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

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 -

Table of Contents

List of Figures

List of Tables

Appendices

(published in separate report)

Executive Summary

Purpose of Report

In 2015, the Minnesota Legislature directed the Department of Natural Resources (DNR), in consultation with the Metropolitan Council, to estimate the cost to use surface water from the Saint Paul Regional Water Services (SPRWS) chain of lakes to augment White Bear Lake. This report provides concept level cost estimate and describes the assumptions on which the cost estimates are based. The report identifies information and engineering that would be needed to develop more detailed costs and identifies issues that would need to be resolved prior to determining final costs.

This report does not evaluate the effects of augmentation on lake or aquifer levels or water quality.

Concept Alignment Alternatives

Two concept alignment alternatives, named for the source lakes from which water would be drawn, were used for estimating the costs of augmentation: Sucker Lake alternative and East Vadnais Lake alternative (see Figure 1). Both lakes are part of a chain of lakes located in Vadnais Heights, Minnesota, a community in the northeast Minneapolis/Saint Paul metropolitan area, and approximately four miles west of White Bear Lake. Water is pumped from the Mississippi River and conveyed to the McCarrons Water Treatment Plant in Maplewood through the chain of lakes, open channels and pipes.

Both alignment alternatives were assumed to have similar infrastructure systems comprised of an intake structure in the source lake, a pump station and treatment facility near the source lake, a pipeline from the source lake to White Bear Lake, and an outlet structure for discharge of water into White Bear Lake. The system is designed to move approximately two billion gallons of treated water to White Bear Lake per year.

It is important to note that these are theoretical alignments identified for the purposes of developing concept level cost estimates and would need to be explored further in future evaluations. The report attempts to identify known issues with each alignment, but there are significant uncertainties associated with each including availability of specific lands in question.

Water Treatment Assumptions

The water treatment facilities included in the cost estimates were based on a filtration system that would remove some solids and all known aquatic invasive species (including zebra mussels).

There are other water quality issues that might require additional treatment. Evaluating these was beyond the scope of the report. However, the report does estimate the costs associated with additional treatment to remove phosphorus. Phosphorus is a nutrient that is associated with algal blooms and reduced water clarity when present in excessive amounts.

Phosphorus concentrations are lower in White Bear Lake than in Sucker Lake and East Vadnais Lake. The filtration system described above would provide partial treatment for phosphorus by removing particles that carry phosphorus. Advanced phosphorus treatment might be required to avoid degrading water quality in White Bear Lake. Costs were estimated for different treatment technologies that would further reduce phosphorus in the augmentation water supply. There may also be higher levels of other contaminants in Sucker Lake and East Vadnais Lake than in

White Bear Lake, and these would need to be considered in future evaluation of treatment requirements.

Capital Costs

Total costs were estimated in 2015 dollars and then adjusted with annual escalation rates assuming construction would take place between 2018 and 2019.

Estimated capital construction costs in 2018-2019 dollars are:

- $67 million for the Sucker Lake alternative
- $55 million for the East Vadnais Lake alternative
- $23-$40 million more for either alternative if more substantial treatment of phosphorus in the source water is required

The Sucker Lake alignment has a higher construction cost estimate than the East Vadnais Lake alignment primarily because a 1,600-foot-long tunnel would have to be constructed under I-35E. A tunnel under I-35E would not be required for the East Vadnais Lake alternative. The Sucker Lake alternative also has more contaminated soils and more areas with poor soils for construction. The cost of treatment is also higher for the Sucker Lake alignment because the lake is smaller and shallower with higher concentrations of solids and phosphorus.

Annual Operations and Maintenance Costs

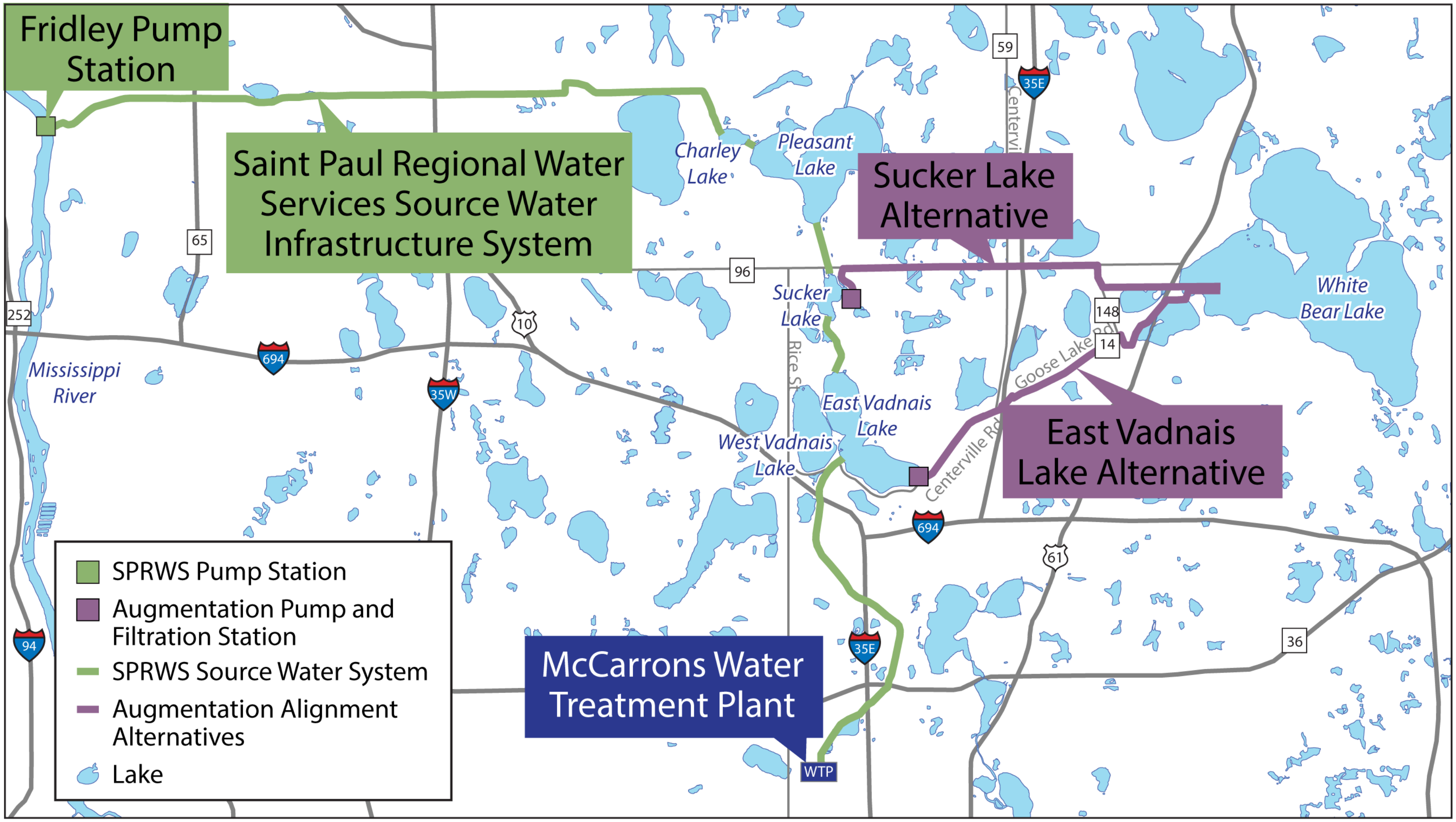
The estimated annual cost for the first year of operation is $570,000, assuming an eight-month operational season and annual pumping of two billion gallons per year. Annual operations and maintenance costs associated with higher levels of phosphorus reduction would increase to a range of $900,000 - $4.1 million per year. The large range of costs for additional phosphorus treatment is because different levels of treatment have substantially different costs for energy and other operating and maintenance expenses.

