leak files associated with the fuel stations reported minor petroleum impacts to soil and groundwater that appeared to be confined to the sites. Additional releases on the corridor are also associated with Spills. For example, at the intersection of CSAH 96 and CR 50 (Otter Lake Road) where a mineral oil release occurred.

Site 43 is a Voluntary Investigation and Cleanup (VIC) site located southeast of CSAH 30 and Whitaker Street. The site had been utilized by the Water Gremlin Company (Water Gremlin) as an industrial manufacturing facility since approximately 1949. Chlorinated solvents and their related degradation products in groundwater were below drinking water standards when response actions at the site were complete.

The major concern identified at the intersection of TH 61 and Whitaker Street is documented dumping. Dumping of lime sludge material and fill material, and small quantities of demolition debris, and household garbage was identified in the large wetland at Site 45. The associated State Assessment file was closed because dumping was no longer taking place. A former fuel station on site 45 (closed Leak site) was the source of petroleum impacted soil and groundwater that is documented to remain on-site. Site 46 was remediated of debris-laden fill that was impacted with diesel range organics (DRO), polycyclic aromatic hydrocarbons (PAHs), lead, mercury, and asbestos. Site 48 is a closed Leak site that had a gasoline release from a small gasoline tank that was removed from the site adjacent to White Bear Lake. A dry cleaners is present in the strip mall at Site 49.

EAST VADNAIS LAKE ALTERNATIVE (ALTERNATIVE 2):

Alternative 2 is generally aligned along the BNSF Railroad and extends from East Vadnais Lake to and Goose and White Bear Lakes. The railroad has been active since at least 1902 and a former rail yard was located along White Bear Parkway. Historically, more industrial activity has occurred along this alternative versus Alternative 1. Site 45 and Sites 49 through 88 (8 high, 16 medium, and 17 low) were identified within the Alternative 2 alignment buffer for potential environmental risk, and are summarized on the attached Table 1 and Figure 3 (multiple maps). The summaries in this section are presented generally from northeast southwest along the alignment corridor.

Near East Vadnais Lake, Sites 86 and 87 were identified for former auto repair and fueling. Closed Leaks and Spill listings document petroleum impacted soil and groundwater and rusty colored sludge on the ground surface. Petroleum impacted groundwater was identified at approximately 20 feet bgs. Petroleum impacted soil was still present; however, the tanks have all been removed.

The most notable concerns near the intersection of I-35E and CSAH 59 along the alignment are historic structures (Site 73) and a dump (Site 76). No MPCA files were available for the dump. Site 74 is a dump with additional listings; however, the activities appear to be located south of the alignment. Sites 71, 77 and 78 were noted for non-native fill and outdoor storage. A transformer released mineral oil that was cleaned up in the right-of-way adjacent to Site 75.

The BNSF Railroad wye is located near the intersection of CSAH 60 and CSAH 14 and is surrounded primarily by industrial properties. Sites identified in this area include a wood treating facility with historic bulk storage tanks (Site 53), former auto repair State Assessment Site (Site 55), a plastics company with large tanks (Site 56), a historic rail yard (Site 57), and the Lindsey Water Softener VIC site (Site 67). Site 67 was identified for shallow soil impacted with metals and buried concrete structures. A 1950s fuel station may have been located at the corner of CSAH 14 and Goose Lake Road (Site 60). The northern edge of a milk company (Site 53), identified as a dump with several other database listings, is located in the alignment corridor southeast of CSAH 12 and CSAH 146.

As summarized for Alternative 1, the major concern identified at the intersection of TH 61 and Whitaker Street is documented dumping. Dumping of lime sludge material and fill material, and small quantities of demolition debris, and household garbage was identified in the large wetland at Site 45. The associated State Assessment file was closed because dumping was no longer taking place. A former fuel station on site 45 (closed Leak site) was the source of petroleum impacted soil and groundwater that is documented to remain on-site. A dry cleaners is present in the strip mall at Site 49. What appears to be a significant amount of fill material was placed across Goose Lake (Site 51) in the 1950s for the construction of TH 61.

RECCOMMENDATIONS:

SEH recommends a subsurface investigation be completed along the alignments in the areas discussed above if earthwork, dewatering and/or acquisition is planned.

eeb
Attachments – Figure 1, Table 1, Figure 2 (multiple maps), Figure 3 (multiple maps)
c: Don Lutch, SEH
s:\ko\m\mces\134593\4-prelim-dsgn-rpts\draft report\v3 appendices\appendix d contaminant site inventory review\v3.1_contaminant site inventory review_011816.docx

Table 1

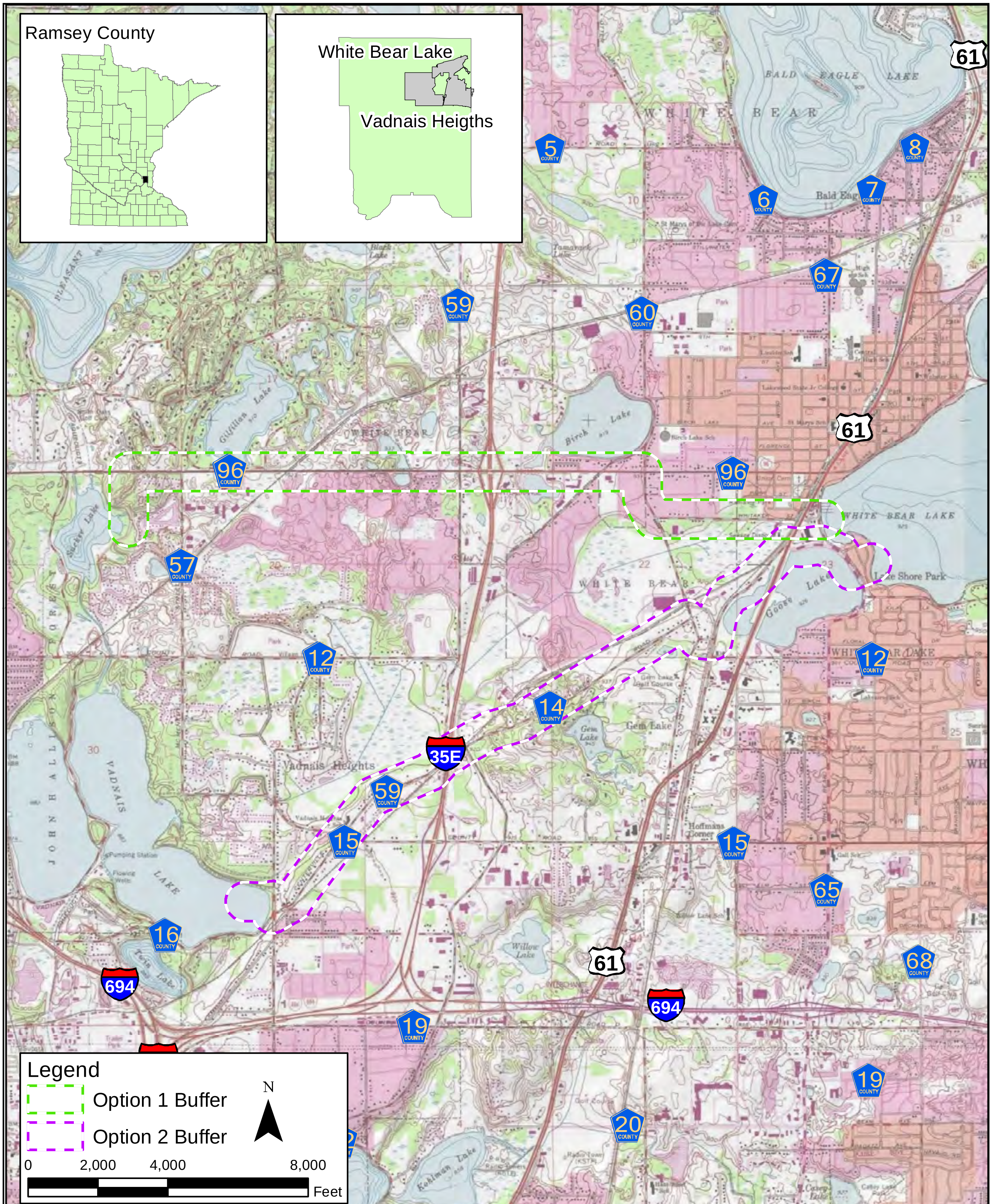
Environmental Sites Summary

Environmental Review

Concept Cost Report for Augmentation of White Bear Lake with Surface Water

SEH ID	RANK	SHORT SUMMARY	Alternative
01	Medium	Suspicious 1940s-1980s surface disturbances - potential dumps off access road.	Alternative 1
02	Medium	Closed Spills.	Alternative 1
03	Medium	Pond filled around the 1950s.	Alternative 1
04	Medium	Large diesel generator and non-native fill observed, hazardous waste generator.	Alternative 1
05	Low	1950s-1970s historic commercial building.	Alternative 1
06	Low	Pond filled in the 1990s.	Alternative 1
07	Medium	Pond filled around the 1960s. Site developed with residence in 1972.	Alternative 1
08	Low	Large unknown structure present from the 1940s-1950s.	Alternative 1
09	Medium	Ponds filled in the 1960s or 1970s.	Alternative 1
10	Medium	Pond filled and a surface disturbance in the 1980s. Site developed with residence in 1987.	Alternative 1
11	Low	Gas main emergency shut off.	Alternative 1
12	Medium	Fill likely placed for road project prior to 1940s, and during improvements in 1990s.	Alternative 1
13	Medium	Monitoring wells on-site.	Alternative 1
14	Low	Unknown structure from 1940s through 1970s - appears larger than a residence and is directly adjacent to the highway.	Alternative 1
15	High	VIC site for off-site source determination of impacted groundwater from the Highway 96 dump site.	Alternative 1
16	Medium	Fill placed for road project prior to 1940s and during improvements in 1990s.	Alternative 1
17	High	Dry cleaners, VIC site, Superfund, Highway 96 dump site, regional groundwater impacts.	Alternative 1
18	Medium	1970s-1990s unknown removed structure. Fill placed for road project prior to 1940s and during improvements in 1990s.	Alternative 1
19	Low	Valvoline oil change.	Alternative 1
20	Low	Unknown 1950s surface disturbance adjacent to CSAH 96.	Alternative 1
21	Low	Auto parts store, hazardous waste generator.	Alternative 1
22	Low	Hazardous waste generator.	Alternative 1
23	Medium	Former fuel station, dry cleaners, closed Leaks/Spills.	Alternative 1
24	High	VIC, historic surface disturbances/fill, buried ash removed from site during redevelopment.	Alternative 1
25	Low	Hazardous waste generator.	Alternative 1
26	Medium	Fuel station, closed Leak, active tanks, petroleum impacted soil and groundwater remained on-site.	Alternative 1
27	Medium	Filled ditch/marsh around 1970s. Developed with commercial structure in 1985.	Alternative 1
28	Low	Potential fill of unknown origin.	Alternative 1
29	Medium	Former petroleum retail facility/auto repair, closed Leak, removed tanks, petroleum impacted soil and groundwater remained on-site, monitoring wells.	Alternative 1
30	Low	Historic (1970s-1990s) removed structure, tire shop, hazardous waste generator.	Alternative 1
31	Low	VIC/CERCLIS, former gun club investigated for lead in soil - no impacts identified.	Alternative 1
32	Low	Auto parts store, hazardous waste generator.	Alternative 1
33	Medium	Closed spill (25 gallons of diesel).	Alternative 1
34	Low	Hazardous waste generator.	Alternative 1
35	Low	Hazardous waste generator.	Alternative 1
36	Medium	Former fuel station, auto service center, closed Leak, removed tanks/hoists, petroleum impacted soil and groundwater remained on-site. Groundwater 12-15 feet bgs.	Alternative 1
37	Low	Abandoned industrial well.	Alternative 1
38	Low	Hazardous waste generator.	Alternative 1
39	Medium	Fuel station, closed Leak, low level petroleum impacted soil confined to dispenser island, active petroleum tanks, closed spills.	Alternative 1
40	Medium	Closed Spill (43 gallons mineral oil).	Alternative 1
41	Medium	Closed Leaks, residential fuel oil AST.	Alternative 1
42	Low	Hazardous waste generator.	Alternative 1
43	High	Industrial manufacturing, VIC, RCRA Cleanup, ASTs, hazardous waste generator, under construction, non-native fill, flammables cage with containers.	Alternative 1
44	Medium	Monitoring well.	Alternative 1
45	High	State Assessment Site, unpermitted dump of lime and sludge in wetland, former fuel station, closed Leak/Spills, outdoor storage observed.	Both

SEH ID	RANK	SHORT SUMMARY	Alternative
46	High	VIC, Petroleum Brownfield, Closed Leak, PAHs, lead, mercury, asbestos, and debris in soil - impacted soil excavated to native soil, groundwater not evaluated, no VOCs in soil vapor.	Alternative 1
47	Low	Hazardous waste generator.	Alternative 1
48	Medium	Closed Leak from a small gasoline tank adjacent to White Bear Lake, petroleum impacted soil and groundwater remained on-site.	Alternative 1
49	Medium	Dry cleaners, hazardous waste generator.	Both
50	Low	Historic commercial/industrial structures in 1940s and 1950s.	Alternative 2
51	Medium	Fill material placed for construction of TH 61 across Goose Lake in 1950s.	Alternative 2
52	Low	Petroleum Brownfield site investigated for nearby Leak site - no contamination found during construction of cell tower, soil stockpiles observed.	Alternative 2
53	High	Wood treating facility, closed Leak (no impacts idenfied for soil or groundwater), RCRA Cleanup site, hazardous waste generator, historic bulk storage tanks, outdoor storage observed.	Alternative 2
54	Low	Outdoor storage at lumber yard.	Alternative 2
55	High	State Assessment Site (no MPCA file), former auto repair, hazardous waste generator.	Alternative 2
56	Medium	Plastics company, outdoor storage, large holding tanks observed.	Alternative 2
57	High	Historic railyard.	Alternative 2
58	NOT A SITE	Leak site not on this site. Residence. No issues	Alternative 2
59	Low	Outdoor storage, poor housekeeping observed.	Alternative 2
60	Medium	Small structure at intersection in 1950s. Potentially a corner store or fuel station.	Alternative 2
61	Low	Hazardous waste generator, outdoor boat storage lot.	Alternative 2
62	Low	Outdoor storage of implements and water heaters.	Alternative 2
63	Low	Hazardous waste generator, outdoor storage observed.	Alternative 2
64	Low	Hazardous waste generator, printing shop.	Alternative 2
65	High	Milk company, Unpermitted Dump, State Assessment Site, petroleum/other tanks, hazardous waste generator.	Alternative 2
66	Medium	Railroad spur owned by wood treating company.	Alternative 2
67	High	VIC, releases identified with the Lindsey Water Softener Site. Shallow soil impacted with metals and buried concrete structures. Groundwater impacted with metals and petroleum.	Alternative 2
68	Medium	Historic removed structures, potentially outdoor storage, surface disturbances 1940s-1970s, pit filled in 1970s.	Alternative 2
69	Low	Stockpile with asphalt/rocks observed.	Alternative 2
70	Low	Monitoring well and lake level augmentation well.	Alternative 2
71	Medium	Historic gravel pit filled in 1980s, small junk yard.	Alternative 2
72	Low	Owned by a Structural Wood Sales Company.	Alternative 2
73	Medium	Historic removed structures below roadway. Probably only residences/farms.	Alternative 2
74	High	VIC, Solid Waste Permit-by-rule, dump.	Alternative 2
75	Medium	Closed Spill (mineral oil from transformer) in right-of-way, hazardous waste generator, outdoor storage observed.	Alternative 2
76	High	Unpermitted dump, State Assessment Site (no MPCA files).	Alternative 2
77	Medium	Debris and stockpiles, wood pallets, drum, snowmobiles/auto, acetylene tanks, generators observed.	Alternative 2
78	Medium	Excavating company, removed/active petroleum tanks, historic surface disturbance, stockpile observed.	Alternative 2
79	Low	Historic removed structures in the 1950s, structures removed in the 1970s.	Alternative 2
80	Medium	Closed Spill (waste oil).	Alternative 2
81	Low	Stockpile observed.	Alternative 2
82	Low	Former farmstead razed in the 1960s.	Alternative 2
83	Low	Hazardous waste generator.	Alternative 2
84	Medium	Non-native fill in railroad embankment. Farmland until City Hall built in 2000.	Alternative 2
85	Low	Outdoor storage of vehicles, equipment or other objects, and surface disturbances from 2008-2011.	Alternative 2
86	Medium	Closed Spill, former tanks, staining inside structure, hazardous waste generator.	Alternative 2
87	Medium	Former fuel station, close Leak, closed Spill, removed tanks, auto repair, petroleum impacted soil on-site, groundwater impacted on and off-site, groundwater 20 feet bgs, hazardous waste generator.	Alternative 2
88	Low	Potentially a commercial structure present in the 1940s. Residential from the 1950s-2015.	Alternative 2



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Print Date: 11/30/2015

Map by: msherrill
Projection: NAD83 UTM 15N
Source: ESRI, SEH

Site Location

Environmental Review
White Bear Lake Augmentation Concept
White Bear Lake, Minnesota

Figure
1

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Map by: dc
Projection: MN SP South ft
Source: MnDOT, MnDNR, MnGEO, MnHD, Ramsey Co. and SEH Inc.

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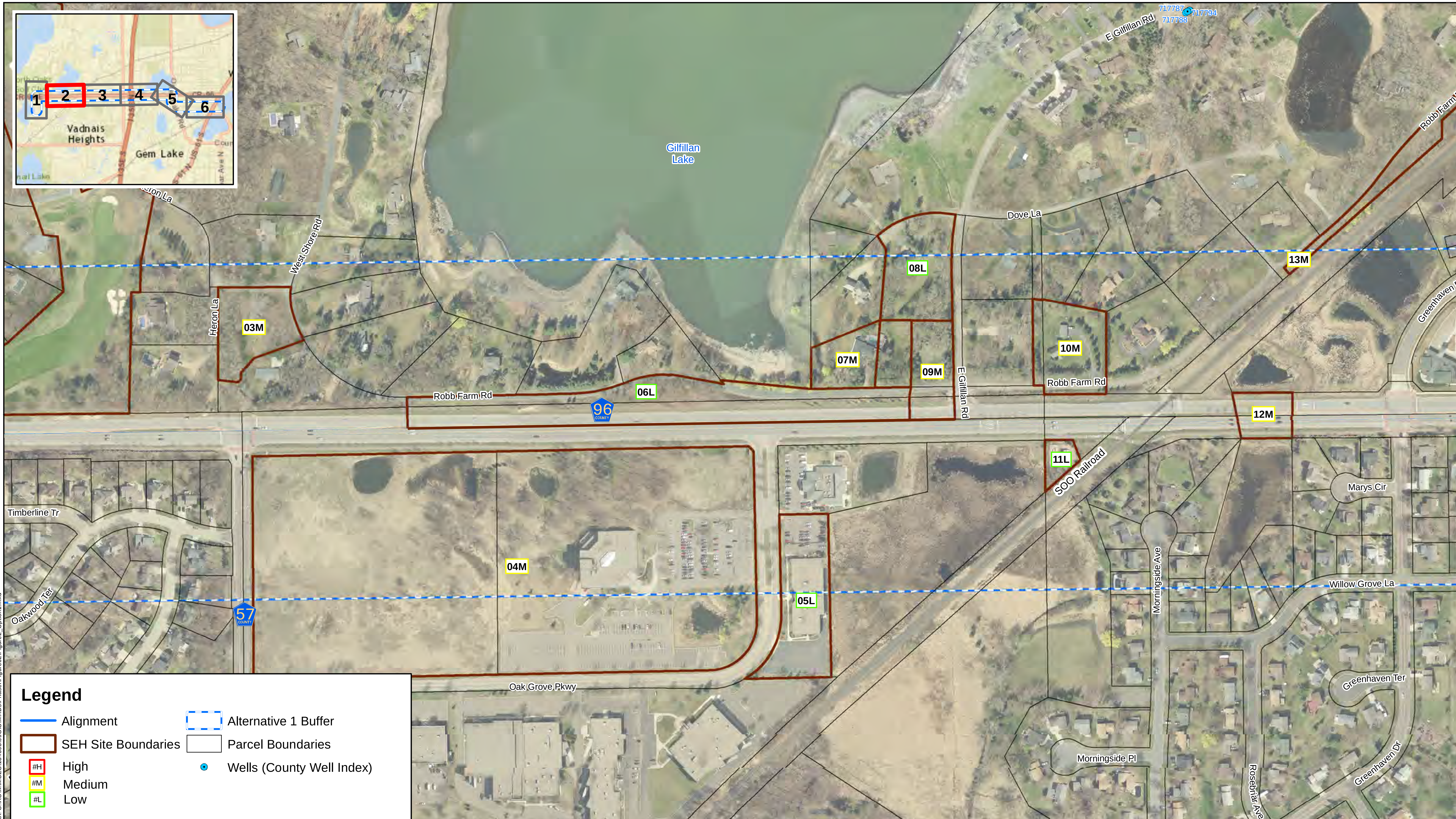
Site Features

Contaminant Site Inventory Review
White Bear Lake Augmentation Concept
White Bear Lake, Minnesota

Figure 2-1 Alternative 1



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White Bear Lake, Minnesota

Figure 2-2 Alternative 1

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Site Features

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White Bear Lake Augmentation Concept
White Bear Lake, Minnesota

Figure 2-3
Alternative 1

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Site Features

Contaminant Site Inventory Review
White Bear Lake Augmentation Concept
White Bear Lake, Minnesota

Figure 2-4
Alternative 1

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Site Features

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White Bear Lake Augmentation Concept
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Figure 2-5
Alternative 1

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Site Features

Contaminant Site Inventory Review
White Bear Lake Augmentation Concept
White Bear Lake, Minnesota

Figure 2-6
Alternative 1

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Site Features

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White Bear Lake Augmentation Concept
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Figure 3-1
Alternative 2

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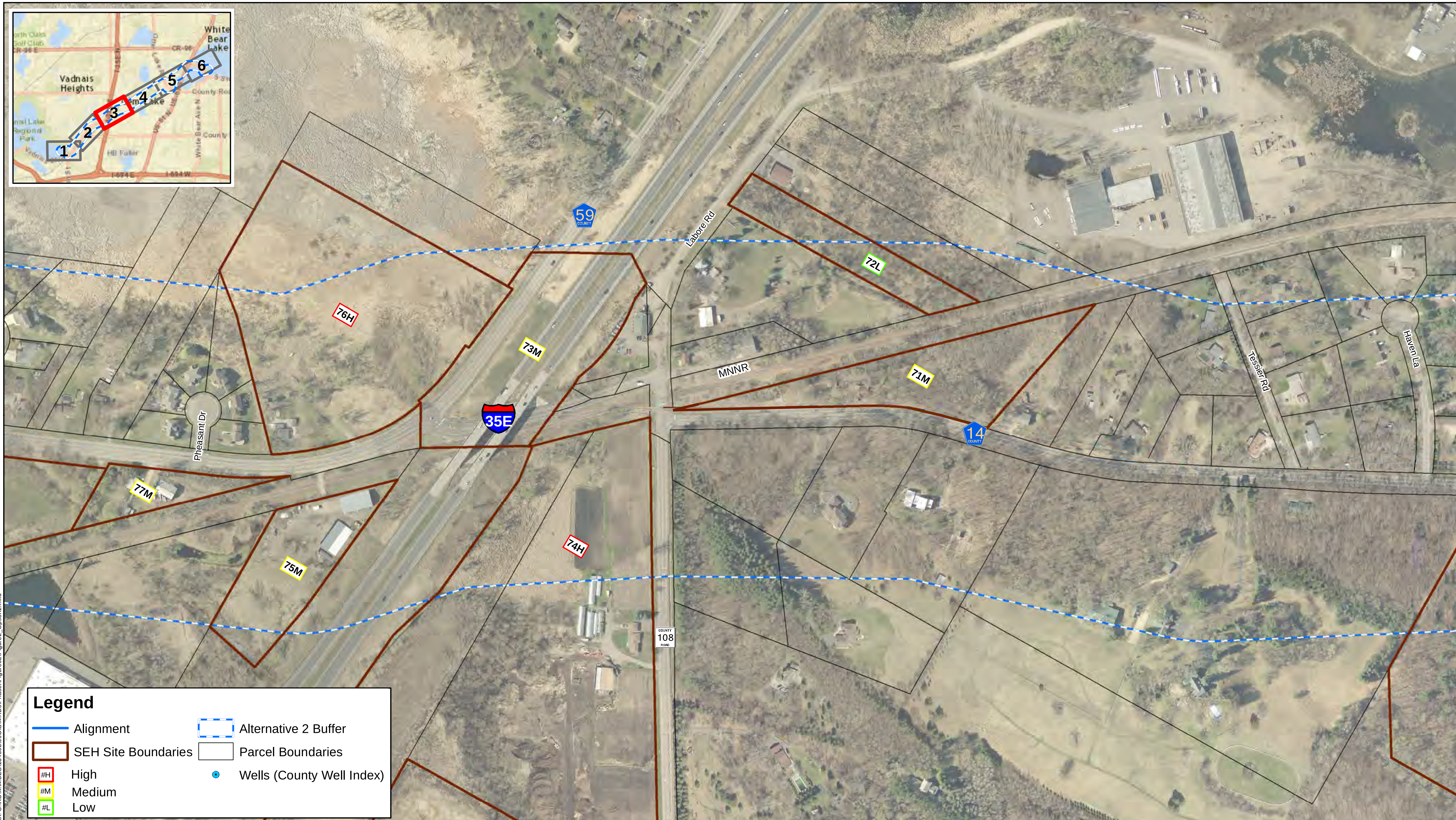
Site Features

Contaminant Site Inventory Review
White Bear Lake Augmentation Concept
White Bear Lake, Minnesota

Figure 3-2
Alternative 2



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Site Features

Contaminant Site Inventory Review
White Bear Lake Augmentation Concept
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Figure 3-3
Alternative 2

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Site Features

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White Bear Lake Augmentation Concept
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Figure 3-4
Alternative 2

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Site Features

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White Bear Lake Augmentation Concept
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Figure 3-5 Alternative 2

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Site Features
Contaminant Site Inventory Review
White Bear Lake Augmentation Concept
White Bear Lake, Minnesota

Figure 3-6
Alternative 2

Appendix E: Preliminary Wetlands Inventory Review

SEH

Building a Better World for All of Us®

TECHNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Brendan Wolohan, Project Engineer

DATE: November 16, 2015

RE: Preliminary Wetlands Inventory Review
SEH No. MCES 134593 14.00

This Technical Memorandum (TM) has been prepared to summarize the review of the National Wetland Inventory (NWI) as it relates to the Concept Cost Report for Augmentation of White Bear Lake with Surface Water**.** Its purpose is to summarize the impact to wetlands along each of the two (2) alternative alignments assumed for developing costs for augmentation of approximately two (2) billion gallons (BG) per year of water into White Bear Lake (WBL): The Sucker Lake Alternative (Alternative 1) and the East Vadnais Lake Alternative (Alternative 2). The NWI map was referenced to determine the location and type of wetlands present in the area that will be affected. Two major types of wetlands were displayed on the NWI map throughout the two options, they include Freshwater Emergent and Freshwater Forested or Shrub Wetlands.

A Freshwater Emergent Wetland typically consists of marsh or wet meadow areas. These areas are often covered with six (6) or more inches of water, and contain waterlogged soils. Vegetation found in Emergent Wetlands consist of rooted, herbaceous hydrophytes, most notably cattails. Forested or Shrub Wetlands are similar, however contain more woody vegetation such as deciduous or evergreen typically less than twenty feet tall and can be seasonally flooded.

Alternative 1 would intersect a Freshwater Emergent Wetland at the Sucker Lake intake. This wetland is prevalent alongside the entire eastern shore of Sucker Lake and would be unavoidable when constructing the intake system. More sections of Emergent Wetland are found along Highway 96 in two different locations. Although the proposed watermain would not run directly through the wetland, it is possible that the wetland may be affected during construction. Figure 1 depicts the locations of the above referenced wetlands**.**

Alternative 2 would intersect a Freshwater Forested/ Shrub Wetland near the proposed Vadnais Lake intake located on the south eastern shore. A Freshwater Pond along Centerville Road south of Lambert Lake would need to be watched carefully during construction. Also along Centerville Road, on the north side of the road, is a Freshwater Emergent Wetland south east of Lambert Lake. Figure 2 depicts the locations of the above referenced wetlands.

Wetland areas listed above would need to be avoided as much as possible to minimize the impact and mitigation requirement wherever possible. Proper means of stormwater runoff and erosion prevention shall be taken, especially in areas where construction sites will be in the near vicinity of wetland areas as depicted on the NWI map.

Attachments – Figures 1 and 2

BCW

c: Don Lutch
Jessica Daignault

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References:

Tiner, Ralph W. U.S. Fish and Wildlife Service. Wetland Definitions and Classifications in the United States. Fish and Wildlife Service Website. Available at: https://www.fws.gov/northeast/ecologicalservices/pdf/WetlandDefinitionsClassificationsarticle.pdf. Accessed November 16, 2015.

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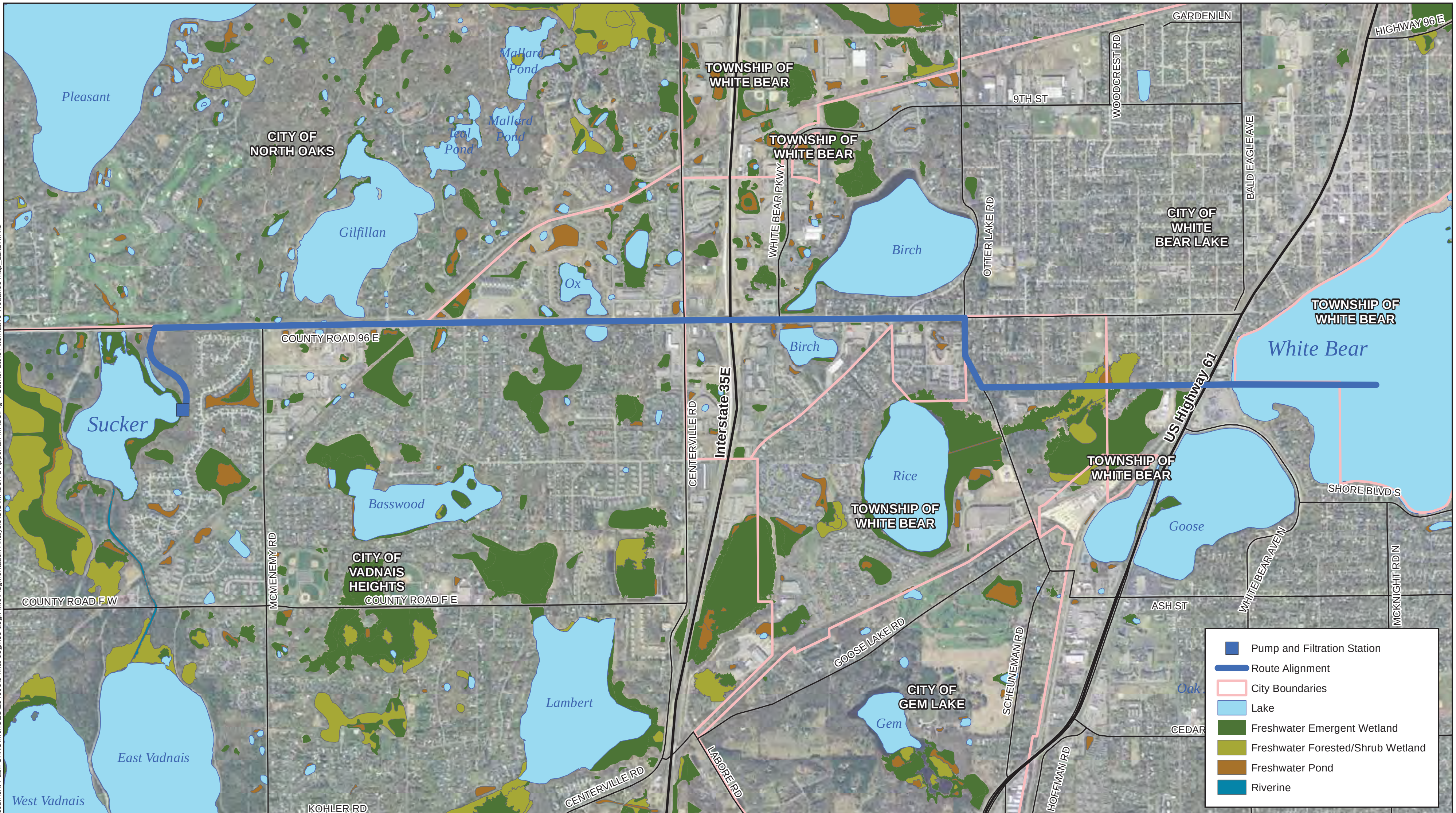

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Map by: LO
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

0 850 1,700 3,400 5,100 6,800 Feet

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Sucker Lake Alternative Wetlands

Figure 1

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Map by: LO
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

0 850 1,700 3,400 5,100 6,800 Feet

N

East Vadnais Lake Alternative Wetlands

Figure 2

Appendix F: Sucker Lake Alternative System Characteristics and Infrastructure

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TECHNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Jessica Daignault, Project Engineer

DATE: November 19, 2015

RE: Sucker Lake Alternative (Alternative 1) - System Characteristics and Infrastructure
SEH No. MCES 134593 14.00

Metropolitan Council Environmental Services (MCES) has retained Short Elliott Hendrickson Inc. (SEH) to prepare the Concept Cost Report for Augmentation of White Bear Lake with Surface Water. The proposed water source is the Mississippi River via the Saint Paul Regional Water Services (SPRWS) chain of lakes. Two concept alternatives have been developed to estimate costs for augmentation of approximately two (2) billion gallons (BG) of water per year into White Bear Lake (WBL): The Sucker Lake Alternative (Alternative 1) withdrawals water from Sucker Lake and the East Vadnais Lake Alternative (Alternative 2) withdrawals water from East Vadnais Lake. This Technical Memorandum (TM) summarizes the system characteristics and infrastructure for the Sucker Lake Alternative (Alternative 1). Figure 1 provides an overview of the proposed Sucker Lake Alternative alignment.

During the augmentation process, source water would be pumped from the northeast bay of Sucker Lake and discharged into the west bay of WBL. A pump station would be installed on the shoreline of Sucker Lake and water would be pumped to a filtration system located near Highway 96. The filtered water would flow through 30-inch High Density Polyethylene Pipe (HDPE) to an outlet structure located in WBL. The filtration system would prevent the transfer of zebra mussels (both adult and veliger) from the infested waters of Sucker Lake, as well as improve the water quality by reducing the volume of solids and nutrients currently found in the source water.

The intake structure would be constructed approximately 10 to 15 feet deep in Sucker Lake. Due to constraints as described in the Technical Memorandum titled “Sucker Lake Intake Site” dated October 28, 2015, the intake will need to be located a significant distance off-shore into the lake. The facility is assumed to include the intake structure with intake portals, 30-inch HDPE intake pipe with a concrete armor mat to minimize bottom disturbance, and a well pump. Located north of the intake site near Highway 96 would be a filter house, which would include the following: primary filters, secondary filters, a magnetic flow meter, an overhead service crane, and a filter house. The filtration facility would also include a maintenance and storage area and control room.

