Bass Lake Drawdown Feasibility Report

Prepared for
Town of St. Joseph (in partnership with the Bass Lake Rehabilitation District)

5/4/2018 DRAFT

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Certifications

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Wisconsin.

	date
Karen Chandler, PE	Date
PE #: 32101-6 (WI)	

1.0 Introduction

Barr was retained by the Town of St. Joseph to conduct a feasibility study for the drawdown of Bass Lake water levels in light of new discharge requirements from the Wisconsin Department of Natural Resources (WDNR), including requirements to manage aquatic invasive species (AIS), including zebra mussels, and manage the discharge water quality such that it meets the requirements established by the WDNR.

The project was funded through several different grants obtained by the Town of St. Joseph, including:

- WDNR Surface Water Grant - Aquatic Invasive Species (AIS) Grant for Education, Prevention, and Planning
- WDNR Surface Water Grant – Large Scale Planning for Lake Management Planning Grant for Surface Water Pumping and Evaluation
- WDNR Surface Water Grant – Large Scale Planning for Lake Management Planning Grant for Groundwater Pumping and Evaluation
- Corridor 64 Storm water/Wastewater Coalition funds

The feasibility study project team included representatives from the following agencies/organizations:

- Town of St. Joseph
- Bass Lake Rehabilitation District (BLRD)
- WDNR
- St. Croix County

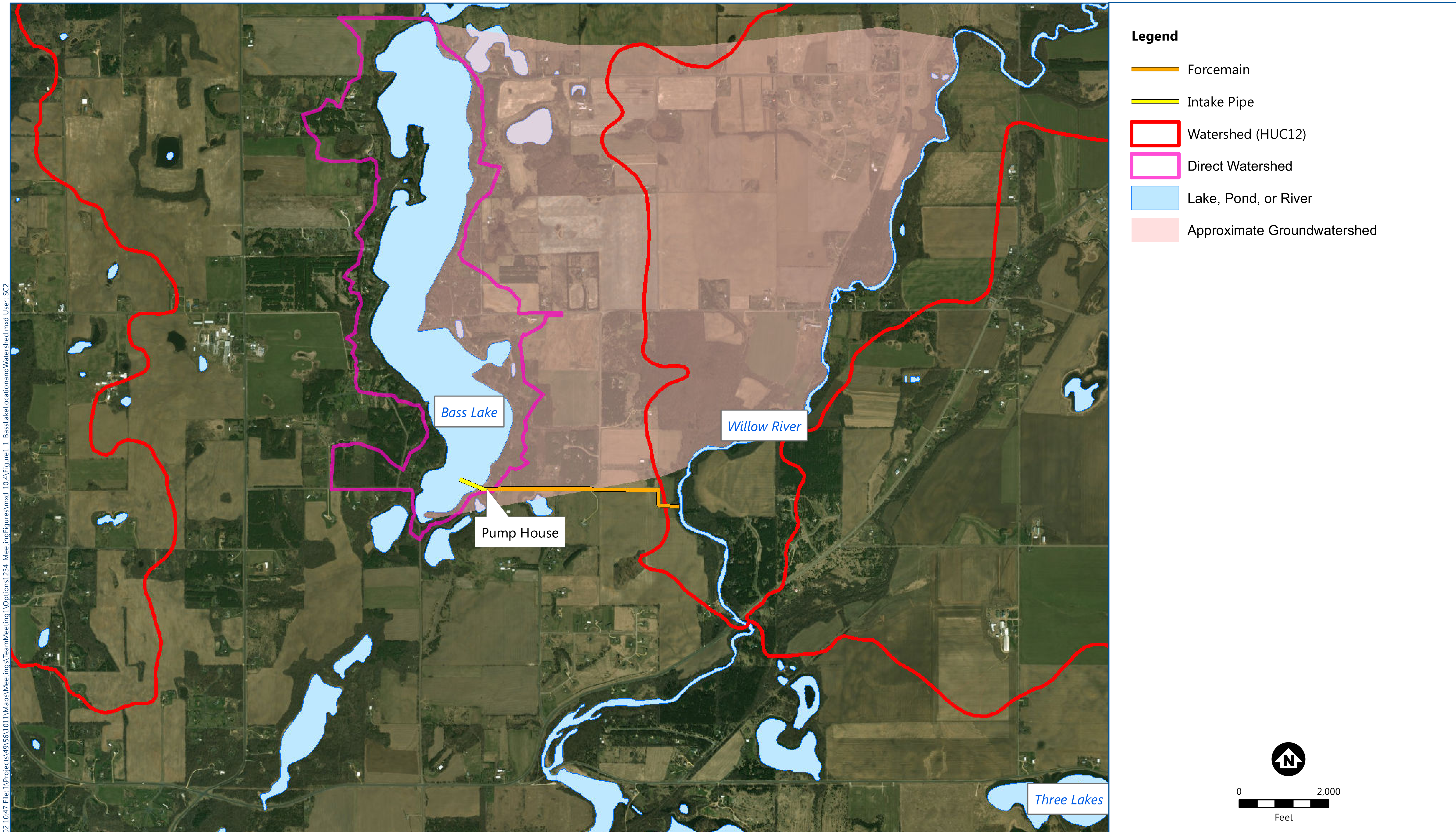
At the project kickoff meeting held on February 12, 2018 at the Town of St. Joseph town hall, Barr reviewed the known information regarding Bass Lake with the feasibility study team. The information is outlined in the following sections. At this meeting, we also discussed the preliminary feasibility options to meet the discharge requirements for zebra mussels and phosphorus to be considered as part of high level review (see further discussion in Section 2.0), as well as the original discharge temperature requirement from the original permit. Appendix A includes the presentation slides from the kickoff meeting.

1.1 Background

Bass Lake is a 370-acre lake located in the Willow River and St. Croix River watersheds. The WDNR considers Bass Lake an outstanding resource water (ORW). The 35-foot deep lake has a small watershed of approximately 314 acres, not including the lake surface. The direct watershed is primarily forest and residential development. Based on the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) SSURGO soils data, soils in the watershed are dominated by hydrologic soil groups A and B, suggesting higher infiltrating soils. The lake is primarily fed by regional groundwater (flow through the lake is from northeast to southwest), direct precipitation, and watershed runoff.

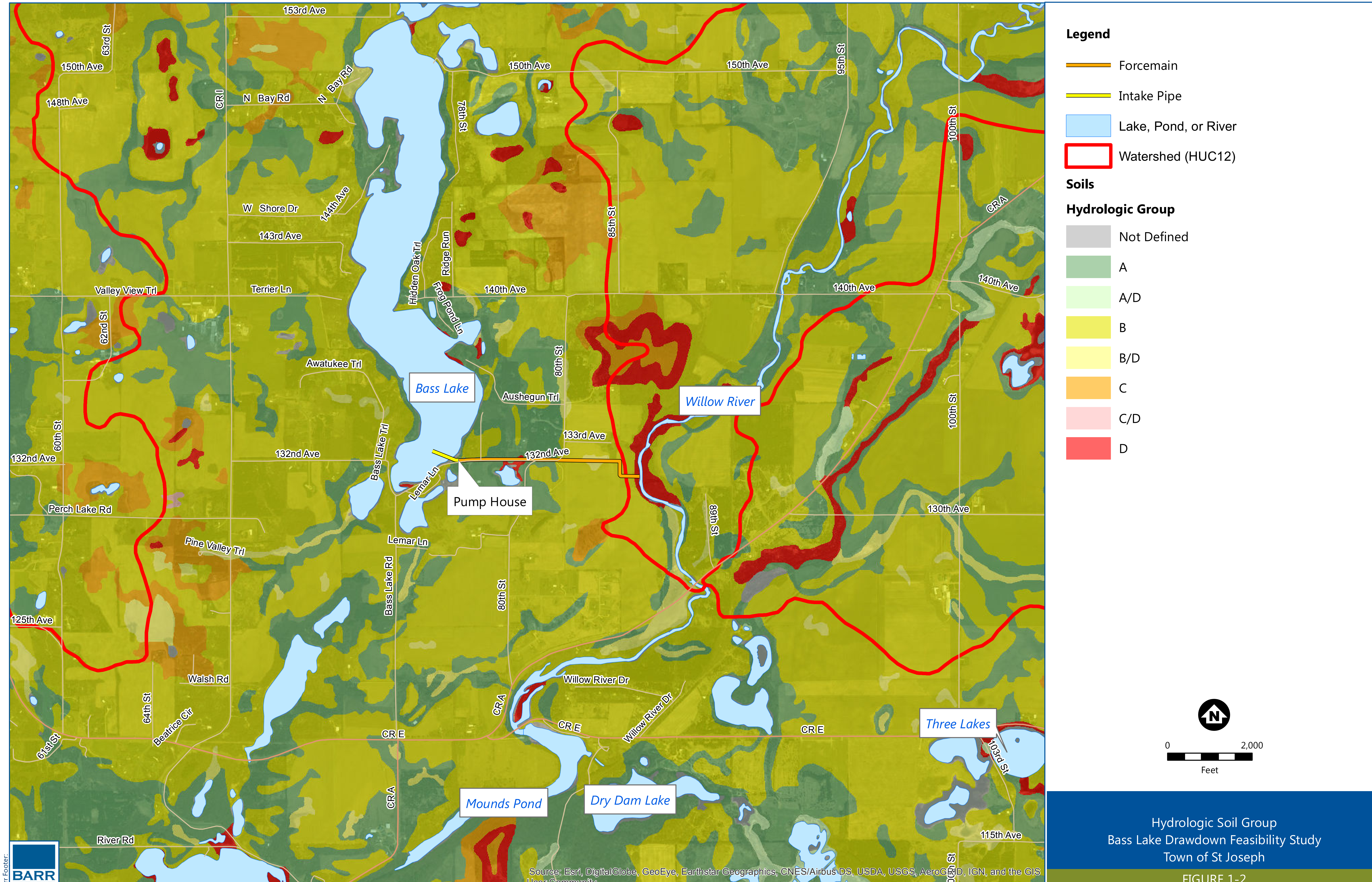
Prior to 1997, Bass Lake had no outlet, and the WDNR established the lake's ordinary high water mark (OHWM) at elevation 886.1 ft MSL. When water levels rise above the OHWM, adjacent structures are susceptible to flooding. Additionally, at 886.0 ft MSL, the no wake ordinance comes into effect. In 1997, a pumped-outlet system was installed to prevent flooding of homes and structures surrounding Bass Lake. The Federal Emergency Management Agency (FEMA) designated Bass Lake as a Zone A floodplain (1% chance flood), with no base flood elevation determined.

Figure 1-1 shows the location of Bass Lake, the Bass Lake area, the direct surface watershed, and the estimated groundwatershed. Figure 1-2 shows the hydrologic soils groups in the area around Bass Lake.



Bass Lake Location and Watersheds
Bass Lake Drawdown Feasibility Study
Town of St Joseph

FIGURE 1-1



Hydrologic Soil Group
Bass Lake Drawdown Feasibility Study
Town of St Joseph

FIGURE 1-2

1.2 Existing Pump System

The BLRD hired Barr to design the original pumped outlet system to prevent flooding of homes and structures surrounding Bass Lake. The system was installed in 1997. The original construction plan set of the Bass Lake pump system is included as Appendix B.

1.2.1 Original Permit (Expired)

To prevent flooding to adjacent structures, the Town of St. Joseph received a permit from the WDNR allowing them to install and operate a pumped outlet from the lake. The system discharges to the Willow River, one of Wisconsin's premier trout streams, and ultimately flows through Lake Mallalieu and the St. Croix River. To meet WDNR permit requirements, the project included:

- limiting the pumping rate to 2 million gallons per day for any 30 day period;
- a slotted intake pipe to prevent rough fish from entering the Willow River; and
- drawing water from the colder lake bottom to address temperature concerns for discharges to the Willow River.

The original permit was dated July 23, 1997 and is included as Appendix C to this report.

1.2.2 Pump System Description and Estimated Drawdown Rate

The existing pumping system (shown in Figure 1-3) includes the following components:

- Approximately 660 lineal feet (LF) of 24" diameter high density polyethylene (HDPE) pipe, including a slotted intake, that extends into Bass Lake on the southeast side of the lake. The intake pipe is anchored to the bottom of the lake with an intake elevation of approximately 856 ft MSL, drawing water from the lake hypolimnion when the pump is operating.
- 46 horsepower (HP) submersible pump (KSB KRT-K200-400) with a 4.3 – 6.3 cubic feet per second (cfs) (1950 – 2850 gallons per minute (gpm)) capacity, depending on head. The pump is located in a below-grade, wet-well pump station with access hatches, with the invert of the pump station at approximately 876.0 ft MSL (approximately 15 feet below grade). Conversations with the BLRD during pump operation indicated the pump was operating at approximately 4.5 cfs.
- Approximately 4,615 LF of 18" diameter HDPE forcemain that runs along 132nd Street to the Willow River. Cover over this system is a minimum of 6 feet, except at road and driveway crossings where the pipe has a minimum of 8 feet of cover.

Based on the estimated flow rate and dimensions of the system, water pumped from the lake reaches the Willow River in about 30 minutes.

Although the original WDNR permit allowed pumping of up to 2.0 million gallons per day, our understanding is that the pump was typically operated at 800,000 to 1.0 million gallons per day (about 8 hours of pumping per day). At the time the pump was installed and operated, it was set-up on an on-demand charge electricity rate, so running it for a small period could result in a large charge that month.

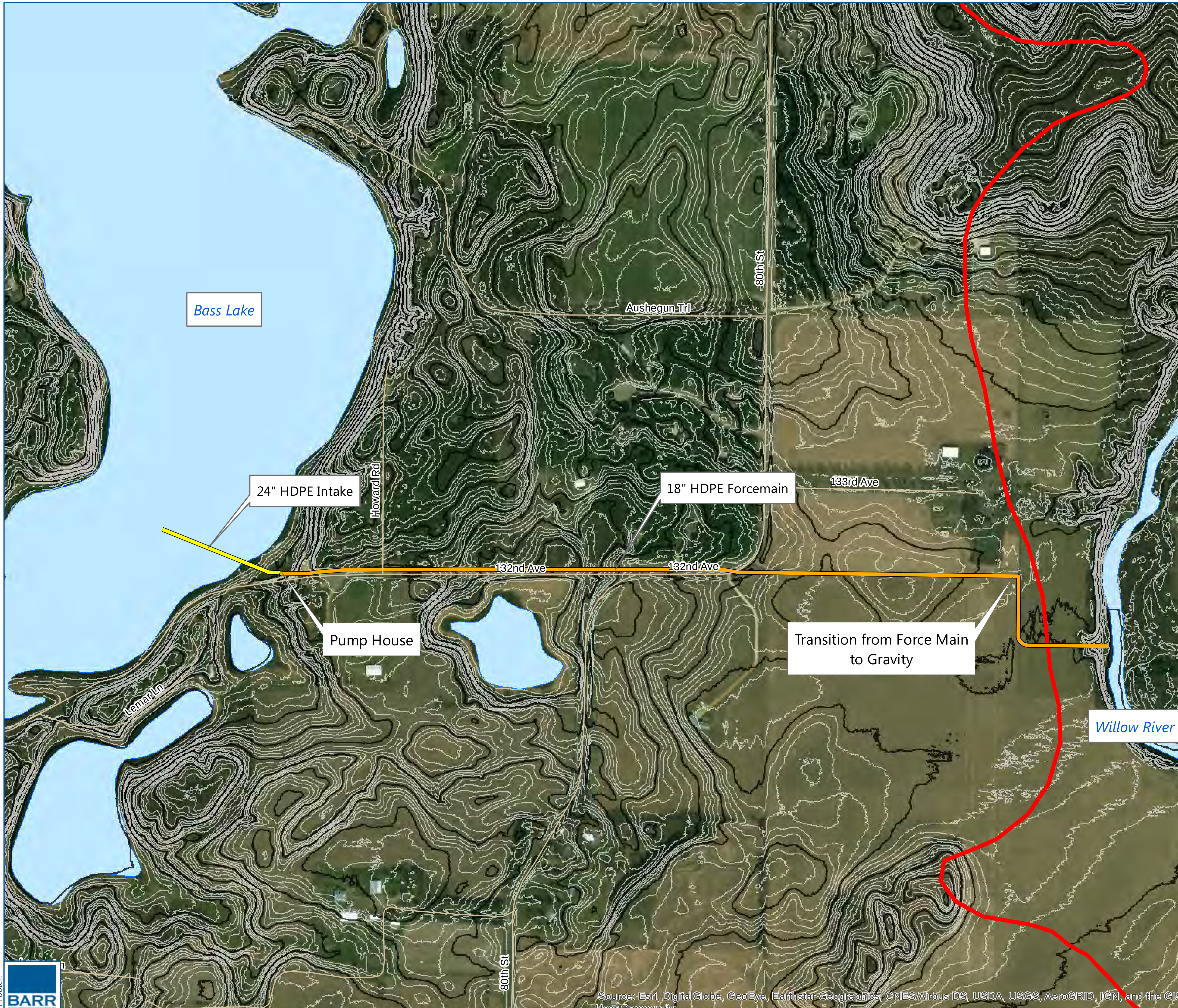
However, the system was also operated on off-peak power to substantially reduce the pump operation cost.

To estimate the time to draw down the lake using the pumping system, we utilized the stage-storage curve for Bass Lake based on bathymetric data collected in 2008 by Professor Sean Hartnett of University of Wisconsin – Eau Claire (UWEC). Figure 1-4 shows the Bass Lake bathymetry. Starting at an elevation of 886.1 ft MSL (the OHWM) and assuming the system can pump at either 1.0 million gallons per day (MGD) (historic operation during off peak periods) or 2.0 MGD (per the original WDNR permit), the estimated time to drawdown the lake is summarized in Table 1-1.

In general, to draw down the lake approximately one (1) foot, the BLRD will need to pump 1.0 MGD for 4.5 months (this is equivalent to 0.1 inch/day). However, this drawdown rate could take more time if the elevations of the regional groundwater during pumping are higher than the targeted lake elevations during pumping.

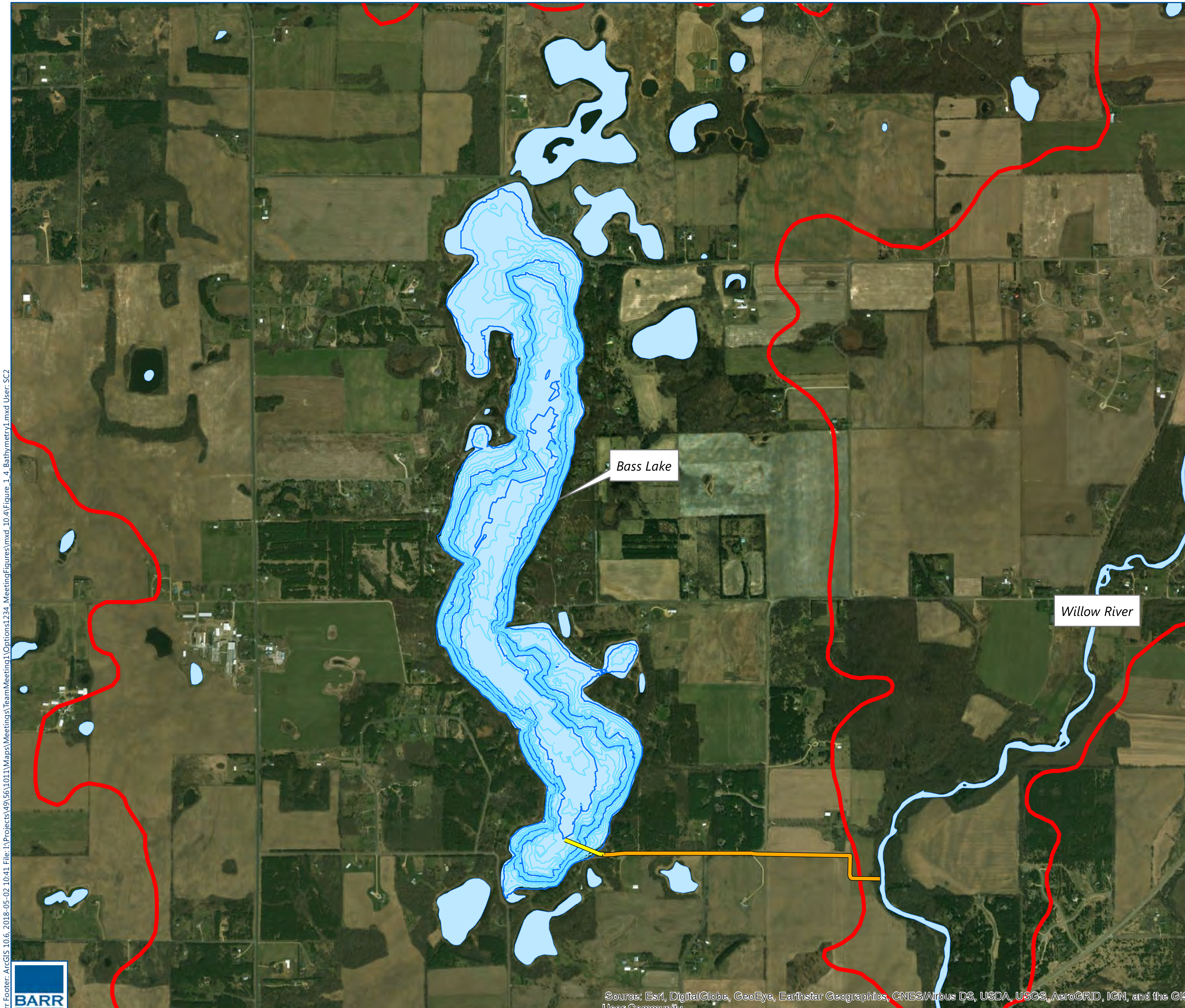
Table 1-1 Bass Lake Estimated Drawdown Rate

Lake Elevation	Drawdown Time (Days) At Pumping Rate 1.0 MGD	Drawdown Time (Days) At Pumping Rate 2.0 MGD
886.1	0	0
886	14	7
885.5	81	40
885	147	74
884.5	213	107
884	279	140



Existing Pump Station Alignment
Bass Lake Drawdown Feasibility Study
Town of St Joseph

FIGURE 1-3



Legend

Forcemain

Intake Pipe

Lake, Pond, or River

Watershed (HUC12)

Bathymetry

10 ft

2 ft

N

0 1,500

Feet

Bathymetry
Bass Lake Drawdown Feasibility Study
Town of St Joseph

FIGURE 1-4

1.2.3 Operations and Maintenance

After the pump system was installed in 1997, the BLRD operated the pump from October 21, 1997 continuously until about May 1998 when the lake level reached 886 feet. This was the level established by the WDNR permit. Pumping then occurred sporadically through the fall of 1998.

After the fall of 1998, water levels continued to drop without pumping and the pump was no longer operated for water level management. For a period of approximately 2 years after the pumping, the BLRD ran the pump for a brief period every month or two.

Because water levels were dropping without pumping, the pump maintenance contact advised the BLRD to not operate the pump monthly as running it did not substantially decrease the risk of it needing future maintenance.

The pump has not been operated since the early 2000's. After the discovery of the zebra mussels in the lake in 2010, there was concern that zebra mussels could be pulled into the pump if it were operated and cause damage to the system. Additionally, under the existing set-up, operating the pump would transport zebra mussels directly to the Willow River.

1.3 Current Conditions

1.3.1 Lake Levels

Recent wet climatic conditions (including increased rainfalls, more saturated conditions, and higher groundwater levels) have caused the Bass Lake levels to begin rising. The lake is currently at elevation 884.6—1.5 feet below the critical OHWL (see Figure 1-5). With the lake level expected to continue rising, the Town of St. Joseph needs to obtain a new WDNR pumping permit to protect against potential flooding of adjacent structures and septic systems.

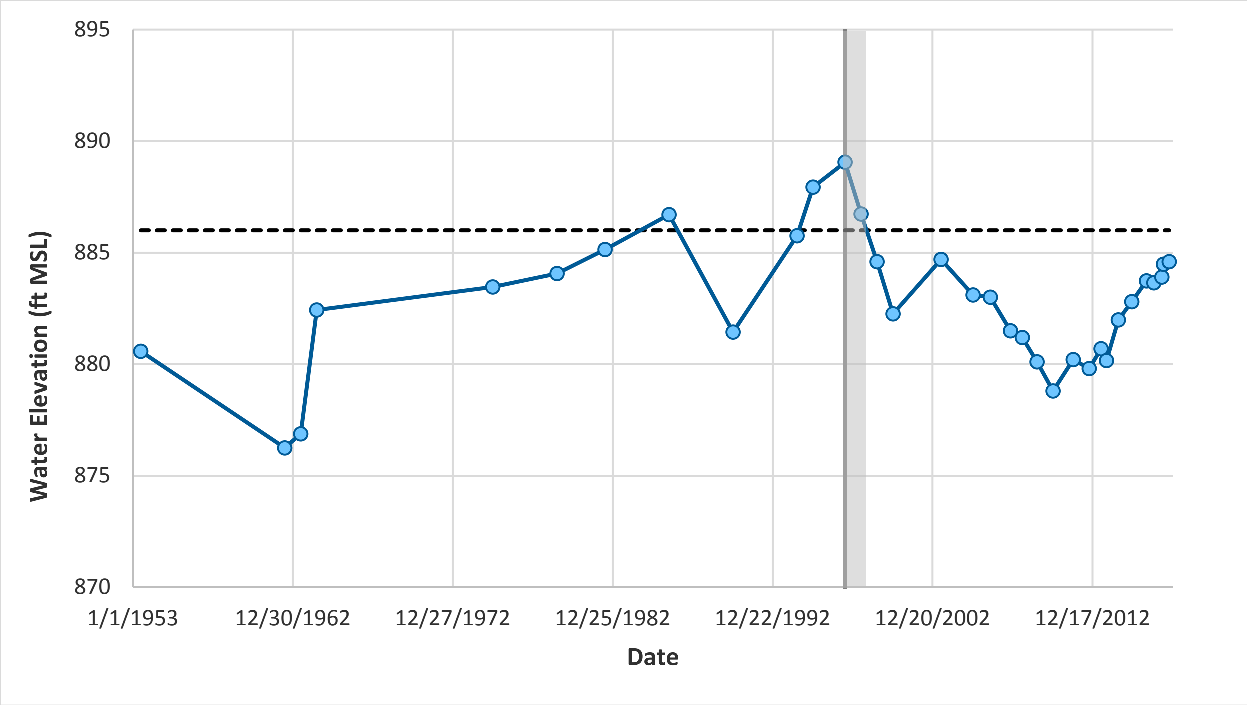


Figure 1-5 Bass Lake Water Elevations

1.3.2 Water Quality

1.3.2.1 Bass Lake

Volunteers and WDNR staff have collected water quality data on Bass Lake from 1986 through the present, with data typically collected over the deepest hole in the lake. The data reflects the epilimnion (surface) water quality and the sampling parameters typically included total phosphorus, chlorophyll a, and Secchi disc transparency.

In 2017, sampling was conducted at two locations in Bass Lake including over the deepest hole and at the pump intake location. Total phosphorus samples were collected from both the epiliminion and the hypolimnion (near bottom, below the thermocline) for two sampling events (late July and mid-September, 2017). Temperature and dissolved oxygen profiles were also collected at the deep hole and at the pump intake location.

In general, the condition of Bass Lake is excellent and it is classified as a high quality mesotrophic lake. Based on water quality data provided by the WDNR staff, the summer average total phosphorus concentrations in the epilimnion of Bass Lake ranged from 12 to 20 µg/L in the past decade and a trend analysis on this period indicates that the water quality is stable (see Figure 1-6).

The data collected in 2017 indicates that hypoliminion phosphorus concentrations can be elevated during a period of low oxygen in both the deep hole and at the pump intake, when phosphorus can be released from the lake bottom sediments. At the pump intake, the phosphorus concentrations ranged from 31 µg/L in July to 107 µg/L in September. Given typical lake dynamics, we would anticipate the hypolimnion phosphorus concentrations would remain elevated until the lake complete turns over in the fall (typically in late September or early October) and mixes with the lower concentration surface waters.

Water quality sampling was also conducted over the pump intake in February 2018. Sampling included total phosphorus concentrations in both the epilimnion and hypolimnion and presence/absence of zebra mussel veligers. The phosphorus concentrations at both the surface and the bottom of the lake were very low, with concentration of 5.8 µg/L and 8.2 µg/L, respectively. Additionally, the testing confirmed that zebra mussel veligers were absent from the sample, as was expected due to the reproductive and life cycles of zebra mussels in this region.

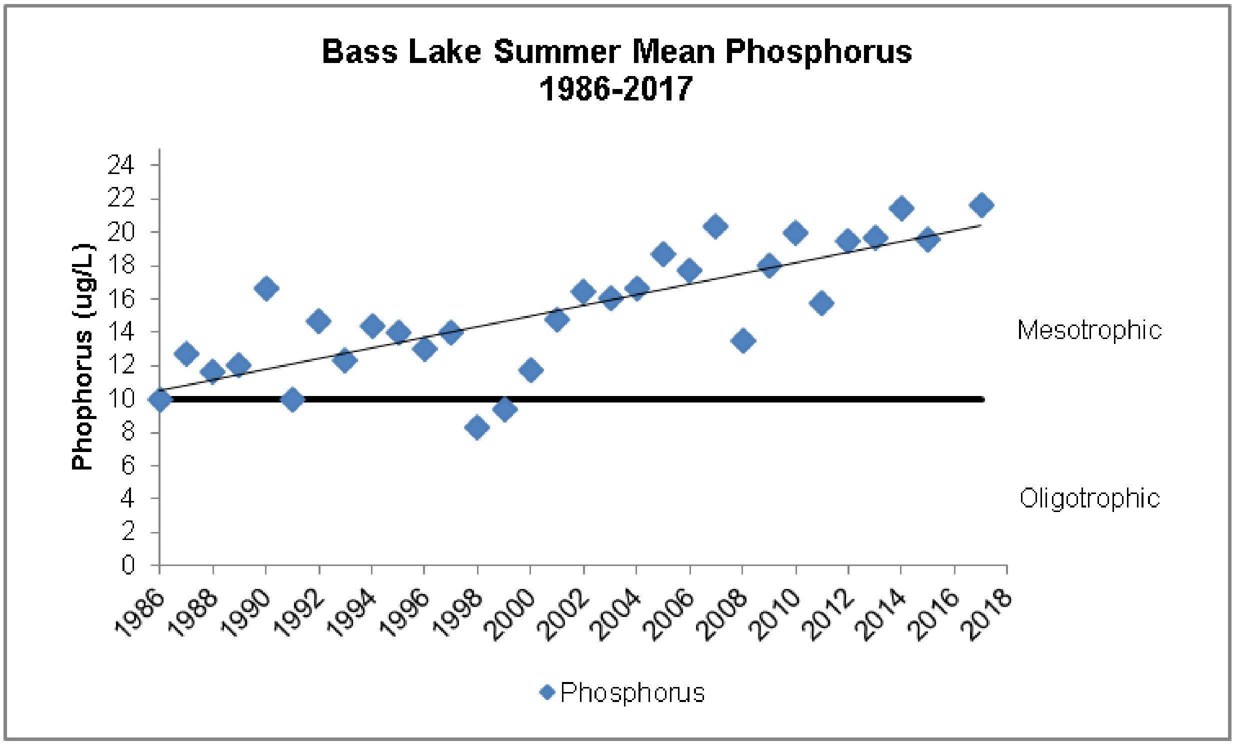


Figure 1-6 Summer Average Total Phosphorus Concentrations (Epilimnion)

1.3.2.2 Groundwater Quality

The University of Wisconsin – Stevens Point professor Paul McGinely provided an updated analysis of water chemistry in 269 wells in the Town of St. Joseph in St. Croix County on data available through present. Table 1-2 summarizes the groundwater chemistry data in the Bass Lake area for alkalinity, calcium, magnesium, chloride, nitrate, and total phosphorus.

Table 1-2 Groundwater Chemistry Summary Statistics for Town of St. Joseph Wells

Analyte	25th Percentile Concentration (mg/L)	Median Concentration (mg/L)	75th Percentile Concentration (mg/L)
Alkalinity (as CaCO3)	176	190	208
Calcium	41	48	54
Magnesium	17	21	25
Chloride	3.1	7.8	17.9
Nitrate (as N)	0.4	2.0	4.0
Phosphorus (P)	0.010	0.021	0.040

The total phosphorus concentration observed in the groundwater is similar to the concentrations observed in Bass Lake. This is expected since groundwater is a significant source of water to Bass Lake.

Additionally, nitrate concentrations in the groundwater are also low. Although there is no nitrate data collected in Bass Lake, we would anticipate that the concentrations in the lake would be similar to the groundwater (for the same reason as phosphorus levels in the lake are similar to groundwater concentrations). Therefore, there should not be any concern about elevated nitrate levels in pumping and infiltrating Bass Lake water on nearby drinking water wells.

Appendix D includes the groundwater quality summary memo for the Town of St. Joseph provided by the University of Wisconsin – Stevens Point.

1.3.3 Groundwater Modeling

For this study, we obtained the United States Geological Survey's (USGS) three-dimensional regional groundwater-flow model of Pierce, Polk, and St. Croix counties (Juckem, 2009). The model uses the USGS's industry-standard MODFLOW code. For this study, the USGS model was modified in the Bass Lake area as follows:

- The model grid spacing was refined from the original 1,000- by 1,000-foot cells down to 125- by 125-foot cells near Bass Lake.
- In the original model, Bass Lake was represented using MODFLOW's River boundary condition with a fixed stage of 882 ft MSL. To allow variable lake stage for this evaluation, the cells representing Bass Lake were converted to use MODFLOW's Lake boundary condition (Merritt and Konikow, 2000). The version of MODFLOW was changed from the original MODFLOW-2000 to MODFLOW-2005 (Harbaugh, 2005) so the newer Lake boundary option to use detailed bathymetry information for Bass Lake could be used.
- The stages assigned to the River boundary cells representing the reaches of the Willow River, Apple River, and St. Croix River that encircle Bass Lake were updated using the St. Croix County LiDAR data.
- Model parameters (horizontal hydraulic conductivity, recharge from precipitation, and riverbed leakance) were adjusted as necessary for cells in the vicinity of Bass Lake to obtain appropriate

initial lake stage conditions for the predictive simulations. Initial Bass Lake stages of 886 ft MSL and 887 ft MSL were considered in this study.

The modified groundwater model was used to:

- Estimate the amount of groundwater pumping required to maintain or reduce lake levels,
- Quantify the potential impacts to water levels in domestic wells around the lake under such a groundwater pumping condition,
- Evaluate the impact of the "infiltration of pumped discharge" option on groundwater mounding and travel time, as well as the potential impacts to domestic wells and adjacent structures, as applicable.

The following limitations of the groundwater model are known:

- The original USGS model is a coarse, regional-scale model of three (3) counties; in other words, it lacks local detail near Bass Lake, particularly in the shallow subsurface stratigraphy. This is particularly important for simulations of infiltration basins, the performance of which are highly dependent on site-specific soil conditions. Additional refinement of the groundwater model would be needed during final design, if infiltration options would be selected.
- While model parameters were adjusted to obtain reasonable Bass Lake stages, how accurately the model represents local groundwater levels is unknown because recent water table elevation data for the area are not available for comparison. Therefore, the model is most useful at predicting relative changes in water levels due to pumping or infiltration rather than absolute water elevations.

With Bass Lake at 886-887 ft MSL, the typical groundwater elevations in the vicinity of Bass Lake ranged from 900-920 ft MSL near the Willow River east of the lake to 880-885 ft MSL west of the lake. Bass Lake is a groundwater flow-through lake and when the lake is at approximately 886 ft MSL, the estimated flow-through rate is 4.0 to 7.0 cfs. Based on this flow-through rate, we estimated that the approximate residence time for Bass Lake is 1.7 to 2.9 years.

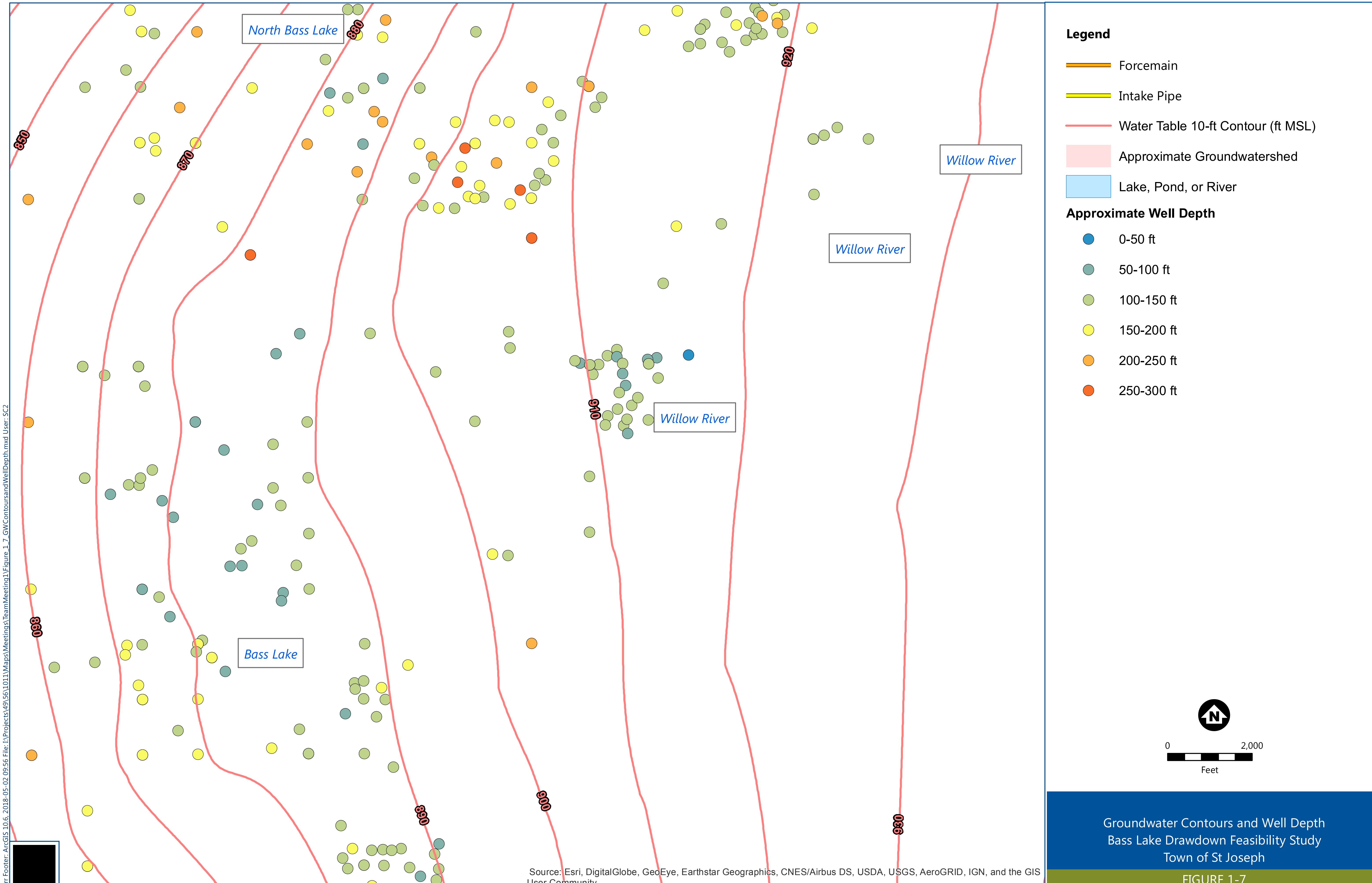
Figure 1-7 shows the estimated groundwater elevation contours through the project area and groundwatershed, and the approximate location and depth of the Bass Lake area well data, further discussed in the following section.

