Engineer's Report

Lake Susan Subwatersheds LS-2.4/LS-2.12 Water Quality Improvement Project

Prepared for
Riley Purgatory Bluff Creek Watershed District

July 2014

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Certifications

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Scott Sobiech PE #: 41338	July 24, 2014 Date
Brandon Barnes PE #: 49540	July 24, 2014 Date

1.0 Introduction

This Engineer's Report summarizes the proposed actions within subwatershed LS-2.12 to improve the water quality in Lake Susan, located in the city of Chanhassen, Minnesota. It is prepared in accordance with Section 103D.711 of the Minnesota Watershed Act, under the direction of the Board of Managers of the Riley-Purgatory-Bluff Creek Watershed District.

2.0 Background

The Riley-Purgatory-Bluff Creek Watershed District (RPBCWD or District) was established by the Minnesota Water Resources Board in 1969, acting under authority of the Watershed Law. As charged by the law and the order establishing the District, the general purpose of the District is to protect public health and welfare and to provide for the provident use of natural resources through planning, flood control, and conservation projects.

The District is located in the southwestern portion of the Twin Cities Metropolitan Area, encompassing an area of 47.3 square miles. There are three major subwatersheds within the District—Riley Creek, with a watershed area of 10.0 square miles; Purgatory Creek (31.4 square miles), and Bluff Creek (5.9 square miles). All three creeks discharge to the Minnesota River. Stormwater management and development were guided by the District's 1973 Overall Plan, revised in May 1996 and February 2011 in accordance with the Metropolitan Surface Water Management Act and Watershed Law (Minnesota Statutes Chapters 103B and 103D). In 2013 the District completed a major amendment to the 2011 Plan (CH2M Hill). This was approved by the Board of Water and Soil Resources (BWSR) in early 2014 and is the current guiding document of the District (the Plan).

The Lake Susan and Rice Marsh Lake use attainability analysis (UAA) was prescribed by the 1996 Riley-Purgatory-Bluff Creek Watershed District Water Management Plan and completed in 1999. The updated Lake Susan UAA, which recommended remedial measures to improve the lake's water quality, was completed in July 2013.

The Lake Susan UAA provides the scientific foundation for lake-specific management plans that will preserve existing—or achieve potential—beneficial uses of the lake. The UAA is a structured, scientific assessment of the factors affecting attainment of a beneficial use under both current and ultimate watershed development conditions. "Use Attainment" refers to achievement of water quality conditions that support lake-specific uses such as swimming, fishing, wildlife habitat, and aesthetic viewing.

The 2013 UAA Update for Lake Susan was completed with the goal of: (1) assessing the water quality in Lake Susan based on more recent physical, chemical, and biological data, (2) improving the understanding of current water quality concerns in the lake, and (3) identifying best management practices (BMPs) to improve and protect the lake's water quality and increase the likelihood of it being removed from the Minnesota Pollution Control Agency's (MPCA) list of impaired waters list for excess nutrients. The overarching purpose of the UAA update was to identify and evaluate watershed and in-lake BMPs that can be implemented to improve and/or protect the lake's water quality and achieve the long-term vision of sustainable uses, as outlined in the District's Plan.

The District's Plan articulates the long-term vision of sustainable uses for each of its water bodies. Achieving this vision will result in:

- Waters dominated by diverse native fish and plant populations.
- Lakes with water clarity of 2 meters or more.
- Delisting of half of all impaired (303d) lakes or stream reaches.
- An engaged and educated public and scientific community that participates in adaptive management activities.
- Regulatory recommendations necessary for municipal, county, and state authorities to sustain the achieved conditions.

3.0 Lake and Watershed Description

Lake Susan, used for fishing, boating, and canoeing, is identified in the Plan as an important recreational resource for the RPBCWD with lake-specific water quality goals. There are two adjacent public parks which include a public landing, fishing piers, observation decks, and hiking trails.

Lake Susan is located entirely within the City of Chanhassen, directly along Riley Creek. Its watershed is approximately 2,553 acres (Wenck 2013). Figure 1 shows the major watersheds, subwatersheds, and flow direction for the Lake Susan watershed. Much of the watershed is characterized by low-density residential, undeveloped, and industrial land. Future development is anticipated to be for residential and commercial land use.

Lake Susan has a surface area of roughly 88 acres, maximum depth of approximately 17 feet, and a mean depth of 10.3 feet at a water surface elevation of 880.6 (NAVD88). According to the Minnesota Department of Natural Resources (MnDNR), the estimated littoral zone (area typically less than 15 feet deep where light can penetrate and promote the growth of macrophytes) is estimated to be about 75 acres, or about 85 percent of the lake. Because of its depth and coverage by macrophytes, the MPCA classifies Lake Susan as a shallow lake. Review of temperature profile data indicates that thermal stratification of Lake Susan typically occurs during the summer, indicating that it is a dimictic system. The outlet from Lake Susan is a 4- x 6-foot reinforced-concrete box culvert on the east side of the lake, with the discharge passing directly to Rice Marsh Lake. Table 1 summarizes the physical characteristics of Lake Susan.

Table 1 Lake Susan physical parameters

Characteristic	Lake Susan
Lake MnDNR ID	10-0013-00
MPCA Lake Classification	Shallow
Water Level Control Elevation (feet NAVD88)	880.6
Surface Area (acres)	88
Mean Depth (feet)	10.3
Maximum Depth (feet)	17
Littoral Area (acres)	75
Volume (below the control elevation) (acre-feet)	885
Thermal Stratification Pattern	Dimictic
Estimated Residence Time (years)	0.96
Watershed Area (acres)[1]	2,553
Trophic Status Based on Average Water Quality Data for Past 10 Years of Growing Season	Eutrophic

1 – Watershed area includes surface area of lake

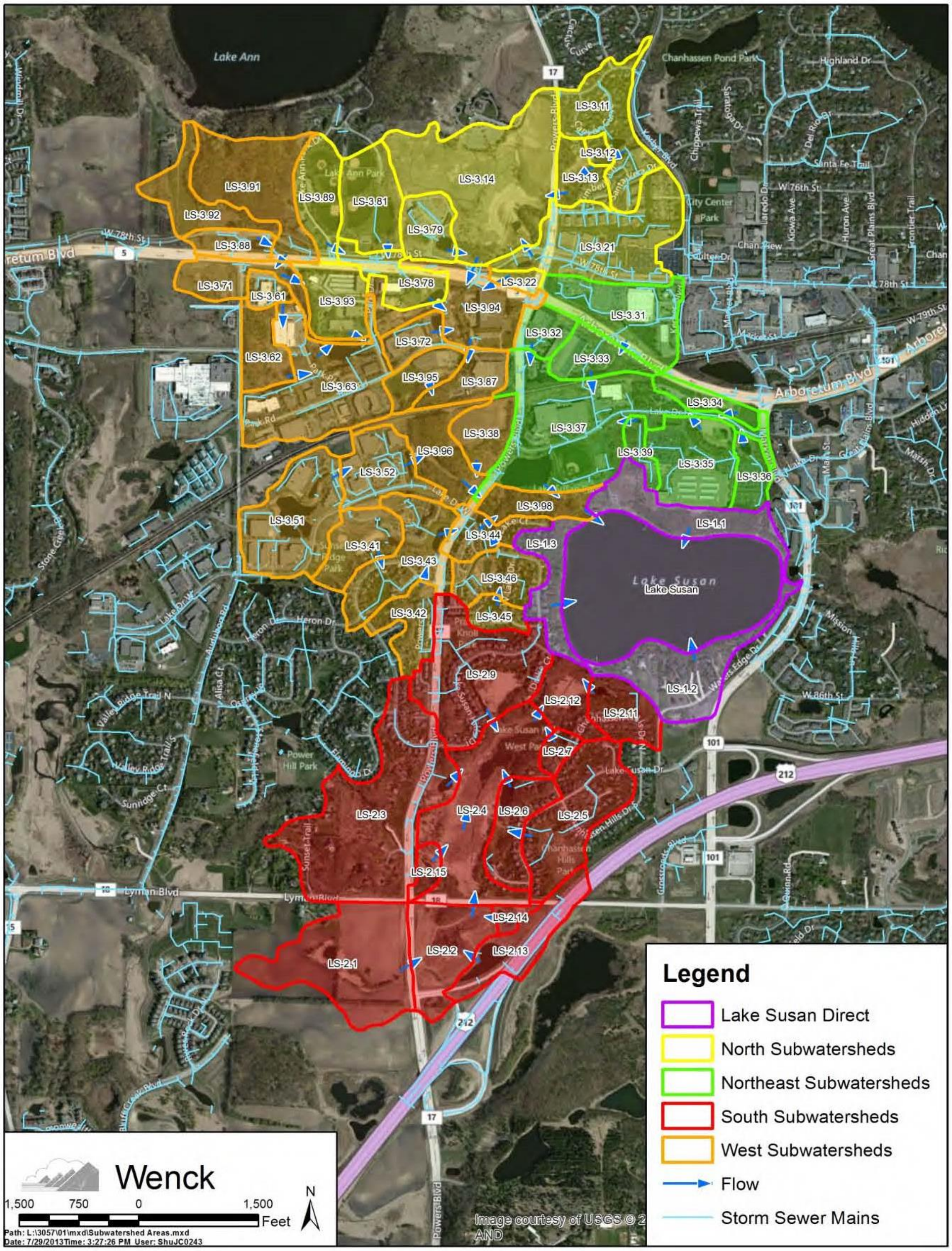

Image Source: Figure 3-2 Lake Susan Use Attainability Assessment (UAA) Update (Wenck 2013)

Figure 1 Lake Susan watershed and flow patterns

4.0 Water Quality Goals and Current Lake Conditions

The MPCA lake eutrophication criteria establish water quality standards for lakes based on total phosphorus, chlorophyll *a*, and Secchi disc transparency (Minnesota Rules, 7050). The standards are based on the geographic location of the water body (and associated ecoregion) and its depth (shallow vs. deep lakes). Lake Susan is located within the North Central Hardwood Forest ecoregion of Minnesota. It is designated by the MPCA as a shallow Class 2B lake (Wenck 2013); associated MPCA shallow lake eutrophication standards apply.

The RPBCWD has adopted state goals for the water resources within the watershed as part of its Plan, including the MPCA lake water quality standards. However, in the 2011 Plan, Lake Susan was classified as a deep lake, establishing the MPCA deep lake water quality standards as the minimum requirement for the lake. An additional long-term goal is for all lakes to achieve water clarity of 2 or more meters. Table 2 summarizes the RPBCWD water quality goals and MPCA standards applicable to Lake Susan.

Table 2 Water quality goals and standards for Lake Susan

Agency	Parameter	Lake Susan
MPCA	Ecoregion	North Central Hardwood Forest
	Depth Classification	Shallow
	Total Phosphorus	TP ≤ 60 µg/L
	Chlorophyll *a*	Chl-*a* ≤ 20 µg/L
	Secchi Disc Transparency	SD ≥ 1.0 m
RPBCWD	Total Phosphorus	TP ≤ 40 µg/L
	Chlorophyll *a*	Chl-*a* ≤ 14 µg/L
	Secchi Disc Transparency	SD ≥ 1.4 m
	Long Term Goal for all Lakes	SD ≥ 2.0 m

Historical water quality data for Lake Susan (average total phosphorus concentrations, chlorophyll *a* concentrations, and Secchi disc transparency during the growing season) are presented in Figure 2. MPCA shallow lake water quality standards for each parameter are also shown.

Lake Susan is currently on the MPCA 303(d) impaired waters list for excess nutrients. Improvements in water quality will help Lake Susan meet the MPCA shallow lake criteria. Improvements in water quality will also help protect water resources located downstream, including Rice Marsh Lake, Lake Riley, and Riley Creek.

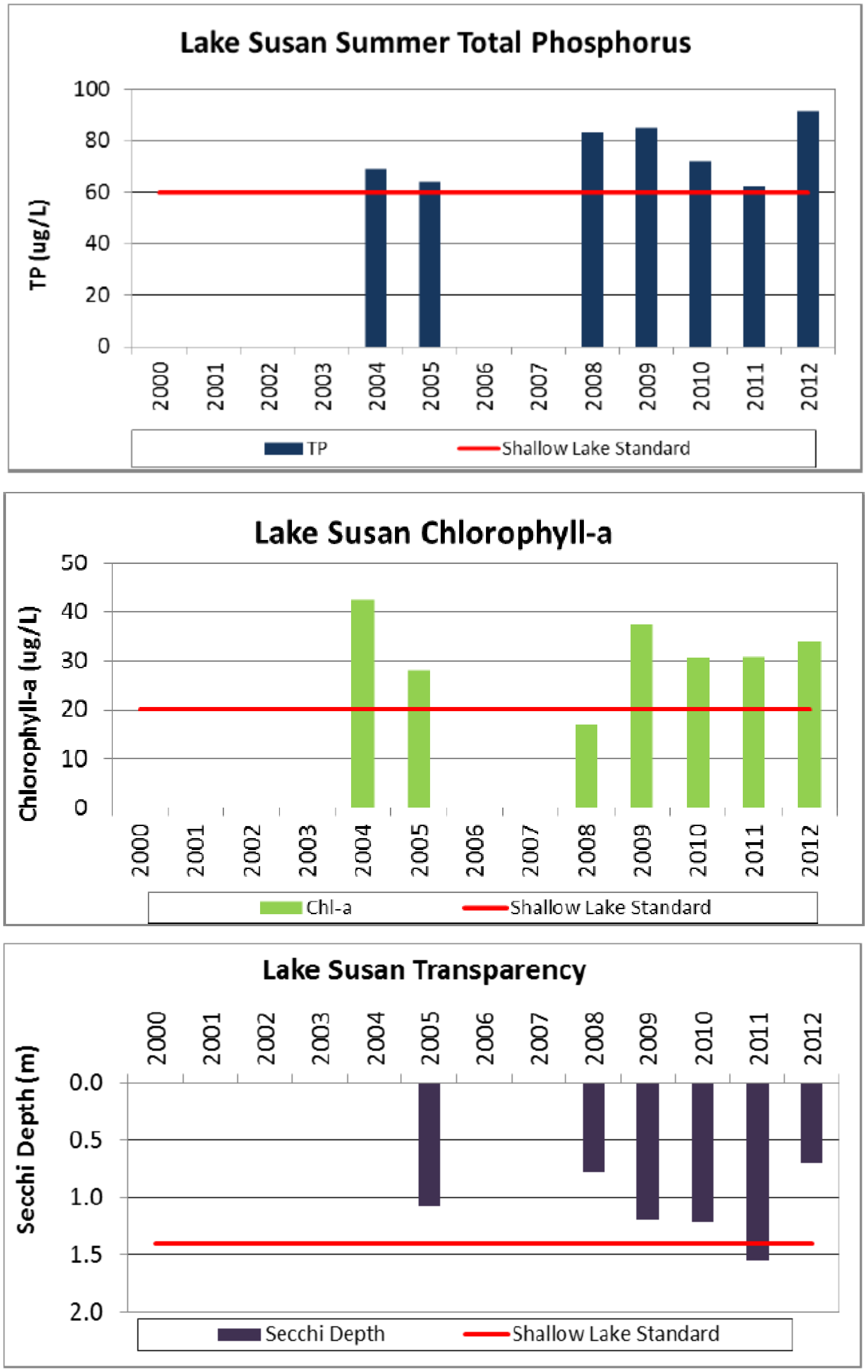

Image Source: Figure 3-10, Figure 3-11, and Figure 3-12 Lake Susan Use Attainability Assessment (UAA) Update (Wenck 2013)

Figure 2 Historic growing season water quality data for Lake Susan

5.0 Lake Susan Improvement Plan

The 2013 UAA Update included several near-term projects in the Lake Susan implementation plan. Figure 3 shows the locations of the proposed near-term projects evaluated as part of the 2013 UAA Update. The BMPs evaluated for water quality improvement are listed below. Table 3 provides a summary of these BMPs, estimated total phosphorus removals, and estimated costs.

1. Modify the outlet from Lake Susan Hills West Park wetland. The modification includes construction of an iron-enhanced sand filtration system (subwatershed LS-2.12).
2. Expand the footprint of the existing Target Pond to create additional live storage. Construct an iron-enhanced sand filtration system at the pond outlet and increase the dead storage by 1 foot (subwatershed LS-3.31).
3. Construct an iron-enhanced sand filtration system at Lake Susan Park Pond and modify the pond to increase dead pool storage by 1 foot (subwatershed LS-3.37).
4. Construct an iron-enhanced sand filtration system at Lake Drive West Pond and increase the dead pool storage by 1 foot (subwatershed LS-3.43).
5. Treat areas deeper than 10 feet with alum to control internal phosphorus loading from lake-bottom sediments.

The remainder of this document focuses on the evaluation of BMP alternatives in or adjacent to subwatershed LS-2.12. Evaluation of the other BMPs identified for Lake Susan will be completed at a later date.