The 30-inch HDPE forcemain (FM) would leave the filtration facility to transport flow to WBL. The FM alignment would primarily follow Highway 96 headed east and would be installed 8 to 12 feet underground. The alignment requires extensive tunneling, including an approximate 40-foot deep tunnel to pass under Interstate 35-East at a minimum depth of 10 feet. Water would exit the FM through the outlet structure within WBL. 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-inch diameter ports spaced six (6) feet apart. The structure would be made of 30-inch capped HDPE with concrete armor mat.

jkd
Attachments – Figures 1
c: Don Lutch
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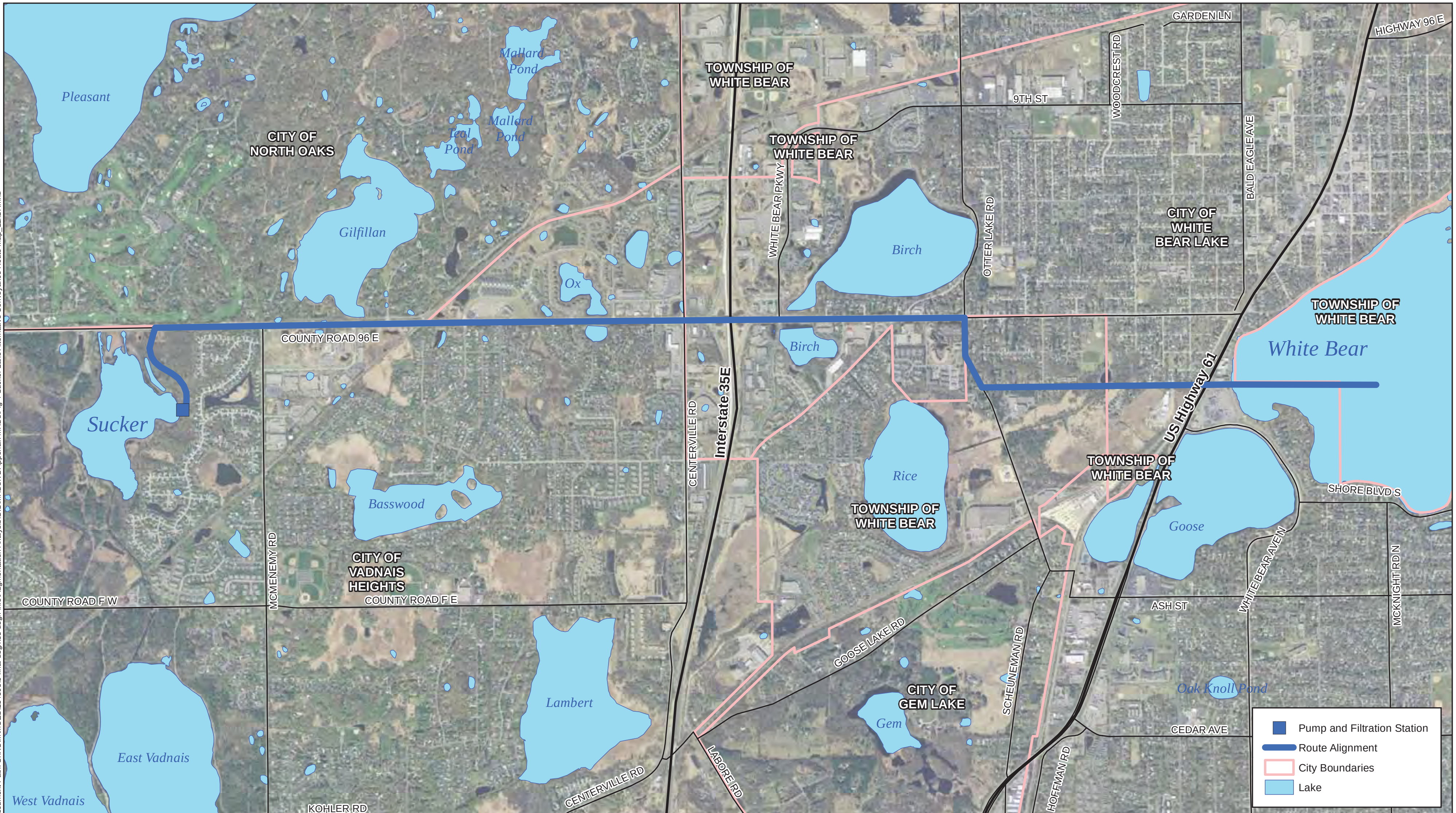

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Project: MCES 134593
Print Date: 1/6/2016

Map by: LO
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

0 850 1,700 3,400 5,100 6,800 Feet

N

Sucker Lake Alternative Conveyance Route

Figure 1

Appendix G: Sucker Lake Intake Site Review

TECHNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager – Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Jessica Daignault, Project Engineer

DATE: October 28, 2015

RE: Sucker Lake Intake Site Review
SEH No. MCES 134593 14.00

Metropolitan Council Environmental Services (MCES) has retained Short Elliott Hendrickson Inc. (SEH) as part of a mutual agreement with the Minnesota Department of Natural Resources (MnDNR) to develop a concept level cost estimate for augmentation of White Bear Lake in conjunction with the creation of the Concept Cost Report for Augmentation of White Bear Lake with Surface Water. On October 23, 2015 SEH staff visited Vadnais-Snail/Sucker Lakes Regional Park to investigate potential intake locations along the northeast bay of Sucker Lake (herein referred as the Lake). The attached Photo Journal contains photographs from the site visit as described in this Technical Memorandum (TM).

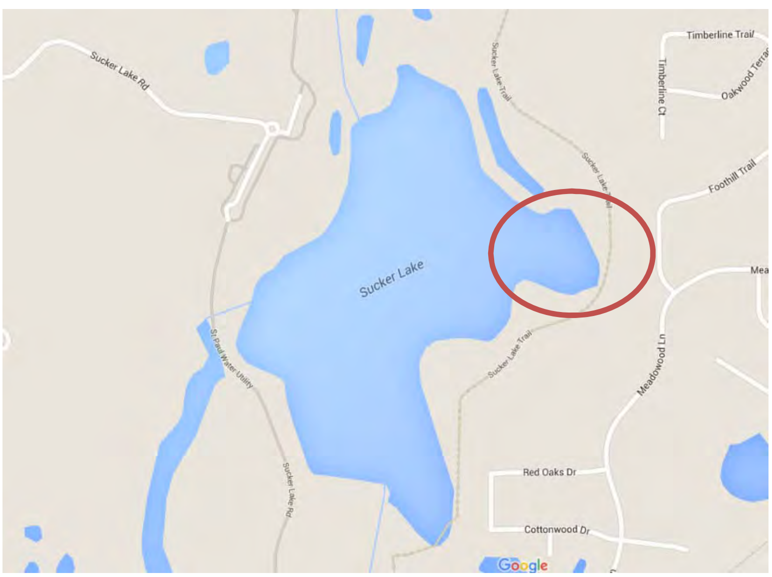

Figure 1. Sucker Lake with Highlighted Northeast Bay (Source: Google)

An access path runs parallel with Highway 96 for pedestrian traffic to reach the Sucker Lake Trail as shown in Photos 1 and 2. The wide path offers versatile access for maintenance vehicles, but general vehicular traffic is prohibited. Cattails have proliferated on the north side of the Lake as shown in Photo 3, which is indicative of wetland habitat and increased permitting requirements. Destruction of wetland habitat must be mitigated under Section 404 of the Clean Water Act. Per the U.S. EPA, “compensatory mitigation refers to the restoration, establishment, enhancement, and/or preservation of wetlands, streams, or other aquatic resources conducted specifically for the purpose of offsetting authorized impacts to these resources".

There are multiple Saint Paul Regional Water Services (SPRWS) outlets into Sucker Lake as shown in Photos 4, 19, and 20. Photo 4 shows the two outlets from the abandoned SPRWS that currently transport drainage from the North Oaks Golf Club (NOGC). It is possible that this runoff water carries higher pollutant concentrations from the golf course. As a result of the existing screening facilities used by the NOGC, the runoff water discharged at this location is free from mature zebra mussels. Photos 19 and 20 show the current SPRWS outlet from Pleasant Lake to continue water flow through the chain of lakes. This location is a popular spot among local fisherman.

Photo 5 shows an access gate to the park from Highway 96. It is likely in place to allow access and maintenance vehicles to pass when necessary. This gate offers potential access during construction for heavy equipment. The Sucker Lake Trail heads south from the access gate around the east side of the Lake. Access is sufficient with tall trees and a wide trail as shown in Photos 8, 9, and 10.

Access to the water from the trail becomes difficult and/or limited at the desired intake location. A yellow sign denotes "Area Closed, For Wildlife and Watershed Protection" as shown in Photo 11. As a result, SEH personnel were not able to access the shoreline at this location. These signs are placed in multiple locations along the trail within the park. In addition to Wildlife and Watershed Protection, benches are located along the trail for the enjoyment of bird watchers, wildlife enthusiasts, families and other trail users as shown in Photo 12.

A monitoring flume is located south of the desired intake location as shown in Photo 15. The flume is located in front of an outlet into the lake to measure surface water inflow as part of the SPRWS lake monitoring program. The access to this location is narrow and limited. The shoreline is comprised of grassy wetland growth and approximately 50 feet of standing water before a buffer of trees dividing the standing water from the lake body. Algal growth and the tree buffer are highlighted in Figure 2 with respect to the Sucker Lake Trail.

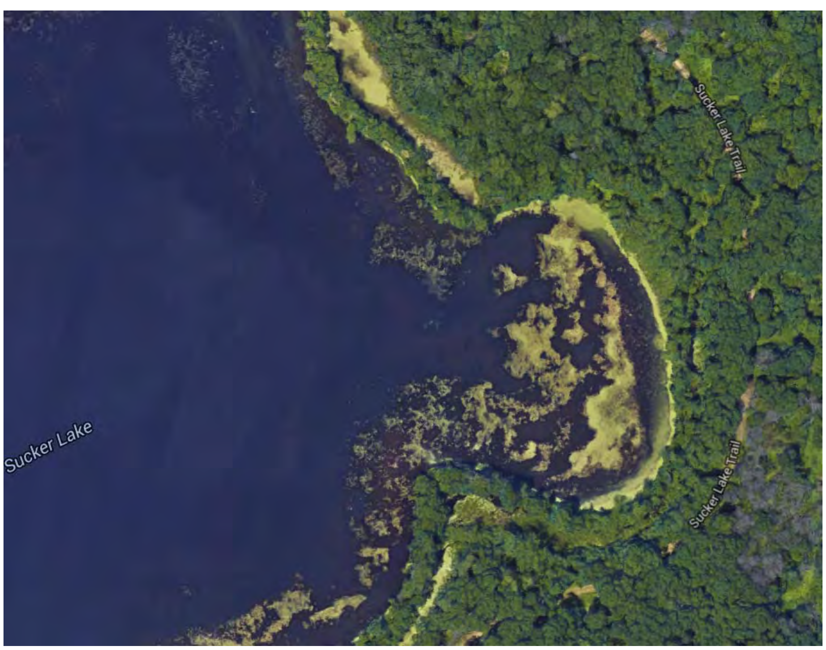

Figure 2. Sucker Lake North East Bay Satellite Imagery (Source: Google)

Figure 3 provides an overview of Sucker Lake with respect to the surrounding area.

The results of the site visit identified many environmental constraints to be mitigated in the permitting process before the potential use of this location as a construction site for the intake structure and filtration facility on the shoreline of Sucker Lake.

Major constraints include:

- wetland mitigation and permitting
- groundwater table and buoyancy
- protected watershed and wildlife habitat
- difficult access to deep water and higher water quality
- permitting requirements to construct and maintain a facility on this site

As a result of these constraints, SEH does not believe it feasible to construct a pumping and filtration facility at the northeast bay of Sucker Lake. Alternate options, might include an intake into the lake and an on shore pumping facility discharging through a forcemain pipeline to the filtration facility closer to the access trail intersection with Highway 96.

jkd
Attachments – Figure 3, Ramsey County Parks & Recreation map, and Photo Journal

c: Don Lutch
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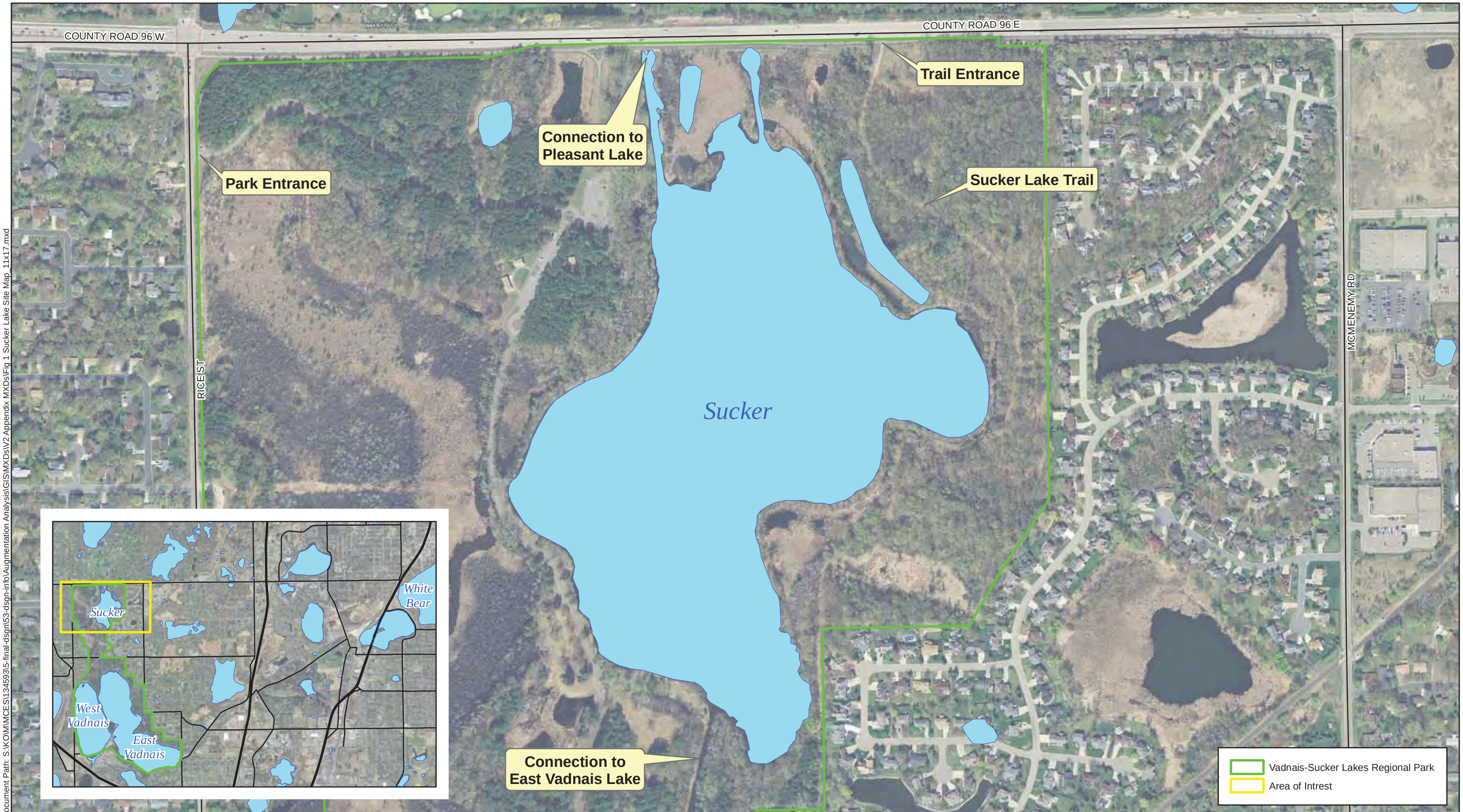

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Project: MCES 134593
Print Date: 1/6/2016

Map by: LO
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Datum: D_North_American_1983_HARN
Source: MnDNR,MnDOT, MnGEO, SEH, Ramsey County

0 200 400 800 1,200 1,600 Feet

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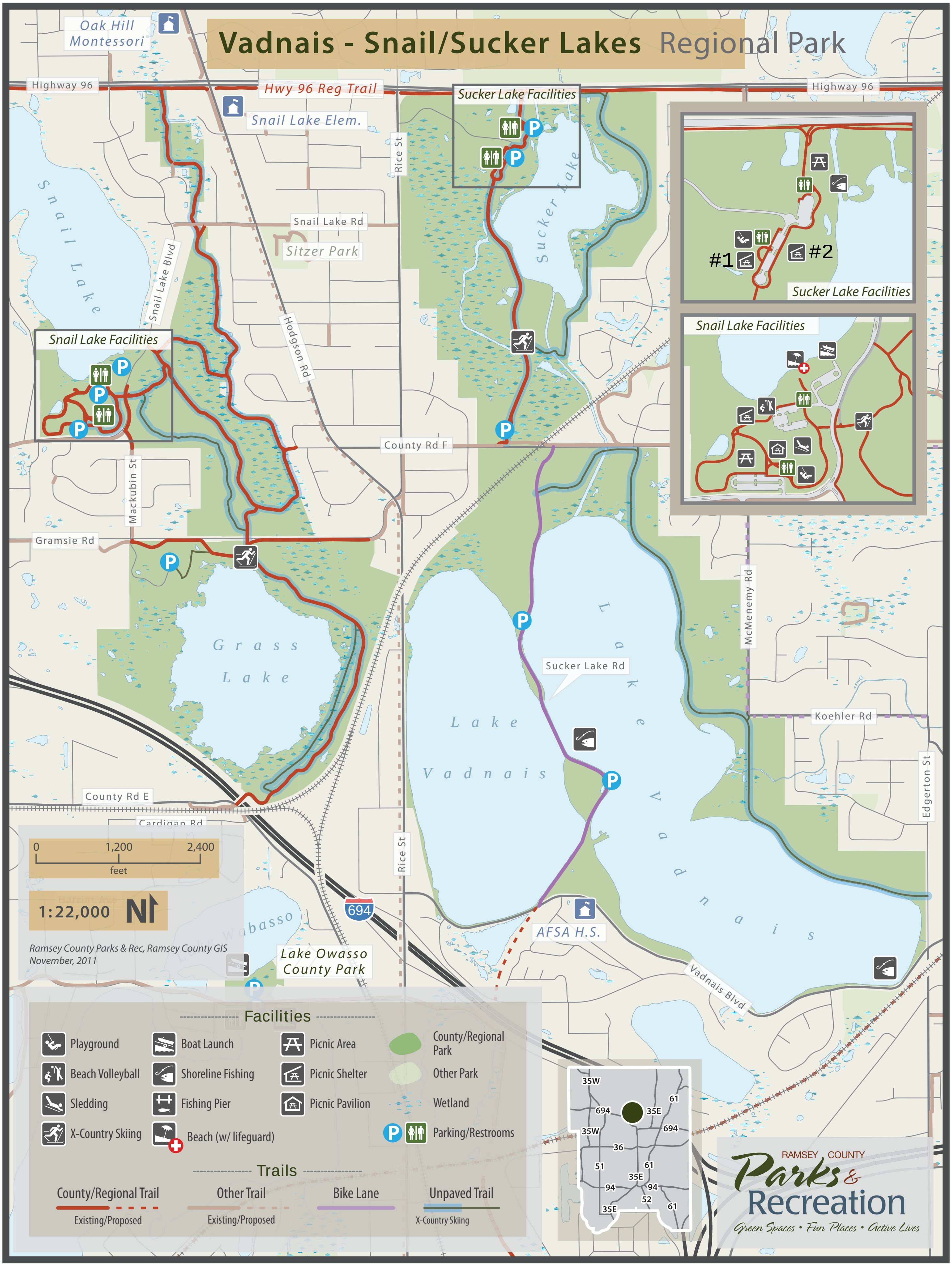
Sucker Lake Site

Figure 3


Vadnais - Snail/Sucker Lakes Regional Park
Oak Hill Montessori
Highway 96
Hwy 96 Reg Trail
Sucker Lake Facilities
Snail Lake Elem.
Rice St
Snail Lake
Sucker Lake
Snail Lake Rd
Sitzer Park
Snail Lake Blvd
Hodgson Rd
Snail Lake Facilities
#1
#2
County Rd F
Mackubin St
Gramsie Rd
Grass Lake
Lake Vadnais
Sucker Lake Rd
McMenemy Rd
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Ramsey County Parks & Rec, Ramsey County GIS
November, 2011
694
AFSA H.S.
Vadnais Blvd
Lake Owasso County Park
Facilities
Playground
Beach Volleyball
Sledding
X-Country Skiing
Boat Launch
Shoreline Fishing
Fishing Pier
Beach (w/ lifeguard)
Picnic Area
Picnic Shelter
Picnic Pavilion
County/Regional Park
Other Park
Wetland
Parking/Restrooms
Trails
County/Regional Trail
Existing/Proposed
Other Trail
Existing/Proposed
Bike Lane
Unpaved Trail
X-Country Skiing
35W
61
694
35E
35W
694
36
51
61
35E
94
94
52
35E
61
RAMSEY COUNTY
Parks & Recreation
Green Spaces • Fun Places • Active Lives

Photo 1 Access path with Highway 96 - Looking East

Photo 2 Access path with Highway 96 - Looking West

Photo 3 Sucker Lake Cattails – Looking South

Photo 4 Abandoned SPRWS outlet discharging North Oaks Golf Club drainage – Looking South

Photo 5 Highway 96 gate access to Regional Park Trail

Photo 6 Trail regulations - Looking South

Photo 7 Decorative sign - Looking South


Photo 8 Sucker Lake trail access - Looking South

Photo 9 Access trail - Looking North

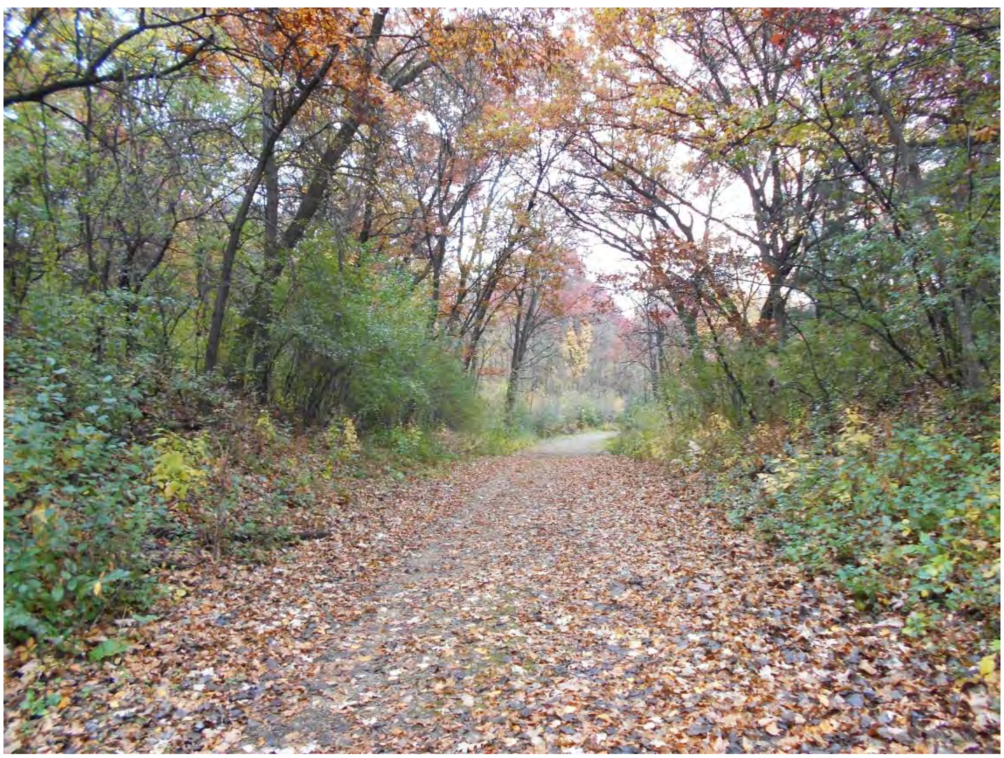

Photo 10 Access trail - Looking South

Photo 11 Area closed sign at potential intake location –Permit conditions

Photo 12 Bench to accommodate trail users

Photo 13 Inundation between lake and tree buffer at potential intake location – Looking West

Photo 14 Inundation between lake and tree buffer south of potential intake location – Looking West

Photo 15 Monitoring flume south of potential intake location – Looking West

Photo 16 Inundation between lake and tree buffer at monitoring flume location – Looking West

Photo 17 Outlet to monitoring flume – Looking East

Photo 18 Trail regulation sign looking east adjacent to Highway 96

Photo 19 SPRWS outlet from Pleasant Lake to Sucker Lake

Photo 20 SPRWS outlet from Pleasant Lake to Sucker Lake

Appendix H: East Vadnais Lake Alternative System Characteristics and Infrastructure

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TECHNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Jessica Daignault, Project Engineer

DATE: November 19, 2015

RE: East Vadnais Lake Alternative (Alternative 2) - System Characteristics and Infrastructure
SEH No. MCES 134593 14.00

Metropolitan Council Environmental Services (MCES) has retained Short Elliott Hendrickson Inc. (SEH) to prepare the Concept Cost Report for Augmentation of White Bear Lake with Surface Water. The proposed water source is the Mississippi River via the Saint Paul Regional Water Services (SPRWS) chain of lakes. Two concept alternatives have been developed to estimate costs for augmentation of approximately two (2) billion gallons (BG) of water per year into White Bear Lake (WBL): The Sucker Lake Alternative (Alternative 1) withdrawals water from Sucker Lake and the East Vadnais Lake Alternative (Alternative 2) withdrawals water from East Vadnais Lake. This Technical Memorandum (TM) summarizes the system characteristics and infrastructure for the East Vadnais Lake Alternative (Alternative 2). Figure 1 provides the proposed East Vadnais Lake Alternative alignment and Figure 2 shows the East Vadnais Lake site area.

During the augmentation process, source water would be pumped from the southeast bay of East Vadnais Lake and discharged into the west bay of WBL. A pump station and filtration facility would be installed on the shoreline of East Vadnais Lake, and filtered water would flow through a 30-inch High Density Polyethylene Pipe (HDPE) to an outlet structure located in WBL. The filtration system would prevent the transfer of zebra mussels (both adult and veliger) from the infested waters of East Vadnais Lake, as well as improve the water quality by reducing the volume of solids and nutrients currently found in the source water.

The intake structure would be constructed approximately 20 feet deep in East Vadnais Lake. This allows higher quality water to enter the system prior to filtration. The pump and filtration facility would include the intake structure with intake portals, 30-inch HDPE intake pipe with concrete armor mat to minimize bottom disturbance, and a well pump. The filtration facility would consist of the following: primary filters, secondary filters, a magnetic flow meter, an overhead service crane, and a filter house. The filtration facility also includes a maintenance and storage area and control room.

The 30-inch HDPE forcemain (FM) pipe would leave the filtration facility to transport flow to WBL. The FM alignment would primarily follow Highway 98 north to east and would be installed 8 to12 feet underground. Tunneling may be required under the existing Burlington Northern Santa Fe (BNSF) Railroad corridor and Minnesota State Highway 61. Water would exit the FM pipe through the outlet structure with WBL.

The outlet structure would be constructed on the bottom of WBL in approximately 15 feet of water. Water would exit the structure at a velocity that ensures complete mixing and protects both fish and plant life.

Components of the outlet structure include 6-inch diameter ports spaced six (6) feet apart. The structure would be made of 30-inch capped HDPE with concrete armor mat.

jkd
Attachments – Figures 1 and 2
c: Don Lutch
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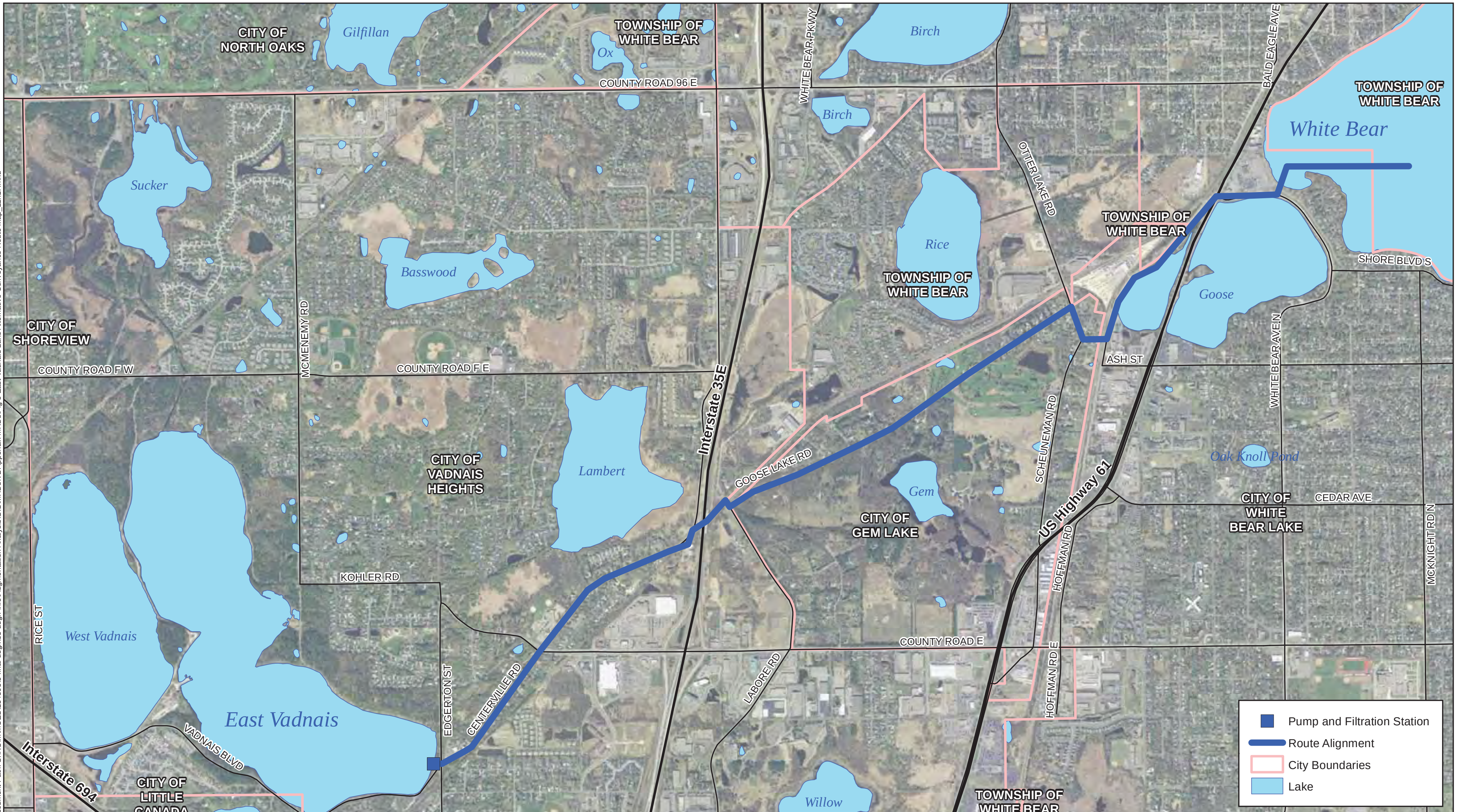

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Map by: LO
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

0 850 1,700 3,400 5,100 6,800 Feet

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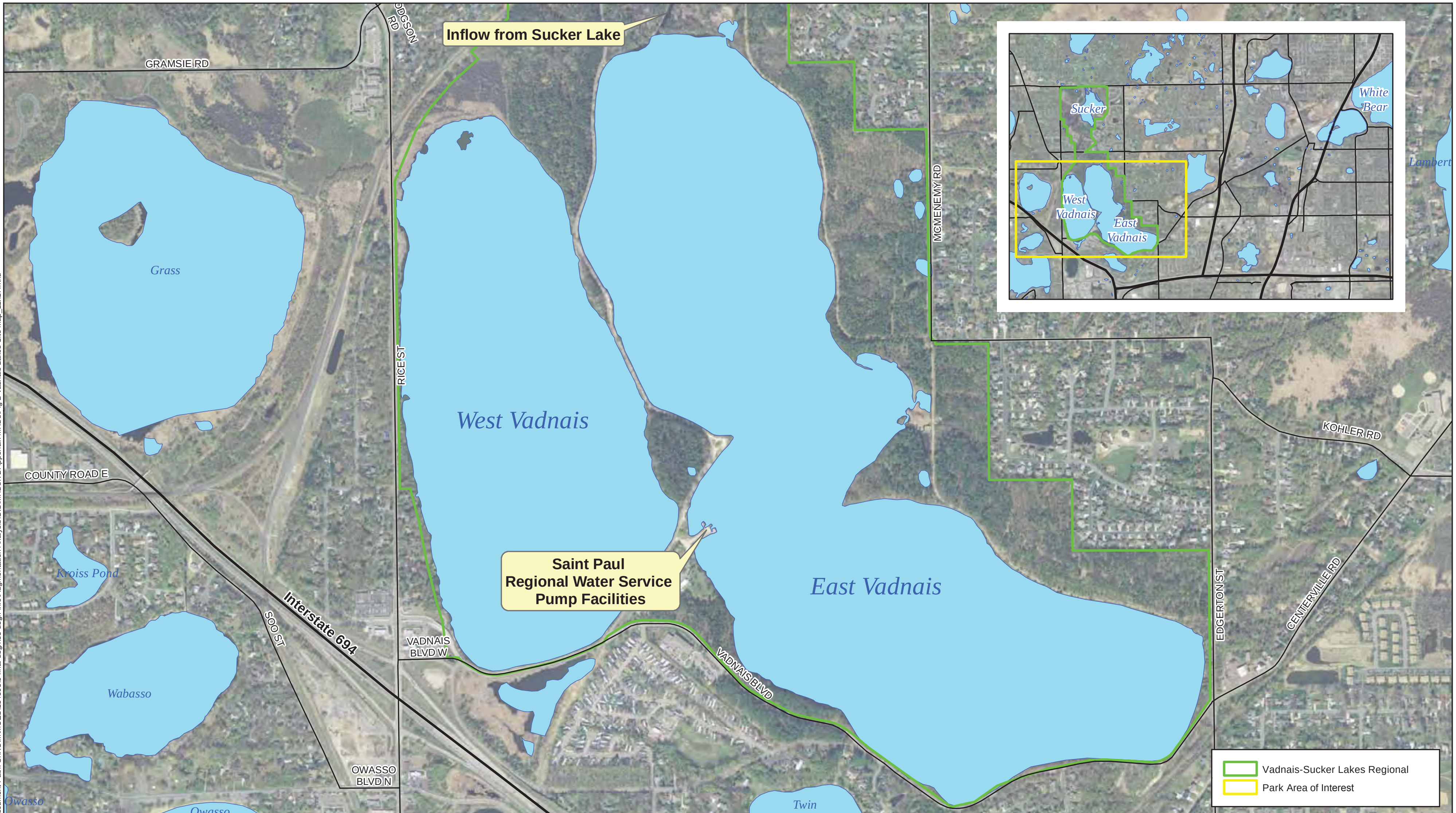
East Vadnais Lake Alternative Conveyance Route

Figure 1



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Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, SEH, Ramsey County

0 425 850 1,700 2,550 3,400 Feet

N

East Vadnais Lake Site

Figure 2

Appendix I: Water Quality Review

METROPOLITAN COUNCIL

MEMORANDUM

TO: Sam Paske, Assistant General Manager, Environmental Quality Assurance (EQA) – Metropolitan Council Environmental Services (MCES)

FROM: Karen Jensen and Erik Herberg, Water Resources Assessment Unit – MCES

DATE: January 4, 2016

SUBJECT: Comparison of water quality between White Bear Lake and potential surface water augmentation sources (Sucker and East Vadnais Lakes) and identification of data gaps and potential risks

Executive Summary

This memo was assembled by Metropolitan Council Environmental Services (MCES) staff as part of the *Concept Cost Report for Augmentation of White Bear Lake with Surface Water,* prepared by the Minnesota Department of Natural Resources (DNR) with cooperation from MCES in response to legislative request ("Sucker Lake Chain of Lakes to White Bear Lake Augmentation"; SF 5: 2nd Engrossment – 89th Legislature, 2015 Special Session (2015-2015), Posted on 06/17/2015; HF 4: House for the 89th Legislature, 2015 1st Special Session (2015-1015).

The purpose of this memo is to assemble and compare available water quality data for White Bear Lake to that of potential surface water augmentation sources (Sucker Lake and East Vadnais Lake); to identify potential risks to White Bear Lake water quality, aquatic life, and aquatic recreation; to identify potential data gaps for permit preparation and regulatory review; to identify potential data gaps for sizing and estimating costs for any necessary treatment; and to recommend potential actions to reduce risk.

MCES has determined that

- While multiple organizations have monitored Sucker, East Vadnais, and White Bear Lakes over time, the most recent and complete datasets have been collected by Ramsey County (White Bear Lake) and Saint Paul Regional Water Services; SPRWS; Sucker and East Vadnais Lakes).
- Ramsey County, SPRWS, and MCES (for Mississippi River at Anoka, upstream from the SPRWS Fridley water intake) collected data using different monitoring programs with different end goals, leading to data collected at different depths, at different time intervals, with different equipment, for non-uniform chemical parameters determined by different laboratories. Concentrations for low level data, particularly phosphorus, were reported inconsistently by the three laboratories, with the SPRWS and Ramsey County labs having different reporting limits for phosphorus (0.02 mg/L vs. 0.01 mg/L, respectively). These factors make it difficult to conduct an accurate comparison of water quality in the river and lakes.
- Total phosphorus is the sole water quality parameter with sufficient data to allow comparison between the Mississippi River, and Sucker, East Vadnais, and White Bear Lakes. Different reporting limits for low level samples in the SPRWS, Ramsey County, and MCES labs likely

skewed reported average values. Comparison of average total phosphorus for May through September during 2005-2010 (which is when data were available for White Bear Lake) indicates phosphorus concentrations of 0.104 mg/L in the Mississippi River at Anoka, 0.015 mg/L in White Bear Lake and 0.039 mg/L and 0.035 mg/L in Sucker and East Vadnais Lakes, respectively, with the Mississippi River, Sucker and East Vadnais having more variable, with higher periodic concentrations.