1.3.3.1 Well Information

Well data was obtained from St. Croix County, which included data from the Wisconsin DNR Groundwater Retrieval Network that were geocoded with well address or PLSS quarter-quarter centroid coordinates. The data set included a variety of well information, but more specifically included information related to well depth, static water level, and casing depth.

This data was used to understand the depth/elevation of wells in relation to the groundwater elevation to better understand potential impacts to wells under a groundwater pumping scenario.

Although the well locations are approximate, the data was used in combination with the St. Croix County LiDAR elevation data to estimate the elevation of the bottom of the well. In the area surrounding Bass Lake (generally within the direct watershed), the average residential well elevation was 804 ft MSL, ranging from 735 ft MSL to 862 ft MSL.


North Bass Lake
Bass Lake
Willow River
Willow River
Willow River
850
860
870
880
890
900
910
920
930
Legend
Forcemain
Intake Pipe
Water Table 10-ft Contour (ft MSL)
Approximate Groundwatershed
Lake, Pond, or River
Approximate Well Depth
0-50 ft
50-100 ft
100-150 ft
150-200 ft
200-250 ft
250-300 ft
N
0
2,000
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Groundwater Contours and Well Depth
Bass Lake Drawdown Feasibility Study
Town of St Joseph
FIGURE 1-7

1.3.4 Water Balance and In-Lake Phosphorus Modeling

A daily mass balance model of Bass Lake was developed for the period from July 2005 through late 2017 to track water through the Bass Lake system, estimate the volume of water in the epiliminion and hypoliminon at different times per year, and estimate the mass of phosphorus in the lake based on the observed water quality data.

1.3.4.1 Water Balance

The water balance portion of the model utilized the bathymetric data to develop a stage-storage curve for the lake and estimate the inflows and outflows from the lake. A basic P8 model (a runoff and pollutant loading model) was used to generate daily runoff volumes from the direct watershed to the lake, based on the current watershed land use conditions, soils, and long-term climatic data available from the Minneapolis-St. Paul International Airport (MSP). The MSP precipitation data was used to estimate the volume of direct precipitation onto the lake surface. Pan evaporation data from the University of Minnesota – St. Paul campus using a pan coefficient of 0.7 was used to estimate evaporation from the lake surface. During the mass balance period, no pumping was conducted so there was no surface discharge from the lake. Additionally, because the lake is a groundwater flow-through lake, we assumed that the groundwater inflow to the lake was equal to the groundwater outflow. The estimated water elevation from the water balance was compared against the lake level data for Bass Lake, which for much of the record (until recently) only includes one reading per year to confirm that the model resulted in a similar trend in its predicted water levels. Figure 1-8 summarizes the average annual water load to Bass Lake by source of water. The total estimated annual water load to the lake is approximately 4,998 acre-ft.

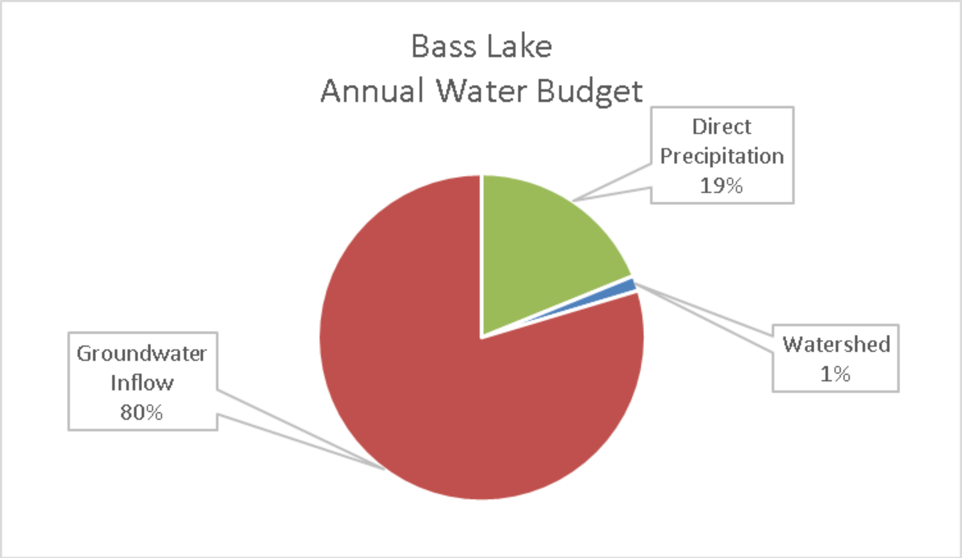


Figure 1-8 Bass Lake Annual Water Load

1.3.4.2 Phosphorus Balance

Based on the estimated water loads to the lake, we summarized the estimated external total phosphorus loads to the lake. The P8 model was used to estimate average annual watershed runoff loads to Bass Lake. Annual loads from the groundwater were estimated based on the modeled groundwater inflow rate and the observed total phosphorus concentrations in the Town of St. Joseph well data. Atmospheric deposition was based on the rate estimated in the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (MPCA, 2004; Barr, 2005) and applied to the surface area of the lake. Figure 1-9 summarizes the average annual phosphorus loads from external sources to Bass Lake. The total estimated annual external phosphorus load to the lake is approximately 453 pounds.

Two samples collected from the Bass Lake hypolimnion in 2017 indicate that internal loading from the lake bottom sediment may also contribute to the Bass Lake phosphorus load. Sediment core data, analysis of the bottom sediments for mobile phosphorus, and more detailed lake modeling would allow for better quantification of the magnitude of the internal phosphorus load into Bass Lake.

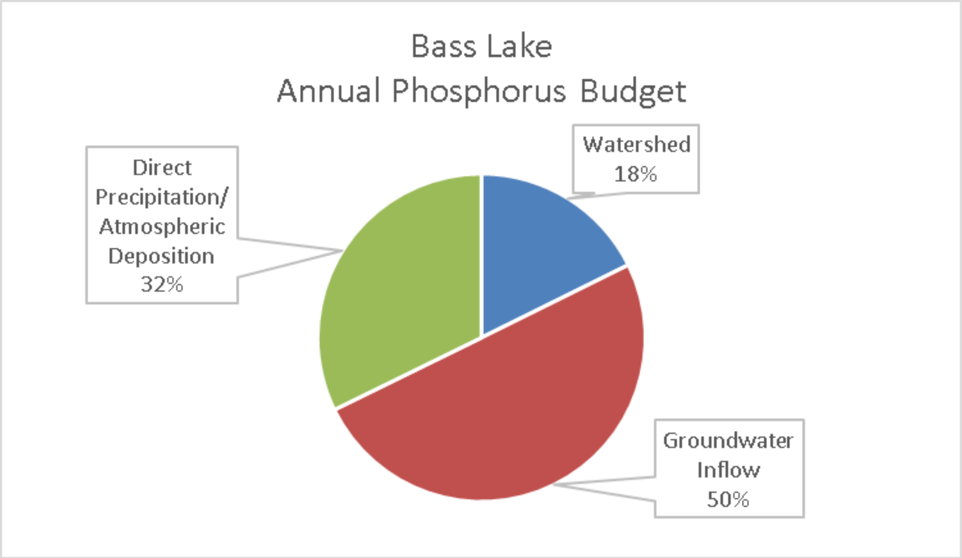


Figure 1-9 Bass Lake Annual External Phosphorus Load

Impact of Hypolimnetic Pumping on Bass Lake Water Quality

The water balance model was also used to track the hypoliminion and epilimnion volume in the lake through time, based on the depth of the observed thermocline in the available monitoring data. Applying the observed concentrations in the epiliminion and hypoliminion in the lake at different times in the year, we estimated the total mass of phosphorus in each layer of the lake on any given day. For years where monitoring data was not available, estimated averages at different times of the year were applied to the lake based on the corresponding season.

Tracking the mass of total phosphorus in the lake on a daily time step allowed us to use the water balance model to evaluate the impact of operating the pump system during different seasons and periods of time, and estimate the mass of phosphorus that would be removed from the hypolimnion. More significant phosphorus mass can be removed from the lake if pumping occurs during the mid to late summer through fall turnover, when elevated phosphorus concentrations are observed in the hypolimnion.

Based on the estimated annual phosphorus and water loads to Bass Lake, along with the estimated lake characteristics, several empirical lake models were used to estimate the in-lake phosphorus concentrations. These models were then used to estimate change in the expected lake water quality, based on a reduction to the annual loading to Bass Lake due to hypoliminetic pumping during different seasons.

However, the mass of phosphorus removed from the hypolimnion does not directly translate to an equivalent removal in the epilimnion (and resultant surface phosphorus concentrations) due to the thermal stratification that occurs in the lake and the rate of diffusion across the thermocline. For this analysis, we assumed that half of the mass pumped from the hypolimnion would directly translate to a reduction in the annual loading to the lake and the observed concentrations in the epilimnion.

Based on the long-term water balance that tracked the mass of phosphorus estimated in both the epilimnion and the hypolimnion, the average mass of phosphorus in the Bass Lake epilimnion was 200 pounds while the mass in the hypolimnion was 118 pounds.

Assuming the pumps were operated for about 4.5 months at 1.0 million gallons per day to draw the lake down approximately one (1) foot during various seasons, we quantified the estimated mass of phosphorus that could be removed from the lake system.

Table 1-3 Estimated Total Phosphorus Mass Removal by Hypolimnetic Pumping by Season

	Winter Hypolimnetic Pumping	Spring Hypolimnetic Pumping	Summer Hypolimnetic Pumping
Total Phosphorus Removed from System (lbs)[1]	7.3	9.4	35.0

1- Assumes 50% of the mass removed by pumping would translate to a direct removal from the lake system and observed epilimnion water quality

Using the empirical lake models and reducing the annual phosphorus loading to the lake by the value above, the estimated reduction in the observed water quality (the predicted total phosphorus concentration) is between 1.5 and 7.4 percent, with the most significant impact on water quality occurring during puming during the summer when elevated hypolimnetic phosphorus concentrations have been observed. For example, if the summer average total phosphorus concentration in Bass Lake is 20 µg/L, this is a change of 0.3 µg/L to 1.5 µg/L. However, because of the already high water quality in Bass Lake, this level of change may not be discernable to the lake residents or users.

1.4 Discharge Requirements

To obtain the new permit, the WDNR will require alterations to the pump system and discharge into the Willow River to address issues related to impaired waters and aquatic invasive species.

1.4.1 Zebra Mussels and Other Aquatic Invasive Species

Zebra mussels (Dreissena polymorpha) have been present in Bass Lake since 2010 and there is concern about spreading this AIS to downstream resources. Additionally, although research would indicate that zebra mussels should not survive in the anoxic conditions in the hypoliminion and at the existing intake pipe (Cohen), divers for the WDNR observed at least three year classes of zebra mussels colonizing the pump intake hardware in 2017.

Because of the presence of zebra mussels in Bass Lake and at the pump intake, and in accordance with Wisconsin Administrative Code Chapter NR 40, the WDNR requires a zero sum transfer of zebra mussels for any of the water-level management options. This means that filtering or otherwise preventing the zebra mussels from entering the Willow River will be needed.

In this region, the zebra mussels will start to spawn (releasing veligers) when the water temperature rises above 53° F (Murphy 2008 and Ferry 2018); maximum spawning occurs at about 62° -64° F (Ferry 2018), resulting in a reproductive season from potentially late-May (Mackie 1991) through mid-August (McCartney 2017). The last veligers to result from the mid-August reproduction would settle in about 3 weeks (early September) (MAISRC). When first released, veligers are 70-100 microns in size (McCartney, MAISRC, Cohen, USGS). Based on their typical growth rate, zebra mussels would be about 2 to 2.5 mm in length at the time of settlement (Cohen, McCartney 2017). Literature suggests that the average growth rate of a 2-mm zebra mussel is 0.05 mm per day (Karatayev, et al. 2006). At this growth rate, we would expect the 2- to 2.5-mm newly settled zebra mussels to grow to a length of 5 to 5.5 mm between early September and early November.

Although many scientists had found that zebra mussels stop growing when the temperature is 10 degrees C or colder, other research has found that food, not temperature, limits growth (Karatayev et al. 2010). In this research, they found that growth was dependent upon the quantity of algae present. In temperate regions, such as Minnesota and Wisconsin, lakes freeze in winter and light limitation reduces algae available for the zebra mussels in winter. The lack of growth in zebra mussels at temperatures less than 10 degrees C was due to reduced food supply during the winter months, due to light limitation beneath the ice-covered lakes. The 2010 study discovered that zebra mussels grew at colder temperatures if they had adequate food, as their experiment involved supplementing the natural waters with added algae during the winter months (Karatayev et al. 2010).

This is important when we consider the question of growth of zebra mussels in Bass Lake. We know that lake turnover results in an increase in algae as nutrients from hypolimnetic (bottom) waters are mixed and become available for algae in fall (lakes start turning over in September and attain full turnover in October). During the period from September through November, we would anticipate sufficient algae would be present in Bass Lake to support zebra mussel growth until the lake freezes.

Other aquatic invasive species in Bass Lake include Eurasian watermilfoil, curly-leaf pondweed, and the Chinese mystery snail. However, it is assumed that if precautions are taken to prevent the transport of zebra mussel veligers, the methods will also prevent the transport of other aquatic invasive species.

1.4.2 Total Phosphorus Discharge Requirements (Lake Mallalieu)

Lake Mallalieu, which is an impoundment of the Willow River downstream of the Bass Lake pumped-outlet discharge point, was placed on Wisconsin's 303(d) list of impaired waters in 2004 due to eutrophication (excess nutrients), excess algal growth, and elevated pH. Lake Mallalieu's whole lake average phosphorus concentrations (72.6 μg/L) exceed the recreational threshold for total phosphorus (40 μg/L) but meet the fish and aquatic life threshold (100 μg/L). A total maximum daily load (TMDL) study for Lake Mallalieu is under development but has not yet been completed.

Although Bass Lake is located in the watershed contributing to Lake Mallalieu, Bass Lake is essentially landlocked and has not been pumped in recent years. Bass Lake thermally stratifies and experiences low oxygen levels at depths greater than 16 to 23 feet, suggesting that the sediments can release phosphorus, which would result in elevated levels of phosphorus in the hypolimnion. 2017 sampling within Bass Lake found that the total phosphorus levels at the inlet of the pump intake pipe can be elevated during periods of anoxia and, if pumped, would result in additional phosphorus loading to Lake Mallalieu.

The WDNR is also concerned about the phosphorus concentrations in the proposed Bass Lake discharge because it would consider the Bass Lake discharge a new discharge to an impaired water. According to NR217, a new discharge will not be permitted unless: 1.) it is allocated in the reserve capacity of an EPA-approved TMDL (however, there is not an approved TMDL for Lake Mallalieu and it is unlikely one will be approved in time for the desired start of the discharge); 2.) the discharge will improve phosphorus water quality (the WDNR recommends a phosphorus discharge limit of 39 μg/L to meet this requirement); or 3.) higher phosphorus-discharge concentrations can be offset with pollutant trading.

In response to these items, the WDNR requires that the total phosphorus concentration in the discharge from Bass Lake must meet the 39 μg/L water quality requirements. Water quality in Bass Lake typically meets this standard except during the mid- to late-summer months until lake turnover occurs in the fall (July-September).

2.0 Preliminary Feasibility Options

After compiling and reviewing the available data for the project, the next step of the feasibility study was to perform a high level screening to evaluate the feasibility of preliminary options that could be considered to meet the WDNR discharge requirements for both zebra mussels and water quality.

The following section discusses the preliminary feasibility options, which were discussed at the first team meeting held on March 16, 2018 at the Town of St. Joseph town hall. Barr reviewed the high level analysis of the preliminary options with the team and based on this discussion, four options were selected for further consideration and development as part of the feasibility study. Appendix E includes the presentation slides and comparative matrix handout from the first team meeting.

2.1 Preliminary Evaluation of Options

2.1.1 Options to Control Zebra Mussels

Several approaches were evaluated to determine their overall feasibility on controlling the movement of zebra mussels and the veligers during pumping and are generally discussed below.

2.1.1.1 Pumping from Hypolimnion

The existing pump intake draws water from the hyplimnion; the intent of the original design was to meet temperature discharge requirements. The hypolimnion often has very low oxygen levels and zebra mussels require oxygen to survive (Cohen). As a result, they are not expected to be found in the anoxic hypolimnion.

In 2017, the WDNR sent divers to inspect the pump intake. Although oxygen levels were low/anoxic, at least three year classes of zebra mussels were colonizing the hardware. This suggests that zebra mussels are able to survive in low oxygen conditions and this alone cannot be used as an approach to prevent the transfer of zebra mussels.

2.1.1.2 Use of Shallow Wetlands to Filter Zebra Mussels

Some research suggests that pumping water through shallow, vegetated wetlands can be effective at filtering all life stages of zebra mussels. The wetlands evaluated provided a flow path of about 1 kilometer (Bodamer et al 2008).

We evaluated potential shallow wetland opportunities around Bass Lake for the treatment of pumped water prior to entering the Willow River. There are limited wetland opportunities around Bass Lake, with the largest wetland located about 0.75 miles southwest of the lake; however, the wetland is only about 0.5-0.8 km long and appears to be landlocked. This wetland does not provide the minimum length of treatment outlined in the literature, and it is not possible to guarantee this approach will result in complete zebra mussel/veliger mortality/removal. Additionally, because the system is landlocked, the wetland likely cannot handle the 1.0 MGD of pumping that is required to draw down Bass Lake.

2.1.1.3 Use of Filtration to Treat Discharge

The smallest zebra-mussel life stage is the veliger stage, when they range in size from 70 to 200 microns (Cohen, McCartney 2017, MAISRC). To remove all veligers (when present), filtration must provide removal down to about 50 microns. Filtration to this level cannot be achieved with the addition of an intake screen alone, which can only provide screening to 0.5 mm (500 microns); however, screening of the intake is helpful in preventing the movement of juvenile and adult zebra mussels into the intake pipe and pump system.

A variety of filtration options were evaluated for the removal of zebra mussel veligers. These systems would be located downstream of the existing pump system and may require additional easement/land purchase. Some of the systems evaluated would only target zebra mussels, other systems could remove zebra mussels and reduce phosphorus levels.

The following filtration systems were considered as part of the evaluation, which includes a brief discussion of each and the main considerations, including relative magnitude of cost.

- AMIAD mechanical filtration system – provides a permanent automated filtration/backwash down to 40 microns, but does not reduce total phosphorus levels, so this would need to be paired with seasonal pumping or some other form of total phosphorus control if utilized during periods of elevated phosphorus. Initial screening of this approach suggests implementation of this system is considered moderate to expensive.

- Rain-for-Rent portable bag filtration system – provides semi-permanent bag filtration down to 25 microns, but does not reduce total phosphorus levels, so this would need to be paired with seasonal pumping or some other form of total phosphorus control if utilized during periods of elevated phosphorus. This system requires daily (or potentially more frequent) monitoring and manual maintenance, including checks on system pressure and replacing filtration bags. Although the system can be rented, permanent modifications would be needed to allow for the connection to the rental system. Initial screening of this approach suggests implementation of this system is considered moderate to expensive.

- Nexom phosphorus-specific disk filtration system – provides a permanent automated filtration/backwash system typically used for treatment of wastewater that can remove veligers and can achieve phosphorus removal down to 100 ug/L, but cannot guarantee removal down to 39 ug/L (however, Bass Lake is typically well below these levels with the exception of periods in late summer and early fall in the hypolimnion). Implementation of this system is considered very expensive.

- Nexom phosphorus-specific sand filtration system – provides a permanent automated filtration/backwash system typically used for treatment of wastewater that can remove veligers and can achieve phosphorus removal down to 20 ug/L; this system requires the use of chemicals and due to the anticipated flow rate, is expected to have a very large footprint. Implementation of this system is considered very expensive.

2.1.1.4 Use of Chemicals to Treat Pumped Water

Two molluscicides (chemicals) have been used for the treatment of zebra mussels, Earthtec QZ and Zequanox. Typically, these chemicals are used directly in lakes or ponds and require a specific contact time to achieve mortality. Earthtec QZ, a copper-based molluscicide, requires a dose of 1 ppm with a 5-day contact time to achieve 100 percent mortality (Hammond 2018, Hammond 2017, Watters et al. 2013, and Claudi et al. 2014). For Zequanox, a dose of 100 ppm for adults and 50 ppm for veligers with a contact time of 8 hours is required; however, this chemical does not guarantee 100 percent mortality (Glomski 2015, Lund et al 2017, Luoma et al. 2016). Both chemicals are approved for use in the State of Wisconsin and would require an NR107 permit. This chemical treatment will not reduce phosphorus levels in the discharge, so this would need to be paired with seasonal pumping or some other form of total phosphorus control if utilized during periods of elevated phosphorus.

Treatment of Bass Lake is not practical in these circumstances, so for the pumping system, the use of chemicals would include a building for chemical management/storage and a dosing system for the addition of the molluscicides to achieve the appropriate dosing for the 1.0-MGD discharge. However, since the estimated contact time in the existing forcemain is approximately a half hour, a detention pond that would provide the necessary contact time for the chemical and flow rate would be required. For example, to use Earthtech QZ with a 5-day contact time would require a 10-acre retention pond (requiring land purchase). These systems require intensive monitoring during operation. Implementation of this system is considered very expensive.

2.1.1.5 Use of Ultraviolet Light (UV) to Treat Pumped Water

UV light has been used on pipe intakes in dams in the western United States to prevent the settlement/colonization of zebra mussel veligers on pumps and intake equipment, and research suggests 99 percent effectiveness for this application. However, these applications were not studying veliger mortality.

Bench-scale research indicates that exposure to high intensity/dose UV light is effective at killing zebra mussel veligers, requiring long exposure time of 12 to 72 hours (Stewart-Malone et al. 2015, Chalker-Scott et al. 1994, Pucherelli et al. 2015, and Wright et al. 1997). However, this approach to achieve veliger mortality has not been applied in the field. In the case of Bass Lake, the daily pumped volume (1.0 MGD) would need to be contained in a reactor/container and the appropriate dose of UV would need to be applied to this volume of water. This may not be feasible. Additionally, the effectiveness of UV is tied to the clarity of the water (e.g. turbidity, solids) and additional samples/data would need to be collected from the hypolimnion of Bass Lake to better understand the lake conditions. Implementation of this system would likely not achieve 100 percent mortality, is likely not feasible, and if it were, it would be considered very expensive.

Additionally, UV treatment (if feasible) would not reduce phosphorus levels in the discharge, so this would need to be paired with seasonal pumping or some other form of total phosphorus control if utilized during periods of elevated phosphorus.

2.1.1.6 Infiltration of Pumped Water

Infiltration of the pumped discharge to an infiltration basin would be effective at meeting both zebra mussel and water quality discharge requirements, although these systems cannot typically be operated during the winter/frozen conditions. The performance of these systems is highly contingent on soils in the watershed and sufficient space to develop the infiltration system, although the soil survey indicates that many of the soils in the watershed are hydrologic soils groups A and B, which tend to have a higher infiltration capacity. The size of the basin is based on the expected infiltration rate. Soil borings and in-situ field tests are required to better understand these conditions. This option would require the purchase of land. Implementation of this approach is considered expensive.

Because Bass Lake is groundwater fed, the infiltration basins should be located outside the anticipated groundwatershed. Based on historic information and the current groundwater model of the area, the proposed infiltration systems should be located south of the existing forcemain alignment.

2.1.1.7 Groundwater Pumping

Because Bass Lake is groundwater fed, pumping of groundwater can be used to control lake levels. Additionally, because the lake water would flow through the ground before reaching the pump, this approach could be used to remove zebra mussels from the pumped water. It is also likely that the pumped water would be groundwater or water drawn from the epilimnion of the lake, which have phosphorus concentrations below the total phosphorus discharge limits.

The groundwater model for the area was used to evaluate the installation of a shoreline drain tile system on the east side of the lake to intercept groundwater flowing into the lake and draw water through the ground from the lake. The modeling suggested a shoreline drain tile system would need to be approximately 4,700 feet long and located approximately 2 feet below the targeted drawdown elevation. Because the pumping is not directly from the lake, a higher pumping rate is needed to achieve the same level of drawdown. For example, to achieve 1 foot of drawdown, a pumping rate of approximately 2,500 gpm (1.25 times the existing pumping rate) would be needed; to achieve 2 feet of drawdown, approximately 3,500 gpm would be needed (1.75 times the existing pumping rate). A new pump would be needed along with the installation of the shoreline drain tile system. However, the existing forcemain should have the capacity to convey these flows.

To install this system, easements from 8 land owners would be needed and topography would make construction challenging. If constructible, this option would require the purchase of land. Implementation of this approach is considered expensive.

2.1.1.8 Seasonal Pumping

Seasonal pumping is based on the zebra mussel life cycle and the water quality in the lake. This approach, in combination with a modified intake screen, can be used to meet the WDNR discharge criteria for both zebra mussels and water quality. The WDNR will also require sampling before and potentially during pump operation.

Zebra mussels end reproduction in mid-August (McCartney 2017) and the last veligers to result from the mid-August reproduction will likely settle in approximately 3 weeks (early September) (MAISRC) and be between 2 to 2.5 mm in length (Cohen, McCartney 2017). The literature suggests that the average growth rate of a 2-mm zebra mussel is 0.05 mm per day (Karatayev, et al. 2006). At this growth rate, the newly settled zebra mussels will likely grow to a length of 5 to 5.5 mm between early September and early November. At this size, the zebra mussels will be screened out by the intake screen with a slot width of 0.125 inches (3.1 mm). Additionally, because of the reproductive cycle, veligers should not be present in the lake from October through April (Mackie 1991, McCartney 2017) and sampling in February 2018 confirmed that veligers were absent (as expected).

Implementation of this approach would be considered moderately expensive, and of the alternatives considered, would be the most cost effective approach.

2.1.2 Options to Meet Water Quality (Phosphorus) Discharge Requirements

Several approaches were evaluated to determine their overall feasibility of meeting the WDNR total phosphorus discharge limit of 39 µg/L during pumping and are generally discussed below.

2.1.2.1 Pumping from Epilimnion (Surface)

The existing pump intake draws water from the hyplimnion; the intent of the original design was to meet temperature discharge requirements. Although modification of the pump-intake location to Bass Lake surface waters would meet the water quality discharge requirements year-round (the total phosphorus concentration in the epilimnion in Bass Lake ranged from 12 to 20 µg/L in the past decade), during the warmer summer months, the temperature of water from the epilimnion would likely not meet the temperature requirements without passing through a heat exchanger. This approach may not meet the zero sum transfer of zebra mussel requirement.

2.1.2.2 Use of Alum to Treat Discharge

Aluminum sulfate (alum) is commonly used in to reduce phosphorus concentrations in lakes and stormwater inflows. For example, the stormwater inflows (up to 5 cfs) to Tanners Lake, located in St. Paul, Minnesota, have been treated with alum since 1998, removing 70–89 percent of the annual total phosphorus load being treated by the facility (RWMWD 2017). Alum permanently binds with phosphorus and creates a floc that settles out of the water column that can then be removed and disposed of. This approach would help meet the water quality discharge requirements for Bass Lake, but would not address the concerns about zebra mussel transfer.

The application of alum would require a building for chemical management/storage and a dosing system for the addition of the alum to achieve the appropriate dosing for the 1.0 MGD discharge. However, to provide an opportunity for the alum floc settlement, a 0.5- to 1.0-acre detention pond would be needed, requiring the purchase of land. Because access to municipal sanitary sewer service is not available, the management of the floc that accumulates in the pond is more challenging, requiring dewatering of the pond and physical removal and hauling/disposal of the floc. These systems require intensive monitoring during operation. Implementation of this system is considered very expensive.

2.1.2.3 Use of Filtration to Treat Pumped Water

Filtration of phosphorus, especially the dissolved form that is not attached to particles, is challenging. A variety of filtration options were evaluated for the removal of zebra mussel veligers, although some of the systems were able to target the reduction in phosphorus as well. These systems would be located downstream of the existing pump system and may require additional easement/land purchase. See additional discussion in Section 2.1.1.3.

2.1.2.4 Infiltration of Pumped Water

Infiltration of the pumped discharge to an infiltration basin would be effective at meeting both zebra mussel and water quality discharge requirements for Bass Lake. See discussion in Section 2.1.1.6 for more information.

2.1.2.5 Groundwater Pumping

Because Bass Lake is groundwater fed, pumping of groundwater can be used to control lake levels. Additionally, because the lake water would flow through the ground before reaching the pump, this approach could be used to remove zebra mussels from the pumped water. It is also likely that the pumped water would be groundwater or water drawn from the epilimnion of the lake which have phosphorus concentrations below the total phosphorus discharge limits. See discussion in Section 2.1.1.7 for more information.

2.1.2.6 Water Quality Trading

Water quality trading provides an opportunity to offset the water quality impacts of pumping, if a preferred zebra mussel control option does not meet the water quality discharge requirements. This approach requires establishing partnerships between the point source facility and their trading affiliates, which can require complex legal agreemenets and can be expensive. This also requires annual reporting. WDNR staff suggested not pursuing this approach unless it is absolutely necessary. However, as mentioned previously, the water quality in the Bass Lake hypolimnion typically meets the water quality discharge requirement from November through June, so if pumping can be limited to this period, water quality trading may not be needed.

2.1.2.7 Seasonal Pumping

Seasonal pumping is based on the zebra mussel life cycle and the water quality in the lake. This approach, in combination with a modified intake screen, can be used to meet the WDNR discharge criteria for both zebra mussels and water quality.

The WDNR requires the total phosphorus concentration in the discharge water from Bass Lake to be below the 39 µg/L water quality standard. Between the months of November and June, the total phosphorus in the hypolimnion has historically been below the established limit

3.0 Final Evaluation of Options

Based on the discussion at the first team meeting held on March 16, 2018, the team selected the following four options for further evaluation for the Bass Lake drawdown feasibility:

- Option 1: Infiltration (including modified pump intake and pump maintenance)
- Option 2: Seasonal Pumping (including modified pump intake and pump maintenance)
- Option 3: Filtration (including modified pump intake and pump maintenance)
- Option 4: Shoreline Drain Tile System

Sections 3.2 – 3.5 outline the following information for each of the options:

- Project Components
- Meeting the Zebra Mussel and Phosphorus Discharge Requirements
- Design Considerations
- Permitting
- Operations and Maintenance
- Feasibility Level Opinions of Cost

The opinion of probable cost developed for each option is a Class 4 feasibility-level cost estimate as defined by the American Association of Cost Engineers International (AACI International) and uses the assumptions listed below.

1. The cost estimate assumes a 30% construction contingency.
2. Costs associated with design, permitting, and construction observation (collectively "engineering") is assumed to be 30% of the estimated construction costs.
3. The feasibility level cost includes estimated land purchase costs and/or easement purchase, as applicable.

The Class 4 level cost estimates have an acceptable range of between -15% to -30% on the low range and +20% to +50% on the high range. Based on the level of development of concepts, we estimate the final project costs may be between -20% and +50% of the estimated opinion of cost for each option. Appendix F includes the feasibility level opinions of probable cost for the options.

Annual operation and maintenance costs include estimated system start-up costs, electrical costs (assumed to be off-peak for pump and other mechanical system operation), water quality monitoring costs, equipment rental fees (if applicable), equipment maintenance, system shut-down costs, etc. These annual costs assume the system will be operating for 5 months (equivalent to drawing the lake down about 1 foot). The operation and maintenance costs assumes a 30% contingency.

Table 3-1 summarizes the estimated costs of the feasibility options discussed in the following sections, including the overall capital cost and the estimated annual operation and maintenance costs.

Table 3-1 Summary of Estimated Feasibility Level Costs

Option	Description	Estimated Land Easement/ Purchase Cost	Estimated Construction Cost	Engineering & Design Cost	Total Capital Cost (-20/+50%)	Annual Operation and Maintenance Cost
--	2018 Monitoring	$0	$0	$0	$5,600	$0
Option 1a	Intake Modification (Option A) and Infiltration Englehart Property	$90,000	$1,703,000	$511,000	$2,304,000 ($1,844,000 - $3,456,000)	$12,700
Option 1b	Intake Modification (Option A) and Infiltration Orf Property	$90,000	$1,359,000	$408,000	$1,857,000 ($1,486,000 - $2,786,000)	$12,700
Option 2a	Intake Modification (Option A) and Seasonal Pumping	$0	$268,000	$80,000	$348,000 ($279,000 - $522,000)	$15,600
Option 2b	Intake Modification (Option B) and Seasonal Pumping	$0	$380,000	$114,000	$494,000 ($396,000 - $741,000)	$15,700
Option 3a	Intake Modification (Option A), Filtration (AMIAD), and Seasonal Pumping	$1,700	$849,000	$255,000	$1,106,000 ($885,000 - $1,659,000)	$14,000
Option 3b	Intake Modification (Option A), Filtration (Rain For Rent), and Seasonal Pumping	$3,700	$694,000	$208,000	$906,000 ($725,000 -$1,359,000)	$95,200
Option 4	Shoreline Drain Tile System	Determined to not be feasible				

3.1 2018 Intensive Monitoring

Regardless of the option selected, the WDNR requested more intensive monitoring of Bass Lake in 2018, beginning after ice-out. The monitoring would including lake level, water quality, and zebra mussel monitoring as outlined below:

- Biweekly (every two weeks) lake level monitoring, starting at ice out
- Biweekly water quality monitoring (May through September) and monthly at other times (October, November) over the pump intake location, at a minimum, for the following parameters:
  - Dissolved oxygen and temperature, along the profile of the lake
  - Total phosphorus (low-level method due to the low concentrations in the lake) at the surface and at the pump intake depth (elevation approximately 856 ft MSL)
- Biweekly zebra mussel sizing analysis beginning in mid-August through mid-November at a minimum at pipe intake (and potentially at other locations in the lake as required by WDNR). This sampling should capture the last release of zebra mussel veligers in mid-August and will allow for the tracking of zebra mussel size through the fall until November, when the proposed seasonal pumping could begin.

Figure 3-1 shows the proposed water quality and zebra mussel veliger sampling location over the existing pump intake.

Our understanding is that BLRD representatives will perform the water quality sampling. Currently the BLRD owns a water quality meter to collect dissolved oxygen and temperature data. To collect the total phosphorus and zebra mussel samples at the surface and at depth, the BLRD will need to purchase the following equipment:

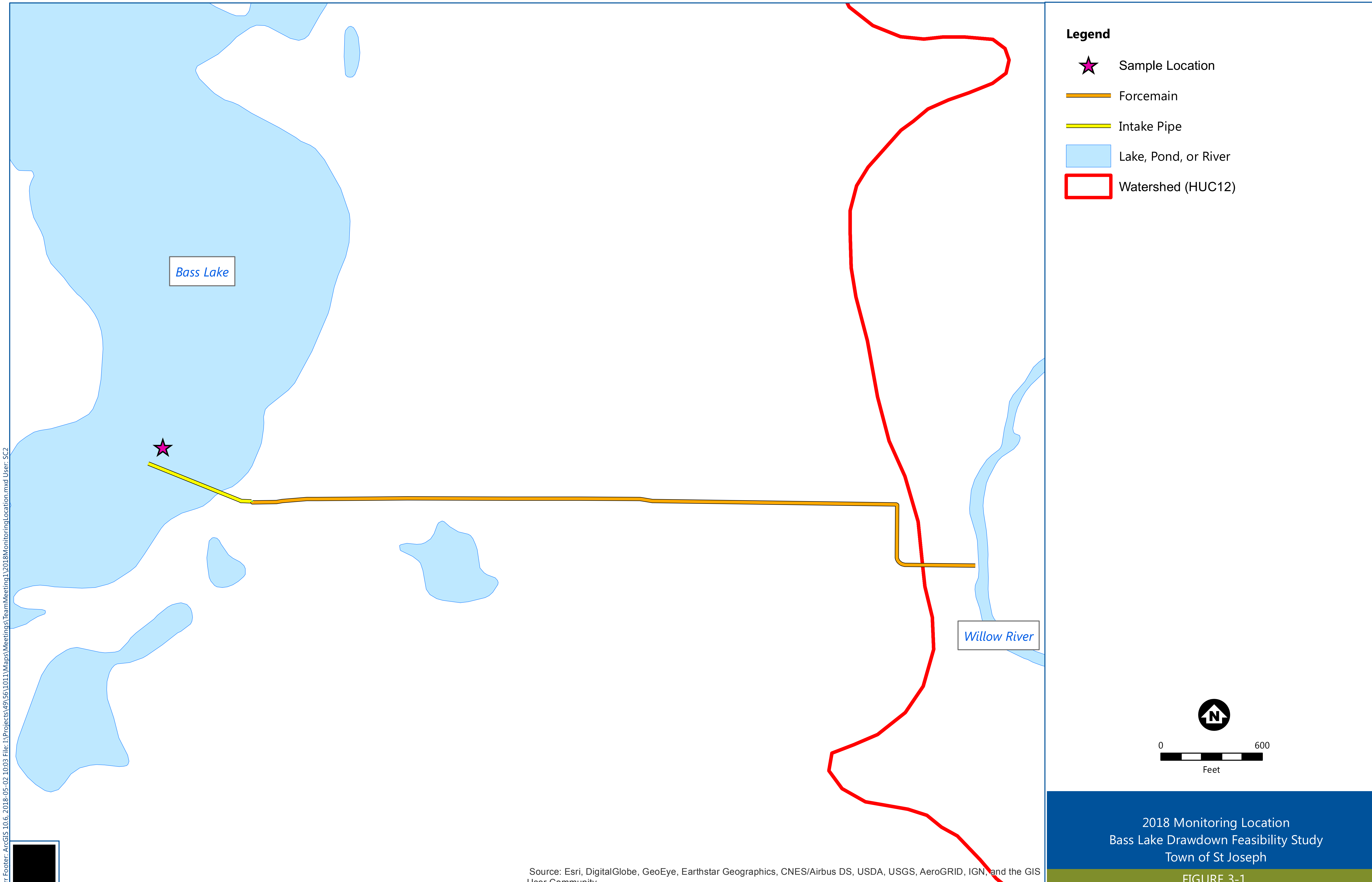
- Pump and tubing – this can be used for total phosphorus and zebra mussel veliger samples
- Plankton net (63 micron) – this can be rinsed and reused
- Other miscellaneous equipment including: pump battery, isopropyl alcohol (91%), volumetric cylinder (to determine pumping rate), and buckets/jug

The laboratory should provide containers for collecting water quality samples. For total phosphorus samples, the containers should include the appropriate preservative for the analysis. For zebra mussel veliger and young of year sampling, RMB Laboratories recommends filtering 200 liters of lake water through a plankton net for each sample. The condensed sample (within the net) can go into a plastic bottle and preserved with isopropyl alcohol (91%) (three parts alcohol to one part sample).