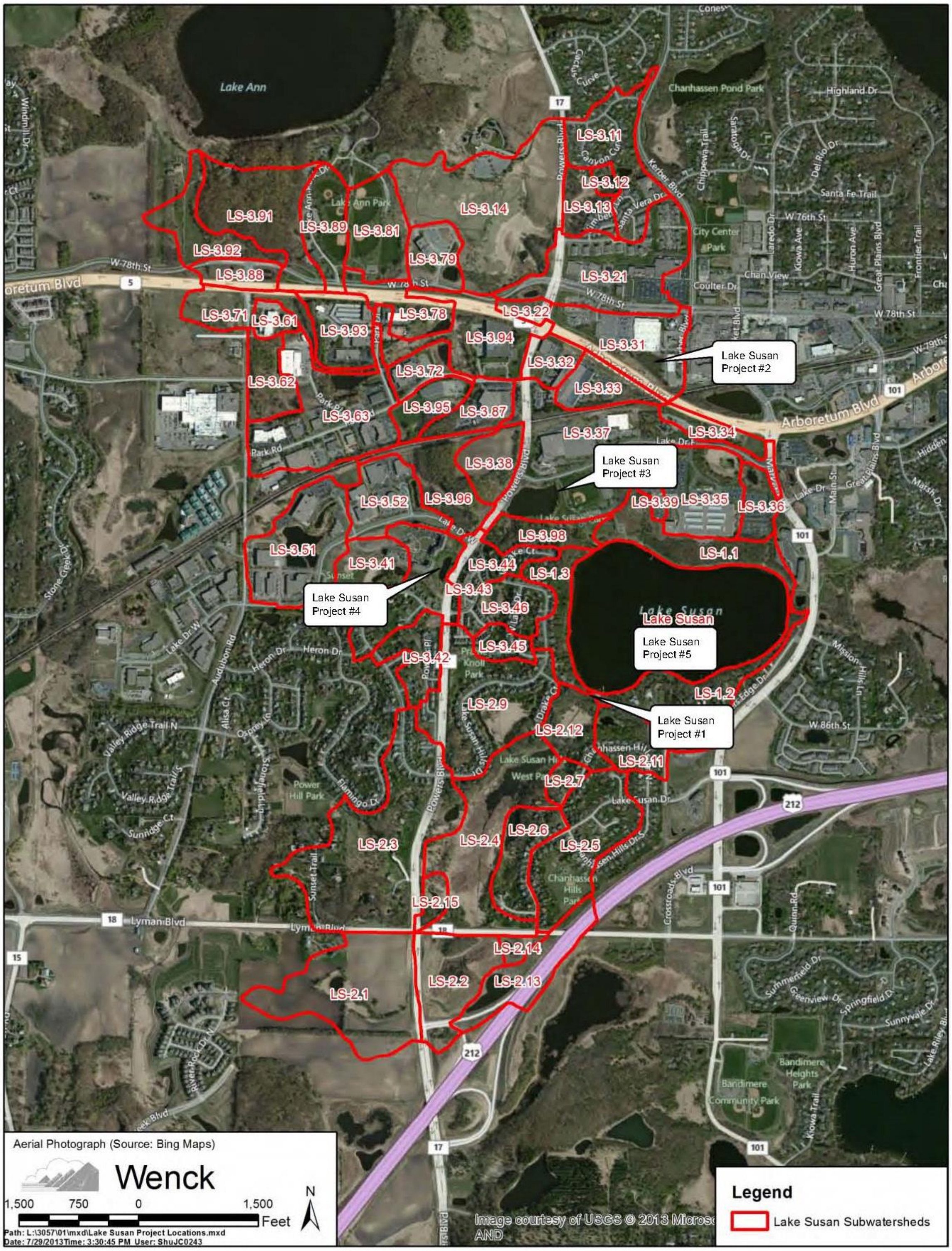

Image Source: Figure 5-2 Lake Susan Use Attainability Assessment (UAA) Update (Wenck 2013). Project numbers updated to match list in Section 5.0

Figure 3 Near-term projects for Lake Susan

Table 3 **Summary of water quality management projects[1] identified in the 2013 Lake Susan UAA Update (Wenck, 2013)**

Water Quality Management Strategy	Estimated Annual TP Reduction (lbs/yr)[1]	Planning Level Opinion of Cost[1]	Annual Cost per Pound TP Removed[1]
Lake Susan Hills West Park – Wetland Restoration LS-2.12	67	$251,553	$126
Target Pond Upgrade LS-3.31	19	$81,181	$142
Lake Susan Park Pond Enhancement LS-3.37	31	$89,507	$98
Lake Drive West Pond Enhancement LS-3.43	5	$25,421	$177
Alum Treatment in Lake Susan	250	$280,071	$37

1 – Values shown in the table are from the Lake Susan 2013 UAA Update (Wenck 2013)

5.1 Proposed Improvement Plan

The 2013 Lake Susan UAA Update evaluated an iron-enhanced sand filtration system located at the outlet of subwatershed LS-2.12, immediately upstream of Lake Susan. Constructing an iron-enhanced sand filtration BMP at this location requires raising the normal water elevation of the wetland in subwatershed LS-2.12. This would ensure that the iron-enhanced sand would be above the ordinary high-water elevation of Lake Susan, reducing the potential for the filtration media to become anoxic and release phosphorus (Wenck 2013). However, modifying the normal water level in the wetland could have large construction costs and trigger wetland mitigation. Therefore, this study also evaluated potential BMPs located at the outlet of LS-2.4, immediately upstream of LS2-12.

Four conceptual designs for a stormwater BMP were considered for this location:

1. Woodchip bioreactor (west location)
2. Woodchip bioreactor (east location)
3. Iron-enhanced sand filtration system
4. Spent-lime treatment system

The BMP proposed in the UAA Update was also evaluated (i.e., a total of five alternative BMPs were evaluated). Each conceptual design is discussed in more detail below. The goal was to identify a system that would fit within existing city-owned parcels and minimize site impacts.

5.2 Best Management Practices Evaluated

Three different types of BMPs were considered: (1) woodchip bioreactor, (2) iron-enhanced sand filtration, and (3) spent-lime treatment. Each of these BMPs is described in the following sections.

5.2.1 Woodchip Bioreactor

Woodchip bioreactor stormwater treatment consists of routing stormwater through a trench of buried woodchips. Within the woodchip bioreactor, naturally occurring bacteria use the carbon in the woodchips as food and use nitrate as part of their respiration process. Since bacteria preferentially use oxygen for respiration, it is important that anaerobic (oxygen-free) conditions exist within the reactor to ensure the bacteria use nitrates within the stormwater (Christianson 2011). Under anaerobic conditions, dissolved phosphorus is converted to an insoluble mineral and trapped by the woodchips, or taken up by bacteria and stored in a form called polyphosphate (Andry Ranaivoson, University of Minnesota, meeting, 7/2/2014). Particulate phosphorus is also removed by filtration through the woodchip media. Figure 4 shows photographs of woodchip bioreactors.

Originally, woodchip bioreactors were designed for removal of nitrates by denitrification (i.e., conversion of nitrate to nitrogen gas) and were located near agricultural fields. Although the use of woodchip bioreactors in stormwater management is still an emerging concept, 2 years of monitoring of a woodchip bioreactor treatment system in Claremont, Minnesota (2009 and 2010), has shown promising results. Total phosphorus removal through the system is approximately 53 percent (Andry Ranaivoson, University of Minnesota, meeting, 7/2/2014).

Construction of woodchip bioreactor. Photograph from presentation "Anaerobic Woodchip Bioreactors Under Minnesota Conditions," courtesy of Andry Ranaivoson, University of Minnesota

Construction of trench for woodchip bioreactor. Photograph from presentation "Anaerobic Woodchip Bioreactors Under Minnesota Conditions," courtesy of Andry Ranaivoson, University of Minnesota

Figure 4 Photographs of Woodchip Bioreactors

Using inexpensive and readily available filter media (i.e., woodchips), a woodchip bioreactor was identified as a cost-effective BMP for removing soluble phosphorus in the Lake Susan watershed. However, because phosphorus removal requires a long residence time within the reactor (minimum of 12 hours) to maintain anaerobic conditions, a large BMP footprint is required to treat a significant volume of water (Andry Ranaivoson, University of Minnesota, meeting, 7/2/2014). Preliminary conceptual designs for a woodchip bioreactor assumed that the woodchip media could be wet all the time (i.e., the bioreactor would not need to completely drain between rainfall events). However, following additional evaluation by the University of Minnesota, the current recommendation is that the woodchip bioreactor should be designed to allow for complete drainage between rainfall events. This reduces the potential of methyl mercury formation caused by stagnant water within the reactor (Andry Ranaivoson, University of Minnesota, meeting, 7/2/2014). The recommendation poses a design constraint because the bottom of the bioreactor cannot be deeper than the bottom of the drainage way. Thus, to achieve the minimum residence time, the woodchip bioreactor must become longer or wider.

The woodchip material has a relatively long lifespan of 10 or more years (Ranaivoson et al. 2014). Although routine maintenance is required, these activities are simple including inspection of inlet and outlet structures and occasional addition of woodchip material to maintain the design depth (contact time) of the bioreactor.

5.2.2 Iron-Enhanced Filtration

Iron-enhanced filtration consists of mixing iron filings or steel wool with a filtration media (i.e., sand). Filtration through the sand (or other filtration media) removes the particulate phosphorus, while the iron filings, which form iron oxide when rusted, increase the removal of dissolved phosphorus. When water containing dissolved phosphorus contacts the iron oxide, the dissolved phosphorus is removed from the stormwater through surface sorption. Figure 5 includes photographs of iron-enhanced sand filtration systems.

Construction of Beam Avenue iron-enhanced sand filtration system.

Iron-enhanced sand filtration system near Beam Avenue following a rainfall event.

Figure 5 Photographs of iron-enhanced sand filtration system

The use of iron-enhanced filtration in stormwater management is recognized by the MPCA and included as a BMP in the *Minnesota Stormwater Manual* (MPCA 2014). Monitoring data reported in the *Minnesota Stormwater Manual* has shown promising results for the removal of both total and dissolved phosphorus. Total phosphorus removal through the system is approximately 71 percent (MPCA 2014).

Use of iron-enhanced filtration was identified to target the removal of soluble phosphorus in the Lake Susan watershed. A relatively short contact time (20–30 minutes) is required for the surface sorption to bind phosphorus to the iron oxide on the iron filings. However, the filtration media must dry out between rainfall events to prevent anoxic conditions within the filter that can release phosphorus. Therefore, the filter must be drawn down within 48 hours of a rainfall event. This means the BMP footprint is proportional to the volume of water to be treated. The estimated lifespan of the iron material is approximately 35 years, although this has not been confirmed in the field (Erickson et al. 2012). Simple, periodic maintenance activities are required, including inspection of inlet and outlet structures, cleanout of the underdrain system, and occasional addition of filtration media to maintain the design depth (i.e., contact time) of the material.

5.2.3 Spent-Lime Treatment

Spent lime consists of calcium and carbonate and is a byproduct of the drinking water treatment process. Since this material is fresh (i.e., recently precipitated), it has properties that allow it to bind with phosphorus. When water with dissolved phosphorus contacts the lime material, calcium from the lime binds with phosphorus and forms calcium phosphate, a solid material that remains within the treatment system. Figure 6 includes photographs of spent-lime treatment systems that have been constructed.

Spent-lime treatment system upstream of Wakefield Pond during construction before spent lime has been added.

Completed spent-lime treatment system upstream of Wakefield Pond.

Figure 6 Photographs of spent-lime treatment system

Although the use of spent lime in stormwater management is still an emerging concept, 2 years of monitoring a test spent-lime treatment system in Maplewood (2012 and 2013) have shown promising results for the removal of both total and dissolved phosphorus. Total phosphorus removal through the system is approximately 65 percent. However, for most monitored events, the dissolved phosphorus levels at the discharge were at laboratory detection limits, suggesting that dissolved phosphorus removal may be higher than the reported removal. Additionally, removal of total suspended solids and heavy metals has been observed.

Spent-lime treatment is a cost-effective BMP, using a waste byproduct of the drinking water treatment system typically disposed of via agricultural land application. Because only a short contact time (5–10 minutes) is required for the chemical reaction to bind phosphorus to the calcium in the lime, a fairly small BMP footprint can be used to treat a significant volume of water. Additionally, the spent-lime material has a significant phosphorus binding capacity and an estimated lifespan of 100+ years (unconfirmed in the field). Routine maintenance is required, including inspection of inlet and outlet structures, annual mixing of the lime material to maintain its porosity and hydraulic conductivity, and occasional addition of spent-lime material to maintain the design depth (contact time) of the material.

5.3 Conceptual Designs

Five conceptual designs for a stormwater BMP were considered:

1. Woodchip bioreactor (west location)
2. Woodchip bioreactor (east location)
3. Iron enhanced sand filtration system
4. Spent lime treatment system
5. Iron enhanced sand filtration (Location proposed in the 2013 UAA Update)

Each conceptual design is discussed in more detail below. The goal for each of the conceptual designs was to identify a BMP that would fit within the existing City-owned parcels and minimize site impacts.

5.3.1 Conceptual Design 1 – Woodchip Bioreactor (West Location)

Conceptual Design 1 is shown in Figure 7. This alternative takes advantage of the existing outlet structure from the wetland in LS-2.4. The proposed alignment of the bioreactor is adjacent to the existing trail along the west side of the creek. It is located in an upland area to minimize impacts to the existing wetland. However, the alignment would require removal of several large trees and vegetation.

The bioreactor was sized to fit the existing topography and vegetation. To ensure at least 12 hours of contact time with the woodchips, stormwater flow through the bioreactor is limited to a proposed discharge rate of 0.13 cubic feet per second (cfs). This would treat roughly 48 percent of the annual flow passing through this location. The bioreactor would be comprised of woodchips enclosed in an impermeable geomembrane. High flows would completely bypass the bioreactor via the existing outlet structure (with the overflow elevation raised 0.5 feet to 884.5 feet NAVD88).

To divert low flows to the woodchip bioreactor, the existing weir would be replaced with two weirs as shown in Figure 7. The upstream weir would control the normal water level in the wetland, while the second weir would allow high flows to bypass the bioreactor. The upstream weir would be set at elevation 883.5 feet NAVD88, the same elevation shown on the as-built plans for the restored wetland (about 0.5 feet lower than the current weir elevation). Based on available data, the modified weir elevation would submerge the 24-inch inlet pipe. This would allow the existing inlet to continue functioning as a skimmer, preventing debris and other floatable materials from entering the bioreactor. Flows entering the bioreactor would pass through approximately 260 feet of woodchips. A 6-inch PVC pipe would be located near the downstream end and would act as the primary outlet from the bioreactor. The outlet pipe would pass through a manufactured adjustable stoplog structure which would ultimately control and allow for future modifications to the discharge rate. Downstream of the stoplog structure, a backflow prevention device—preventing lake water from backing up into the woodchip reactor—would be installed in the discharge pipe. Discharge monitoring could occur in the stoplog structure. The woodchip bioreactor will have access hatches included for inspection and maintenance activities. The approximate depth from the access hatch to the top of the woodchip material would be 1 to 2 feet.

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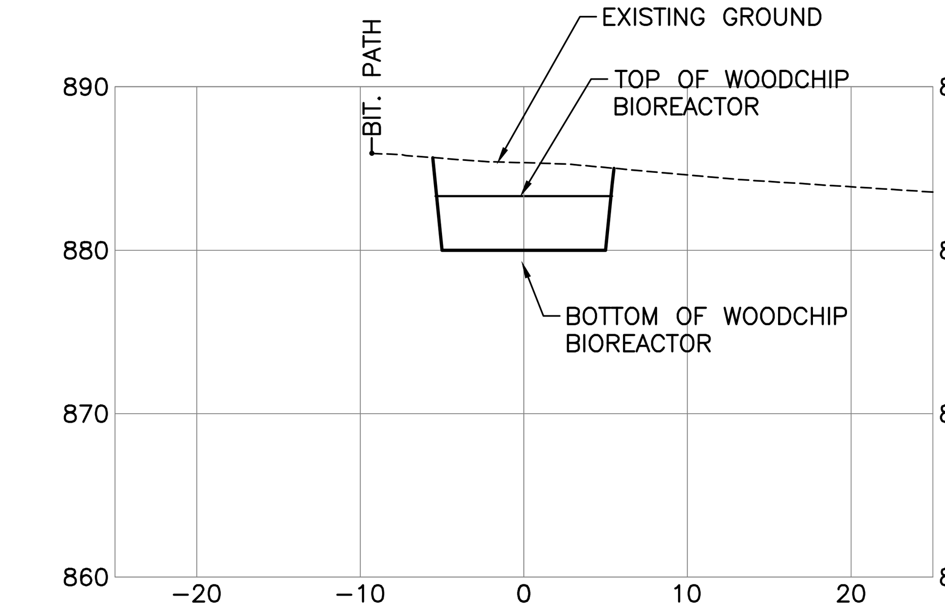

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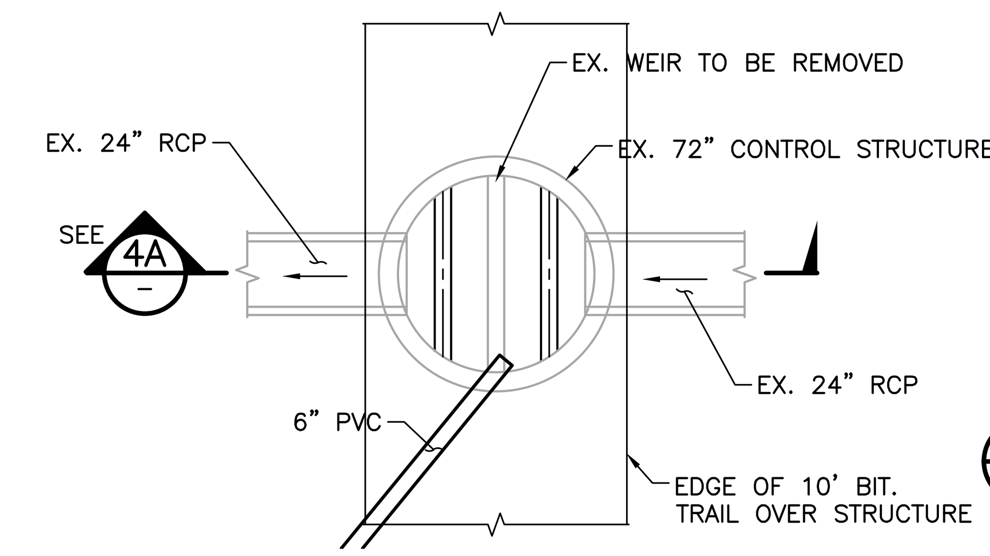