- Comparison of total phosphorus for 2011-2015 indicates an average concentration of 0.121 mg/L in the Mississippi River at Anoka; 0.019 mg/L in White Bear Lake and 0.026 mg/L in East Vadnais. Data were not available for Sucker Lake during this time.
- The relatively low concentration of phosphorus in White Bear Lake means input of additional phosphorus to the lake may cause a disproportionately large decrease in water transparency, as predicted by statistical relationships developed by the MPCA and others.
- Temperature and dissolved oxygen profile plots indicate that thermal stratification at the West monitoring site in White Bear Lake has been intermittent, with short periods of near-sediment anoxia. Discharge of augmentation water could potentially disrupt stratification and cause delivery of near-sediment phosphorus to the lake surface.
- Effective operation of the East Vadnais hypolimnetic oxygenation system is essential to reduce and control phosphorus concentration in the lake. Disruption or discontinuance of the oxygenation system would like result in elevated phosphorus concentrations in the lake.
- Besides phosphorus, other chemical and biological parameters are crucial to consider for protecting White Bear Lake, including differences between Sucker and East Vadnais Lakes and White Bear Lake in alkalinity, hardness, pH, sulfide, metals concentrations, bacteria abundance, chloride concentration, pesticide concentrations, trace chemicals of emerging concern (like pharmaceuticals, estrogen disrupters, etc.), and others. Insufficient data are available to compare the lakes for these parameters.
- Sufficient data are not available to identify, size, and cost any necessary treatment to remove contaminants other than phosphorus.
- Lack of sufficient data for phosphorus, alkalinity, hardness, trace contaminants, and other parameters may hinder preparation of permits and verification of compliance with relevant state water quality standards and nondegradation requirements.

In specific, MCES identifies the following data gaps and potential risks

- Insufficient total phosphorus data to estimate potential changes to trophic level and water transparency in White Bear Lake with augmentation from Sucker or East Vadnais Lakes
- Lack of long-term monitoring showing effectiveness of East Vadnais hypolimnetic oxygenation (HO) system and lack of emergency operation plan for augmentation system if HO is disabled
- Insufficient data to assess potential threats to human and aquatic life from White Bear Lake augmentation
- Insufficient data to prepare necessary permits and meet regulatory requirements
- Insufficient data to identify, size, and estimate cost of treatment of augmentation water

Based on these conclusions, MCES recommends

- Identification of acceptable water quality goals for White Bear Lake, given potential detrimental effects from augmentation

- Collection of uniform, comparable data for the Mississippi River, Sucker Lake, East Vadnais Lake, and White Bear Lake, and potentially Centerville Lake, including sampling at depth. To facilitate accurate statistical comparison of water quality between the water bodies, each should be sampled synoptically using the same type equipment and all samples analyzed using one laboratory. Parameters sampled should include those that will help
  - Identify level of treatment required for augmentation water prior to discharge to White Bear Lake
  - Identify those parameters which may present risks to human health, aquatic recreation and aquatic life (including fisheries, aquatic plants, aquatic macroinvertebrates, and other aquatic life) in White Bear Lake
  - Quantify those parameters necessary to negotiate permits for augmentation with appropriate regulatory authorities and to verify compliance with state water quality standards and nondegradation requirements.
- Inclusion in augmentation system planning an acknowledgment that a long term monitoring plan should be implemented for the purpose of assessing White Bear Lake during augmentation, in order to evaluate short term and long term effects on lake water quality.
- Creation of a lake computer simulation model for White Bear Lake to assess potential alterations in water quality and biological activity from proposed augmentation program.

Technical Memo Body

Purpose of Memo

This memo was assembled by Metropolitan Council Environmental Services (MCES) staff as part of the *Concept Cost Report for Augmentation of White Bear Lake with Surface Water,* prepared by the Minnesota Department of Natural Resources with cooperation from MCES in response to legislative request ("Sucker Lake Chain of Lakes to White Bear Lake Augmentation"; SF 5: 2nd Engrossment – 89th Legislature, 2015 Special Session (2015-2015), Posted on 06/17/2015; HF 4: House for the 89th Legislature, 2015 1st Special Session (2015-1015). The purpose of this memo is to

- Assemble available water quality data for Sucker Lake, East Vadnais Lake, and White Bear Lake, as well as other sources waters (i.e. Mississippi River, Pleasant Lake, etc.), where possible.
- Compare water quality
- Identify potential water quality issues potential risks to aquatic life, human health, and aquatic recreation; and data gaps for regulatory authority review and permit preparation
- Identify potential water quality issues and data gaps for designing, sizing, and estimating cost for potential treatment of source water before discharge to White Bear Lake
- Assemble conclusions
- Recommend future actions, if any

MCES did not attempt to identify any changes in White Bear Lake water quality over. MCES did not attempt to correlate water quality in Sucker and East Vadnais Lakes with annual variation in Saint Paul Regional Water Services (SPRWS) operations or to volume of discharge to the lakes from SPRWS source waters.

Data Sources and Existing Monitoring Programs

The water quality data presented in this memo originate from three agencies: Metropolitan Council Environmental Services (MCES), St. Paul Regional Water Services (SPRWS) and Ramsey County. The three agencies collect data using three separate monitoring programs, with disparate goals for the data and associated water quality assessments. To summarize,

- MCES collects water quality data from multiple stations within the region's three major rivers – the Mississippi, the Minnesota, and the St. Croix – in order to assess water quality impacts from wastewater treatment plant (WWTP) effluent discharge and to assess region-wide river water quality. Samples are regularly collected throughout the year and parameters include nutrients (phosphorus and nitrogen), sediment, chlorophyll, chloride, biological and chemical oxygen demand, alkalinity, hardness, bacteria, and metals, and occasionally miscellaneous parameters such as pesticides, PCBs, and contaminants of emerging concern.

  Temperature, pH, and dissolved oxygen data from the Mississippi River at Anoka was downloaded from Metropolitan Council's database via the EIMS website (*http://es.metc.state.mn.us/eims/*). Data for the remaining parameters for the Mississippi River at Anoka were obtained from MCES data management staff.

- SPRWS collects water quality data from multiple stations in water bodies used to transport and supply source water to the SPRWS water treatment plant (McCarron's WTP). SPRWS removes river water from the Mississippi at an intake located at the City of Fridley, adds a coagulant, and then pumps it through two pipes to Charley Lake. The coagulant allows formation of particles which then settle out in Charley Lake, removing various constituents, such as phosphorus and suspended sediment, from the river water. From Charley Lake the water flows by gravity to Pleasant Lake to Sucker Lake to East Vadnais Lake and then to McCarron's WTP. Additional source water may be discharged to Pleasant Lake from the Rice Creek/Centerville Chain of Lakes and from Otter and Bald Eagle Lakes. Well water from Prairie du Chien/Jordan Aquifer wells may be added downstream of East Vadnais Lake.

A one-year snapshot of the source waters entering the McCarrons's WTP is provided by the water use allocations reported to the Minnesota Department of Natural Resources (DNR) by SPRWS for 2014:

- Mississippi River water = 8,098 MGY (52%)
- East Vadnais Lake = 13,223 MGY (33% after subtracting Mississippi River volume)
- Centerville Lake = 0 MGY (0%)
- Prairie du Chien/Jordan Aquifer wells = 2,277 MGY (15%)
- Total = 15,500 MGY (assumes 100% of Mississippi River water flows to East Vadnais)

Since 1984, SPRWS has installed multiple practices to the Mississippi intake, to Pleasant Lake, and to Vadnais Lake with the goal of reducing taste and odor issues in drinking water produced by the McCarron's Water Treatment Plant (WTP). A timeline of installed practices includes (Austin et al., 2015):

- 1984 — No treatment on any lake
- November 1986 — Hypolimnetic aeration (HA) installed at East Vadnais Lake
- April 1987 — Ferric chloride feed at Mississippi River intake
- 1988 — Ferric feed piloted on East Vadnais Lake
- 1990 — HA replaced in East Vadnais Lake
- August 1994 — HA installed on Pleasant Lake
- 2007 — Pleasant Lake aeration system ceased
- 2009 — CH2M begins reservoir work
- Summer 2011 — Aeration systems removed from Pleasant and East Vadnais Lakes
- Fall 2011 — Hypolimnetic Oxygenation (HO) installed in East Vadnais Lake
- Fall 2013 — HO system installed in Pleasant Lake

Surface water samples from Sucker and East Vadnais Lakes were primarily collected by SPRWS during spring, summer, and fall (when lakes are more biologically active), except for the McCarron's WTP inlet, which was sampled year round. The SPRWS lake monitoring program focuses on the water quality parameters which provide pertinent data on potential drinking water taste and odor issues and potential human health metrics, in order to help optimize the efficiency of water treatment processes from the Mississippi River to the McCarron's WTP inlet. The SPRWS's end goal is to produce drinking water that meets and exceeds the Safe Drinking Water Act.

Water quality data for the water bodies along the SPRWS supply line (i.e. Mississippi River at Fridley, Pleasant Lake, Sucker Lake, East Vadnais Lake, and raw water entering McCarron's WTP) were provided by SPRWS staff.

- Ramsey County collects data from four monitoring stations within White Bear Lake, typically between May and September. The primary purpose of the county monitoring program is to assess the lake's trophic status – i.e. level of biological production – with a particular focus on those parameters indicative of level of human satisfaction with recreating (swimming, boating, and fishing) on the lake. Parameters assessed include Secchi disk depth (lake transparency), phosphorus concentration, chlorophyll a, (a surrogate for algal production), dissolved oxygen and temperature.

  White Bear Lake data were supplied to MCES by Ramsey County staff.

Descriptions of Study Lakes

Sucker Lake is small (68 acres) and relatively shallow (24 feet maximum depth), East Vadnais larger and deeper (394 acres; greater than 50 feet maximum depth); while White Bear Lake has a surface area of greater than 2,400 acres and maximum depth greater than 83 feet at the East monitoring station (Table 1). Note that the West lobe of White Bear Lake, which is the proposed location for augmentation water discharge, is relatively shallow (approximately 22 feet). All three lakes have been listed in the MPCA's 303(d) (Impaired Water List; MPCA, 2014) as impaired for aquatic consumption due to mercury in fish tissue.

Table 1: Comparison of lake morphologies, beneficial uses, and impairments in Sucker, East Vadnais, and White Bear Lakes

Lake	ID	Area (acres)	Maximum Depth (feet)	MPCA Beneficial Use Classification[4]	Impairments[5]
Sucker Lake	62002800	68[1]	24[1]	1C, 2Bd, 3C	Aquatic Consumption (Hg in fish tissue)
East Vadnais	62003801	394[2]	53 (North)[2] 58 (South)[2]	1C, 2Bd, 3C	Aquatic Consumption (Hg in fish tissue)
White Bear Lake	82016700	2,416[3]	83 (East)[3] 28 (North)[3] 35 (Center)[3] 22 (West)[3]	2B, 3C	Aquatic Consumption (Hg in fish tissue)

[1] According to Minnesota Department of Natural Resources (DNR) bathymetric maps dated 3/12/1980 (http://files.dnr.state.mn.us/lakefind/data/lakemaps/c2758010.pdf). Water level unknown.
[2] According to Minnesota Department of Natural Resources (DNR) bathymetric maps dated 7/30/1981 (http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0486010.pdf). Water level unknown.
[3] According to Minnesota Department of Natural Resources (DNR) bathymetric maps dated 8/3/1978 (http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0469011.pdf). Water level unknown.
[4] MPCA beneficial use classifications. 1C = drinking water; 2Bd = cool and warm water fisheries, drinking water; 3C = Industrial uses and cooling; 2B = cool and warm water fisheries
[5] MPCA 303(d) list, 2014. *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/impaired-waters-list.html*

East Vadnais and Sucker Lakes have more complicated contributing watersheds than that in White Bear Lake, which receives runoff from a directly-contributing watershed of 2,300 acres during normal precipitation years (7.744 acres during unusually wet years) (Table 2). East Vadnais and Sucker Lakes are identified as a single hydrologic system by the Vadnais Lakes Area Water Management Organization (VLAWMO). Both receive runoff from the landscape directly surrounding the lakes (2,192 acres) and from upstream waterbodies like Pleasant Lake and Lambert Creek (12,897 ac). The Mississippi River at the SPRWS Fridley intake location has a watershed area of greater than 12,000,000 ac, with associated water quality affected by agricultural drainage, wastewater treatment plant discharge, urban runoff, and gully and river bank erosion, among other sources.

Table 2: Comparison of watershed areas of Sucker, East Vadnais, and White Bear Lakes

Waterbody	Lake ID	Direct Contributing Watershed Area (acres)	Upstream Watershed Area (acres)	SPRWS Source Watershed Area (Mississippi River at Fridley) (acres)	Total Area (Contributing, Upstream, and SPRWS) (acres)
East Vadnais/Sucker Lakes	62003801 62002800	2,192 [1]	12,897 [2]	12,380,000 [3]	12,392,897
White Bear Lake	82016700	2,300 – normal years [4] 7,744 – wet years [4,5]	0	0	2,300 (7,744 wet years)

[1] Vadnais Lake Area Watershed Management Organization (VLAWMO) Watershed Management Plan dated December, 2007. Accessed 12/16/2015. (http://www.vlawmo.org/files/6113/9343/9936/07_Chapter_2.pdf)

[2] Calculated as the sum of the upstream areas of Lambert Creek (5,140 acres), Tamarack/Wilkinson (4,391 acres), and Pleasant/Charley/Deep (3,366 acres), as reported in Vadnais Lake Area Watershed Management Organization (VLAWMO) Watershed Management Plan dated December, 2007. Accessed 12/16/2015. (http://www.vlawmo.org/files/6113/9343/9936/07_Chapter_2.pdf)

[3] Calculated using the drainage area delineation tool of USGS StreamStats with NAD 1983 Latitude 45.1033 and Longitude -93.2779 (approximate location of SPRWS intake pipe in the Mississippi River at Fridley).

4 Contributing watershed area in typical years. In extremely wet years, an additional 5,250 acres can contribute to the lake. Reported in Appendix 1 of White Bear Lake Conservation District (WBLCD) Lake Management Plan 4/27/99. Accessed 12/16/2015. (http://www.wblcd.org/wl/index.php/appendix-i#Drainage).

[5] 2010 Rice Creek Watershed District (RCWD) Watershed Management Plan, amended November 2014. Accessed 12/16/2015. (http://www.ricecreek.org/vertical/Sites/%7BF68A5205-A996-4208-96B5-2C7263C03AA9%7D/uploads/2010-RCWD-Watershed_Management_Plan-amended_11-12-14%281%29.pdf)

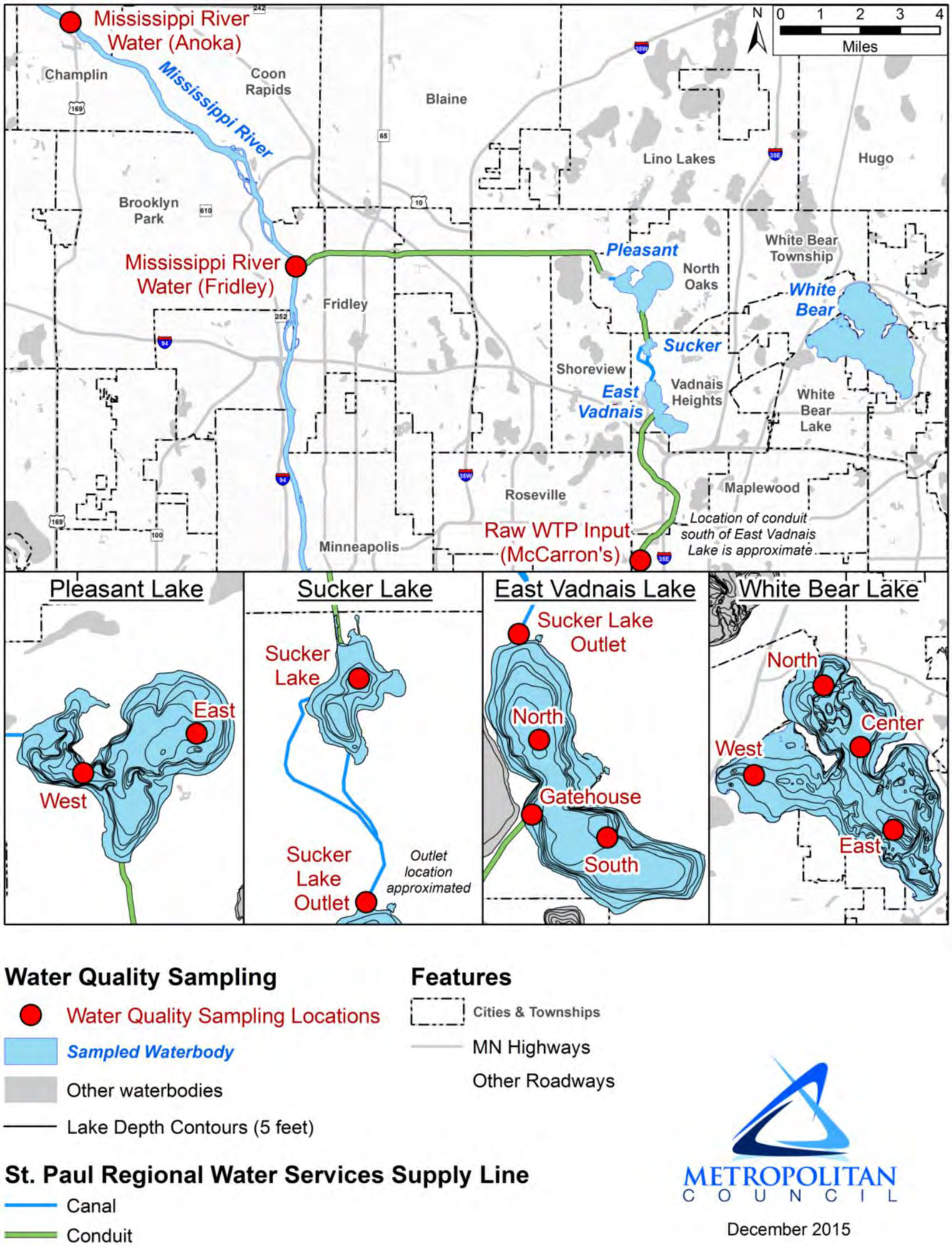
Available Data and Sampling Locations

While the *Concept Cost Report for Augmentation of White Bear Lake with Surface Water* was specifically designed to look at the potential for surface water augmentation from Sucker Lake and from East Vadnais Lake, MCES staff compiled all available surface water quality data from 2005 to 2015 for 13 sampling sites on five water bodies – Mississippi River (at Anoka and Fridley), Pleasant Lake (East and West), Sucker Lake (Lake and Outlet), East Vadnais Lake (North, South, and Gatehouse), and White Bear Lake (North, East, West, and Central). For completeness, MCES also compiled data on the raw water entering McCarron's WTP from East Vadnais Lake. At some sites, water quality data are available before 2005, but is not included in this analysis. The locations of each sampling site are shown in Figure 1. A summary of the sampling at each site is presented below:

- **Mississippi River at Anoka** – sampled year-round since 1976 by MCES from the middle of the river, one meter below the surface.
- **Mississippi River at Fridley** – sampled year round by SPRWS from the intake pumping station (depth of the intake pipe in the Mississippi River was not provided).
- **Pleasant Lake (East and West)** – collected April to September by SPRWS, most often around 3 and 13 meters below the surface of the lake. Temperature and dissolved oxygen (DO) were measured at 1 meter increments from lake surface to lake bottom during multiple years.
- **Sucker Lake** – sampled April to October by SPRWS, most often at 3 and 5 meters deep. Monitoring ended in Sucker Lake at the end of 2009. Temperature and dissolved oxygen (DO) were measured at 1 meter increments from lake surface to lake bottom for multiple years, with 2008 as the last complete year of data.
- **Sucker Lake Outlet** – sampled by SPRWS during April to November at 3 meters below the surface of the end of the canal which drains into East Vadnais Lake. The exact location of the sampling station was not provided. Monitoring ended at the site after 2010.
- **East Vadnais (North and South)** – collected April to September by SPRWS, most often around 3 and 13 meters below the surface of the lake. Temperature and dissolved oxygen (DO) were measured at 1 meter increments from lake surface to lake bottom for multiple years.
- **East Vadnais (Gatehouse)** – sampled year-round by SPRWS near the intake pipe to McCarron's treatment plant, ranging from 7 – 15 meters below the surface, although exact depths were not provided.
- **Raw WTP Input (McCarron's Potable Water Treatment Plant (WTP))** - sampled year-round by SPRWS from the terminal chamber of the pipe bringing water from East Vadnais Lake to McCarron's WTP.
- **White Bear Lake** – four monitoring sites sampled May to September by Ramsey County, most often at or near the lake surface. Temperature and dissolved oxygen (DO) were measured at 1 meter increments from lake surface to lake bottom at all four sites for multiple years. At the East and Central sites, Total Phosphorus, turbidity, chloride, chlorophyll a, nitrate/nitrite, and ammonia were often monitored at additional depths.

Between 2005 and 2015, there are several periods of time where sampling was not performed regularly for parameters at several of the sites. These gaps in the datasets are summarized in the footnotes of Table 5 and Table 6.

Figure 1. Water Quality Sampling Locations



Water Quality Comparison

Comparison of water quality between the various water bodies for many typical water quality parameters was not possible due to disparate and incomplete datasets for the river and each lake. Each of the three monitoring agencies (MCES, SPRWS, and Ramsey County) collected samples at dissimilar depths, different frequencies, and different seasons of the year, for different chemical and biological parameters, with different equipment, using different environmental testing laboratories, ultimately to meet different goals.

White Bear Lake was only sampled in the months of May through September, so datasets for all lakes were limited to those months. Sucker Lake and Sucker Lake Outlet were only sampled until 2009 and 2010, respectively, so MCES separated the datasets into two time frames: 2005 – 2010 and 2011 – 2015. The 2005 - 2010 allowed more direct comparison of Sucker, East Vadnais, and White Bear Lake.The 2011 - 2015 period presents the most recent available data for East Vadnais and White Bear Lakes, but excludes direct comparison with Sucker Lake, since no data were collected during that time. MCES used that data collected closest to the surface of the waterbodies, which is the most common practice in limnological comparisons.

MCES, Ramsey County and SPRWS have in-house laboratories. Variations in equipment and methods between laboratories resulted in variation in detection limits and reporting limits, particularly of total phosphorus (Table 3). Both SPRWS and Ramsey County use their respective reporting limits (which are determined by laboratory precision and accuracy, which are influenced by laboratory equipment, processes, analytical methods, and analysts) as minimal reported values for total phosphorus concentrations. MCES processed data as needed. For example, if multiple measurements of a parameter occurred on the same day at the same depth (for example, duplicate samples), those results were averaged to produce one value.

Table 3. Summary of laboratory certification, phosphorus detection limits, and phosphorus reporting limits, for MCES, Ramsey County, and SPRWS labs

Agency	Laboratory Name	Certification	Total Phosphorus Detection Limit (mg/L)	Total Phosphorus Reporting Limit (mg/L)
MCES	MCES Analytical Services	MN Dept. of Health - ID 027-123-172	0.02	0.05
Ramsey County	Ramsey County Lake Management	MPCA - ID MNL0002	0.004	0.01
SPRWS	SPRWS – Water Quality Unit Laboratory	MN Dept. of Health - ID 027-123-106	0.009	0.02

Table 4 identifies a minimal slate of water quality parameters typically used by regulatory agencies to assess suitability of lake quality for human recreation and aquatic life. Additional parameters may be required by regulatory agencies before negotiating necessary permits for discharge of augmentation water to White Bear Lake. Table 4 also provides a summary of the calculated averages for those parameters for the Mississippi River at Anoka, and Sucker, East Vadnais, and White Bear Lakes for the months of May to September for 2005 – 2010 and 2011 –, while averages, medians, maximums, minimums, and counts of parameters at the original monitoring sites are detailed in Table 4 (for period 2005 – 2010) and Table 5 (for period 2011 – 2015).

Table 4. Summary of averages for various water quality parameters in Sucker, East Vadnais, and White Bear Lakes for May to September in 2005-2010 and 2011-2015

	2005 – 2010 (May – Sept)					2011-2015 (May – Sept)				
Sites	Mississippi River (Anoka)	Sucker Lake	Sucker Lake Outlet	East Vadnais Lake [a]	White Bear Lake [b]	Mississippi River (Anoka)	Sucker Lake	Sucker Lake Outlet	East Vadnais Lake [a]	White Bear Lake [b]
Data Source	MCES	SPRWS	SPRWS	SPRWS	Ramsey County	MCES	SPRWS	SPRWS	SPRWS	Ramsey County
Sample Depth (meters)	1	3	3	3	0 - 0.5	1	3	3	3	0 - 0.5
Alkalinity, Total (mg/L as CaCO3)	174	-	-	-	#	168	-	-	-	-
Ammonia (mg-N/L)	0.04	0.256 *	0.075 *	#	0.055	0.03	-	-	-	0.024
Chloride (mg/L)	17.2	-	-	-	37.8	14.8	-	-	-	39.0
Chlorophyll a, corrected (ug/L)	39.3	-	-	-	4.62	19.5	-	-	-	4.91
Chlorophyll a, uncorrected (ug/L)	42.6	19.93 *	14.97	-	-	22.4	-	-	12.73	-
Coliform, Total (CFU Count/100 mL) [c]	-	-	1224	-	-	-	-	-	-	-
Dissolved Oxygen (mg/L)	8.78	-	#	#	9.43	8.20	-	-	-	9.16
E. coli (MPN Count/100 mL) [c]	44	-	1 *	-	-	71	-	-	-	-
Hardness, Total (mg/L as CaCO3)	208	-	-	-	#	198	-	-	-	-
Nitrate/Nitrite (mg-N/L)	0.89	0.146 *	0.096 *	#	0.012	0.90	-	-	#	0.016
Nitrogen, Total (mg-N/L) [d]	1.87	#	#	-	0.77	1.94	-	-	0.681	0.81
pH [e]	8.27	-	-	-	7.99	8.05	-	-	#	8.30
Phosphorus, Total (mg-P/L)	0.104	0.039 *	0.056 *	0.034	0.015	0.121	-	-	0.026	0.019
Secchi (m)	-	#	-	#	3.8	-	-	-	-	3.2
Temperature (°C)	21.3	#	-	#	20.80	20.7	-	-	-	21.03
Turbidity (NTU)	#	-	-	-	1.7	-	-	-	#	1.8
Turbidity (NTRU)	11 *	-	-	-	-	12				

Table Notes:
- Pound (#) = at least one sample was taken, but overall sampling was too infrequent (less than half of the time interval) to calculate a comparable average
- Dash (-) = not sampled
- Asterisk (*) = data gaps exist, meaning sampling was not performed regularly over the period of interest. See full tables in Appendix 1 for more information
- Data was used at the depth were samples were taken most frequently. Additional data is available at some sites at other depths.
- Basic data cleaning was performed which involved removing censored values (errors), converting units, and averaging replicate samples (i.e. samples which occurred on the same day at the same depth)

[a] East Vadnais averages were calculated using data from both the North and South sites
[b] White Bear Lake averages were calculated using data from all four sites (North, Center, East, West)
[c] Bacteria is reported as counts which can be exceptionally skewed, so the averages are calculated as Geometric Means
[d] For the Mississippi River at Anoka and White Beal Lake sites, Total Nitrogen was calculated as the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen
[e] pH is a log scale, so averages are calculated by converting values to hydrogen ion concentration [H+], averaging [H+], then converting back to pH

As shown in Table 4, there are no sites for which averages could be calculated for all parameters and likewise there are no parameters for which averages could be calculated at all sites. The most complete comparable dataset available is for total phosphorus. Comparison of average phosphorus concentrations for period 2005-2010 indicates phosphorus concentrations in Mississippi River were higher (0.104 mg/L) than those in the lakes; while concentrations in the SPRWS lakes (0.039 mg/L in

Sucker Lake and 0.034 mg/L in East Vadnais Lake) were higher than those in White Bear Lake (0.015 mg/L). For period 2011-2015, phosphorus concentrations were again higher in the Mississippi River (0.121 mg/L) than the lakes. No data were available for Sucker Lake for that period, but phosphorus in East Vadnais Lake (0.026 mg/L) appeared to remain higher than that in White Bear Lake (0.019 mg/L), despite the presence of the hypolimnetic oxygenation system.

Comparison graphs of total phosphorus for 2005 – 2015 (Figure 2) indicate the phosphorus concentrations in White Bear Lake remain fairly stable over time, while there is greater variability observed in the Mississippi River at Anoka and in Sucker and East Vadnais Lakes. The Mississippi River is the primary source water for the SPRWS system. River water enters the system at the Fridley intake, and flows to Charley and Pleasant Lakes before discharge to Sucker and East Vadnais Lakes. Phosphorus, as well as many other constituents, in the Mississippi is influenced by multiple factors, including precipitation and snowmelt, urban stormwater and agricultural runoff, discharge of wastewater effluent, and ditch, gully, and river bank erosion. Phosphorus, as well as many other chemical constituents in Sucker and East Vadnais Lakes are influenced by constituent concentration and volume of Mississippi River water delivered to the lakes, the constituent concentration and volume of water pumped from the Rice Creek Chain of Lakes and Otter and Bald Eagle Lakes, volume and constituent concentration of stormwater runoff from the lakes' direct watersheds, as well as by frequent modifications to aeration systems and alterations to coagulant application and dose.

Figure 2. Annual average concentration of total phosphorus in the Mississippi River, Sucker, East Vadnais, and White Bear Lakes using data from May – September during 2005 – 2015

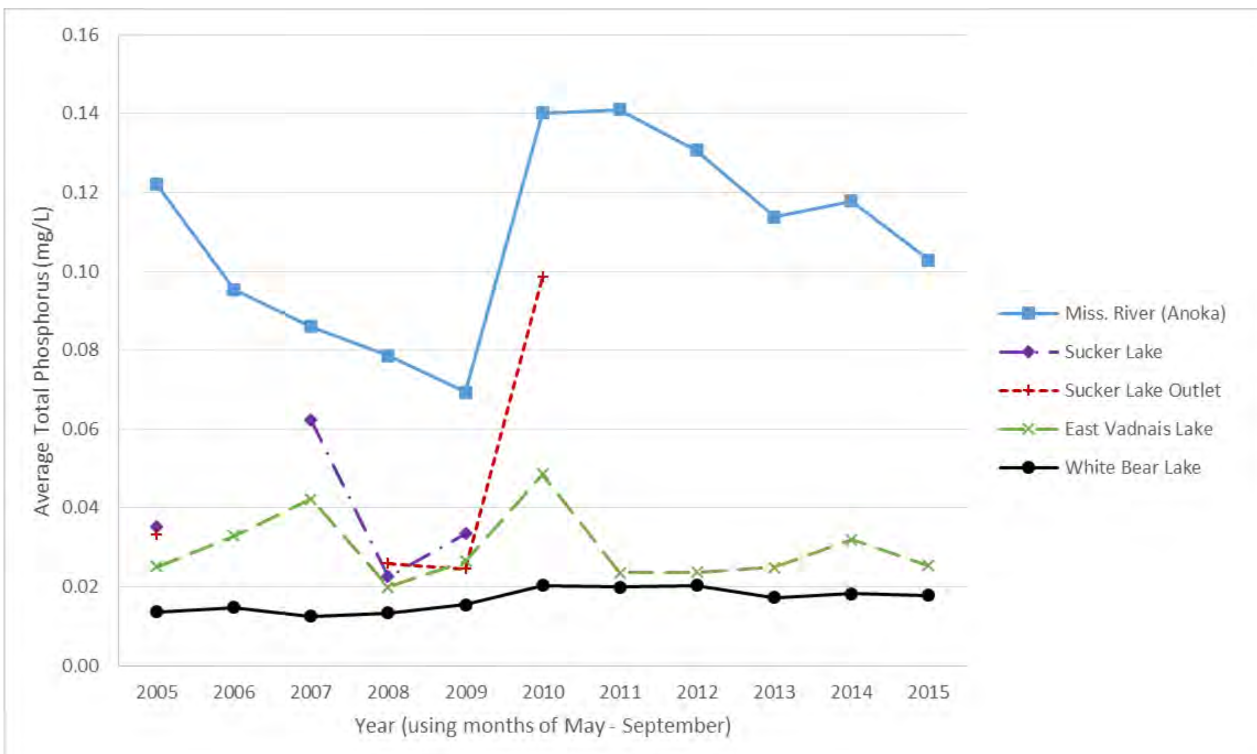
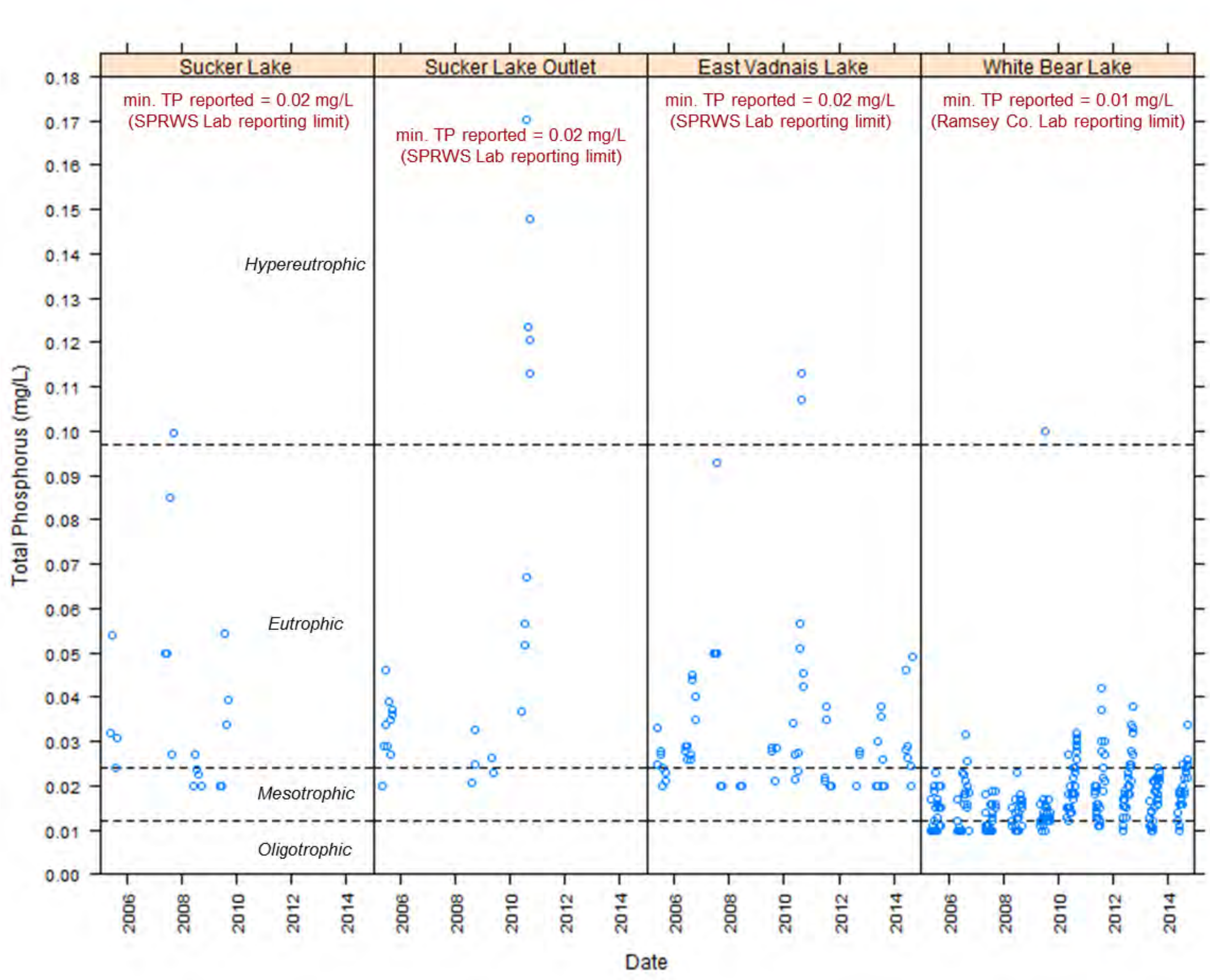


Figure 3 shows individual total phosphorus concentrations, including associated trophic status, for May through September during 2005-2015 in the Mississippi River and the monitoring stations within Sucker, East Vadnais, and White Bear Lakes. Trophic status was determined according to Carlson's Trophic State Index (Carlson,1977; MPCA, 2005) by using phosphorus as the sole parameters, since the chlorophyll dataset was not nearly as complete. Trophic status in lakes is generally classified as oligotrophic (very clear water with low phosphorus and few algae), mesotrophic (moderately clear water with relatively low phosphorus and algae), eutrophic (highly biologically active with elevated phosphorus, algae blooms, and low water clarity), or hypereutrophic (extremely biologically active with various high phosphorus, noxious and potentially toxic algae blooms, and very low water clarity).. The phosphorus concentrations at each White Bear Lake sampling site are generally around the borderline oligotrophic-mesotrophic to mesotrophic, with a few values trending toward eutrophic. In comparison, Sucker and East Vadnais Lake had much more variable phosphorus concentrations over time, which frequently reached eutrophic, and at times hypereutrophic, levels.