The total estimated cost for the 2018 monitoring is $5,600. This cost includes:

- Purchasing the additional monitoring equipment,
- Laboratory analytical costs for the proposed samples (24 total phosphorus, up to 12 to 24 zebra mussel sizing samples), and
- Training of BLRD representatives for the collection of samples and laboratory coordination

At the second team meeting held on April 27, 2018, WDNR staff suggested that the BLRD use the Wisconsin State Laboratory of Hygiene to perform the 2018 water quality analysis. However, the Wisconsin State Lab of Hygiene can only test for zebra mussel veliger presence or absence but cannot perform zebra mussel sizing analysis. Therefore, the BLRD will need to utilize a commercial laboratory for the zebra mussel analyses. Correspondence with RMB Environmental Laboratories can perform zebra mussel veliger presence/absence and sizing analyses. WDNR staff will also assist the BLRD in selecting and acquiring the additional needed monitoring equipment and in training BLRD representatives for the required sampling protocol.



2018 Monitoring Location
Bass Lake Drawdown Feasibility Study
Town of St Joseph

FIGURE 3-1

3.2 Option 1: Infiltration

Option 1 includes the feasibility level design of an infiltration system to manage the discharges from Bass Lake. Soil data in the Bass Lake watershed suggest that soils in the watershed have higher infiltration capacity that could be conducive to this approach. Figure 3-2 shows the general layout of Option 1, including the two potential sites for infiltration, which are further discussed in the following sections.

3.2.1 Project Components

Option 1 includes the following components:

- **Maintenance of Existing Pump and Intake Pipe**
    - The existing pump is 20-years old and has not been operated in about 19 years. We assume the pump will need to be rebuilt, including replacing the motor, the bearing, o-rings, and seals.
    - Removal/treatment of zebra mussels in the existing intake pipe (if established).
- **Modification of Pump Intake**
    - Modification of the pump intake will protect the pump equipment by preventing the movement of juvenile and adult zebra mussels into the intake pipe, wet well, and pump. The modification includes removal of 60 feet of 24-inch diameter HDPE slotted intake pipe and replacing with equivalently sized solid wall HDPE. It also includes installation of an intake screen with openings of 0.125 inches (3.175 mm) with an automated air burst (hydroburst) backwash system (Intake Screen Option A). The current intake system floats; however, with the addition of the intake screen, a stand will need to be installed on the lake bottom to keep the screen elevated a minimum of 5 feet above the lake bottom (see Figure 3-3). The WDNR may require an intake screen with smaller slot openings (0.5 mm) (Intake Screen Option B) depending on the results from the 2018 monitoring effort.
    - The air burst system requires a compressor located on land with an airline that will run along the existing intake pipe to the intake screen. Intake Screen Option A (0.125 inch) requires a 200 gallon compressor tank system with a 2-inch line to the intake screen. Intake Screen Option B (0.5 mm) requires a 1,040 gallon compressor tank system with a 4-inch line to the intake screen.
    - Because of the age of the existing electrical panel, it may need to be replaced. Additionally, there may not be enough capacity or space for additional equipment, thus requiring a new panel.
- **Infiltration basin system and modifications to the forcemain:** Based on the estimated groundwatershed, infiltration sites would need to be located south of the existing forcemain so that infiltrated water does not return to Bass Lake. The Town Chair reached out to several landowners in this area. Based on preliminary discussions with landowners who were open to the potential sale of land for the management of the Bass Lake pumped discharge, two sites were identified for the potential development of infiltration basins (see Figure 3-2).
    - Option 1a is a basin located on the Englehart property (see Figure 3-4). Based on a preliminary footprint and grading, a basin of about 5.6 acres could be developed on this site. Because this property is located south of the existing forcemain, approximately

1,000 feet of new 18” diameter HDPE forcemain will need to be installed to divert flows to the proposed basin.

- o Option 1b is a basin located on the Orf property (see Figure 3-5). Based on a preliminary footprint and grading, a basin of about 5.4 acres could be developed on this site. Because this property is located along the existing forcemain, only minor modifications will be needed to divert flows to the proposed basin.
- o At both sites, a system will be required to evenly distribute the discharge throughout the basin.

3.2.2 Meeting the Zebra Mussel and Phosphorus Discharge Requirements

The infiltration system proposed in Option 1 will meet both the WDNR zebra mussel veliger (zero sum transfer) and total phosphorus discharge (<39 µg/L) requirements.

3.2.3 Considerations

- **Maintenance of Existing Pump and Intake Pipe**
    - o Because zebra mussels were observed to be established on the pump intake, there is concern that they are already established in the intake pipe. We looked into televising the 600-foot intake pipe for zebra mussels by local service providers, and they stated it is not possible because the existing intake pipe is completely submerged and cannot be dewatered. Televising the pipe may be possible with a sonar camera, although there are no local contractors with this equipment. However, we consulted a contractor with the sonar equipment, and they did not think that the equipment would detect zebra mussels on the intake pipe and it may be easiest to assume they are established in the pipe or fully-replace the intake pipe
    - o Because the intake pipe is fully-submerged, jetting of the intake pipe will likely not be effective at removing the zebra mussels, if they are established in the intake pipe. Mechanical removal (via mechanical pigging) is another option for the removal of zebra mussels, although access via the wet well may not be feasible due to space limitations.
    - o Another option for the treatment of zebra mussels in the intake pipe is chemical treatment of the wet well and intake pipe with Earthtec QZ. The treatment would need to occur after the slotted intake pipe is removed and a temporary cap is placed on the end of the intake. To achieve 100 percent mortality, the chemical would be dosed to 1 ppm in the wet well and intake pipe with a 5-day contact time (minimum). All chemical applications would need to be completed by a licensed applicator. For our cost estimates, we assumed this approach would be appropriate.
    - o If the WDNR decides that chemical treatment to kill zebra mussels potentially established in the intake pipe is not an acceptable approach, the entire intake pipe (approximately 600 feet of 24” diameter HDPE) may need to be replaced.

- **Modification of Pump Intake**
    - o We considered two different intake screen slot sizes as WDNR staff do not yet know the slot size opening they will require for Bass Lake. Option A includes a proposed intake

screen with openings that are 0.125 inches (3.125 mm). Based on the reproductive season of zebra mussels and their anticipated growth rates, it appears that a mesh size on the intake screen of 0.125 inches (3.125 mm) should be sufficient to filter out zebra mussels if pumping would not begin until November. All cost estimates summarized in the report for Options 1 and 3 assume Intake Screen Option A costs.

If the WDNR requires a smaller intake screen slot opening (0.5 mm), the overall size of the screen will need to increase to convey the same amount of flow with minimal head loss through the screen. This increases the screen cost, increases the screen weight (approximately 3 times heavier than Intake Screen Option A), and requires a significantly larger hydroburst air backwash system.

- The intake screen vendor expressed concerns about debris and other solids accumulation on the screen during periods of no operation. This may be the case for Bass Lake, where the operation of the system may only occur for one or two years, and then the system may remain unused for another decade. The vendor does not have any sort of cover available for the intake screen, but some sort of cover could be developed that would be installed over the intake screen during periods when the system is not operating. This cover can help prevent the migration of veligers into the intake pipe where they could establish when the system is not operating.

- **Infiltration basin system and modifications to the forcemain**
  - Both sites will require land purchase.
  - Soil borings (Appendix G) were collected in April 2018 by American Engineering and Testing (AET) for the Town of St. Joseph on the Englehart and Orf properties, as shown in Figure 3-2. Five borings were collected at each site to classify the soils and assign estimated infiltration rates based on the soil textures and other characteristics. At both sites, several feet of excavation will be required to expose the sandy soils (soil texture SP) profile below, with an assigned infiltration rate of 3.6 inches per hour. At the Englehart property, there are two borings indicating areas that will require over-excavating and replacing the material with sand (see Figure 3-4). At the Orf property, there was one boring indicating an area that will require over-excavating and replacing the material with sand (Figure 3-5).
  - There are two different design approaches for the infiltration basin that can result in significantly different basin sizes. At this time, WDNR staff does not know what permits, regulatory oversite, or design criteria would specifically apply to the type of system proposed at Bass Lake.

    The first approach would be to design the system in accordance with the Wisconsin Stormwater Manual. A second approach would be to design the basin in accordance with guidance for rapid infiltration system of wastewater. Because the Bass Lake system is neither stormwater runoff nor wastewater, the WDNR has not yet decided the required design approach. Because the system will pump 1.0 million gallons over 8 hours each day, the goal of any system design would be to allow for pumping/loading 1/3 of the time (8 hours) with the other 2/3 of the time for drying (16 hours).

The infiltration design assumed a pumping rate of 1.0 MGD. The stormwater design approach gives 50 percent credit to the field-determined infiltration rate (1.8 inches per hour), so using this method would result in a 2.5-acre basin. The wastewater rapid infiltration design approach only gives 10 percent credit to the field determined infiltration rate (0.36 inches per hour), and results in a 12.5-acre basin (distributed between a minimum of three basins).

The feasibility designs as shown at both properties provide basins of approximately 5.5 acres, which falls between the two design methodologies.

- With any infiltration project, groundwater mounding is a concern that should be evaluated. Depending on the soil characteristics (for both vertical and lateral movement), infiltration will create a "mound" of higher water table elevations under and around the infiltration basin. These locally higher groundwater levels may adversely affect nearby basements and septic systems, wetlands, and slopes, and may alter groundwater flow directions.

  The groundwater model was utilized to simulate the potential changes to groundwater levels and flow directions resulting from rapid infiltration basins located on the Englehart and Orf properties. While the Englehart and Orf sites are located outside of the Bass Lake groundwatershed to the south, they are located east of the lake and close enough to the groundwatershed boundary that altered groundwater flow directions caused by the mounding may cause infiltrated water to flow back to Bass Lake.

  The groundwater model results are likely conservative with respect to the degree of mounding because the horizontal and vertical hydraulic conductivity values in the model are lower than values estimated from the soil boring data at each site. Lower hydraulic conductivity means more resistance to flow and therefore a higher groundwater mound at the infiltration basin. Additionally, the groundwater model evaluates a steady-state condition, which assumes the infiltration would be happening continuously throughout the year at a rate equivalent to the pumping of 1.0 MGD for five months; however, given the past operations of the pump, it is unlikely that the system would operate under those conditions.

  At the Englehart site, the model estimated a maximum groundwater mound height of 1-7 feet and 0 to 30 percent of the infiltrated water returning to Bass Lake. Additionally, infiltrated water may move laterally toward the wetland to the north of the proposed site.

  At the Orf site, the model estimated a maximum groundwater mound height of 1-5 feet and 0 to 20 percent of the infiltrated water returning to Bass Lake. We are also concerned about infiltration of water so close to the bluff along the Willow River. Lateral movement of the infiltrated water could result in the formation of seeps on the steep slopes along the Willow River and could result in slope stability issues.

Due to the depth to groundwater, we do not anticipate that groundwater mounding will affect nearby basements at either location.

These potential impacts due to groundwater mounding and lateral movement of the infiltrated water will need to be further investigated during final design, should Option 1 be selected.

- Although five borings were completed at each site, additional soil borings and in-situ infiltration testing will be required in accordance with WDNR guidance, should this option be selected. The number of test locations would be based on the anticipated footprint of the basin. This work would be completed prior to final design and permitting.
- The infiltration system cannot be operated during the winter months/frozen soil conditions (assume November – March).
- At both sites, stormwater runoff from the small watersheds upstream of these basins will need to be routed around the edge of the system.

3.2.4 Permitting

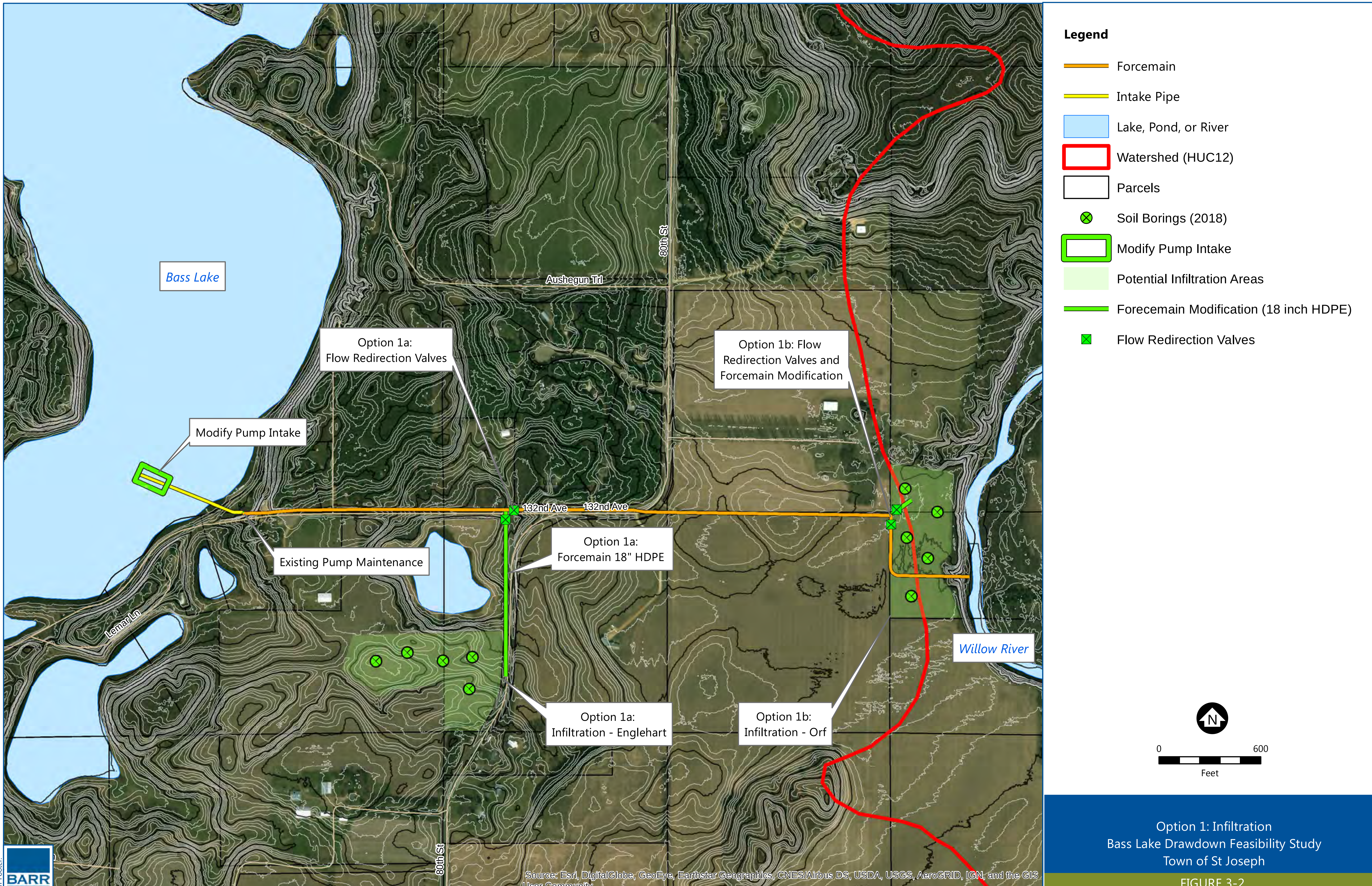
The following are the permits anticipated for Option 1.

- **NR107 Chemical Aquatic (Invasive Plant/Animal) Control Application Permit/WPDES General Permit for discharging a Pollutant due to Activities to Control Detrimental or Invasive Aquatic Animals (WI-0064564-2) -** for compliance with provisions of chapter 283, Wisconsin Statutes: Required for chemical treatment of Bass Lake intake pipe/wet well for control of zebra mussels (if used)
- **Chapter 30 permit –** for placement of Intake/Outfall in water and support base on lake bottom - Applicable statutes and codes include Section 30.12, Wis. Stats. and Chapter NR 329, Wis. Adm. Code.
- **Chapter 30 permit with a NR40 exemption** – Applicable for the reinstatement of pumping from Bass Lake
- **WPDES Storm Water Associated with Land Disturbing Construction Activity (WI-S067831-5) –** for compliance with provisions of chapter 283, Wisconsin Statutes and chapters NR151 and NR216 of Wisconsin Administrative Code: Required for land disturbing activity affecting one (1) acre or more of land or pit/trench dewatering discharge from a construction site
- **Infiltration System –** WDNR has not yet determined what regulatory oversite is required for the proposed pumping/infiltration system for Bass Lake

3.2.5 Operation and Maintenance

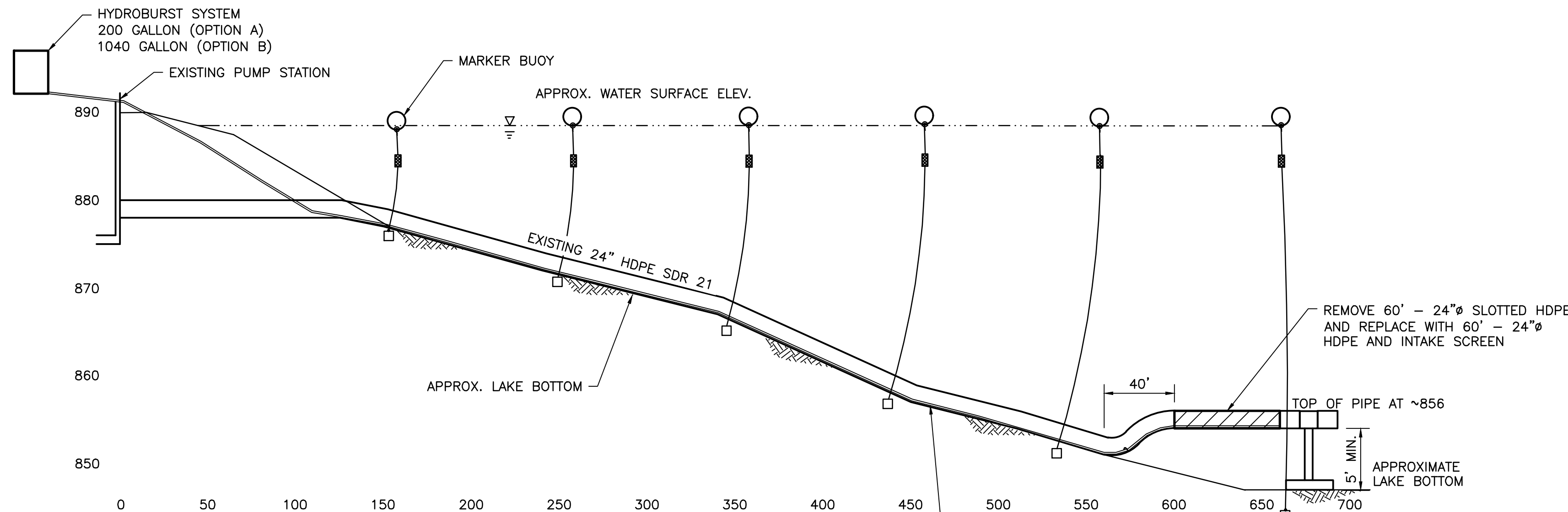
The anticipated operations and maintenance activities and costs for Option 1 include:

- Removal of the intake screen cover (via diver) and preparation of the pumping system prior to pumping.
- Chemical treatment (Earthtec QZ)of the wet well and intake pipe prior to operation to manage/kill any zebra mussels potentially within the intake pipe, dosed to meet 1 ppm for a 5-day contact time to achieve mortality.
- Adjustment of the valves along the forcemain to direct flows to the infiltration basin.
- The pump and air compressor, which is part of the air burst backwash system, will need to be monitored during pump operation.
- Electrical costs for the operation of the pump and airburst backwash system.
- Inspection and maintenance of the basin, including inspections around the inlets and distribution system for evidence of erosion or standing water, areas bare of vegetation, etc.
- Replacing the intake screen cover (via diver) and shut down of the pumping system.

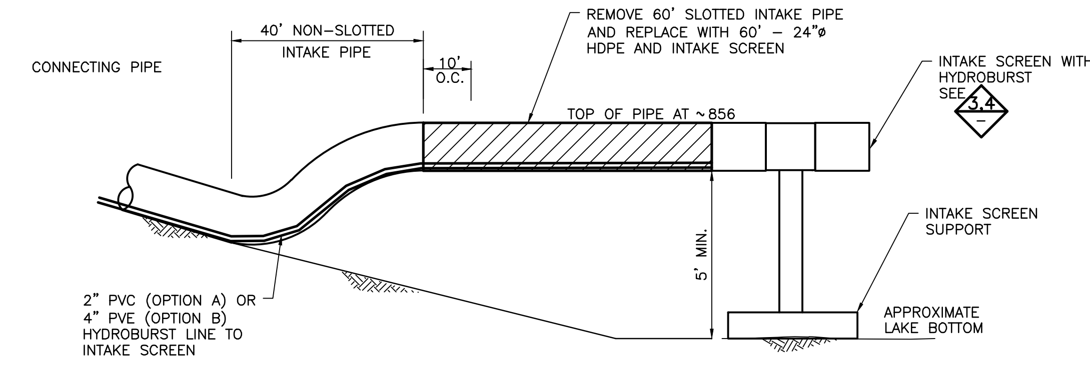


Option 1: Infiltration
Bass Lake Drawdown Feasibility Study
Town of St Joseph

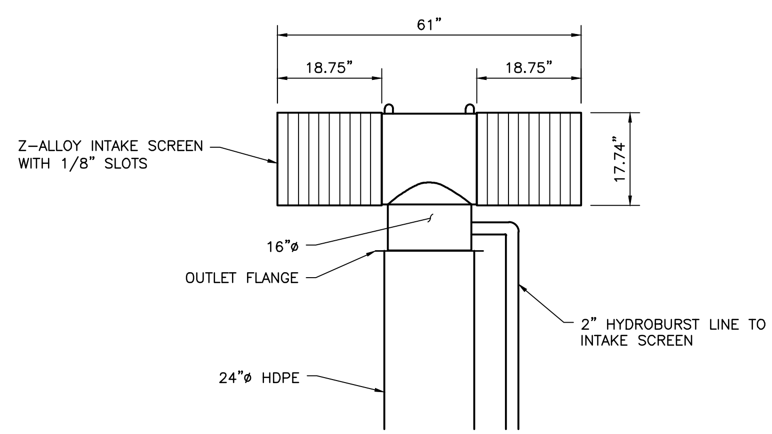
FIGURE 3-2



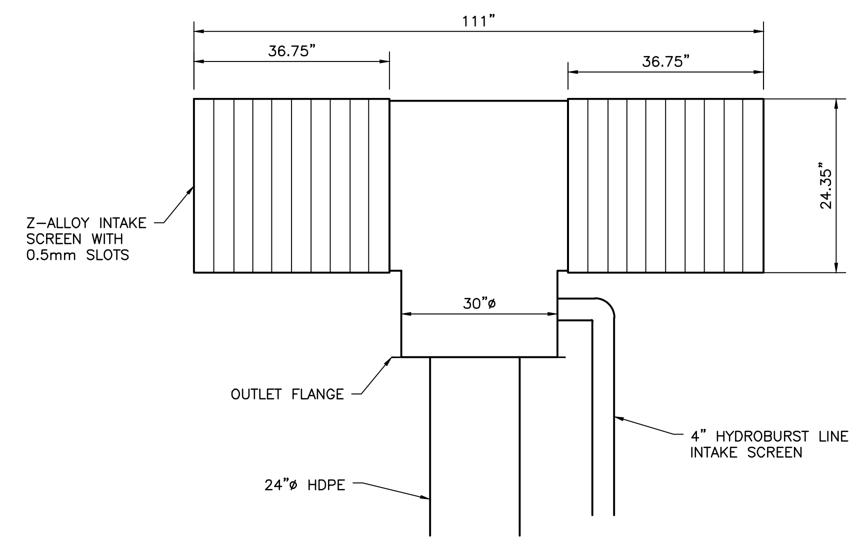
1 SECTION: INTAKE PIPE



2 SECTION: INTAKE PIPE
1"=20'–0"



3 DETAIL: INTAKE SCREEN (OPTION A)
N.T.S.



4 DETAIL: INTAKE SCREEN (OPTION B)
N.T.S.

NOTE: OPTION B DIMENSIONS ARE APPROXXIMATE.

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Scale	AS SHOWN
Date	04/18/18
Drawn	EPF
Checked	–
Designed	BARR
Approved	–

TOWN OF ST. JOSEPH
ST. CROIX COUNTY, WISCONSIN

BASS LAKE DRAWDOWN FEASIBILITY STUDY
ST. JOSEPH TOWNSHIP, WISCONSIN

FIGURE 3–3
INTAKE MODIFICATION

BARR PROJECT No. 49/56–1011.00
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REV. No.

CADD USER: Gareth W. Becker FILE: M:\DESIGN\49561011.00\49561011_INTAKE MODIFICATIONS.DWG PLOT SCALE: 1:2 PLOT DATE: 5/3/2018 1:41 PM
epf M:\Design\49561011.00\49561011_Intake Modifications.dwg Plot at 0 04/18/2018 13:36:13

1 PLAN: INFILTRATION BASIN

0 50 100 SCALE IN FEET

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FIGURE 3-4
OPTION 1a: INFILTRATION – ENGLEHART PROPERTY

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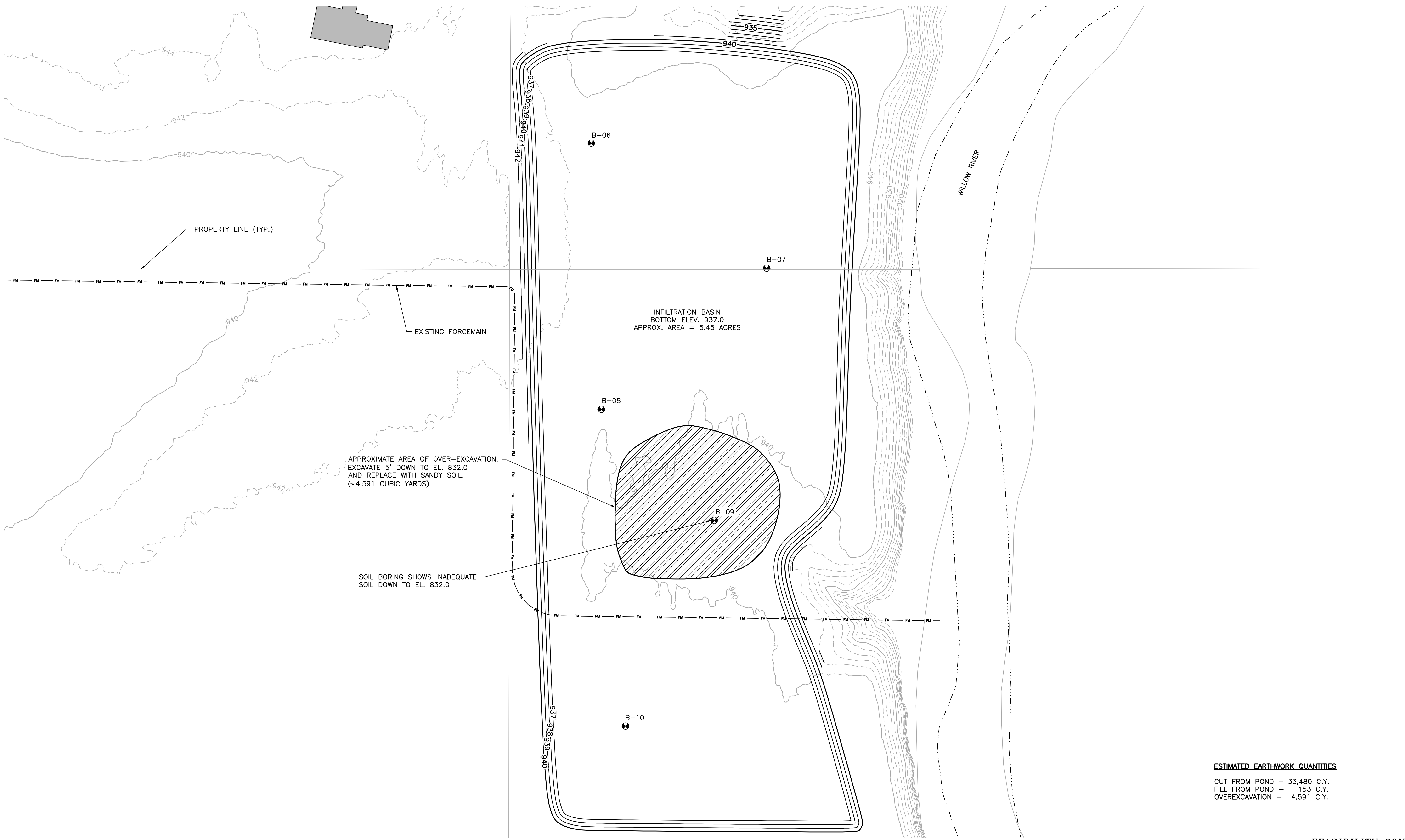
REV. No.

CADD USER: Eric P. Fitzgerald FILE: M:\DESIGN\49561011.00\49561011_INFILTRATION BASIN.DWG PLOT SCALE: 1:2 PLOT DATE: 4/26/2018 10:44 AM
BAR M:\AutoCAD 2011\AutoCAD 2011 Support\enu\Template\Barr_2011_Template.dwt Plot at 1 10/05/2010 14:03:50



ESTIMATED EARTHWORK QUANTITIES

CUT FROM POND – 33,480 C.Y.
FILL FROM POND – 153 C.Y.
OVEREXCAVATION – 4,591 C.Y.

FEASIBILITY CONCEPT
NOT FOR CONSTRUCTION

1 PLAN: INFILTRATION BASIN

0 50 100
SCALE IN FEET

N

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DATE . LICENSE # .

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Approved	–

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FIGURE 3-5
OPTION 3b: INFILTRATION – ORF PROPERTY

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CLIENT PROJECT No.
DWG. No. –
REV. No.

CADD USER: Eric P. Fitzgerald FILE: M:\DESIGN\49561011.00\49561011_INFILTRATION BASIN.DWG PLOT SCALE: 1:2 PLOT DATE: 4/26/2018 10:46 AM
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3.3 Option 2: Seasonal Pumping

Option 2 includes the feasibility level evaluation of seasonal pumping to manage the discharges from Bass Lake. Figure 3-6 shows the general layout of Option 2, which is further discussed in the following sections.

3.3.1 Project Components

- **Maintenance of Existing Pump and Intake Pipe**
  - See discussion in Section 3.2.1 for Option 1.
  - Option 2a assumes seasonal pumping with the Intake Screen Option A (0.125-inch/3.125-mm slot openings). Option 2b assumes seasonal pumping with the Intake Screen Option B (0.5-mm slot openings).
- **Modification of Pump Intake**
  - See discussion in Section 3.2.1 for Option 1.
- **Seasonal Pumping**
  - The information regarding zebra mussel veliger reproductive and growth cycles and total phosphorus levels in the Bass Lake hypoliminion throughout the year , indicate that seasonal pumping could be an option for the operation of the Bass Lake pumping system. Seasonal pumping would likely take place around the start of November and continue through the end of April.

3.3.2 Meeting the Zebra Mussel and Phosphorus Discharge Requirements

The seasonal pumping proposed in Option 2 will meet both the WDNR zebra mussel veliger (zero sum transfer) and total phosphorus discharge (<39 µg/L) requirements.

3.3.3 Considerations

- **Maintenance of Existing Pump and Intake Pipe**
  - See discussion in Section 3.2.3 for Option 1.
- **Modification of Pump Intake**
  - See discussion in Section 3.2.3 for Option 1.
- **Seasonal Pumping**
  - The BLRD could consider operating the pump for longer periods each day, up to 2.0 MGD; this would allow the lake levels to be drawn down at a faster rate.

3.3.4 Permitting

The following are the permits anticipated for Option 2.

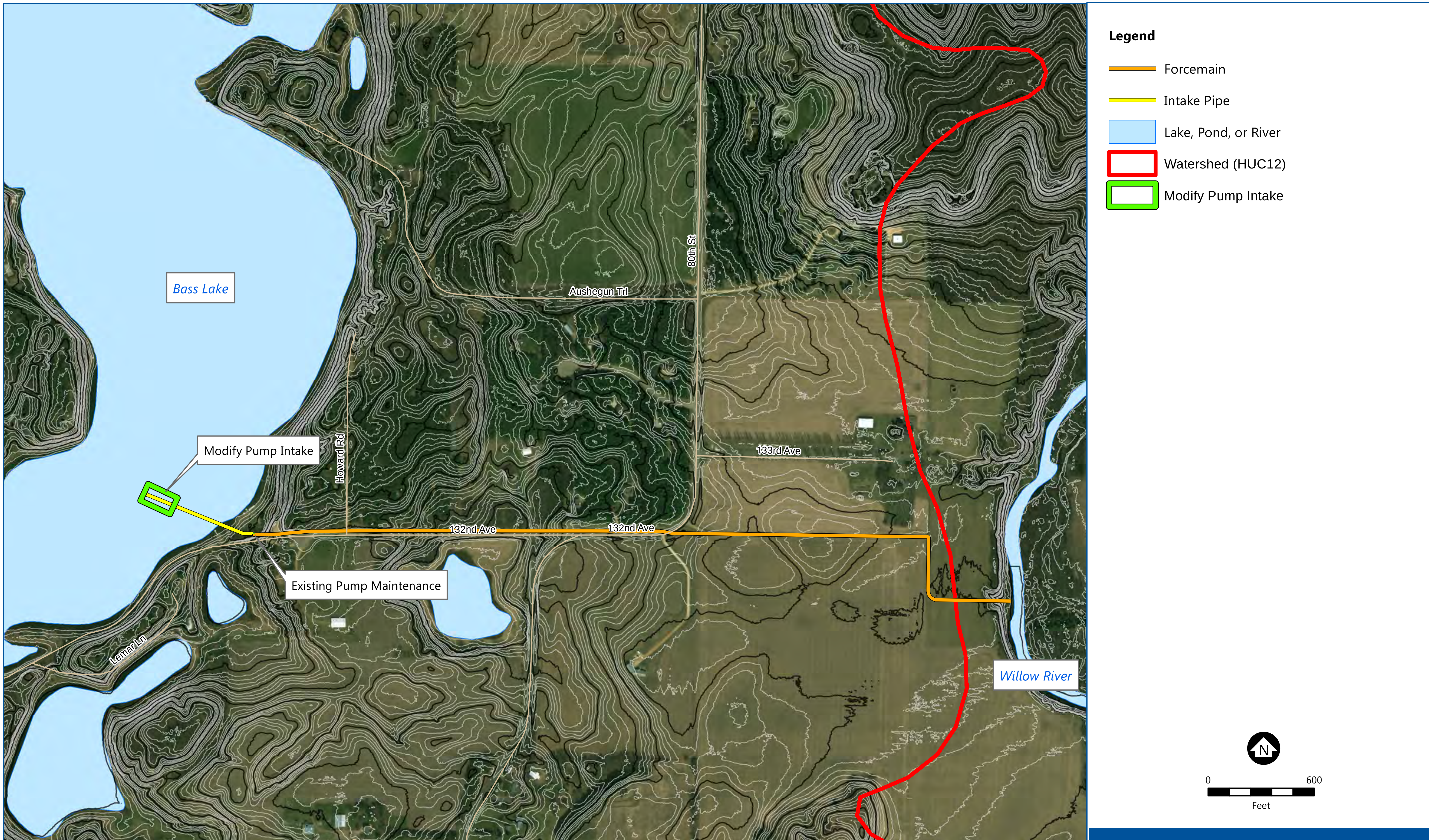
- **NR107 Chemical Aquatic (Invasive Plant/Animal) Control Application Permit/WPDES General Permit for discharging a Pollutant due to Activities to Control Detrimental or Invasive Aquatic Animals (WI-0064564-2) -** for compliance with provisions of chapter 283, Wisconsin Statutes: Required for chemical treatment of Bass Lake intake pipe/wet well for control of zebra mussels (if used).