Cost Uncertainties

While the cost estimates provided in this report are credible estimates based on the amount of design completed to date, there are still unknowns that could result in changes in the capital and operating cost estimates to implement surface water augmentation for White Bear Lake. Some of the most critical issues that create cost uncertainty and could result in higher or lower costs include:

- Level of water quality treatment required (affects capital and annual costs)
- Unknown underground conditions including soils, groundwater levels, boundaries of contamination and location of existing utilities (affects capital costs)
- Amount of water pumped each year (affects capital and annual costs)
- Additional information or regulatory decisions that may result in changed design assumptions such as the system capacity (affects capital and annual costs)
- Different alignments or modifications to the concept alignments (affects capital costs)

Figure 1: Augmentation Alignment Alternatives



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Chapter 1 – Introduction

1.1 Purpose of Report

In 2015, the Minnesota Legislature directed the Department of Natural Resources (DNR), in consultation with the Metropolitan Council, to estimate the cost to use surface water from the Saint Paul Regional Water Services (SPRWS) chain of lakes to augment White Bear Lake. This report provides concept level cost estimate and describes the assumptions on which the cost estimates are based. The report identifies information and engineering that would be needed to develop more detailed costs and identifies issues that would need to be resolved prior to determining final costs.

This report does not evaluate the effects of augmentation on lake or aquifer levels or water quality.

1.2 Location

White Bear Lake is located in the northeastern portion of the Minneapolis/Saint Paul metropolitan area. The local jurisdictions in the vicinity of White Bear Lake and the Saint Paul Regional Water Services chain of lakes are shown in Figure 2 and include Ramsey and Washington Counties, White Bear Township, and the cities of White Bear Lake, Shoreview, Vadnais Heights, Gem Lake, North Oaks, Birchwood Village, Mahtomedi and Dellwood.

1.3 Existing Surface Water Supply and Treatment System

Saint Paul Regional Water Services currently pumps surface water from the Mississippi River near Fridley, Minnesota (see Figure 1). The water is carried through pipes east approximately nine miles and emptied into Charley Lake in the City of North Oaks. Charley Lake is the first lake in a series of lakes that also includes Pleasant Lake, Sucker Lake and East Vadnais Lake. This chain of lakes is referred to as the Saint Paul Regional Water Services chain of lakes in this report. The Saint Paul Regional Water Services chain of lakes acts as treatment, conveyance and reservoirs for the system. Pipes deliver surface water from East Vadnais Lake to the Saint Paul Regional Water Services McCarrons Water Treatment Plant located in Maplewood. Treated water from the McCarrons plant is distributed to the customers of the Saint Paul Regional Water Services.

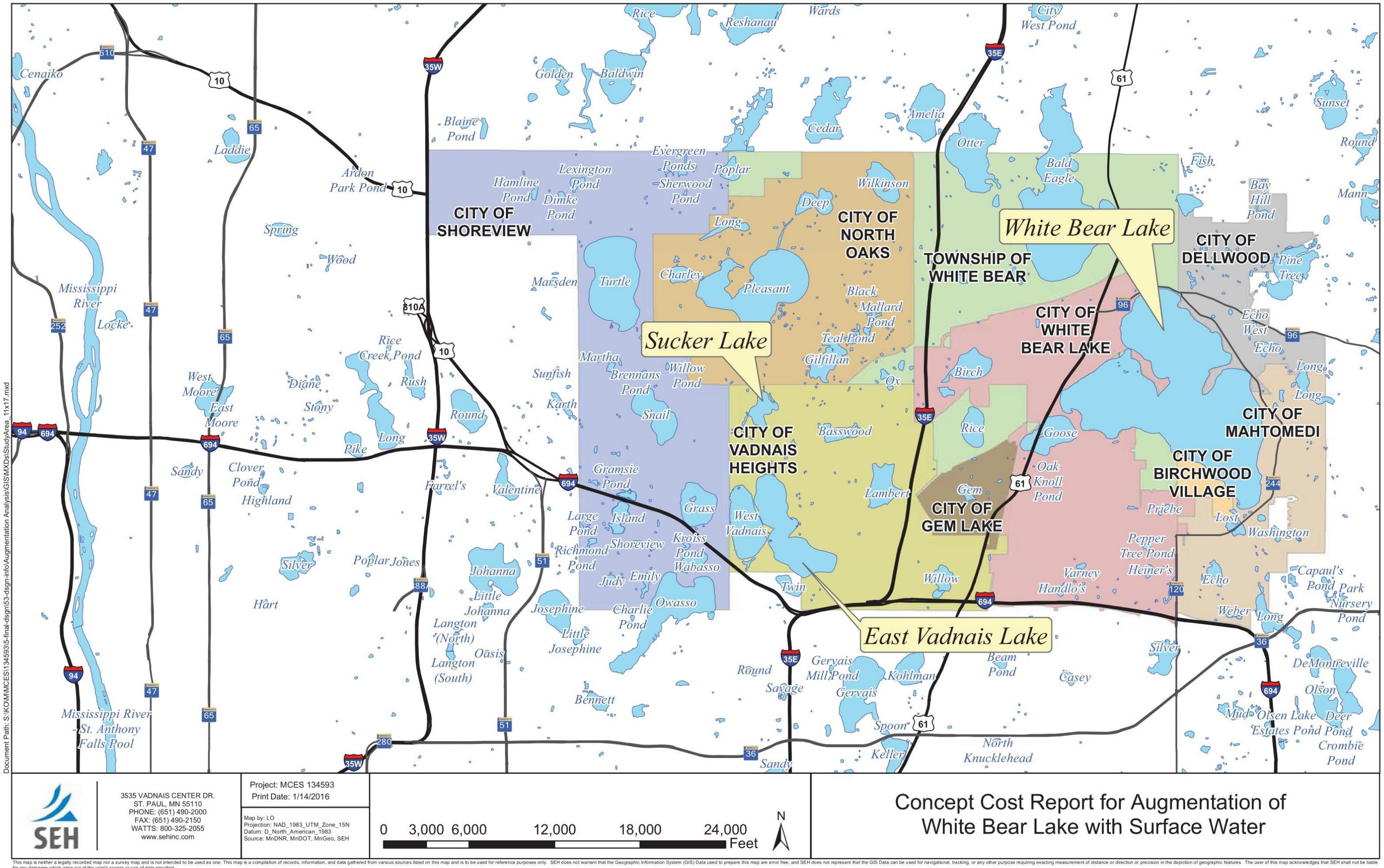
The lakes act as sedimentation basins, allowing solids to settle out of the water and improving the raw water quality in advance of the water treatment plant. The lakes also store water in advance of the treatment plant. Chemicals are added at the Fridley pump station and to East Vadnais Lake to reduce phosphorus and help solids to settle. Oxygen is added to the water in Pleasant Lake and East Vadnais Lake to further improve water quality.