Figure 3. Individual total phosphorus concentrations in Sucker, East Vadnais, and White Bear Lakes compared with Carlson's Trophic State Index (May to September, 2005 – 2015)



Deep lakes thermally stratify annually during the open water season in the Twin Cities metropolitan area. Thermal stratification forms a water density gradient that eventually becomes strong enough which prevents the mixing of warmer surface waters with the deeper and more dense colder waters. Since the denser lower waters (called the hypolimnion) do not mix with the oxygenated surface waters, oxygen decreases over time. The hypolimnion of these lakes eventually become oxygen depleted (anoxic) after stratification occurs. The hypolimnion experiences differences in its chemistry compared to the surface waters because of the anoxic conditions.Anoxic conditions drive changes to sediment chemistry, resulting in chemical conversion and release of multiple chemicals, including phosphorus, iron, sulfide, and mercury. This chemical process has been manipulated over time in East Vadnais Lake due to the installation and alteration of hypolimnetic aeration and oxygenation systems, as well as intermittent application of ferric chloride.

Data were collected at uniform depth intervals during May through September for temperature and dissolved oxygen in all three lakes, although the last year with complete data for Sucker Lake was 2008. Depth profile plots for 2008 for Sucker Lake, East Vadnais Lake (South monitoring station, which is nearest proposed augmentation withdrawal site) and White Bear Lake (West monitoring station, which is nearest proposed augmentation discharge site) (Figure 4) indicate the formation of thermal stratification and resulting anoxia in both Sucker and East Vadnais Lakes, despite the presence of hypolimnetic aeration in East Vadnais at the time. White Bear Lake does not strongly stratify at the West monitoring site due to shallow depths; the temperature profiles indicate weak stratification with mid-summer mixing. This is reflected in the dissolved oxygen profiles, which indicate cycles of near-sediment anoxic and oxygenated conditions due to intermittent mixing. Similar plots for the most recent complete year of data (2014; Figure 5) indicate the influence of the hypolimnetic oxygenation system in East Vadnais; while the lake appears to have thermally stratified, near-sediment oxygen levels remain high. As in 2008, the 2014 profiles for White Bear Lake indicate weak thermal stratification and intermittent anoxia near the sediment.

Multiple corollary effects on lake water quality likely result from thermal stratification patterns, resulting near-sediment anoxia (in Sucker and East Vadnais Lakes), and manipulation of near-sediment oxygen levels using hypolimnetic aeration, hypoliminetic oxygenation, and application of ferric chloride (in East Vadnais Lake). SPRWS has focused data collection on total phosphorus due to assess potential effects on drinking water taste and odor. However multiple chemical parameters may be created, transported, and/or affected by thermal stratification cycles and near-sediment oxygen conditions, including sulfide, sulfate, iron, mercury, pH, alkalinity, and others. Withdrawal and transport of low oxygen water from either Sucker or East Vadnais Lakes for White Bear Lake augmentation could result in equipment corrosion, odor issues, and potential transport of high concentration pollutants to White Bear Lake. No data, beyond that for phosphorus, are available to assess level of chemical transformation and transport from either East Vadnais or Sucker Lakes to White Bear Lake.

Figure 4. Interpolated Depth Profiles of Dissolved Oxygen and Temperature in Sucker Lake, East Vadnais Lake (South), and White Bear Lake (West) in May to September, 2008

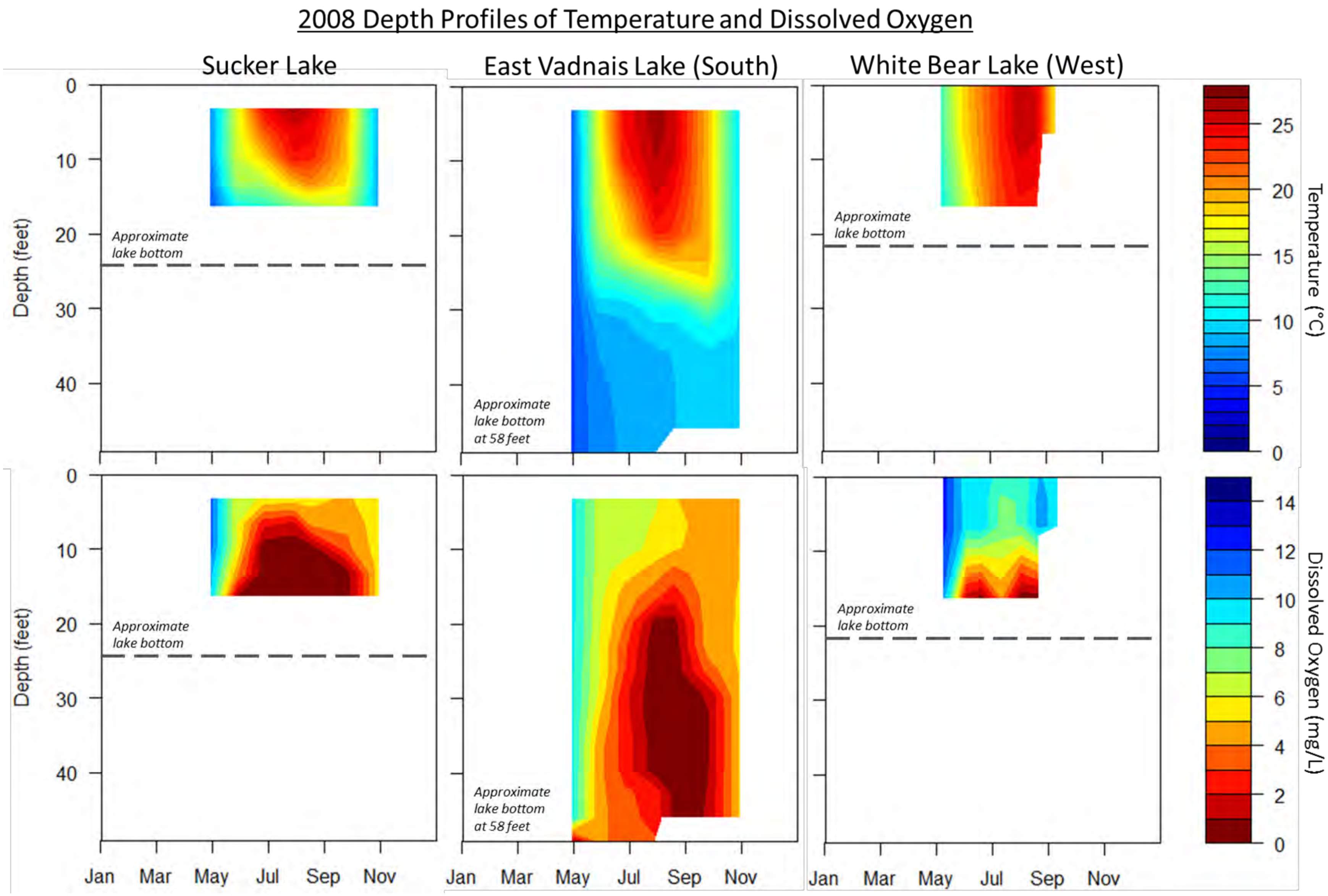
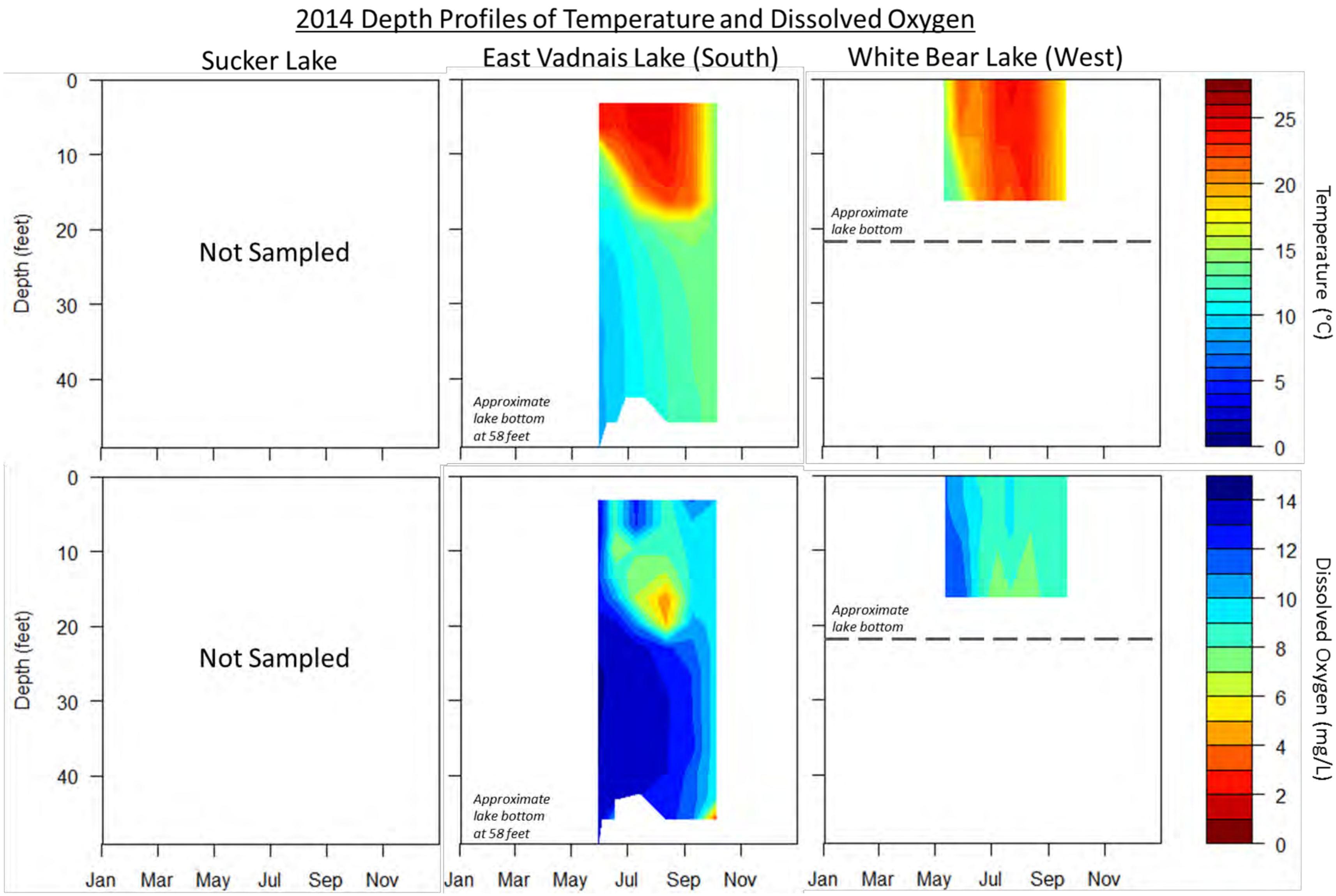


Figure 5. Interpolated Depth Profiles of Dissolved Oxygen and Temperature in Sucker Lake, East Vadnais Lake (South), and White Bear Lake (West) in May to September, 2014



Identification of Data Gaps and Potential Risks

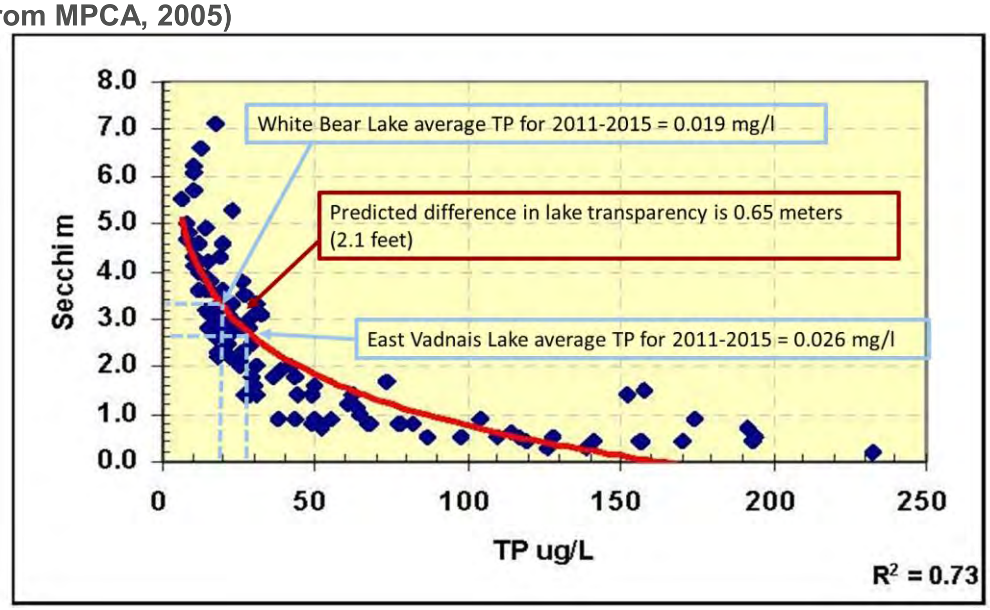
MCES has identified the following issues and data gaps as presenting potential risk to water quality, to accurate sizing and costing of necessary treatment, and to adequately address potential regulatory permit requirements:

1. **Lack of comparable total phosphorus data to estimate potential changes to trophic level and water transparency in White Bear Lake with augmentation from Sucker or East Vadnais Lakes**

   Total phosphorus concentrations have been reported for White Bear Lake and Sucker and East Vadnais Lakes, although differences in laboratory reporting limits for low level samples reduces the accuracy of any comparisons. Comparison of averages for 2005 – 2010 indicate phosphorus levels in Sucker and East Vadnais (0.039 and 0.035) higher than that in White Bear Lake (0.015 mg/L), while averages for 2011 – 2015 indicate phosphorus levels in East Vadnais (0.026 mg/L) and White Bear (0.019 mg/L) closer in value. White Bear Lake is mesotrophic and at times trending toward eutrophic. Lakes with relatively low phosphorus levels, like White Bear Lake, are particularly sensitive to additional inputs of phosphorus; elevated phosphorus results in more abundant algal growth, resulting in decreased lake transparency. The Minnesota Pollution Control Agency (MPCA, 2005) and others have documented the relationship between elevated phosphorus and declining water transparency (Figure 7), with low phosphorus lakes more susceptible to greater relative reductions in transparency. Collection of data from all three lakes, on same dates, using same laboratory, with emphasis on using low-level phosphorus methods, would allow accurate comparison between lakes and allow assessment of potential changes in White Bear Lake concentration and water transparency.

   Minnesota Statutes (M.S.) Chapter 7050 lists nondegradation (7050.0185) policy and specific water quality standards pertinent to White Bear Lake (7050.0220, 7050.0222, 7050.0223), including narrative eutrophication standards (7050.0222 subp.4a). It is beyond the scope of this memo to address potential permitting or treatment requirements, but both the nondegradation policy and eutrophication standards indicate maintenance of the existing concentration of phosphorus in White Bear Lake.

Figure 7. Relationship between total phosphorus and transparency in Minnesota reference lakes (excerpted from MPCA, 2005)



2. **Insufficient data demonstrating effectiveness of East Vadnais hypolimnetic oxygenation (HO) system and lack of emergency operation plan for augmentation system if HO is disabled**

   SPRWS has historically implemented hypolimnetic aeration in Pleasant and East Vadnais Lakes to control phosphorus concentrations, and has applied coagulants (primarily ferric chloride) to control near-sediment phosphorus release. Most recently, the SPRWS has installed hypolimnetic oxygenation in both Pleasant and East Vadnais Lakes (approximately 2011). SPRWS has collected four years of phosphorus data since installation of the hypolimnetic aeration, which indicates the phosphorus concentration in East Vadnais Lake has been at times higher, and is more variable, than that in White Bear Lake. In addition, installation and operation of the hypolimnetic aeration system and application of ferric chloride is necessary to control phosphorus concentrations in East Vadnais Lake. Discontinued operation of these controls would likely result in elevated phosphorus in East Vadnais. Identification of actions necessary to protect White Bear Lake quality if HO system is disabled need to be identified.

3. **Insufficient data to assess potential threats to human and aquatic life from White Bear Lake augmentation**

   MCES identified a slate of additional parameters typically used to assess suitability of water bodies for sustaining human recreation and aquatic life and which may be required for regulatory permit preparation and for sizing and costing necessary treatment of augmentation water. Parameters included alkalinity, hardness, pH, bacteria (fecal coliform and E. coli), chloride, chlorophyll a, nitrogen (including nitrate, ammonia, and total nitrogen), transparency, and turbidity. No comparable data are available for three lakes for these parameters.

   Discharge of Mississippi River water to the SPRWS system may influence the concentration of additional parameters in East Vadnais and Sucker Lakes, many not measured (for example, pesticides, estrogen compounds, pharmaceuticals, personal care products, and other trace contaminants). Mississippi River water quality is influenced by numerous pollutant sources, including runoff from agricultural and urban areas, discharge from wastewater treatment plants, and gully, ravine, and riverbank erosion, draining from approximately 19,300 square miles (12,380,000 acres). In addition, potential spills or illicit discharges to the river upstream of the Fridley SPRWS water intake potentially could impact the quality of water ultimately discharged to White Bear Lake.

4. **Insufficient data to prepare necessary permits and meet regulatory requirements**

   Feasibility Assessment of Approached to Water Sustainability in the Northeast Metro (MCES, 2014) identified a slate of potential permits required for construction of augmentation system. Of those, the following likely have requirements for presentation of comparative water quality data or proof or removal through treatment: Vadnais Lakes Area Water Management Organization (VLAWMO), Rice Creek Watershed District (RCWD), Minnesota Pollution Control Agency (MPCA) National Pollutant Discharge Elimination System (NPDES) and Stormwater Pollution Prevention Program (SWPPP) permits/requirements, and potentially Environmental Assessment Worksheet (EAW) and/or Environmental Impact Study (EIS) through Minnesota Environmental Quality Board (EQB).

5. **Insufficient data to identify, size, and cost of treatment of augmentation water and identify correct elevations for withdrawal and discharge pipes**

   Data necessary to properly identify, size, and cost treatment to remove pollutants that may detrimentally affect White Bear Lake (like phosphorus, metals, trace contaminants, and others) are not available. In addition, discharge pipe into West lob of White Bear Lake has potential to disrupt thermal stratification in the relatively shallow water, causing delivery of sediment phosphorus to lake surface. Some temperature and dissolved oxygen data are available at depth increments in the West lobe, but data may not have been collected frequently enough to assess potential of disrupting stratification.

Conclusions

MCES has determined that

- While multiple organizations have monitored Sucker, East Vadnais, and White Bear Lakes over time, the most recent and complete datasets have been collected by Ramsey County (White Bear Lake) and SPRWS (Sucker and East Vadnais Lakes). Data on the Mississippi River (the primary SPRWS source water delivered to Sucker and East Vadnais Lakes) were collected by SPRWS and MCES.
- Ramsey County, SPRWS, and MCES collected data using different monitoring programs with different end goals, leading to data collected at different depths, at different time intervals, with different equipment, for non-uniform chemical parameters determined by different laboratories. Concentrations for low level data, particularly phosphorus, were reported inconsistently by the three laboratories, with the SPRWS and Ramsey County labs using different reporting limits for phosphorus (0.02 mg/L vs. 0.01 mg/L). These factors make it difficult to conduct an accurate comparison between the datasets.
- Total phosphorus is the one dataset complete enough to allow comparison between the Mississippi River, and Sucker, East Vadnais, and White Bear Lakes, although different reporting limits in the SPRWS and Ramsey County labs likely skew reported average values. Comparison of total phosphorus for May through September during 2005-2010 (which is when data were available for White Bear Lake) indicates phosphorus concentrations 0.015 mg/L of in White Bear Lake and 0.039 and 0.035 in Sucker and East Vadnais Lakes, respectively, with Sucker and East Vadnais more variable, with higher periodic concentrations. This variability may be caused by a combination of stormwater inputs from the surrounding Sucker Lake and East Vadnais Lake watershed areas, inflow of SPRWS source water from the Mississippi River and/or Centerville Lake/Rice Creek Chain of Lakes, and alterations in operation of the aeration systems in Pleasant Lake and East Vadnais Lake.
- Comparison of total phosphorus for 2011-2015 indicates an average concentration of 0.019 mg/L in White Bear Lake and 0.026 mg/L in East Vadnais. Data were not available for Sucker Lake.
- Comparison of total phosphorus for May through September during 2005-2015, using Carlson's Trophic State Index, indicates that White Bear Lake water trophic status has ranged from oligotrophic (clear water with low algal abundance) to mesotrophic/eutrophic (higher phosphorus with lower clarity and greater algal abundance). Sucker and East Vadnais Lakes have ranged from mesotrophic to hypereutrophic (low clarity, high phosphorus, noxious algal blooms).

- Input of additional phosphorus to White Bear Lake may cause a disproportionately large decrease in water transparency, as predicted by relationships developed by the MPCA and others.
- Temperature and dissolved oxygen profile plots indicate that thermal stratification in Sucker Lake results in near-sediment anoxia; that thermal stratification at the West monitoring site in White Bear Lake is intermittent, with short periods of near-sediment anoxia; and that while East Vadnais Lake thermally stratifies, hypolimnetic oxygenation appears to have disrupted near-sediment anoxia.
- That said, minimal information is available to assess potential of stratification disruption in the West lob of White Bear Lake due to discharge of augmentation water and subsequent delivery of near-sediment high phosphorus water to the lake surface.
- Effective operation of the East Vadnais hypolimnetic oxygenation system is essential to reduce and control phosphorus concentration in the lake. Disruption or discontinuance of the oxygenation system would like result in elevated phosphorus concentrations in the lake.
- Besides phosphorus, other chemical and biological parameters are crucial to consider for protecting White Bear Lake, including differences between Sucker and East Vadnais Lakes and White Bear Lake in alkalinity, hardness, pH, sulfide, metals concentrations, bacteria abundance, chloride concentration, pesticide concentrations, trace chemicals of emerging concern (like pharmaceuticals, estrogen disrupters, etc.), and others. Insufficient data are available to compare the lakes for these parameters.
- Necessary data are not available to identify, size, and estimate cost for any necessary treatment.
- Lack of data for phosphorus, alkalinity, hardness, trace contaminants, and other parameters may hinder preparation of permits and to verify compliance with relevant state water quality standards and nondegradation requirements.

Recommendations

Based on the results of the water quality comparison, MCES recommends

- Identification of ultimate water quality goal for White Bear Lake, given potential effects from augmentation
- Collection of uniform, comparable data for the Mississippi River, Sucker Lake, East Vadnais Lake, and White Bear Lake, and potentially Centerville Lake, including sampling at depth. To facilitate accurate statistical comparison of water quality between the water bodies, each should be sampled synoptically using the same type equipment and all samples analyzed using one laboratory. Parameters sampled should include those that will help
    - Identify level of treatment required of augmentation water prior to discharge to White Bear Lake
    - Identify those parameters which may present risks to human health and risks to aquatic life (includes fisheries, aquatic plants, aquatic macroinvertebrates, and other aquatic life) in White Bear Lake
    - Quantify those parameters necessary to negotiate permits for augmentation with appropriate regulatory authorities and to verify compliance with state water quality standards and nondegradation requirements.
- Include in the concept planning for the augmentation system an acknowledgment that a long term monitoring plan should be implemented for the purposes of monitoring White Bear Lake

during implementation of the augmentation system, in order to evaluate the short term and long term effects that augmentation will have on White Bear Lake.

- Creation of a lake computer simulation model for White Bear Lake to assess potential alterations in water quality and biological activity from proposed augmentation program.

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Table 5. Summary of water quality for various sampling stations during May to September, 2005-2010

Water Quality Statistics 2005 - 2010 (May - September) – Page 1

Sites		*Mississippi River Water (Anoka)*	*Mississippi River Water (Fridley)*	*Pleasant Lake (West)*	*Pleasant Lake (East)*	*Sucker Lake*	*Sucker Lake Outlet*	*East Vadnais Lake (North)*	*East Vadnais Lake (South)*	*East Vadnais Lake (Gatehouse)*	*Raw WTP Water (McCarron's)*	*White Bear Lake (North)*	*White Bear Lake (Central)*	*White Bear Lake (East)*	*White Bear Lake (West)*
Data Source		MCES	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	Ramsey County	Ramsey County	Ramsey County	Ramsey County
Sample Depth (meters)		1	Taken from a pipe	3	3	3	3	3	3	At pipe inlet (7 - 15)	Taken from a pipe	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Alkalinity , Total (mg/L as CaCO3)	Mean	174 [e]	-	-	-	-	-	-	-	-	-	#	#	-	#
	Median	171	-	-	-	-	-	-	-	-	-	#	#	-	#
	Max	224	-	-	-	-	-	-	-	-	-	#	#	-	#
	Min	128	-	-	-	-	-	-	-	-	-	#	#	-	#
	Count	43	-	-	-	-	-	-	-	-	-	#	#	-	#
Ammonia (mg-N/L)	Mean	0.04	0.08 *	#	#	0.256 * †	0.075 *	#	#	0.045 *	0.068 *	#	0.058 * †	0.056 †	#
	Median	0.02	0.01	#	#	0.137	0.072	#	#	0.033	0.035	#	0.043	0.050	#
	Max	1.31	1.48	#	#	1.150	0.248	#	#	0.130	0.529	#	0.401	0.302	#
	Min	0.02	0.00	#	#	0.010	0.003	#	#	0.000	0.006	#	0.009	0.009	#
	Count	121	39	#	#	18	27	#	#	28	39	#	35	44	#
Chloride (mg/L)	Mean	17.2 [e]	-	-	-	-	-	-	-	-	-	37.1	37.5 * †	38.6 * †	37.8
	Median	18.0	-	-	-	-	-	-	-	-	-	38.0	39.0	40.0	39.8
	Max	24.0	-	-	-	-	-	-	-	-	-	45.0	43.5	46.5	44.0
	Min	8.0	-	-	-	-	-	-	-	-	-	30.0	30.0	30.0	30.0
	Count	55	-	-	-	-	-	-	-	-	-	39	37	36	40
Chlorophyll a, corrected (ug/L)	Mean	39.3	-	-	-	-	-	-	-	-	-	4.77	5.04 †	5.02 †	3.65
	Median	37.0	-	-	-	-	-	-	-	-	-	3.41	3.53	3.84	2.90
	Max	100.0	-	-	-	-	-	-	-	-	-	14.90	14.70	17.44	13.64
	Min	13.0	-	-	-	-	-	-	-	-	-	1.18	1.02	1.10	0.63
	Count	77	-	-	-	-	-	-	-	-	-	43	45	45	45
Chlorophyll a, uncorrected (ug/L)	Mean	42.6	30.3 *	-	-	19.93 *	14.97	-	-	-	-	-	-	-	-
	Median	40.0	27.6	-	-	17.88	14.78	-	-	-	-	-	-	-	-
	Max	95.0	74.2	-	-	55.76	42.51	-	-	-	-	-	-	-	-
	Min	16.0	4.1	-	-	3.75	2.06	-	-	-	-	-	-	-	-
	Count	77	30	-	-	21	86	-	-	-	-	-	-	-	-
Coliform, Total (CFU /100 mL) [a]	Mean	-	9411	-	-	-	1224	-	-	-	339	-	-	-	-
	Median	-	9200	-	-	-	1300	-	-	-	560	-	-	-	-
	Max	-	99999	-	-	-	99999	-	-	-	99999	-	-	-	-
	Min	-	448	-	-	-	0	-	-	-	0	-	-	-	-
	Count	-	27	-	-	-	111	-	-	-	103	-	-	-	-
Dissolved Oxygen (mg/L)	Mean	8.78	-	#	#	-	#	#	#	-	-	9.43 †	9.48 †	9.37 †	9.46 †
	Median	8.65	-	#	#	-	#	#	#	-	-	9.33	9.29	9.36	9.51
	Max	12.42	-	#	#	-	#	#	#	-	-	12.16	13.43	12.68	12.57
	Min	6.50	-	#	#	-	#	#	#	-	-	7.78	7.60	7.35	7.24
	Count	118	-	#	#	-	#	#	#	-	-	44	45	45	45

Water Quality Statistics 2005 - 2010 (May - September) – Page 2

		Mississippi River Water (Anoka)	*Mississippi River Water (Fridley)*	*Pleasant Lake (West)*	*Pleasant Lake (East)*	*Sucker Lake*	*Sucker Lake Outlet*	*East Vadnais Lake (North)*	*East Vadnais Lake (South)*	*East Vadnais Lake (Gatehouse)*	*Raw WTP Water (McCarron's)*	*White Bear Lake (North)*	*White Bear Lake (Central)*	*White Bear Lake (East)*	*White Bear Lake (West)*
E. coli (MPN/100 mL) [a]	Mean	44	#	-	-	-	1 *	-	-	2 *	0 *	-	-	-	-
	Median	37	#	-	-	-	0	-	-	1	0	-	-	-	-
	Max	2420	#	-	-	-	82	-	-	155	10	-	-	-	-
	Min	3	#	-	-	-	0	-	-	0	0	-	-	-	-
	Count	112	#	-	-	-	51	-	-	58	47	-	-	-	-
Hardness, Total (mg/L as CaCO3)	Mean	208	-	-	-	-	-	-	-	-	-	#	#	-	#
	Median	200	-	-	-	-	-	-	-	-	-	#	#	-	#
	Max	300	-	-	-	-	-	-	-	-	-	#	#	-	#
	Min	176	-	-	-	-	-	-	-	-	-	#	#	-	#
	Count	12	-	-	-	-	-	-	-	-	-	#	#	-	#
Nitrate/Nitrite (mg-N/L)	Mean	0.89	0.381 *	#	#	0.146 * †	0.096 *	#	#	0.082 *	0.171 *	#	0.012 * †	0.012 †	#
	Median	0.49	0.312	#	#	0.079	0.058	#	#	0.029	0.094	#	0.010	0.010	#
	Max	3.20	1.483	#	#	0.677	0.309	#	#	0.387	1.036	#	0.044	0.040	#
	Min	0.08	0.004	#	#	0.002	0.007	#	#	0.000	0.002	#	0.009	0.009	#
	Count	74	40	#	#	18	25	#	#	28	38	#	35	44	#
Nitrogen, Total (mg-N/L) [b]	Mean	1.87	#	-	-	#	#	-	-	#	0.760 *	#	0.794 * †	0.824 †	#
	Median	1.46	#	-	-	#	#	-	-	#	0.742	#	0.778	0.750	#
	Max	4.40	#	-	-	#	#	-	-	#	1.437	#	1.212	1.410	#
	Min	0.81	#	-	-	#	#	-	-	#	0.356	#	0.334	0.386	#
	Count	73	#	-	-	#	#	-	-	#	26	#	34	42	#
pH [c]	Mean	8.27	-	-	-	-	-	-	-	-	-	8.18 †	8.16 †	7.69 †	8.16 †
	Median	8.31	-	-	-	-	-	-	-	-	-	8.32	8.28	8.16	8.39
	Max	8.71	-	-	-	-	-	-	-	-	-	8.88	8.86	8.81	9.06
	Min	7.84	-	-	-	-	-	-	-	-	-	7.65	7.52	6.65	7.36
	Count	121	-	-	-	-	-	-	-	-	-	44	45	45	45
Phosphorus, Total (mg-P/L) [d]	Mean	0.104	0.075 *	#	#	0.039 * †	0.056 *	0.035 †	0.034 †	0.034 *	0.032 *	0.014	0.013 †	0.019 †	0.014
	Median	0.099	0.063	#	#	0.031	0.036	0.028	0.027	0.026	0.022	0.013	0.012	0.016	0.012
	Max	0.274	0.272	#	#	0.100	0.170	0.113	0.107	0.177	0.096	0.031	0.030	0.100	0.031
	Min	0.050	0.020	#	#	0.020	0.020	0.020	0.020	0.020	0.020	0.010	0.010	0.010	0.010
	Count	75	40	#	#	19	24	29	27	44	39	44	44	45	45
Secchi (m)	Mean	-	-	#	#	#	-	#	#	-	-	3.7	4.0	4.1	3.5
	Median	-	-	#	#	#	-	#	#	-	-	3.7	3.9	3.7	3.2
	Max	-	-	#	#	#	-	#	#	-	-	6.0	7.8	7.8	5.4
	Min	-	-	#	#	#	-	#	#	-	-	1.9	2.1	2.1	2.0
	Count	-	-	#	#	#	-	#	#	-	-	42	44	45	45
Temperature (°C)	Mean	21.3	-	#	#	#	-	#	#	-	-	20.84 †	20.75 †	20.64 †	20.96 †
	Median	22.4	-	#	#	#	-	#	#	-	-	22.01	22.08	21.61	22.26
	Max	30.0	-	#	#	#	-	#	#	-	-	28.72	28.26	27.48	28.54
	Min	10.3	-	#	#	#	-	#	#	-	-	10.23	10.28	11.58	11.19
	Count	122	-	#	#	#	-	#	#	-	-	44	45	45	45

Water Quality Statistics 2005 - 2010 (May - September) – Page 3

		Mississippi River Water (Anoka)	*Mississippi River Water (Fridley)*	*Pleasant Lake (West)*	*Pleasant Lake (East)*	*Sucker Lake*	*Sucker Lake Outlet*	*East Vadnais Lake (North)*	*East Vadnais Lake (South)*	*East Vadnais Lake (Gatehouse)*	*Raw WTP Water (McCarron's)*	*White Bear Lake (North)*	*White Bear Lake (Central)*	*White Bear Lake (East)*	*White Bear Lake (West)*
Turbidity (NTU)	Mean	-	-	-	-	-	-	-	-	-	-	1.8	1.7 †	1.7 †	1.6
	Median	-	-	-	-	-	-	-	-	-	-	1.5	1.4	1.5	1.5
	Max	-	-	-	-	-	-	-	-	-	-	4.6	4.2	3.8	3.2
	Min	-	-	-	-	-	-	-	-	-	-	0.1	0.7	0.5	0.7
	Count	-	-	-	-	-	-	-	-	-	-	44	44	45	45
Turbidity (NTRU)	Mean	11 *	-	-	-	-	-	-	-	-	-	-	-	-	-
	Median	10	-	-	-	-	-	-	-	-	-	-	-	-	-
	Max	28	-	-	-	-	-	-	-	-	-	-	-	-	-
	Min	4	-	-	-	-	-	-	-	-	-	-	-	-	-
	Count	101	-	-	-	-	-	-	-	-	-	-	-	-	-

General Table Notes:

- Pound (#) = at least one sample was taken, but overall was sampled too infrequently (less than 3 years) to calculate a comparable average
- Dash (-) = not sampled
- When values were flagged with "Non-Detects" or "Reporting Limit" and had a sign (e.g. <), the sign was removed and the value of the given limit was used
- Since White Bear Lake was only sampled in the months of May - September, all datasets were filtered to only include data from 2005 - 2010 for the months of May - September. Additional data is available at some sites outside of those criteria.
- Data was used at the depth where samples were taken most frequently. Additional data is available at some sites at other depths.
- Basic data cleaning was performed which involved pivoting the data, removing censored values (errors), converting units, and averaging replicate samples (i.e. samples which occurred on the same day at the same depth)

[a] Bacteria is reported as counts which can be exceptionally skewed, so the averages are calculated as Geometric Means

[b] For the Mississippi River at Anoka and White Beal Lake sites, Total Nitrogen was calculated as the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen

[c] pH is a log scale, so averages are calculated by converting values to hydrogen ion concentration [H+], averaging [H+], then converting back to pH

[d] For consistency and accuracy between datasets from the different agencies, Total Phosphorus values which were below the Reporting Limit of each laboratory (MCES – 0.05 mg/L, SPRWS – 0.02 mg/L, Ramsey County – 0.01 mg/L) were censored and the value of the respective Reporting Limit was used

[e] Chloride and alkalinity samples at the Mississippi River at Anoka were sometimes filtered, sometimes not. This should not affect results since both parameters are dissolved.