- **Chapter 30 permit –** for placement of Intake/Outfall in water and support base on lake bottom - Applicable statutes and codes include Section 30.12, Wis. Stats. and Chapter NR 329, Wis. Adm. Code.
- **Chapter 30 permit with a NR40 exemption** – Applicable for the reinstatement of pumping from Bass Lake

3.3.5 Operation and Maintenance

The anticipated operations and maintenance activities and costs for Option 2 include:

- Removal of the intake screen cover (via diver) and preparation of the pumping system prior to pumping.
- Chemical treatment (Earthtec QZ)of the wet well and intake pipe prior to operation to manage/kill any zebra mussels potentially within the intake pipe, dosed to meet 1 ppm for a 5-day contact time to achieve mortality.
- Total phosphorus and zebra mussel veliger monitoring prior to, and during, pump operation.
- The pump and air compressor, which is part of the air burst backwash system, will need to be monitored during pump operation.
- Electrical costs for the operation of the pump and airburst backwash system.
- Replacing the intake screen cover (via diver) and shut down of the pumping system.



Option 2: Seasonal Pumping
Bass Lake Drawdown Feasibility Study
Town of St Joseph

FIGURE 3-6

3.4 Option 3: Filtration Systems

Option 3 includes the feasibility level design of two potential filtration systems to manage the discharges from Bass Lake. Figure 3-7 shows the general layout of Option 3, which is further discussed in the following sections.

3.4.1 Project Components

- **Maintenance of Existing Pump and Intake Pipe**
  - o See discussion in Section 3.2.1 for Option 1.
- **Modification of Pump Intake**
  - o See discussion in Section 3.2.1 for Option 1.
- **Modification to Existing Forcemain, Filtration System and Shelters**
  - o We evaluated two filtration options for this alternative, which would be located downstream from the existing pump system. This option will require modifications to the existing forcemain line including the addition of valves, piping and the filtration systems. The first option (3a) is an automatic backwashing mechanical filtration system, the OMEGA-54000 Filter by AMIAD, which provides filtration down to 40 microns (see Figure 3-8). The second option (3b) is a rental bag filtration system, including two BF2000 filters, from Rain for Rent that each house 16 removable filter bags that can filter down to 25 microns. These filtration systems will need to be housed in a shelter/garage style building.

3.4.2 Meeting the Zebra Mussel and Phosphorus Discharge Requirements

The filtration system proposed in Option 3 will meet the WDNR zebra mussel veliger (zero sum transfer) requirement. However, depending on the time of year the system is operated (e.g. if operated during July, August, September, and potentially October), the system may not meet the total phosphorus discharge requirements. Therefore, seasonal pumping may be required to meet the total phosphorus discharge requirements.

3.4.3 Considerations

- **Maintenance of Existing Pump and Intake Pipe**
  - o See discussion in Section 3.2.3 for Option 1.
- **Modification of Pump Intake**
  - o See discussion in Section 3.2.3 for Option 1.
- **Modification to Existing Forcemain, Filtration System and Shelters**
  - o The AMIAD filter system (3a) would be purchased and permanently remain on-site, available for use whenever needed. The Rain for Rent filtration and booster pump system (3b) would be rented for the period needed and delivered and assembled on the site; however, some permanent modifications to the existing forcemain system are needed to accommodate this temporary filtration system.
  - o Both filtration systems will require a shelter and heating/insulation for operation of the equipment during the winter months. This would also include the use of heat trace on the

modified forcemain that will be routed into the shelter and connected to the filtration systems to prevent freezing during winter months.

- Both filters would require daily monitoring during operation. However, the AMIAD system (3a) includes an automatic backwash system, which can discharge back to the existing wet well or to Bass Lake. As a result, this system should not require a lot of hands-on maintenance during operation. The Rain for Rent system (3b) is a very manual system that will require daily (if not more frequent) checks on the filter pressure and will require replacement of the filter bags, as needed. It is difficult to estimate how frequently the filter bags will need to be replaced, but for cost estimating purposes, we assumed that the filter bags are replaced daily during pump operation. When the system is first brought online, the pressure drop across the BF2000 filters will likely need to be monitored closely to determine the frequency of bag replacement.
- Based on discussions with the AMIAD filtration system vendor, at 2,000 gpm, the pressure drop across the AMIAD filter is estimated at only 0.35 pounds per square inch (psi), increasing to 7 psi as the screens become dirty, prior to the automatic backwashing. A booster pump is not anticipated to be needed to pump water from the filtration system to the Willow River. However, as the filter bags in the Rain for Rent system become fouled, there will be a significantly higher pressure drop. At 2,000 gpm, the pressure drop across the BF2000 filters can range between 35-50 psi, which means a booster pump will need to be installed after the filter to pump the discharge to the Willow River.
- The AMIAD system (3a) requires a smaller building with approximate dimensions of 20'x14'x14'. The Rain for Rent system (3b) will require a larger building with approximate dimensions of 22'x28'x10'.
- Additional electrical and related controls work may be needed as the existing panel may not have the capacity or space to incorporate new equipment. The AMIAD filter has an automated system to mechanically clean the filter, which requires additional electrical supply. The filter bags from Rain for Rent do not require any additional electrical work, however the booster pump will require additional electrical service.
- The AMIAD system (3a) would be purchased
- The lake water will need to be monitored prior to use of the system to ensure acceptable total phosphorus levels. Seasonal pumping will take place when the total phosphorus levels are typically below the 39 µg/L water quality standard, which generally occurs between October and June.

3.4.4 Permitting

The following are the permits anticipated for Option 3.

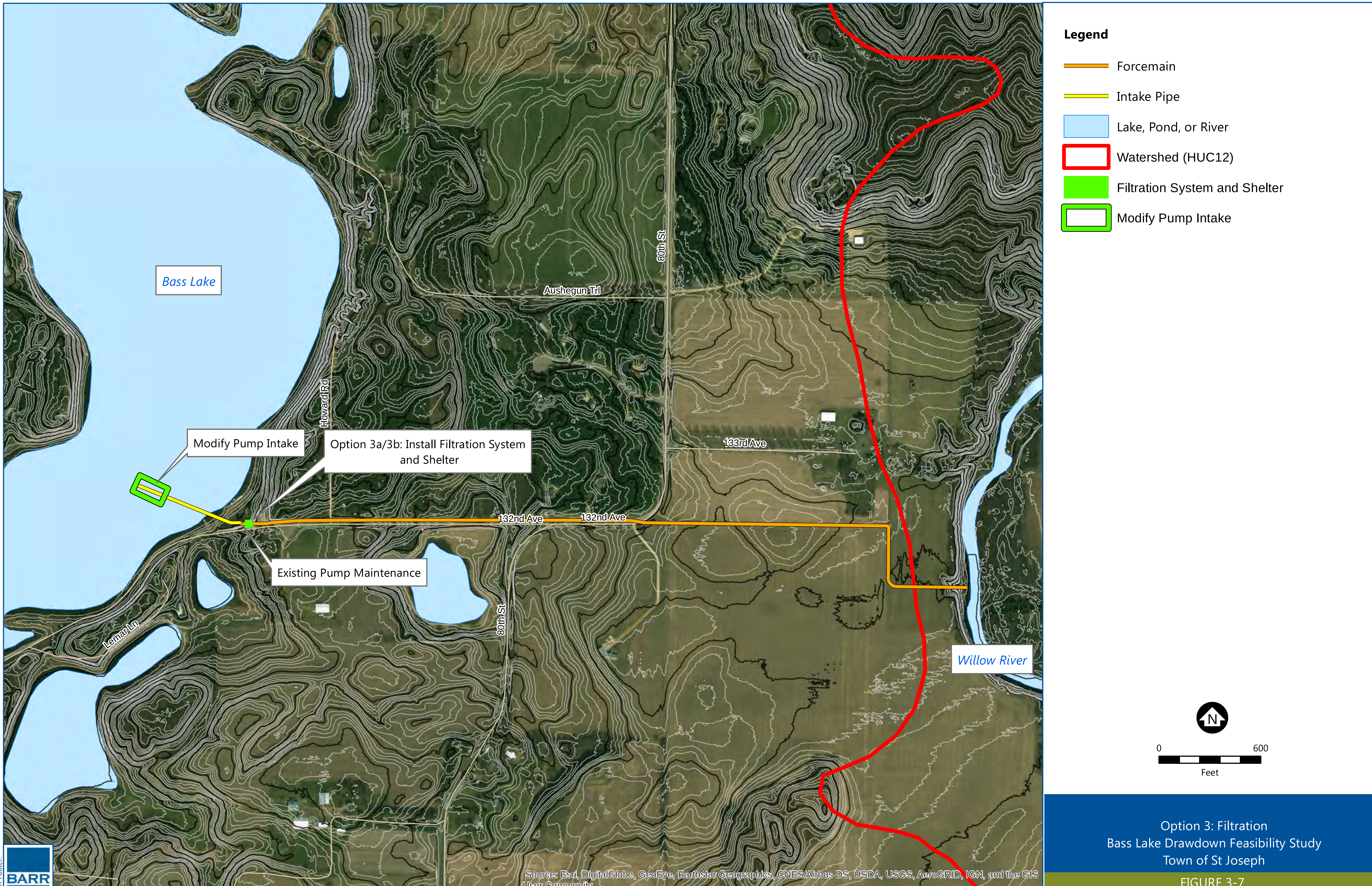
- **NR107 Chemical Aquatic (Invasive Plant/Animal) Control Application Permit/WPDES General Permit for discharging a Pollutant due to Activities to Control Detrimental or Invasive Aquatic Animals (WI-0064564-2) -** for compliance with provisions of chapter 283, Wisconsin Statutes: Required for chemical treatment of Bass Lake intake pipe/wet well for control of zebra mussels (if used)

- **Chapter 30 permit –** for placement of Intake/Outfall in water and support base on lake bottom - Applicable statutes and codes include Section 30.12, Wis. Stats. and Chapter NR 329, Wis. Adm. Code.
- **Chapter 30 permit with a NR40 exemption** – Applicable for the reinstatement of pumping from Bass Lake
- **Chapter 283 Permit/Storm Water Associated with Land Disturbing Construction Activity (WI-S067831-5) –** for compliance with provisions of chapter 283, Wisconsin Statutes and chapters NR151 and NR216 of Wisconsin Administrative Code: Required for land disturbing activity affecting one (1) acre or more of land or pit/trench dewatering discharge from a construction site
- **Town permits** for the construction of a shelter that is greater than 12 feet by 12 feet.

3.4.5 Operation and Maintenance

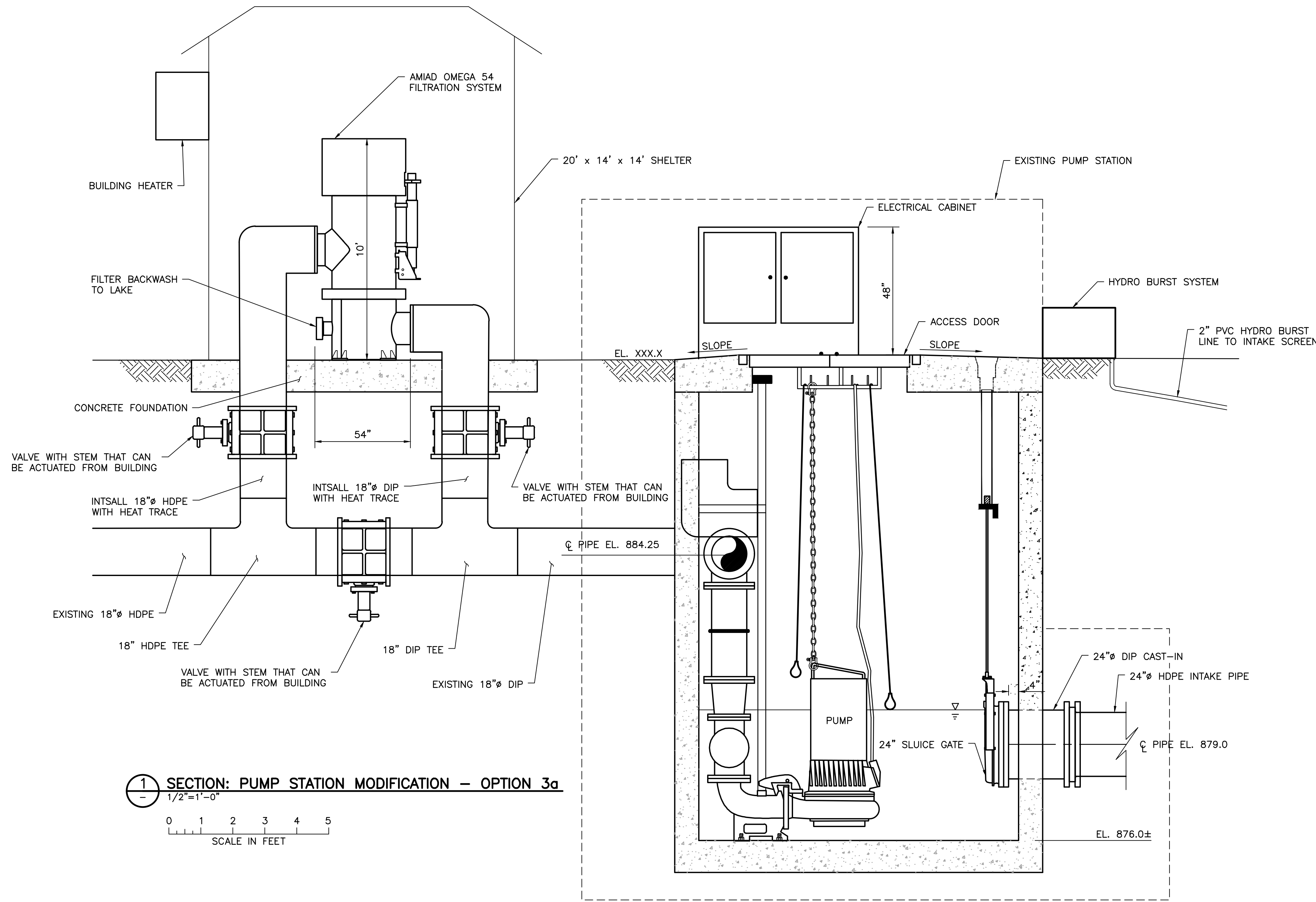
The anticipated operations and maintenance activities and costs for Option 3 include:

- Removal of the intake screen cover (via diver) and preparation of the pumping system prior to pumping.
- Total phosphorus monitoring prior to and during pump operation.
- The pump and air compressor, which is part of the air burst backwash system, will need to be monitored during pump operation.
- Both filtration systems will require a significant amount of operational monitoring, including on-site physical inspections by the operator to detect if there are issues/problems with either filter system. The AMIAD system (3a) has an automatic backwash system, but requires monitoring to ensure the pressure drop across the filter is adequate and the cleaning mechanism is functioning correctly. The pressure drop across the two Rain for Rent filter bags (3b) will need to be monitored manually and between the two filters, there are a total of 32 separate filter bags that will likely need to be changed out on a daily basis (potentially more frequently).
- Electrical costs for the operation of the pump, airburst backwash, shelter heating/pipe heat trace, and filtration (AMIAD) or booster pump (Rain for Rent).
- Replacing the intake screen cover (via diver) and shut down of the filtration and pumping system.



Option 3: Filtration
Bass Lake Drawdown Feasibility Study
Town of St Joseph

FIGURE 3-7



1 SECTION: PUMP STATION MODIFICATION – OPTION 3a
1/2"=1'-0"

0 1 2 3 4 5
SCALE IN FEET

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ST. JOSEPH TOWNSHIP, WISCONSIN

FIGURE 3–8
OPTION 3a: AMIAD FILTRATION

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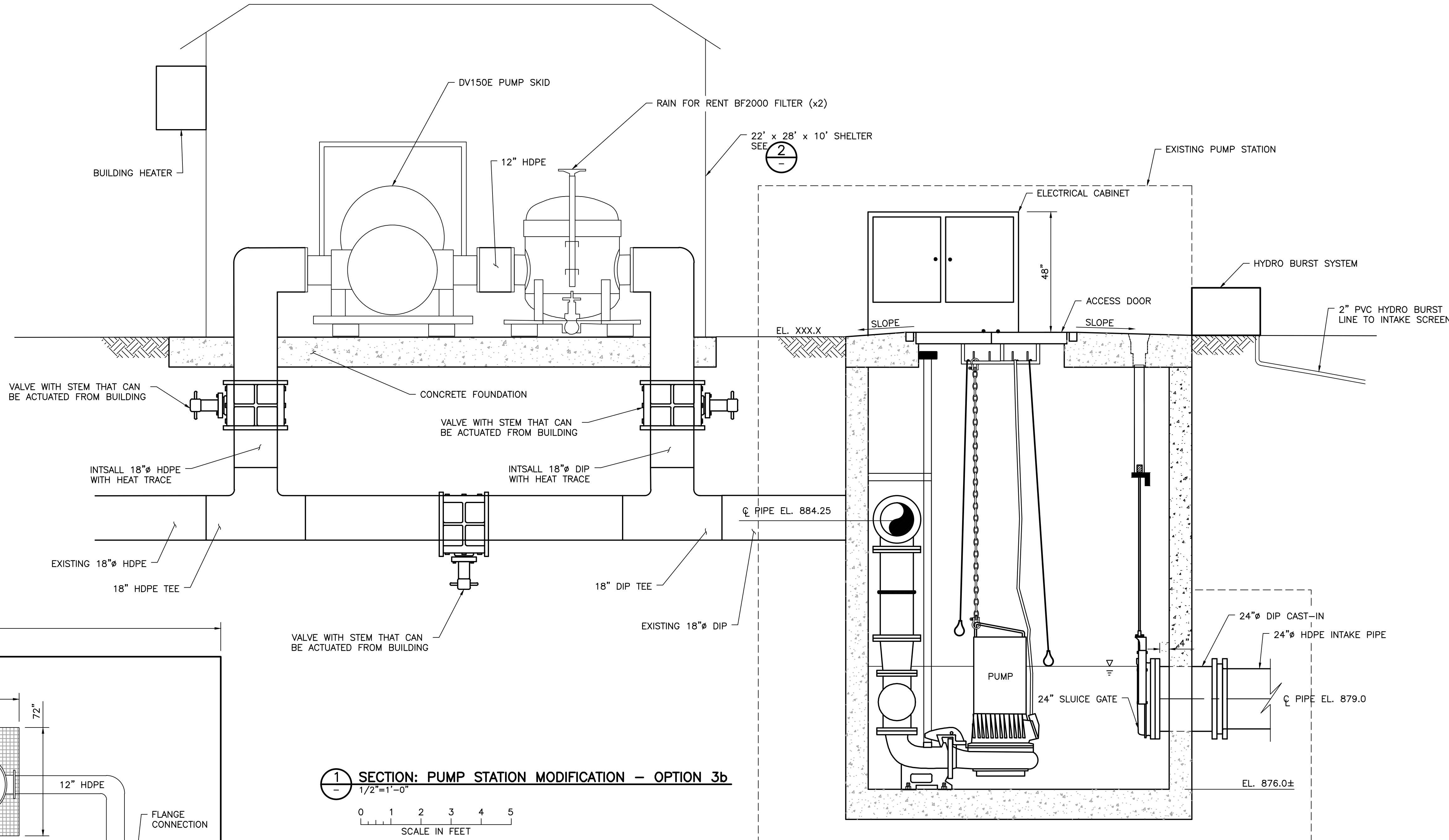

1 SECTION: PUMP STATION MODIFICATION – OPTION 3b
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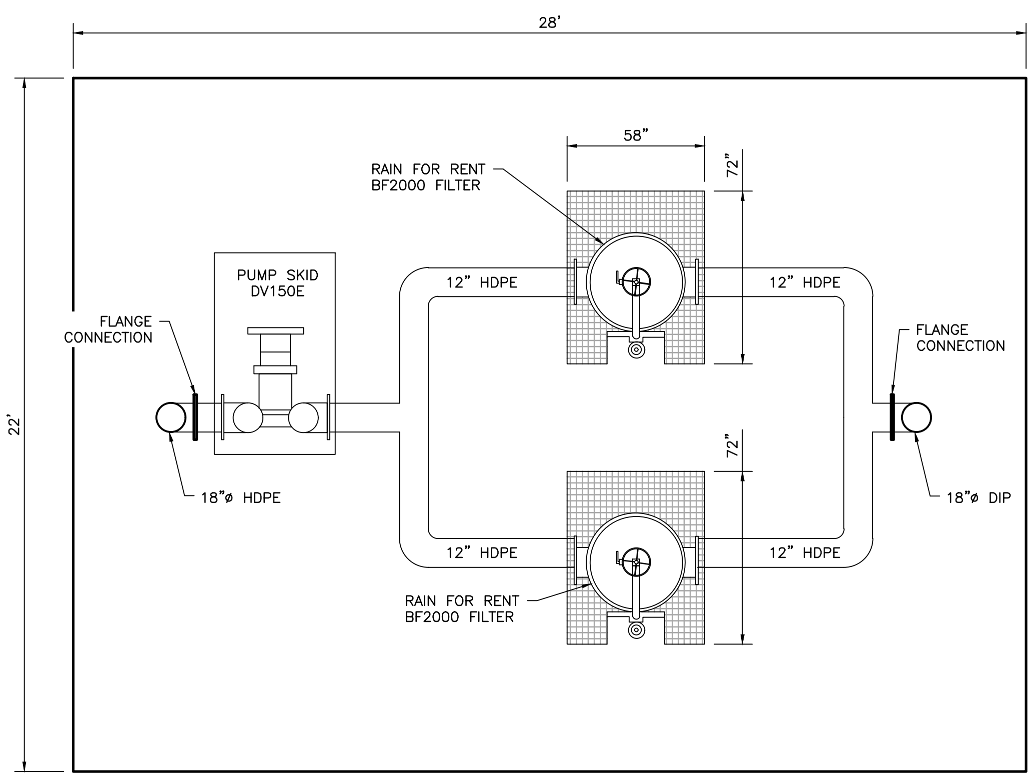
SCALE IN FEET



2 PLAN: BUILDING LAYOUT

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TOWN OF ST. JOSEPH
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BASS LAKE DRAWDOWN FEASIBILITY STUDY
ST. JOSEPH TOWNSHIP, WISCONSIN
FIGURE 3-9
OPTION 3b: RAIN FOR RENT FILTRATION

BARR PROJECT No. 49/56-1011.00
CLIENT PROJECT No.
DWG. No. –
REV. No.

3.5 Option 4: Shoreline Drain Tile System

Option 4 includes the feasibility level evaluation of a shoreline drain tile system that would intercept and pump groundwater and lake water to help control Bass Lake water levels. Figure 3-10 shows the general layout of Option 4, which is further discussed in the following sections.

3.5.1 Project Components

- **Modification/Elimination of Existing Pump Intake**
  - Because this system relies on the use of the shoreline drain tile system, the existing intake pipe in the lake could be eliminated or, at a minimum, capped off.
- **Shoreline Drain Tile System**
  - Installation of a 4,700-foot long drain tile system parallel to the Bass Lake shoreline, set approximately 2 feet below the targeted lake elevation.
- **Installation of a New Pump**
  - Based on the groundwater model results, the anticipated pumping rates for the shoreline drain tile system would need to be approximately 1.25 to 1.75 times greater than the existing pumping rate, if operated similar to the existing system (8 hours per day). A new pump would likely be required to pump the water collected by the drain tile system into the forcemain, but the existing 18" forcemain could be reutilized for this system, as the existing forcemain can handle flows up to about 4,700 gpm.

3.5.2 Meeting the Zebra Mussel and Phosphorus Discharge Requirements

The shoreline drain tile system proposed in Option 4 will meet both the WDNR zebra mussel veliger (zero sum transfer) and total phosphorus discharge requirements.

3.5.3 Considerations

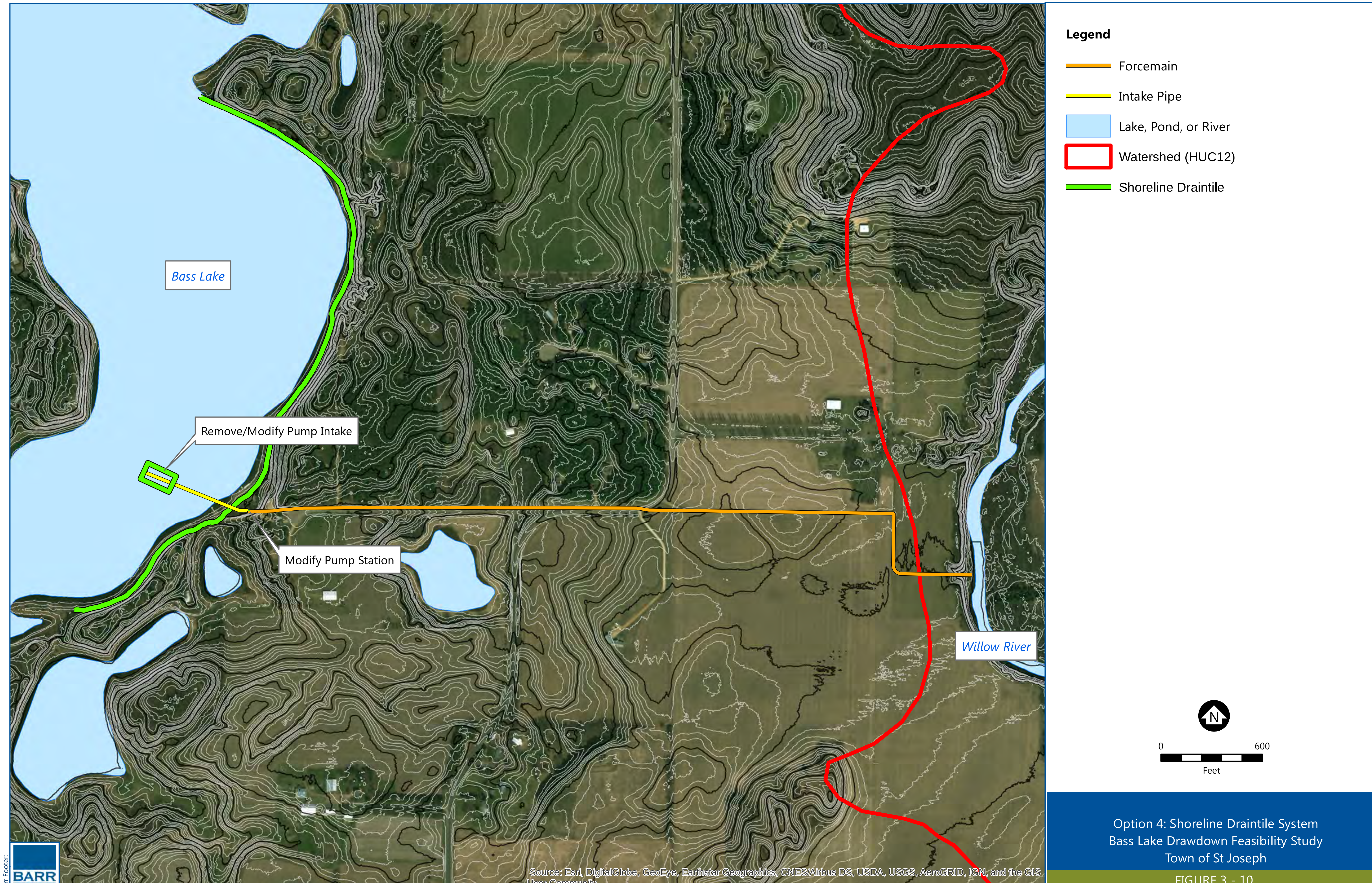
Although this type of drain tile system has been used for the control of water levels in other situations, we determined that Option 4 was not feasible, based on the topography and other conditions around Bass Lake, which led to constructability concerns. We identified the following concerns during our further evaluation of the alternative:

- Review of the required length of the shoreline drain tile system (about 4,700 ft) against the LiDAR topographic data suggests that the drain tile system would need to be offset from the lake shore (assumed lake shore edge at 885) about 10 feet to minimize conflicts with the shoreline topography. However, several areas of the drain tile alignment would have some conflicts with steep slopes and the system would need to be moved closer to the shoreline/potentially in the water, which is not preferred.
- Given the topography, access to construct the drain tile trench would be challenging or nearly impossible at some locations, or would require construction access from the water (via barge).
- To install the drain tile at the required depth to achieve the level of drawdown needed, the trench excavation width becomes wider and would impact existing steep slopes in many locations.

Although the slopes could be restored, there are slope stability concerns about impacting the existing vegetated steep slopes.

- Approximately one mile of shoreline would be disturbed, so additional shoreline restoration would be needed the whole length of the shoreline.
- Significant dewatering would be needed to excavate the trench, and there is concern that if the soils are saturated sand (due to lake water and groundwater), the trench walls would collapse back into the trench, which is a significant constructability issue.
- Easements would be required from 8 property owners and if one owner is not interested in participating, the project could not proceed and still achieve the flow rate needed to draw down the lake effectively.

No further evaluation of this alternative was completed, including development of planning level cost estimates.



Option 4: Shoreline Draintile System
Bass Lake Drawdown Feasibility Study
Town of St Joseph

FIGURE 3 - 10

4.0 Recommendations

The following four drawdown feasibility options were presented and discussed at the second team meeting on April 27, 2018 (see presentation in Appendix H):

- Option 1: Infiltration (including modified pump intake and pump maintenance)
- Option 2: Seasonal Pumping (including modified pump intake and pump maintenance)
- Option 3: Filtration (including modified pump intake and pump maintenance)
- Option 4: Shoreline Drain Tile System

For Options 1, 2, and 3, the design considerations, permitting and opinions of probable cost were presented and discussed with the team. Option 4, although discussed, was determined to not be feasible due to constructability issues.

All feasible options come with design and operation nuances as well as significant costs to meet the WDNR discharge requirements. In addition to Options 1, 2, and 3, another option the Town of St. Joseph/BLRD could consider is the "do nothing" approach. Under this approach, the Town of St. Joseph/BLRD would not reinstate pumping from Bass Lake and would not manage rising Bass Lake water levels. If water levels are allowed to rise, this could result in several flooded homes, structures, and septic systems. Although the financial implications of this approach have not be quantified, we anticipate the following impacts:

- Property loss and flood damage to several homes and structures
- Flooded/non-functioning septic systems that could lead to Bass Lake water quality issues and public health concerns
- Damaged and unusable roads,
- Flooded conditions for extended periods of time
- Impaired use of the boat landing and no-wake ordinance in effect for extended periods of time (beginning at 886), affecting the recreational use of the lake, and
- Shoreline erosion.

We understand that this is not the preferred approach by the Town of St. Joseph, the BLRD, or the WDNR.

Given the costs of the Bass Lake drawdown options, the general consensus at the second team meeting was support for Option 2 Seasonal Pumping (with intake modification). This approach includes maintenance to the existing pump, modifications to the intake pipe, including the incorporation of an intake screen with an air backwash system, and pumping during the period from November to April. Pumping during this time period will meet the temperature requirements from the original WDNR permit. Additionally, during this period, the water quality (absence of zebra mussel veligers/small juveniles and low total phosphorus concentrations in the hypolimnion) in Bass Lake should meet the WDNR discharge requirements. Monitoring for presence of zebra mussel veligers/small juveniles and total phosphorus concentrations in the hypolimnion and reporting to the WDNR will be needed prior to and during the operation of the pump system. WDNR will need to defined the exact details of the required monitoring as part of the permit terms.

Because this approach results in a limited period where pumping can occur, WDNR staff indicated that they would allow for flexibility regarding the elevation at which pumping can begin. The original permit (1997) listed elevation 886 as the historic pumping start elevation; however, the WDNR would consider allowing the BLRD to begin pumping if water levels reach 885 and water levels are showing an upward trend coming into the fall and winter (when pumping would be allowed).

Additionally, although the pumping system was historically operated at 1.0 MGD during off-peak periods, the original permit allowed for pumping up to 2.0 MGD for any 30-day period. WDNR staff would expect a new permit to allow for this same level of pumping. Option 2 would allow the BLRD to pump up to 2.0 MGD without changes to the system design or approach.

The WDNR will require the BLRD to conduct additional monitoring in 2018 related to lake levels, water quality (dissolved oxygen, temperature, and total phosphorus), and zebra mussels (veligers/ sizing). Additionally, further discussion with WDNR staff related to zebra mussel size based on the 2018 sampling will be needed to determine which intake screen slot size the WDNR will require, should the BLRD pursue Option 2. Option 2a includes an intake screen with 0.125-inch (3.125-mm) openings (intake screen Option A) while Option 2b includes an intake screen with 0.5-mm openings (intake screen Option B).

Because this pumping would happen during the winter months when hypolimnetic total phosphorus levels are low, this option will likely result in no significant change in the Bass Lake water quality.

Table 4-1 summarizes the feasibility level costs for Option 2, the recommended water level management option for Bass Lake.

Table 4-1 Summary of Recommended Option (Option 2) Feasibility Level Costs

Option	Description	Total Capital Cost (-20/+50%)	Annual Operation and Maintenance Cost
	2018 Monitoring	$5,600	$0
Option 2a	Intake Modification (Option A) and Seasonal Pumping	$348,000 ($279,000 - $522,000)	$15,600
Option 2b	Intake Modification (Option B) and Seasonal Pumping	$494,000 ($396,000 - $741,000)	$15,700

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Appendix A

Project Kickoff Meeting Presentation (2/12/2018)

Bass Lake Drawdown Feasibility Study

Project Kickoff Meeting

2/16/2018

Jen Koehler PE and Karen Chandler PE, Barr Engineering Company

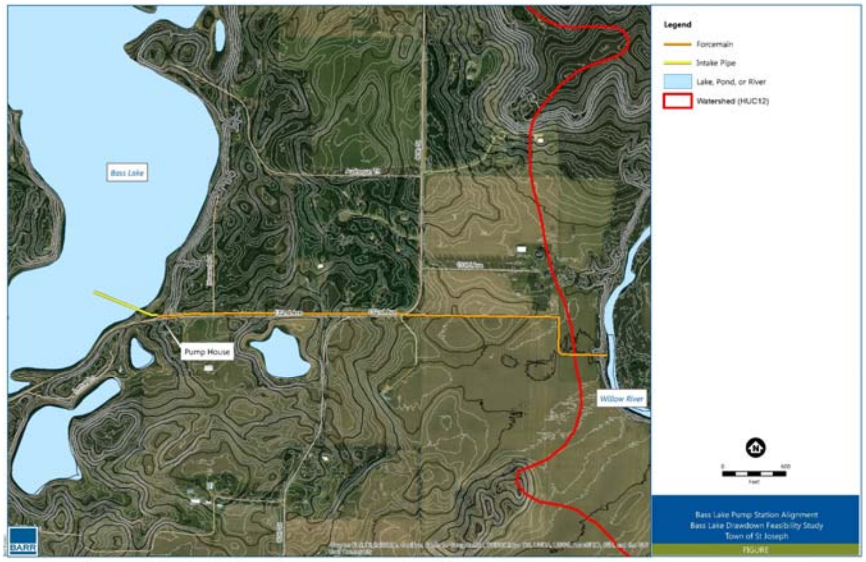
BARR

Review Agenda/Introductions

- Introductions
- Review of Existing Outlet and Lake Conditions
- Review Goals and Work Plan
- Review Data Requests and Available Data
- Outline Next Steps/Schedule

BARR

Existing System Alignment

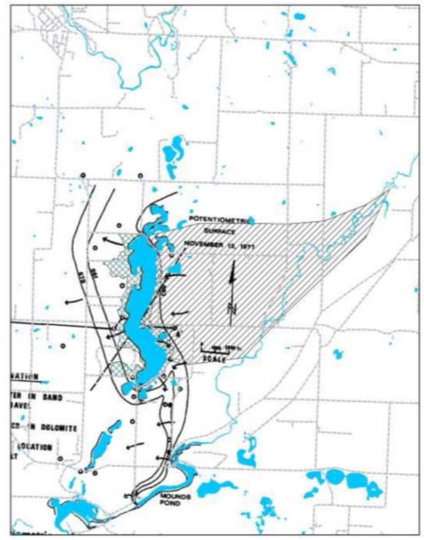


Existing Pumped Outlet

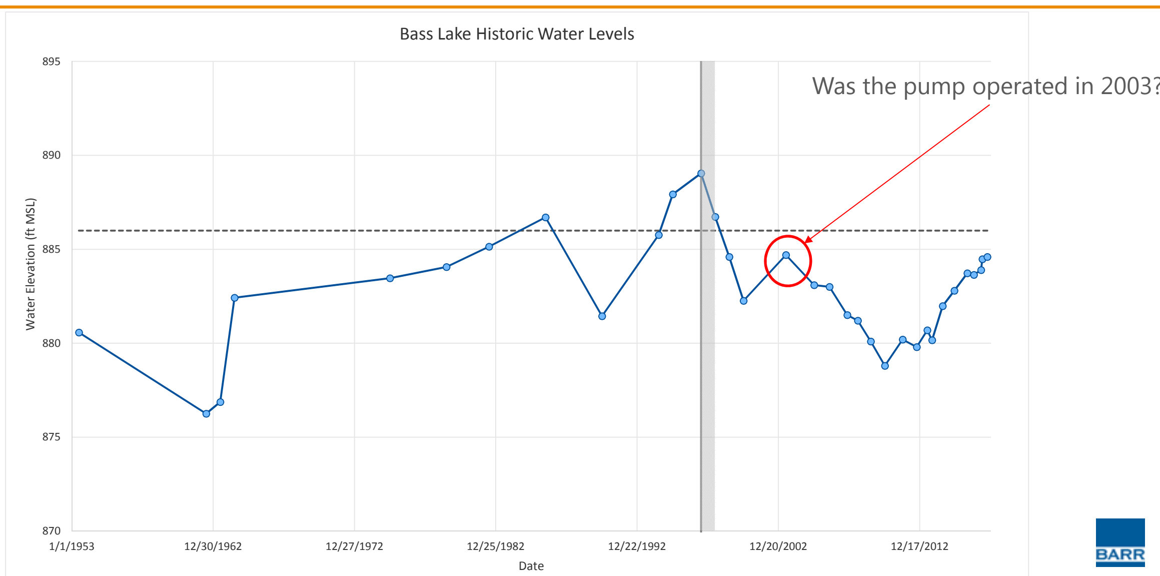
- Pump Capacity
  - Flow = 1,950 gpm (4.3 cfs) @ 65 ft TDH (total dynamic head)
  - Flow = 2,850 gpm (6.3 cfs) @ 55 ft TDH
  - Per 11/4/97 phone call with Bill Lawson, he felt they were pumping more than 2,000 gpm (4.5 cfs).
- WI DNR permit
  - Limited pumping to 1.0 Million gallons per day (1.55 cfs)
    - Operated the system off-peak, ~8hr/day
  - Slotted intake to prevent movement of rough fish to the Willow River
  - Water drawn from hypoliminion to address temperature concerns
- Installed 1997, Operated from Fall 1997 through May 1998
  - Maintain lake 886.1 ft MSL
  - Other than maintenance, has not been operated in recent years

Surface and Groundwater "Watersheds"

- 380-acres, 38-ft Deep
- Surface Watershed = 341 acres (not including lake) – Primarily forest and residential development
- Groundwater generally moving west/southwest from Willow River to Bass Lake

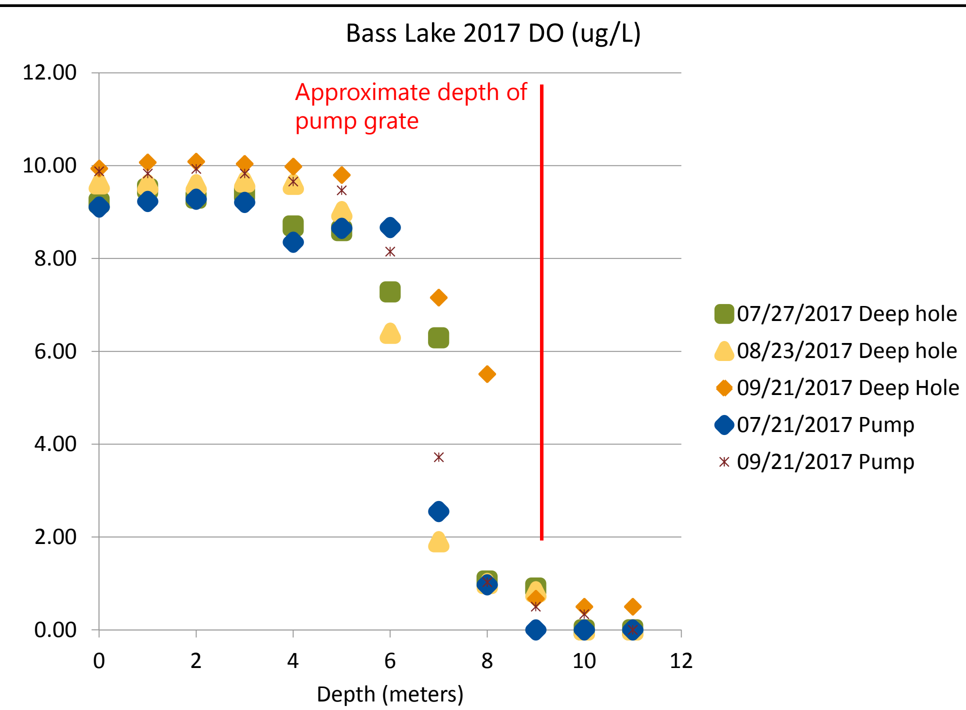


Bass Lake Historic Water Levels



Water Quality & Discharge Restrictions

- Bass Lake
  - Oligotrophic/Mesotrophic
  - Deep Lake that thermally-stratifies
  - Epilimnion TP Concentrations: 12 to 20 µg/L
  - Hypolimnion TP Concentrations: 31 - 107 µg/L
- Lake Mallalieu – Impaired for Excess Nutrients (Phosphorus)
  - Exceeds Recreation Threshold: 40 µg/L
  - Meets Fish and Aquatic Life Threshold: 100 µg/L
  - Discharge from Bass Lake must meet: 39 µg/L



Zebra Mussel/AIS & Discharge Restrictions

- Zebra Mussels
  - Since 2010
  - At least three year classes of zebra mussels colonizing the hardware in anoxic conditions
  - Veligers 70-100 microns, Screening to 50 microns
- Others:
  - Eurasian Watermilfoil, Curlyleaf PondWeed, Spiny water flea (?)