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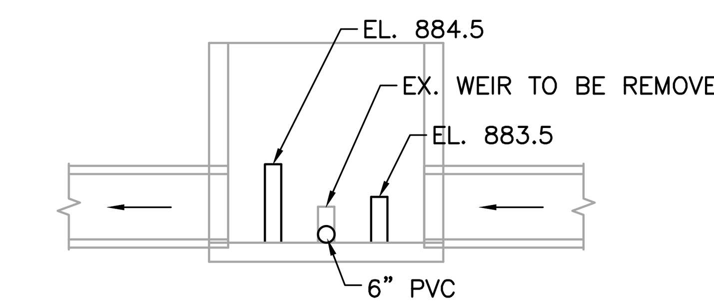

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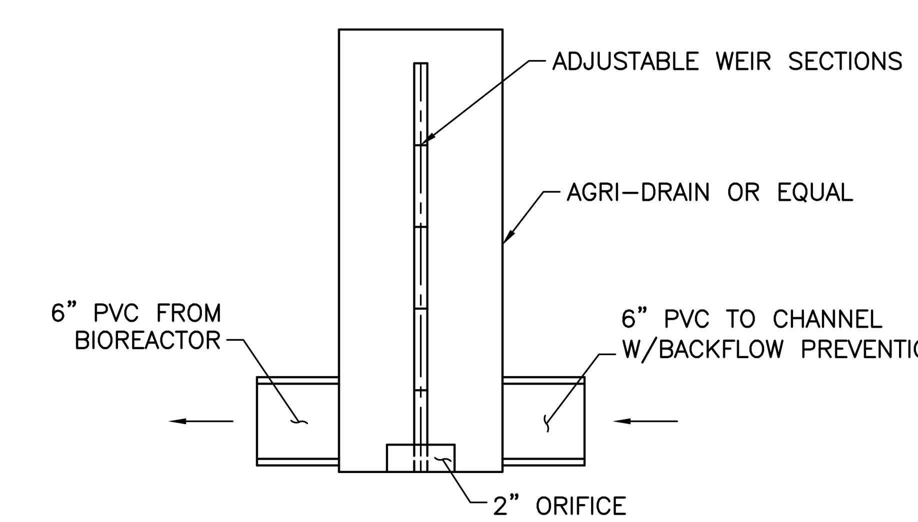

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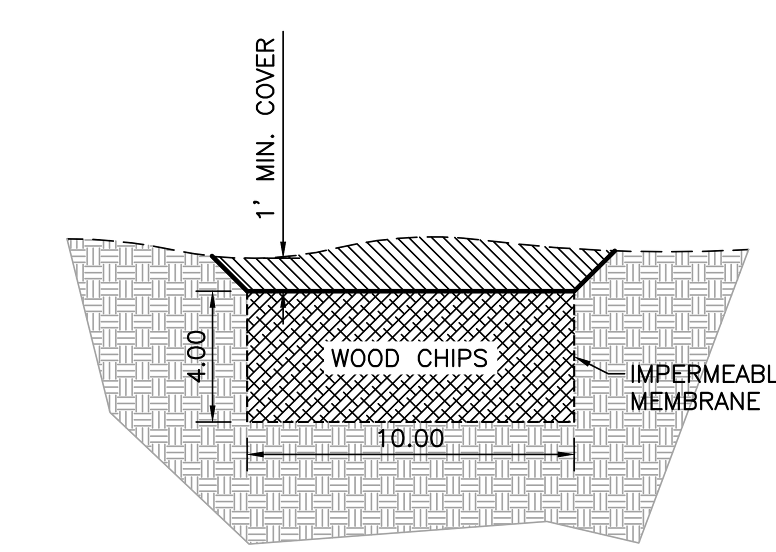

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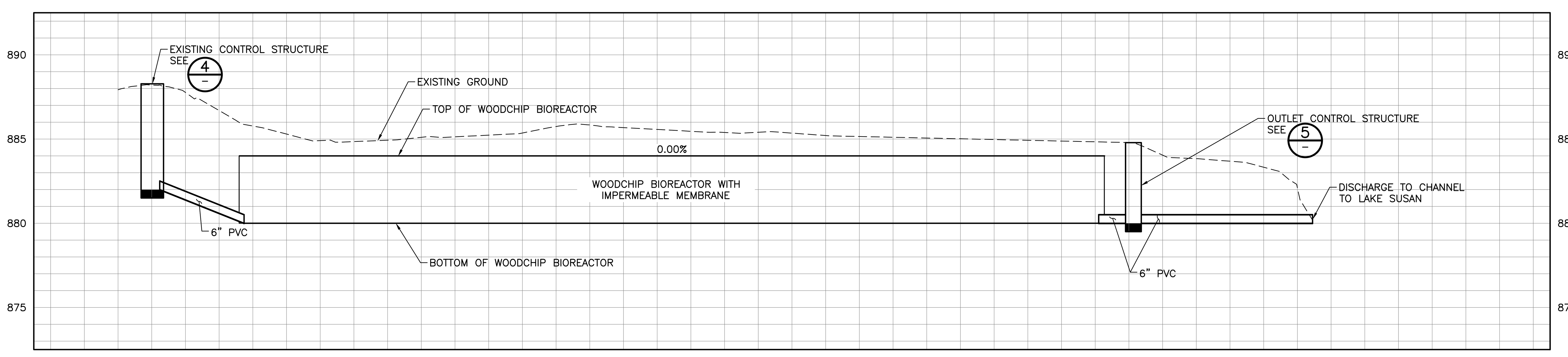

2 PROFILE
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PRELIMINARY DRAFT
NOT FOR CONSTRUCTION

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

SIGNATURE ______
PRINTED NAME ______
DATE ______ REG. NO. ______

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	DATE RELEASED						

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Date	6/26/2014
Drawn	GGN
Checked	
Designed	BARR
Approved	

RILEY PURGATORY
BLUFF CREEK WATERSHED DISTRICT

LAKE SUSAN STORMWATER TREATMENT SYSTEM

WOODCHIP BIOREACTOR
OPTION 1

BARR PROJECT No. 23/27-0053.14
CLIENT PROJECT No.

Figure 7

REV. No.

5.3.1.1 Regulatory Approval

Permits for Conceptual Design 1 will be required by the City of Chanhassen. The wetlands in subwatershed LS-2.4 and LS-2.12 are not part of the public waters inventory; as a result, no permits are required from the Minnesota Department of Natural Resources (MnDNR).

The MPCA regulates the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program. A NPDES permit is required for construction projects on less than 1 acre of soil that the MPCA determines pose a risk to water resources. Considering the location of the proposed BMP (adjacent to the drainage way), it is likely that a NPDES permit will be required. The MPCA will also require a stormwater pollution prevention plan.

5.3.1.2 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the City of Chanhassen. Access to the site during construction would be via the city trail. No residential properties should be permanently affected by this proposed stormwater BMP, as shown in Figure 8.

Figure 8 **Affected properties for Conceptual Design 1 through 4**

5.3.1.3 Wetland and Upland Impacts

A wetland delineation was performed as part of the feasibility evaluation to define the wetland boundary near the existing trail. The feasibility evaluation of Conceptual Design 1 included efforts to minimize any work within the wetland boundary. Based on the wetland delineation completed, it is estimated that less than 0.1 acre of wetland will be temporarily impacted by construction of the outlet from the woodchip bioreactor.

The City of Chanhassen is the wetland permitting authority for this project. The wetland located in subwatershed LS-2.4 is classified by the city as a Manage 1 wetland. The following are the current City of Chanhassen hydrologic guidelines for a Manage 1 wetland:

- Elevation bounce for the 10-year event should not be greater than existing conditions plus 0.5 feet.
- Inundation for the 1- and 2-year event should not be greater than existing conditions plus 1 day.
- Inundation for the 10-year event should not be greater than existing conditions plus 7 days.
- Runout control should not change.
- The existing hydrology should be maintained.

In addition to the management guidelines, the city's management strategy for Manage 1 wetlands is to maintain the wetland without degrading existing functions, values, or wildlife habitat. Table 4 summarizes the City of Chanhassen wetland management guidelines for Conceptual Design 1. Although Conceptual Design 1 lowers the outlet elevation 0.5 feet to 893.5 feet NAVD88, the elevation shown on the City of Chanhassen CSAH17 wetland mitigation and pathway improvement plans, it is not anticipated that the modification to the outlet structure will change the wetland type, functions, or wildlife habitat.

Table 4 Summary of wetland management guidelines for Conceptual Design 1

Parameter	Management Guideline	Conceptual Design 1 Impact
Elevation bounce for the 10-year event	Existing conditions +0.5 ft	0.1 ft
Inundation duration for the 1-year event	Existing conditions +1 day	Within 0.6 ft after 1 day[1]
Inundation duration for the 2-year event	Existing conditions +1 day	Within 0.7 ft after 1 day[1]
Inundation duration for the 10-year event	Existing conditions +7 days	Within 0.5 ft after 7 days[1]
Runout control	No change	-0.5 ft[1]
Hydrology	Maintain existing	No change to existing hydrology
Increase in 100-year flood elevation[2]	-	0 ft
Change in average water surface elevation over 10-year simulation period in upstream wetland[3]	-	-0.1 ft

1 – Conceptual design will not likely change the existing functions, values, or wildlife habitat of the wetland. If this is the selected alternative, additional coordination will be required with the City of Chanhassen during the next phase of design to ensure the final design satisfies the intent of the city's wetland management guidelines.

2 – Elevation bounce for the 100-year event was checked as part of the evaluation; this, however, is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.

3 – Average change in water surface elevation was checked for the 10-year period from 2003 to 2012 to estimate the average impact of the proposed BMP on the water surface elevation in the wetland; however, this is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.

Conceptual Design 1 will result in long-term impacts to the existing upland vegetation. The footprint for the woodchip bioreactor would remove approximately 0.2 acres of existing forest and dense brush adjacent to the trail. Following construction, native grasses could be planted; however, the larger trees and dense brush could not be restored without impacting the functionality of the woodchip bioreactor.

5.3.1.4 Water Quality Improvements

The calibrated P8 model for existing conditions developed for the 2013 UAA Update by Wenck Associates was used to define the phosphorus loading within the watershed. The storage in subwatershed LS-2.4 was updated to reflect the 2011 LiDAR data, and the rating curve for the LS-2.4 outlet structure was updated to match surveyed data. No other modifications were made to the calibrated existing conditions model.

The performance of Conceptual Design 1 was evaluated using the same P8 model, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals. The performance of Conceptual Design 1 was evaluated for a 10-year period, including the calendar years 2003 through 2012. The estimated average annual total phosphorus removal for Conceptual Design 1 was 32 pounds/year.

5.3.1.5 Engineer's Opinion of Probable Cost

The Engineer's opinion of probable cost is reported as a range of probable costs. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design the cost range for construction, planning engineering and design, permitting, construction management, and contingency is $111,000 to $194,000. Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 1.

5.3.2 Conceptual Design 2 – Woodchip Bioreactor (East Location)

Conceptual Design 2 is shown in Figure 9. This alternative also takes advantage of the existing outlet structure from the wetland in LS-2.4, and would not require construction of a new inlet structure to the woodchip bioreactor. The proposed alignment of the bioreactor is to the east of the creek, located in an upland area of dense brush (but no large trees). The alignment also minimizes impacts to the existing wetland.

The bioreactor was sized to fit the existing topography and vegetation. To ensure a 12-hour contact time, stormwater flow through the woodchips would be limited to a proposed discharge rate of 0.13 cfs. This would treat roughly 48 percent of the annual flow passing through this location. The bioreactor would be comprised of woodchips enclosed in an impermeable geomembrane. High flows would completely bypass the bioreactor via the existing manhole structure (with the outlet elevation raised 0.5 feet to 884.5 feet NAVD88).

The inlet structure to the woodchip bioreactor is identical to Conceptual Design 1. The outlet structure design is also similar to Conceptual Design 1, except that it is placed on the east side of the creek.

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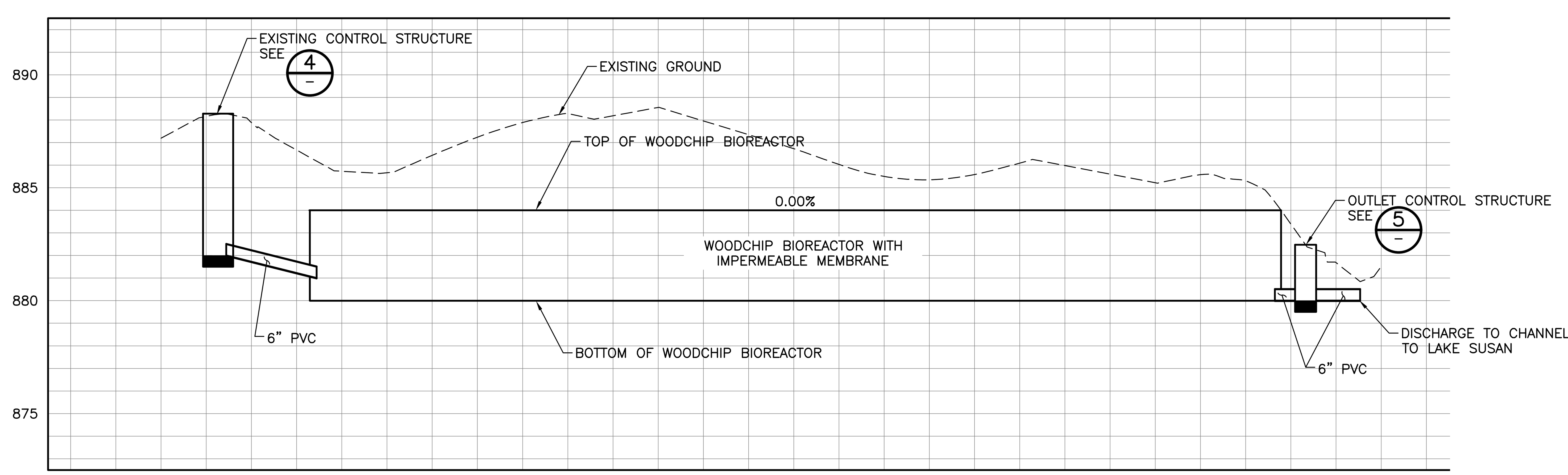

2 PROFILE
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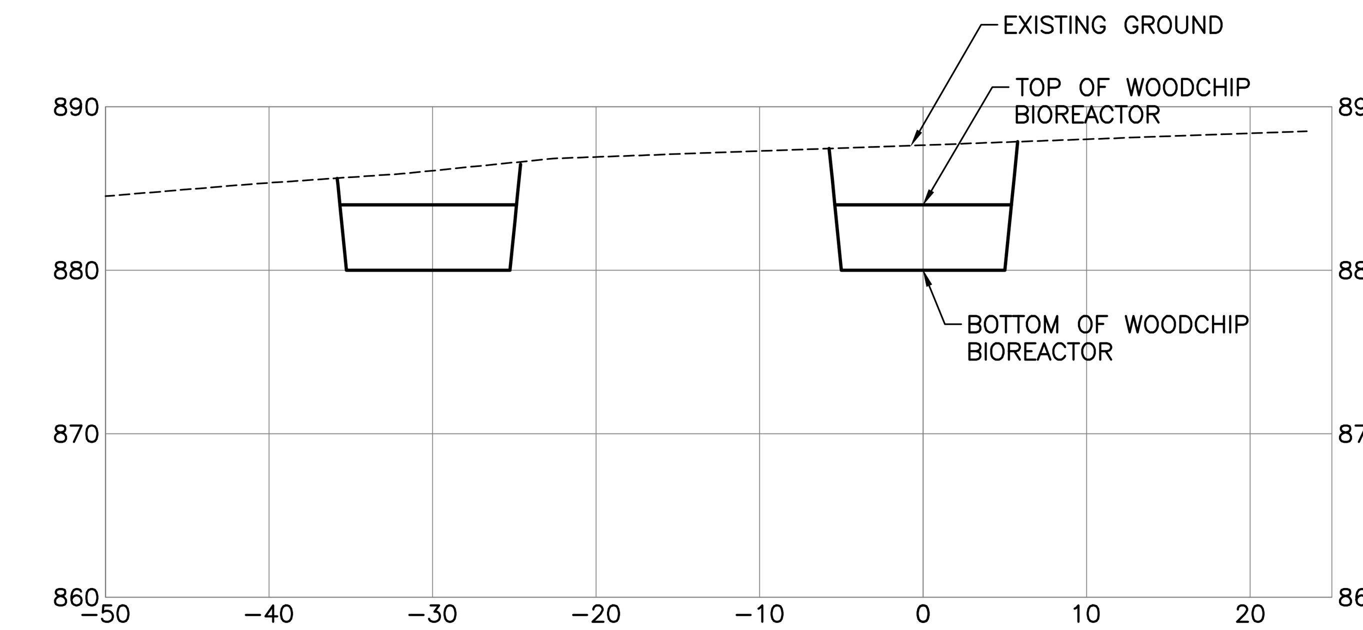
SCALE IN FEET



3 SECTION: 1+25
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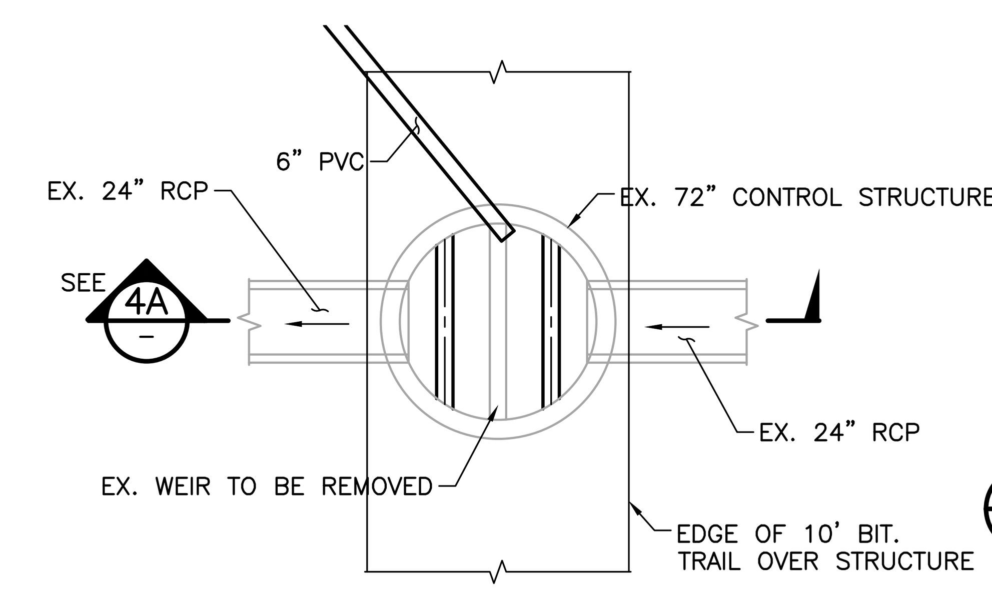

4 DETAIL: EXISTING STRUCTURE MODIFICATION
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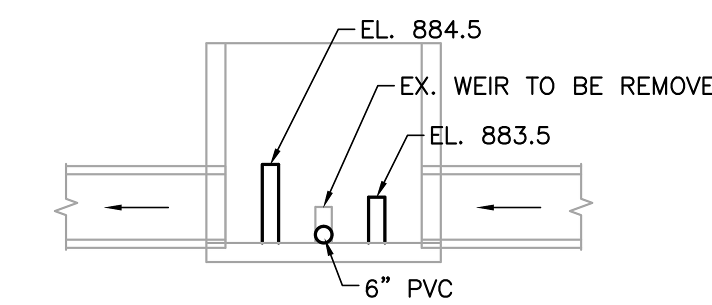