* There are gaps in the data:

- Mississippi River Water (Anoka)
  - Turbidity (NTRU) – 2005
- Mississippi River Water (Fridley)
  - Total Phosphorus, Ammonia, and Nitrate/Nitrite - 2006 to mid-2007
  - Chlorophyll a (uncorrected) - 2005 and 2010
- Sucker Lake
  - Monitoring of all parameters stopped after 2009
  - Total Phosphorus, Ammonia, and Nitrate/Nitrite – 2006
- Sucker Lake Outlet
  - E. coli – 2005
  - Total Phosphorus, Ammonia, and Nitrate/Nitrite - 2006, 2007, half of 2008 and 2009
- Vadnais Lake (Gatehouse)
  - E. coli – 2005
  - Ammonia and Nitrate/Nitrite - 2007-2009
  - Total Phosphorus - 2007-2008, 2010
- Raw WTP Water (McCarron's)
  - Total Phosphorus, Ammonia, Nitrate/Nitrite, and Total Nitrogen - 2006 to mid-2007
  - E. coli - 2005 to mid-2006
- White Bear Lake (Central)

- White Bear Lake (East)
    - Chloride - 2005

† Additional data is available at other depths:

- Sucker Lake
    - Total Phosphorus, Ammonia, and Nitrate/Nitrite - at 5 meters
- Vadnais (North)
    - Total Phosphorus – at 6 meters and occasionally at 10 and 13 meters
- Vadnais (South)
    - Total Phosphorus - at 6 meters and occasionally at 10 and 13 meters
- White Bear Lake (North)
    - Dissolved Oxygen, Temperature, and pH - down to 6 meters at 1-2 meter intervals
- White Bear Lake (Central)
    - Dissolved Oxygen, Temperature, and pH - down to 8-12 meters at 1 meter intervals
    - Total Phosphorus, Turbidity (NTU), and Chloride - down to 8-12 meters at irregular 3-5 meter intervals
    - Chlorophyll a (corrected), Nitrate/Nitrite, Ammonia, and Total Nitrogen - at 2 meters
- White Bear Lake (East)
    - Dissolved Oxygen, Temperature, and pH - down to 16-20 meters at 1 meter intervals
    - Total Phosphorus, Turbidity (NTU), and Chloride - down to 14-18 meters at irregular 3-5 meter intervals
    - Chlorophyll a (corrected), Nitrate/Nitrite, Ammonia, and Total Nitrogen - at 2 meters
- White Bear Lake (West)
    - Dissolved Oxygen, Temperature, and pH - down to 3-5 meters at 1-2 meter intervals

Table prepared and completed in December, 2015 by Metropolitan Council Environmental Services staff

Table 6. Summary of water quality for various sampling stations during May to September, 2011-2015

Water Quality Statistics 2011 - 2015 (May - September) – Page 1

Sites		*Mississippi River Water (Anoka)*	*Mississippi River Water (Fridley)*	*Pleasant Lake (West)*	*Pleasant Lake (East)*	*Sucker Lake*	*Sucker Lake Outlet*	*East Vadnais Lake (North)*	*East Vadnais Lake (South)*	*East Vadnais Lake (Gatehouse)*	*Raw WTP Water (McCarron's)*	*White Bear Lake (North)*	*White Bear Lake (Central)*	*White Bear Lake (East)*	*White Bear Lake (West)*
Data Source		MCES	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	SPRWS	Ramsey County	Ramsey County	Ramsey County	Ramsey County
Sample Depth (meters)		1	Taken from a pipe	3	3	3	3	3	3	At pipe inlet (7 - 15)	Taken from a pipe	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Alkalinity , Total (mg/L as CaCO3)	Mean	168	140 *	-	-	-	-	-	-	-	144 *	-	-	-	-
	Median	169	142	-	-	-	-	-	-	-	142	-	-	-	-
	Max	225	176	-	-	-	-	-	-	-	238	-	-	-	-
	Min	107	91	-	-	-	-	-	-	-	118	-	-	-	-
	Count	50	40	-	-	-	-	-	-	-	85	-	-	-	-
Ammonia (mg-N/L)	Mean	0.03	0.04 *	-	-	-	-	-	-	0.251 *	0.043 *	-	0.024	0.025	-
	Median	0.02	0.00	-	-	-	-	-	-	0.000	0.000	-	0.020	0.020	-
	Max	0.16	0.73	-	-	-	-	-	-	5.380	0.320	-	0.057	0.065	-
	Min	0.02	0.00	-	-	-	-	-	-	0.000	0.000	-	0.020	0.020	-
	Count	108	34	-	-	-	-	-	-	34	34	-	37	39	-
Chloride (mg/L)	Mean	14.8 [e]	18.8 *	-	-	-	-	-	-	-	33.2 *	#	#	39.2	#
	Median	15.0	18.0	-	-	-	-	-	-	-	33.5	#	#	40.0	#
	Max	23.0	31.0	-	-	-	-	-	-	-	42.0	#	#	52.0	#
	Min	7.0	12.0	-	-	-	-	-	-	-	24.0	#	#	24.5	#
	Count	107	40	-	-	-	-	-	-	-	40	#	#	39	#
Chlorophyll a, corrected (ug/L)	Mean	19.5	-	-	-	-	-	-	-	-	-	5.32	5.00	5.40	3.87
	Median	18.0	-	-	-	-	-	-	-	-	-	4.68	4.12	5.00	3.41
	Max	56.0	-	-	-	-	-	-	-	-	-	14.95	13.41	13.14	10.29
	Min	2.9	-	-	-	-	-	-	-	-	-	1.15	0.73	0.87	1.12
	Count	105	-	-	-	-	-	-	-	-	-	39	39	39	37
Chlorophyll a, uncorrected (ug/L)	Mean	22.4	12.9 *	19.0 * †	13.5 * †	-	-	12.2 *	13.4 *	-	-	-	-	-	-
	Median	21.0	12.0	12.2	13.0	-	-	13.0	14.7	-	-	-	-	-	-
	Max	63.0	26.0	124.1	30.8	-	-	20.6	25.8	-	-	-	-	-	-
	Min	2.1	3.0	1.4	3.7	-	-	1.5	3.1	-	-	-	-	-	-
	Count	105	23	15	15	-	-	14	12	-	-	-	-	-	-
Coliform, Total (CFU /100 mL) [a]	Mean	-	#	-	-	-	-	-	-	-	193 *	-	-	-	-
	Median	-	#	-	-	-	-	-	-	-	166	-	-	-	-
	Max	-	#	-	-	-	-	-	-	-	2420	-	-	-	-
	Min	-	#	-	-	-	-	-	-	-	10	-	-	-	-
	Count	-	#	-	-	-	-	-	-	-	29	-	-	-	-
Dissolved Oxygen (mg/L)	Mean	8.20	10.11 *	-	-	-	-	-	-	-	9.62 *	9.26 †	9.19	9.06	9.14
	Median	8.05	9.90	-	-	-	-	-	-	-	9.70	9.29	9.13	8.78	9.14
	Max	11.36	13.40	-	-	-	-	-	-	-	12.10	12.22	12.29	12.52	11.63
	Min	5.97	7.60	-	-	-	-	-	-	-	4.80	7.84	7.40	5.85	7.22
	Count	106	39	-	-	-	-	-	-	-	39	39	39	40	37

Water Quality Statistics 2011 - 2015 (May - September) – Page 2

		Mississippi River Water (Anoka)	*Mississippi River Water (Fridley)*	*Pleasant Lake (West)*	*Pleasant Lake (East)*	*Sucker Lake*	*Sucker Lake Outlet*	*East Vadnais Lake (North)*	*East Vadnais Lake (South)*	*East Vadnais Lake (Gatehouse)*	*Raw WTP Water (McCarron's)*	*White Bear Lake (North)*	*White Bear Lake (Central)*	*White Bear Lake (East)*	*White Bear Lake (West)*
E. coli (MPN/100 mL) [a]	Mean	71	51 *	-	-	-	-	-	-	2 *	1 *	-	-	-	-
	Median	55	46	-	-	-	-	-	-	1	1	-	-	-	-
	Max	1986	548	-	-	-	-	-	-	299	488	-	-	-	-
	Min	6	1	-	-	-	-	-	-	0	0	-	-	-	-
	Count	108	33	-	-	-	-	-	-	38	38	-	-	-	-
Hardness, Total (mg/L as CaCO3)	Mean	198	156 *	-	-	-	-	-	-	-	163 *	-	-	-	-
	Median	192	158	-	-	-	-	-	-	-	157	-	-	-	-
	Max	268	196	-	-	-	-	-	-	-	263	-	-	-	-
	Min	164	106	-	-	-	-	-	-	-	131	-	-	-	-
	Count	13	40	-	-	-	-	-	-	-	77	-	-	-	-
Nitrate/Nitrite (mg-N/L)	Mean	0.90	0.381 *	#	#	-	-	#	#	0.180 *	0.256 *	-	0.015	0.017	-
	Median	0.63	0.383	#	#	-	-	#	#	0.202	0.202	-	0.010	0.010	-
	Max	3.26	0.753	#	#	-	-	#	#	0.464	0.496	-	0.074	0.065	-
	Min	0.14	0.004	#	#	-	-	#	#	0.001	0.178	-	0.010	0.010	-
	Count	107	39	#	#	-	-	#	#	39	39	-	37	39	-
Nitrogen, Total (mg-N/L) [b]	Mean	1.94	1.24 *	0.81 * †	0.72 * †	-	-	0.67 * †	0.69 * †	0.76 *	0.82 *	-	0.79	0.84	-
	Median	1.71	1.05	0.78	0.73	-	-	0.65	0.68	0.74	0.73	-	0.74	0.86	-
	Max	4.76	6.24	1.25	0.89	-	-	0.90	0.82	2.99	2.34	-	1.41	1.39	-
	Min	0.96	0.53	0.46	0.49	-	-	0.38	0.40	0.10	0.12	-	0.15	0.11	-
	Count	107	37	12	12	-	-	13	12	37	37	-	37	38	-
pH [c]	Mean	8.05	8.13 *	#	#	-	-	#	#	-	7.93 *	8.39 †	8.41	8.11	8.40
	Median	8.09	8.21	#	#	-	-	#	#	-	7.96	8.41	8.42	8.35	8.45
	Max	8.58	8.70	#	#	-	-	#	#	-	10.91	9.07	9.16	9.70	9.23
	Min	7.61	7.83	#	#	-	-	#	#	-	7.56	7.98	7.98	7.31	7.97
	Count	109	32	#	#	-	-	#	#	-	120	38	38	39	36
Phosphorus, Total (mg-P/L) [d]	Mean	0.121	0.072 *	0.035 * †	0.031 * †	-	-	0.026 †	0.025 †	0.032 *	0.029 *	0.018	0.018	0.018	0.020
	Median	0.111	0.063	0.028	0.026	-	-	0.024	0.020	0.025	0.025	0.018	0.017	0.018	0.019
	Max	0.275	0.229	0.075	0.065	-	-	0.049	0.046	0.250	0.058	0.034	0.038	0.037	0.042
	Min	0.050	0.020	0.020	0.020	-	-	0.020	0.020	0.020	0.020	0.010	0.010	0.010	0.013
	Count	107	39	16	16	-	-	20	19	39	38	38	39	39	37
Secchi (m)	Mean	-	-	-	-	-	-	-	-	-	-	3.2	3.4	3.4	2.8
	Median	-	-	-	-	-	-	-	-	-	-	3.0	3.2	3.1	2.9
	Max	-	-	-	-	-	-	-	-	-	-	6.0	6.3	7.2	3.8
	Min	-	-	-	-	-	-	-	-	-	-	1.8	1.8	1.8	1.7
	Count	-	-	-	-	-	-	-	-	-	-	36	39	38	31
Temperature (°C)	Mean	20.7	-	-	-	-	-	-	-	-	19.22 *	20.94 †	20.87	20.76	21.60
	Median	21.8	-	-	-	-	-	-	-	-	21.00	21.89	21.97	21.51	22.88
	Max	27.8	-	-	-	-	-	-	-	-	26.00	29.53	28.37	28.88	29.57
	Min	7.8	-	-	-	-	-	-	-	-	0.00	7.66	7.56	7.58	10.77
	Count	109	-	-	-	-	-	-	-	-	97	39	39	40	37

Water Quality Statistics 2011 - 2015 (May - September) – Page 3

		Mississippi River Water (Anoka)	*Mississippi River Water (Fridley)*	*Pleasant Lake (West)*	*Pleasant Lake (East)*	*Sucker Lake*	*Sucker Lake Outlet*	*East Vadnais Lake (North)*	*East Vadnais Lake (South)*	*East Vadnais Lake (Gatehouse)*	*Raw WTP Water (McCarron's)*	*White Bear Lake (North)*	*White Bear Lake (Central)*	*White Bear Lake (East)*	*White Bear Lake (West)*
Turbidity (NTU)	Mean	-	8.4 *	#	#	-	-	#	#	-	0.7 *	2.0	1.8	2.0	1.6
	Median	-	5.9	#	#	-	-	#	#	-	0.4	1.3	1.3	1.8	1.6
	Max	-	28.3	#	#	-	-	#	#	-	6.8	6.0	9.8	5.1	3.3
	Min	-	1.8	#	#	-	-	#	#	-	0.2	0.7	0.6	0.5	0.8
	Count	-	41	#	#	-	-	#	#	-	92	37	38	38	36
Turbidity (NTRU)	Mean	12	-	-	-	-	-	-	-	-	-	-	-	-	-
	Median	10	-	-	-	-	-	-	-	-	-	-	-	-	-
	Max	65	-	-	-	-	-	-	-	-	-	-	-	-	-
	Min	3	-	-	-	-	-	-	-	-	-	-	-	-	-
	Count	108	-	-	-	-	-	-	-	-	-	-	-	-	-

General Table Notes:

- Pound (#) = at least one sample was taken, but overall was sampled too infrequently (less than 2.5 years) to calculate a comparable average
- Dash (-) = not sampled
- When values were flagged with "Non-Detects" or "Reporting Limit" and had a sign (e.g. <), the sign was removed and the value of the given limit was used
- Since White Bear Lake was only sampled in the months of May - September, all datasets were filtered to only include data from 2011 - 2015 for the months of May - September. Additional data is available at some sites outside of those criteria.
- Data was used at the depth where samples were taken most frequently. Additional data is available at some sites at other depths.
- Basic data cleaning was performed which involved pivoting the data, removing censored values (errors), converting units, and averaging replicate samples (i.e. samples which occurred on the same day at the same depth)

[a] Bacteria is reported as counts which can be exceptionally skewed, so the averages are calculated as Geometric Means

[b] For the Mississippi River at Anoka and White Beal Lake sites, Total Nitrogen was calculated as the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen

[c] pH is a log scale, so averages are calculated by converting values to hydrogen ion concentration [H+], averaging [H+], then converting back to pH

[d] For consistency and accuracy between datasets from the different agencies, Total Phosphorus values which were below the Reporting Limit of each laboratory (MCES – 0.05 mg/L, SPRWS – 0.02 mg/L, Ramsey County – 0.01 mg/L) were censored and the value of the respective Reporting Limit was used

[e] Chloride samples at the Mississippi River at Anoka were sometimes filtered, sometimes not. This should not affect results since Chloride is dissolved in water.

* There are gaps in the data:

- Mississippi River Water (Fridley)
  - All parameters – 2011
  - E. coli and Chlorophyll a (uncorrected) - also 2012
- Pleasant Lake (West)
  - All parameters - 2011 to mid-2012
- Pleasant Lake (East)
  - All parameters - 2011 to mid-2012
- East Vadnais Lake (North)
  - Chlorophyll a (uncorrected) and Total Nitrogen - 2011 to mid-2012
- East Vadnais Lake (South)
  - Chlorophyll a (uncorrected) and Total Nitrogen - 2011 to mid-2012
- East Vadnais Lake (Gatehouse)
  - All parameters – 2011
- Raw WTP Water (McCarron's)
  - All parameters – 2011
  - E. coli and Total Coliform - also 2012

† Additional data is available at other depths:

- Pleasant Lake (West)
  - Total Nitrogen and Total Phosphorus - at 13 meters
- Pleasant Lake (East)
  - Total Nitrogen and Total Phosphorus - at 13 meters

Water Quality Statistics 2011 - 2015 (May - September) – Page 4

- East Vadnais Lake (North)
  - Total Nitrogen and Total Phosphorus - at 13 meters
- East Vadnais Lake (South)
  - Total Nitrogen and Total Phosphorus - at 13 meters
- White Bear Lake (North)
  - Dissolved Oxygen, Temperature, and pH - down to 6-7 meters at 1-3 meter intervals
- White Bear Lake (Central)
  - Dissolved Oxygen, Temperature, and pH - down to 8-10 meters at 1 meter intervals
  - Total Phosphorus, Turbidity (NTU), and Chloride - down to 8-10 meters at irregular 2-3 meter intervals
  - Chlorophyll a (corrected), Nitrate/Nitrite, and Ammonia - at 2 meters
- White Bear Lake (East)
  - Dissolved Oxygen, Temperature, and pH down to 20 - 22 meters at 1-2 meter intervals
  - Total Phosphorus, Turbidity (NTU), and Chloride - down to 20-22 meters at irregular 2-4 meter intervals
  - Nitrate/Nitrite, Ammonia, and Chlorophyll a (corrected) - at 2 meters
- White Bear Lake (West)
  - Dissolved Oxygen, Temperature, and pH - down to 3-5 meters at 1-2 meter intervals

Table prepared and completed in December, 2015 by Metropolitan Council Environmental Services staff

Appendix J: Peer Review of Water Quality Review

Technical Memo

WENCK ASSOCIATES

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To: Sam Paske, Assistant General Manager – Environmental Quality Assurance, Metropolitan Council

From: Joe Bischoff, Wenck Associates, Inc.
Brian Beck, Wenck Associates, Inc.

Date: December 22, 2015

Subject: Technical Review of Water Quality Assessment of Surface Water White Bear Lake Augmentation Concept

The purpose of this technical memorandum is to review and provide comments on MCES's technical memorandum reviewing water quality risks associated with augmenting White Bear Lake with water from Sucker Lake or East Vadnais Lake. The following tasks were completed for this scope of work:

i. Review draft water quality technical memorandum prepared by MCES
ii. Develop conceptual figure for St. Paul water system and augmentation of White Bear Lake to outline treatment process, potential changes in water supply quality, and risks such as invasive species.
iii. Identify significant differences in constituent concentrations and estimate the cost implications of mitigating them. Cost estimates will be high level, order of magnitude costs.
iv. Identify data gaps or potential issues where further study or future data collection may be required.
v. Recommend follow up actions.

Review of MCES Draft Water Quality Technical Memorandum

Wenck reviewed MCES's December 14, 2015 Technical Memorandum titled "*Analysis of available data for comparing water quality between White Bear Lake and potential surface water augmentation sources in order to identify data gaps and potential risks to aquatic life for regulatory authorities; to identify data gaps for designing, sizing, and costing any required treatment of source water; and to scope future studies*".

The Technical Memorandum clearly lays out the lack of data available to truly assess the potential water quality issues associated with increased flow from the Mississippi River into the St. Paul Regional Water Services (SPRWS) water supply system to support augmentation of White Bear Lake water levels as well as impacts on White Bear Lake. We agree that increased Total Phosphorus may increase the risk of algal blooms in White Bear Lake and that near-sediment anoxia can result in increased nutrient and metal release from the sediments causing long term water quality issues.

While we think these issues present the highest risk for water quality impacts and have the most robust data set to demonstrate potential impacts, we also believe that there are other risks that need to be carefully considered when evaluating the potential water quality impacts to White Bear Lake when augmenting water levels with water from Sucker Lake or

East Vadnais Lake. And while a full screening is beyond the scope of this current work order, we present some higher risk constituents based on professional experience (Table 1).

Concepts and Considerations to Include in the Evaluation

There are a number of concepts that we recommend including in the evaluation to assess the risk of augmenting White Bear Lake with surface water from the SPRWS.

First, we think the evaluation should include the risk for the entire chain of lakes in the SPRWS and not just White Bear Lake (Attached Figure 1). Water quality in the SPRWS lakes will reflect inflow water concentrations after mixing and settling. As the amount of water drawn from the Mississippi River increases, the lakes will increasingly reflect water quality conditions in the Mississippi River especially the early lakes in the chain. Since water quality in Sucker and East Vadnais Lake is strongly impacted by settling in prior lakes (Charley Lake and Pleasant Lake), increased flow through these lakes from the Mississippi River could deteriorate water quality conditions in all of the lakes. Therefore, the water quality evaluation should consider changes as a result of increased flow from the Mississippi River. We are not aware of any nutrient modeling completed by the SPRWS or MCES that estimates changes in lake water quality in the chain as inflow water volumes from the Mississippi River or groundwater are increased. And we are aware that the SPRWS has operated periodically at these rates in the past. However, long term, continuous changes in inflow quantity may also affect the inflow water quality to the SPRWS and ultimately affect the water treatment process.

Second, both long and short term changes should be considered. While a comparison of current concentrations in Sucker Lake or East Vadnais Lakes is a good start for assessing water quality considerations, long term impacts may occur as a result of increased flows to the chain of lakes from other sources. For example, increased metal concentrations from the Mississippi River may initially be mitigated by settling, sediment release of dissolved forms of the metals may increase over time as sediment concentrations increase. These releases may be mitigated in Pleasant and East Vadnais Lakes because of the hypolimnetic oxygenation system, but could increase from Charlie and Sucker Lakes.

Third, lakes respond to changes in load and flushing and differences in concentrations are not the whole story. To truly evaluate impacts to water quality, a lake response model should be developed to determine steady state lake concentration with new inflow loads. Therefore, flow is a data gap not addressed in the current risk analysis.

Finally, the impacts to shallow lakes will be functionally different than impacts to deep lakes due to their limited water volumes and increased impacts from the biological community. Both Charley and Sucker Lake are shallow lakes and will respond quite differently to changes in water quality than the deep lakes.

Proposed Risk Assessment

There are potential short and long term changes to water quality in the lakes since we know increased inflow from outside water sources will change water quality in the entire chain of lakes. Therefore, we ultimately need to know changes in water quality in Sucker Lake and East Vadnais Lake since these are the potential sources of water. A risk assessment can be developed using Mississippi River water quality data. MCES identified many of the potential issues in the December 2015 technical memorandum including toxics, pesticides, organics, and pharmaceuticals among others. However, these risks were not further considered due

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to the lack of data in the chain of lakes. Rather, it was recommended that a monitoring program be developed to assess these parameters. While we fully agree that monitoring is necessary to fully evaluate potential issues, monitoring should be targeted to high risk constituents identified during a risk assessment. We recommend the completion of a risk assessment using Mississippi River monitoring data to screen for potential issues. The risk assessment would screen the Mississippi River source water for constituents in high enough concentrations to pose a threat to the source water and then develop a mass balance for the chain of lakes to determine risk under varied flow conditions. This task is currently outside the scope of this task order.

To facilitate the screening, we developed a list of parameter groups, available data in the Mississippi River, fate and transport considerations, and potential issues. It is important to note that this list is not comprehensive and data in the Mississippi River were not evaluated for completeness or detection limits. However, it provides some thoughts on potential issues that should be evaluated during the system design.

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Table 1. Risks associated with each parameter group sampled in the Mississippi River

Parameter Group	**Data Availability (Mississippi River)**	**Fate and Transport**	**Potential Impacts and Mitigation**
Bacteria	4 bacteria parameters sampled from 1976 to 2015	▲ Some settling and dilution may occur in early lakes	▲ The SPRWS lakes are recreational and the Mississippi River may exceed bacteria standards periodically to protect human health. However, it is unlikely to be an ongoing issue in Sucker and Vadnais Lakes (a few exceedances on the standard did occur in East Vadnais Lake)
General Chemistry	6 general chemistry parameters have been sampled from 1976 to 2015	▲ Hardness in the Mississippi River and the Water Treatment Plant are similar (around 160 mg/L as CaCO3), but one sample in White Bear Lake suggests it is much lower (83 mg/L as CaCO3) ▲ Surface water temperatures are not significantly different in the River and White Bear Lake	▲ Hardness affects fish habitat and inflow water may increase the hardness of White Bear Lake. A mass balance to predict future lake hardness should be conducted ▲ While temperatures appear similar in source water lakes and White Bear Lake, the depth of withdrawal and discharge is critical to prevent artificial mixing or destratification
Nutrients and Phytoplankton	28 nutrient and phytoplankton parameters have been sampled from 1976 to 2015	▲ Organic and particulate nutrients will settle out in Charley Lake and dissolved constituents may be removed through reaction and settling processes a result of ferric chloride injection. ▲ MCES memorandum demonstrated significant differences in TP between the potential source water and White Bear Lake	▲ Increased flow in the chain of lakes may decrease the ability of the lakes to settle out phosphorus ▲ However, the increased P mass may increase sediment P concentrations leading to sediment P release and ultimately increased lake management (increased iron dosing and oxygenation in more lakes) ▲ TP may increase in White Bear Lake since Sucker Lake and Vadnais Lake have higher TP concentrations (25-32 µg/L) than White Bear Lake and TP may increase in Sucker Lake and East Vadnais Lake long term with increased Mississippi River water (72 µg/L). Concentrations are seasonally higher suggesting a greater impact in the growing season. Nutrients can be removed through treatment; however these are low levels which may increase the cost of removal.

Parameter Group	Data Availability (Mississippi River)	Fate and Transport	Potential Impacts and Mitigation
Oxygen and Oxygen Demand	20 parameters have been sampled	▲ Most biological oxygen demand (BOD) will settle out in Charley or Pleasant Lake	▲ Although data were not reviewed, increases in oxygen demanding substances in the chain can result in greater doses of oxygen to the hypolimnion and the need for oxygenation in other lakes.
Ions	12 ionic substances or conductivity have been collected from 1976 to 2015	▲ Most ions of concern are conservative and will flow through each system, however, they may interact with sediments ▲ Median sulfate concentrations in Mississippi are 16 mg/L, which is higher than sulfate concentration measured by USGS in White Bear Lake of 3.9 mg/L. This may increase the number of fish consumption advisories for mercury in the chain of lakes	▲ Elevated sulfate can increase methylmercury if the receiving system is sulfate limited (< 5 mg/L sulfate). Sulfate removal is difficult and may require reverse osmosis ▲ Elevated sulfate may increase internal loading by scavenging free iron. Sulfide scavenging of iron can be mitigated by increased iron dosing in SPRWS

Parameter Group	Data Availability (Mississippi River)	Fate and Transport	Potential Impacts and Mitigation
Metals/Trace	15 metals sampled in MS River quarterly over 10 years for 40 samples	▲ Metals associated with particulates may settle in Charley while dissolved metals will flow through each lake until they become associated with particulate matter or are taken up by biota ▲ Long term buildup of metals in sediments from increased Mississippi River inflows may lead to rerelease of metals in the long term ▲ Median concentration of iron in the Mississippi River (260 µg/L) is similar to historic iron concentrations in White Bear Lake (275 µg/L). It is unclear how injection of ferric chloride to the system impacts downstream iron concentrations but the drinking water standard for iron is 300 µg/L and EPA criterion for aquatic life is 1,000 µg/L	▲ Increased metal concentrations in sediments can lead to aquatic toxicity in macroinvertebrates, fish and plants that interact with the sediments. The lakes earlier in the chain are at the greatest risk ▲ Redox sensitive metals may diffuse into the water column and increase metal concentrations in the source water over the long term. A review of metals in the Mississippi River should be conducted to assess risk. ▲ Manganese and iron would decrease the amount of phosphorus released from sediments. ▲ Sediments anoxia may result in sediment release of metals ▲ Metals previously deposited through particulate settling may re-release during periods of anoxia. This may result in increased metal toxicity for macroinvertebrates and fish
Organics Contaminants	102 Organic parameters were sampled since 1981 or 1993 depending on parameter	▲ Organic contaminants typically are strongly adsorbed to particulates ▲ Most will settle out as particulate material in Charley Lake or Pleasant Lake	▲ May result in high sediment organic contaminant concentrations that may impact lake biota ▲ Polycyclic aromatic hydrocarbons (PAHs) are regularly a concern for stormwater pond dredging projects and may build up in chain of lake sediments
Invasive Species	N/A	▲ The SPRWS provides a conduit for invasive species to move from the Mississippi River into the source water chain of lakes	▲ While the current study focuses on filtration to prevent zebra mussel veligers from moving from the source water lakes to White Bear Lake and is likely protective of all species, it does not address risk to the entire chain and does not address other potentially small species such as the spiny water flea. A review of all species is necessary to ensure filtration is adequate.

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Recommendations

The following considerations should be included in the report for further consideration. We identified some risk areas based on results of the MCES memo or professional experience, but this is not a comprehensive screening of potential issues.

General Recommendations

- We recommend introducing the concept of evaluating the entire chain of lakes as a whole and impacts that may occur as source water increase. The higher the amount of water pumped from the Mississippi River, the greater the risk to the chain of lakes.

- While concentration differences are a good screening tool to identify potential impacts, a mass balance for high risk constituents should be applied to determine the magnitude of the impact. A lake response model is necessary for determining eutrophication impacts. It is important to note that selections of input data are critical for developing a credible lake response model.

- While we agree that the data are limited for most of the other parameters in each of the lakes, a risk assessment for toxics, organics, and other toxic substances should be conducted using Mississippi River data and estimating parameter concentrations in the lakes using a simple mass balance approach. This would include any injection for lake management such as ferric chloride.

- In general, water chemistry in the source water lakes and White Bear Lake are similar enough that surface water augmentation appears feasible with limited impacts, however a new steady state model in the chain of lakes is necessary to assess the impacts of increased pumping form the Mississippi River is evaluated.

- While it is difficult to identify treatment options prior to a complete screening of potential issues, it appears that many of the issues can be mitigated through treatment or lake management that is already in place in the lakes. However, toxicity issues associated with metals or organics may prove challenging.

Eutrophication

Total phosphorus is the key parameter for assessing eutrophication.

- While the MCES technical memorandum demonstrates the potential for eutrophication in White Bear Lake as a result of increased phosphorus discharge from into the lake, the concentration differences are small enough that they may not represent a large impact. SEH included a rudimentary lake response model in the Feasibility Assessment of Approaches to Water Sustainability in the Northeast Metro (2014) that suggested improvements in TP concentrations would occur. However, the model inputs suggested that augmented water quality is better than White Bear Lake and did not consider seasonal difference. It is important to note that we suggest inputs for these models be refined and the entire chain should be modeled

- It is unlikely that White Bear Lake is nitrogen limited, however data in the MCES technical memorandum suggest that nitrogen loading, especially nitrate, to White

Bear Lake would increase. While we don't expect this to increase algal productivity, increased nitrogen loading may lead to impacts on the submersed aquatic vegetation community by enriching sediments with nitrogen that favors tolerant and invasive species. Since the concentration differences are small, we don't expect any noticeable impacts. However, increases in nitrogen from the Mississippi River to Charley Lake and Sucker Lake may impact vegetation quality.

General Lake Chemistry

- The hardness of White Bear Lake may be significantly less than the inflow water sources and a mass balance model should be used to assess potential changes in the hardness of White Bear Lake. This may have important implications for the fish community.

- The depth and location of the inflow and discharge is critical to avoid impacts to fish spawning, rearing and feeding and to ensure that artificial mixing or destratification does not occur.

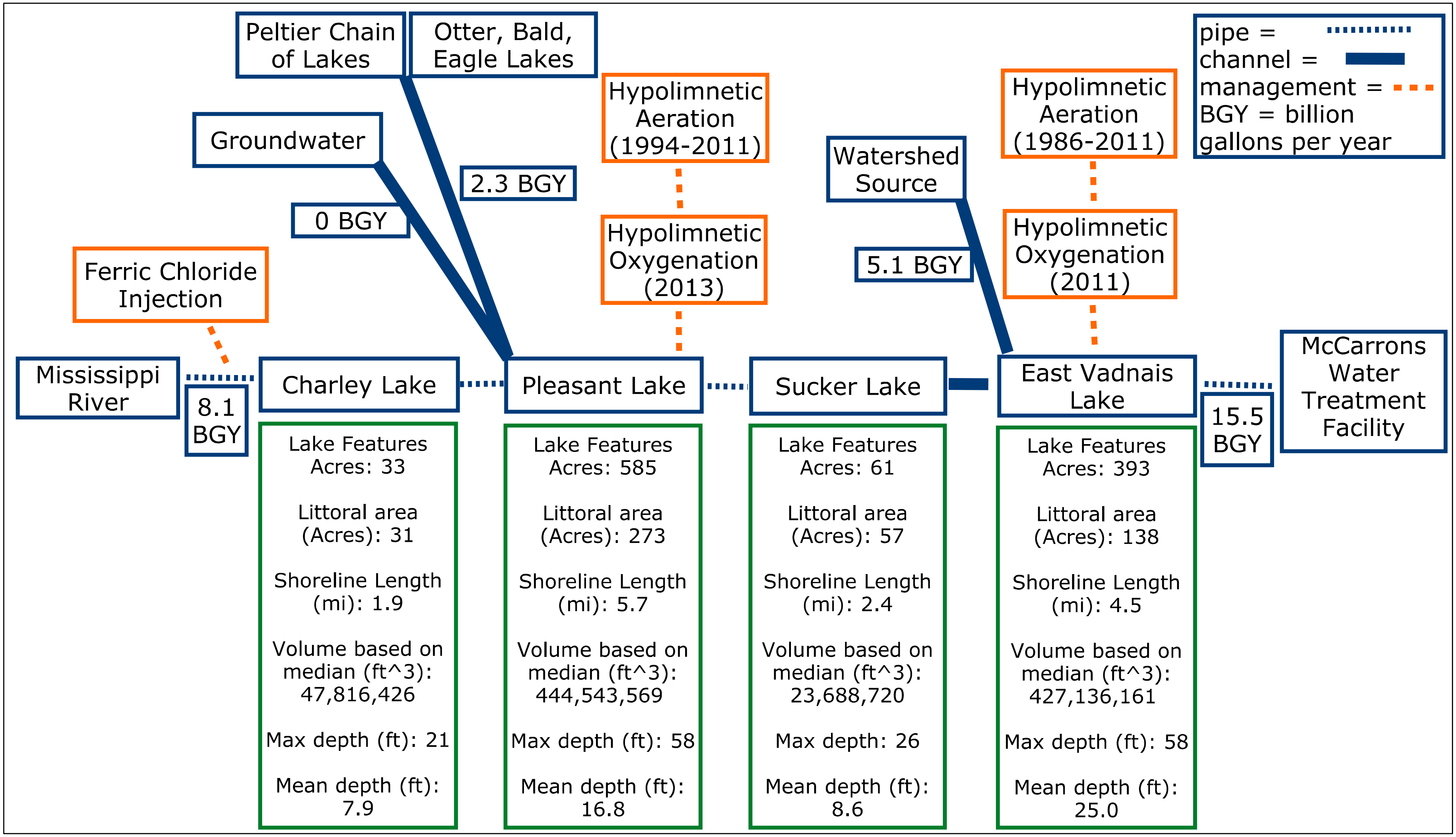
Toxic Substances

- A review of potential toxic substances in the Mississippi River and a mass balance evaluation should be completed to assess the risk of increased toxic substances in the chain of lakes, the source water lakes, and ultimately White Bear Lake.

- Median sulfate concentrations in Mississippi are 16 mg/L, which is higher than sulfate concentration measured by USGS in White Bear Lake of 3.9 mg/L. This may increase the number of fish consumption advisories for mercury in the chain of lakes due to increased mercury methylation.

Invasive Species

- The current study focuses on filtration to prevent zebra mussel veligers from moving from the source water lakes to White Bear Lake. This approach is likely protective for most or all other invasive species, however a review of other species may be warranted. For example, some invasive plants may have seeds that are smaller than veligers. Also, a short term failure of the filters can lead to an infestation in White Bear Lake. A secondary protection system or procedure should be considered.



The Metropolitan Council Environmental Services

St. Paul Regional Water System Chain of Lakes

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JAN 2015

Figure 1

Appendix K: Water Treatment Facilities and Basis for Concept System

TECHNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager, Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Patti Craddock, PE

DATE: January 15, 2016

RE: Water Treatment Facilities and Basis for Concept System
Augmentation of White Bear Lake with Surface Water
SEH No. 134593 14.00

INTRODUCTION

This memorandum describes the basis for the treatment facilities assumed for the concept level cost estimate for a system supplying water from Sucker Lake and East Vadnais Lake to White Bear Lake. It provides supporting information for the Concept Cost Report for Augmentation of White Bear Lake with Surface Water (Minnesota Department of Natural Resources (DNR), February 2016).

BASIS OF CONCEPT SYSTEM TREATMENT

Water treatment costs were assessed by comparing the water quality characteristics of the source water (Sucker Lake and East Vadnais Lake) to those of White Bear Lake. The selection of treatment facilities at this concept level was based on water quality characteristics used to design other augmentation systems in the metropolitan area. Water quality characteristics that were considered in the cost estimates included aquatic invasive species, suspended solids and phosphorus.

The cost estimates for treatment processes were based on assumed treatment technology performance and limited available water quality records. Once sufficient water quality data are available and permitting requirements are established, it may be determined that different treatment facilities and different system configurations would be required to address parameters such as nitrogen, alkalinity, chloride, temperature, dissolved oxygen, contaminants of emerging concern, and other water quality characteristics.

Water quality goals and treatment are significant issues that would need to be resolved before a final cost can be determined.

CONCEPT SYSTEM FACILITIES

The facility components shown in Figure 1 were included in the augmentation system concept costs:

- Intake structure – located in the source lake
- Pump station – located in proximity to the intake and treatment facility as dictated by site specific conditions
- Treatment facility – housed in a building with or near the pump station

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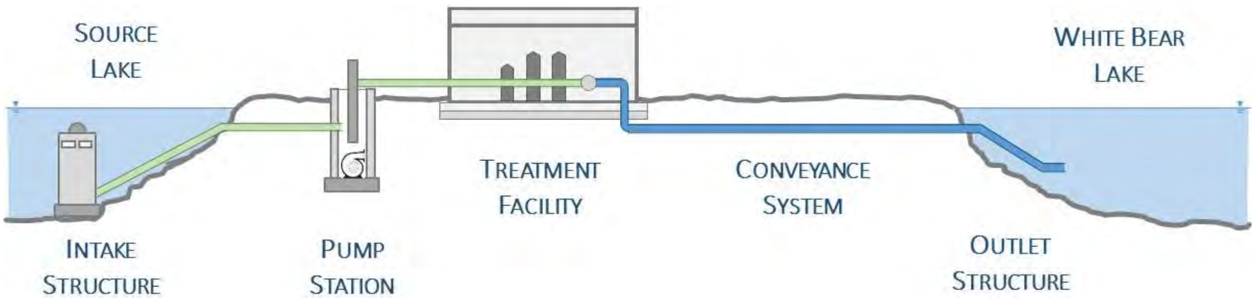
- Conveyance system – pipeline and related appurtenances such as vaults and air release valves delivering water from the source lakes to White Bear Lake
- Outlet structure – discharge pipe into White Bear Lake

Figure 1. Augmentation System Components



The focus of this memorandum is on the 'treatment facility' component of the concept system. The intake and outlet structures are other system components with design features that address water quality impacts to White Bear Lake, but have lower costs and are not detailed at this concept level.