Saint Paul Regional Water Services has sufficient excess capacity in its conveyance system to meet the demands of a two billion gallon per year augmentation system for White Bear Lake.

1.4 Augmentation System

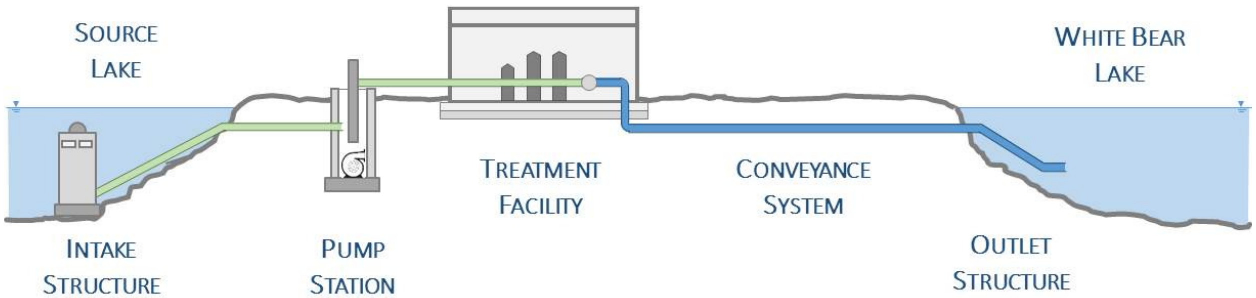
Two alignment alternatives, shown in Figure 1, were identified for conveying surface water from Sucker Lake or East Vadnais Lake. Capital and annual operations and maintenance costs were developed for each of these alternatives. These alignment alternatives, including specific siting considerations, are described in detail in Chapter 2.

Figure 2: Study Area



For cost estimating purposes the augmentation conveyance system assumed a capacity to move and treat up to two billion gallons per year. The volume is based on historic annual rates of augmentation and previous hydraulic analysis. Cost estimates include the infrastructure required to take water from the source lake (either Sucker Lake or East Vadnais Lake) and convey the water to White Bear Lake. Similar infrastructure was assumed for both alternatives (see Figure 3).

Figure 3: Schematic of Augmentation System Components



1.4.1 Intake Structure

The submerged intake structure would be located far from shore in the source lake and would provide initial screening of the lake water being drawn and would allow routine maintenance and cleaning. Water would be pumped from the source lake to the treatment facility by a pump station.

1.4.2 Pump Station

The pump station would be located near the source lake and, ideally, would be located within or near the treatment facility. The exact location of these facilities would be determined by specific site conditions. Pumping equipment would consist of two high capacity pumps, each capable of the required flow rates.

1.4.3 Treatment Facility

Water would be pumped into the treatment facility, where the water would be filtered (and further treated, if needed) to improve water quality before it is conveyed to White Bear Lake.

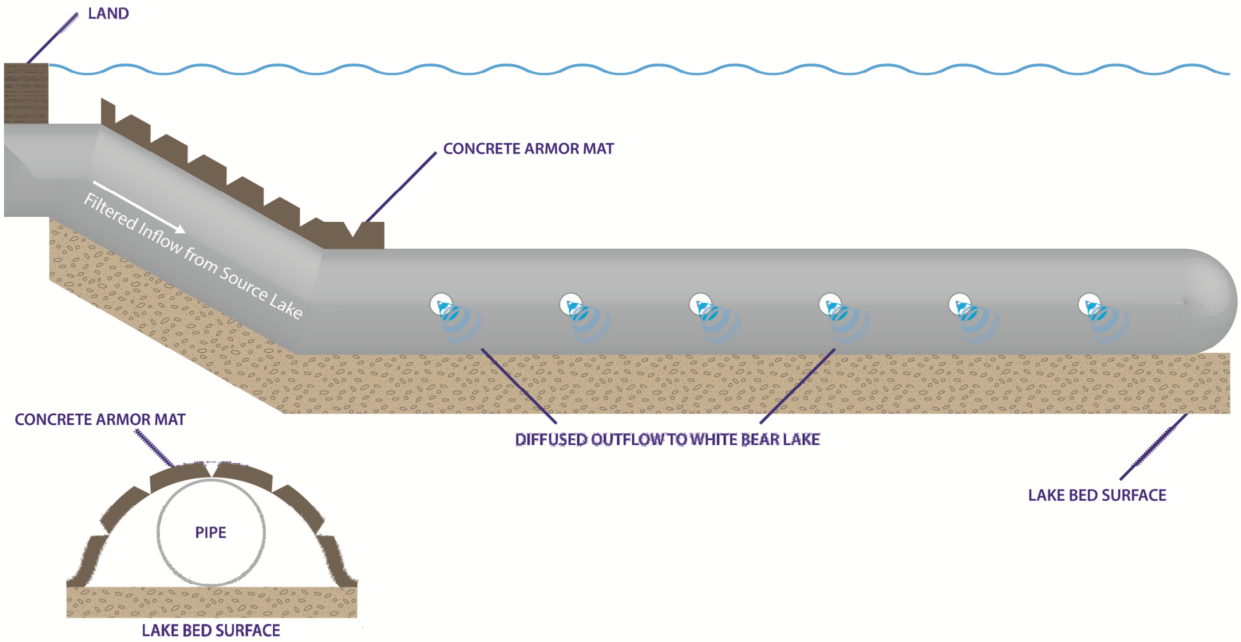
1.4.4 Conveyance System

A pipeline would convey water from the source lake to White Bear Lake along the assumed alignments as described in Chapter 2. The pipeline was assumed to be installed at a depth of 8 to 10 feet, with variable depths along the route and at road and railroad crossings.