4A SECTION: EXISTING STRUCTURE MODIFICATION
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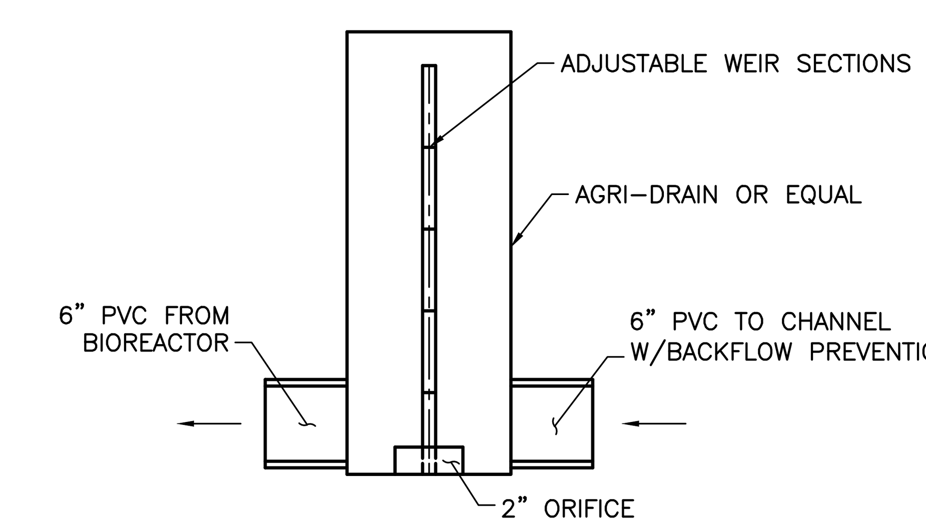

5 SECTION: OUTLET CONTROL STRUCTURE
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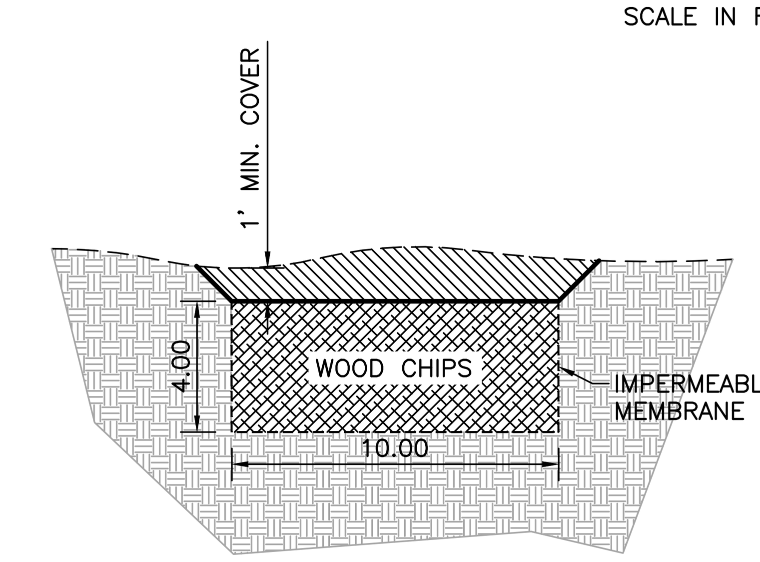

6 TYP. SECTION: WOODCHIP BIOREACTOR
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SCALE IN FEET

PRELIMINARY DRAFT
NOT FOR CONSTRUCTION

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Xrefs in Drawing – M:\Design\23270053.14\23270053.14_Lake Susan BMP Survey Base.dwg M:\Design\23270053.14\23270053.14_Lake Susan BMP Design Base.dwg
ggn M:\Design\23270053.14\23270053.14_SHEET_WOODCHIP OPT 2.dwg Plot at 0 07/01/2014 12:03:38

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.
SIGNATURE
PRINTED NAME
DATE REG. NO.

RELEASED TO/FOR | A | B | C | 0 | 1 | 2 | 3 | DATE RELEASED

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Scale	AS SHOWN
Date	6/30/2014
Drawn	GGN
Checked	
Designed	BARR
Approved	

RILEY PURGATORY
BLUFF CREEK WATERSHED DISTRICT

LAKE SUSAN STORMWATER TREATMENT SYSTEM

WOODCHIP BIOREACTOR OPTION 2

BARR PROJECT No. 23/27–0053.14
CLIENT PROJECT No.
Figure 9
REV. No.

5.3.2.1 Regulatory Approval

The permits required for Conceptual Design 2 will be similar to the permits required for Conceptual Design 1, discussed in Section 5.3.1.1.

5.3.2.2 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the City of Chanhassen. During construction, access to the site would be via the city trail. Similar to Conceptual Design 1, no residential properties should be permanently affected by the proposed stormwater BMP, as shown in Figure 8.

5.3.2.3 Wetland and Upland Impacts

A wetland delineation was performed as part of the feasibility evaluation to define the wetland boundary near the existing trail. The feasibility evaluation of Conceptual Design 2 included efforts to minimize any work within the wetland boundary. Based on the wetland delineation completed, it is estimated that less than 0.1 acre of wetland will be temporarily impacted by construction of the outlet from the woodchip bioreactor.

The City of Chanhassen is the wetland permitting authority for this project, and the applicable wetland management guidelines are similar to Conceptual Design 1, discussed in Section 5.3.1.3.

Table 5 summarizes the City of Chanhassen wetland management guidelines for Conceptual Design 2. Similar to Conceptual Design 1, Conceptual Design 2 lowers the outlet elevation 0.5 feet to 893.5 feet NAVD88, the elevation shown on the City of Chanhassen CSAH17 wetland mitigation and pathway improvement plans. It is not anticipated that the modification to the outlet structure will change the wetland type, functions, or wildlife habitat.

Table 5 **Summary of wetland management guidelines for Conceptual Design 2**

Parameter	Management Guideline	Conceptual Design 2 Impact
Elevation bounce for the 10-year event	Existing conditions +0.5 ft	0.1 ft
Inundation duration for the 1-year event	Existing conditions +1 day	Within 0.6 ft after 1 day[1]
Inundation duration for the 2-year event	Existing conditions +1 day	Within 0.7 ft after 1 day[1]
Inundation duration for the 10-year event	Existing conditions +7 days	Within 0.5 ft after 7 days[1]
Runout control	No change	-0.5 ft[1]
Hydrology	Maintain existing	No change to existing hydrology
Increase in 100-year flood elevation2	-	0 ft
Change in average water surface elevation over 10-year simulation period in upstream wetland[3]	-	-0.1 ft

1 – Conceptual design will not likely change the existing functions, values, or wildlife habitat of the wetland. If this is the selected alternative, additional coordination will be required with the City of Chanhassen during the next phase of design to ensure the final design satisfies the intent of the city's wetland management guidelines.

2 – Elevation bounce for the 100-year event was checked as part of the evaluation; this, however, is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.

3 – Average change in water surface elevation was checked for the 10-year period from 2003 to 2012 to estimate the average impact the proposed BMP would have on the water surface elevation in the wetland; however, this is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.

Conceptual Design 2 will result in long-term impacts to the existing upland vegetation. The footprint for the woodchip bioreactor would remove approximately 0.3-acres of existing dense brush adjacent to the trail. Following construction, native grasses could be planted; however, the larger bushes and dense brush could not be restored without impacting the functionality of the woodchip bioreactor.

5.3.2.4 Water Quality Improvements

Similar to Conceptual Design 1, the calibrated P8 model for existing conditions developed for the 2013 UAA Update by Wenck Associates was used to define the phosphorus loading within the watershed and is discussed in Section 5.3.1.4.

The performance of Conceptual Design 2 was evaluated using the same P8 model, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals. The performance of the conceptual design was evaluated for a 10-year period, including the calendar years 2003 through 2012. The estimated average annual total phosphorus removal for Conceptual Design 2 was 32 pounds/year.

5.3.2.5 Engineer's Opinion of Probable Cost

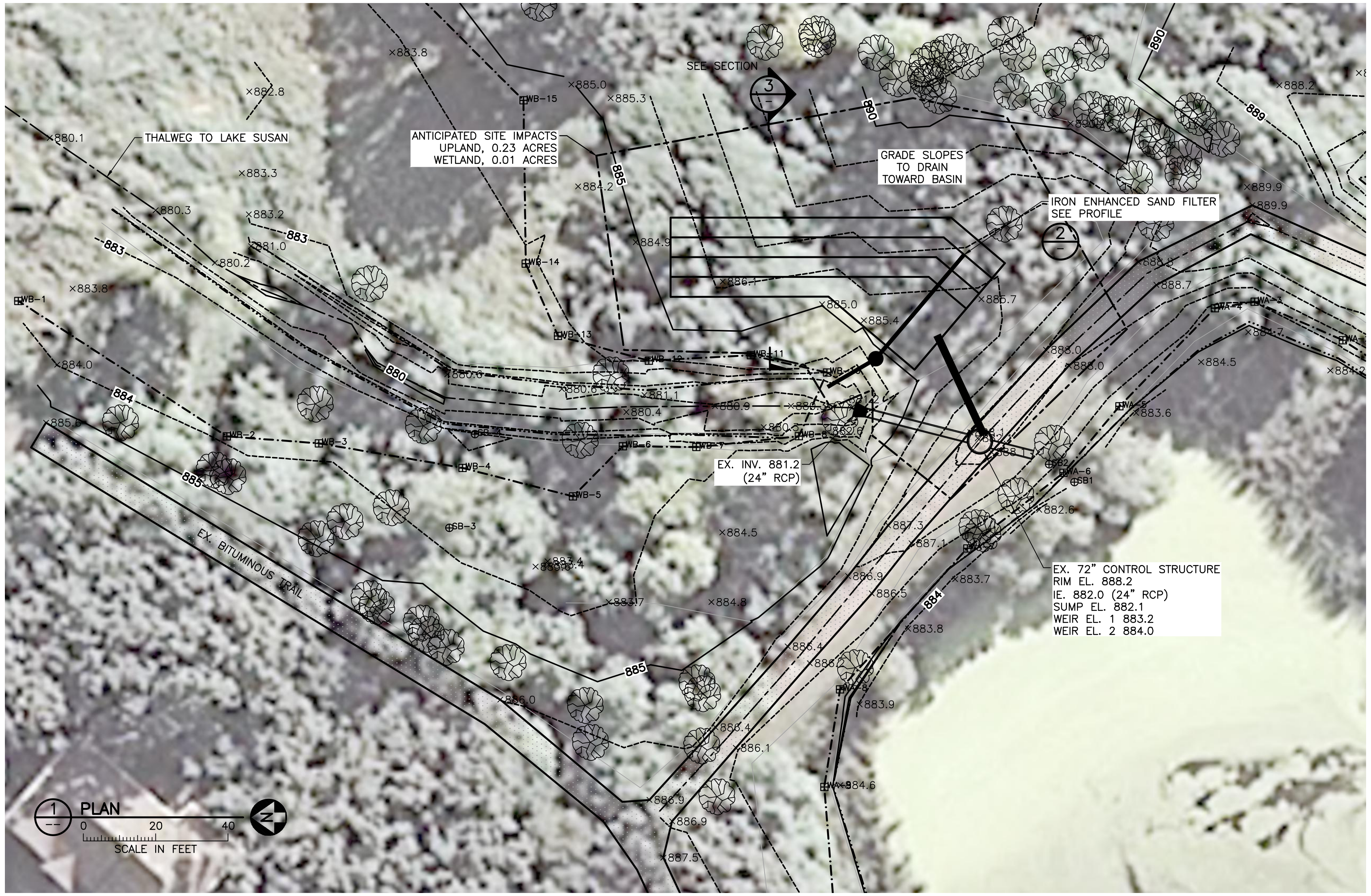
The Engineer's opinion of probable cost is reported as a range of probable costs. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design, the cost range for construction, planning engineering and design, permitting, construction management, and contingency is $107,000 to $187,000. Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 2.

5.3.3 Conceptual Design 3 – Iron-Enhanced Sand Filtration

Conceptual Design 3 is shown in Figure 10. Similar to the previous alternatives, this design takes advantage of the existing outlet structure from the wetland in LS-2.4. The proposed location of the filtration system is north of the existing trail along the east side of the creek; it is located in the upland area to minimize impacts to the existing wetland. The selected location would avoid removal of existing trees, but would require removal of some brush.

The filtration system was sized to maximize the filtration media surface area, resulting in a design discharge rate of 1.4 cfs to achieve a 20-30-minute contact time with the filtration media (i.e., iron-enhanced sand). The design discharge rate allows the filter to draw down the upstream wetland within 48 hours of a rainfall event to prevent the filtration media from becoming anoxic, and potentially releasing phosphorus. This design would treat approximately 26 percent of the flow passing through this location. The filtration media would be comprised of a mixture of sand and iron filings. It is anticipated that the iron filings would be 5 percent by weight of the filtration media. An underdrain would be located below the filtration media to covey filtered stormwater to the outlet structure. An impermeable geomembrane is located below the underdrain to prevent groundwater from seeping into the filtration system. High flows would completely bypass the bioreactor via the existing outlet structure.

To divert low flows to the filtration system, the existing weir within the manhole under the trail would be replaced with two weirs as shown in Figure 10. The upstream weir would control the normal water level in the wetland, while the second weir would allow for high flows to bypass the filtration system. The modified weir would submerge the 24-inch inlet pipe. This would allow the existing inlet to continue functioning as a skimmer, preventing debris and other floatable materials from entering the filter. Flows entering the filtration system would be filtered through approximately 1.5 feet of iron-enhanced sand. A perforated underdrain would be located below the filtration media and act as the primary outlet from the filtration system. Downstream of the filtration system, a backflow prevention device would be installed in the discharge pipe to prevent Lake Susan from backing up into the filtration system.