WATER QUALITY RECORDS

Water quality monitoring has been conducted by different entities for different purposes over different time periods for the three water bodies. Water quality records for Sucker Lake, East Vadnais Lake and White Bear Lake are not adequate to provide comparisons of all key water quality parameters. However, general conclusions can be drawn by evaluating specific time periods for key water quality parameters, primarily phosphorus.

Metropolitan Council Environmental Services reviewed historic data for the Mississippi River, Sucker Lake, East Vadnais Lake and White Bear Lake. The findings are documented in a companion technical memorandum, Appendix I of the Concept Cost Report for Augmentation of White Bear Lake with Surface Water (Minnesota Department of Natural Resources (DNR), February 2016). This memorandum and the peer review findings of Wenck Associates, Inc. documented in Appendix J of the same report provide additional information on water quality considerations for a surface augmentation system for White Bear Lake.

Appendix I of the Concept Cost Report for Augmentation of White Bear Lake with Surface Water (DNR, February 2016) is the reference for all water quality data presented in this memorandum.

TREATMENT FOR AQUATIC INVASIVE SPECIES

Overview

Presence and identification of aquatic invasive species present in both potential source water lakes and White Bear Lake were verified by the DNR Infested Waters List (which is found at the following website: http://www.dnr.state.mn.us/invasives/ais/infested.html. The DNR lists Sucker Lake, East Vadnais Lake and White Bear Lake on the infested waters list for both zebra mussels and Eurasian watermilfoil, which are difficult to remove once they are established in a lake. The state restricts the transfer of infested waters from water body to water body. Even though these aquatic invasive species are present in White Bear Lake, treatment will still be required for the source water.

Zebra mussels were used as the target aquatic invasive species because physical barriers that filter out the smallest stage of the zebra mussel, known as "veligers", will also remove other known aquatic invasive plant and animal species. Zebra mussels can cause damage to facilities and infrastructure, reducing the amount of intake head and incapacitating the system. Zebra mussels will colonize on hard surfaces and are costly to eradicate once populations have been established.

The treatment technology selected to control aquatic invasive species for the White Bear Lake augmentation system is a mechanical control system using fine screen automatic cleaning filters. There are two general technology options: mechanical control and chemical control.

Mechanical Control

Mechanical filtration targets the veliger of the zebra mussel. Screen sizes of 25 micrometers and 40 micrometers have been shown to be equally effective at removing the 40-250 micrometer veligers (USACE, 1997). In one independent trial using a 40 micrometer filter, a small amount of eggs and veligers did pass through the filter, however all of them were dead or dying- torn, compressed or deflated from passage through the filter (Lauria, 2009). In addition to zebra mussel control, such a filter would also remove the future possibility of faucet snails if they were to migrate south, as their smallest stage is 1.2 millimeters in size.

Filtration with a 25 micrometer screen has been selected as the preferred control method for aquatic invasive species transfer from the proposed source waters to White Bear Lake. This filtration system is similar to the filter systems for Snail Lake and Lake Gilfillan which use the Mississippi River water and the chain of lakes system as their augmentation supply.

Chemical Control

Aquatic invasive species chemical control methods for a White Bear Lake augmentation system were removed from consideration for the concept cost report. Summary information on the chemical control methods is provided to support the screening decision.

Chemical methods include chlorination, and use of ozone, potassium permanganate, and Zequanox. None of these methods have demonstrated complete removal of zebra mussels and have other unsuitable characteristics. The concentrations needed for zebra mussel mortality using chlorination methods are also toxic to other forms of aquatic life (USACE, 1997). Chlorine must be shipped to the site and stored on-site and requires a fully secured and contained storage area for the protection of the public. While ozone dissipates quickly from water and would not be toxic to other forms of aquatic life, it is an explosive chemical and must be generated on-site as it cannot be shipped (USACE, 1997). Cost and safety concerns make both options unsuitable. Potassium permanganate does not have as high a lethality rate as other chemical methods (USACE, 1997). Zequanox is a molluscicide comprised of a zebra mussel food source that breaks down the digestive lining of the zebra mussels that consume it (MBI, 2014). It is reported to be highly selective to zebra mussels, making it safe for other aquatic species. This option is currently being investigated for use in infested lakes in Minnesota (MCWD, 2014). However this option requires removal of the zebra mussel remains from the system.

Treatment Facilities

A multi-stage ultra-fine automatic self-cleaning strainer system is proposed. This system contains a final 25 micrometer screen sized to remove the larval and smallest stage of the zebra mussel. This size screen is anticipated to capture other known aquatic invasive species and reduce the solids transferred from the source lakes to White Bear Lake. It will also reduce phosphorus associated with solids.

As shown in Figures 2 and 3, water would be drawn from the source lake through an intake structure and pumped through primary and secondary filters, before being metered and conveyed to White Bear Lake. The filtration system would be housed in a building that includes an overhead service crane, maintenance and storage area, and an office - control room.

Figure 2. Filtration System Profile View

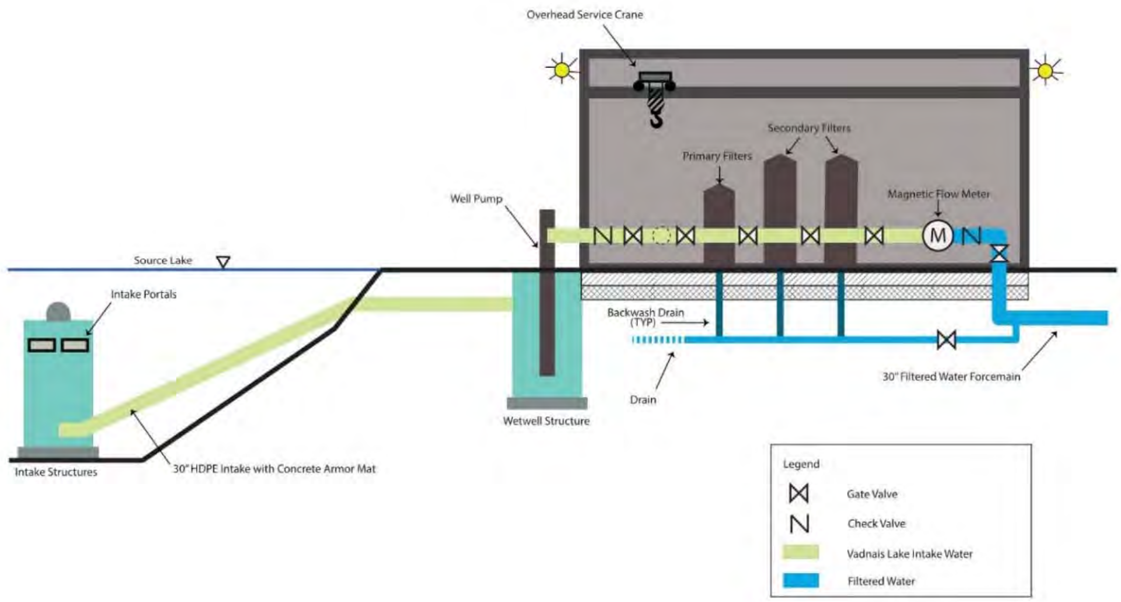
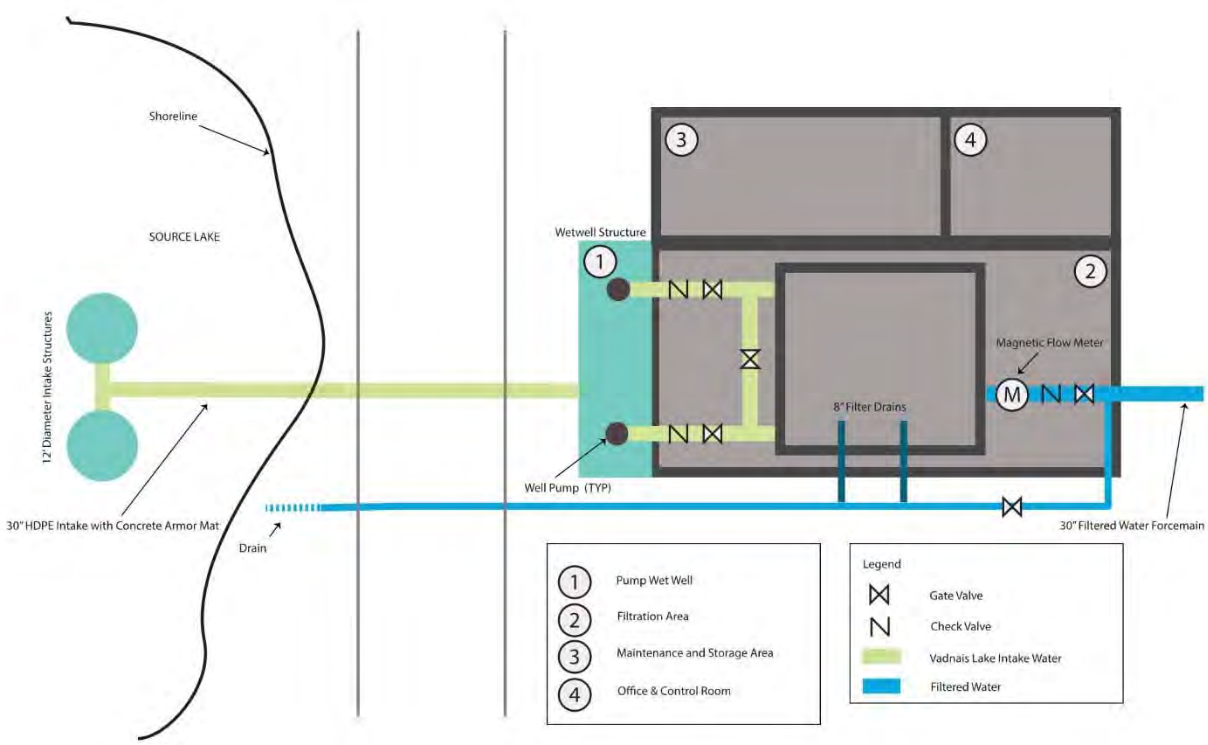


Figure 3. Filtration System Plan View



The filters are sized and configured based upon the selected pumping rate, water quality of the source lake, and selected operating assumptions. Table 1 summarizes the filtration system criteria and design features assumed for the concept augmentation system. The filtration systems for source water from Sucker Lake and Vadnais Lake are similar except that the Sucker Lake primary screens require larger screen openings to keep the screens from clogging and are expected to have a higher backwash requirement than for the East Vadnais Lake system.

Table 1. Filtration System – Basis for Concept System

Item	Description
Capacity	One pump, one primary stage screen vessel, five secondary stage screen vessels and five final stage screen vessels will have the 6,000 gpm capacity at the system design pressure. System redundancy will be one pump and one screen vessel in each of the three stages. This scenario allows for continued operation during planned maintenance without disruption of flow and system capacity.
Filter Configuration	Twelve (12) vessel automatic cleaning skid unit to have two (2) primary stage vessels, followed by five (5) secondary stage vessels followed by five (5) final stage vessels with the 25 micrometer screens.
Filter Screen Size	
Sucker Lake	Primary stage – 250 micrometer; Secondary stage – 125 micrometer; Final stage – 25 micrometer
East Vadnais Lake	Primary stage – 150 micrometer; Secondary stage – 100 micrometer; Final stage – 25 micrometer
Backwash Procedure	Each vessel in each of the three stages will backwash on differential pressure and/or a pre-set timer. Timed sequence backwash will step clean each of the stages vessel screens. No two vessel backwash sequence will run at the same time period for each stage. A backwash event can occur in each stage at the same time. Backwash water to return to the source water reservoir per DNR requirements.

The treatment system defined for aquatic invasive species control will also remove solids. It also has the potential to achieve phosphorus goals established by a regulatory review. However, additional treatment may be required to meet predictable phosphorus limits as described in the following section.

The estimated cost of the filtration system, related facilities, and building is listed in Table 2.

Table 2. Estimated Cost of Filtration Treatment Facilities for Aquatic Invasive Species Control

Cost Item	Sucker Lake ($ millions)	East Vadnais Lake ($ millions)
Filtration Facility	$6.40	$5.96
Electrical & Controls (shared cost with pump station)	$0.53	$0.53
Total Construction Cost	**$6.93**	**$6.49**
Contingency @20%	$1.39	$1.30
Total Construction Cost with Contingency	**$8.31**	**$7.78**
Engineering, Legal and Administrative @ 25%	$2.08	$1.95
Total Cost in 2015 Dollars	**$10.39**	**$9.73**
Total Cost at Mid-Point of Construction (2018-19)	**$11.3**	**$10.6**

Reference: Appendix N, Concept Cost Report for Augmentation of White Bear Lake with Surface Water, DNR, February 2016

TREATMENT FOR SOLIDS REMOVAL

Water Quality Records

Limited data exists to compare solids concentrations in both source lakes and White Bear Lake. Turbidity, an indication of cloudiness of water, was used as a surrogate measure of the amount of suspended solids in each water body Historic records exist for the Mississippi River, East Vadnais Lake reported as the source supply to the Saint Paul Regional Water Services McCarrons Water Treatment Plant, and White Bear Lake. Turbidity values are highest in the river as shown in Table 3.

Table 3. Turbidity (NTU) in Source Waters and White Bear Lake, May-September, 2011-2015

Description	Mississippi River[1]	East Vadnais Lake[2]	White Bear Lake - North	White Bear Lake - Central	White Bear Lake - East	White Bear Lake - West
Average	8.4*	0.7*	2.0	1.8	2.0	1.6
Median	5.9	0.4	1.3	1.3	1.8	1.6
Minimum	1.8	0.2	0.7	0.6	0.5	0.8
Maximum	28.3	6.8	6.0	9.8	5.1	3.3
No. Samples	41	92	37	38	38	36

Source: Mississippi River and East Vadnais Lake monitoring data collected and reported by Saint Paul Regional Water Services; White Bear Lake monitoring data collected and reported by the Ramsey County.

Notes: NTU = Nephelometric Turbidity Units
* Gaps in the data record.
[1] Mississippi River at Fridley Pump Station, Saint Paul Regional Water Services.
[2] Sampling location: Saint Paul Regional Water Services conduit from East Vadnais Lake to McCarrons water treatment plant. Sample includes groundwater that may be used to augment the lake supply. For this time period groundwater was estimated to be less than 10% of the total volume.

The historic record shows that East Vadnais Lake withdrawals supplying the Saint Paul Regional Water Services McCarrons water treatment plant is on average lower in turbidity than in White Bear Lake. However, historic records indicate that concentrations in East Vadnais Lake could be higher than in White Bear Lake at a given time.

Turbidity has not been measured in Sucker Lake, but a review of phosphorus concentration data suggests that Sucker Lake has higher suspended solids concentrations than in East Vadnais Lake. Shallower lakes have a greater potential for disturbance of the bottom sediments resulting in increased pollutant concentrations. Sucker Lake is smaller and shallower than East Vadnais Lake and for this report is assumed to have higher solids and phosphorus concentrations.

Treatment

The treatment facilities assumed for the augmentation system remove all types of suspended material in the water. While the design goal of the treatment facility is based on removing aquatic invasive species, the system features selected must consider other water quality parameters, and suspended solids is an important one. The number of filters and size of the filter screen openings was based on experience with other augmentation systems in the area and the assumption that Sucker Lake has higher suspended solids than East Vadnais Lake. As shown in Table 1, the screen size openings are different for the two alternative systems to account for expected differences in suspended solids concentrations.

TREATMENT FOR PHOSPHORUS REMOVAL

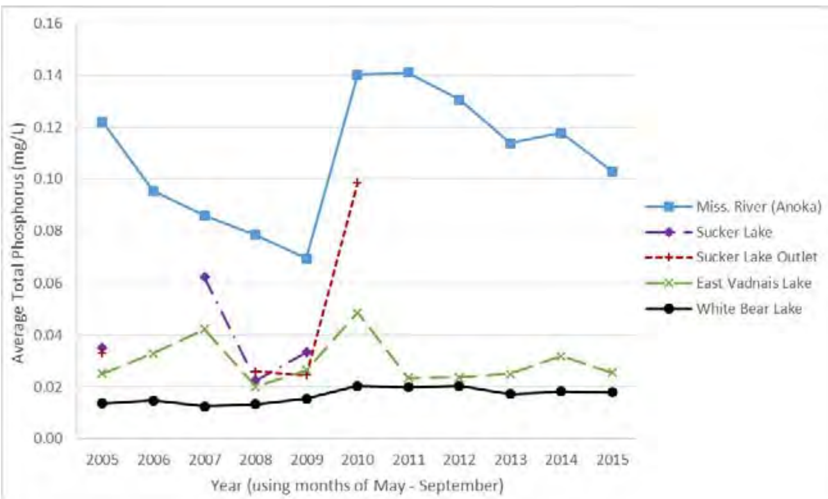
Water Quality Records

Elevated levels of phosphorus in lakes can lead to algal blooms. Increased levels of algae can affect the aquatic life, recreation activities and overall quality of the lake. Algal blooms can also affect the aesthetic taste and odor qualities of the water. To improve the aesthetic quality of their drinking water supply, Saint

Paul Regional Water Services has been managing phosphorus in the chain of lakes system through a variety of management practices. Phosphorus and solids are managed by the addition of chemicals and oxygen in the chain of lakes system.

Phosphorus is the only parameter with similar sampling periods for comparison between the lakes. Phosphorus is also a parameter that has significant cost implications for an augmentation system. Figure 4 presents average annual phosphorus concentrations in the river, source lakes, and White Bear Lake. White Bear Lake has lower phosphorus levels than the source waters. While there is limited data available for Sucker Lake, it is observed to have higher concentrations than East Vadnais Lake. Higher solids and phosphorus concentrations at Sucker Lake will increase the costs to treat water from this lake in comparison to East Vadnais Lake.

Figure 4. Annual Averages for Total Phosphorus for Concept System Water Bodies, May – September, 2005 – 2015

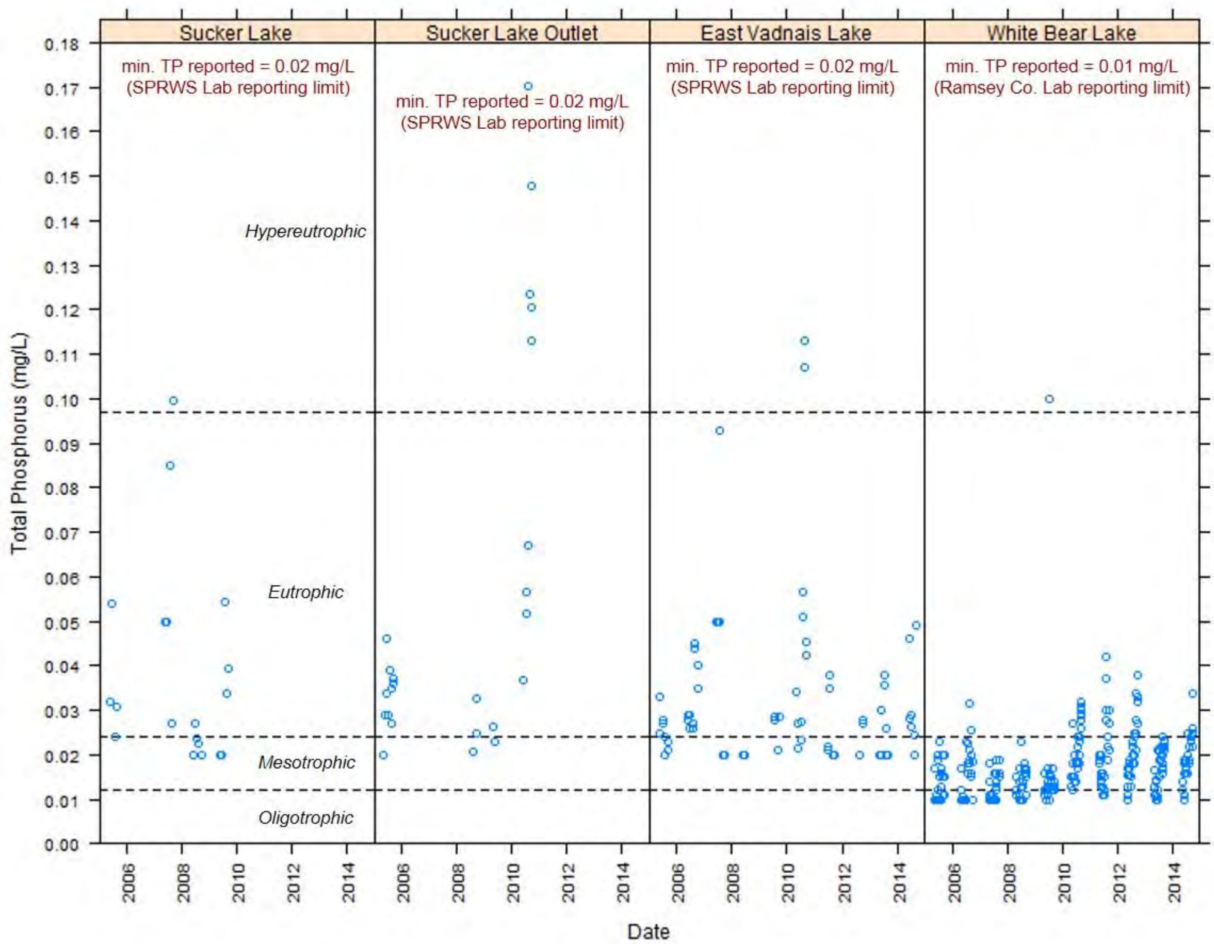


Source: Samples collected and analyzed by Ramsey County, Saint Paul Regional Water Services and Metropolitan Council were used to develop average annual (May-Sept.) phosphorus concentrations. Refer to Appendix I, Concept Cost Report for Augmentation of White Bear Lake with Surface Water (Minnesota Department of Natural Resources (DNR), February 2016) for the specific sources and data details.

The selection of treatment facilities and estimate of related costs are based on limited water quality data for the source lakes. Figure 5 provides individual phosphorus monitoring results over the past ten years in context with typical trophic levels that characterize a lake system to provide context to potential phosphorus goals. The source lake shows phosphorus in the range of 0.02-0.05 mg/L with some sampling locations recording over 0.1 mg/L. At concentrations over 0.02 mg/L phosphorus, lakes tend to have more eutrophic characteristics supporting more plant life with a reduction in water clarity. White Bear Lake is a deep, clear lake that is classified as mesotrophic, while Sucker Lake and East Vadnais Lakes are considered more eutrophic.

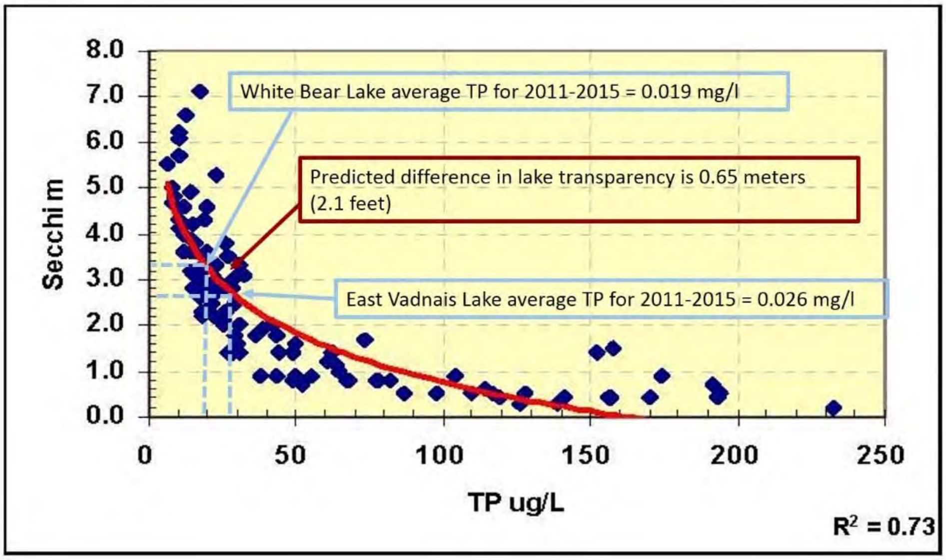
Average phosphorus concentrations in White Bear Lake and East Vadnais Lake were compared in context with water clarity. In Figure 6, the secchi depth measurement serves as an indicator of water clarity, and is plotted versus total phosphorus for a set of Minnesota lakes (MPCA, 2005). The average total phosphorus concentrations for White Bear Lake and East Vandais Lake are shown on this graph and indicate that with a phosphorus concentration difference of 0.007 mg/L (7 ug/L), the clarity difference could be over 2 ft.

Figure 5. Individual Total Phosphorus Concentrations in Sucker, East Vadnais, and White Bear Lakes Compared with Carlson's Trophic State Index (May to September, 2005 – 2015)



Source: Appendix I, Concept Cost Report for Augmentation of White Bear Lake with Surface Water (Minnesota Department of Natural Resources (DNR), February 2016). Memorandum prepared by Metropolitan Council Environmental Services, January 15, 2016.

Figure 6. Effect of Total Phosphorus on Water Clarity – White Bear Lake and East Vadnais Lake compared to Minnesota Reference Lakes (Source: MPCA, 2005)



Source: Appendix I, Concept Cost Report for Augmentation of White Bear Lake with Surface Water (Minnesota Department of Natural Resources (DNR), February 2016). Memorandum prepared by Metropolitan Council Environmental Services, January 15, 2016.

Water Quality Limits

Water quality limits for discharges into White Bear Lake from another surface water will be established by regulatory agencies and local permitting authorities. At this concept level stage, water quality impacts on costs were assessed by comparing the water quality characteristics of the source water (Sucker Lake and East Vadnais Lake) to those in White Bear Lake. If a water quality characteristic in the source water has a concentration greater than in White Bear Lake there is a potential for additional treatment and thus additional costs.

The filtration system assumed for aquatic invasive species control defined in this memorandum, combined with lake management practices and chemical addition facilities could potentially remove enough phosphorus to meet the phosphorus limit required by regulating and permitting agencies. However, that may not be the case and additional treatment processes could be required.

For this concept level analysis, two levels of treatment were evaluated that correspond to different total phosphorus goals. These goals are based on the generally accepted lake trophic level indicator phosphorus concentrations and technology performance to achieve the low levels of phosphorus to achieve these goals.

Treatment Facilities

The selection of treatment technologies to achieve low level phosphorus concentrations assumes source water concentrations fluctuate from 0.02 mg/L to over 0.1 mg/L. While the average concentration in East Vadnais Lake was 0.026 mg/L for the past five years (May-September), it has fluctuated above 0.03 mg/L. Sucker Lake has a much more variable phosphorus concentration. Data for Sucker Lake is only available prior to 2011, which is before the oxygenation system was installed to reduce phosphorus in the upstream Pleasant Lake. Sucker Lake concentrations ranged from 0.02 to 0.10 mg/L and averaged 0.039 mg/L.

High level concept system costs were developed based on cost curves and recent planning studies for similar treatment systems scaled to the augmentation system capacity. Costs presented include a construction contingency of 30%, contractor overhead/profit/bonds of 20%, engineering/legal of 15%, and escalation factor to mid-point of construction of 8.66%.

Level 1 Phosphorus Goal

Two technologies used to consistently meet phosphorus limits below 0.1 mg/L are two-stage granular media adsorption/filtration and tertiary/high-rate clarification followed by filtration. For purposes of this report, two-stage granular media adsorption/filtration was selected because it has a smaller footprint and fewer supporting systems than for the clarification process. Two-stage granular media adsorption/filtration processes involve a series of filters containing media which uses filtration and adsorption to remove phosphorus in the water. These two-stage filtration systems report achieving effluent phosphorus as low as 0.03 mg/L depending on phosphorus speciation. Long-term, reliable operations assume a higher concentration. The process consists of below ground up-flow continuous backwash filters operated in series, the number of filters in series is determined by flow and influent phosphorus concentration.

The cost of a two-stage media adsorption/filtration facility is estimated to be $23.0 million and would cost $400,000 a year to operate and maintain.

Assumptions for the system requirements at this concept level include:

- Based on the manufacturer Blue Pro concept quote and scale-up from smaller system estimate.
- Adequate soluble reactive phosphorus content.
- Residual management addressed with an allowance of $1 million in capital cost and $50,000 per year.
- Additional land required for the treatment facility – allowance of $2 million.
- Power cost is $0.06/kWH.

Level 2 Phosphorus Goal (Best Available Technology)

The best available technology for low level phosphorus removal is reverse osmosis (RO), in conjunction with nanofiltration (NF). Pilot testing would be required to determine the phosphorus level achievable for water from Sucker Lake and East Vadnais Lake. Reverse osmosis systems have reported achieving total phosphorus levels as low as 0.015 mg/L. The levels achievable are dependent on the speciation of the phosphorus and other factors. Long-term, reliable operations assume a higher concentration.

The reverse osmosis process demineralizes water by pushing through a pressurized semi-permeable reverse osmosis membrane. Nanofiltration membrane filters are installed ahead of the reverse osmosis system to avoid excess clogging of the filters and optimum removal efficiency. This technology produces a highly concentrated reject water that needs proper disposal. In addition, the system needs to be oversized by at least 20% to account for the reject water losses and provide the desired flow to augment White Bear Lake.

Assumptions for the system requirements at this concept level include:

- System capacity is 10 mgd (based on 6,000 gpm augmentation system flow and 20% for reject stream flow).
- Reject stream further concentrated and final reject discharged to sanitary sewer within proximity to the treatment facility. Sanitary sewer connection allowance of $500,000.

- Additional land required for the treatment facility – allowance of $2 million.
- Based on seasonal use; requires maintenance program and costs for annual startup – allowance of $100,000.
- Power cost is $0.06/kWH.

The cost of a nanofiltration/reverse osmosis facility is estimated to be $39.7 million and will cost $3.9 million a year to operate and maintain. Cost curves from SEH (2015) and Metropolitan Council (2007) are the basis for these high level concept costs.

SUMMARY

The concept augmentation system is comprised of filtration facilities to prohibit the transfer of aquatic invasive species and reduce solids. It is not known how much phosphorus associated with suspended solids would be removed. Additional treatment may be required to remove phosphorus to lower levels. A regulatory review process would establish the allowable phosphorus loadings, and other contaminant loadings to White Bear Lake. Without a known phosphorus goal, two different scenarios were considered to determine the potential treatment processes required and the additional cost for these facilities.

The treatment costs assumed for the concept augmentation system are summarized in Table 3.

Table 3. Cost Summary

Filtration Facility for Aquatic Invasive Species and Solids Removal

Alternative	Capital Cost ($ millions)	Operations and Maintenance Cost ($ millions/year)
Sucker Lake	$11.3	$0.12
East Vadnais Lake	$10.6	$0.12

Enhanced Phosphorus Removal Treatment Facilities

Phosphorus Goal	Capital Cost ($ millions)	Operations and Maintenance Cost ($ millions/year)
Level 1	$23.0	$0.4
Level 2 (Best Available Technology)	$39.7	$3.9

Additional monitoring is needed to fully characterize phosphorus in the source lakes. This includes monitoring at different locations and depths and more frequently to understand changes related to climatic conditions and Saint Paul Regional Water Services operations and management practices. It is also important to analyze for the various types of phosphorus. The soluble fraction of phosphorus, and in particular, the nonreactive portion, needs to be characterized to select treatment technologies and optimize design. There is no current information on the soluble phosphorus concentration.

The next step in reducing the uncertainty in treatment costs is to implement a coordinated water quality monitoring program for the Mississippi River, source water lakes, and White Bear Lake. This information is critical to assessing the potential impacts of an augmentation supply on White Bear Lake and what treatment is required to mitigate the impacts. A comprehensive recommendation for sampling and related water quality analysis and modeling is documented in companion report technical memoranda as Appendices I and J in the Concept Cost Report for Augmentation of White Bear Lake with Surface Water (DNR, February 2016).

REFERENCES

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United States Army Corps of Engineers (USACE). Zebra Mussel (Dreissena polymorpha) Control Handbook for Facility Operators, First Edition. Miscellaneous Paper EL-97-1. June 1997. http://el.erdc.usace.army.mil/elpubs/pdf/98e176.pdf

Appendix L: Peer Review of Concept System Treatment Facilities

Memo

Date: Wednesday, January 13, 2016

Project: White Bear Lake Concept Report Technical Peer Review

To: Sam Paske, Assistant General manager – Environmental Quality Assurance, Metropolitan Council Environmental Services

From: Kathryn Jones, Matt Cochran

Subject: Technical Peer Review of Proposed Treatment System (HDR Scope Task 2)

Introduction

This memorandum summarizes HDR's review of the treatment concept proposed by SEH in the Concept Report for Augmentation of White Bear Lake with Surface Water. The review incorporated an assessment of a conceptual system that will control and/or limit zebra mussel transport in the lake augmentation process. A review of treatment systems to address other water quality parameters, other types of invasive species, or other treatment requirements was not included in the scope for this peer review.

The review was conducted by HDR between December 15 and December 22, 2015. Documents reviewed for this assessment included:

WBL Augmentation Concept Report_Draft_Less Appendices_09Dec2015.pdf

WBL Augmentation Concept Report_Draft_Appendices_10Dec2015-Complete.pdf

WBL Augm TM_Cost Estimate_wExh_12_15-2015.pdf

Fluid Engineering Preliminary TM Filtration Figures (*20151216182330215.pdf*)

Water Quality Chapter – draft_121615.docx

Water Treatment TM-Draft_121715.docx

Water Treatment TM-Draft_121715.pdf

Applicability of Overall Design

As outlined in the draft Concept Report for Augmentation of White Bear Lake with Surface Water, the overall design concept that provides three stage mechanical screening with automatic backwash of water from either Sucker Lake or East Vadnais Lake is an appropriate treatment alternative for zebra mussels. Control of invasive mussels can be categorized into physical, chemical, and biological controls. While chemical and biological controls have some applicability in certain circumstances, the continuous flow of the proposed augmentation project

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would exclude their consideration within the operation presented. For this reason, the mechanical based automatic backwash strainers are appropriate to reduce the risk of zebra mussel transport.

The use of multiple steps or stages with increasing smaller screen size at each step as outlined in the concept report is also applicable. The larger screen sizes proposed for the first step will allow larger debris to be removed lessening the burden of the smaller 25 micron screen proposed for the final treatment. Further, the 25 micron size outlined is consistent with recommended screen sizes for zebra mussels given the size of the veligers is in the 70 - 100 micron range and the eggs are in the 40 - 90 micron range.

The velocity outlined by the designers of less than 0.5 feet per second (fps) at the intake is consistent with impingement and entrainment protective velocities for fish. This means a reduced risk of entrainment of fish in to the intake and follows the same guidance as EPA 316 (b) protocols. Proper management of zebra mussel encrustation at the intake will be required to maintain the design velocity.

As described in the review meeting on December 22, 2015, the final stage of treatment consists of a continuously wound wedge-wire strainer fitted with a 25 micron x 25 micron mesh screen on the interior. Mesh designs with discrete openings are appropriate for controlling passage of debris and unattached mussels, and veligers. More detailed information about the 25 micron mesh strainer design should be shown in the Concept Report for clarity.

Other Considerations

The Concept Report references general control of invasive species versus specifically discussing zebra mussels. There will be some additional screening of unwanted species but broad statements about additional controls should be used carefully. However, it can be reasonably assumed that an aquatic invasive species with a body size equal to or larger than a zebra mussel egg will be effectively screened out by the proposed system.

Appendix M: Zebra Mussel Impacts

TEHCNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Brendan Wolohan, Project Engineer

DATE: November 19, 2015

RE: Zebra Mussel Impacts
SEH No. MCES 134593 14.00

This memorandum has been prepared to summarize the review of zebra mussel impacts as they relate to the Concept Cost Report for Augmentation of White Bear Lake with Surface Water. The Minnesota DNR (MnDNR) lists each of the potential intake surface waters including Sucker Lake and East Vadnais Lake, as well as White Bear Lake (WBL) on the infested waters list for zebra mussels.

Zebra mussels of various stages of life grow and reproduce in the Mississippi River, which is being considered as a water source for augmentation of WBL. These zebra mussels can cause damage to facilities and infrastructure, reducing the amount of intake head and incapacitating the system. Zebra mussels will colonize on hard surfaces and are costly to eradicate once populations have been established. The MnDNR restricts the transfer of infested waters from water body to water body unless treatment is provided.