1.4.5 Outlet Structure

Water conveyed from the source lake into White Bear Lake would be discharged through a submerged concrete structure located in approximately 20 feet deep water. The rate at which water would leave the structure would be controlled to prevent undesirable mixing of water with lake bottom sediments and prevent impacts on the lake ecology. A schematic illustration of an outlet structure is shown in Figure 4.

Figure 4: Schematic of Typical Outlet Structure



Chapter 2 – Description of Alignment Alternatives

2.1 Introduction
This chapter describes the two alignment alternatives assumed for surface water augmentation and the conditions associated with each alignment that formed the basis for the capital cost estimates. Specific alignments and system features are assumed based on the information reviewed and best engineering practices.

2.2 System Capacity
The costs for the two augmentation alternatives assumed a size and type of pumps that would pump water at a rate of up to 6,000 gallons per minute. This pumping rate equates to roughly two billion gallons over an eight-month period. The volume is based on historic annual rates of augmentation and previous hydraulic analysis. Appendix A provides more information about these assumptions.

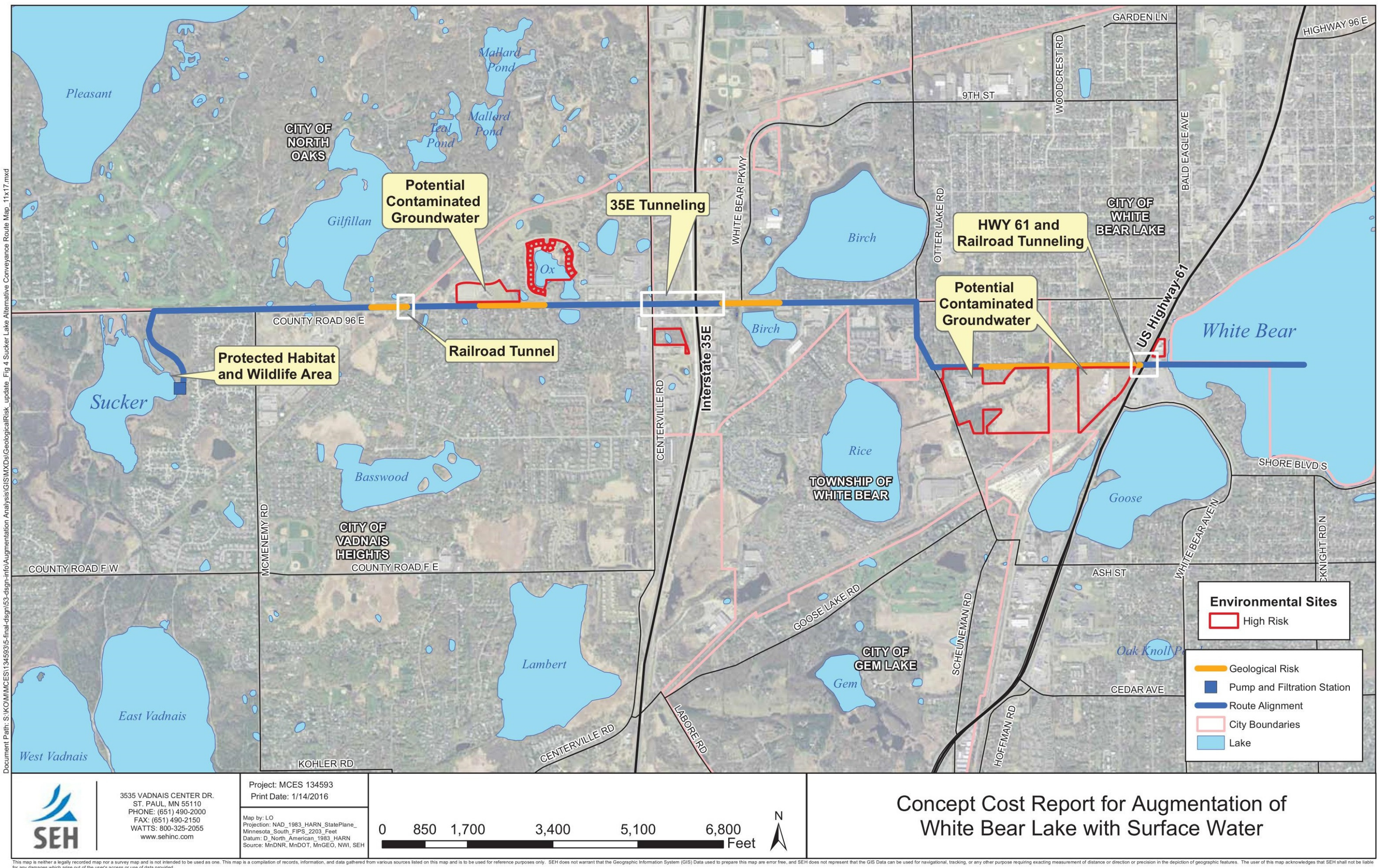
2.3 Soil Conditions
Geology and soil conditions were reviewed for the alignment alternatives. Alignments were adjusted where possible to avoid known poor soil conditions such as peat. Additional costs were included where poor soil conditions could not be avoided. Additional details on the geological review are provided in Appendices B and E.

2.4 Contaminated Site Inventory
Potentially contaminated soil, groundwater, and soil vapor sites were inventoried within approximately 500 feet of the alignments to determine the extent of contamination. This information was used to adjust alignments where possible to avoid these sites and to estimate additional costs for soil clean-up when the sites could not be avoided. Additional details on the contaminated sites review are provided in Appendices C and D.

2.5 Augmentation Alignment Alternatives
DNR and Metropolitan Council staff met with public works representatives in the communities where the alignments are located to better understand site conditions, site context, and future plans associated with each alignment. Communities involved in these discussions included Ramsey County, Vadnais Heights, Shoreview, White Bear Lake, Gem Lake and White Bear Township. Adjustments were made to the preliminary alignments, where possible, to avoid contaminated sites, highly developed areas, private property, high volume roadways, and newly constructed infrastructure in public rights-of-way.

2.5.1 Sucker Lake Alternative
Sucker Lake is located in Vadnais-Snail Lake Regional Park in the City of Vadnais Heights. It is a small and shallow lake that is subject to changes in water quality due to wind-induced mixing of lake bottom sediments. The alignment extends from Sucker Lake to White Bear Lake along Highway 96. Figure 5 shows the alignment features for the Sucker Lake alternative. Additional information about this alternative is provided in Appendices F and G.