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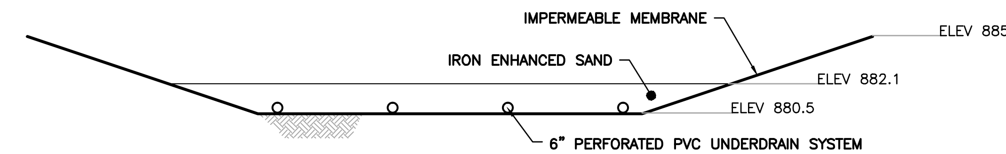

3 SECTION: IRON ENHANCED SAND FILTER
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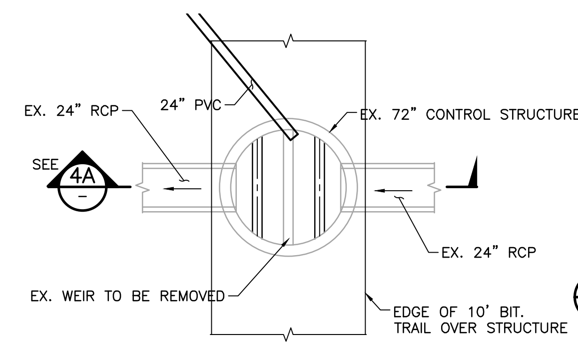

4 DETAIL: EXISTING STRUCTURE MODIFICATION
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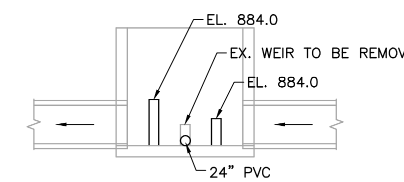

4A SECTION: EXISTING STRUCTURE MODIFICATION
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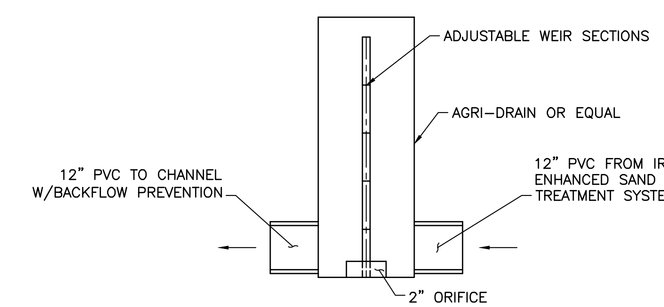
SCALE IN FEET



5 SECTION: OUTLET CONTROL STRUCTURE
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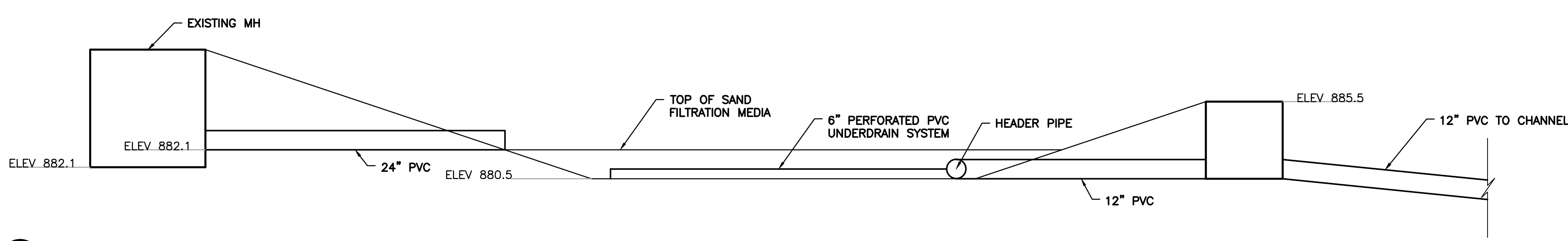
SCALE IN FEET



2 PROFILE: IRON ENHANCED SAND FILTER
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SCALE IN FEET

PRELIMINARY DRAFT
NOT FOR CONSTRUCTION

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ggn M:\Design\23270053.14\23270053.14_SHEET_Enhanced Sand.dwg Plot at 0 07/24/2014 10:45:32

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I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

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Date	7/1/2014
Drawn	GGN/PEB
Checked	
Designed	BARR
Approved	

RILEY PURGATORY
BLUFF CREEK WATERSHED DISTRICT

LAKE SUSAN STORMWATER TREATMENT SYSTEM

IRON ENHANCED SAND TREATMENT SYSTEM

BARR PROJECT No.
23/27-0053.14
CLIENT PROJECT No.

Figure 10 REV. No.

5.3.3.1 Regulatory Approval

The permits required for Conceptual Design 3 will be similar to the permits required for Conceptual Design 1 discussed in Section 5.3.1.1.

5.3.3.2 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the City of Chanhassen. During construction, access to the site would be via the city trail. Similar to Conceptual Design 1, no residential properties should be permanently affected by the proposed stormwater BMP, as shown in Figure 8.

5.3.3.3 Wetland and Upland Impacts

A wetland delineation was performed as part of the feasibility evaluation to define the wetland boundary near the existing trail. The feasibility evaluation of Conceptual Design 3 included efforts to minimize work within the wetland boundary. Based on the wetland delineation completed, it is estimated that less than 0.1 acre of wetland will be temporarily impacted by construction of the outlet from the iron-enhanced filtration system.

The City of Chanhassen is the wetland permitting authority for this project, and the applicable wetland management guidelines are similar to Conceptual Design 1, discussed in Section 5.3.1.3.

Table 6 summarizes the City of Chanhassen wetland management guidelines for Conceptual Design 3.

Table 6 Summary of wetland management guidelines for Conceptual Design 3

Parameter	Management Guideline	Conceptual Design 3 Impact
Elevation bounce for the 10-year event	Existing conditions +0.5 ft	0.1 ft
Inundation duration for the 1-year event	Existing conditions +1 day	Within 0.1 ft after 1 day[1]
Inundation duration for the 2-year event	Existing conditions +1 day	Within 0.2 ft after 1 day[1]
Inundation duration for the 10-year event	Existing conditions +7 days	Within 0.0 ft after 7 days[1]
Runout control	No change	No change
Hydrology	Maintain existing	No change to existing hydrology
Increase in 100-year flood elevation[2]	-	0 ft
Change in average water surface elevation over 10-year simulation period in upstream wetland[3]	-	0.3 ft

1 – Conceptual design will not likely change the existing functions, values, or wildlife habitat of the wetland. If this is the selected alternative, additional coordination will be required with the City of Chanhassen during the next phase of design to ensure the final design satisfies the intent of the city's wetland management guidelines.

2 – Elevation bounce for the 100-year event was checked as part of the evaluation; this, however, is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.

3 – Average change in water surface elevation was checked for the 10-year period from 2003 to 2012 to estimate the average impact the proposed BMP will have on the water surface elevation in the wetland; this, however, is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.

Conceptual Design 3 will result in long-term impacts to the existing upland vegetation. The footprint for the iron-enhanced sand filtration system would remove approximately 0.2-acres of existing dense brush adjacent to the trail. Following construction, native grasses could be planted adjacent to the filtration system; however, the larger bushes and dense brush could not be restored without impacting the functionality of the iron-enhanced sand filtration system.

5.3.3.4 Water Quality Improvements

Similar to Conceptual Design 1, the calibrated P8 model for existing conditions developed for the 2013 UAA Update by Wenck Associates was used to define the phosphorus loading within the watershed and is discussed in Section 5.3.1.4.

The performance of Conceptual Design 3 was evaluated using the same P8 model, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals. The performance of the conceptual design was evaluated for a 10-year period, including the calendar years 2003 through 2012. The estimated average annual total phosphorus removal for Conceptual Design 3 was 22 pounds/year.

5.3.3.5 Engineer's Opinion of Probable Cost

The Engineer's opinion of probable cost is reported as a range of probable costs. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design, the cost range for construction, planning engineering and design, permitting, construction management, and contingency is $194,000 to $339,000. Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 3.

5.3.4 Conceptual Design 4 – Spent-Lime Treatment System

Conceptual Design 4 is shown in Figure 11. This alternative utilizes the existing outlet structure located in the trail from the wetland in subwatershed LS-2.4 to divert flows to the spent-lime treatment system located in the upland area east of the drainage way to minimize impacts to the existing wetland. The selected location would avoid removal of existing trees, but would require removal of some brush.

The spent-lime treatment system was sized for a 5-minute contact time with the spent-lime material, with a proposed discharge rate of 0.2 cfs. This would treat roughly 56 percent of the annual flow passing through this location. The spent-lime treatment system would be comprised of either a large box culvert or cast-in-place concrete structure. High flows would completely bypass the spent-lime treatment system via the existing overflow (with the overflow weir elevation raised to 884.5 ft NAVD88).

To divert low flows to the spent-lime treatment system, a new 12-inch-diameter pipe will be connected to the existing manhole. Within the manhole, there would be two weirs; the first weir would control the normal water level of the wetland in subwatershed LS-2.4 at 883.5 feet NAVD88. The second weir (at elevation 884.5 feet NAVD88) would be located downstream of the 12-inch-diameter pipe and allow high flows to bypass the spent-lime treatment system. Flows entering the spent-lime system would pass through approximately 1.3 feet of spent-lime material and an additional 0.5 feet of pea gravel. Perforated drain tile would be located in the pea gravel. It would act as the primary drainage from the system and pass through an outlet structure. Downstream of the structure, a backflow prevention device would be installed in the discharge pipe to prevent Lake Susan from backing up into the treatment system. Discharge monitoring could occur in the structure. The spent-lime treatment structure will have a grated cover for inspection and maintenance activities. The minimum depth from the access hatch to the top of the spent-lime material would be 2 feet.

1 PLAN

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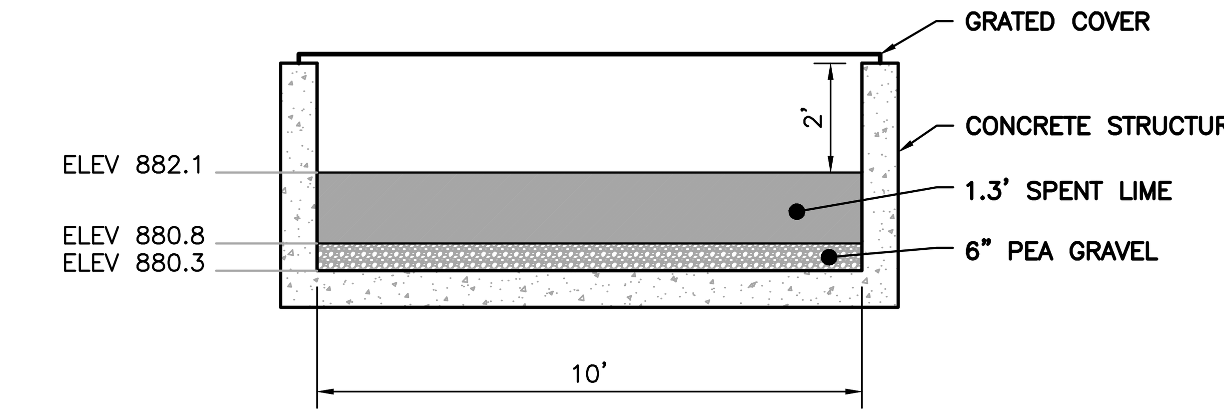

3 SECTION: CONCRETE STRUCTURE

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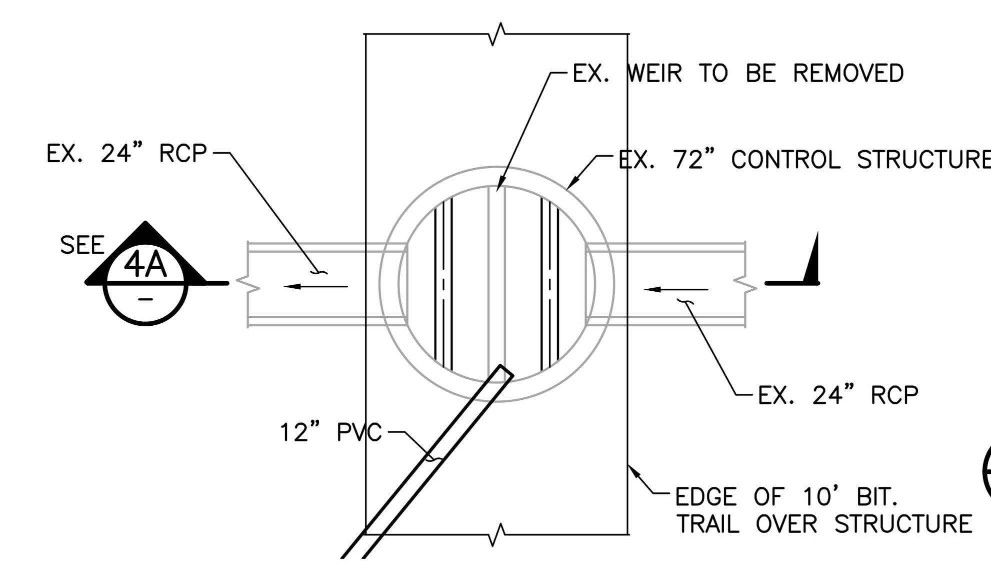

4 DETAIL: EXISTING STRUCTURE MODIFICATION

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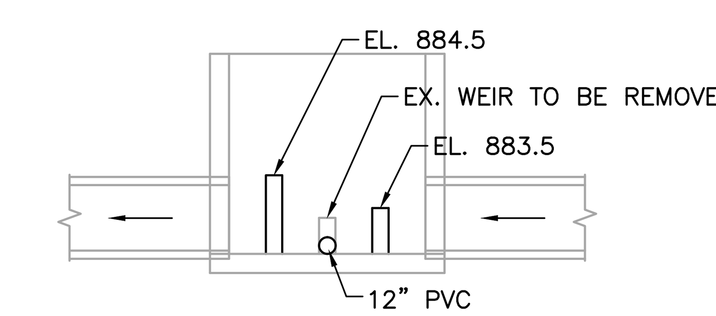

4A SECTION: EXISTING STRUCTURE MODIFICATION

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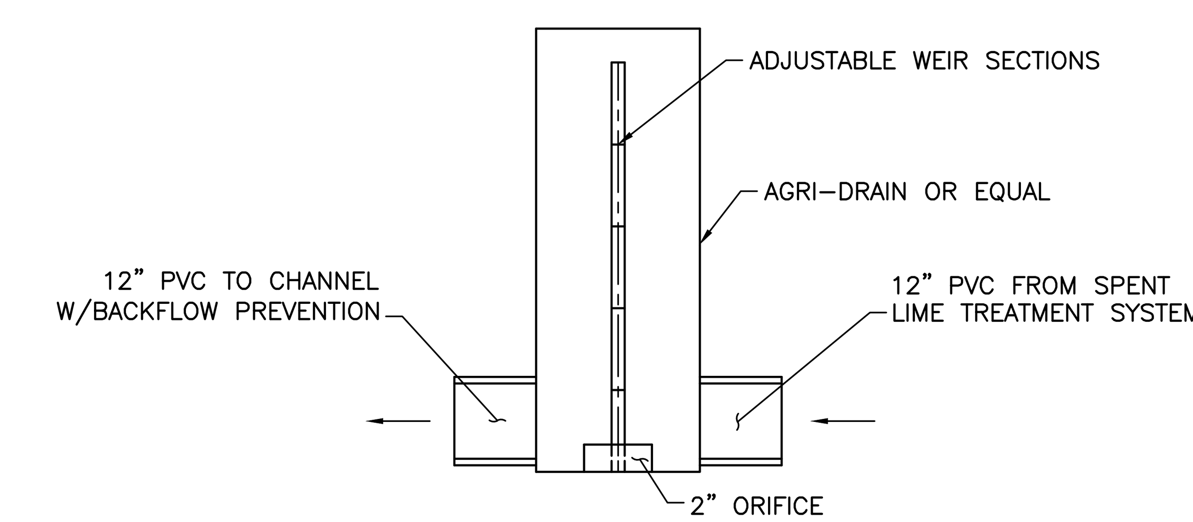

5 SECTION: OUTLET CONTROL STRUCTURE

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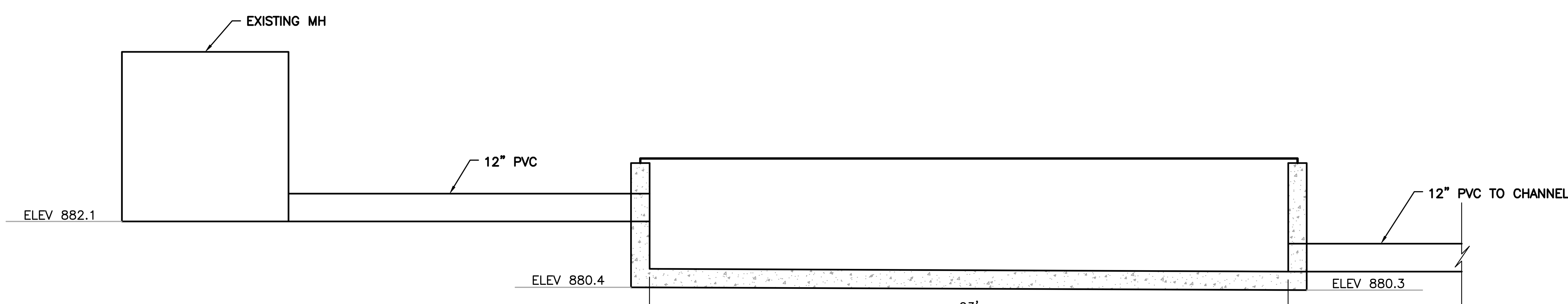
SCALE IN FEET



2 PROFILE: CONCRETE STRUCTURE

0 3 6
SCALE IN FEET

PRELIMINARY DRAFT
NOT FOR CONSTRUCTION

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PRINTED NAME ______
DATE ______ REG. NO. ______

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Fax: (952) 832-2601
www.barr.com

Scale	AS SHOWN
Date	7/1/2014
Drawn	GGN/PEB
Checked	
Designed	BARR
Approved	

RILEY PURGATORY
BLUFF CREEK WATERSHED DISTRICT

LAKE SUSAN STORMWATER TREATMENT SYSTEM

SPENT LIME TREATMENT SYSTEM

BARR PROJECT No. 23/27-0053.14
CLIENT PROJECT No.

Figure 11

REV. No.

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5.3.4.1 Regulatory Approval

The permits required for Conceptual Design 4 will be similar to the permits required for Conceptual Design 1, discussed in Section 5.3.1.1.

5.3.4.2 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the City of Chanhassen. During construction, access to the site would be via the city trail. Similar to Conceptual Design 1, no residential properties should be permanently affected by the proposed stormwater BMP, as shown in Figure 8.