Zebra mussels are small, quarter-sized freshwater mussels that attach to solid surfaces in lakes and rivers. Female zebra mussels can produce 100,000 to 500,000 eggs each year, which eventually develop into microscopic larvae called "veligers." After two to three weeks, these veligers grow shells and eventually settle and begin to attach to surfaces. Zebra mussels were brought over to the Great Lakes region from their native Eastern Europe in the ballast water tanks of shipping vessels. Populations have slowly been increasing in the Mississippi River, and the MnDNR has set regulations in place in order to prevent them from being distributed from water body to water body.

The major impact of zebra mussels associated with the augmentation of WBL is clogging of the water intake piping and screening equipment. A considerable amount of maintenance needs to be done on the intake equipment to ensure optimal operating conditions and prevent excess wear on the equipment. Therefore maintenance costs must be considered to maintain equipment for both alternative intake locations. Zebra mussels can also impact the environment of lakes and rivers in which they live. They eat tiny food particles that they filter out of the water, which can reduce available food for larval fish and other animals. Once established in a waterbody, zebra mussels are extremely difficult to completely get rid of and costly to eradicate. Zebra mussels out compete other small animals in the water body for food and have taken over in many lakes and rivers.

Screening will be required in the augmentation of WBL at the intake to prevent damage to the augmentation system components as well as prevent the transfer of invasive species into WBL. It is important that the screening equipment is sized accordingly to filter out both the adult and veliger zebra mussels.

BCW
c: Don Lutch

s:\ko\m\mces\134593\4-prelim-dsgn-rpts\draft report\v3 appendices\appendix m zebra mussel impacts\v3.1_tm_zebra mussels impacts_01202016.docx

References:

Department of Natural Resources. Zebra mussel (Dreissena polymorpha). MNDNR Website. Available at: http://www.dnr.state.mn.us/invasives/aquaticanimals/zebramussel/index.html. Accessed November 18th, 2015.

Appendix N: Concept Level Cost Estimate

SEH

Building a Better World for All of Us®

TECHNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council Environmental Services

FROM: Donald Lutch, PE

DATE: January 15, 2016

RE: Concept Level Cost Estimate for Augmentation of White Bear Lake with Surface Water
SEH No. 134593 14.00

This memorandum has been prepared to summarize the costs for two concept level alternatives as it relates to the Concept Cost Report for Augmentation of White Bear Lake with Surface Water (Minnesota Department of Natural Resources (DNR), February 2016).

Two concept alternatives have been developed to estimate costs for an augmentation system supplying approximately two (2) billion gallons (BG) of water per year to White Bear Lake (WBL): The Sucker Lake Alternative would withdraw water from Sucker Lake and the East Vadnais Lake Alternative would withdraw water from East Vadnais Lake. The purpose of this memorandum is to provide an overview of the elements and references used in the preparation of the conceptual estimate for each alternative and present concept level costs.

ALTERNATIVES

The Sucker Lake Alternative would connect Sucker Lake to WBL. The alignment assumed for the cost estimate begins on the east shore of Sucker Lake, within the Sucker Lake County Park, and runs northward to County Road 96. The alignment would then follow County Road 96 eastward, cross beneath I-35-East (I-35E), turn south along Otter Lake Road, turn east along Whitaker Street, continue east beneath Minnesota State Highway 61, turn southeast along Old White Bear Avenue, and finally terminate in Lions Park in the west bay of WBL. Figure 1 provides an overview of the proposed Sucker Lake Alternative alignment route with Stationing Numbers.

The East Vadnais Lake Alternative would connect East Lake Vadnais to WBL. The alignment assumed for the cost estimate begins at the far east shoreline of East Lake Vadnais, near the intersection of Vadnais Boulevard and Centerville Road. The alignment would follow Centerville Road northeastward toward I-35E, continue beneath I-35E along Goose Lake Road, turn south and follow Otter Lake Road, turn north along Hoffman Road and west side of Goose Lake, continue east beneath Minnesota State Highway 61 and along White Bear Avenue, and finally terminate in Lions Park on the west bay of WBL. Figure 2 provides an overview of the proposed East Vadnais Lake Alternative alignment route with Stationing Numbers.

BASIS OF COST ESTIMATING

General

The process used to develop the concept cost estimates followed the recommended practices of the American Association of Cost Engineering (AACE) International Recommended Practice No. 18R-97, Cost Estimating Classification System – as Applied in Engineering, Procurement, and Construction for the Process Industries. The current level of Project Definition as expressed as a percentage of complete definition is in the 1% to 15% range for each Concept Alternative and can be defined as a Class 4 Estimate Class with an end usage of the estimate being associated with concept report for feasibility. The Class 4 Estimate expected range is from a low range of -15% to -30% and a high range of +20% to +50%. The individual line item elements estimate may vary within the low and high ranges noted above as indicated in the table below.

CLASS 4 ESTIMATE	
Description: Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists. **Level of Project Definition Required:** 1% to 15% of full project definition. **End Usage:** Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.	**Estimating Methods Used:** Class 4 estimates virtually always use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.

Source: AACE International Recommended Practice No. 18R-97, Cost Estimating Classification System – as Applied in Engineering, Procurement, and Construction for the Process Industries. February 2, 2005

For the purpose of this memorandum, the nominal depth of the augmentation pipeline is assumed to be in the range of 10 to 15 feet below existing ground elevations.

Capital Costs Estimate Reference Documents

The capital cost estimate for the two alternatives have been prepared with the use of the following cost estimate references:

- The Minnesota Department of Transportation (MnDOT) Average Bid Price for awarded project for Specification Year 2014 for site.
- RS Means Estimating Guidebook for civil works projects, process equipment, electrical, controls and piping.
- SEH past project bid cost summaries for projects awarded in 2014 and 2015.

- Direct budgetary estimates and quotes for equipment from local major equipment and piping system suppliers specific to this project.

Other Sources

As part of the development of the alignment alternatives and the preliminary cost analysis the SEH, MCES and DNR team members met with members of Ramsey County Engineering and Public Works, public works representatives of Vadnais Heights, Shoreview, White Bear Lake, Gem Lake and White Bear Lake Township to present the preliminary alignments, probe their knowledge of the routes related to existing utilities and site conditions, better understand the future project plans of each entity related to the project alignment and the current usage of the facilities associated with each alignment.

In addition, a Contaminated Site Inventory Review of all properties within the immediate proximity of each general alignment was evaluated. As a result of these discussions and research the planned location adjustments were considered with respect to risk avoidance of contaminated properties, staying clear of high risk contaminated parcels, adjustment of traveled ways with high average daily traffic counts, if at all possible, and staying clear of newly constructed right-of-way projects.

The following geotechnical documents were reviewed in preparing this memorandum:

- Ramsey County Geologic Atlas (Plate 3 – Surficial Geology) and limited soil boring related to the actual alignment from the following:
  - Soil boring logs prepared by American Engineering Testing for MCES (1992)
  - Soil boring logs prepared by Geo Engineering Consultants for MCES (2001)
  - Soil boring logs prepared by Stork Twin City Testing for MCES (2001)
  - Soil boring logs prepared by GME Consultants for MCES (2004, 2005)
  - Soil boring logs prepared by Braun Intertec for MCES (2005)
  - Construction Plans for TH 61 between County Road E and TH 96 by MnDOT (1956)

The Contaminated Site Inventory Review included a desktop review of the project areas and a site reconnaissance and was limited to the following research tasks listed below:

- Review of contaminated site information available from the MPCA What's in my Neighborhood (WIMN), Minnesota Department of Agriculture (MDA) WIMN and Petroleum Remediation Program (PRP) websites
- Limited review of the MPCA Spill sites
- Historic aerial photograph review (1947, 1957, 1966, 1980, 1991, 2003, 2004, 2008, 2009, 2011)
- Historic topographic map review (1902, 1910, 1918, 1943, 1954, 1959, 1965, 1969, 1973, 1981, 1987, 1993)
- Review of available Solid Waste, Voluntary Investigation and Cleanup (VIC), Petroleum Brownfield, and Leak Files.
- Review of located monitoring and abandoned wells available on the Minnesota Department of Health (MDH) County Well Index (CWI) website.

Line Item Assumptions and Uncertainty Factor

Assumptions used to estimate each line item are documented. From the information provided in the above sources, an "uncertainty factor" (low, medium, high) was considered for each individual line item of the cost estimate as it relates to the uncertainty of field conditions. Unit price ranges were adjusted accordingly or quantity calculations were adjusted generally for unknown subsurface conditions. Details of the uncertainty considered for each line item of the estimate are provided with the assumptions in the tables referenced under the Capital Costs section.

Line item costs were developed by SEH and adjusted based upon the results of the peer review by HDR, Inc. (refer to Appendix O, Concept Cost Report for Augmentation of White Bear Lake with Surface Water, DNR (February 2016)) and MCES.

Development of Total Costs

Total costs were estimated based on the following: 20% contingency to account for unknown conditions and undeveloped design detail, 25% for engineering, legal and administration, and an escalation to the mid-point of construction (assumed to be 2018-2019) of 8.66%. The escalation factor is based upon the HDR, Inc. recommendation documented in Appendix O, Concept Cost Report for Augmentation of White Bear Lake with Surface Water, DNR, February 2016.

CAPITAL COSTS

The two alternative concept level cost estimates are summarized in the table below.

Capital Costs for Concept Level Surface Water Augmentation Alternatives

Cost Item	Sucker Lake ($ millions)	East Vadnais Lake ($ millions)
Grading and Restoration	$14.7	$15.7
Filtration Facility	$6.9	$6.5
Pump and Pipe Work	$8.0	$7.8
Tunneling	$9.6	$1.1
Permits/Easements	$2.0	$2.7
Total Construction Cost	**$41.2**	**$33.8**
Contingency @ 20%	$8.2	$6.7
Total Construction Cost with Contingency	**$49.4**	**$40.5**
Engineering, Legal and Administrative @ 25%	$12.4	$10.1
Total Cost in 2015 Dollars	**$61.8**	**$50.6**
Total Cost at Mid-Point of Construction* (2018-19)	**$67**	**$55**

*Total capital costs for a system to meet higher levels of phosphorus removal would increase the total cost of the Sucker Lake alternative to $90-$107 million and for the East Vadnais Lake alternative to $78-$95 million, depending on the level of treatment required. Refer to Appendix L, Concept Cost Report for Augmentation of White Bear Lake with Surface Water (DNR, February 2016).

Table 1 for the Sucker Lake Cost Estimate and Table 2 for the Vadnais Lake Cost Estimate are provided as exhibits to this memorandum. Line item details identify the system characteristics assumed in developing the concept costs. Additional detail on the system characteristics are provided in the Concept Cost Report for Augmentation of White Bear Lake with Surface Water (DNR, February 2016) and related appendices.

The concept level costs presented in this memorandum are based on treatment facilities that remove aquatic invasive species. The assumed technology is a mechanical control system using fine screen automatic cleaning filters. Additional data and evaluations are needed to determine treatment needs for other water quality characteristics. Other treatment technologies may be required to achieve other water quality goals identified by regulatory and permitting authorities. The costs for additional treatment facilities are not included in the concept cost estimates presented in this memorandum. Refer to Appendices I-L, Concept Cost Report for Augmentation of White Bear Lake with Surface Water (DNR, February 2016) for costs on additional treatment facilities.

Operation and Maintenance Costs and Considerations

Operation and maintenance (O&M) costs have been developed for the initial years of operation assuming a yearly pumping rate of two (2) billion gallons of filtered surface water delivered to White Bear Lake annually.

O&M costs are based on a set work schedule of daily, weekly, semi-annual and trouble response to system alarms and community call-ins and Gopher One Locate requirements. Include in the preventative maintenance items is zebra mussel control.

The O&M costs may be higher in the initial years. The schedule for ongoing years of operation of the system will likely be adjusted to reduce the frequency of checking on the system and need for equipment adjustments based on source water conditions and the establishment of normal equipment wear rates.

The cost of surface water purchased from Saint Paul Regional Water Services is assumed to be $110 per million gallons and may be adjusted once a formal purchase agreement has been executed for the purchase of the surface water and location of intake facilities within the source water lake.

The first year of projected annual O&M costs are listed in the table below.

Estimated Annual O&M Costs

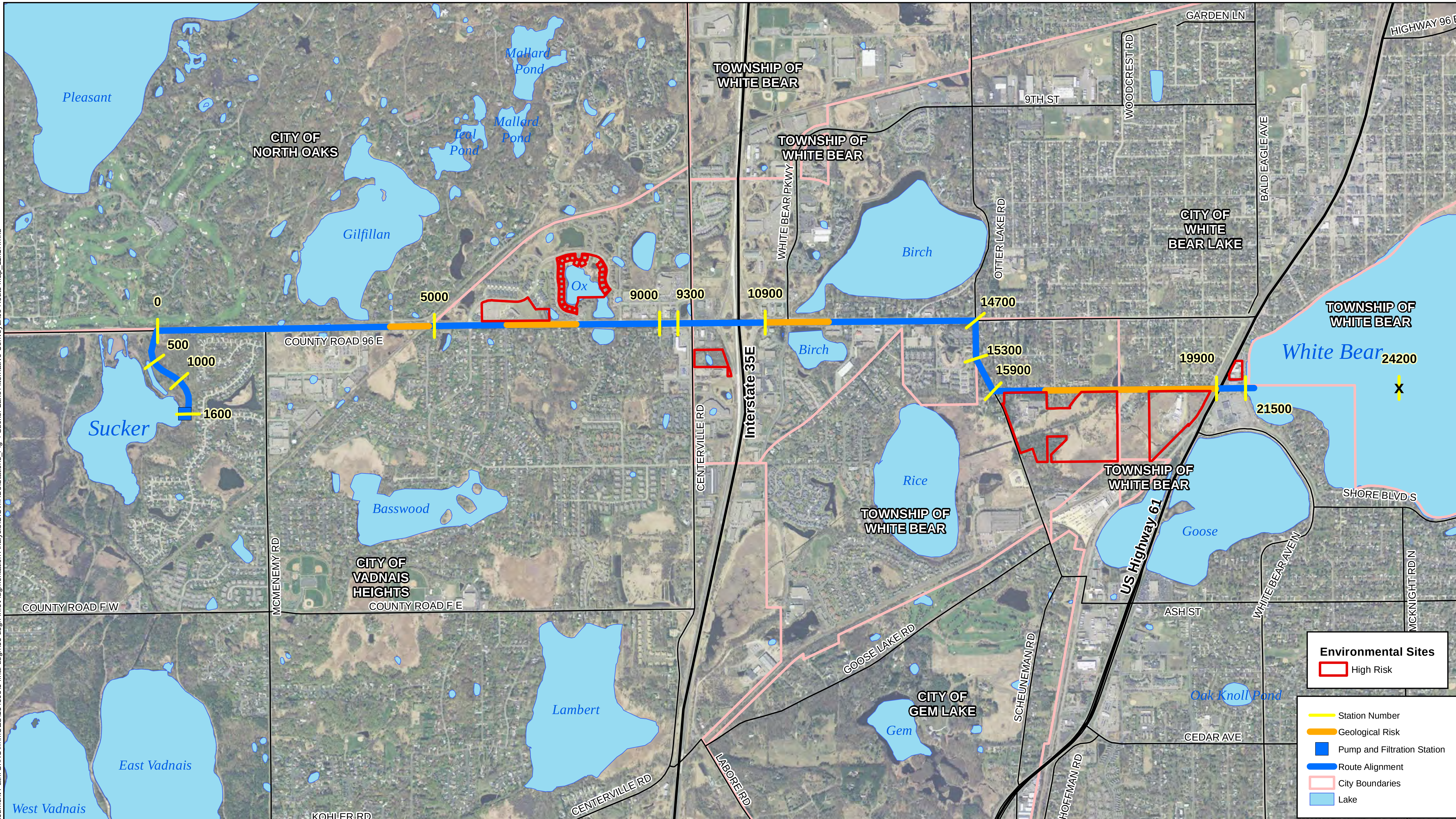
Items	Filtration System	Pump System	Pipe	Water Purchase Costs	Total O&M Annual Costs*
Yearly operation	$6,000	$95,000	$13,000	-	$114,000
Weekly system check	$8,000	$2,000	$2,000	-	$12,000
Semi-annual checks	$39,000	$37,000	$58,000	-	$134,000
Trouble response	$59,000	$31,000	-	-	$90,000
Water purchase from Saint Paul Regional Water Services	-	-	-	$220,000	$220,00
Potential Total Annual O&M Costs	**$112,000**	**$165,000**	**$73,000**	**$220,000**	**$570,000**

*Based on first year operation and subsequent years operation at 2 billion gallons per year pumping capacity

The estimated water purchase price based on $110 per million gallons is $220,000 for each year assuming two (2) billion gallons of water is pumped per year.

The total purchase plus Operation and Maintenance costs for two (2) billion gallons pumped to White Bear Lake is approximately $570,000 per year.

Attachments – Figures 1 and 2, Tables 1 and 2
C: Don Lutch
bat



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Print Date: 12/11/2015

Map by: LO
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

0 850 1,700 3,400 5,100 6,800 Feet

N

Sucker Lake Alternative Conveyance Route With Station Numbers

Figure 1

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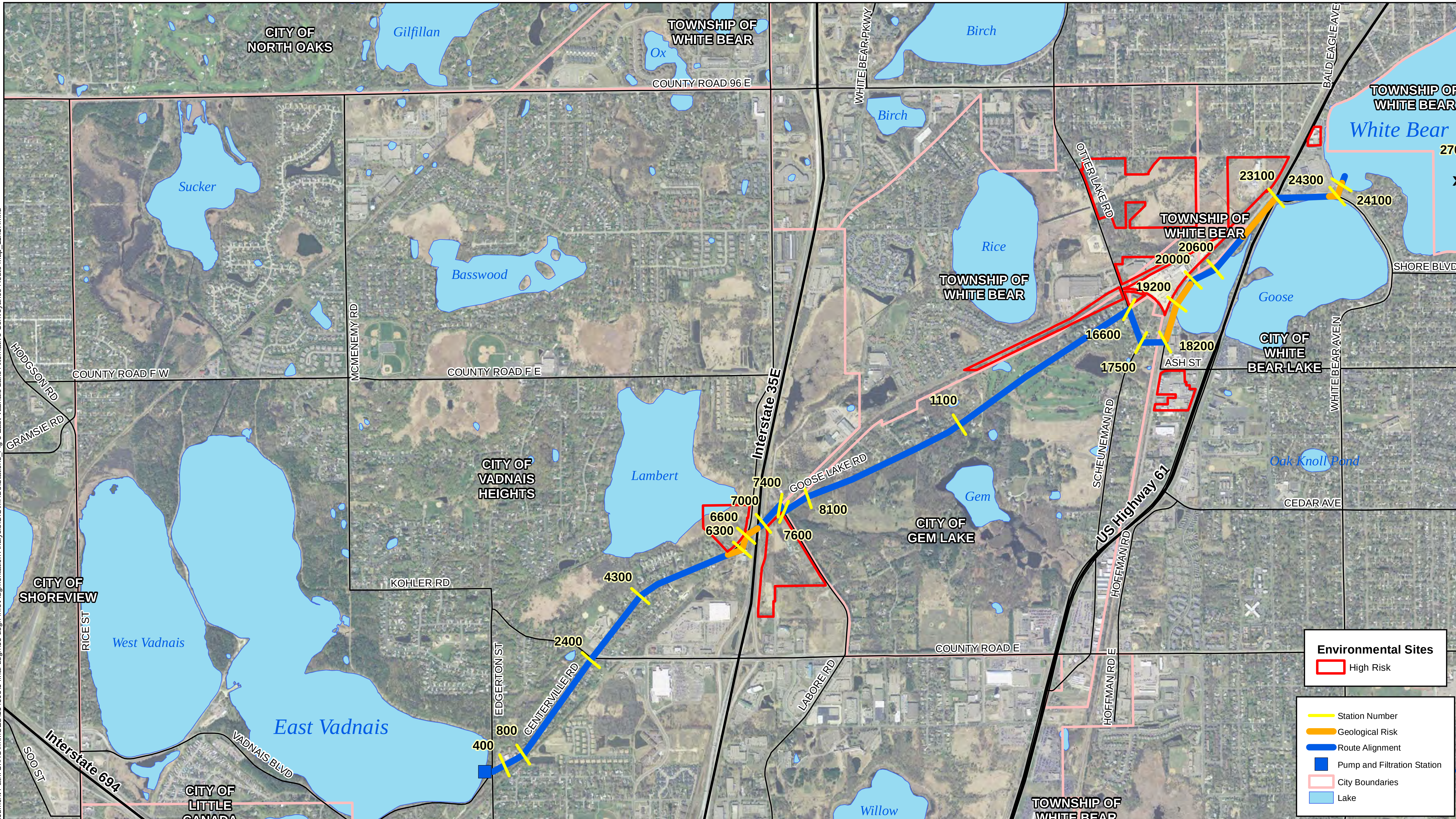

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Datum: D_North_American_1983_HARN
Source: MnDNR, MnDOT, MnGEO, NWI, SEH

0 850 1,700 3,400 5,100 6,800 Feet

N

East Vadnais Lake Alternative Conveyance Route With Station Numbers

Figure 2

Table 1. Sucker Lake Alternative

Augmentation of White Bear Lake with Surface Water
Capital Costs for Concept Level Surface Water Augmentation
Updated: 01-05-16

Code	Item	Unit	QTY	Unit Price	Total Price	Uncer-tainty	Basis of Cost
	Sitework						
S1	Mobilization	LS	1	1,483,000	1,483,000		3% construction $
S2	Traffic Control: Barricades and Lights	LS	1	300,000	300,000	low	$150k/yr as long as Centerville Rd/I35E is tunneled from SW corner of Centerville Rd to NE Corner of White Bear Parkway.
S3	Erosion Control and Additional Restoration	LS	1	50,000	50,000		Replace amenities along trail.
S4	Tree Removal and Replacement	TREE	300	1,000	300,000		Tree spacing along south parkway of 96 is approximately 25'C/C from Sucker Lake East toward HWY I 35E.
S5	Excavation	CY	128,100	45	5,765,000	high	6CY/LF with assumed 40% useable material for backfill based on Ramsey County Geological Atlas and no soil borings. Risk is high. To lower the risk SEH Geotechnical Staff recommend 40-50 borings along this alignment with multiple ground water pump tests to verify the level of dewatering that may be needed in certain segments.
S6	Bituminous Trail Replacement	SY	16,350	40	654,000	medium	Bituminous walk section assumed based on visual site drive through with no pavement cores. Note: MnDOT -2014 AVG Bid = $22/SY '= (6.98*2) +3.7+1.6+2.75. Which includes milling the existing surface for use as reclaimed Base, placement of reclaimed + additional Class 5 + 2" of Bit placed back over geotextile fabricate.
S7	Concrete Sidewalk	SY	800	45	36,000	low	4" Walk at intersections for sidewalk ADA Access.
S8	Asphalt Pavement 2"+2"+6" CL5	SY	19,940	32	639,000	high	Rural road section assumed based on visual site drive through - no pavement cores MnDOT - 2014 AVG Bid = $22/SY=(6.98*2)+3.7+1.6+2.75 Based on type of pavement cracking and fractures there appears to minimal base along Whittaker Street (as one would expect from a rural road section with no design drainage or storm water collection system
S9	Asphalt Pavement 2"+3 lifts x 2" +8" CL5	SY	4,300	45	194,000	high	County Primary Route assumed based on visual - no pavement cores -MnDOT -2014 AVG Bid = $37/SY = '= (6.98*4)+4.9+1.6+2.75. Based on 4 lifts of Bit + geotextile fabric + milling of existing bit for use as base + additional Class 5 for final grading. Based on type of pavement cracking and fractures there appears to minimal base along in several segments. This rural road section has no to limited design drainage system or storm water collection system with most surface runoff to large lot yards or natural wetlands.
S10	Concrete Pavement	SY	3,500	60	210,000	low	Assumed 8" note: 6"=$44.00/SY. Most road crossings are primary bit with some potential for concrete aprons.
S11	Concrete Curb and Gutter B618	LF	15,300	16	245,000	low	Primarily rural road with limited curb and no storm sewer. Most curb along Hwy 96 may be damaged alongparkway pipe install and need to be replaced.
S12	Dewatering (Wells/Well Points)	LS	1	400,000	400,000	high	Install local segment system w/Frac tank settling treatment prior to discharge to surface waters or sanitary system. If contaminated. Geotechnical investigations including well pump testing to establish potential drawdown rates necessary.
S13	Trucking to Waste	CY	50,000	18	900,000	high	Assumed quantity based on Ramsey Atlas - no borings. Geotechnical investigations necessary to further quantify poor soil areas. Assumes 60% of material is hauled away.
S14	Trucking to Waste (contaminated)	CY	16,800	61	1,025,000	high	Assumed quantity based on Contaminated Site Inventory. Phase 1 investigations and potential for Phase 2 needed. Geotechnical investigations including well pump testing to establish potential drawdown rates necessary.
S15	Site Grading	SY	9,850	3	30,000	Low	
S16	CLSM Backfill	CY	1,200	110	132,000	medium	Casing backfill and potential utility crossing support.
S17	Select Fill	CY	50,000	18	900,000	medium	Assumed quantity based on Ramsey Sub-geological Atlas - no borings. Used in areas where existing pipe trench will be backfilled with existing materials encountered. See Geotechnical TM for general locations and Descriptions of potential for sands, gravels and glacial deposits. Assumes 60% of material is hauled away.
S18	Granular Foundation Material	CY	16,000	25	400,000	medium	Assumed quantity based on Ramsey Sub-geological Atlas - no borings. Used in areas where existing pipe trench will be backfilled with existing materials encountered. See Geotechnical TM for general locations and descriptions of potential for sands, gravels and glacial deposits. Assumes 60% of material is hauled away.

Table 1. Sucker Lake Alternative

Code	Item	Unit	QTY	Unit Price	Total Price	Uncer-tainty	Basis of Cost
S19	3" Crushed Rock & Fabric	CY	1,200	55	66,000	high	Assumed quantity based on Ramsey Sub-geological Atlas - no borings. Used in areas where existing pipe trench will be backfilled with existing materials encountered. See Geotechnical TM for general locations and descriptions of potential for sands, gravels and glacial deposits.
S20	Ground Support System	LS	1	500,000	500,000	medium	Assumed tandem trench box for open cut installation of pipe. Separation for pipe install along HWY 96 sound wall under the bit trail is such that the profile depth when installed with the tandem trench box (6' WIDE WIDTH) and the planned 10' trench excavation will not impact the sound wall installation.
S21	CIP Vault (Walls, Base Slab, Footings)	EA	2	40,000	80,000	medium	For two maintenance access structures at 35 E tunnel crossing.
S22	Precast Utility Vault	LF	10	10,000	100,000	medium	For two air release structures at primary high points of FM profile.
S23	72" Manhole (10' Deep)	EA	6	10,000	60,000	low	For segment issolation valves, for testing and potential maintenance needs.
S24	Top Soil	CY	6,490	30	195,000	low	Assumed 6" topsoil. Represents site grading area covered with six inches of topsoil.
S25	Landscape and Turf Restoration	SY	12,970	4	52,000	low	Assumed seeding for rural road way disturbed shoulders within the right-of-way.
	Subtotal				**$14,716,000**		
	Screening Facility Structure						
F1	Skid-Mounted Screening Equipment	LS	1	2,811,000	2,811,000	low	Assumed lesser quality raw water available at Sucker Lake. Thirteen (13) vessel automatic cleaning skid unit to have two (2) first vessels with 250 micron screens, followed by five (5) secondary stage vessels with 125 micron screens followed by five (5) last stage vessels with the 25 micron screens. Each vessel in each of the three stages will backwash on differential pressure and/or a pre-set timer. Timed sequence backwash will step clean each of the stages vessel screens. No two vessel backwash sequence will run at the same time period for each stage. A backwash event can occur in each stage at the same time. Backwash water to return to the source water reservoir per DNR requirements. One pump, One first stage screen vessel, two second stage screen vessels and two last stage screen vessels will have the 6,000 gpm capacity at the system design pressure. System redundancy will be one pump and one screen vessel in each of the three stages. This scenario provides the opportunity for planned maintenance without disruption of flow and system capacity. Preliminary quote.
F2	Skid-Mounted Screening Equipment Installation	LS	1	1,125,000	1,125,000	low	Assumed 40%+/-installation with crane and piping bolt ups, electrical and platform grating.
F3	Framing, Siding & Roof	SF	15,000	150	2,250,000	low	Assumed neighborhood architectural finishes (for Sucker Lake to match the Ramsey County Park Structures).
F4	Monorail Support System (Hoist & Trolley)	LS	1	75,000	75,000	low	Structural framing and monorail beams and hoists for screen vessel inspection & O&M.
F5	Grating, stairs & platforms	LS	1	80,000	80,000	low	Galvanized steel framing and grating.
F6	Backwash System (additional to Skid Cost)	LS	1	35,000	35,000	low	Pressure booster pump and piping connected to filter skid piping and vessels.
F7	Painting	LS	1	24,000	24,000	low	Miscellaneous painting.
	Subtotal				**$6,400,000**		
	Pump & Forcemain						
C1	30" HDPE Lake Intake with Concrete Armor Mat	LF	900	458	413,000	medium	Assumed two precast intake stuctures and single intake piping on lake bottom. Pipe on bottom to be secured/protected with eight foot wide CONTECH Armormat or equal. Material Quote at $8-9/SF for materials.
C2	30" HDPE Lake Outfall with Concrete Armor Mat	LF	2,700	458	1,237,000	medium	Assumed special HDPE diffuser section and piping on lake bottom. Pipe on bottom to be secured/protected with eight foot wide CONTECH Armormat or equal.
C3	SPRWS Connection Fee	EA	1	30,000	30,000	medium	Assumed Initial connection fee to include SPRWS engineering review.
C4	12' DIA RCP Lake Intake Structure	EA	2	50,000	100,000	medium	Per schematic detail in report each with 6 intake portals – 1'H x 4' long equally spaced at the predetermined intake water depth.
C5	30" Forcemain	LF	23,350	200	4,670,000	high	Based on conceptual site alignment (HDPE DR17).
C6	30" Check Valve	EA	3	10,000	30,000		Pump Piping System >Note: Installation included in estimate line item F2.
C7	30" Plug Valve	EA	9	15,000	135,000		Pump Piping System plus FM issolation valves
C8	30" DIP Fittings	EA	30	2,500	75,000		Miscellaneous FM fittings Installation included in estimate line item F2.
C9	30" DIP Spool	EA	40	1,250	50,000		Miscellaneous FM fittings Installation included in estimate line item F2.
C10	8" Filter Backwash Drain & Building Drain to lake	LF	350	200	70,000		Miscellaneous FM fittings.
C11	12" HDPE Backwash Return Drain Pipe	LF	500	250	125,000		Miscellaneous FM fittings.
C12	Magnetic Flow Meter	LS	1	29,288	30,000		Miscellaneous FM fittings Installation included in estimate line item F2.

Table 1. Sucker Lake Alternative

Code	Item	Unit	QTY	Unit Price	Total Price	Uncer-tainty	Basis of Cost
C13	Pump (submersible Pump & Motor)	LS	2	148,700	298,000		Vendor Budgetary Quote > 280 HP 460/3 phase complete with rails and hatch.
C14	Pump Installation and Piping	LS	1	446,100	447,000		RS Means and SEH project comparisons.
C15	Utility Relocation	LS	1	250,000	250,000		Assume relocation along 1/3 of alignment.
	Subtotal				**$7,960,000**		
	Permits						
P1	DNR Public Waters Work Permit	LS	1	1,500	1,500		SEH Project Comparisons.
P2	DNR Water Appropriation Permit	LS	1	1,350	1,350		SEH Project Comparisons.
P3	DNR Invasive Species Permit	LS	1	1,400	1,400		SEH Project Comparisons.
P4	DNR Utility Permit	LS		-	-		SEH Project Comparisons.
P5	Wetland Conservation Act Permit	LS	1	3,400	3,400		SEH Project Comparisons.
P6	U.S. Army Corps of Engineer Structures Permit	LS	1	3,400	3,400		SEH Project Comparisons.
P7	MnDOT Utility Accommodation on Highway ROW	LS	1	2,500	2,500		SEH Project Comparisons.
P8	Ramsey-Washington Metro WD Erosion Control	LS	1	2,700	2,700		SEH Project Comparisons.
P9	Ramsey County Right of Way Permit	LS	1	1,000	1,000		SEH Project Comparisons.
P10	Rice Creek Watershed District Permits	LS	1	4,500	4,500		SEH Project Comparisons.
P11	VLAWMO Wetland Replacement Plan	LS	1	1,800	1,800		SEH Project Comparisons.
P12	Construction SWPPP & NPDES Permit	LS	1	3,200	3,200		SEH Project Comparisons.
P13	BNSF Pipeline Permit	LS	2	10,000	20,000		SEH Project Comparisons.
	Subtotal $46,750				**$47,000**		
	Tunneling						
T1	35-E (42" steel casing + shafts)	LS	1	8,500,000	8,500,000	high	Shafts at each end $250,000 west end $100,000 east end + 1600 LF casing at $5,000/LF (casing pipe installed by ramming method) Note: Carrier pipe and installation under FM line items.
T2	HWY 61 + RR (42" steel casing + shafts)	LS	1	950,000	950,000	high	Trench box shafts at each end double on driving end casing installed by pipe ramming (600 LF at $1200/LF + west shaft at $150,000 + East shaft at $80,000) Note: Carrier pipe and installation under FM line items.
T3	Railroad Crossings	LS	1	100,000	100,000	medium	Pump Piping System >Note: Installation included in estimate line item F2.
	Subtotal				**$9,550,000**		
	Electrical Controls						
E1	Electrical Service Feed	LS	1	225,000	225,000	medium	RS Means and SEH project comparisons > 600amp service w/ meter and disconnect).
E2	Miscellaneous Electrical, Communications, Security	LS	1	200,000	200,000	medium	RS Means and SEH project comparisons.
E3	Controls & SCADA	LS	1	100,000	100,000	medium	RS Means and SEH project comparisons.
	Subtotal				**$525,000**		
	Easements						
M1	Ramsey County Parks	LS	1	20,000	20,000		Temporary disruption and permanent easements.
M2	HWY 96 and Centerville Rd	SF	76,000	25	1,900,000	high	Temporary disruption and permanent easements (parking lot and green space with in roadway setback space).
M3	WBL Outlet Easement	LS	1	50,000	50,000		Temporary disruption and permanent easements.
	Subtotal				**$1,970,000**		

Total Construction Costs	$41,168,000
Contingency @ 20%	$8,234,000
Total Construction Costs with Contingency @ 20%	$49,402,000
Engineering, Administration, Legal, and Bonding @25 %	$12,351,000
TOTAL COST (2015)	**$61,753,000**
TOTAL COST at Mid-Point of Construction (2018-2019)	**$67,100,810**

Table 2. East Vadnais Lake Alternative

Augmentation of White Bear Lake with Surface Water
Capital Costs for Concept Level Surface Water Augmentation
Updated: 01-05-16

Code	Item	Unit	QTY	Unit Price	Total Price	Uncer-tainty	Basis of Cost
	Sitework						
S1	Mobilization	LS	1	1,215,000	1,215,000		3% construction $
S2	Traffic Control: Barricades and Lights	LS	1	300,000	300,000	low	$150k/yr as long as construction follows the south and east side of roadway centerline for most of route to Otter Lake Road.
S3	Erosion Control	LF	22,370	4	90,000	low	Plugged in footage for downstream (low) side of trench or edge of easement/ROW.
S4	Tree Removal and Replacement	Tree	50	1,000	50,000	low	Estimated from Google Street view of potential trees encountered along route.
S5	Excavation	CY	114,900	40	4,596,000	high	6CY/LF with assumed 40% useable material for backfill based on Ramsey County Geological Atlas and no soil borings. Risk is high. To lower the risk SEH Geotechnical Staff recommend 40-50 borings along this alignment with multiple ground water pump tests to verify the level of dewatering that may be needed in certain segments. Assumes trench box included in ground support item.
S6	Bituminous Trail Replacement	SY	0	50	0	low	Bituminous walk section assumed based on visual site drive through - no pavement cores MnDOT -2014 AVG Bid = $22/SY '=(6.98*2)+3.7+1.6+2.75. No trail on this segment.
S7	Concrete Sidewalk	SY	1,800	45	81,000	low	4" Walk at intersections for sidewalk ADA Access.
S8	Asphalt Pavement 2"+2"+6" CL5	SY	0	32	0	high	Rural road section assumed based on visual site drive through - no pavement cores MnDOT -2014 AVG Bid $22/SY '=(6.98*2)+3.7+1.6+2.75 Based on type of pavement cracking and fractures there appears to minimal base along most of the streets (as one would expect from a rural road section with no design drainage other than storm water runoff.
S9	Asphalt Pavement 2"+3 lifts x 2" +8" CL5	SY	85,688	45	3,856,000	high	County Primary Route assumed based on visual - no pavement cores -MnDOT -2014 AVG Bid = $37/SY = '=(6.98*4) +4.9+1.6+2.75. Based on 4 lifts of Bit + geotextile fabric + milling of existing bit for use as base + additional Class 5 for final grading. Based on type of pavement cracking and fractures there appears to minimal base along several segments. This rural road section has no limited design drainage system or storm water collection system with most surface runoff to large lot yards or natural wetlands.
S10	Concrete Pavement	SY	500	60	30,000	low	Assumed 8" note: 6"=$44.00/SY. Most road crossings are primary bit with some potential for concrete aprons.
S11	Concrete Curb and Gutter B618	LF	1,000	16	16,000		Primarily rural road with limited curb and no storm sewer.
S12	Dewatering (Wells/Well Points)	LS	1	400,000	400,000	high	Install local segment system w/Frac tank settling treatment prior to discharge to surface waters or sanitary system. If contaminated. Geotechnical investigations including well pump testing to establish potential drawdown rates necessary.
S13	Trucking to Waste	CY	50,000	18	900,000	high	Assumed quantity based on Ramsey Atlas - no borings. Geotechnical investigations necessary to further quantify poor soil areas. Assumes 60% of material is hauled away.
S14	Trucking to Waste (contaminated)	CY	15,810	61	965,000	high	Assumed quantity based on Contaminated Site Inventory. Phase 1 investigations and potential for Phase 2 needed. Geotechnical investigations including well pump testing to establish potential drawdown rates necessary.
S15	Site Grading	SY	27,778	10	278,000	low	Assumed limited disturbance (15') beyond rural road shoulder for segments along pipe installed in roadway. Include site demolition.
S16	CLSM Backfill	CY	1,200	110	132,000	low	Casing backfill and potential utility crossing backfill.
S17	Select Fill	CY	46,000	18	828,000	medium	Assumed quantity based on Ramsey Sub-geological Atlas - no borings. Used in areas where existing pipe trench will be backfilled with existing materials encountered. See Geotechnical TM for general locations and descriptions of potential for sands, gravels and glacial deposits. Assumes 60% of material is hauled away.
S18	Granular Foundation Material	CY	11,500	25	288,000	medium	Assumed quantity based on Ramsey Sub-geological Atlas - no borings. Used in areas where existing pipe trench will be backfilled with existing materials encountered. See Geotechnical TM for general locations and descriptions of potential for sands, gravels and glacial deposits.
S19	3" Crushed Rock & Fabric	CY	8,500	55	468,000	High	Assumed quantity based on Ramsey Sub-geological Atlas - no borings. Used in areas where existing pipe trench will be backfilled with existing materials encountered. See Geotechnical TM for general locations and descriptions of potential for sands, gravels and glacial deposits.