Figure 5: Sucker Lake Alternative Alignment and Features



It was assumed that the intake structure would be constructed in a water depth of approximately 10-15 feet. The intake structure would consist of intake portals, intake pipe, a concrete armor mat to minimize bottom disturbance, and design features for zebra mussel control and maintenance. A pump station would be installed on the northeast bay shoreline of Sucker Lake, and water would be pumped to a treatment facility located on park property near Highway 96. Several environmental factors may make it difficult to construct a facility on a site closer to the lake.

The pipe would primarily follow Highway 96 east, passing under the BNSF railroad, I-35E and Highway 61 in tunnels, and would enter the western lobe of White Bear Lake. The pipe was assumed to be installed 8-12 feet underground except under I-35E. The tunnels under the railroad and Highway 61 would be about 100-150 feet long. The tunnel under I-35E would be approximately 40 feet deep at each end and would be approximately 1,600 feet long, adding significant cost to this alignment. This is the minimum depth and length required to complete the piping under I-35E at this crossing.

The environmental review identified six high-risk, 23 medium-risk, and 20 low-risk sites within the alignment buffer area. High-risk sites are shown in Figure 5. Additional details on the contaminated sites review are provided in Appendices C and D.

2.5.2 East Vadnais Lake Alternative

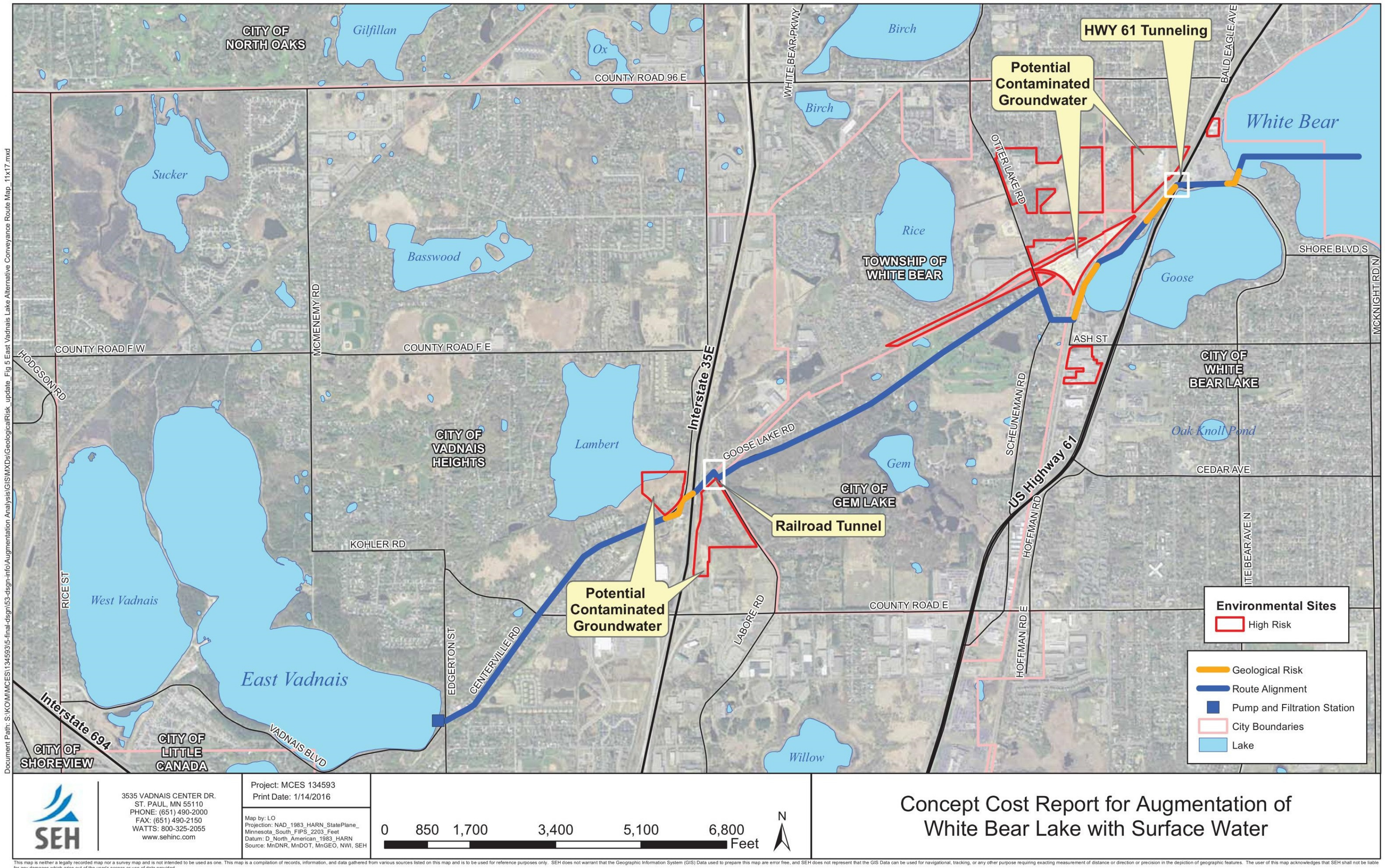
East Vadnais Lake is located in Vadnais-Snail Lake Regional Park. East Vadnais Lake is larger than Sucker Lake and is less susceptible to wind-induced mixing of water and sediment. The East Vadnais Lake alternative would extend from the southeast corner of East Vadnais Lake near Centerville Road (County Road 59) and would generally be aligned along Centerville Road (County Road 59), crossing under the railroad, going northeast on Goose Lake Road (County Road 14) toward Goose Lake and White Bear Lake. Figure 6 shows the alignment features for the East Vadnais Lake alternative. Additional information about this alternative is provided in Appendix H.

It was assumed that the intake structure would be constructed in a water depth of approximately 20 feet. This would allow higher quality water to enter the system prior to filtration. The pump and treatment facility would include the intake structure with intake portals, intake pipe with concrete armor mat to minimize bottom disturbance, and design features for zebra mussel control and maintenance. Water would be pumped from the southeast bay of East Vadnais Lake, and a pump and treatment facility would be installed near the shoreline of East Vadnais Lake. The specific property for a treatment facility has not been selected.

The pipe would primarily follow Centerville Road (County Road 59) and Goose Lake Road (County Road 14), crossing under the railroad, I-35E and Highway 61. The pipe would be installed 8-12 feet underground along the entire alignment. Tunnels about 100-120 feet long would be required under the railroad and Highway 61. Tunneling is not required under I-35E because I-35E is bridged over Goose Lake Road (County Road 14).

The environmental review identified eight high-risk, 16 medium-risk, and 17 low-risk sites along this alignment. High-risk sites are shown in Figure 6. Additional details on the contaminated sites review are provided in Appendices C and D.