BARR

Project Goals

- Goals:
  - Determine feasibility of modifications to the existing pumping system to:
    - Meet phosphorus discharge requirements
    - Filter or otherwise prevent Zebra Mussels from entering the Willow River
    - Effectively maintain lake levels

BARR

Work Plan Tasks

- Task 1: Data Collection and Review
- Task 2: Development and Evaluation of Options
- Task 3: Meetings and Project Management
- Task 4: Feasibility Report

Task 1: Data Requests

Data Type	Status
Lake Level Data	Complete
Bathymetric Data	Complete
Water Quality Data	Complete
Groundwater Quality Data	UWSP/Extension Staff Processing most current data – should have by end of next week
AIS/Zebra Mussel Data	Complete
LiDAR Elevation Data	Complete
USGS Groundwater Model of Pierce, Polk, and St. Croix counties	Complete
St Croix County Well Index Data	GIS data obtained for wells installed through 1989, GIS not available for wells installed after 1989

Task 2: Development and Evaluation of Options

- Option 1: modifying the existing pump system
- Option 2: developing an alternative pumping system concept
- Option 3: evaluating an alternative discharge location (by pump and/or gravity) to avoid impacts to the Willow River
- Option 4: reducing groundwater levels to maintain stable lake levels

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Task 2: Development and Evaluation of Options

Zebra Mussel

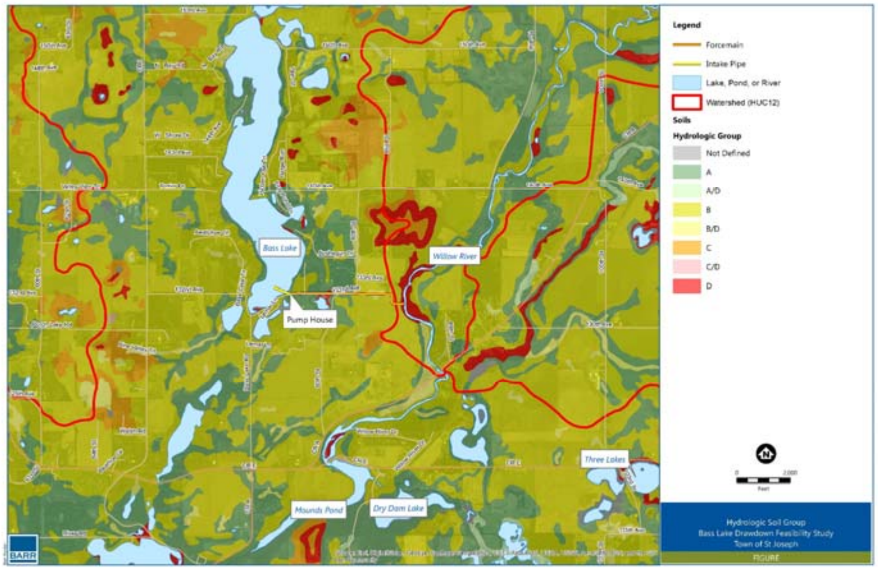
- Pumping from Hypolimnion
- Using a shallow wetland to filter zebra mussels (existing/creating)
- Using Filtration (pump)/Infiltration (into ground)
- Using potassium compounds in pumped lake water
- Groundwater pumping
- ***Timing of Pumping/Discharge***

Phosphorus

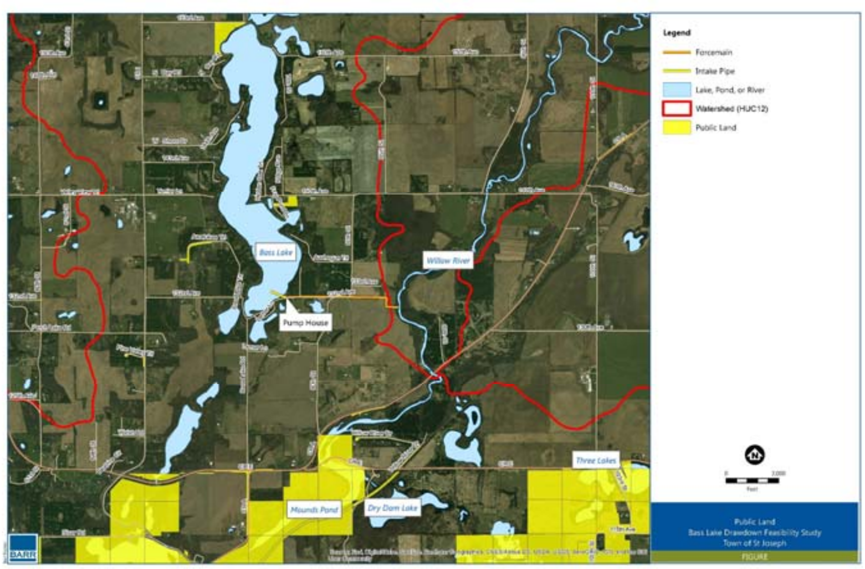
- Modify pump intake location (move to surface)
- Treating discharge with Alum
- Infiltration (into ground)
- Groundwater pumping
- Water quality trading
- ***Timing of Pumping/Discharge***

BARR

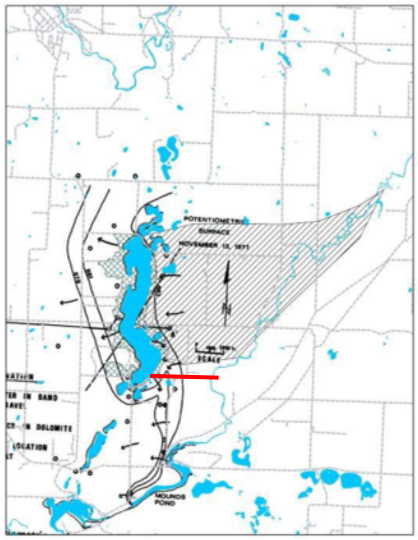
Infiltration Capacity of Soils



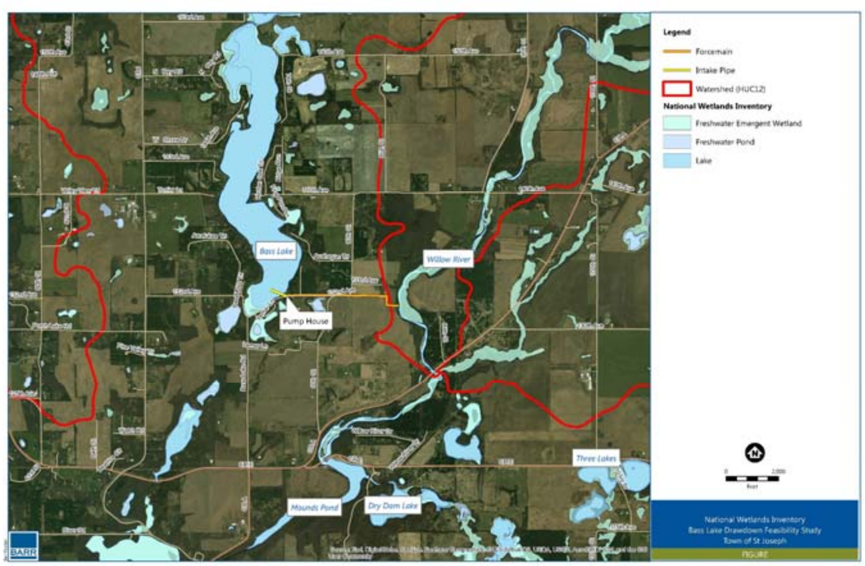
Publicly-Owned Land



Groundwater Watershed



Surrounding Wetlands/Water Bodies



Next Steps: Development of Options

- Option 1: modifying the existing pump system
- Option 2: developing an alternative pumping system concept
- Option 3: evaluating an alternative discharge location (by pump and/or gravity) to avoid impacts to the Willow River
- Option 4: reducing groundwater levels to maintain stable lake levels

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Schedule

task			est. completion date
1.0	data gathering and review		March 2, 2018
2.0	development and evaluation of options		April 27, 2018
3.0	meetings and project management	▪ kick-off meeting ▪ **feasibility team meeting #1** ▪ feasibility team meeting #2 ▪ town board meeting	February 16, 2018 **March 16, 2018** April 27, 2018 May 10, 2018
4.0	feasibility report	▪ draft feasibility report ▪ final feasibility report	May 1, 2018 June 1, 2018

Appendix B

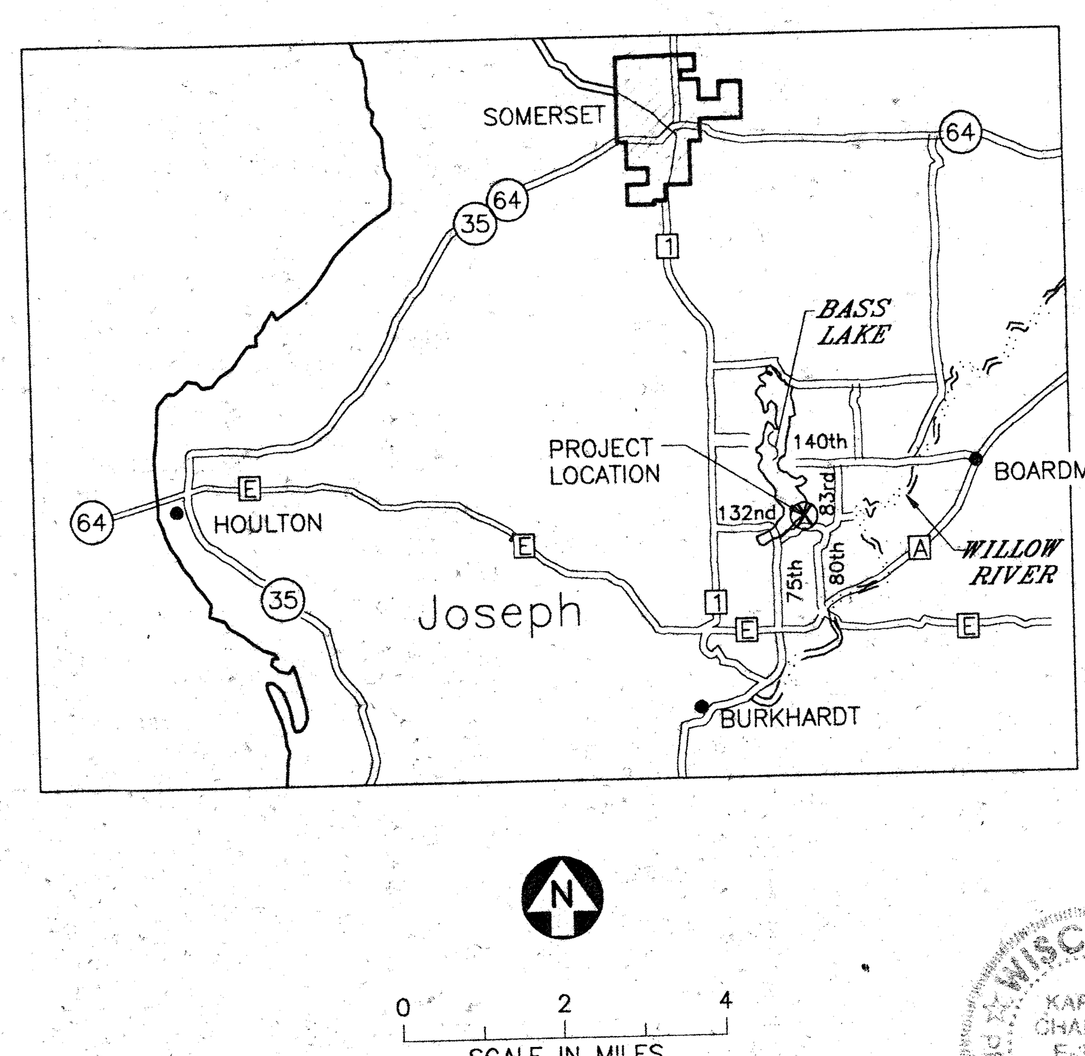
Bass Lake Pumping System Plan Set (May 1997)

BASS LAKE REHABILITATION DISTRICT

BASS LAKE OUTLET PROJECT

ST. CROIX COUNTY, WISCONSIN

LOCATION MAP



VICINITY MAP

SHEET INDEX

A – ARCHITECTURAL
C – CIVIL
S – STRUCTURAL
M – MECHANICAL
E – ELECTRICAL

WISCONSIN KAREN L. CHANDLER E-32101 MINNEAPOLIS, MINNESOTA PROFESSIONAL ENGINEER

NO. | BY | CHK. | APP. | DATE | REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF WISCONSIN.
Karen L. Chandler
DATE 5/20/97 REG. NO. E-32101

CLIENT / BID / CONSTRUCTION — 5-19-97
RELEASED TO/FOR | A | B | C | 0 | 1 | 2 | 3 | DATE RELEASED

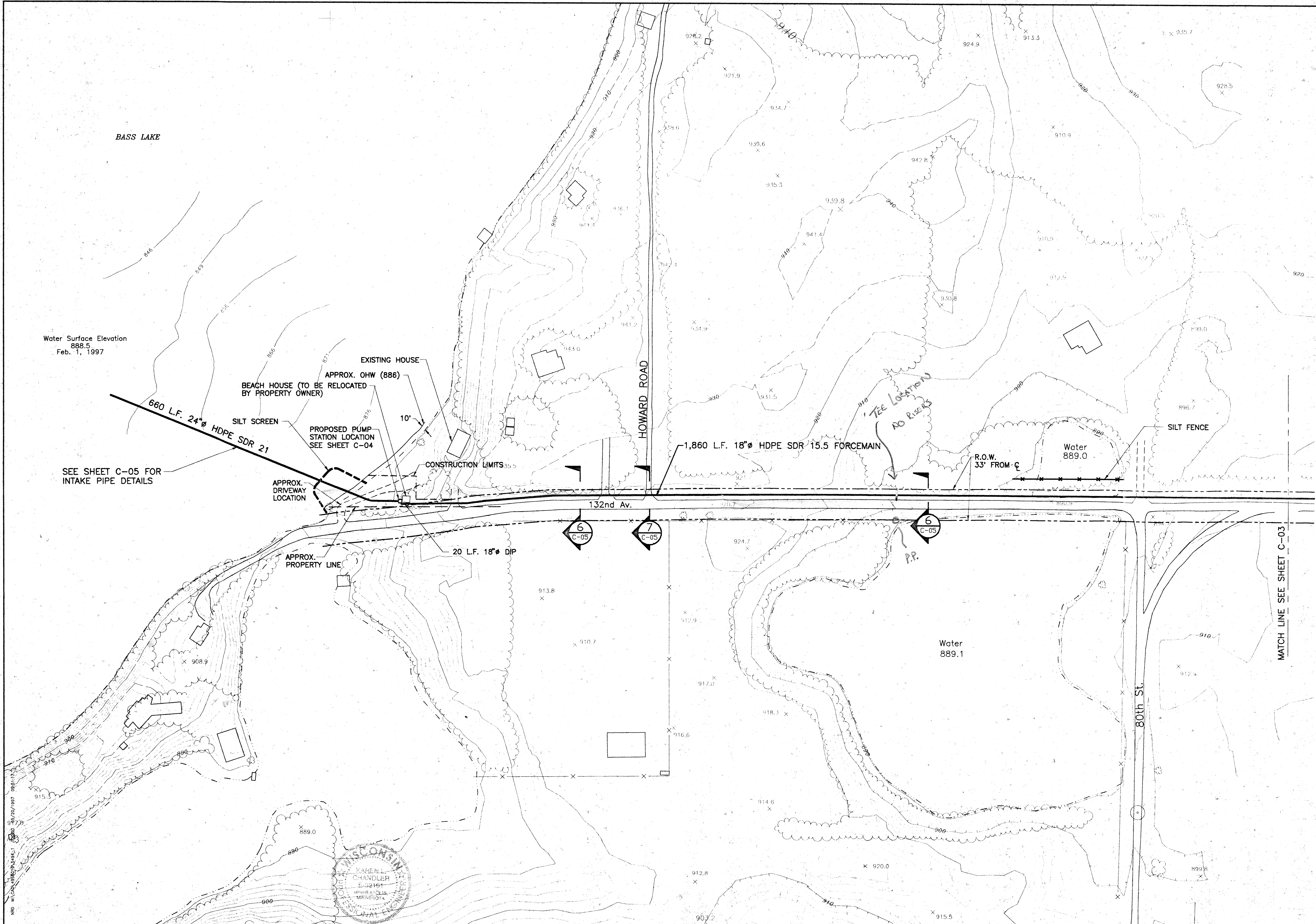
Barr Engineering Company
8300 NORMAN CENTER DRIVE MINNEAPOLIS, MINNESOTA
555 WEST 27TH STREET HIBBING, MINNESOTA

Scale	AS SHOWN
Date	1/30/97
Drawn	PVJ
Checked	KLC
Designed	PVJ
Approved	

BASS LAKE REHABILITATION DISTR.
ST. CROIX COUNTY, WISCONSIN

BASS LAKE OUTLET PROJECT
ST. JOSEPH TOWNSHIP, WISCONSIN
SITE LOCATION AND INDEX

BARR PROJECT No. 4956019KLC020
CLIENT PROJECT No.
SHEET No. C–01
REV. No. 0



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SCALE IN FEET

LEGEND

- ROAD
- DRIVEWAY
- LAKE / POND
- TREE
- TREE COVER
- FENCE
- BUILDING
- POLE
- INDEX CONTOUR
- INTERMEDIATE CONTOUR
- DEPRESSION CONTOUR
- OBSCURED CONTOUR

NOTE:

1. TOPOG. MAPPING FROM; 11/4/95 – 4/23/96 AERIAL PHOTOGRAPHY. APPROX. DRIVEWAY LOCATIONS ADDED BY BARR ENGINEERING CO.
2. CONTRACTOR SHALL PERFORM TRAFFIC CONTROL IN ACCORDANCE WITH SECTION 643 OF THE WI/DOT STANDARD SPECIFICATIONS.
3. CONTRACTOR SHALL FIELD VERIFY ALL DRIVEWAY LOCATIONS AND SURFACE MATERIALS.
4. CONTRACTOR SHALL INSTALL SILT FENCE AND/OR HAY BALES AS NECESSARY TO PREVENT EROSION AND SEDIMENTATION.
5. CONTRACTOR SHALL LOCATE ALL BURIED UTILITIES. AVAILABLE INFORMATION REGARDING BURIED ELECTRICAL AND TELEPHONE LINES CAN BE FOUND IN THE APPENDIX OF THE SPECIFICATIONS.

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF WISCONSIN.

Karen L. Chandler
DATE 5/20/97 REG. NO. E-32101

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CLIENT							
BID				5-19-97			
CONSTRUCTION							
	DATE RELEASED						

Barr Engineering Company
8300 NORMAN CENTER DRIVE MINNEAPOLIS, MINNESOTA
555 WEST 27TH STREET HIBBING, MINNESOTA

Scale	AS SHOWN
Date	1-30-97
Drawn	PVJ
Checked	KLC
Designed	
Approved	

BASS LAKE REHABILITATION DIST.
ST. CROIX COUNTY, WISCONSIN

BASS LAKE OUTLET PROJECT
ST. JOSEPH TOWNSHIP, WISCONSIN

INTAKE PIPE AND FORCEMAIN PLAN

BARR PROJECT No. 4956019KLC020
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SHEET No. C-02
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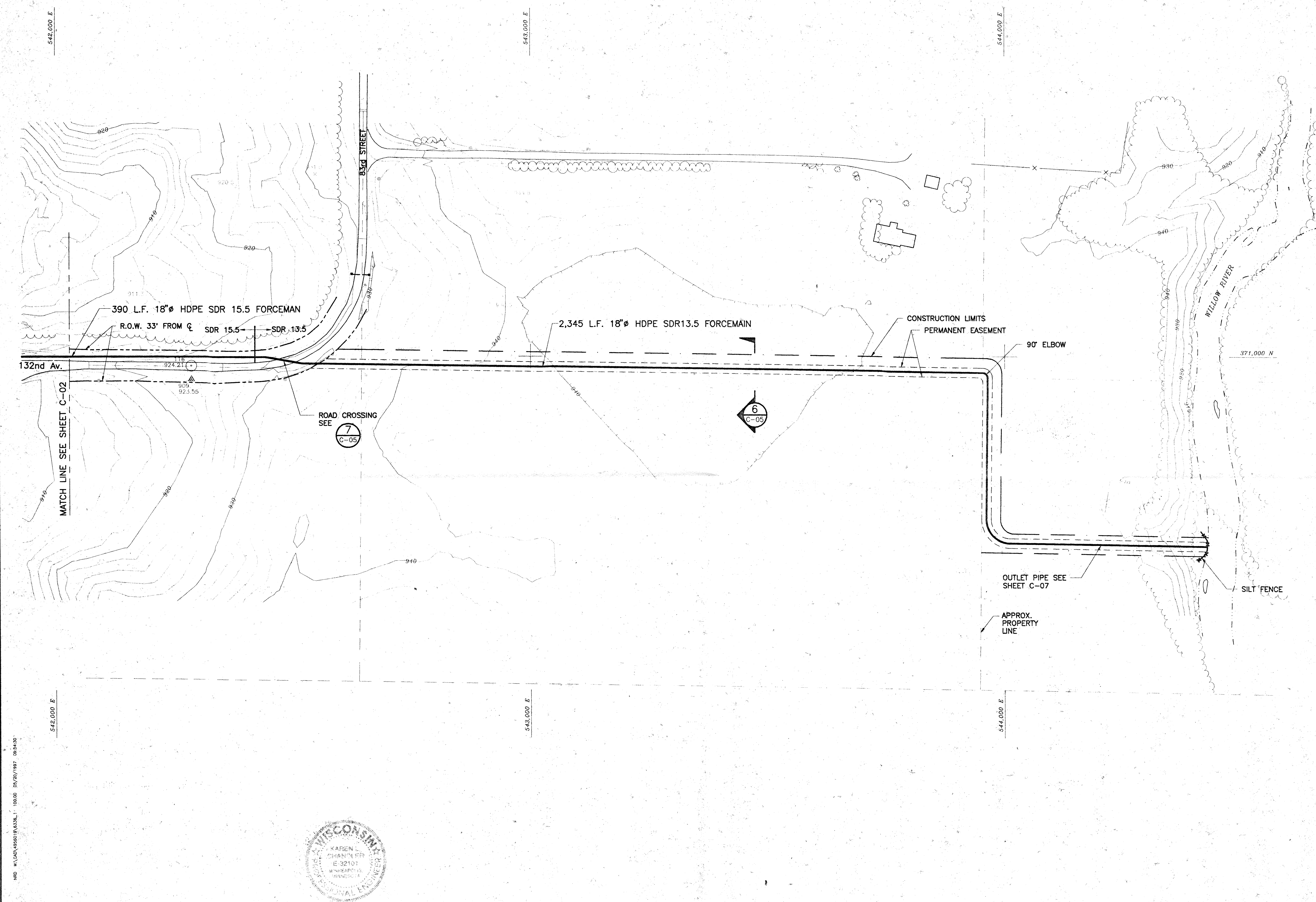

LEGEND

- ROAD
- DRIVEWAY
- LAKE / POND
- TREE
- TREE COVER
- FENCE
- BUILDING
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- INDEX CONTOUR
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	DATE RELEASED						

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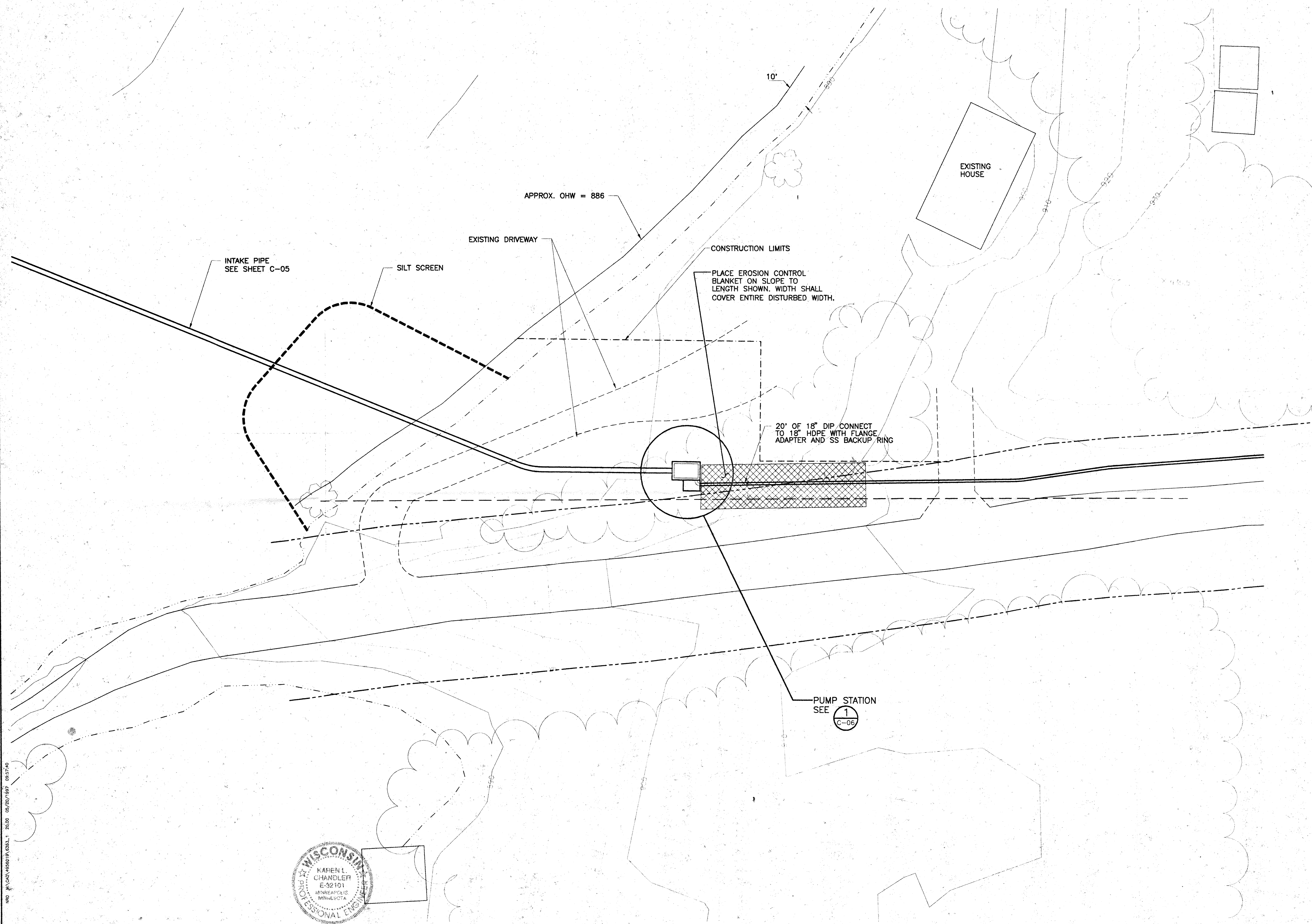
Approved	

BASS LAKE REHABILITATION DIST.
ST. CROIX COUNTY, WISCONSIN

BASS LAKE OUTLET PROJECT
ST. JOSEPH TOWNSHIP, WISCONSIN

OUTLET PIPE AND FORCEMAIN PLAN

BARR PROJECT No. 4956019KLC020
CLIENT PROJECT No.
SHEET No. C-03
REV. No. 0



N

0 20 40
SCALE IN FEET

LEGEND

- ROAD
- DRIVEWAY
- LAKE / POND
- TREE
- TREE COVER
- FENCE
- BUILDING
- POLE
- INDEX CONTOUR
- INTERMEDIATE CONTOUR
- DEPRESSION CONTOUR
- OBSCURED CONTOUR
- RIGHT-OF-WAY
- CONSTRUCTION LIMIT

NOTE:
1. THE EXISTING BEACH HOUSE, WHICH IS TO BE RELOCATED BY OWNER, IS NOT SHOWN. SEE SHEET C-02.

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF WISCONSIN.

Karen L. Chandler

DATE 5/20/97 REG. NO. E-32101

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT							
BID				5-19-97			
CONSTRUCTION							
	DATE RELEASED						

Barr Engineering Company
8300 NORMAN CENTER DRIVE MINNEAPOLIS, MINNESOTA
555 WEST 27TH STREET HIBBING, MINNESOTA

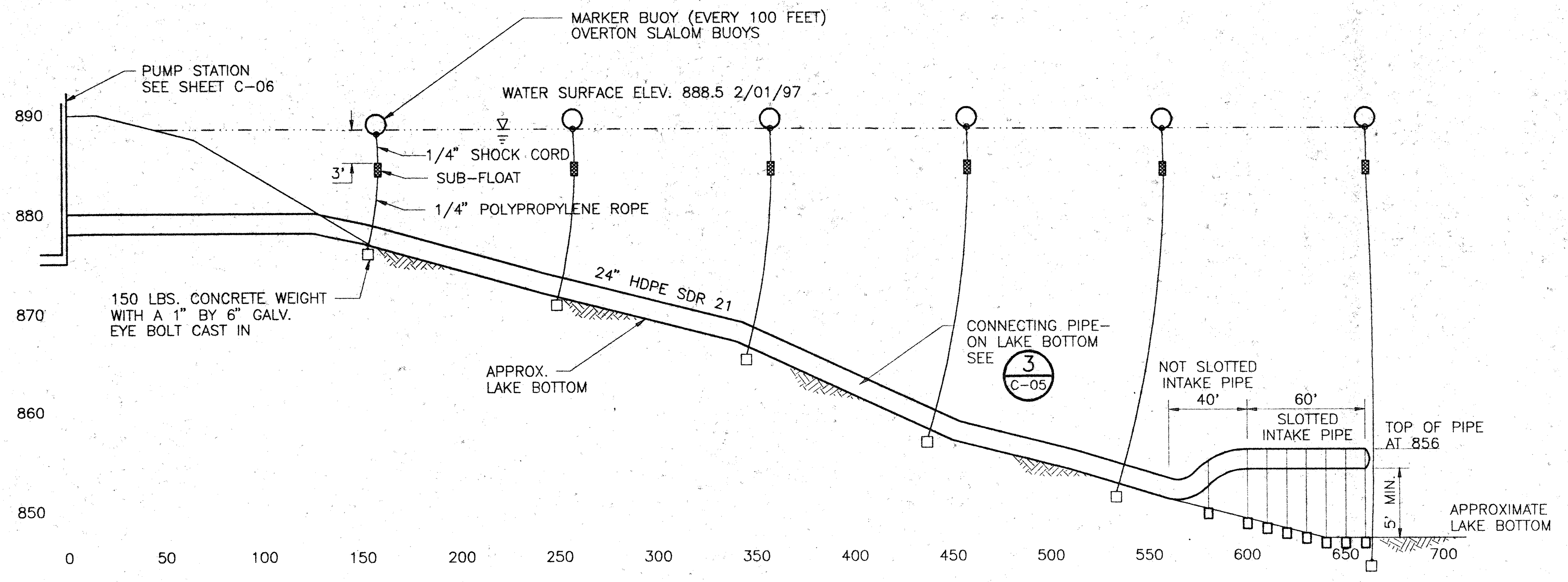
Scale	AS SHOWN
Date	5-14-97
Drawn	CJJ
Checked	KLC
Designed	CJJ
Approved	CJJ/KLC

BASS LAKE REHABILITATION DIST.
ST. CROIX COUNTY, WISCONSIN

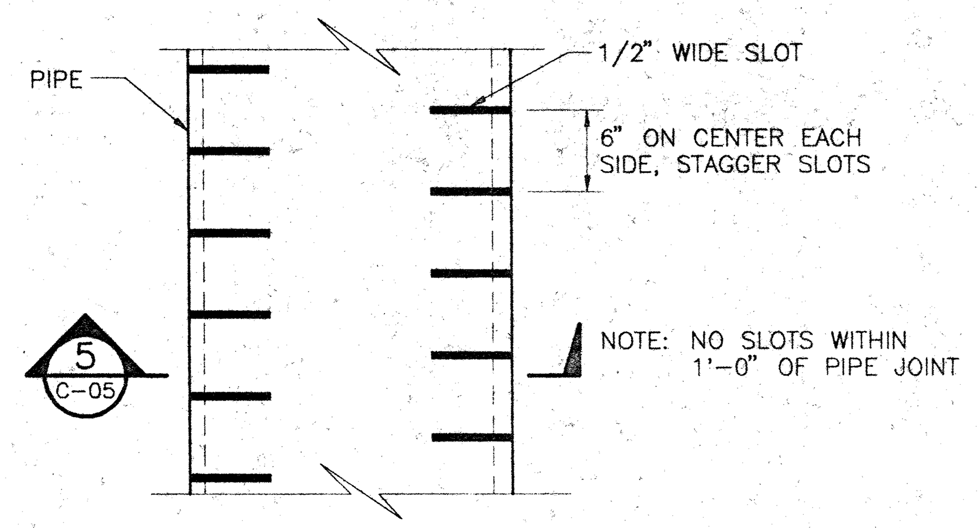
BASS LAKE OUTLET PROJECT
ST. JOSEPH TOWNSHIP, WISCONSIN

PUMP STATION LAYOUT

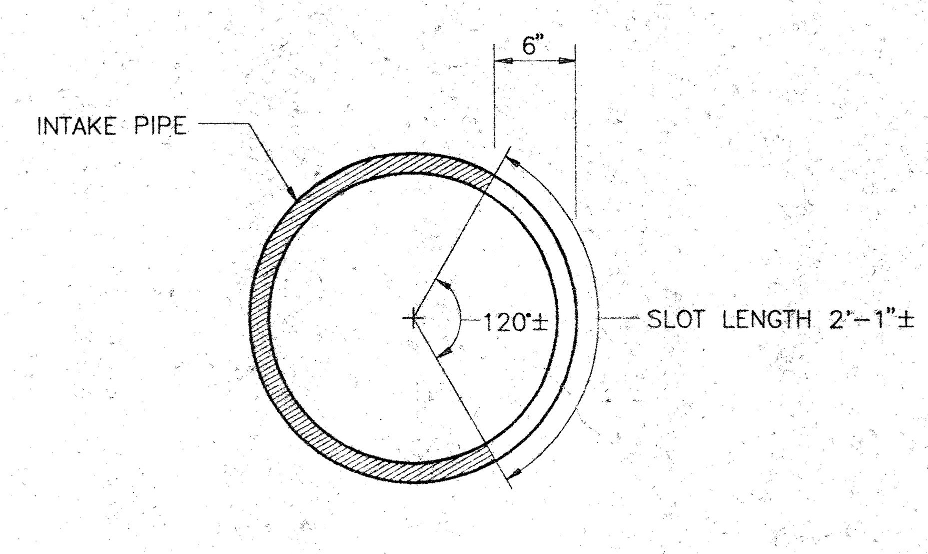
BARR PROJECT No. 4956019KLC020
CLIENT PROJECT No.
SHEET No. C-04
REV. No. 0