5.3.4.3 Wetland and Upland Impacts

A wetland delineation was performed as part of the feasibility evaluation to define the wetland boundary near the existing trail. The feasibility evaluation of Conceptual Design 4 included efforts to minimize work within the wetland boundary. Based on the wetland delineation completed, it is estimated that less than 0.1 acre of wetland will be temporarily impacted by construction of the outlet from the spent-lime treatment system.

The City of Chanhassen is the wetland permitting authority for this project, and the applicable wetland management guidelines are similar to Conceptual Design 1, discussed in Section 5.3.1.3.

Table 7 summarizes the City of Chanhassen wetland management guidelines for Conceptual Design 4. Similar to Conceptual Design 1, Conceptual Design 4 lowers the outlet elevation 0.5 feet to 893.5 feet NAVD88, the elevation shown on the City of Chanhassen CSAH17 wetland mitigation and pathway improvement plans. It is not anticipated that the modification to the outlet structure will change the wetland type, functions, or wildlife habitat.

Table 7 Summary of wetland management guidelines for Conceptual Design 4

Parameter	Management Guideline	Conceptual Design 4 Impact
Elevation bounce for the 10-year event	Existing conditions +0.5 ft	0.1 ft
Inundation duration for the 1-year event	Existing conditions +1 day	Within 0.6 ft after 1 day[1]
Inundation duration for the 2-year event	Existing conditions +1 day	Within 0.7 ft after 1 day[1]
Inundation duration for the 10-year event	Existing conditions +7 days	Within 0.4 ft after 7 days[1]
Runout control	No change	-0.5 ft[1]
Hydrology	Maintain existing	No change to existing hydrology
Increase in 100-year flood elevation[2]	-	0 ft
Change in average water surface elevation over 10-year simulation period in upstream wetland[3]	-	-0.1 ft

1 – Conceptual design will not likely change the existing functions, values, or wildlife habitat of the wetland. If this is the selected alternative, additional coordination will be required with the City of Chanhassen during the next phase of design to ensure the final design satisfies the intent of the city's wetland management guidelines.
2 – Elevation bounce for the 100-year event was checked as part of the evaluation; this, however, is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.
3 – Average change in water surface elevation was checked for the 10-year period from 2003 to 2012 to estimate the average impact the proposed BMP will have on the water surface elevation in the wetland; this, however, is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.

Conceptual Design 4 will result in long-term impacts to the existing upland vegetation. The footprint for the spent-lime treatment system would remove approximately 0.1 acres of existing dense brush. Following construction, native grasses could be planted adjacent to the treatment system.

5.3.4.4 Water Quality Improvements

Similar to Conceptual Design 1, the calibrated P8 model for existing conditions developed for the 2013 UAA Update by Wenck Associates was used to define the phosphorus loading within the watershed and is discussed in Section 5.3.1.4.

The performance of Conceptual Design 4 was evaluated using the same P8 model, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals. The performance of the conceptual design was evaluated for a 10-year period, including the calendar years 2003 through 2012. The estimated average annual total phosphorus removal for Conceptual Design 4 was 45 pounds/year.

5.3.4.5 Engineer's Opinion of Probable Cost

The Engineer's opinion of probable cost is reported as a range of probable costs. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design, the cost range for construction, planning engineering and design, permitting, construction management, and contingency is $160,000 to $280,000. Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 4.

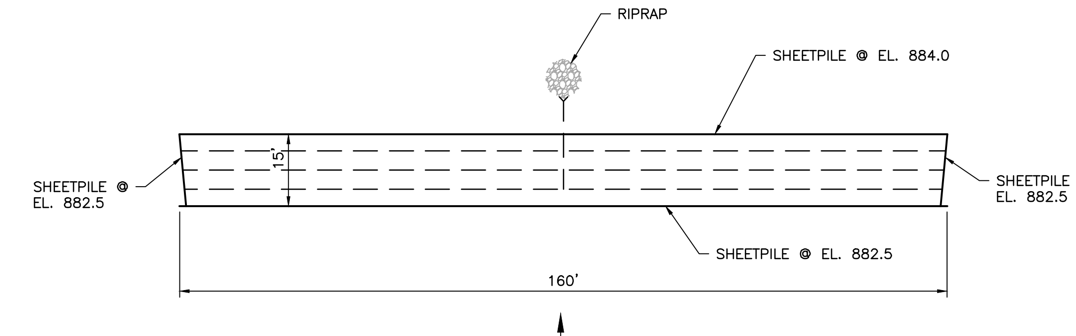
5.3.5 Conceptual Design 5 – Iron-Enhanced Sand Filtration at UAA Location

Conceptual Design 5 is shown in Figure 12. This alternative is in the location proposed in the 2013 UAA Update, near the outlet from LS-2.12. It consists of a mixture of sand and iron filings between two parallel sheetpile weirs. The first weir, at elevation 882.5 feet NAVD88, would control the normal water level in subwatershed LS-2.12. This weir would establish a permanent pool in the wetland and ensure that the layer of iron-enhanced sand is above the ordinary high water level of Lake Susan—reducing the potential for the iron layer to become anoxic and release phosphorus. The second weir, at elevation 884.0 feet NAVD88, would allow high flows to bypass the filtration system. An underdrain between the two weirs would serve as the primary outlet from the filtration system.

The filtration system was sized for a minimum 20-30-minute contact time with the iron-enhanced sand, with a proposed maximum discharge rate of 2.6 cfs. This would treat roughly 75 percent of the flow passing through this location.

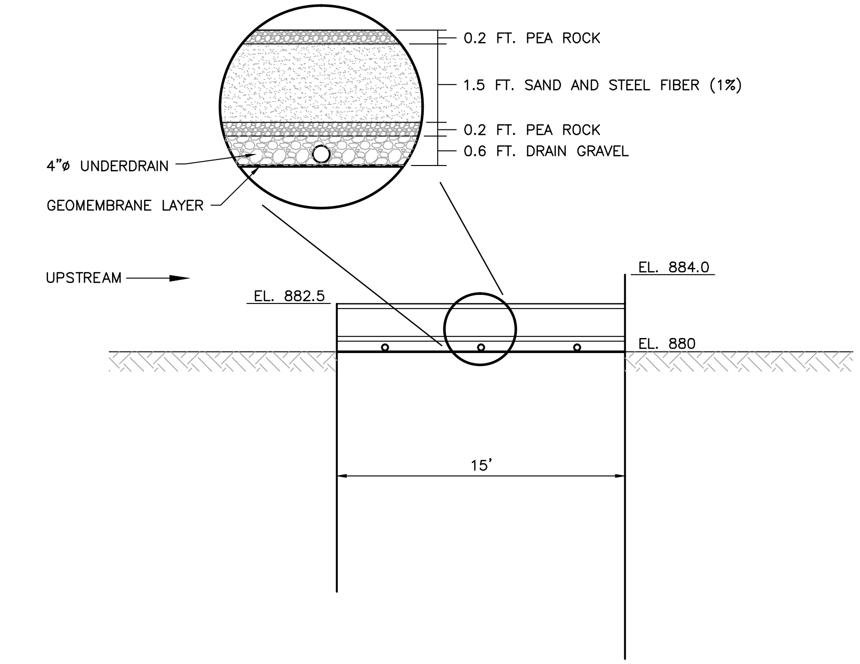
1 PLAN

0 40 80 SCALE IN FEET



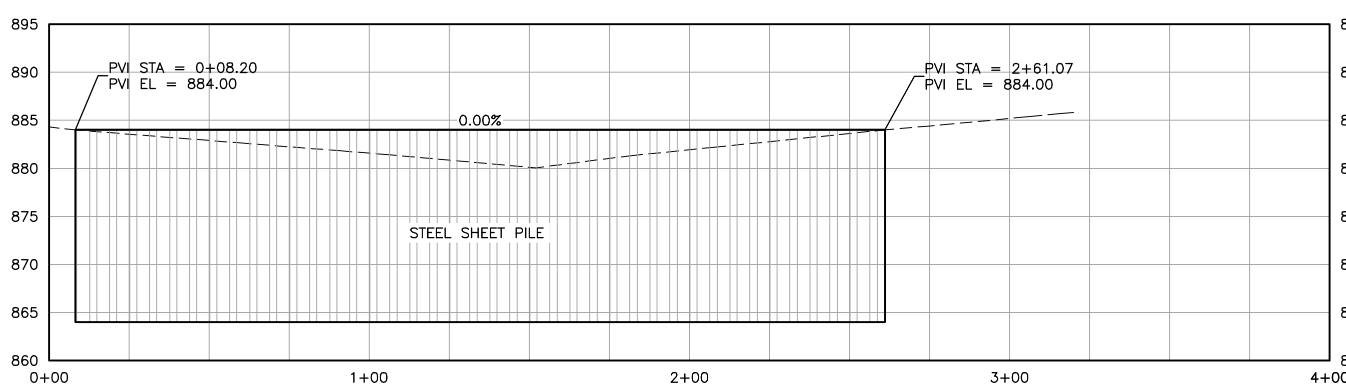
4 PLAN:

0 20 40 SCALE IN FEET



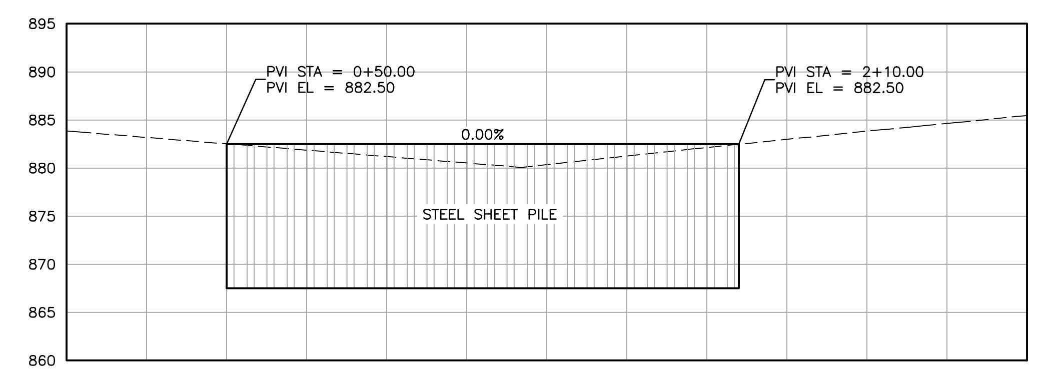
5 SECTION:

0 5 10 SCALE IN FEET



2 PROFILE: SHEET WALL TOP EL. 884.00

0 30 60 HORIZ. SCALE IN FEET — 0 10 20 VERT. SCALE IN FEET



3 PROFILE: SHEET WALL TOP EL. 882.5

0 30 60 HORIZ. SCALE IN FEET — 0 10 20 VERT. SCALE IN FEET

PRELIMINARY DRAFT
NOT FOR CONSTRUCTION

CADD USER: Greg Nelson FILE: M:\DESIGN\23270053.14\23270053.14_SHEET_ENHANCED SAND_SHEET WALL.DWG PLOT SCALE: 1:2 PLOT DATE: 7/17/2014 7:08 PM
Xrefs in Drawing – M:\Design\23270053.14\23270053.14_Lake Susan BMP Survey Base.dwg
.dgn M:\Design\23270053.14\23270053.14_SHEET_Enhanced Sand_Sheet Wall.dwg Plot at 0 07/17/2014 18:56:44

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

SIGNATURE ____
PRINTED NAME ____
DATE ____ REG. NO. ____

RELEASED TO/FOR	A	B	C	0	1	2	3
DATE RELEASED							

BARR
Corporate Headquarters: Minneapolis, Minnesota Ph: 1-800-632-2277

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Scale	AS SHOWN
Date	7/17/2014
Drawn	GGN/RLG
Checked	
Designed	BARR
Approved	

RILEY PURGATORY
BLUFF CREEK WATERSHED DISTRICT

LAKE SUSAN STORMWATER TREATMENT SYSTEM

IRON ENHANCED SAND TREATMENT SYSTEM

BARR PROJECT No. 23/27-0053.14
CLIENT PROJECT No.

Figure 12 REV. No.

5.3.5.1 Regulatory Approval

The permits required for Conceptual Design 5 will be similar to the permits required for Conceptual Design 1, discussed in Section 5.3.1.1.

The U.S. Army Corps of Engineers (USACE) regulates the placement of fill material into wetlands which are hydraulically connected or adjacent to a navigable or interstate water under the authority of Section 404 of the Clean Water Act. If the USACE has jurisdiction over any portion of a project, they may also review impacts to isolated wetlands under the authority of the National Environmental Policy Act. The conceptual design includes placement of fill material within an existing wetland, so a permit will be required from the USACE for Conceptual Design 5.

5.3.5.2 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the City of Chanhassen. During construction, access to the site would be via the city trail. No residential properties should be permanently affected by the proposed stormwater BMP, as shown in Figure 13.

Figure 13 **Affected properties for Conceptual Design 5**

5.3.5.3 Wetland and Upland Impacts

A wetland delineation was not performed near the location of Conceptual Design 5 as part of the feasibility evaluation. However, based on the National Wetland Inventory (NWI), much of this site appears to be classified as a wetland. If Conceptual Design 5 is selected, a wetland delineation will need to be completed during the next phase of design. Based on the available information, it is estimated that wetland impacts for this conceptual design will be approximately 0.3 acres.

The City of Chanhassen is the wetland permitting authority for this project. The wetland located in subwatershed LS-2.12 is classified by the city as Manage 1 wetland and the applicable wetland management guidelines are similar to Conceptual Design 1, discussed in Section 5.3.1.3.

Table 8 summarizes the City of Chanhassen wetland management guidelines for Conceptual Design 5. Conceptual Design 5 will raise the outlet elevation from the wetland in LS-2.12 by approximately 2.5 feet to elevation 882.5 feet NAVD88. However, the normal water level would be contained within the existing drainage way, and it is not anticipated that the modification would change the existing functions, values, or wildlife habitat of the wetland.

Table 8 Summary of wetland management guidelines for Conceptual Design 5

Parameter	Management Guideline	Conceptual Design 5 Impact
Elevation bounce for the 10-year event	Existing conditions +0.5 feet	2.8 ft
Inundation duration for the 1-year event	Existing conditions +1 day	Within 1.7 ft after 1 day[1]
Inundation duration for the 2-year event	Existing conditions +1 day	Within 1.9 ft after 1 day[1]
Inundation duration for the 10-year event	Existing conditions +7 days	Within 1.2 ft after 7 days[1]
Runout control	No change	2.5 ft[1]
Hydrology	Maintain existing	No change to existing inflow
Increase in 100-year flood elevation[2]	-	0 ft
Change in average water surface elevation over 10-year simulation period in upstream wetland[3]	-	N/A

1 – Conceptual design will not likely change the existing functions, values, or wildlife habitat of the wetland. If this is the selected alternative, additional coordination will be required with the City of Chanhassen during the next phase of design to ensure the final design satisfies the intent of the city's wetland management guidelines.

2 – Elevation bounce for the 100-year event was checked as part of the evaluation; this, however, is not specifically listed as a wetland management guideline in the City of Chanhassen SWMP.

3 – The average water surface elevation in the wetland for existing conditions is determined by the water surface elevation in Lake Susan, which is not modeled in P8. Therefore, an average change in elevation over the simulation period could not be determined.

Based on NWI wetland delineation, it is not anticipated that Conceptual Design 5 would have significant impacts to upland vegetation. The footprint for the iron-enhanced filtration system would remove approximately 0.1acres of existing dense brush. However, if this is the selected conceptual design, a detailed site survey would be required to identify trees and existing upland vegetation that would be impacted. A wetland delineation would also be required at this site.

5.3.5.4 Water Quality Improvements

Similar to Conceptual Design 1, the calibrated P8 model for existing conditions developed for the 2013 UAA Update by Wenck Associates was used to define the phosphorus loading within the watershed and is discussed in Section 5.3.1.4.

The performance of Conceptual Design 5 was evaluated using the same P8 model, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals. The performance of the conceptual design was evaluated for a 10-year period, including the calendar years 2003 through 2012. The estimated average annual total phosphorus removal for Conceptual Design 5 was 53 pounds/year.

5.3.5.5 Engineer's Opinion of Probable Cost

The Engineer's opinion of probable cost is reported as a range. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design, the cost range for construction, planning engineering and design, permitting, construction management, and contingency is $592,000 to $1,035,000. Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 5.

The Engineer's opinion of probable cost is higher than the planning estimate included in the 2013 UAA Update of approximately $252,000. The primary difference between the estimates is the quantity of sheetpile that will be installed to construct the iron-enhanced sand filtration system. The 2013 UAA Update assumes the BMP can be constructed with only 1,750 square feet of sheetpile. If weir lengths of 160 feet are assumed (for both the weir at elevation 882.5 feet and the weir at elevation 884.0 feet NAVD88), this equates to an average sheetpile depth of 5.5 feet. This relatively shallow depth may be sufficient for normal flow conditions. However, during large rainfall events this depth may not be sufficient to withstand the additional force resulting from the higher water surface elevation in wetland LS-2.12.

To develop the Engineer's opinion of probable cost for this evaluation it was assumed that a depth of 20 feet would be required. Soil borings and a geotechnical evaluation were not completed during this evaluation and will be required during the next phase of design to determine adequate sheetpile depth.

5.4 Conceptual Design Summary

Table 9 summarizes the estimated annual total phosphorus removal, site impacts, and Engineer's opinion of probable cost for each of the five conceptual designs considered.