Figure 6: East Vadnais Lake Alternative Alignment and Features



Chapter 3 – Water Quality and Treatment

3.1 Overview

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. Appendices I and J provide the results of the water quality review conducted for this report. Appendices K and L provide more details on the treatment processes. 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 water quality 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 to augment White Bear Lake with surface water can be determined.

3.2 Water Quality Records

Water quality monitoring has been conducted by different entities for different purposes over different time periods for Sucker Lake, East Vadnais Lake and White Bear Lake. Water quality records for the three lakes are not sufficient to provide comparisons of all key water quality parameters. General conclusions can be drawn for initial design and cost estimating purposes by evaluating specific time periods for key water quality parameters and comparing them to target water quality goals. Appendix I provides the detailed analysis of the existing water quality records that were considered in developing this report.

3.3 Aquatic Invasive Species

3.3.1 Water Quality

The DNR lists Sucker Lake, East Vadnais Lake and White Bear Lake as infested waters for both zebra mussels and Eurasian watermilfoil, which are difficult to remove once they are established in a lake. The State of Minnesota restricts the transfer of infested waters from water body to water body. Therefore, even though zebra mussels are present in White Bear Lake, treatment would still be required for the source water.

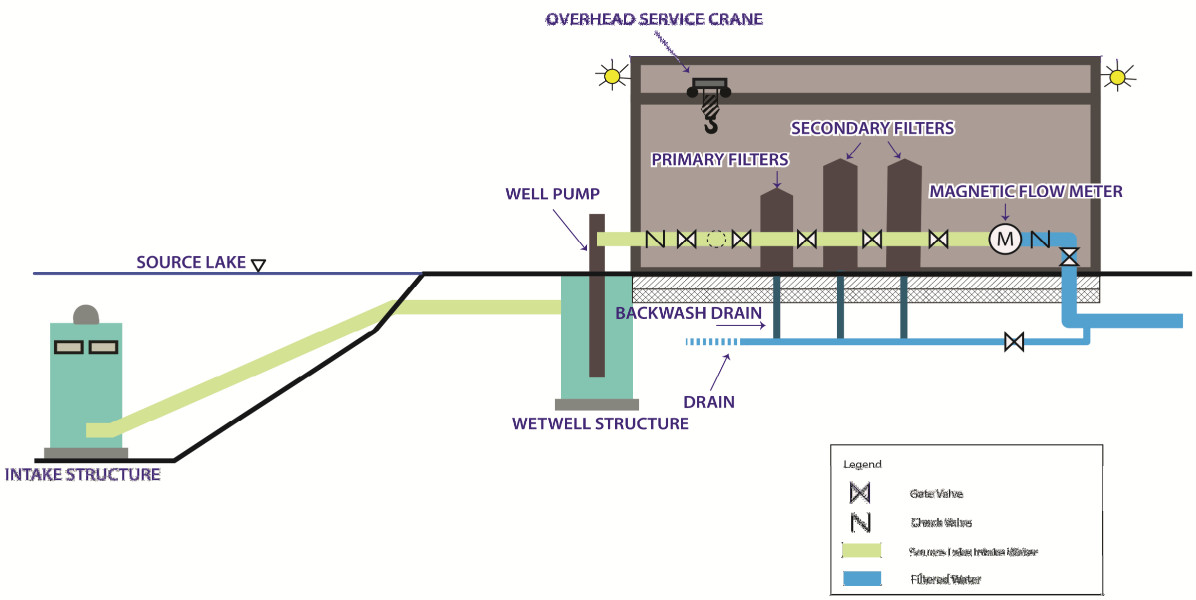
Zebra mussels were used as the target aquatic invasive species because a system that can filter out the smallest stage of the zebra mussel, known as “veligers,” would also be able to remove other known aquatic invasive plant and animal species. Appendix M describes zebra mussel impacts.

3.3.2 Treatment

The mechanical filtration system selected for cost estimating purposes uses a series of filters with progressively decreasing screen size openings to remove solids from the water. The final stage filters have openings that are smaller than the size of a zebra mussel veliger. These types of filtration systems remove all types of suspended material in the water, which includes aquatic invasive species. Design of the filtration facilities considers the amount of suspended solids in the source lake. Shallower lakes have a greater potential for wind-induced disturbance of lake bottom sediments, resulting in increased solids concentrations. Sucker Lake was assumed to have periods with higher suspended solids than East Vadnais Lake because it is shallower than East Vadnais Lake. The Sucker Lake system was assumed to have larger screen openings in the first two filter stages to keep the screens from clogging while handling a higher volume of solids. The Sucker Lake treatment system is also expected to have more frequent backwash requirements than the East Vadnais Lake system. Otherwise, the assumptions for the filtration systems were the same for the two alignments.

The filtration system would have built-in redundancy, which would also allow planned maintenance without disruption of water flow and capacity. Backwash water would be discharged back to the source lake. Treatment facility costs would include an overhead service crane, a maintenance and storage area, and an office and control room. The building would be approximately 15,000 square feet in size and would be constructed of materials consistent with local zoning requirements and the natural setting. A schematic of the treatment facility is shown in Figure 7.

Figure 7: Schematic of Typical Treatment Facility



3.4 Suspended Solids

3.4.1 Water Quality

Limited data exist to compare the concentration of suspended solids in both source lakes and White Bear Lake. However, a comparison of historic records of turbidity (a measure of water clarity and indicator of suspended solids) in 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 was possible. The comparison found that the turbidity is consistently higher in the river water than in the lake water. East Vadnais Lake turbidity was on average lower than in White Bear Lake. Turbidity has not been measured in Sucker Lake, but the lake was assumed to have higher periods of suspended solids than East Vadnais Lake because it is a smaller and shallower lake. This assumption is important in designing the filtration system, as described in the previous section, and estimating the cost of the treatment system.

3.4.2 Treatment

The same treatment system designed to remove aquatic invasive species would also reduce solids in the treated water delivered from the source lakes. The Sucker Lake filtration system would address higher solids concentrations than the East Vadnais Lake system. Figure 7 provides a schematic of the treatment system.

3.5 Phosphorus

3.5.1 Water Quality

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 its drinking water supply, Saint Paul Regional Water Services has been managing phosphorus in the chain of lakes by the addition of chemicals and oxygen.

The Mississippi River, Sucker Lake and East Vadnais Lake have higher annual average phosphorus concentrations than White Bear Lake (see Figure 8).