Table 2. East Vadnais Lake Alternative

Augmentation of White Bear Lake with Surface Water
Capital Costs for Concept Level Surface Water Augmentation
Updated: 01-05-16

Code	Item	Unit	QTY	Unit Price	Total Price	Uncer-tainty	Basis of Cost
S20	Ground Support System	LS	1	435,000	435,000	medium	Assumed tandem trench box for open cut installation of pipes such that the profile depth when installed with the tandem trench box (6’ WIDE WIDTH) and the planned 10’ trench excavation will not impact adjacient utilities except for crossings.
S21	CIP Vault (Walls, Base Slab, Footings)	EA	2	40,000	80,000	medium	For two maintenance access structures for potential pipeline cleaning.
S22	Precast Utility Vault	LS	2	10,000	20,000	medium	For two air release structures.
S23	72" Manhole (10' Deep)	EA	8	10,000	80,000	low	For segment issolation valves.
S24	Top Soil	CY	6,450	75	484,000	low	Assumed 6" topsoil. Represents site grading area covered with six inches of topsoil.
S25	Landscape and Turf Restoration	SY	27,880	4	112,000	low	Assumed seeding for rural road way shoulders with the right-of-way.
	Subtotal				**$15,704,000**		
	Screening Facility Structure						
F1	Skid-Mounted Screening Equipment	LS	1	2,511,000	2,511,000	low	Assumed lesser quality raw water available at Sucker Lake. Thirteen (13) vessel automatic cleaning skid unit to have two (2) first vessels with 150 micron screens, followed by five (5) secondary stage vessels with 100 micron screens followed by five (5) last stage vessels with the 25 micron screens. Each vessel in each of the three stages will backwash on differential pressure and/or a pre-set timer. Timed sequence backwash will step clean each of the stages vessel screens. No two vessel backwash sequence will run at the same time period for each stage. A backwash event can occur in each stage at the same time. Backwash water to return to the source water reservoir per DNR requirements. One pump, One first stage screen vessel, two second stage screen vessels and two last stage screen vessels will have the 6,000 gpm capacity at the system design pressure. System redundancy will be one pump and one screen vessel in each of the three stages. This scenario provides the opportunity for planned maintenance without disruption of flow and system capacity. Preliminary quote.
F2	Skid-Mounted Screening Equipment Installation	LS	1	1,005,000	1,005,000	low	Assumed 40%+/-installation with crane and piping bolt ups, electrical and platform grating.
F3	Framing, Siding & Roof	SF	15,000	150	2,250,000	low	Assumed neighborhood architectural finishes.
F4	Monorail Support System (Hoist & Trolley)	LS	1	65,000	65,000	low	Structural framing and monorail beams and hoists for screen vessel inspection & O&M.
F5	Grating, stairs & platforms	LS	1	75,000	75,000	low	Galvanized steel framing and grating.
F6	Backwash System (additional to Skid Cost)	LS	1	28,000	28,000	low	Pressure booster pump connected to filter skid piping and vessels.
F7	Painting	LS	1	24,000	24,000	low	Miscellaneous painting.
	Subtotal				**$5,958,000**		
	Pump & Forcemain						
C1	30" HDPE Lake Intake with Concrete Armor Mat	LF	1,000	458	458,000	medium	Assumed two precast intake stuctures and single intake piping on lake bottom. Pipe on bottom to be secured/protected with eight foot wide CONTECH Armormat or equal. Material Quote at $8-9/SF for materials.
C2	30" HDPE Lake Outfall with Concrete Armor Mat	LF	2,700	458	1,237,000	medium	Assumed special HDPE diffuser section and piping on lake bottom. Pipe on bottom to be secured/protected with eight foot wide CONTECH Armormat or equal.
C3	SPRWS Connection Fee	EA	1	30,000	30,000	medium	Initial connection fee to include SPRWS engineering review.
C4	12' DIA RCP Lake Intake Structure	EA	2	50,000	100,000	medium	Per schematic detail in report each with 6 intake portals – 1’H x 4’ long equally spaced at the predetermined intake water depth.
C5	30" Forcemain	LF	22,370	200	4,474,000	high	Based on conceptual site alignment HDPE DR17.
C6	30" Check Valve	EA	2	10,000	20,000	low	Pump Piping System >Note: Installation included in estimate line item F2.
C7	30" Plug Valve	EA	8	15,000	120,000	low	Pump Piping System plus FM issolation valves.
C8	30" DIP Fittings	EA	30	2,500	75,000	low	Pump Piping System >Note: Installation included in estimate line item F2.
C9	30" DIP Spool	EA	28	1,250	35,000	low	Pump Piping System >Note: Installation included in estimate line item F2.
C10	8" DIP Filter Backwash Drain & Building Drain	LF	50	200	10,000	low	Miscellaneous FM fittings.
C11	12" HDPE Backwash Return Drain Pipe	LF	500	250	125,000	low	Miscellaneous FM fittings.
C12	Magnetic Flow Meter	LS	1	29,288	30,000	low	Pump Piping System >Note: Installation included in estimate line item F2.

Table 2. East Vadnais Lake Alternative

Augmentation of White Bear Lake with Surface Water
Capital Costs for Concept Level Surface Water Augmentation
Updated: 01-05-16

Code	Item	Unit	QTY	Unit Price	Total Price	Uncer-tainty	Basis of Cost
C13	Pump (Submersible Pump & Motor)	LS	2	148,700	298,000		Vendor Budgetary Quote > 280 HP 460/3 phase complete with rails and hatch.
C14	Pump Installation and Piping	LS	1	535,320	536,000		RS Means and SEH project comparisons.
C15	Utility Relocation	LS	1	250,000	250,000		Assume relocation along 1/3 of alignment.
	Subtotal				**$7,798,000**		
	Permits						
P1	DNR Public Waters Work Permit	LS	1	1,500	1,500		SEH Project Comparisons.
P2	DNR Water Appropriation Permit	LS	1	1,350	1,350		SEH Project Comparisons.
P3	DNR Invasive Species Permit	LS	1	1,400	1,400		SEH Project Comparisons.
P4	DNR Utility Permit	LS		-	-		SEH Project Comparisons.
P5	Wetland Conservation Act Permit	LS	1	3,400	3,400		SEH Project Comparisons.
P6	U.S. Army Corps of Engineer Structures Permit	LS	1	3,400	3,400		SEH Project Comparisons.
P7	MnDOT Utility Accommodation on Highway ROW	LS	1	2,500	2,500		SEH Project Comparisons.
P8	Ramsey-Washington Metro WD Erosion Control	LS	1	2,700	2,700		SEH Project Comparisons.
P9	Ramsey County Right of Way Permit	LS	1	1,000	1,000		SEH Project Comparisons.
P10	Rice Creek Watershed District Permits	LS	1	4,500	4,500		SEH Project Comparisons.
P11	VLAWMO Wetland Replacement Plan	LS	1	1,800	1,800		SEH Project Comparisons.
P12	Construction SWPPP & NPDES Permit	LS	1	3,200	3,200		SEH Project Comparisons.
P13	BNSF Pipeline Permit	LS	2	10,000	20,000		SEH Project Comparisons.
	Subtotal				**$47,000**		
	Tunneling						
T1	35-E (open cut no tunneling)	LS	1	0	0	low	Not in this alternative. Crossing under at Goose lake road by open cut.
T2	HWY 61 (42' steel casing & shafts)	LS	1	950,000	950,000	high	Trench box shafts at each end double on driving end casing installed by pipe ramming (600 LF at $1200/LF + west shaft at $150,000 + East shaft at $80,000) Note: Carrier pipe and installation under FM line items.
T3	Railroad Crossings	LS	1	100,000	100,000	medium	Pump Piping System >Note: Installation included in estimate line item F2.
	Subtotal				**$1,050,000**		
	Electrical Controls						
E1	Electrical Service Feed	LS	1	225,000	225,000	medium	RS Means and SEH project comparisons > 600amp service w/ meter and disconnect).
E2	Miscellaneous Electrical, Communications, Security	LS	1	200,000	200,000	medium	RS Means and SEH project comparisons.
E3	Controls & SCADA	LS	1	100,000	100,000	medium	RS Means and SEH project comparisons.
	Subtotal				**$525,000**		
	Easements						
M1	Edgerton and Centerville Rd. Screenhouse	LS	1	2,500,000	2,500,000	high	Temporary disruption and permanent easements.
M2	WBL Outlet Easement	LS	1	40,000	40,000	medium	Temporary disruption and permanent easements.
M3	Temporary Easements	SF	10,000	10	100,000	medium	Temporary disruption and permanent easements.
	Subtotal				**$2,640,000**		

Total Construction Costs	$33,722,000
Contingency @ 20%	$6,745,000
Total Construction Costs with Contingency @ 20%	$40,467,000
Engineering, Administration, Legal, and Bonding @25 %	$10,117,000
TOTAL COST (2015)	**$50,584,000**
TOTAL COST at Mid-Point of Construction (2018-2019)	**$54,964,574**

Appendix O: Peer Review of Concept Level Cost Estimate

Memo

Date: Friday, January 08, 2016

Project: White Bear Lake Concept Report Technical Peer Review

To: Sam Paske, Assistant General Manager – Environmental Quality Assurance, Metropolitan Council Environmental Services

From: Kathryn Jones, Jacob Woolsey, Scott Aronson

Subject: Technical Peer Review of Costs and Cost Estimating Methodologies (HDR Scope Task 1)

I. Introduction

This memorandum summarizes HDR's review of costs and cost estimating methodology presented by SEH as related to the Concept Report for Augmentation of White Bear Lake with Surface Water. The review was conducted by HDR between December 15 and December 22, 2015. Documents reviewed for this assessment included:

- *WBL Augm TM_Cost Estimate_wExh_12_15-2015.pdf*
- *WBL Augmentation Concept Report_Draft_Less Appendices_09Dec2015.pdf*
- *WBL Augmentation Concept Report_Draft_Appendices_10Dec2015-Complete.pdf*
- Fluid Engineering Preliminary TM Filtration Figures (*20151216182330215.pdf*)
- Fluid Engineering Quotation (*20151214FE Quote.pdf*)
- *costestimate121515_drl_revised format.xlsx*
- *TAB 2. WBL Augmentation East Vadnais Lake Alternative Cost Estimate Table 2.docx*
- *TAB 1.WBL Augmentation Sucker Lake Alternative Cost Estimate Table_drl12152015.docx*
- *Flygt 280HP Budgetary Proposal.pdf*
- *Rosemount Mag Meter Proposal.pdf*

The work under this scope item assumed that the engineer's estimate provided to HDR for review conforms to the requirements of AACE Recommended Practice (RP) No. 17R-97: "Cost Estimate Classification System" and No. 18R-97 "Cost Estimate Classification System – as Applied in Engineering, Procurement, and Construction for the Process Industries". HDR's review is limited to that of the estimate provided as part of the V.1 draft report.

A scope of work (SOW), project schedule, procurement information and estimate information contained in the Confidential-Technical Memorandum were examined. HDR's review was concentrated on elements valued at $250,000 or greater.

II. Method of Accomplishment

The evaluation consisted of analysis of the unit rates proposed in the estimate performed by SEH. The pricing basis of the unit rates assumes that they are “all in.” “All in” is a standard industry statement meaning that the total unit rates include not only the costs for the direct work accomplished but also indirect costs including all labor burdens, taxes, general conditions, overhead and profit, mobilization, contingencies, escalation, insurances and bonds. It is standard industry practice to show indirect costs as stand-alone items calculated as a percentage of the construction cost subtotals below the direct costs. This was not done, with the exception of mobilization, which was shown as a lump sum line item, and contingencies and legal and bonding costs which were shown as indirect costs calculated from the construction cost subtotal below the direct costs. Because the other indirect costs were not shown in this way a percentage-based extrapolation method was used to determine the probable make up of the unit rates as they relate to both direct and indirect costs of work. This allowed us to examine the direct and indirect components of the unit rates used in the estimate.

The basis for the unit rate examination was based on the following percentage extrapolation:

- 30% of the unit cost is labor,
- 40% is material and installation equipment,
- The remaining 30% is the indirect costs not called out separately in the estimate (labor burden, taxes, general conditions, overhead and profit).

The project assumes a 24 month construction schedule for all work included in the SOW. In order to complete the SOW it is assumed, based on standard industry practice, that the Prime Contractor (PC) would provide overall project management, client relationship management, construction management and field non-manual support. Direct project support would include: project controls, scheduling, engineering, and procurement. The PC would hire an individual Sub Contractor (SC) for each scope discipline who would provide craft support for all construction related tasks procured under that scope of work. Additionally, procured SCs would be required to provide project construction field documentation, and minor material procurement.

Since the estimate is in a concept level stage of development, HDR was not provided with the PC staffing plan, so a thorough examination of the amount of full time equivalent (FTE’s) functional support and field non-manual support could not be completed. In addition, FTE hourly rates could not be examined. Costs noted within the basis of estimate (BOE) suggest that the PC is utilizing a standard staffing organization for a project this size. It could not be ascertained as to the costs related to staffing for either of the subcontractors, so a staffing cost analysis was not attempted.

Overall the unit costs shown in the cost breakdowns appear to be the direct costs for the work and do not include the indirect costs. It has been our experience that labor burden percentage averages around 40%. Taxes do not appear to be covered, and there doesn’t seem to be enough monies for general conditions (GC), overhead (OH) and profit. However, it is hard to determine without a detailed breakdown of those costs. Standard GC’s range between 5% - 10% of total unit cost, Standard Overhead ranges between 10%-15% of total unit cost, and Standard Profit ranges from 5%-10% of total unit cost for projects similar in scope and size.

III. Construction Costs

The following construction costs were examined based on an ‘all in’ rate.

Sitework (Sucker Lake 10,044,210 and East Vadnais Lake 15,800,523)

Code	Item:	Comments
S2	Traffic Control: Barricades and Lights	This appears reasonable, assuming 2 craft at $40 per hour, 1,800 hours per year working signs, and renting traffic delineators and cones at $2,500 per month. 2 x $40/hour x 1,800 hours + $2,500/month x 24 mos. = $204,000
S4	Excavation	Reasonable, if it includes Trench Box approach. Assumes excavating, bedding, backfilling, and compaction of 80 LF of pipe per day. 8 craft, 4 pieces of equipment and trench boxes and bedding materials.
S5	Bituminous Trail	Reasonable. Assumes that this is a crew of 6: 1 truck driver, 1 Skidsteer OP, 1 Roller OP, and 3 asphalt rakers. Asphalt placed by hand, without the use of a paver. $485,000 in labor and equipment, $155,000 in materials.
S7	Asphalt Pavement 2"+2"+6" CL5	This seems reasonable. Assumes the placement of 4,500 tons of asphalt with a paving crew.
S12	Trucking to Waste	This seems reasonable. Assumes 1,300 truckloads with an hourly rate of $80/hour and 2 hours to load and haul = $208,000 or $9.40/cy for trucking and $190,880 or $8.60/cy for a tipping fee.
S13	Trucking to Waste (contaminated)	This appears low. Assuming 988 truck loads with an hourly rate of $80/hour 2 hours to load and haul time = $158,080 or $9.40/cy for trucking and $446,720 or $26/cy for a tipping fee. Typical costs experienced for tipping fees for contaminated soils is $30/ton or $48/cy.
S19	Ground Support System	This line item as indicated by SEH includes extra trench boxes for construction and sheet piling for the tunneling operations.

Screening Facility (Sucker Lake 4,875,274 and East Vadnais Lake 4,432,714)

Code	Item:	Comments
F1	Allowance: Skid-Mounted Screening Equipment	This is a quote. Reconfirmed by vendor October 2015. Appears reasonable.
F2	Skid-Mounted Screening Equipment Installation	This seems reasonable. Assumes 8 craft / 30 days to install all skids = $200,000. $400,000 materials for header construction, drain connections and heavy equipment & cranes. $300,000 for electrical installation; and $200,000 for startup and testing of 5 skids
F10	Additional Water Treatment Allowance	Not enough information to examine. If the allowance covers initial chemicals needed for startup and testing of system then the allowance is valid. Need to verify contents of cost.

Pump & Forcemain (Sucker Lake 6,704,988 and East Vadnais Lake 6,637,058)

Code	Item:	Comments
C1	30" HDPE Lake Intake with Concrete Armor Mat	Contacted manufacture of product. Representative did not respond back in the limited time given for the examination.
C2	30" HDPE Lake Outfall with Concrete Armor Mat	Contacted manufacture of product. Representative did not respond back in the limited time given for the examination.
C5	30" Forcemain	This appears 10-15% high. The cost includes material, and installation of the pipe and does not include ancillary items such as tracing wire. Bedding would normally be assumed to be covered in excavation Line Item S4. HDR historical costs have been between $125 - $135/LF.
C15	Pump (submersible Pump & Motor)	This pump package appears low. The quote excludes the pump control panel. Costs for the control panel should be confirmed, and are estimated to range from $80,000 to $100,000.
C16	Pump Installation and Piping	Based on time limitations this cost could not be fully examined. The cost element is believed to be part of C15-Pump costs but could not be determined without additional time and elaboration of line item scope.

Tunneling (Sucker Lake 7,625,000 and East Vadnais Lake 950,000)

Code	Item:	Comments
T1	35-E (42" steel casing + shafts)	Costs not in line with historical actual costs. HDR historical costs are based on a quote in April, 2015 for $1,200 per foot for a 42" casing, excluding ancillary items such as grouting. SEH indicated that unit cost assumed boulder removal in the unit cost. Verify costs.
T2	HWY 61 + RR (42" steel casing + shafts)	Reasonable.

Tunneling (Sucker Lake 278,000 and East Vadnais Lake 183,000)

Code	Item:	Comments
E1	Electrical Service Feed	Assumes that this number is only for feeding the building, This appears low if it includes the pump control panel. Pump control panel costs are estimated to range from $80,000 to $100,000.

IV. Other Indirect Costs

Other indirect costs analyzed were Escalation, Contingency and Sales Tax.

Escalation

HDR utilized cost indices published by the Bureau of Labor Statistics (BLS) to calculate forward escalation inflation. Several indices are utilized including Field Non-Manual Labor, Craft Labor, Construction Industry, Bulk Commodities and Other Direct Cost Material. Inflationary indices are weighted in a statistical model to produce an average weighted percentage to apply over the construction duration. SEH did not include methodology on how they arrived at their escalation percentage. HDR has included a copy of the statistical model used to determine a single weighted escalation as an attachment to this report. The calculated escalation for the construction period of 2018-2019 is shown to be 8.66%. Additional reports are attached to show escalation for different construction schedule scenarios, such as a construction period of 2019 - 2020.

Contingency

The PC is carrying a contingency of 30% of the total cost. This percentage seems correct for this level of design. However, this contingency would only cover construction related gaps in cost. These include changes to craft labor rates, minor material cost fluctuations based on commodities markets, minor missing materials based on level of design, changes in rental equipment rates, and other miscellaneous cost fluctuations created by the marketplace.

The estimate should present a detailed description of contingency contents and level of confidence associated with the contingency. Since there is no construction schedule, the contingency should make note to exclude all schedule related issues. Other cost elements such as permits, right of way or other regulated agency costs are also at a preliminary understanding and may not be able to be covered by a single contingency line item. AACE and federal government best practices suggest the use of several contingency line items for feasibility level estimates. These include Construction Contingency, Design Contingency, Schedule Contingency, and TP&R Contingency (Technical, Programmatic and Regulatory). These contingencies should be produced based on a risk mitigation strategy provided by the provider of costs. The strategy should be examined and adjusted with each cost update showing where risk has been either mitigated through achievable costs or resolved with no costs

Sales Tax

Since it is not specifically noted that the project carries a tax exemption, tax is believed to be part of the "all in" unit cost rate. The current tax rate for Ramsey County, MN is 7.125%. Based on this rate, $925,500 should be included for tax on materials and rental equipment.

V. Conclusion

HDR sees this estimate as reasonable. At a high level, based on projects of similar nature, major cost components include:

- 5.1 miles of 30" pipe, which have been historically realized between $450-$650/LF;
- Screening Facilities at between $6,000,000 - $12,000,000 based on filtration processes,
- Tunneling ranges from $1,100 - $2,000 based on length and depth, technique, and soil conditions, however items such as boulder removal would be added cost.
- Indirect cost of between 45% - 55% of direct costs to include mobilization/demobilization, general conditions, field overheads, escalation, taxes, insurances and bond, contractors fee and construction contingency

The analysis found that the unit rates utilized for the estimate were generally in line with industry rates experienced around the country. HDR historical data confirmed rates fell within the expected range of accuracy, +10% - 20% of actual construction costs experienced. Some rates were notably high but consideration was given to SEH for their knowledge of local conditions as well as their described execution approach.

Since indirect costs were not broken out, the analysis utilized a percentage based extrapolation methodology to consider the inclusion of all required indirects that would be realized by a procured prime contactor. The assumption that the unit rate includes 30% indirect related costs. This took into consideration that contingency and escalation were shown as stand alone line items.

HDR expected to see an explanation of the makeup of the contingency costs to include what is included or excluded from those set aside dollars. AACE best practice guidelines suggest additional contingency dollars for schedule, design, and programmatic related risk mitigation. Those considerations were not included in this estimate and should be discussed for future updates to this project. Considering the project's major risk elements are time based, mitigation strategy focus must be around the execution schedule and dollars should be allotted to offset risks in both schedule and escalation to properly contain costs.

There are areas of concern with regards to the inclusion of the indirect cost associated with construction. It is the opinion of the examiner that cost may be understated. Based on limited time given for this review, relevant cost information from vendors could not be obtained and a more thorough examination of all existing conditions could not be examined to fully understand the total make up of unit rates. This allows for a greater variation in the probability of inaccurate assessment for the estimated cost of this project.

Appendix P: Permits

SEH

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TECHNICAL MEMORANDUM

TO: Sam Paske, Assistant General Manager - Environmental Quality Assurance
Metropolitan Council

FROM: Brendan Wolohan, Project Engineer

DATE: December 8, 2015

RE: Permitting Requirements
SEH No. 134593

The purpose of this technical memorandum is to summarize the permitting requirements associated with developing a cost estimate in conjunction with the development of the Concept Cost Report for Augmentation of White Bear Lake with Surface Water. Permits will be required from federal, state, local and private agencies for construction of the proposed augmentation system. The following agencies and affiliated permits will be involved:

- Federal
  - U.S. Army Corps of Engineers
    - Section 404 Permit
- State
  - Minnesota Wetland Conservation Act
    - Wetland Conservation Act Permit
  - Minnesota Department of Natural Resources
    - Public Waters Work Permit
    - Water Appropriation Permit
    - Invasive Species Permit
    - Utility Crossing License
  - Minnesota Pollution Control Agency
    - National Pollutant Discharge Elimination System Permit
  - Minnesota Department of Transportation
    - Right of Way Permit
  - Minnesota Department of Health
    - Water Supply Infrastructure Review
- Local
  - Rice Creek Watershed District
    - Wetland Mitigation Permit
    - Erosion Control Permit
  - Vadnais Lake Area Water Management Organization
    - Wetland Mitigation Permit

        - Erosion Control Permit
    - Ramsey-Washington Metro Watershed District
        - Wetland Mitigation Permit
        - Erosion Control Permit
    - Ramsey County
        - Erosion Control Permit
- Private
    - Burlington Northern Santa Fe Railroad
        - Pipeline Permit

Wetland Conservation Act

The Wetland Conservation Act (WCA) basic requirement is that “a wetland must not be drained or filled, wholly or partially, unless replaced by restoring or creating wetland areas of at least equal public value under an approved replacement plan.” The responsibility for administration of the WCA is shared by local and state government. The local government unit (LGU) is responsible for making the initial regulatory determinations for the program, while the Minnesota Board of Water and Soil Resources (BWSR) is at the aid of the LGU and serves as technical resource for complying with determinations set forth by the WCA. LGUs responsible for the administration of WCA include: Vadnais Lake Area Water Management Organization, Ramsey-Washington Metro Watershed District, and Rice Creek Watershed District. Temporary or permanent impacts to wetlands in the project area are subject to wetland permitting under WCA. The extent of permitting needed is dependent on the quantity and location of wetland impacts. Alteration requires replacement of 1:2 – 1:2.5 ratio to ensure no loss of wetland quantity, quality, or biological diversity.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) serves as the federal regulatory review agency for permits regarding work, in or affecting, navigable waters. A Section 404 permit is required for work activities involving the construction or modification of outfall structures and associated intake structures. No intake structure will be authorized unless directly associated with an authorized outfall structure. The permittee must submit a pre-construction notification to the district engineer prior to commencing the activity. Wetland restoration and enhancement will be required when wetland areas are to be modified during construction.

Temporary construction, access and dewatering work necessary for construction activities will be authorized provided that the associated primary construction is authorized by USACE. Appropriate measures must be taken to maintain near normal downstream flows and to minimize flooding. Fill must consist of materials and placed in a manner that will not be eroded by expected flows. The use of dredged material may be allowed if the USACE district engineer determines that it will not cause more than minimal adverse effects on aquatic resources. Upon completion of construction, temporary fill will need to be entirely removed to an area that has no Waters of the United States. Dredged material must be returned to its original location, and affected areas must be restored to pre-construction elevations. The affected areas must be revegetated to original conditions.

Mitigation requirements through the USACE district engineer will need to be considered when determining appropriate and practicable mitigation necessary to ensure that adverse effects on the aquatic environment are minimal. The project must be designed and constructed to avoid and minimize adverse effects to waters of the United States. Avoiding, minimizing, rectifying, reducing, or compensating for resource losses will be required to the extent necessary to ensure that the adverse effects to the aquatic environment in proposed work area are minimal. A mitigation bank or in-lieu fee programs are an option to be proposed to the USACE instead of constructing artificial wetlands for wetland losses.

Pre-construction notification (PCN), required by the terms of the NWP, state that the prospective permittee must submit construction plans to the USACE district engineer as early as possible. The district engineer has 30 days to determine if the PCN is complete. If deemed incomplete, the USACE district engineer has 30 days to notify the permittee to request additional information or clarification. Construction cannot begin until 45 days from when the USACE district engineer received the complete PCN or the permittee has received written notification that construction may proceed by the USACE district engineer. The PCN must include general information on the project such as name, address, contact information of the prospective permittee, location, and a detailed description of the proposed project. The district engineer's decision will determine whether the activity will be authorized by the NWP and result in minimal individual and cumulative adverse environmental effects, or may be contrary to the public interest.

Minnesota Department of Natural Resources

Vadnais Lake, Sucker Lake, and White Bear Lake are listed in the Department of Natural Resources (DNR) Public Waters Inventory (PWI) program and therefore require a Public Waters Work Permit when work is performed in the water body. This permit regulates water development activities below the ordinary high water level (OHWL) which alter the course, current, or cross section of public waters. Applications for all DNR permits shall be made through the MNDNR electronic Permitting and Reporting System (MPARS).

Construction of the White Bear Lake Augmentation system requires a Public Waters Work Permit be submitted for review of both the intake and outlet structure components. The purpose of this permit is to enable the DNR, as well as other regulatory agencies, to review the plans for construction. The Conservation Assistance and Regulations (CAR) Section of the DNR oversees the administration of the Public Waters Work Permit Program. It is recommended to apply for the permit a minimum of 6 months prior to construction. Basic information such as the project location, purpose for construction are required for application, no additional documentation is needed to apply for this permit.

An Infested Waters Diversion or Transportation Permit is necessary when water is moved, diverted or removed from a water body listed as "infested" with aquatic invasive species. Sucker, Vadnais and White Bear Lake all contain zebra mussels, which constitutes the DNR to list each lake as "infested waters." The DNR regulates activities in infested waters to reduce the risk of spreading aquatic invasive species. The permit will include conditions that will reduce the risk of spreading the invasive species such as: seasonal or other timing restrictions, filtering requirements, or treatment requirements to prevent spread of the invasive species. Filtration will be required at the intake to prevent the spread of invasive species through the augmentation system.

The Minnesota DNR Division of Lands and Minerals is responsible for granting permission to cross state land or public waters with utility infrastructure projects. This permission comes by means of a utility crossing license which is granted for 25 to 50 years and may be renewed when expired. An application shall be submitted showing the pipeline layout and how it effects the state land or water.

Minnesota Pollution Control Agency

During the construction phase of the augmentation project, a National Pollutant Discharge Elimination System (NPDES) Construction Stormwater General Permit will be required through the Minnesota Pollution Control Agency (MPCA). The purpose of this permit is to control soil erosion and reduce the amount of sedimentation and other pollutants being transported into public waters by runoff from construction sites. The owner and operator must create a stormwater pollution prevention plan (SWPPP) that explains the proposed actions to control stormwater runoff from the construction site. The permit application shall be completed electronically prior to beginning construction.

Minnesota Department of Transportation

The Minnesota Department of Transportation (MnDOT) provides support for utility accommodation and coordination on or crossing MnDOT right of way (ROW) throughout all project stages. MnDOT regulates the approval for the use and occupancy of highway ROW. Before beginning work, a utility owner must receive an approved permit from MnDOT, and the contractor must carry a copy of this permit at all times while working on the highway ROW. Permit applications must include detailed drawings of the planned right of way crossing. After the miscellaneous work permit has been approved, notification will be given by MnDOT and a security deposit will be required. The security deposit ensures that work is completed to MnDOT's satisfaction and the actual amount required will depend on the specific situation. Upon completion of construction, the applicant must notify the MnDOT District Permit Office for final inspection.

Minnesota Department of Health

The Minnesota Department of Health (MDH) Environmental Health Division works on many environmental issues including water quality. Minnesota State Rules state that prior to installation of any water supply infrastructure, plans and specifications be submitted to the MDH for review and approval. The purpose of review by the MDH is to protect public health, verify that the design complies with rules and standards that are enforced by the MDH, and to allow changes to be made before construction begins. There is no cost associated with this review, however it is very important that plans and specifications for the proposed forcemain be submitted to the MDH for review at least 3-4 months prior to construction.

Rice Creek Watershed District

The Rice Creek Watershed District (RCWD) will regulate wetland alterations that are not subject to the WCA rules and do not qualify for an exemption from the Minnesota state rules. Explanation and justification of each individual wetland alteration area in terms of impact avoidance and minimization alternatives considered must be included in the application. Upon receipt of a complete application, the WCA LGU will review and act on the application in accordance with its procedural rules and WCA procedures. An erosion and sediment control plan must be submitted for surface soil disturbance or removal of vegetative cover. Any disturbance of surface soils, removal of vegetative cover on more than 5,000 square feet of land, or stockpiling on-site more than fifty cubic yards of earth requires a permit. The permit applicant must demonstrate that the standards are met by submitting design criteria to comply with permit requirements.

Vadnais Lake Area Water Management Organization

The Vadnais Lake Area Water Management Organization (VLAWMO) Watershed Management Policy regulates activities that disturb, remove, or cover surface vegetation or appropriation of water from public water basins within the VLAWMO jurisdiction. All other projects that affect lakes, streams, and wetlands within the VLAWMO are also regulated under the watershed management policy. Required exhibits must be submitted a minimum of 60 days prior to construction and includes the following: names and contact information for proposed project owner and engineer, a location map, plat drawing including buffer boundaries identified as conservation easements, grading plan, hydrologic and water quality design exhibits, as well as erosion and sediment control exhibits. The VLAWMO will conduct reviews within a 60 day period.

Ramsey-Washington Metro Watershed District

The Ramsey-Washington Metro Watershed District (RWMWD) is located in the eastern portion of Ramsey County and the western edge of Washington County. The RWMWD's regulatory program includes erosion and sediment control from stormwater runoff of active construction sites, and is designed to allow contractors and developers to work with the district staff to address and prevent erosion issues. The RWMWD issues certificates of exemption or replacement as part of its review and approval process where applicable. Wetland buffer protection is required as well as pretreatment of stormwater prior to discharging to a wetland is also required.

Ramsey County

The location of the intake and outlets as well as forcemain infrastructure for both options of the augmentation project are located in Ramsey County. For the purpose of health, safety, and welfare of its citizens, the County requires a right of way permit to review work to be done within County right of way. The ROW ordinance imposes regulation on the placement and maintenance of facilities within the County right of way. Under this ordinance, the persons excavating and obstructing the right of way will bear financial responsibility for their work. The County shall establish an excavation ROW permit fee schedule specifying fees that are adequate to recover the management costs, degradation costs, and mapping costs. Permit fees are established by the County Board and may be amended at any public meeting.

BNSF Railroad

Installation of a pipeline for water, natural gas, sewage, oil or petroleum on Burlington Northern Santa Fe (BNSF) Railroad property will require a Pipeline or Wire Line Permit through BNSF. A utility license agreement is required when utility facilities are installed, relocated, removed or maintained along BNSF property. Liability insurance may also be required as part of this permit. Applications for utility license agreements shall be submitted with plans for the proposed installation a minimum of four months prior to construction. Pipelines shall be installed to avoid or minimize the need for adjustments to future railroad improvements.

Utilities that parallel the railroad property must be located on uniform alignment within 10 feet or less of the property line to preserve space for future railroad improvements or other utility installation. BNSF engineering must approve installations over one mile along the railroad right of way. BNSF specifications for water utilities call that the utilities shall conform to "American Waterworks Association Specifications." All underground utility installations shall be located on top of the back slope at the outer limits of the railroad property. If the pipeline is to be located 40 feet or less from the centerline of the track, the pipeline must be encased in a steel pipe with a minimum cover of three feet subject to approval by BNSF engineering. No pipe shall be placed closer than 25 feet from the centerline of the track.

Preliminary permit application estimated costs are presented below in Table 1. These values include labor costs associated with preparing applications up to the submittal, further costs may be involved if revisions are required throughout the process. They are subject to change depending on the area of land disturbed during construction, as well as the amount of wetlands and shoreline affected by construction.

Table 1. Construction Permit Cost Estimate	
Permit	Cost
DNR Public Waters Work Permits	$1,500
DNR Water Appropriation Permit	$1,350
DNR Invasive Species Permits	$1,400
Wetland Conservation Act Permits	$3,400
U.S. Army Corps of Engineer Section 404 Permit	$3,400
MnDOT Utility Accommodation on Trunk Highway Right of Way	$2,500
Ramsey-Washington Metro Watershed District Erosion Control	$2,700
Ramsey County Right of Way Permit	$1,000
Rice Creek Watershed District Permits	
- Erosion Control Plans	$2,000
- Floodplain Alteration	$2,000
- Wetland Alteration	$500
VLAWMO Wetland Replacement Plan	$1,800
Construction SWPPP & NPDES/SDS Permit	$3,200
BNSF Pipeline Permit	$20,000
Total Permit Application Estimate	**$46,750**

The permitting requirements listed in this report have been determined with data available at the time of research. Any findings based on future work that yields different information may result in a change in permitting requirements.

BCW

c: Don Lutch
Jessica Daignault

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