Table 9 Summary of Lake Susan water quality management projects

Conceptual Design	Estimated Annual TP Reduction (lbs/yr)[1]	Wetland Impacts (acre)	Upland Impacts (acre)	Engineer's Opinion of Probable Cost ($)	Annual Cost per Pound TP Removed ($/lbs TP/yr)[2]
Conceptual Design 1 Woodchip Bioreactor (West Location)	32	<0.1	0.2	$111,000 - $194,000	$150 - $240
Conceptual Design 2 Woodchip Bioreactor (East Location)	32	<0.1	0.3	$107,000 - $187,000	$150 - $230
Conceptual Design 3 Iron-Enhanced Filtration	22	<0.1	0.2	$194,000 - $339,000	$350 - $580
Conceptual Design 4 Spent-Lime Treatment System	45	<0.1	0.1	$160,000 - $280,000	$140 - $230
Conceptual Design 5 Iron-Enhanced Filtration (2013 UAA Update Location)	53	~0.3[3]	~0.1[3]	$592,000 - $1,035,000	$400 - $670

1 – Estimated annual total phosphorus (TP) reduction is the removal with the BMP, the BMP performance was evaluated over a 10-year period (2003-2012). Additional removals in the upstream wetland through settling or infiltration are not included.

2 – Based on a 30-year period. Includes estimated costs for permitting, engineering, and construction; and estimated annual operation and maintenance costs of $1000/year.

3 – Approximate values based on available information. If this is the selected conceptual design, a wetland delineation is required during the next design phase to determine the impacted area.

The woodchip bioreactors require a relatively long residence time (i.e., minimum of 12 hours). To achieve the required residence time a large BMP footprint is necessary; subsequently, the site impacts are also larger. The impacts are generally located immediately adjacent to the trail and include removal of dense brush and trees, which cannot be replaced following construction without impacting the ability of the bioreactor to function as designed.

By comparison, the iron-enhanced sand filters require a shorter residence time (i.e., 20–30 minutes). During extended periods of constant flow, however, the filtration media may become anoxic and release phosphorus. Therefore, iron-enhanced sand filters are designed to draw down the upstream pool within 48 hours to reduce the potential for anoxic conditions. In this location that means the iron-enhanced sand filter must treat a larger peak discharge, which subsequently increases the footprint of the BMP and site impacts.

Of the conceptual designs evaluated, the spent-lime treatment system has the smallest footprint (0.1 acre), taking advantage of the large wetland upstream of the BMP. Water can be stored in the wetland and slowly released for treatment. Since water can be slowly released over a period of days, a smaller BMP footprint is sufficient to treat a larger volume of water. If the spent-lime treatment system (i.e., Conceptual Design 4) is selected, additional optimization of the BMP can be made during the next phase of design to maximize the volume of water treated while minimizing site impacts. The optimization of the design would need to be coordinated with the City of Chanhassen to ensure that the design meets the city's wetland management guidelines.

6.0 Recommendation

Based on the results of the engineering assessment, potential site impacts, and cost per pound of phosphorous removed, Conceptual Design 4 — spent-lime treatment, is recommended as the most feasible BMP. The engineering assessment was based on information collected during a review of available data and preliminary site characterization. Collection of more data and additional site-specific information (e.g., soil borings) that become available in the next stage of design may result in modifications to the proposed configuration, cost, and function of the spent-lime treatment system presented in this report.

Conceptual Design 4 is a necessary and feasible project, consistent with the Plan (as amended). This BMP meets the intent of the water quality goals of the District without causing adverse impacts to natural resources in the area and will help improve and protect the water quality in Lake Susan and waters located downstream, including Rice Marsh Lake, Lake Riley, and Riley Creek.

The cost for the design, permitting, and construction of Conceptual Design 4 is estimated at $160,000 to $280,000. As plans and specifications for the recommended conceptual design are prepared, the District should continue to consult with City of Chanhassen staff about plan details.

Additionally, it is recommended that the RPBCWD monitor the spent-lime treatment system for 2 to 4 years after construction. This monitoring will be used to optimize the system and evaluate the pollutant removal performance under typical annual variations.

7.0 References

American Society for Testing and Materials. 2006. ASTM E2516-06 Standard Classification for Cost Estimate Classification System. ASTM International, West Conshohocken, PA, DOI: 10.1520/E2516-06

Association for the Advancement of Cost Estimating. 2005. *AACE International Recommended Practice NO. 18R-97*, February 2, 2005.

Barr Engineering. 1999. Susan and Rice marsh Lake Use Attainability Analysis. Prepared for the Riley-Purgatory-Bluff Creek Watershed District.

CH2M Hill. 2011(Amended April, 2014). Water Management Plan. Prepared for Riley-Purgatory-Bluff Creek Watershed District.

Christianson, Laura; Helmers, Matthew. Woodchip Bioreactors for Nitrate in Agricultural Drainage. Iowa State University Extension and Outreach. October, 2011.

Erickson, A.J., Gulliver, J.S., and P.T. Weiss. 2012. *Capturing phosphates with iron enhanced sand filtration*. Water Research. Vol. 26, pp. 3032-3042.

MPCA. 2014. Minnesota Stormwater Manual. Iron enhanced sand filter (Minnesota Filter). http://stormwater.pca.state.mn.us/index.php/Iron_enhanced_sand_filter_%28Minnesota_Filter%29. Accessed on July 17, 2014

Ranaivoson, Andry; Moncrief, John; Dittrich, Mark; Chander, Yogesh; Rice, Pam. Anaerobic Woodchip Bioreacotrs Under Minnesota Conditions. Unversity of Minnesota St. Paul, Minnesota Department of Agriculture, ARS-USDA St. Paul. (Presentation provided by Andry, June 2014)

SEH. 2006. Surface Water Management Plan. Prepared for City of Chanhassen.

Wenck Associates, Inc. 2014. Lake Susan Use Attainability Assessment (UAA) Update, July 2014. Prepared for Riley-Purgatory-Bluff Creek Watershed District.

Appendix A

Engineer's Opinion of Probable Cost

1.0 Cost Estimate

Engineer's opinions of probable costs for design, permitting, and construction were developed for each conceptual design. These opinions of costs, project reserves, contingency, documentation and discussion are intended to provide background information for feasibility alternatives assessment, analysis purposes and budget authorization by the RPBCWD. The cost of time escalation is not included in the opinions of probable cost. All costs are presented in 2014 US dollars.

Quantities were estimated with calculations based on available information presented in previous sections. Dimensions, areas, and volumes for construction were determined using the topographic survey and CAD software.

Unit costs are based on recent bid prices, published construction cost index resources, and similar stormwater BMP projects. Unit process were developed and compared to similar project prices. Costs associated with Base Planning Engineering and Design (PED) are based on percentages of estimated construction cost and are within a range similar to those used in past projects designed by Barr. Costs associated with Construction Management (CM) are based on estimated costs to manage the construction process, based on Barr's experience with similar projects, but may change depending on the services that are provided during construction. The estimates also include Permitting and Regulatory Approvals, which is intended to account for additional planning, coordination, and mitigation costs that are likely to be incurred as the project is permitted with environmental agencies.

The opinions of cost include tasks and items related to engineering and design, permitting, and constructing each conceptual design. The opinions of cost do not include other tasks following construction of each alternative presented such as operations and maintenance, or monitoring.

Contingency used in these opinions of probable cost are intended to help identify an estimated construction cost amount for the minor items included in the current Project scope, but have not yet been quantified or estimated directly during the feasibility evaluation. Stated another way, contingency is the resultant of the pluses and minuses that cannot be estimated at the level of project definition that exists. The contingency includes the cost of ancillary items not currently itemized in the quantity summaries but commonly identified in more detailed design and required for completeness of the work. A 25% contingency is applied to the estimated construction cost to account for the costs of these items.

Industry resources for cost estimating (*AACE International Recommended Practice No. 18R-97, and ASTM E2516-06 Standard Classification for Cost Estimate Classification System*) provide guidance on cost uncertainty, depending on the level of project design developed. The opinion of probable cost for the alternatives evaluated generally corresponds to a Class 3 estimate characterized by completion of limited engineering and use of deterministic estimating methods. As the level of design detail increases, the level of uncertainty is reduced. Figure A-1 provides a graphic representation of how uncertainty (or accuracy) of cost estimates can be expected to improve as more detailed design is developed.

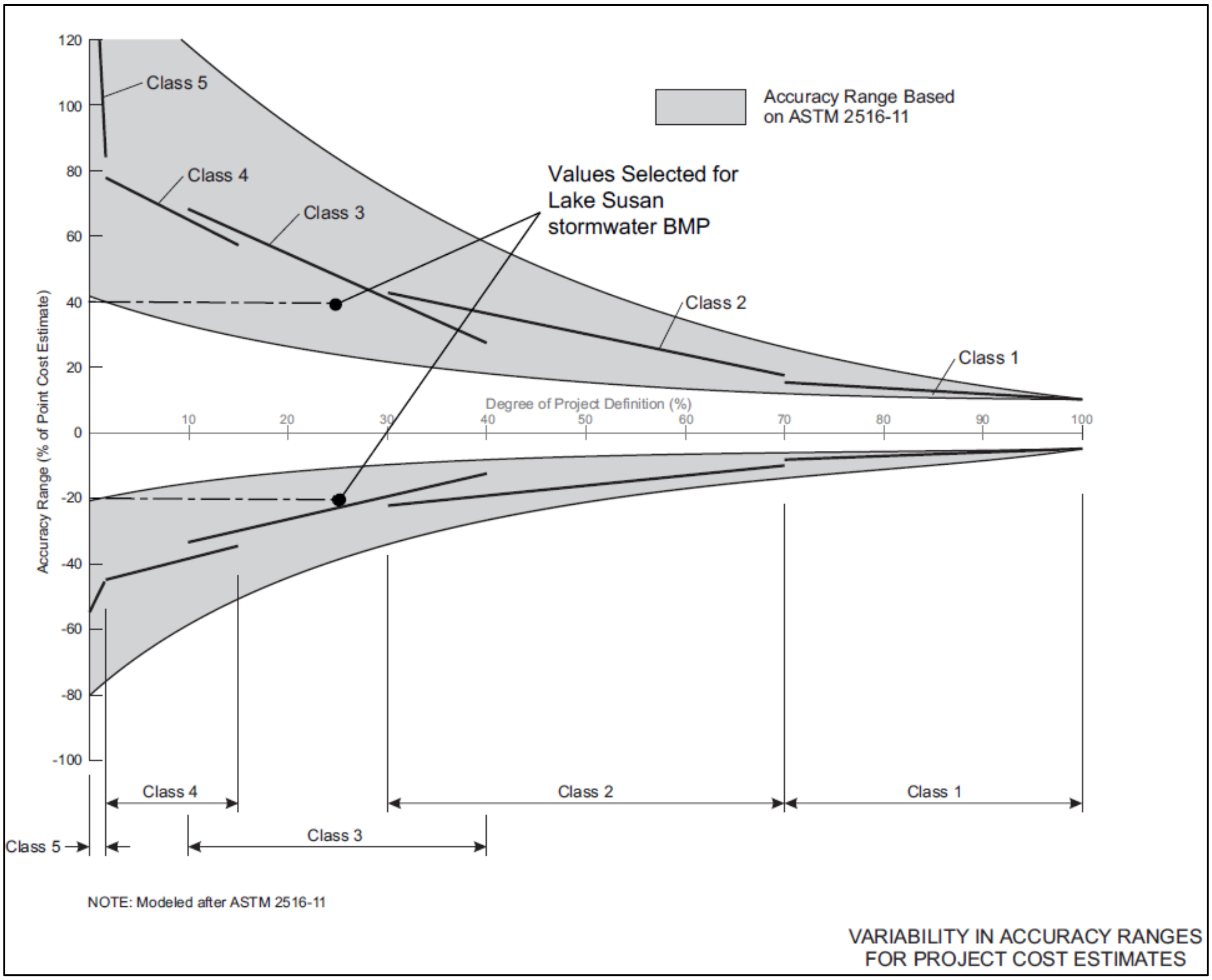

Figure A-1 Relationship between Cost Accuracy and Degree of Project Definition

At this early stage of design, the range of uncertainty of total project cost is high. Due to the early stage of design, it is standard practice to place a broad accuracy range around the point cost estimate.

The accuracy range is based on professional judgment considering the level of design completed, the complexity of the project, and the uncertainties in the project scope; the accuracy range does not include costs for future scope changes that are not part of the project as currently defined or risk contingency. The estimated accuracy range for this point estimate is -20% to +40%.

The opinion of probable cost provided in this memorandum is made on the basis of Barr Engineering's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. It is acknowledged that additional investigations and additional site specific information that becomes available in the next stage of design may result in changes to the proposed configuration, cost and functioning of project features. This opinion is based on project-related information available to Barr Engineering at this time and includes a conceptual-level feasibility design of the project. The opinion of cost may change as more information becomes available and further design is completed. In addition, because we have no control over the eventual cost of labor, materials, equipment or services furnished by others, or over the contractor's methods of determining prices, or over competitive bidding or market conditions, Barr Engineering cannot and does not guarantee that proposals, bids, or actual costs will not vary from the opinion of probable cost presented in this memorandum. If the RPBCWD wishes greater assurance as to the probable project cost, the RPBCWD should authorize further investigation and design of a selected alternative.

Table A-1 provides a comparison of the opinion of costs for each of the five alternatives. These costs assume that all work will be completed within City owned parcels and no purchase of additional easements will be required. Table A-2 through Table A-6 include opinion of cost for each design alternative.

Table A-1 Engineer's Opinion of Probable Cost – Feasibility Estimate Summary

Alternative	Engineer's Opinion of Cost ($)
Conceptual Design 1 – Woodchip Bioreactor (West Location)	$111,000 - $194,000
Conceptual Design 2 – Woodchip Bioreactor (East Location)	$107,000 - $187,000
Conceptual Design 3 Iron Enhanced Filtration	$194,000 - $339,000
Conceptual Design 4 – Spent Lime Treatment System	$160,000 - $280,000
Conceptual Design 5 – Iron Enhanced Filtration at UAA Location	$592,000 - $1,035,000

The opinions of costs above do not include the cost to monitor the stormwater BMP following construction. Monitoring of the system will help optimize and estimate the performance of the system. The proposed monitoring set-up for the stormwater BMP system would include monitoring of flows and water quality into the system, as well as monitoring flows and water quality leaving the system after treatment. The planning level cost for each automated monitoring system is $15,000 to $20,000 per station (two (2) stations would be required to monitor inflow and outflow). These planning level costs include continuous flow and pH monitoring and composite water quality sampling. The composite water quality sampling should focus on nutrients (total phosphorus, total dissolved phosphorus, and orthophosphate), and total suspended sediments. Assuming that 20 storm events are sampled during the growing season, the estimated analytical laboratory costs would be approximately $4,200 per year (based on 2014 analytical laboratory costs). These planning level costs for the monitoring of the stormwater BMP assume that the monitoring systems will be installed and maintained by RPBCWD staff and do not include any additional time or expenses for consulting services.

2.0 References

American Society for Testing and Materials. 2006. ASTM E2516-06 Standard Classification for Cost Estimate Classification System. ASTM International, West Conshohocken, PA, DOI: 10.1520/E2516-06

Association for the Advancement of Cost Estimating. 2005. *AACE International Recommended Practice NO. 18R-97*, February 2, 2005.