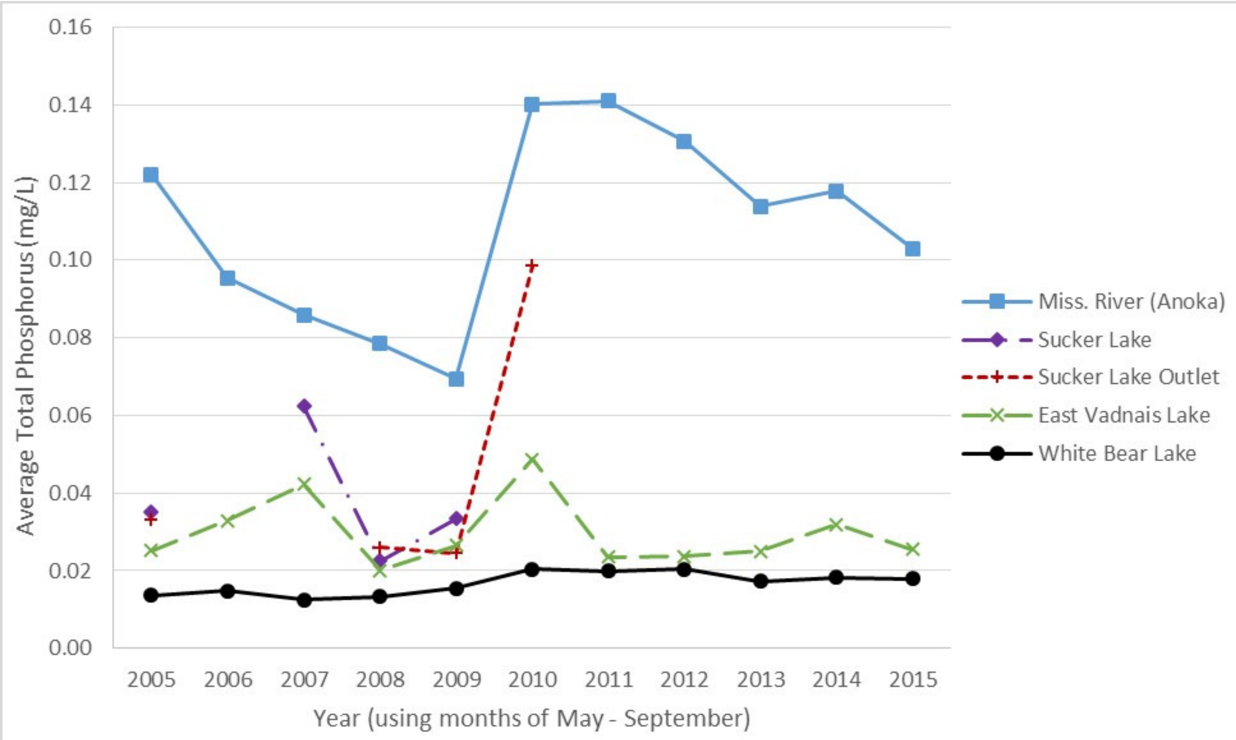
3.5.2 Treatment

The augmentation system would need some form of treatment to reduce or control the amount of phosphorus entering White Bear Lake.

The concept level cost estimates prepared for this report were based on a mechanical filtration system that physically removes aquatic invasive species, solids and some suspended particles of phosphorus. It is possible this level of treatment would meet regulatory requirements for phosphorus. However, further analysis would be required to make this determination. In addition, more effective treatment might be needed to meet lower phosphorus limits. Additional research and regulatory review will be needed to determine the extent of required treatment.

Additional costs were estimated for two different treatment technologies providing higher levels of phosphorus removal. Level 1 treatment costs were based on a granular media (chemically enhanced) two-stage filtration process. Level 2 treatment costs were based on a reverse osmosis treatment technology that typifies the best available treatment practice to achieve the lowest levels of phosphorus, as well as removal of many other contaminants of potential concern. Use of these treatment technologies would require additional land, a larger building, and increased utility costs. Additional detail about these higher levels of phosphorus treatment is provided in Appendix K.

Figure 8: Annual Averages for Total Phosphorus in Source Waters and White Bear Lake



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 for the specific sources and data details.

3.6 Additional Water Quality Monitoring Needs

Additional water quality information is needed to address the gaps and inconsistencies in the existing data, document more accurate phosphorus levels, and identify other parameters of concern in the source lakes and White Bear Lake. This would allow regulators and engineers to identify the most appropriate level of treatment. Frequent monitoring would be needed at multiple locations and depths to analyze the various forms of phosphorus. Monitoring would also be needed to understand changes related to weather conditions and Saint Paul Regional Water Services' operations and management practices. Monitoring would be required to identify additional water quality contaminants that may need to be addressed and that would therefore affect source water treatment processes and design.

An important step in reducing the uncertainty in treatment costs would be to implement a coordinated water quality monitoring program for the Mississippi River, source water lakes, and White Bear Lake. Appendices I and J provide recommendations on how to better characterize water quality and evaluate the potential impacts of an augmentation system on White Bear Lake.

Chapter 4 – Costs

4.1 Introduction

This chapter presents the estimated cost to design and build (capital cost) the two concept alignment alternatives, and the estimated annual operations and maintenance (O&M) costs for an augmentation system. Assumptions are provided, cost differences between the two alternatives are explained, and cost uncertainties are identified. Appendix N provides the details of the concept level cost estimates.

4.2 Process for Capital Cost Estimation

The process used to develop these concept cost estimates followed the recommended practices of the American Association of Cost Engineering (AACE).[1] Best practice in cost estimating uses different assumptions depending on the level of design detail that has been completed for a project. This report documents a "concept" cost estimate, which is based on a low level of design (less than 15% complete) and is considered a "Class 4" estimate based on AACE best practices. The AACE description of a Class 4 cost estimate is provided in Table 1.

Table 1: AACE International Recommended Practice Basis of Cost Estimation

CLASS 4 ESTIMATE[1]
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%).
Alternative Estimate Names, Terms, Expressions, Synonyms: Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.

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

The capital cost estimates for the two alternatives were prepared using the following sources for unit costs of line items:

- Minnesota Department of Transportation (MnDOT) Average Bid Price for awarded projects for Specification Year 2014
- RS Means Estimating Guidebook for civil works projects, process equipment, electrical controls and piping
- Short Elliot Hendrickson Inc. past project bid cost summaries for projects awarded in 2014 and 2015
- Direct budgetary estimates for equipment from local major equipment and piping system suppliers
- Discussion with engineering and public works representatives at Ramsey County, Vadnais Heights, Shoreview, White Bear Lake, Gem Lake and White Bear Lake Township

The capital cost estimates were evaluated in a peer review process documented in Appendix O.

4.3 Capital Cost Estimates

The concept level cost estimate for the augmentation alignment alternatives is $67 million for the Sucker Lake alternative and $55 million for the East Vadnais Lake alternative. The elements that make up the capital cost estimates are summarized in Table 2.

Total costs were estimated in 2015 dollars and then adjusted with annual escalation rates assuming construction would take place between 2018 and 2019. See Appendix N for more details on cost estimates.