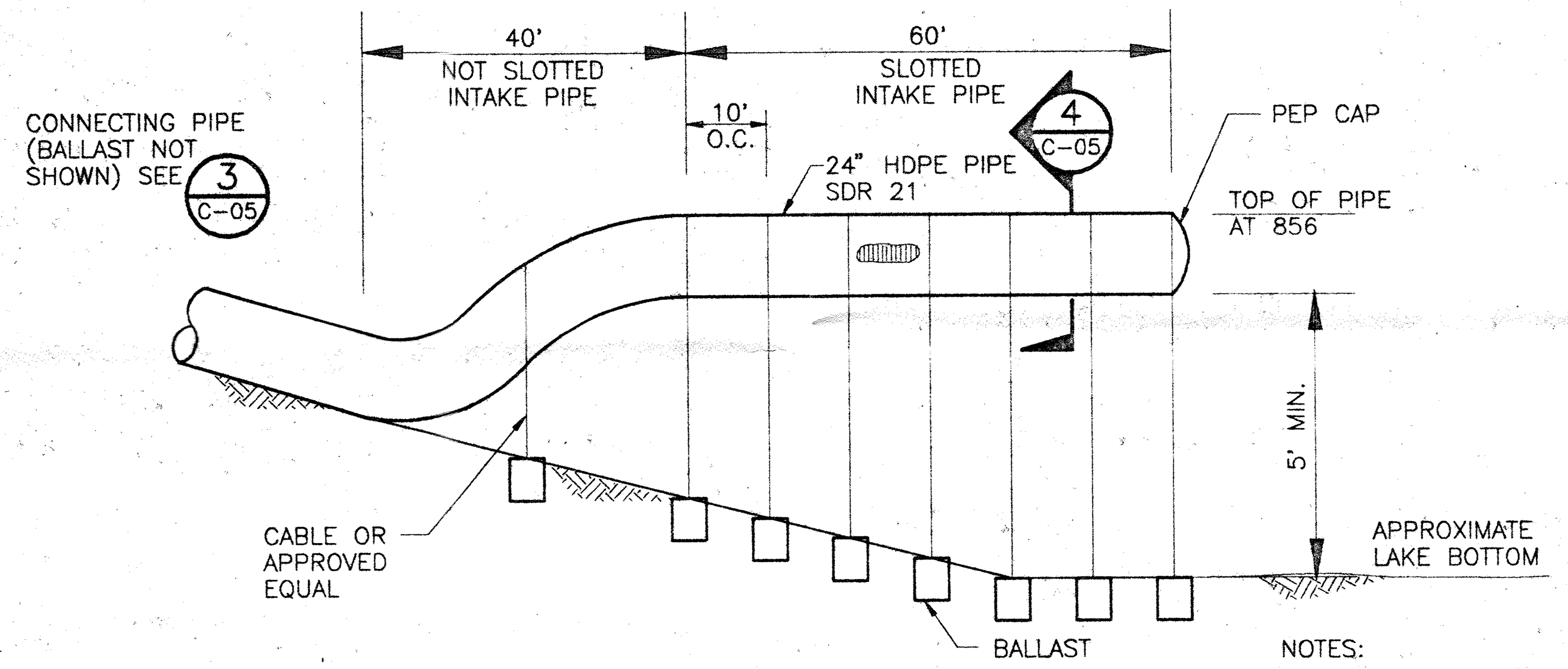
1 C-04 SECTION: INTAKE PIPE



4 C-05 PLAN: SLOTTED INTAKE PIPE
1"=1'-0"
0 6" 1' 2'
SCALE



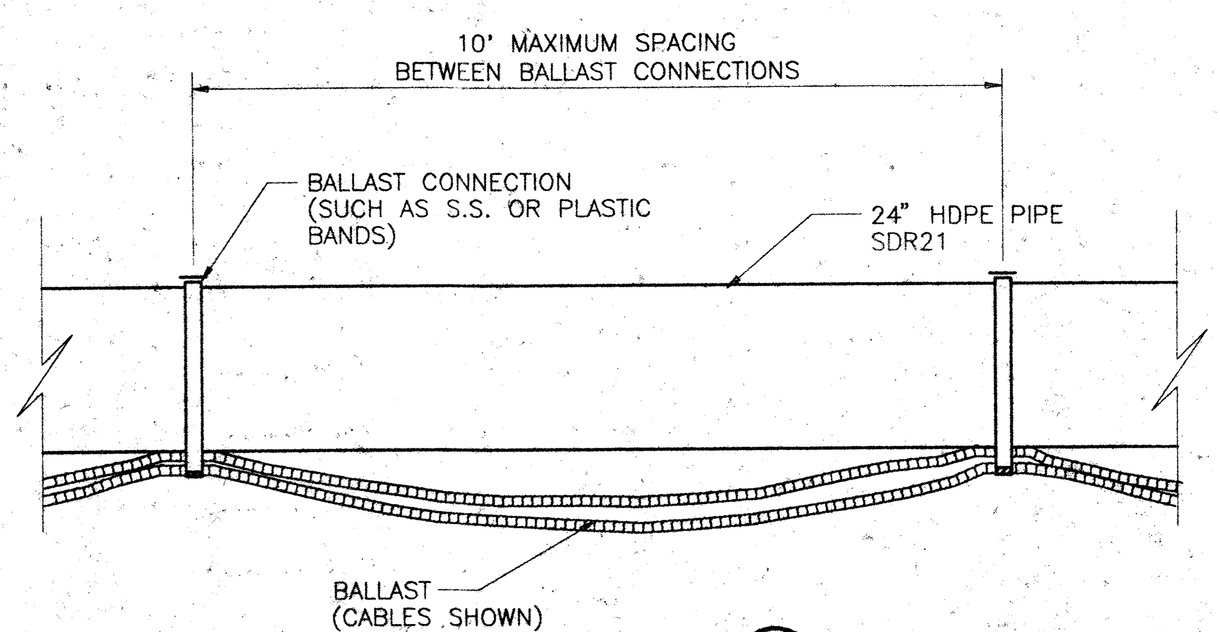
5 C-05 SECTION: SLOT
1"=1'-0"
0 6" 1' 2'
SCALE



2 C-05 SECTION: INTAKE PIPE
1"=20'-0"
0 20 40
SCALE IN FEET

NOTES:

1. BALLAST AND BALLAST CONNECTIONS FOR INTAKE PIPE SHALL BE APPROVED BY ENGINEER.
2. MINIMUM SUBMERGED WEIGHT OF INTAKE PIPE BALLAST SHALL BE 3.6 LBS./L.F. OF PIPE. THIS IS EQUIVALENT TO 4.1 LBS. OF STEEL/L.F. OF PIPE OR 6.1 LBS. OF CONCRETE/L.F. OF PIPE.
3. SUBMERGED WEIGHT OF CABLE SHALL NOT EXCEED 15 LBS. AT EACH LOCATION THIS IS EQUIVALENT TO 17 LBS. OF STEEL.



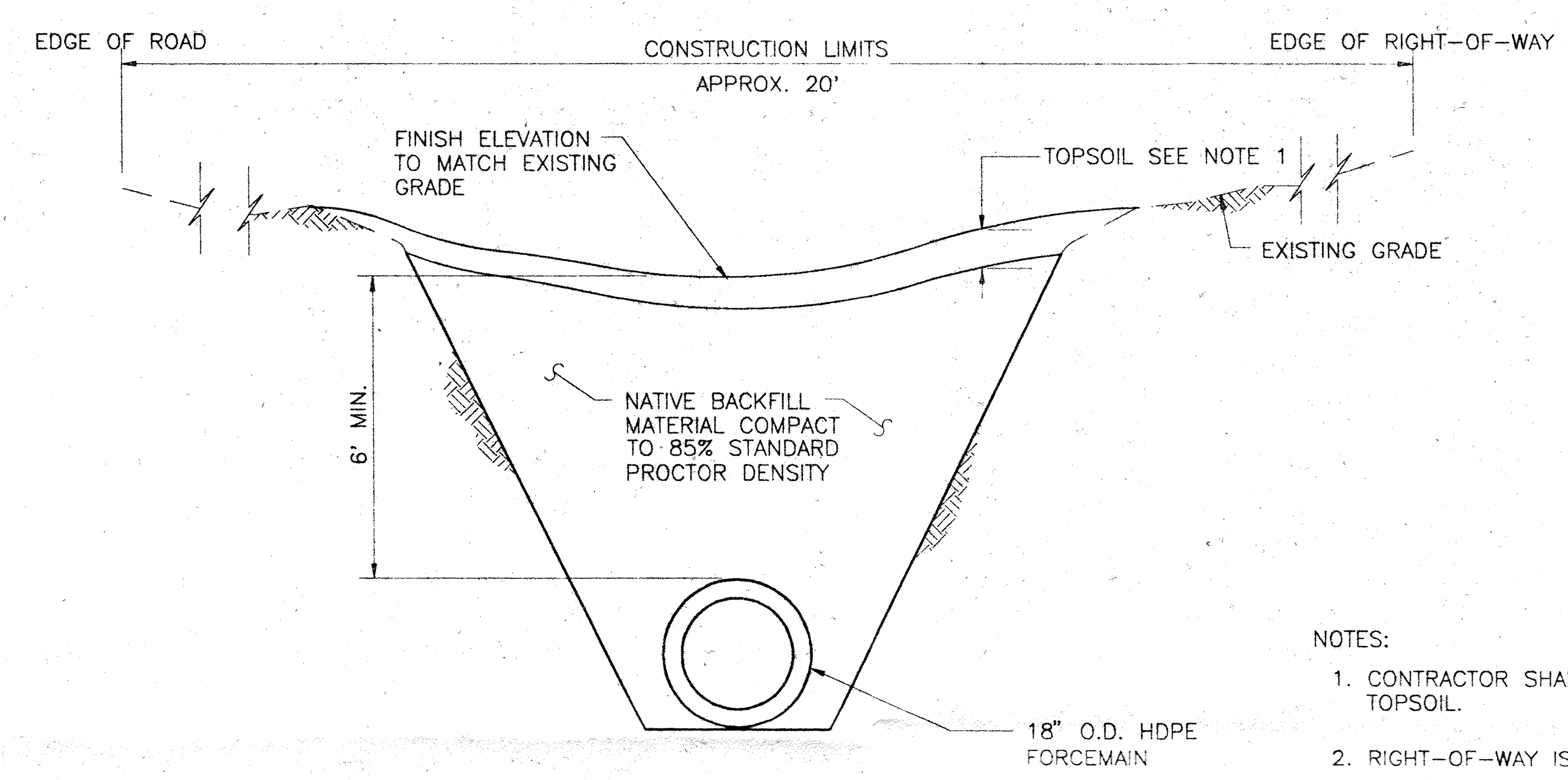
3 C-05 SECTION: CONNECTING PIPE
1"=2'-0"
0 1' 2' 4'
SCALE

NOTES:

1. BALLAST AND BALLAST CONNECTIONS FOR CONNECTING PIPE SHALL BE APPROVED BY ENGINEER.
2. CONNECTING PIPE BALLAST WEIGHT REQUIREMENTS:

MINIMUM SUBMERGED WEIGHT:	3.6 lb/L.F. OF PIPE
WEIGHT FOR STEEL BALLAST:	4.1 lb/L.F. OF PIPE
WEIGHT FOR CONCRETE BALLAST:	6.1 lb/L.F. OF PIPE

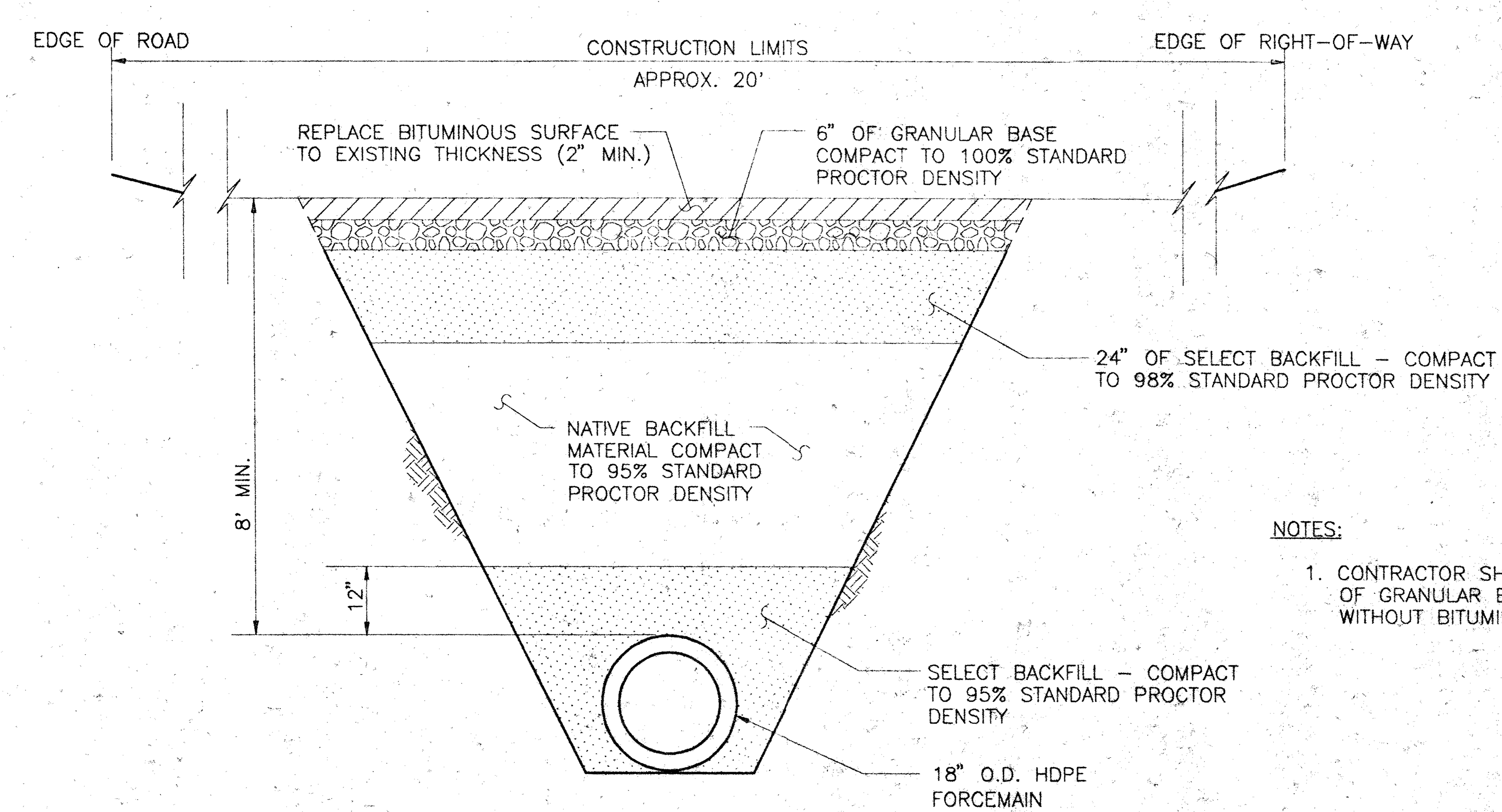
WISCONSIN KAREN L. CHANDLER E-32101 MINNEAPOLIS, MINNESOTA PROFESSIONAL ENGINEER



NOTES:

1. CONTRACTOR SHALL SEGREGATE AND REUSE EXISTING TOPSOIL.
2. RIGHT-OF-WAY IS 33' FROM ROAD ℄.

6 C-05 SECTION: FORCEMAIN PIPE BEDDING WITH NO SURFACE IMPROVEMENTS (TYP.)
NOT TO SCALE



NOTES:

1. CONTRACTOR SHALL PLACE 12" OF GRANULAR BASE ON DRIVEWAYS WITHOUT BITUMINOUS SURFACE.

7 C-05 SECTION: FORCEMAIN PIPE BEDDING UNDER ROADS AND DRIVEWAYS (TYP.)
NOT TO SCALE

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF WISCONSIN.
Karen L. Chandler
DATE 5/20/97 REG. NO. E-32101

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT							
BID				3-19-97			
CONSTRUCTION							
	DATE RELEASED						

Barr Engineering Company
8300 NORMAN CENTER DRIVE MINNEAPOLIS, MINNESOTA
555 WEST 27TH STREET HIBBING, MINNESOTA

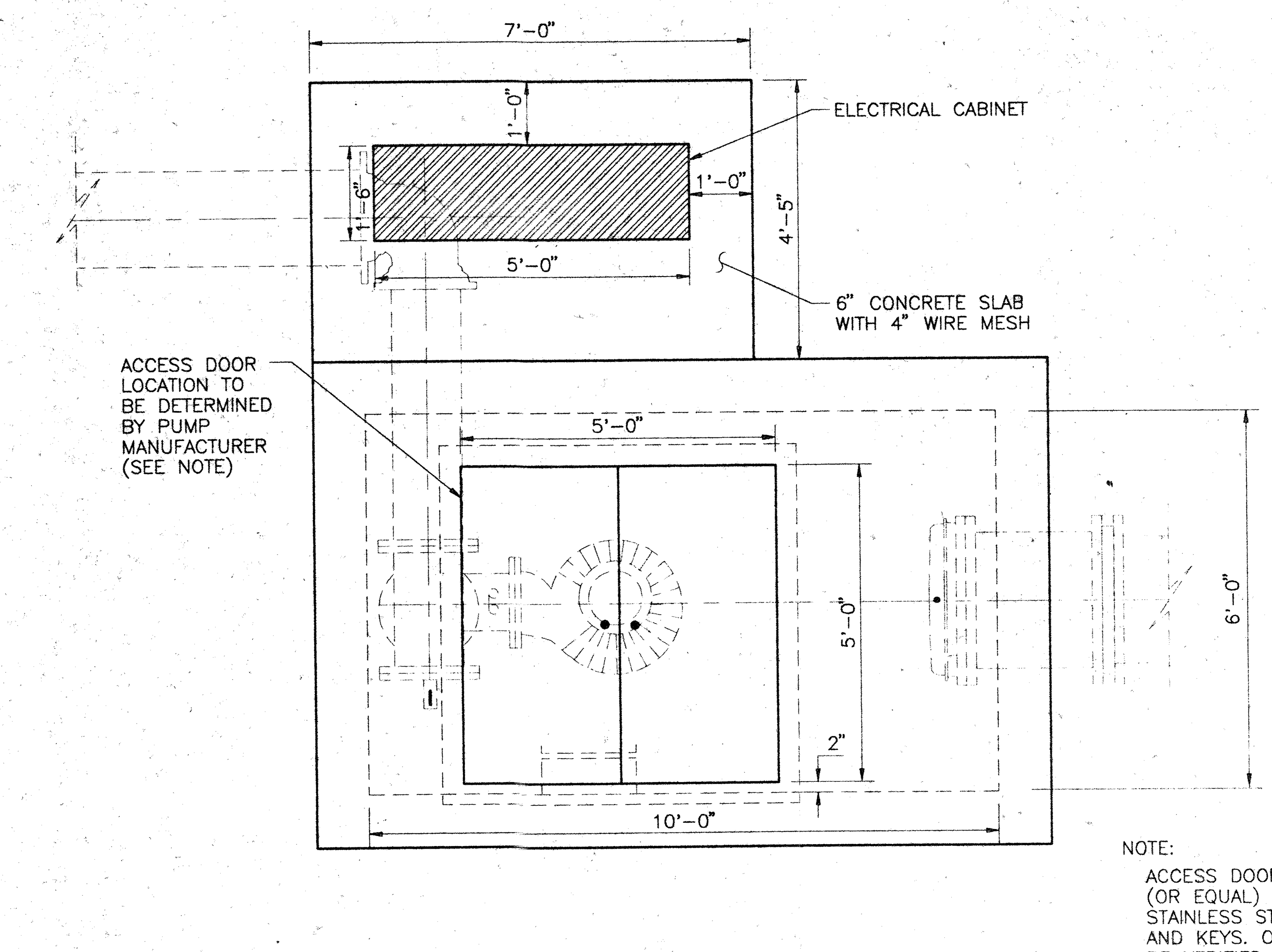
Scale	AS SHOWN
Date	1/27/97
Drawn	JMW
Checked	KLC
Designed	KLC
Approved	KLC

BASS LAKE REHABILITATION DIST.
ST. CROIX COUNTY, WISCONSIN

BASS LAKE OUTLET PROJECT
ST. JOSEPH TOWNSHIP, WISCONSIN

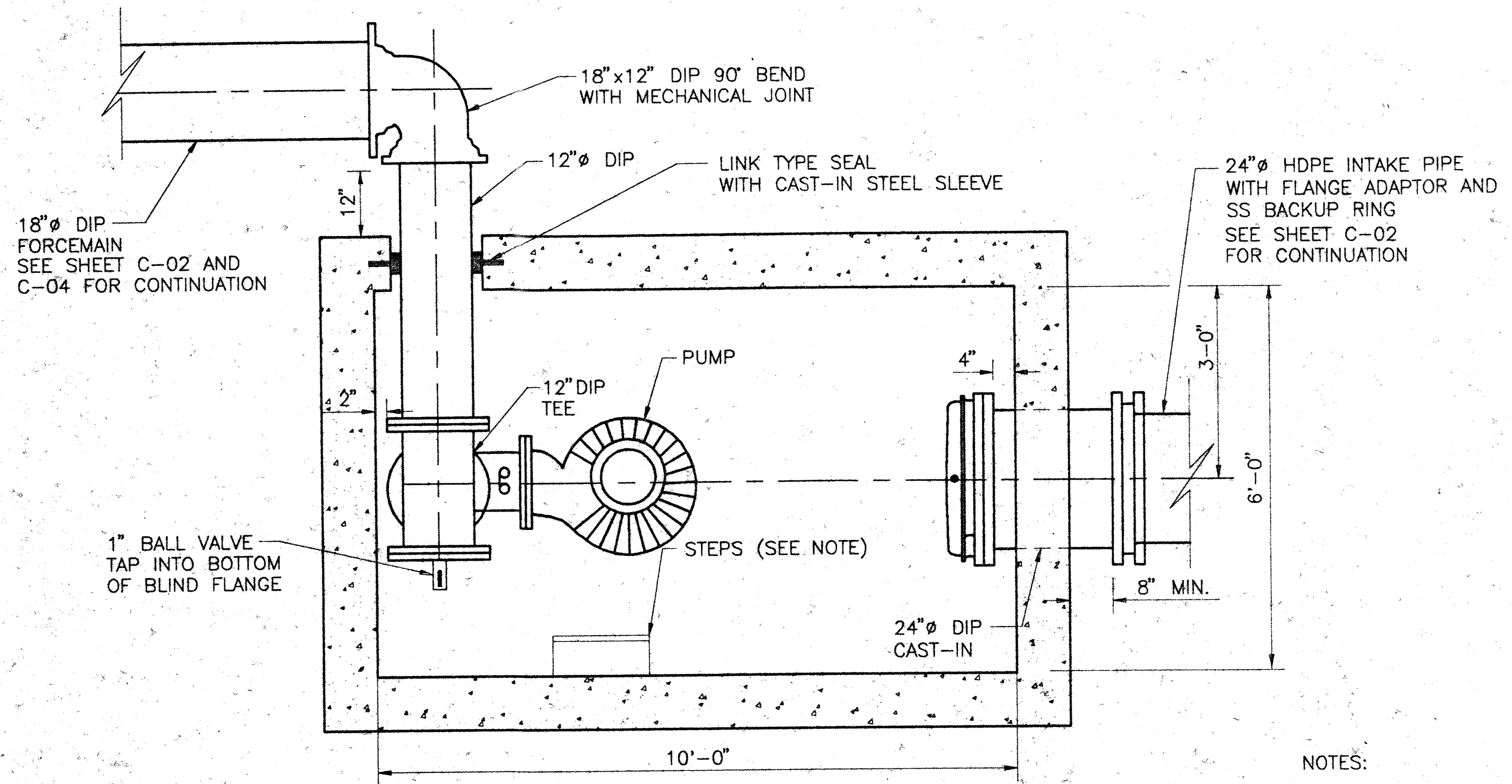
INTAKE PIPE AND MISCELLANEOUS SECTIONS AND DETAILS

BARR PROJECT No. 4956019KLC020
CLIENT PROJECT No.
SHEET No. C-05
REV. No. 0



NOTE:
ACCESS DOOR SHALL BE BILCO JD-4-H-20 (OR EQUAL) DOUBLE LEAF STEEL UNIT WITH STAINLESS STEEL 316 HARDWARE, LOCKS, AND KEYS. OPENING SIZE OF 5'x5' SHALL BE VERIFIED.

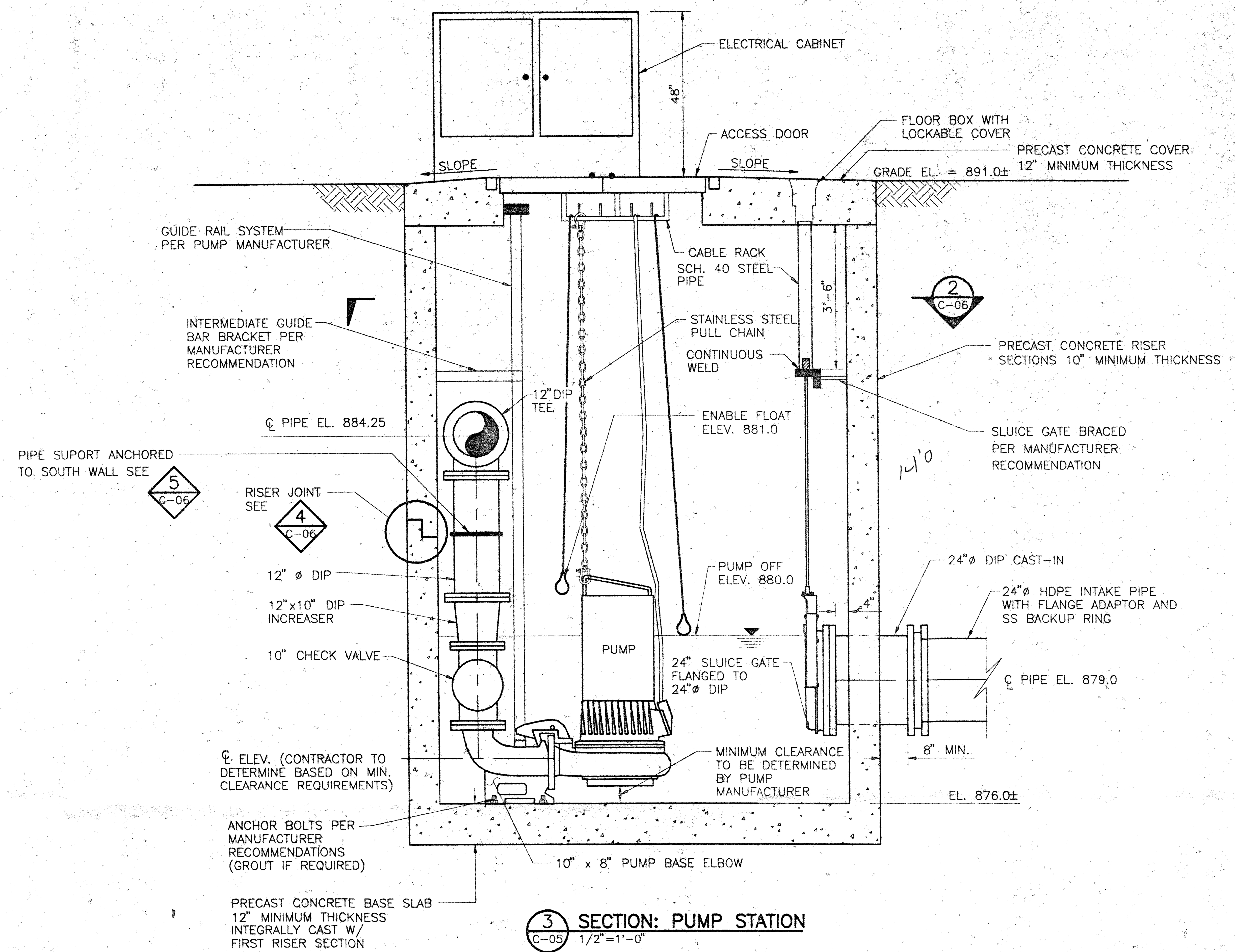
1/C-06 PLAN: PUMP STATION–GRADE FLOOR
1/2"=1'-0"
0 1 2 3 4 5
SCALE IN FEET



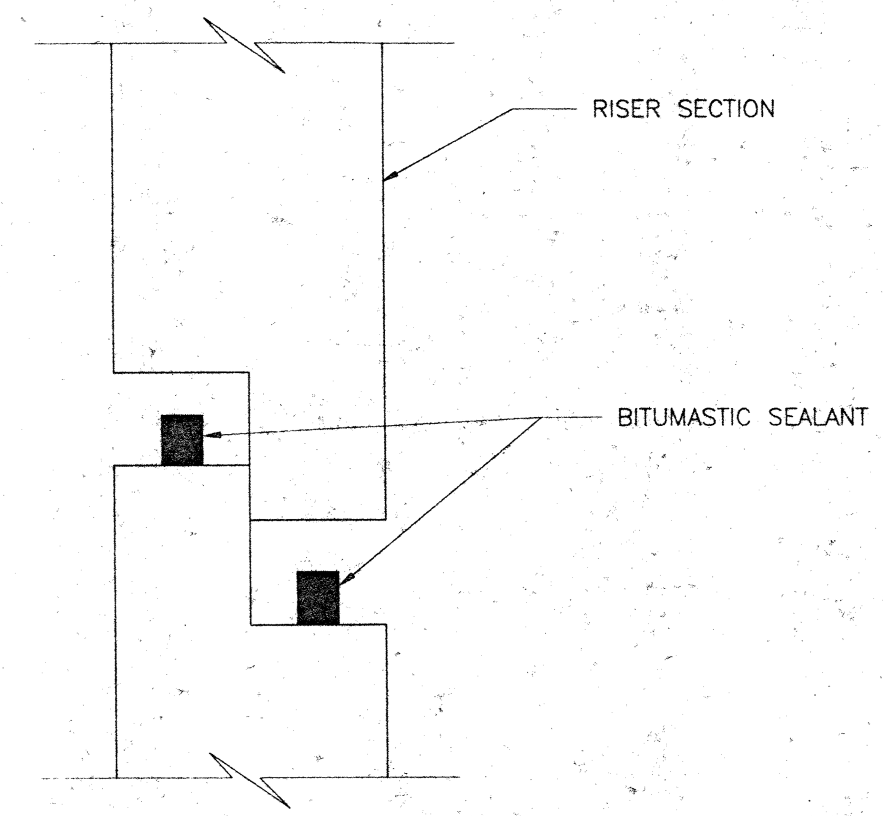
NOTES:
1. STEPS SHALL BE INSTALLED 12" O.C. IN ACCORDANCE WITH ASTM C478. THE TOP RUNG SHALL BE 12" FROM TOP OF ACCESS DOOR. BOTTOM RUNG SHALL BE A MAXIMUM OF 12" FROM BASE SLAB.

2/C-06 SECTION: PUMP STATION–BASE FLOOR
1"=2'-0"
0 1 2 3 4 5
SCALE IN FEET

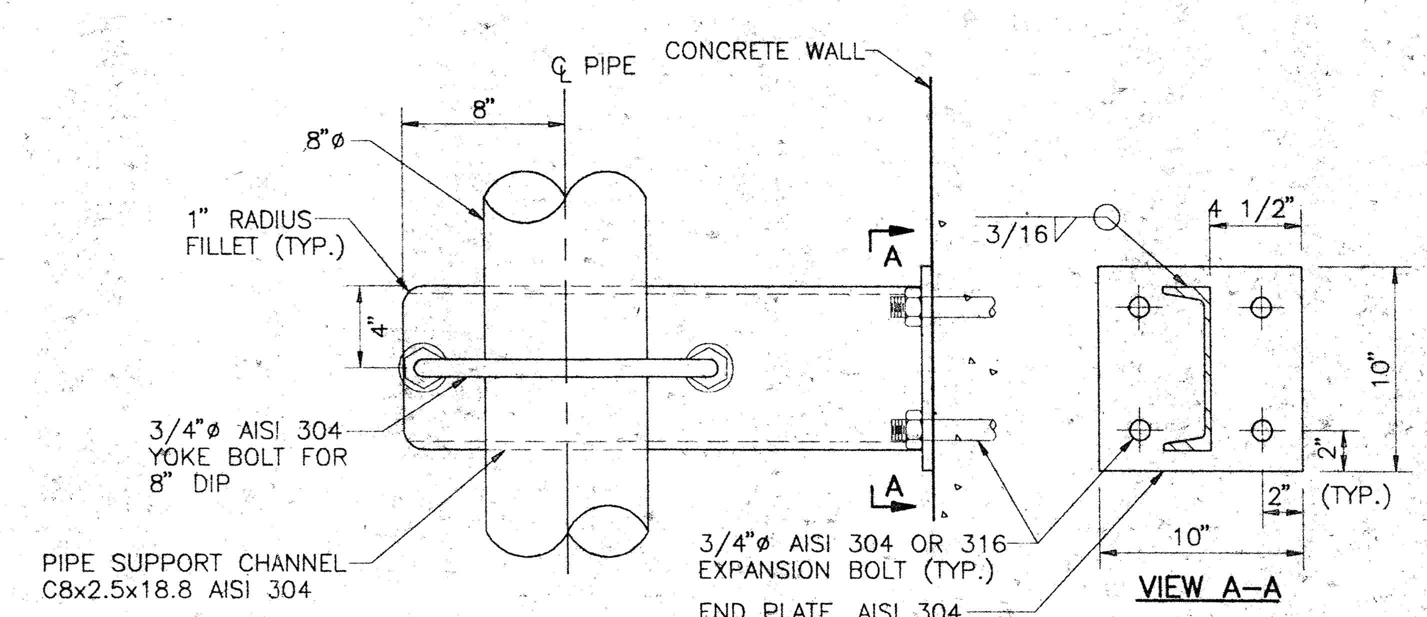
WISCONSIN KAREN L. CHANDLER E-32101 MINNEAPOLIS MINNESOTA PROFESSIONAL ENGINEER



3/C-05 SECTION: PUMP STATION
1/2"=1'-0"
0 1 2 3 4 5
SCALE IN FEET



4/C-06 DETAIL: RISER JOINT
NOT TO SCALE



5/C-06 DETAIL: PIPE SUPPORT
NOT TO SCALE

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF WISCONSIN.
Karen L. Chandler
DATE 5/20/97 REG. NO. E-32101

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT							
BID				5-19-97			
CONSTRUCTION							
	DATE RELEASED						

Barr Engineering Company
8300 NORMAN CENTER DRIVE MINNEAPOLIS, MINNESOTA
555 WEST 27TH STREET HIBBING, MINNESOTA

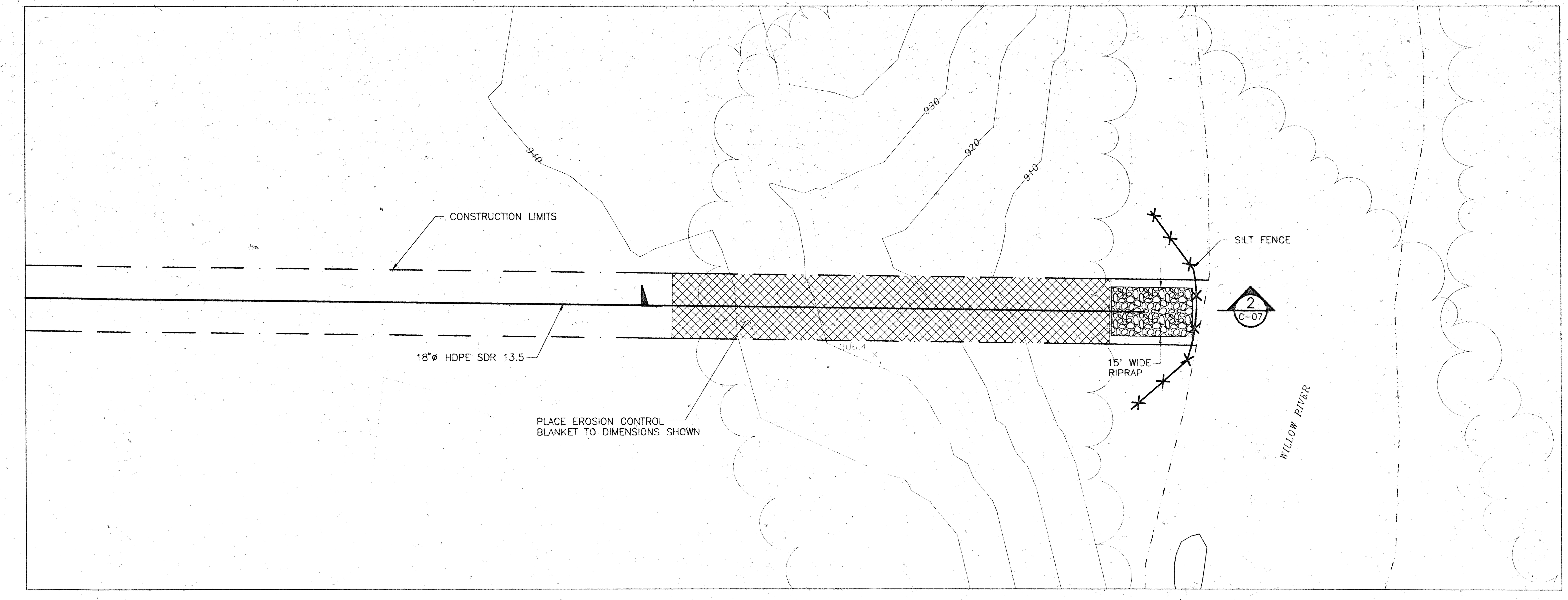
Scale	AS SHOWN
Date	1/21/97
Drawn	CJJ
Checked	KLC
Designed	CJJ
Approved	