Table A-2 Engineer's Opinion of Probable Project Cost: Conceptual Design 1 - Woodchip Bioreactor (West Location)

PREPARED BY: BARR ENGINEERING COMPANY	REV 1	SHEET:	1	OF	5
		BY:	GGN	DATE:	7/17/2014
PRELIMINARY ENGINEERING REPORT		CHECKED BY:	BJB	DATE:	7/20/2014
ENGINEER'S OPINION OF PROBABLE PROJECT COST		APPROVED BY:		DATE:	
PROJECT: Lake Susan Stormwater BMP	ISSUED:			DATE:	
LOCATION: City of Chanhassen, MN	ISSUED:			DATE:	
PROJECT #: 23/27-0053.14-008	ISSUED:			DATE:	
OPINION OF COST - SUMMARY	ISSUED:			DATE:	

Engineer's Opinion of Probable Project Cost
Conceptual Design 1 – Woodchip Bioreactor (WestLocation)
Lake Susan Stormwater BMP

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
A	Mobilization/Demobilization	L.S.	1	$11,800.00	$11,800.00	1,2,3,4,5
B	Rock Erosion Control Construction Entrance	Each	1	$1,200.00	$1,200.00	1,2,3,4,5
C	Clearing & Grubbing	Acre	0.2	$7,000.00	$1,260.00	1,2,3,4,5
D	Remove Select Tree	Each	6	$325.00	$1,950.00	1,2,3,4,5
E	Erosion Control Silt Fence	L.F.	700	$2.75	$1,925.00	1,2,3,4,5
F	Erosion Control Blanket	S.Y.	1000	$3.00	$3,000.00	1,2,3,4,5
G	Riprap, MnDot Class III w/Type IV Geotextile	Ton	4	$75.00	$315.00	1,2,3,4,5
H	Remove/Replace Ex. Bit. Walk Path	S.Y.	10	$25.00	$250.00	1,2,3,4,5
I	Trench Excavation and offsite disposal	C.Y.	526	$30.00	$15,780.00	1,2,3,4,5
J	Site Restoration (Seed & Mulch)	Acre	0.2	$4,000.00	$720.00	1,2,3,4,5
K	Ex. 72" Control Structure Modification	Each	1	$7,000.00	$7,000.00	1,2,3,4,5
L	6" PVC Storm Sewer	L.F.	90	$7.00	$630.00	1,2,3,4,5
M	Outlet Control Structure (Agri-Drain)	Each	1	$1,800.00	$1,800.00	1,2,3,4,5
N	Wood Chips	C.Y.	324	$15.00	$4,860.00	1,2,3,4,5
O	Backfill and Grading (Excav. Borrow)	C.Y.	202	$10.00	$2,020.00	1,2,3,4,5
P	Connect 6" PVC to Ex. Structure	Each	1	$1,500.00	$1,500.00	1,2,3,4,5
AA	Dewatering	L.S.	1	$15,000.00	$15,000.00	1,2,3,4,5
	CONSTRUCTION SUBTOTAL				$71,000.00	1,2,3,4,5,8
	CONSTRUCTION CONTINGENCY (25%)				$18,000.00	1,5,8
	ESTIMATED CONSTRUCTION COST				$89,000.00	1,2,3,4,5,8
	PLANNING, ENGINEERING & DESIGN (30%)				$32,000.00	1,2,3,4,5,8
	PERMITTING & REGULATORY APPROVALS				$8,000.00	1,5,6,8
	CONSTRUCTION MANAGEMENT (10%)				$9,000.00	1,5,8
	ESTIMATED TOTAL PROJECT COST				$138,000.00	1,2,3,4,5,7,8
	ESTIMATED ACCURACY RANGE	**-20%**			**$111,000.00**	5,7,8
		40%			**$194,000.00**	5,7,8

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, and Limited Field Investigation Completed.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required, and only permit required is from the City of Chanhassen, MN.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-3 Engineer's Opinion of Probable Project Cost: Conceptual Design 2 - Woodchip Bioreactor (East Location)

PREPARED BY: BARR ENGINEERING COMPANY	REV 1	SHEET:	2	OF	5
		BY:	GGN	DATE:	7/17/2014
PRELIMINARY ENGINEERING REPORT		CHECKED BY:	BJB	DATE:	7/20/2014
ENGINEER'S OPINION OF PROBABLE PROJECT COST		APPROVED BY:		DATE:	
PROJECT: Lake Susan Stormwater BMP	ISSUED:			DATE:	
LOCATION: City of Chanhassen, MN	ISSUED:			DATE:	
PROJECT #: 23/27-0053.14-008	ISSUED:			DATE:	
OPINION OF COST - SUMMARY	ISSUED:			DATE:	

Engineer's Opinion of Probable Project Cost
Conceptual Design 2 – Woodchip Bioreactor (East Location)
Lake Susan Stormwater BMP

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
A	Mobilization/Demobilization	L.S.	1	$11,300.00	$11,300.00	1,2,3,4,5
B	Rock Erosion Control Construction Entrance	Each	1	$1,200.00	$1,200.00	1,2,3,4,5
C	Clearing & Grubbing	Acre	0.2	$7,000.00	$1,470.00	1,2,3,4,5
D	Remove Select Tree	Each	0	$325.00	$0.00	1,2,3,4,5
E	Erosion Control Silt Fence	L.F.	390	$2.75	$1,072.50	1,2,3,4,5
F	Erosion Control Blanket	S.Y.	945	$3.00	$2,835.00	1,2,3,4,5
G	Riprap, MnDot Class III w/Type IV Geotextile	Ton	4	$75.00	$315.00	1,2,3,4,5
H	Remove/Replace Ex. Bit. Walk Path	S.Y.	10	$25.00	$250.00	1,2,3,4,5
I	Trench Excavation and disposal offsite	C.Y.	546	$30.00	$16,380.00	1,2,3,4,5
J	Site Restoration (Seed & Mulch)	Acre	0.2	$4,000.00	$840.00	1,2,3,4,5
K	Ex. 72" Control Structure Modification	Each	1	$7,000.00	$7,000.00	1,2,3,4,5
L	6" PVC Storm Sewer	L.F.	35	$7.00	$245.00	1,2,3,4,5
M	Outlet Control Structure (Agri-Drain)	Each	1	$1,800.00	$1,800.00	1,2,3,4,5
N	Wood Chips	C.Y.	254	$15.00	$3,810.00	1,2,3,4,5
O	Backfill and Grading (Excav. Borrow)	C.Y.	292	$10.00	$2,920.00	1,2,3,4,5
P	Connect 6" PVC to Ex. Structure	Each	1	$1,500.00	$1,500.00	1,2,3,4,5
AA	Dewatering	L.S.	1	$15,000.00	$15,000.00	1,2,3,4,5
	CONSTRUCTION SUBTOTAL				$68,000.00	1,2,3,4,5,8
	CONSTRUCTION CONTINGENCY (25%)				$17,000.00	1,5,8
	ESTIMATED CONSTRUCTION COST				$85,000.00	1,2,3,4,5,8
	PLANNING, ENGINEERING & DESIGN (30%)				$31,000.00	1,2,3,4,5,8
	PERMITTING & REGULATORY APPROVALS				$8,000.00	1,5,6,8
	CONSTRUCTION MANAGEMENT (10%)				$9,000.00	1,5,8
	ESTIMATED TOTAL PROJECT COST				$133,000.00	1,2,3,4,5,7,8
	ESTIMATED ACCURACY RANGE	**-20%**			**$107,000.00**	5,7,8
		40%			**$187,000.00**	5,7,8

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, and Limited Field Investigation Completed.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required, and only permit required is from the City of Chanhassen, MN.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-4 Engineer's Opinion of Probable Project Cost: Conceptual Design 3 - Iron Enhanced Sand Filtration

PREPARED BY: BARR ENGINEERING COMPANY	REV 1	SHEET:	3	OF		5
		BY:	GGN		DATE:	7/17/2014
PRELIMINARY ENGINEERING REPORT		CHECKED BY:	BJB		DATE:	7/20/2014
ENGINEER'S OPINION OF PROBABLE PROJECT COST		APPROVED BY:			DATE:	
PROJECT: Lake Susan Stormwater BMP	ISSUED:				DATE:	
LOCATION: City of Chanhassen, MN	ISSUED:				DATE:	
PROJECT #: 23/27-0053.14-008	ISSUED:				DATE:	
OPINION OF COST - SUMMARY	ISSUED:				DATE:	

Engineer's Opinion of Probable Project Cost
Conceptual Design 3– Iron Enhanced Sand Filtration
Lake Susan Stormwater BMP

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
A	Mobilization/Demobilization	L.S.	1	$21,800.00	$21,800.00	1,2,3,4,5
B	Rock Erosion Control Construction Entrance	Each	1	$1,200.00	$1,200.00	1,2,3,4,5
C	Clearing & Grubbing	Acre	0.2	$7,000.00	$1,400.00	1,2,3,4,5
E	Erosion Control Silt Fence	L.F.	400	$2.75	$1,100.00	1,2,3,4,5
F	Erosion Control Blanket	S.Y.	975	$3.00	$2,925.00	1,2,3,4,5
G	Riprap, MnDot Class III w/Type IV Geotextile	Ton	5	$75.00	$375.00	1,2,3,4,5
H	Remove/Replace Ex. Bit. Walk Path	S.Y.	10	$25.00	$250.00	1,2,3,4,5
I	Common Excavation and disposal offsite	C.Y.	1038	$30.00	$31,140.00	1,2,3,4,5
J	Site Restoration (Seed & Mulch)	Acre	0.2	$4,000.00	$800.00	1,2,3,4,5
K	Ex. 72" Control Structure Modification	Each	1	$7,000.00	$7,000.00	1,2,3,4,5
L	24" PVC Storm Sewer	L.F.	75	$70.00	$5,250.00	1,2,3,4,5
O	Backfill and Grading (Excav. Borrow)	C.Y.	250	$10.00	$2,500.00	1,2,3,4,5
P	Connect 24" PVC to Ex. Structure	Each	1	$1,500.00	$1,500.00	1,2,3,4,5
S	Geomembrane Liner	S.Y.	385	$2.50	$962.50	1,2,3,4,5
T	4" Under Drain Perforated Pipe	L.F.	295	$12.00	$3,540.00	1,2,3,4,5
U	Under Drain Fittings & Appurtanances	L.S.	1	$1,000.00	$1,000.00	1,2,3,4,5
V	Import Iron Enhanced Sand	Ton	12	$1,650.00	$19,800.00	1,2,3,4,5
W	Clean Washed Sand	Ton	240	$32.00	$7,680.00	1,2,3,4,5
X	Pea Rock	C.Y.	17	$38.00	$646.00	1,2,3,4,5
AA	Dewatering	L.S.	1	$15,000.00	$15,000.00	1,2,3,4,5
AB	4' Diameter Monitoring Manhole, complete	Each	1	$3,500.00	$3,500.00	1,2,3,4,5
AC	Gate Valve	Each	1	$1,500.00	$1,500.00	1,2,3,4,5
	CONSTRUCTION SUBTOTAL				$131,000.00	1,2,3,4,5,8
	CONSTRUCTION CONTINGENCY (25%)				$33,000.00	1,5,8
	ESTIMATED CONSTRUCTION COST				$164,000.00	1,2,3,4,5,8
	PLANNING, ENGINEERING & DESIGN (30%)				$54,000.00	1,2,3,4,5,8
	PERMITTING & REGULATORY APPROVALS				$8,000.00	1,5,6,8
	CONSTRUCTION MANAGEMENT (10%)				$16,000.00	1,5,8
	ESTIMATED TOTAL PROJECT COST				$242,000.00	1,2,3,4,5,7,8
	ESTIMATED ACCURACY RANGE	**-20%**			**$194,000.00**	5,7,8
		40%			**$339,000.00**	5,7,8

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, and Limited Field Investigation Completed.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required, and only permit required is from the City of Chanhassen, MN.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-5 Engineer's Opinion of Probable Project Cost: Conceptual Design 4 - Spent Lime Treatment

PREPARED BY: BARR ENGINEERING COMPANY	REV 1	SHEET:	4	OF	5
BARR		BY:	GGN	DATE:	7/17/2014
PRELIMINARY ENGINEERING REPORT		CHECKED BY:	BJB	DATE:	7/20/2014
ENGINEER'S OPINION OF PROBABLE PROJECT COST		APPROVED BY:		DATE:	
PROJECT: Lake Susan Stormwater BMP	ISSUED:			DATE:	
LOCATION: City of Chanhassen, MN	ISSUED:			DATE:	
PROJECT #: 23/27-0053.14-008	ISSUED:			DATE:	
OPINION OF COST - SUMMARY	ISSUED:			DATE:	

Engineer's Opinion of Probable Project Cost
Conceptual Design 4– Spent Lime Treatment System
Lake Susan Stormwater BMP

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
A	Mobilization/Demobilization	L.S.	1	$17,900.00	$17,900.00	1,2,3,4,5
B	Rock Erosion Control Construction Entrance	Each	1	$1,200.00	$1,200.00	1,2,3,4,5
C	Clearing & Grubbing	Acre	0.1	$7,000.00	$490.00	1,2,3,4,5
E	Erosion Control Silt Fence	L.F.	270	$2.75	$742.50	1,2,3,4,5
F	Erosion Control Blanket	S.Y.	145	$3.00	$435.00	1,2,3,4,5
G	Riprap, MnDot Class III w/Type IV Geotextile	Ton	5	$75.00	$375.00	1,2,3,4,5
H	Remove/Replace Ex. Bit. Walk Path	S.Y.	10	$25.00	$250.00	1,2,3,4,5
I	Common Excavation and Disposal offsite	C.Y.	120	$30.00	$3,600.00	1,2,3,4,5
J	Site Restoration (Seed & Mulch)	Acre	0.1	$4,000.00	$280.00	1,2,3,4,5
K	Ex. 72" Control Structure Modification	Each	1	$7,000.00	$7,000.00	1,2,3,4,5
L	12" PVC Storm Sewer	L.F.	50	$40.00	$2,000.00	1,2,3,4,5
M	Outlet Control Structure (Agri-Drain)	Each	1	$1,800.00	$1,800.00	1,2,3,4,5
O	Backfill and Grading (Excav. Borrow)	C.Y.	35	$10.00	$350.00	1,2,3,4,5
P	Connect 12" PVC to Ex. Structure	Each	1	$1,500.00	$1,500.00	1,2,3,4,5
Q	Precast RC Box Structure	Each	1	$30,000.00	$30,000.00	1,2,3,4,5
R	Fabricated Grate	Each	1	$18,000.00	$18,000.00	1,2,3,4,5
AA	Dewatering	L.S.	1	$15,000.00	$15,000.00	1,2,3,4,5
AB	4' Diameter Monitoring Manhole, complete	Each	1	$3,500.00	$3,500.00	1,2,3,4,5
AC	Gate Valve	Each	1	$1,500.00	$1,500.00	1,2,3,4,5
AD	Haul Spent Lime (St. Paul to Chanhassen)	C.Y.	10	$25.00	$250.00	1,2,3,4,5
AE	Spent Lime	L.S.	1	$1,000.00	$1,000.00	1,2,3,4,5
	CONSTRUCTION SUBTOTAL				$107,000.00	1,2,3,4,5,8
	CONSTRUCTION CONTINGENCY (25%)				$27,000.00	1,5,8
	ESTIMATED CONSTRUCTION COST				$134,000.00	1,2,3,4,5,8
	PLANNING, ENGINEERING & DESIGN (30%)				$45,000.00	1,2,3,4,5,8
	PERMITTING & REGULATORY APPROVALS				$8,000.00	1,5,6,8
	CONSTRUCTION MANAGEMENT (10%)				$13,000.00	1,5,8
	ESTIMATED TOTAL PROJECT COST				$200,000.00	1,2,3,4,5,7,8
	ESTIMATED ACCURACY RANGE	**-20%**			**$160,000.00**	5,7,8
		40%			**$280,000.00**	5,7,8

Notes

1 Limited Design Work Completed (10 - 15%).

2 Quantities Based on Design Work Completed.

3 Unit Prices Based on Information Available at This Time.

4 No Soil Borings Available, and Limited Field Investigation Completed.

5 This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

6 Estimate assumes that wetland mitigation/replacement is not required, and only permit required is from the City of Chanhassen, MN.

7 Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

8 Estimate costs are reported to nearest thousand dollars.

Table A-6 Engineer's Opinion of Probable Project Cost: Conceptual Design 5 - Iron Enhanced Sand Filtration (2013 UAA Update Location)

PREPARED BY: BARR ENGINEERING COMPANY	REV 1	SHEET: 5	OF 5
BARR	BY: GGN		DATE: 7/17/2014
PRELIMINARY ENGINEERING REPORT	CHECKED BY: BJB		DATE: 7/20/2014
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:		DATE:
PROJECT: Lake Susan Stormwater BMP	ISSUED:		DATE:
LOCATION: City of Chanhassen, MN	ISSUED:		DATE:
PROJECT #: 23/27-0053.14-008	ISSUED:		DATE:
OPINION OF COST - SUMMARY	ISSUED:		DATE:

Engineer's Opinion of Probable Project Cost

Conceptual Design 5– Iron Enhanced Sand Filtration (2013 UAA Update Location)

Lake Susan Stormwater BMP

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
A	Mobilization/Demobilization	L.S.	1	$66,000.00	$66,000.00	1,2,3,4,5
B	Rock Erosion Control Construction Entrance	Each	1	$1,200.00	$1,200.00	1,2,3,4,5
E	Erosion Control Silt Fence	L.F.	250.0	$2.75	$687.50	1,2,3,4,5
F	Erosion Control Blanket	S.Y.	500	$3.00	$1,500.00	1,2,3,4,5
G	Riprap, MnDot Class III w/Type IV Geotextile	Ton	5	$75.00	$375.00	1,2,3,4,5
I	Common Excavation and offsite disposal	C.Y.	200	$30.00	$6,000.00	1,2,3,4,5
J	Site Restoration (Seed & Mulch)	Acre	0.4	$4,000.00	$1,480.00	1,2,3,4,5
L	12" PVC Storm Sewer	L.F.	20	$40.00	$800.00	1,2,3,4,5
S	Geomembrane Liner	S.Y.	125.0	$2.50	$312.50	1,2,3,4,5
T	4" Under Drain Perforated Pipe	L.F.	480	$12.00	$5,760.00	1,2,3,4,5
U	Under Drain Fittings & Appurtanances	L.S.	1	$1,000.00	$1,000.00	1,2,3,4,5
V	Import Iron Enhanced Sand	Ton	12	$1,650.00	$19,800.00	1,2,3,4,5
W	Clean Washed Sand	Ton	235	$32.00	$7,520.00	1,2,3,4,5
X	Pea Rock	C.Y.	36	$38.00	$1,368.00	1,2,3,4,5
Y	Drainage Gravel	C.Y.	53	$45.00	$2,385.00	1,2,3,4,5
Z	Steel Sheet Pile	S.F.	7000	$40.00	$280,000.00	1,2,3,4,5
AA	Dewatering	L.S.	1	$15,000.00	$15,000.00	1,2,3,4,5
	CONSTRUCTION SUBTOTAL				$411,000.00	1,2,3,4,5,8
	CONSTRUCTION CONTINGENCY (25%)				$103,000.00	1,5,8
	ESTIMATED CONSTRUCTION COST				$514,000.00	1,2,3,4,5,8
	PLANNING, ENGINEERING & DESIGN (30%)				$154,000.00	1,2,3,5,8
	PERMITTING & REGULATORY APPROVALS				$20,000.00	1,5,6,8
	CONSTRUCTION MANAGEMENT (10%)				$51,000.00	1,5,8
	ESTIMATED TOTAL PROJECT COST				$739,000.00	1,2,3,4,5,7,8
	ESTIMATED ACCURACY RANGE	**-20%**			**$592,000.00**	5,7,8
		40%			**$1,035,000.00**	5,7,8

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, and Limited Field Investigation Completed.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes wetland mitigation accomplished through purchase of credits from a wetland bank. Assumes purchase of 0.5 acres at $20,000/acre. The required wetland mitigation area will be determined during the next phase of design following a field wetland delineation.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.