Table 2: Concept Level Cost Estimates for Augmentation Alignment Alternatives

Cost Item	Sucker Lake Alternative ($ millions)	East Vadnais Lake Alternative ($ 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 assuming construction would take place between 2018 and 2019 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 (see Section 4.5).

The primary reasons that the Sucker Lake alternative would be more expensive than the East Vadnais Lake alternative are as follows:

- A 1,600-foot-long tunnel that is 40 feet deep at each end is the minimum that would be required under I-35E for the Sucker Lake alternative because I-35E goes under Highway 96. I-35E is on a bridge over Goose Lake Road so a tunnel is not required on the East Vadnais Lake alternative. See figures 5 and 6.
- There is more contaminated soil clean-up, removal of poor soils, and dewatering required for the Sucker Lake alternative than for the East Vadnais Lake alternative.
- Conversely, roadway restoration work is more expensive along the East Vadnais Lake alternative than along the Sucker Lake alternative, which only requires trail restoration.

4.4 Operations and Maintenance Costs

Annual operations and maintenance costs of $570,000 were estimated assuming eight months of pumping and a pumping rate that would deliver two billion gallons of filtered surface water to White Bear Lake per year. The estimated annual cost for operations and maintenance is shown in Table 3, based on the following assumptions:

- Set schedule of daily, weekly, semi-annual and trouble response to system alarms, community call-ins, and utility locates
- Semi-annual maintenance including zebra mussel control
- Monitoring system for operation of the treatment facility

In future years, costs for items such as pumping requirements, the schedule for system checks and the need for equipment adjustments may be reduced, thus lowering the annual operations and maintenance costs.

Table 3: Estimated Annual Operations and Maintenance 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 in 2015 dollars.

4.5 Additional Water Treatment Costs

Additional water quality monitoring and decisions on water quality protection requirements and goals would be needed to determine the type of water treatment facility needed for the augmentation system. A mechanical multi-screen filtration facility is the basis for the treatment facility costs shown in Table 2 and Table 3. This system would prevent the transfer of aquatic invasive species and reduce solids, including phosphorus. It is unknown if it would reduce phosphorus to levels that would meet the requirements of regulatory and permitting agencies.

The capital and annual operations and maintenance costs for additional treatment facilities would be considerably higher if lower phosphorus concentrations were required by the regulatory and permitting agencies. The additional capital and operations and maintenance costs for meeting higher levels of water treatment are shown in Table 4.

The range of costs shown in Table 4 represent different types of technology for reducing phosphorus. Level 1 treatment costs were based on a granular media (chemically enhanced) two-stage filtration process. Level 2 treatment costs were based on a reverse osmosis treatment technology that typifies the best available treatment practice to achieve the lowest levels of phosphorus. The reverse osmosis technology would remove other potential contaminants of concern. The reverse osmosis technology would have a large energy requirement and would have much higher operations and maintenance costs than Level 1 technologies. See Appendix K for details on the phosphorus removal treatment technologies and associated costs assumed for this report.

Table 4: Additional Costs of Phosphorus Removal Treatment Options

Level of Treatment for Phosphorus Removal	Phosphorus Treatment Facilities[1] Capital Costs ($ millions)	Phosphorus Treatment Facilities[1] Operations and Maintenance Cost ($ millions)	Total System[2] Capital Cost for Sucker Lake Alternative ($ millions)	Total System[2] Capital Cost for East Vadnais Lake Alternative ($ millions)	Total System[2] Operations and Maintenance Cost for Both Alternatives ($ millions)
Level 1	$23	$0.4 per year	$90	$78	$0.9 per year
Level 2	$40	$3.9 per year	$107	$95	$4.1 per year

[1]Additional facilities for higher levels of phosphorus removal than would be achieved with the mechanical filtration system representing treatment costs in Table 2 and Table 3.
[2]Total system cost based on the Sucker Lake and East Vadnais Lake alignment alternative cost assumptions represented in Table 2 and Table 3 plus the phosphorus treatment facilities listed in this table.

4.6 Cost Uncertainties

The cost estimates provided in this report are credible estimates based on the amount of design completed to date. There are still unknowns that could result in changes in the capital and operating and maintenance cost estimates for surface water augmentation of White Bear Lake. Some of the most critical issues that create cost uncertainty and could result in higher or lower costs include:

- Level of water quality treatment required (affects capital and annual costs)
- Unknown underground conditions including soils, groundwater levels, boundaries of contamination and location of existing utilities(affects capital costs)
- Amount of water pumped each year (affects capital and annual costs)
- Additional information or regulatory decisions that may result in changed design assumptions such as the system capacity (affects capital and annual costs)
- Different alignments or modifications to the concept alignments (affects capital costs)

Chapter 5 – Future Considerations

5.1 Introduction

The concept cost estimates presented in this report were based on what is known today with a concept level design. Additional study would be needed to more fully understand conditions that are currently unknown as these factors may have a significant impact on both construction costs and operations and maintenance costs. Some of the most critical future considerations are described below.

5.2 Water Quality Monitoring and Modelling

Appendix I of this report identifies recommended water quality monitoring and water quality modeling that should be completed prior to final planning. This work would identify the treatment needed to meet regulatory requirements and water quality protection objectives.

5.3 Environmental Review

Environmental review would be needed as part of the planning and engineering process. The appropriate level of environmental review would be determined early in the planning and engineering process.

5.4 Planning and Engineering

Additional planning and engineering would be needed to determine the preferred alignment and the preferred treatment facilities for an augmentation system. This work would include activities such as geotechnical exploration, utility mapping, contaminated site remediation studies, and topographic and boundary surveys. Several additional factors may impact planning and engineering decisions including:

- Further refinement or modifications to the concept alignments
- Disruption of park space and natural settings as well as the use of those facilities
- Neighborhood disruption
- Commercial and business disruption
- Construction impacts including traffic detours, property acquisitions and easements, and commercial and business impacts
- Public interest and engagement
- Design of facilities to account for periods when augmentation is not needed
- Completion of the USGS study[2] on the inter-relationships of lakes and groundwater in the Northeast Metro

5.5 Permitting

The permits required for construction and the requirements of those permits would need to be verified as part of the environmental review and engineering process. Although a preliminary list of potential permits is included in Appendix P of this report, final determination of required permits and the specific permit requirements is beyond the scope of this report. Additional design features such as enhanced water treatment for phosphorus or other contaminants may be required as a part of final permitting.

[2] United States Geologic Survey (in progress, planned publication 2016), *Characterizing Groundwater and Surface Water Interaction in Northeast Metro Area Lakes, MN.*

5.6 Institutional Structure

The public entity responsible for construction and operations and maintenance would need to be identified. This decision may also impact costs.

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