BASS LAKE REHABILITATION DIST.
ST. CROIX COUNTY, WISCONSIN

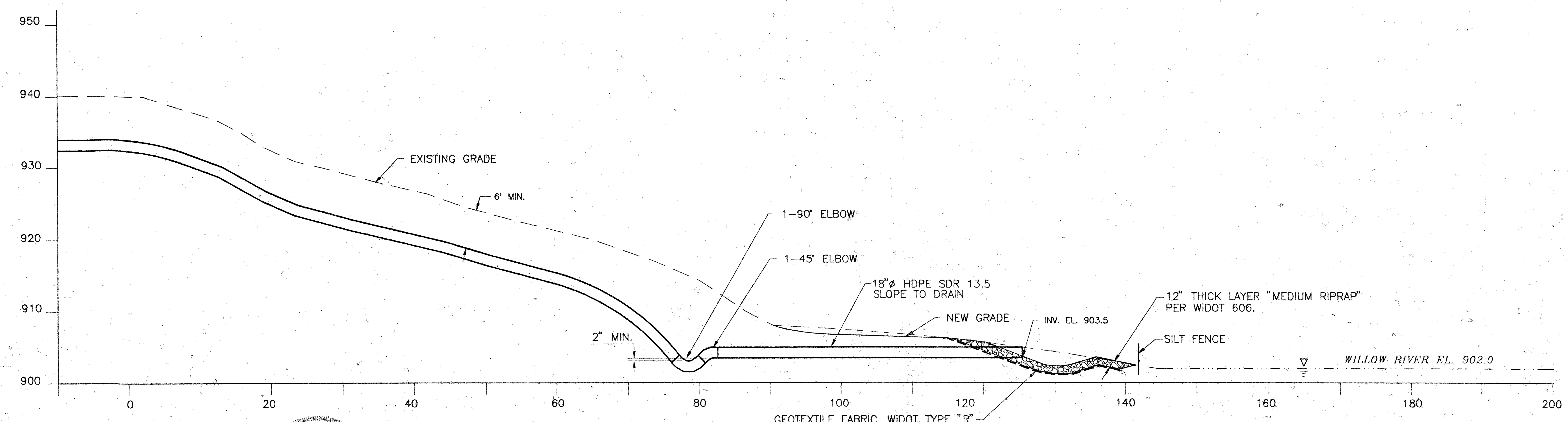
BASS LAKE OUTLET PROJECT
ST. JOSEPH TOWNSHIP, WISCONSIN

PUMP STATION PLAN, SECTION AND DETAILS

BARR PROJECT No. 4956019KLC020
CLIENT PROJECT No.
SHEET No. C-06
REV. No. 0



1 C-07 DETAIL: PIPE OUTLET
1"=20'-0"
0 20 40
SCALE IN FEET



2 C-07 PROFILE: PIPE OUTLET
1"=10'-0"
0 10 20
SCALE IN FEET

WISCONSIN
KAREN L. CHANDLER
E-32101
MINNEAPOLIS, MINNESOTA
PROFESSIONAL ENGINEER

NOTE:
TOPOG. MAPPING FROM; 11/4/95 – 4/23/96 AERIAL PHOTOGRAPHY

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF WISCONSIN

Karen L. Chandler
DATE 5/20/97 REG. NO. E-32101

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT							
BID				5-19-97			
CONSTRUCTION							
	DATE RELEASED						

Barr Engineering Company
8300 NORMAN CENTER DRIVE MINNEAPOLIS, MINNESOTA
555 WEST 27TH STREET HIBBING, MINNESOTA

Scale	AS SHOWN
Date	5/13/97
Drawn	PVJ
Checked	KLC
Designed	KLC
Approved	

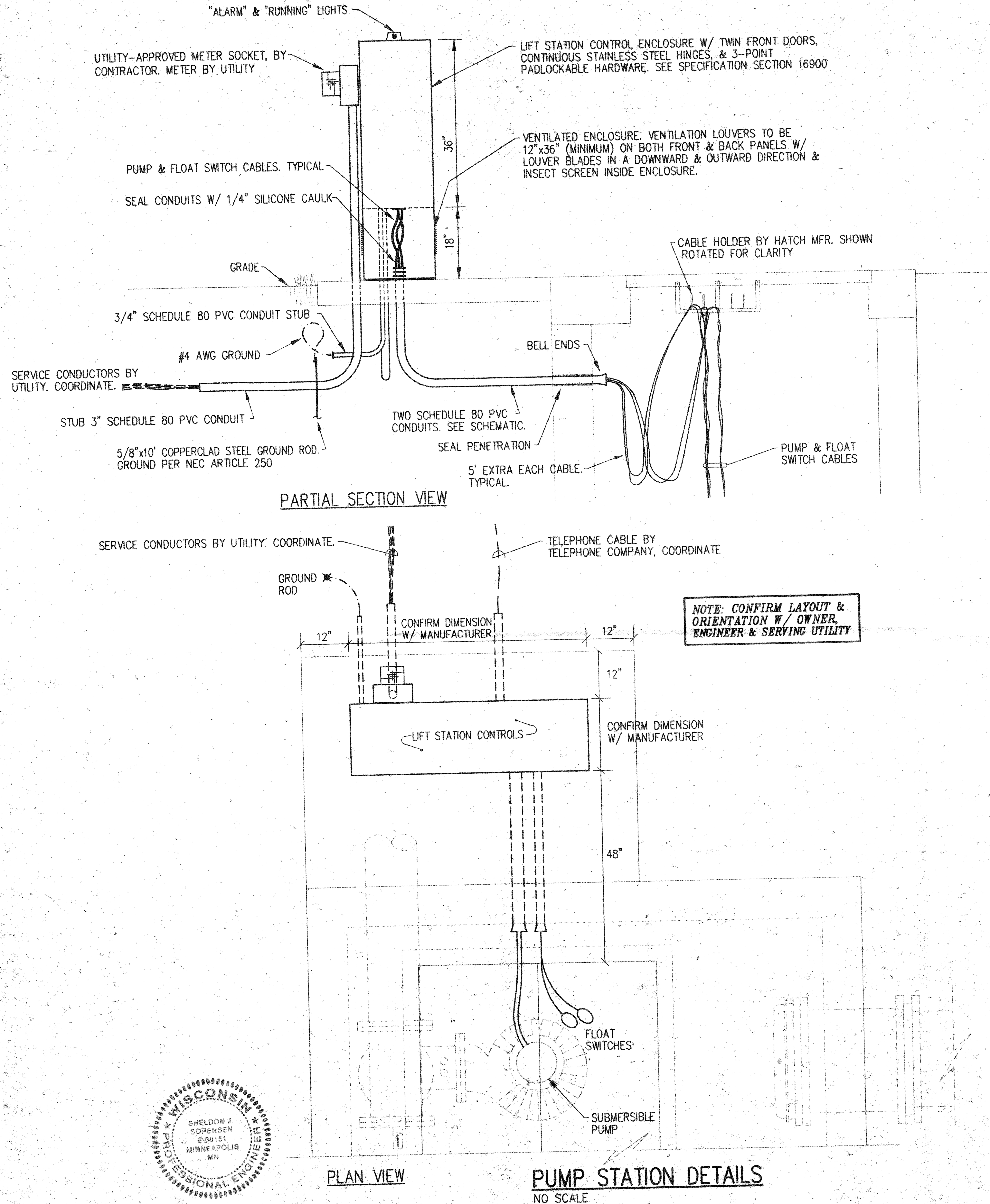
BASS LAKE REHABILITATION DIST.
ST. CROIX COUNTY, WISCONSIN

BASS LAKE OUTLET PROJECT
ST. JOSEPH TOWNSHIP, WISCONSIN

OUTLET PIPE
PLAN AND PROFILE

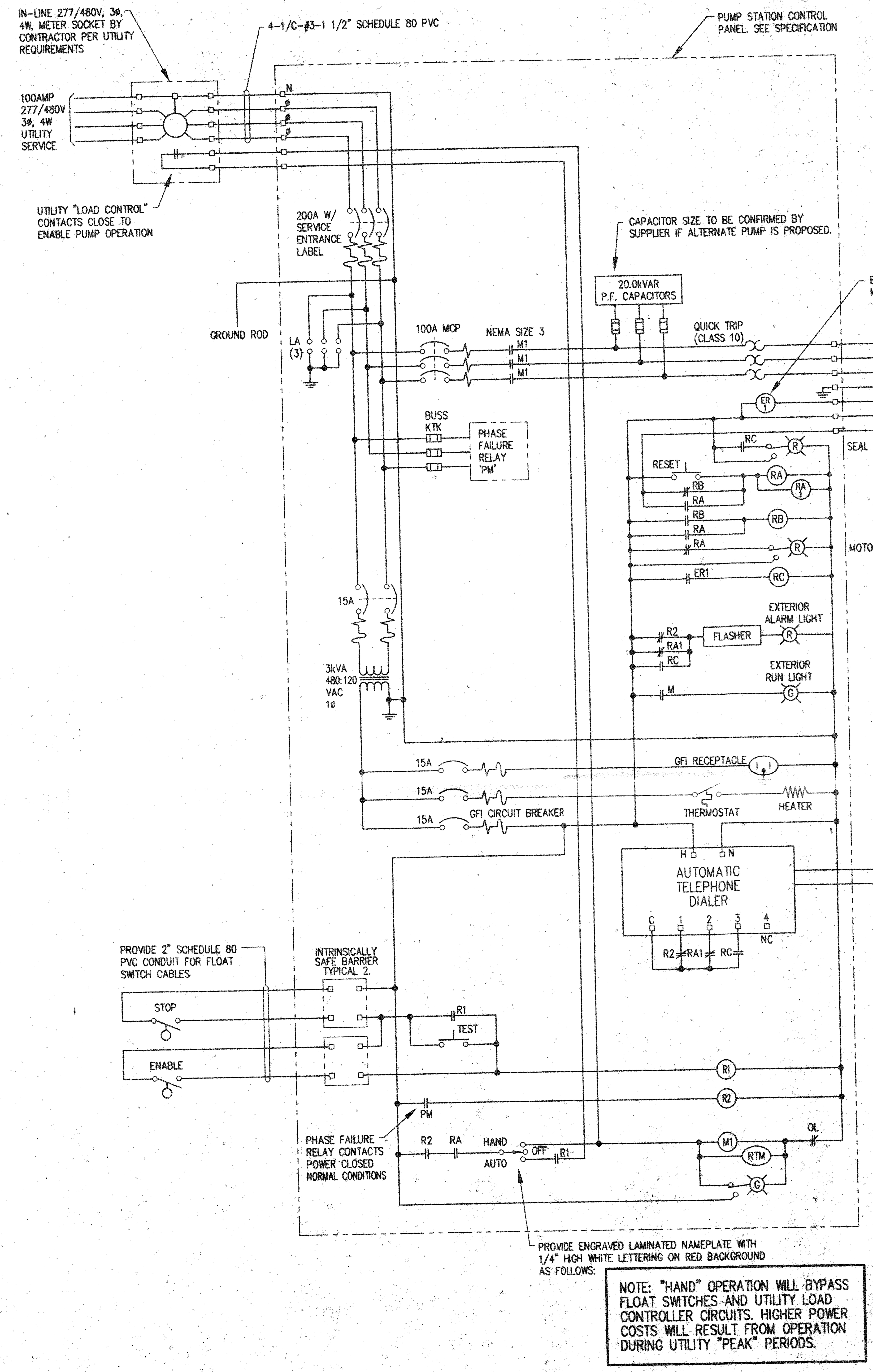
BARR PROJECT No. 4956019KLC020
CLIENT PROJECT No.
SHEET No. C-07
REV. No. 0

KAI #97306A--SHEET E-01--PS: 1=1



PUMP STATION DETAILS

NO SCALE



GENERAL NOTES

1. CONTROL PANEL SHALL BEAR SERIALIZED LABEL INDICATING CONFORMANCE W/ UL508
2. PUMP MOTOR PROTECTIVE CIRCUITRY IS BASED ON KSB EQUIPMENT. ALTERNATE SYSTEMS SHALL INCLUDE PUMP MOTOR OVER TEMPERATURE & LEAK DETECTION CIRCUITS W/ CONTROL MODIFICATIONS AS REQ'D.
3. STARTERS SHALL BE NEMA RATED STARTERS. IEC OR DUAL RATED STARTERS ARE NOT ACCEPTABLE

PUMP STATION CONTROL PANEL SCHEMATIC

NO SCALE

SHELDON J. SORENSEN E-30151 MINNEAPOLIS MN — WISCONSIN PROFESSIONAL ENGINEER

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF WISCONSIN.

DATE 19 MAY 97 REG. NO. E-30151

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT							
BID				5/19/97			
CONSTRUCTION							
DATE RELEASED							

Barr Engineering Company — 8300 NORMAN CENTER DRIVE MINNEAPOLIS, MINNESOTA — 555 WEST 27TH STREET HIBBING, MINNESOTA

Scale	NONE
Date	19 MAY 97
Drawn	CPM
Checked	SJS
Designed	SJS
Approved	SJS

BASS LAKE REHABILITATION DIST.
ST CROIX COUNTY, WISCONSIN

BASS LAKE OUTLET PROJECT
ST. JOSEPH TOWNSHIP, WISCONSIN

PUMP STATION
ELECTRICAL

BARR PROJECT No. 4956019KLC020
CLIENT PROJECT No.
SHEET No. E-01 REV. No. 0

Appendix C

Original WDNR Permit for Bass Lake Pumping System (7/23/1997)

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

WISCONSIN DEPT. OF NATURAL RESOURCES

Tommy G. Thompson, Governor
George E. Meyer, Secretary
Scott Humrickhouse, Regional Director

West Central Region Headquarters
1300 W. Clairemont Avenue
PO Box 4001
Eau Claire, WI 54702-4001
TELEPHONE 715-839-3700
FAX 715-839-6076/1605
TTY 715-839-2786

July 23, 1997

3-WC-97-1036ST

John Eiring, President
Bass Lake Rehabilitation District
1477 North Bay Road
Somerset, WI 54025

Dear Mr. Eiring:

We have reviewed your application for a permit to develop a lake pumping system from Bass Lake to the Willow River in the Town of St Joseph, St Croix County. Your application is approved with a few limitations.

Attached is a copy of your permit which lists the conditions that must be followed. In addition, I have included a copy of our findings of fact and conclusions of law and your rights to appeal our action. A copy of the permit must be kept for reference at the project site. Please read your permit conditions carefully so that you are fully aware of what is expected of you.

Your next step will be to notify me of the date on which you plan to start construction and again after your project is complete.

If you have any questions about your permit, please feel to call me at 715-839-3769. Your permit is not valid until you notify me of your intention to begin construction.

Sincerely,

Daniel Koich

Daniel S. Koich
Water Regulation & Zoning Specialist

Enclosure

BEFORE THE

DEPARTMENT OF NATURAL RESOURCES

Application of the Bass Lake Rehabilitation District for a permit to develop a lake pumping system from Bass Lake to the Willow River, in the Town of St Joseph, St Croix County.	)))	3-WC-97-1036ST

APPROVAL, FINDINGS OF FACT, AND CONCLUSIONS OF LAW

The Bass Lake Rehabilitation District, c/o John Eiring, 1477 North Bay Road, Somerset, WI 54025 IS GRANTED an approval to place a 24-inch diameter water intake pipe, a construction equipment ramp, excavate from the bed of Bass Lake and construct a riprap outfall on the bed of the Willow River, subject to the following conditions:

APPROVAL CONDITIONS

1. You must notify Water Management Specialist Daniel S. Koich, Eau Claire, WI, 54701 (phone 715-839-3769) before starting construction and again ***not more than*** 5 days after the project is complete.

2. You must complete the project on or before October 1, 1998. You may not begin or continue construction after this date unless the Department grants a new permit or permit extension in writing.

3. This permit does not authorize any work other than what you specifically describe in your application and plans, and as modified by the conditions of this permit. If you wish to alter the project or permit conditions, you must first obtain written approval of the Department.

4. You are responsible for obtaining any permit or approval that may be required for your project by local zoning ordinances or by the U.S. Army Corps of Engineers before starting your project.

5. You must allow free and unlimited access to your project site at any time to any Department employee who is investigating the project's construction, operation, or maintenance.

6. The Department may modify or revoke this permit if the project is not completed according to the terms of the permit, or if the Department determines the activity is detrimental to the public interest.

7. You must keep a copy of this permit and approved plans at the project site at all times until the project is complete.

8. Your acceptance of this permit and efforts to begin work on this project signify that you have read, understood and agreed to follow all conditions of this permit.

9. You, your agents, and any involved contractors, shall be jointly and severalty liable for any violation of Chapter 30 or this permit.

10. The permittee/contractor shall certify that all equipment used for this project has been adequately decontaminated for zebra mussels prior to being used if it has been used in any waters which contain zebra mussels. All equipment that comes in contact with infested waters, including but not limited to, tracked vehicles, barges, boats, turbidity curtains, sheet pile, and pumps must be thoroughly disinfected. The permittee/contractor shall use the following inspection and removal procedures for disinfection:
    a. Drain all water from boats, trailers, bilges, live wells, coolers, bait buckets, engine compartments, and any other areas where water may be trapped; and
    b. Inspect boat hulls, propellers, trailers, and other surfaces, scrape off any attached mussels, remove any aquatic plant materials (fragments, stems, leaves, or roots) and dispose of removed mussels and plants in a garbage can prior to leaving the water access area; and
    c. Flush boats (inside and outside) and all other equipment with hot water of 105 degrees F to 110 degrees F for a period of 30 minutes or hot water of 140 degrees F for a period of 5 minutes; or, instead of flushing equipment, leave the equipment in a sunny location so that it dries completely, at least 5 full days.

11. The riprap must be clean fieldstone or quarry stone. It must be placed as shown on the May 20, 1997, plan except that the riprap must extend an additional four feet into the water which will provide a keyway to stabilize the riprapped slope. The use of filter cloth, or a filter layer, under the riprap is required to extend the life of the structure and to reduce maintenance costs.

12. The placement of the riprap outfall structure must be done with equipment designed to minimize the amount of sediment that can escape into the water. Equipment must be properly sized so that excavation conforms to the plans submitted and allows work to be done from the banks rather than in the Willow River.

13. At the Willow River outfall, you may not deposit or store any removed materials in any wetland or upon any part of the bed of the waterway below the ordinary high watermark. Any removed materials must be placed out of the floodway of the Willow River.

14. You are required to install a turbidity curtain in Bass Lake, prior to any excavation, around your project as shown on the application. If the Department determines it to be necessary, a second turbidity curtain may be required to be installed to contain turbidity.

15. In order to install the pipeline on the bed of Bass Lake, you are only allowed to excavate to the dimensions and elevations shown on your application and plans.

16. You may not deposit or stockpile any of the material removed from the bed of Bass Lake upon any part of the bed of Bass Lake or in the waters of Bass Lake.

17. The ramp utilized for the support of the excavation equipment shall be completely removed from the bed of the lake upon completion of the project.

18. When the project is completed, you must have a relatively level bottom in the excavated area.

19. The authority herein granted can be amended or rescinded if the structure becomes an obstruction to navigation or otherwise becomes detrimental to the public interest.

20. The water intake pipe must be marked with buoys conforming to the Wisconsin Uniform Waterway Marker standards.

21. The building or structure constructed to house the lift pump and compressor shall be located a minimum of 75 feet landward of the ordinary high water mark of the waterway.

22. In order to prevent the transport of carp from Bass Lake to the Willow River, no pumping may take place between May 1 and June 15 of any year. These dates may be amended upon findings that carp spawning takes place at or between different dates in Bass Lake.

FINDINGS OF FACT

1. The Bass Lake Rehabilitation District filed a request with the Department on May 30, 1997, for a permit to install a pumping system to lower the current high water level of Bass Lake (approximately at 888.5 MSL). The lake level will be stabilized at elevation 886 MSL. Water will be pumped from Bass Lake to the Willow River at a maximum rate of 4.5 cubic feet per second. The pumping will not exceed 2 million gallons per day for any 30 day period, therein eliminating the need for a diversion permit persuant to Sec. 30.18 Wis. Stats. The project is comprised of three main parts: a water intake pipeline on the bed of Bass Lake, a pumping chamber near the shoreline and a discharge pipeline with an outfall at the Willow River.

The proposed intake pipe is a 24-inch diameter polyethylene pipe that will extend about 660 feet into the lake from the shore. The pipe will be buried beneath the near shore area and the bed of the lake for a distance of approximately 150 ft. after which it will lay on the bed of the lake for a distance of 440 ft. The remaining 100 of the pipe, including the 60 ft. slotted intake pipe will be suspended above the lakebed 5 feet drawing water from the bottom of the lake at a depth of 30 feet. The pipeline will be buried by the contractor by excavation of a trench on the bed of the lake. The backhoe or dragline will work from a timber and steel ramp placed on the bed of the lake and removed upon completion of the pipeline placement. The design for the ramp for the backhoe was submitted by the applicant on July 18, 1997 as an amendment to the plans.

The proposed pump station will be a 6'x 10' concrete box approximately 15' deep located 75 ft from the shoreline. The pump station will house a single 60 horsepower pump capable of delivering 2,000 gpm of flow. A single access hatch will be provided to allow for both pump maintenance and access into the structure. A standpipe will be installed that will provide a connection for fire truck access if needed. A sluice gate will allow flow from the lake to be shut off. The station does have space to accommodate a future screening system for prevention of transportation of exotic species like carp or Eurasian Water Milfoil. Above ground, an electrical circuit box approximately 4'x 4'x 1½' containing the pump controls will be mounted on a concrete pad.

Approximately 4,600 feet of 18 inch outside diameter polyethylene pipe will be used to carry the flow from the pump station to the Willow River. From the pump station, the forcemain route will be easterly, following the right-of-way on the north side of 132nd ave. where it crosses a small wetland. The pipeline continues easterly across private property following an existing ravine down to the Willow River. The pipe will outlet at a flat location adjacent to the river. Riprap will be placed at the pipe outlet at a width of 15 ft. for a length of 30 ft. from which water will then discharge into the Willow River.

2. Carp are present in Bass Lake, but are not present in the Willow River above Willow Falls.

3. The Department has determined that this project will not have adverse affects on the public interest in Wisconsin waterways.

4. The project, if completed in compliance with the conditions of this permit, will not obstruct navigation or reduce the effective flood flow capacity of any stream.

5. The Department has evaluated this project and has determined that the grant or denial would not be a major state action significantly affecting the quality of the human environment.

6. The project will not adversely impact wetlands.

7. The Department and the applicant have completed all procedural requirements and the project as approved will comply with all applicable requirements of Sections 1.11 and 30.12(2), 30.12(3), and 30.20 Wisconsin Statutes and Chapters NR 102, 103, 115, 116, 150, and 299, Wisconsin Administrative Code.

CONCLUSIONS OF LAW

1. The Department has authority under Sections 30.07, 30.12(2), 30.12(3), and 30.20 Wisconsin Statutes, and the foregoing Findings of Fact, to issue an order granting the permit.

2. The Department has complied with Section 1.11, Wisconsin Statutes and NR 103, Wisconsin Administrative Code.

NOTICE OF APPEAL RIGHTS

If you believe that you have a right to challenge this decision, you should know that Wisconsin Statutes and Wisconsin Administrative Rules establish time periods within which requests to review Department decisions must be filed.

For judicial review of a decision pursuant to Sections 227.52 and 227.53, Wisconsin Statutes, you have 30 days after the decision is mailed, or otherwise served by the Department, to file your petition with the appropriate court and serve the petition on the Secretary of the Department. Such a petition for judicial review shall name the Department of Natural Resources as the respondent.

To request a contested case hearing pursuant to Section 227.42, Wisconsin Statutes, you have 30 days after the decision is mailed or otherwise served by the Department, to serve a petition for hearing on the Secretary of the Department of Natural Resources. The filing of a request for a contested case hearing is not a prerequisite for judicial review and does not extend the 30 day period for filing a petition for judicial review. This notice is provided pursuant to Section 227.48(2), Wisconsin Statutes.

Dated at Eau Claire, Wisconsin on July 23, 1997

STATE OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES
For the Secretary

By Daniel Koich

Daniel S. Koich
Water Regulation & Zoning Specialist

Buzz Sage / Duane Popple Bass Lake file

WISCONSIN
DEPT. OF NATURAL RESOURCES

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Tommy G. Thompson, Governor
George E. Meyer, Secretary
Scott Humrickhouse, Region Director

990 Hillcrest Street
Suite 104
Baldwin, Wisconsin 54002
TELEPHONE 715-684-2914
FAX 715-684-5940

August 5, 1997
Certified Mail
Return Receipt Requested

Mr. Lee Mans, Superintendent
Arcon Construction Company
43425 Frontage Road
Harris, MN 55032

Subject: General WPDES Permit for Pit/Trench Dewatering

Dear Mr. Mans:

The enclosed Wisconsin Pollutant Discharge Elimination System (WPDES) permit number WI-0049344-1 authorizes the discharge of **uncontaminated** water from dewatering operations. This permit is necessary for construction of a lift station and an eighteen inch polyethylene forcemain from Bass Lake to the Willow River. Dewatering is necessary at the lift station and at the intersection of 132nd Avenue and 80th Street on the forcemain route. Dewatering will be completed using a series of sand point wells at the final lift station and the effluent discharged to the Willow River (outfall 001) is subject to the monitoring requirements and effluent limits contained below in Table 1.

Table 1
Discharge to the Willow River (Outfall 001)
Monitoring Requirements and Effluent Limits

Parameter	Effluent Limit[1]	Sample Type
Flow	-----	Estimate[2]
Total Suspended Solids	40 mg/l, daily max.[3]	Grab

1 The effluent shall be sampled from the pipeline discharging into the Willow River.
2 The average daily flow during each calendar quarter shall be reported on the attached discharge monitoring report form. It is understood that dewatering will occur at a rate of about 1100 gpm.
3 The effluent total suspended solids concentration shall be sampled once during each calendar quarter.

The dewatering at the intersection of 132nd Avenue and 80th Street will impact two wetlands--one north of 132nd Avenue and one south of 132nd Avenue. **Dewatering of these wetlands is subject to the conditions placed in the Chapter 30 permit which was issued on July 23, 1997.**

The surface water from the wetland north of 132nd Avenue will be pumped into an infiltration basin along the right-of-way on 132nd Avenue (outfall 002) after the culvert between the two wetlands is plugged. The discharge to the infiltration basin is subject to the monitoring requirements and effluent limits contained below in Table 2.

Table 2
Discharge to the Infiltration Basin (Outfall 002)
Monitoring Requirements and Effluent Limits

Parameter	Effluent Limit[1]	Sample Type
Flow	----	Estimate[2]
Oil and Grease	15 mg/l, daily max.[3]	Grab

1 The effluent shall be sampled from the pipe discharging water into the infiltration basin.
2 The average daily flow during each calendar quarter shall be reported on the attached discharge monitoring report form.
3 The effluent oil and grease concentration shall be sampled once during each calendar quarter.

After the wetland north of 132nd Avenue is substantially dry, a series of dewatering wells will be installed and the groundwater from the dewatering system will be discharged to the Willow River. The effluent discharged to the Willow River from the dewatering well system is subject to the monitoring requirements and effluent limits contained above in Table 1.

This permit **expires on December 31, 1997.** Monitoring results shall be reported on the attached discharge monitoring report form no later than **February 15, 1998. Please notify me at least one week prior to commencing the discharges and within 24 hours of any effluent limit violation.**

Because the planned dewatering is greater than 70 gallons per minute, you will also need a high capacity dewatering well system approval from the Drinking Water and Groundwater Bureau prior to commencing operation. I suggest you contact Bob Schaefer at (608) 266-3415 regarding this approval. Management of the project and control of the discharge must be done in compliance with the terms and conditions of this permit.

If you believe coverage of this facility under WPDES Permit No. WI-0049344-1 is not appropriate, you may petition the Department for withdrawal of coverage and, where appropriate, apply for issuance of an individual WPDES permit pursuant to section 283.35. Issuance of such an individual permit will provide for a public comment period, and potentially a public informational hearing and/or an adjudicatory hearing.

Alternatively, you may request judicial or administrative review of the Department's decision to cover your discharge under the enclosed general permit. Either request must be submitted no later that 30 days after this letter is mailed. To request judicial review of this decision pursuant to sections 227.52 and 227.53, Stats., a petition naming the Department of Natural Resources as respondent must be filed with the appropriate circuit court and served on the Department. To request a contested case hearing on this decision pursuant to section 227.42, Stats., a petition for hearing must be served on the Secretary of the Department of Natural Resources. This notice is provided pursuant to s. 227.48(2), Stats.

Section 283.353, Stats., authorizes the Department to issue a general permit for discharges from categories or classes of point sources. The Department may withdraw a facility from coverage under a general permit if it determines a discharge is a significant contributor of pollutants to waters of Wisconsin, if it finds the source is not in compliance with the permit terms and conditions, at your request, or in certain other cases set out in s. 283.35, Stats. In lieu of general permit withdrawal, the Department may refer any violation of WPDES Permit No. WI-0049344-1 to the Department of Justice for enforcement under s. 283.89, Stats.

Please contact me at (715) 684-2914 if you have further questions regarding this permit.

Sincerely,

PWS

Peter W. Skorseth, P.E.
Environmental Engineer

AUG - 6 1997
DNR - WD

Enclosures

c: John Paddock/Duane Popple - WCR
Tom Bauman - WT/2
John Eiring - Bass Lake Rehabilitation District, 1477 N. Bay Road, Somerset, WI 54025
Dan Koich - WCR
Bob Schaefer - DG/2

DISCHARGE MONITORING REPORT FORM

FORM ILS-130.cgw PERMIT NO. WI-0049344-1
YEAR: 1997
Bass Lake Dewatering Project

Arcon Construction
43425 Frontage Road
Harris, MN 55032

Outfall Number	001	001	002	002		
Sample Pt. Description						
Parameter Name	Flow	Total Susp. Solids	Flow	Oil & Grease		
Parameter Units	Gal./Day	mg/1	Gal./Day	mg/l		
Quarter						
Jan - Mar						
Apr - June						
July - Sep						
Oct - Dec						
Daily Maximum Limit		40.0		15		
Daily Minimum Limit						
Sample Type	Estimate	Grab	Estimate	Grab		
Frequency of Sampling	Quarterly	Quarterly	Quarterly	Quarterly		

Unless noted under parameter name, each daily value entered must be the highest value of all sample types analyzed for that day.

WISCONSIN STATUTE 147.08

RETURN REPORT NO LATER THAN: February 15, 1998

I CERTIFY UNDER PENALTY TO LAW THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION SUBMITTED IN THIS DOCUMENT AND ALL ATTACHMENTS AND THAT, BASED ON MY INQUIRY OF THOSE INDIVIDUALS IMMEDIATELY RESPONSIBLE FOR OBTAINING THE INFORMATION, I BELIEVE THAT THE INFORMATION IS TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTED FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINES AND IMPRISONMENT, (40 CFR 122.5). I ALSO CERTIFY THAT THE VALUES BEING SUBMITTED ARE THE ACTUAL VALUES FOUND IN THE SAMPLES; NO VALUES HAVE BEEN MODIFIED FOR CHANGED IN ANY MANNER. WHEREVER I BELIEVE A VALUE BEING REPORTED IS INACCURATE, I HAVE ADDED AN EXPLANATION INDICATING THE REASONS WHY THE VALUE IS INACCURATE.

SEND TO: **Peter Skorseth**
DEPARTMENT OF NATURAL RESOURCES
990 Hillcrest, Suite 104
Baldwin, WI 54002

PLEASE ATTACH NOTES AND/OR ADDRESS-NAME CORRECTIONS ON A SEPARATE SHEET

Signature of Person Completing Form	
Signature of Principal Exec. Officer or Authorized Agent	Title

P:\WW0046566.DMR

Appendix D

Town of St. Joseph Groundwater Chemistry Memorandum – University of Wisconsin - Stevens Point Center for Watershed Science and Education (2/23/2018)

University of Wisconsin-Stevens Point
Center for Watershed Science and Education
Stevens Point WI 54481-3897
715-346-4270; Fax: 715-346-2965
www.uwsp.edu/cnr-ap/watershed

MEMO

To: Jennifer Koehler, Barr
From: Paul McGinley
Date: February 23, 2018
Subject: Groundwater Chemistry in the Town of St. Joseph

The table below summarizes groundwater chemistry from wells in the Town of St. Joseph, St. Croix County. This summarizes results from 269 samples.

Summary Statistics for Well Samples* (n=269)

Analyte	25th Percentile Concentration (mg/L)	Median Concentration (mg/L)	75th Percentile Concentration (mg/l)
Alkalinity (as $CaCO_3$)	176	190	208
Calcium	41	48	54
Magnesium	17	21	25
Chloride	3.1	7.8	17.9
Nitrate (as N)	0.4	2.0	4.0
Phosphorus (P)	0.010	0.021	0.040

*only included analysis results where cation/anion balance was within 15% and calcium was greater than 2 mg/l (to exclude softened samples)
** See McGinley et al., 2016. Applied Geochemistry 72:1-9 for discussion of analysis methods and some background on phosphorus in groundwater (although those results are from a different part of Wisconsin).

Appendix E

Project Team Meeting #1 Presentation and Handouts (3/16/2018)

Bass Lake Drawdown Feasibility Study

Team Meeting #1

3/16/2018

Jen Koehler PE and Karen Chandler PE, Barr Engineering Company

Review Agenda/Introductions

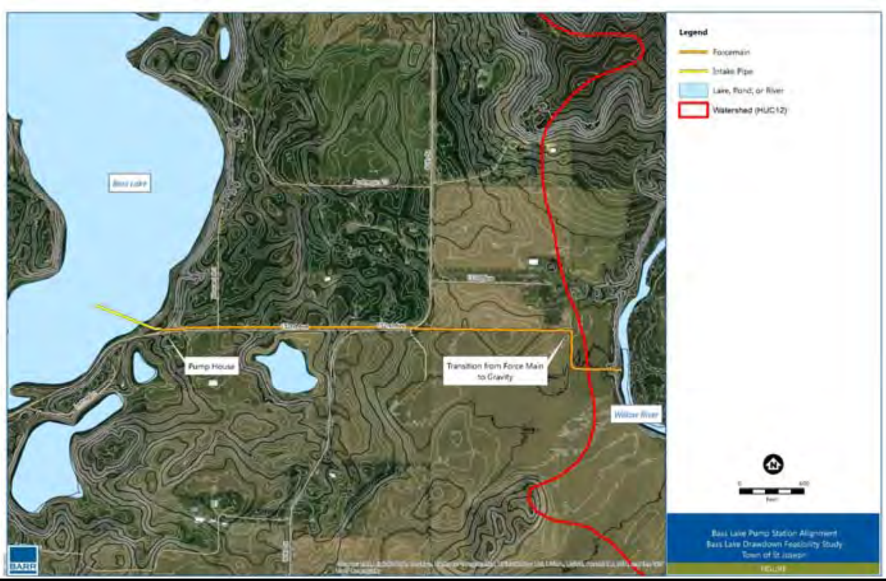
- Recap of Past Meeting
- Review more recently compiled data
- Review of High Level Evaluation of "Treatment" to meet Zebra Mussel and Phosphorus Discharge Requirements
- Select up to 4 feasibility alternatives to further develop for final consideration
- Outline Next Steps/Schedule

Recap of Last Meeting: Data Review

- Reviewed known information about
  - Bass Lake – Water Quality and Lake Levels
  - Watershed – Surface and Ground Watersheds
  - Existing Pumping System
  - Discharge requirements related to zebra mussels and water quality
    - Net zero transfer of zebra mussels
    - Total Phosphorus discharge from Bass Lake must be below 39 ug/L

BARR

Existing System Alignment



BARR

Recap of Last Meeting: Project Goals

- Discussed project goals
  - Determine feasibility of modifications to the existing pumping system to:
    - Meet phosphorus discharge requirements
    - Filter or otherwise prevent Zebra Mussels from entering the Willow River
    - Effectively maintain lake levels
    - Estimate the potential impact of hypolimnetic withdrawal on Bass Lake water quality

Recap of Last Meeting: Options Considered

Zebra Mussel

- Pumping from Hypolimnion
- Using a shallow wetland to filter zebra mussels (existing/creating)
- Using Filtration (pump intake/discharge)
- Using chemicals to treat pumped lake water
- Using UV light to treat pumped lake water
- Infiltration (into ground)
- Groundwater pumping
- Timing of Pumping/Discharge

Phosphorus

- Modify pump intake location (move to surface)
- Treating discharge with Alum
- Treating discharge with filtration
- Infiltration (into ground)
- Groundwater pumping
- Water quality trading
- Timing of Pumping/Discharge

Original WiDNR Permit – Pumping Rate

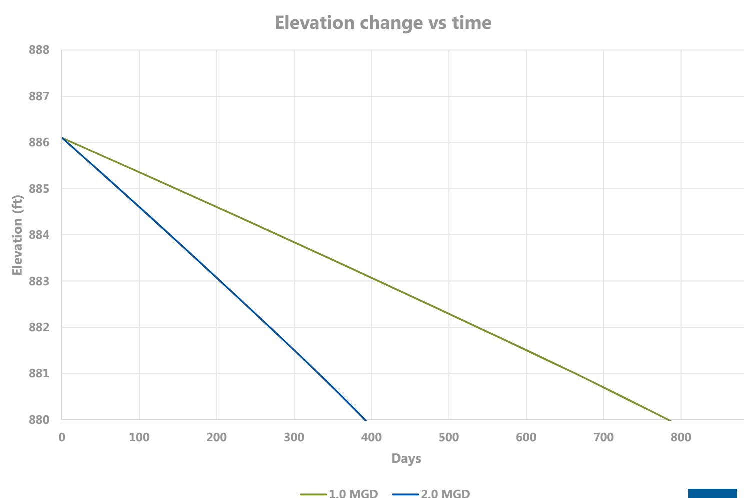
The Bass Lake Rehabilitation District filed a request with the Department on May 30, 1997, for a permit to install a pumping system to lower the current high water level of Bass Lake (approximately at 888.5 MSL). The lake level will be stabilized at elevation 886 MSL. Water will be pumped from Bass Lake to the Willow River at a maximum rate of 4.5 cubic feet per second. The pumping will not exceed 2 million gallons per day for any 30 day period, therein eliminating the need for a diversion permit persuant to Sec. 30.18 Wis. Stats. The project is comprised of three main

1.0 MGD vs 2.0 MGD?
Flexibility on pump start elevation?

BARR

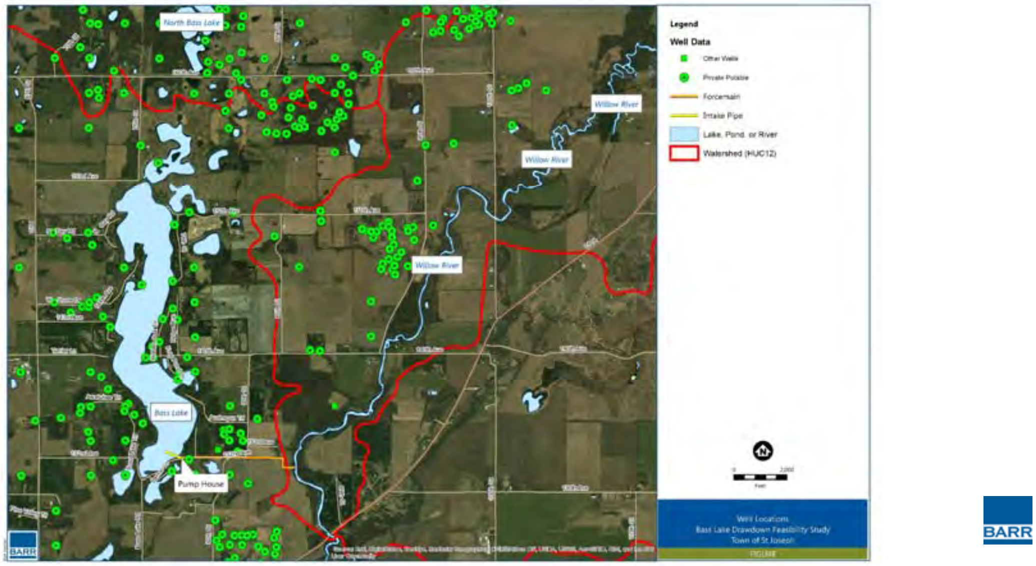
Estimated Drawdown Time/Contact Time in Pipe

- Drawdown based on bathymetric data obtained from UWEC
- At 4.5 cfs, the water takes ~30 minute to go from the pump to the Willow River

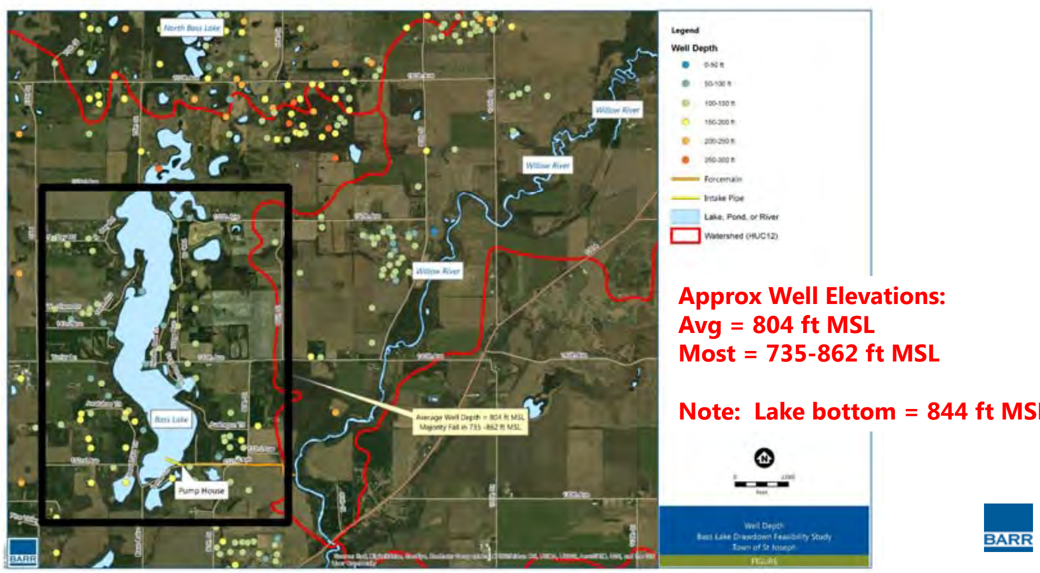


BARR

Well Data Review



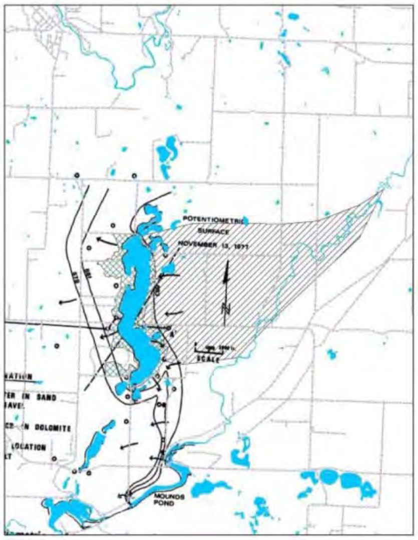
Well Depth Review

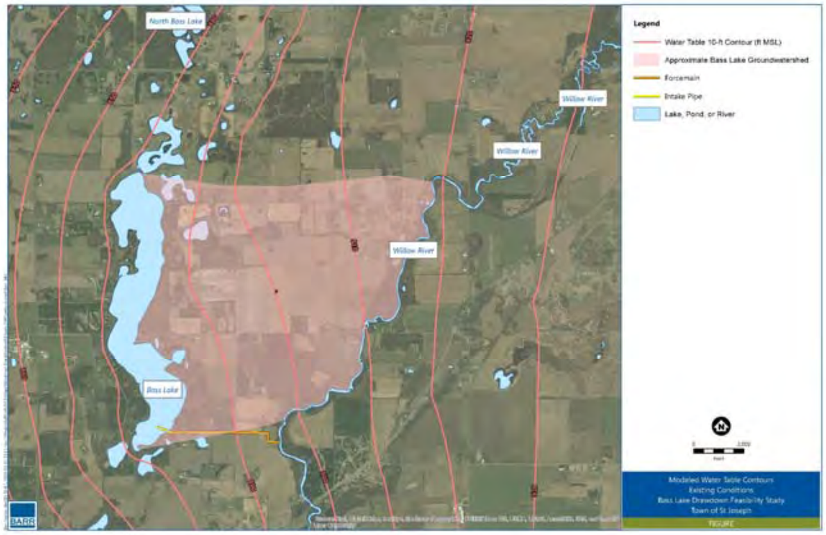


Approx Well Elevations:
Avg = 804 ft MSL
Most = 735-862 ft MSL

Note: Lake bottom = 844 ft MSL

Groundwater “Watershed”

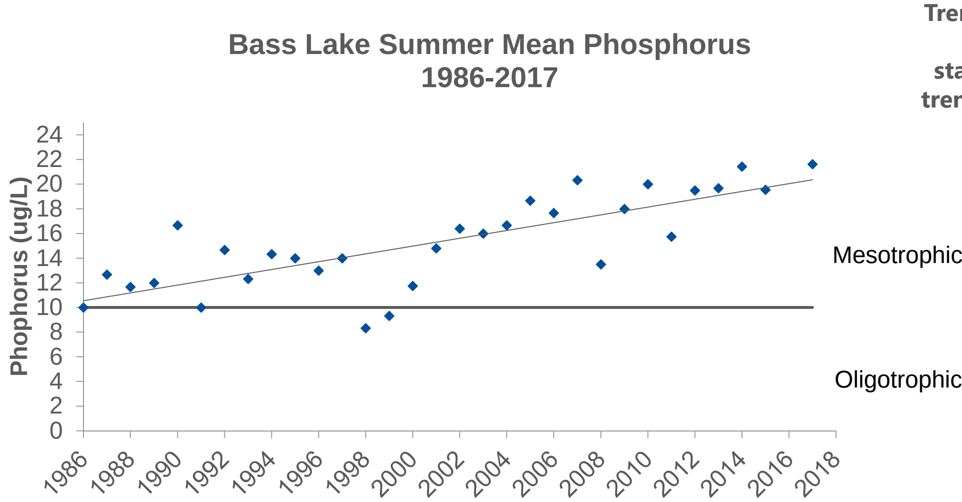




Groundwater Model Summary (USGS Steady-State)

- Bass Lake is a flow-through lake
  – At elevation 886, the flow-through rate = 4.0-7.0 cfs
  – Approx. Residence Time = 1.7-2.9 years

Bass Lake Water Quality



Trend analyses indicates that there are no statistically significant trends based on the past 10-years of data:

Stable WQ

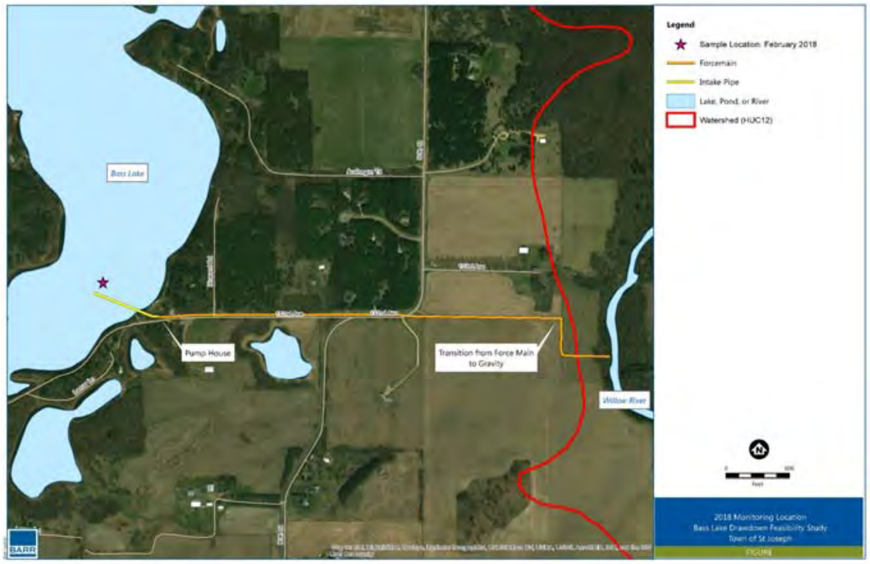
Groundwater Well WQ Data Analysis: Results

- Paul McGinley of UWSP reran the groundwater well water chemistry analysis on most current well data in the Town of St. Joseph (269 wells)

Parameter	25th Percentile	Median	75th Percentile
Total Phosphorus	10 ug/L	**21 ug/L**	40 ug/L

- Similar to previous analysis for 2016 Lake Management Plan

February 2018 Data Collection



February 2018 Data Collection: Results

- Zebra Mussel Veligers: ABSENT (as expected)

- Total Phosphorus – Epilimnion (Surface): 5.8 ug/L
- Total Phosphorus – Hypolimnion (Near bottom/pump intake): 8.2 ug/L

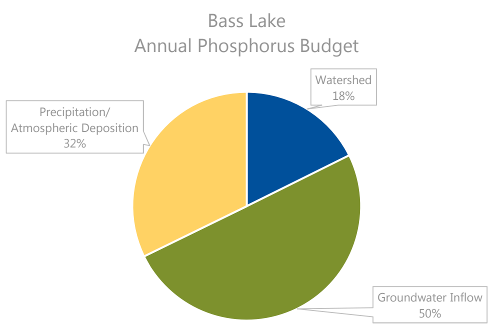
Both conditions meet the WDNR Discharge Requirements

Impact of Pumping on Water Quality

- Preliminary Water Balance and Lake Models
  - P8 model generates daily precipitation and watershed runoff
  - GW model to estimate groundwater inflow/outflow
  - Water Balance used to estimate hypolimnion/epilimnion volumes and TP mass throughout the year
  - Quantify the % change in the phosphorus water quality per empirical lake models

BARR

Impact of Pumping on Water Quality



Assuming 1 ft of drawdown over a 4-5 month period: 1- 5% reduction in the TP conc (If lake is 20 ug/L, the reduction would be 0.2 – 1.0 ug/L)

BARR

Filtration Using Pump Intake Screen Only (Zebra Mussel)

Pros

- Should be used in all scenarios to protect the pump infrastructure and reduce maintenance (by preventing zebra mussels from establishing in the in-take pipe and on the pump)
- Prevention of zebra mussel adults from entering intake/establishing on intake (Z-Alloy material)
- No moving parts, controlled entrance velocity, air backwash
- Inexpensive operation

Cons

- Standard screen slot size is (0.125" opening = ~3000 µm)
- Smallest screens available that can still convey the appropriate capacity cannot screen veligers (0.5mm opening = ~500 µm)
- Does not address discharge water quality requirements
- May require additional cleaning or sediment removal, if the screen sits stagnant for a long period of time to reduce any build up on the screen

BARR

Pumping Intake Screen Options

Z-Alloy materials repel Zebra mussels, resists biofouling and minimizes corrosion

BARR

Use of Shallow Wetlands to Filter Out Zebra Mussels

Pros

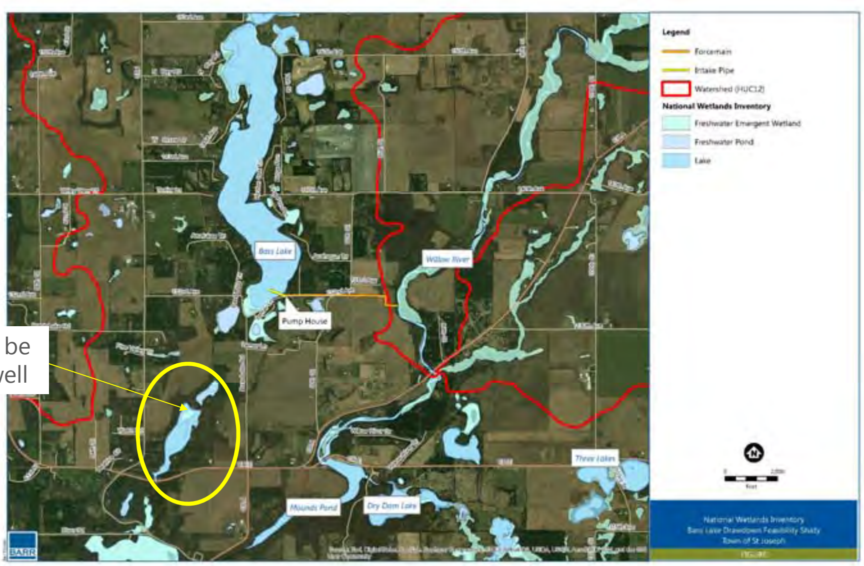
- Once constructed, no operation/maintenance of filtration or dosing equipment

Cons

- Requires ~1 km to provide removals
- Cannot guarantee 100% veliger mortality/removal
- Limited wetland opportunities around Bass Lake
  - ~0.5-0.8 km length
  - Landlocked wetland
- Data would be needed to understand potential impact on water quality discharge requirements
- Additional infrastructure (forcemain) would need to route water to shallow wetland

Surrounding Wetlands/Water Bodies

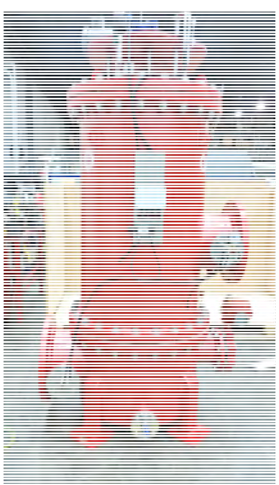
This appears to be landlocked as well

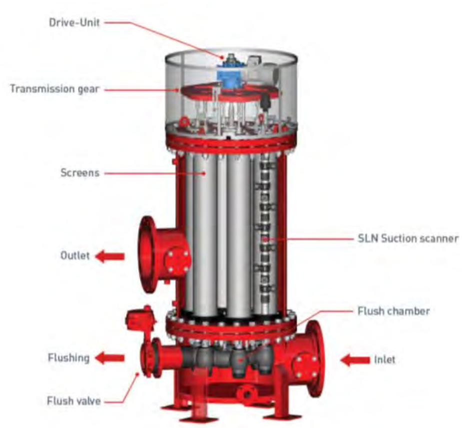


Mechanical Filtration System Downstream of Pump (AMIAD) (Zebra Mussels)

Pros	Cons
▪ Relatively small footprint required for a filtration building/structure (not necessarily needed if only operating in spring/summer) ▪ Ability to filter zebra mussel veligers (would be destroyed by the filter itself/report to the backwash) – filtration down to 40 µm ▪ Year-round treatment/discharge potential	▪ Requires a building with heat for winter operation, if desired (requiring land purchase/easement) ▪ Requires a backwash discharge point, typically back to the lake ▪ Booster pump may be required following filtration to pump filtered water to the discharge location ▪ Does not address discharge water quality requirements ▪ No rental/portable option

Mechanical Filtration System Options (AMIAD)





Phosphorus-Specific Disk Filtration System Downstream of Pump (Nexom) (Zebra Mussels/Phosphorus)

Pros

- Individual effluent ports for operational/maintenance flexibility
- Disk filtration cloths designed to prevent long-term fouling
- Building not required/can be installed underground or inline with current intake
- Year-round treatment potential meeting veliger removal requirements, and potentially phosphorus requirements

Cons

- Removes phosphorus down to ~100 µg/L - Cannot guarantee phosphorus removal down to 39 µg/L
- Requires a backwash discharge point, typically back to the lake
- Booster pump may be required following filtration to pump filtered water to the discharge location
- Larger footprint than traditional mechanical filtration (requiring land purchase/easement)
- No rental/portable option
- Very expensive and more robust design than may be necessary (typically used in wastewater treatment)

Phosphorus-Specific Disk Filtration System Options (Nexom)

Phosphorus-Specific Sand Filtration System Downstream of Pump (Nexom)(Zebra Mussels/Phosphorus)

Pros

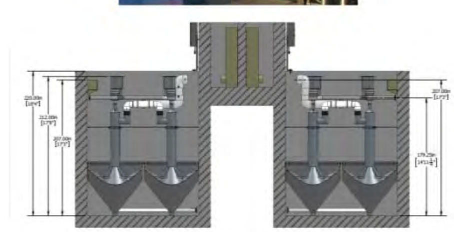
- Removes phosphorus down to 20 µg/L
- Uses 30% less chemical than coagulation for phosphorus removal
- Effective pore size down to 5-10 microns
- Continuous flow, no stopping for backwash, no changing media, uninterrupted filtrate quality
- Also removes trace metals and mercury
- Year-round treatment potential

Cons

- May require a building
- Requires chemical storage/delivery
- Requires a backwash discharge point, typically back to the Lake
- No physical barrier for zebra mussel veligers, harder to obtain 100% retainage
- Booster pump may be required following filtration to pump filtered water to the discharge location
- No rental/portable option
- Larger footprint than all other filtration options
- Very expensive

BARR

Phosphorus-Specific Sand Filtration System Downstream of Pump



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Portable Bag Filtration System (Rental) Downstream of Pump (Zebra Mussels)

Pros

- Ability to filter zebra mussel veligers (25 µm)
- No moving parts, easy to operate
- No backwash required
- Rental option, easily portable/skid-mounted, weather resistant (~6'x5')
- Variety of system sizes available to treat a wide range of flows
- Year-round treatment potential for veliger removal

Cons

- Maximum pressure 150 PSI
- No phosphorus removal
- Would require modification of existing system to provide connection to portable unit – contractor may be required for the connection
- Requiring land purchase/easement
- Booster pump may be required following filtration to pump filtered water to the discharge location
- Requires more frequent monitoring than mechanical filtration, potentially daily and Fouled bag filters require manual replacement, unknown replacement frequency
- With no differential pressure alarms, manual monitoring would be required to protect the pump/filtration skid and mitigate safety concerns

BARR

Portable Bag Filtration System (Rental) Downstream of Pump

BARR

Chemical Treatment of Pumped Discharge: EarthtecQZ & Zequenox (Zebra Mussels)

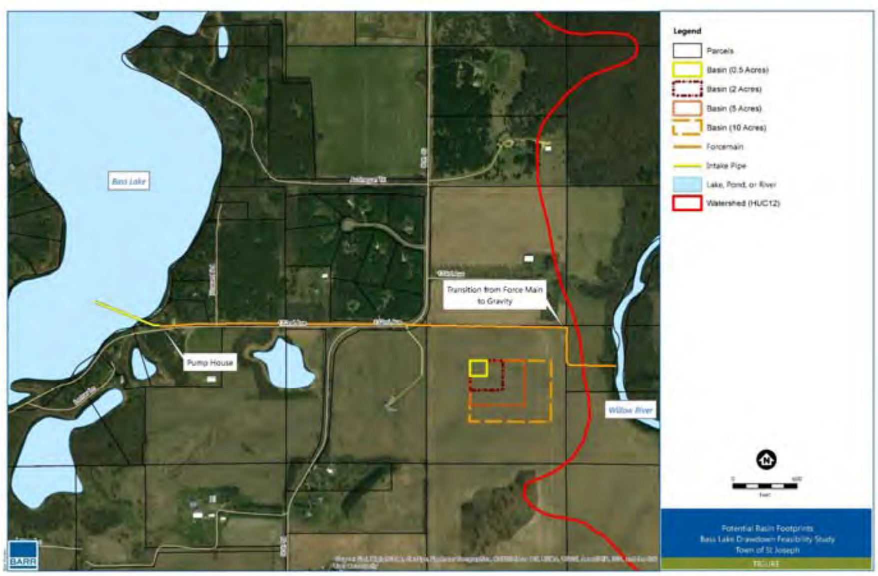
Pros

- Earthtec QZ & Zequenox are approved for use in WI – require a NR 107 permit
- EarthtecQZ achieves 100% mortality

Cons

- Have been used in in-lake applications, but not on discharge treatment
- Zequanox may not achieve 100% mortality
- Contact time – requires retention
  - EarthtecQZ ~5 days (~10.0 acres)
  - Zequanox ~ 8 hours (~0.5 acres)
- May require a building for chemical storage and dosing equipment (land/easement)
- Requires purchase of land/easement near transition from FM to gravity, otherwise secondary pump system will be needed move water through retention
- May require intensive monitoring during operation
- Does not address discharge water quality requirements

Chemical Treatment: Retention Basin for Contact Time



UV Treatment of Pumped Discharge (Zebra Mussels)

Pros	Cons
▪ 100% mortality of veligers with adequate exposure ▪ No backwash/filter maintenance	▪ Long exposure time, variable results and depends on UV intensity/dose: 12 hours to 72 hours (bench test only) ▪ Effectiveness of UV tied to incoming turbidity/solids ▪ Have received limited vendor response, but will need some sort of "reactor" that is fully exposed to UV to achieve contact time ▪ Veligers not killed instantly, but died within a few days ▪ Does not address discharge water quality requirements ▪ UV use on pumped discharges was to prevent settlement/colonization of veligers on pump intake and equipment (but not necessarily about veliger mortality)

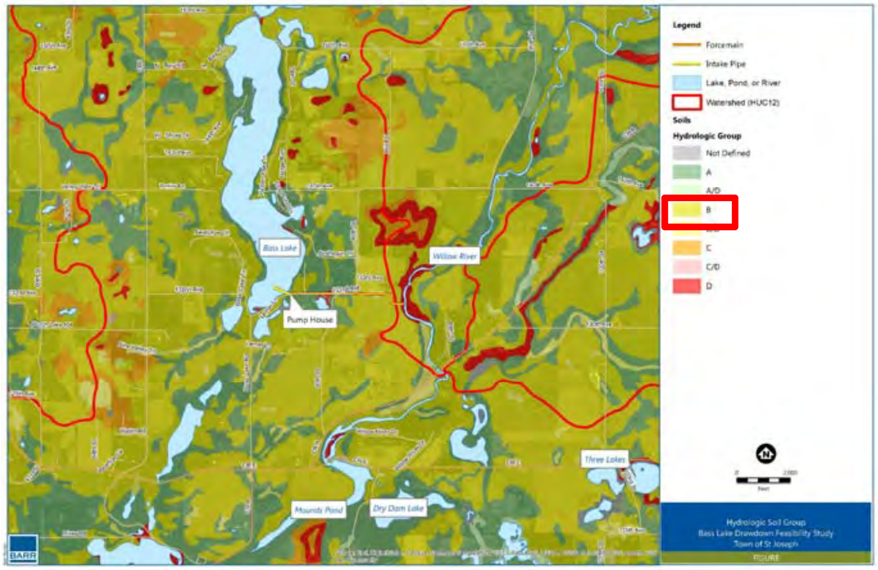
BARR

Infiltration of Pumped Discharge (Zebra Mussels/Phosphorus)

Pros	Cons
▪ Will be effective in the removal of veligers and meeting the discharge water quality requirements	▪ Requires purchase of land/easement outside the Bass Lake groundwatershed – ~2-5 acres ▪ Depending on location of site, may require modification of forcemain alignment/location

BARR

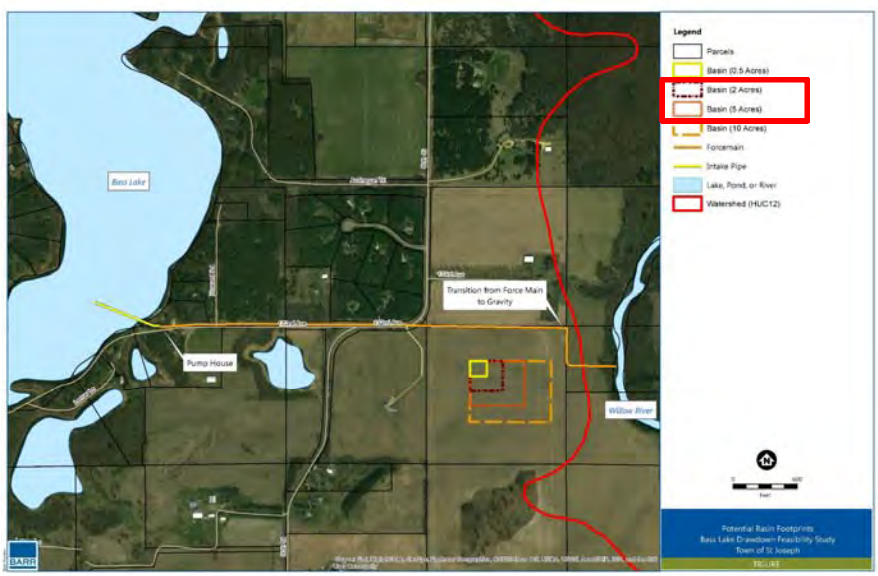
Infiltration Capacity of Soils



HSG B:
0.3 – 0.45 in/hr

BARR

Potential Infiltration Basin Footprint



BARR

Groundwater Pumping - Shoreline Drain Tile System (Zebra Mussels and Phosphorus)

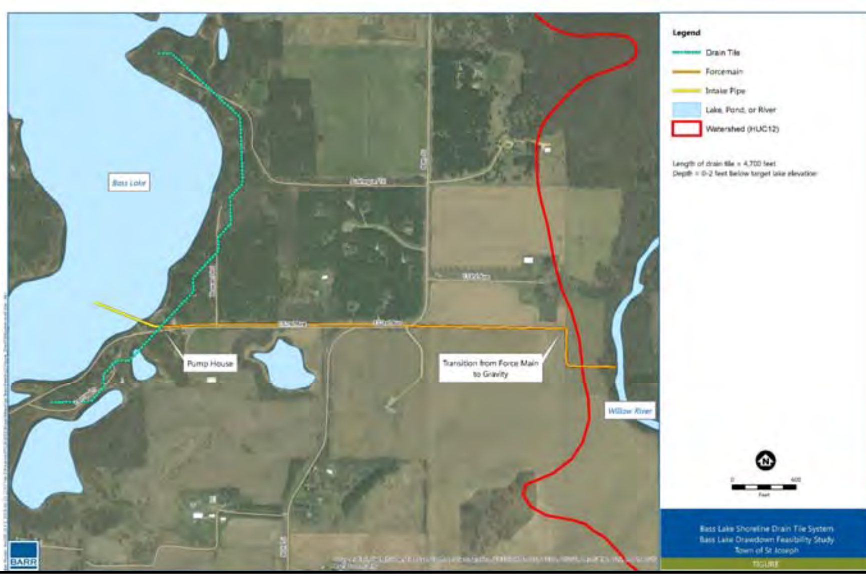
Pros

- Passive system (no equipment except pump)
- Will be effective in the removal of veligers and meeting the discharge water quality requirements

Cons

- Requires long drain tile system to be installed offset from the shoreline (~4,700 ft) – multiple easements, topography may be challenging
- Potentially higher pumping rates than current pump
  - 1 ft of drawdown: 1,000-4,000 gpm (2,500 gpm (1.25x))
  - 2 ft of drawdown: 2,000-5,000 gpm (3,500 gpm (1.75x))

Shoreline Drain Tile System



Seasonal Pumping (Zebra Mussels and Phosphorus)

Pros	Cons
▪ Addresses both zebra mussel veligers and discharge water quality requirements ▪ Can utilize existing system (with a modified pump intake to protect pump) ▪ Less operations and maintenance ▪ Testing fairly inexpensive – ~$30/sample for TP – ~$90/sample for veligers	▪ Limited to ~November – April (6 months) ▪ May require zebra mussel and total phosphorus testing before pumping begins (and during pump operation?) – delay in sampling results and what happens if phosphorus tests come back above 39 ug/L?

BARR

Seasonal Pumping: Water Quality & Discharge Restrictions

- Net zero transfer of zebra mussels
  - Feb 2018 – veligers absent
  - Potential presense: May - September
- Discharge from Bass Lake must meet: 39 µg/L
    - Epilimnion TP Concentrations: 12 to 20 µg/L (long-term record)
    - Epilimnion TP concentration: 5.8 µg/L (February 2018)
    - Hypolimnion TP Concentrations (at intake): 31 - 107 µg/L (2017 summer)
    - Hypolimnion TP Concentration (at intake): 8.2 µg/L (February 2018)
  - Potential Elevated Hypolimnion TP: July – September/October

BARR

Alum Treatment of Pumped Discharge (Phosphorus)

Pros

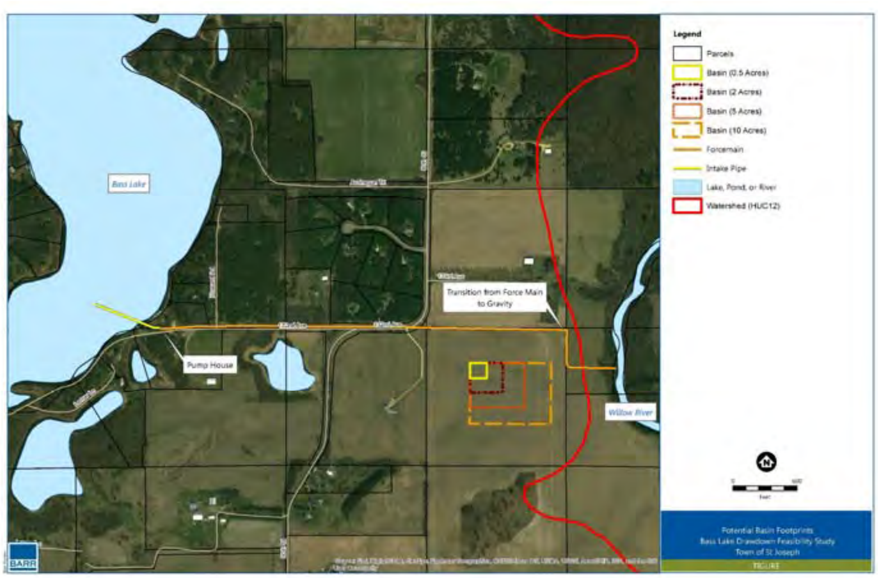
- Effective at reducing phosphorus ~80-90%

Cons

- Does not treat zebra mussel veligers
- Required ~0.5 acre retention pond to settle floc- Will require easement/purchase of land
- Building/chemical storage/dosing required
- Retention pond will need to be located near transition from FM to gravity or a secondary pumping system will be needed Pond may allow for warming of discharge
- Pond will require more maintenance to remove floc as no access to sanitary sewer for disposal
- Portable systems - limited to smaller flow rates
- Significant cost (capital and O&M)

BARR

Alum Treatment System



BARR

Alum Treatment System

Water Quality Trading (Phosphorus)

Pros	Cons
▪ Provides an opportunity to offset water quality of pumping if a preferred zebra mussel control option may not meet the discharge requirements	▪ Does not treat zebra mussel veligers ▪ Partnerships between point source facilities and their trading affiliates ▪ Complicated - Legal hoops ▪ Can be expensive ▪ Annual Reporting

Potential Feasibility Alternatives – For Discussion

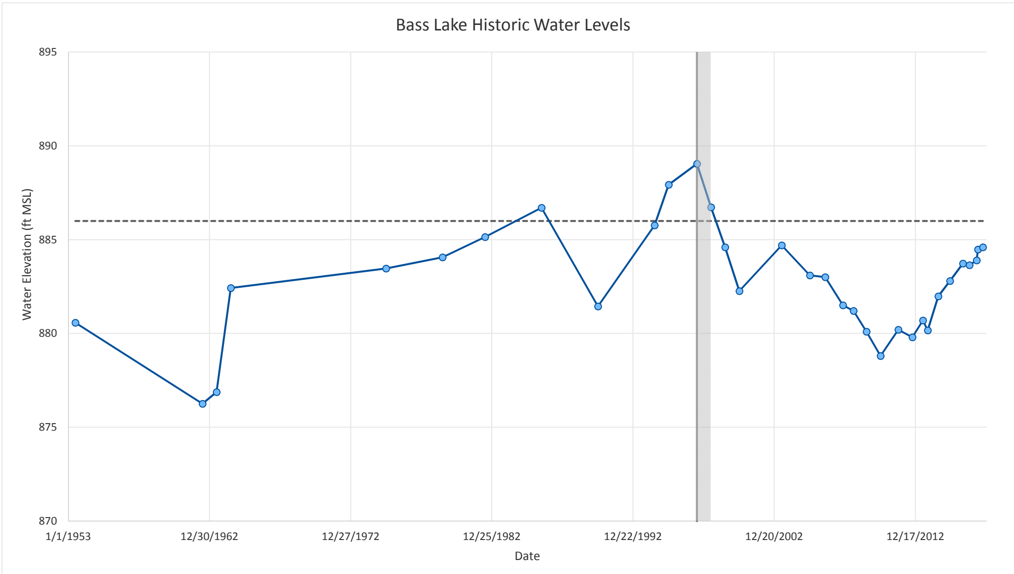
- **Option 1:** Modify Pump Intake (screen), Pump to Infiltration Outside the Bass Lake Groundwatershed
- **Option 2:** Modify Pump Intake (screen), Seasonally (November – April) pump to reduce lake levels*
- **Option 3:** Modify Pump Intake (screen), Mechanical Filtration (AMIAD) or Portable Bag Filtration, and Seasonal Pumping for Total Phosphorus (October – June)*
- **Option 4:** Shoreline Drain Tile System???

*Flexibility in lake level to start pumping may help with seasonal pumping?

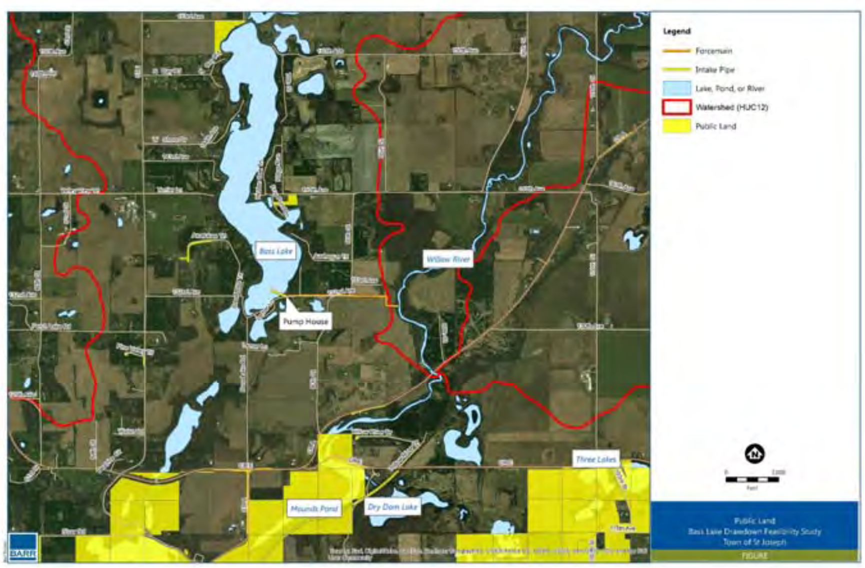
Schedule

task			est. completion date
1.0	data gathering and review		March 2, 2018
2.0	development and evaluation of options		April 27, 2018
3.0	meetings and project management	▪ kick-off meeting ▪ feasibility team meeting #1 ▪ **feasibility team meeting #2** ▪ town board meeting	February 16, 2018 March 16, 2018 **April 27, 2018** May 10, 2018
4.0	feasibility report	▪ draft feasibility report ▪ final feasibility report	May 1, 2018 June 1, 2018

Bass Lake Historic Water Levels



Publicly-Owned Land



Feasibility Option	Meets Net Zero Transfer of Zebra Mussel (Veligers) Requirement	Meets Water Quality Discharge Requirement	Considerations
Pumping from Hypolimnion (Bottom)	No	Maybe/Seasonal	- Veligers and zebra mussels present on pump intake - cannot rely on this alone to prevent movement of zebra mussels/veligers
Pumping from Epilimnion (Surface)	No	Yes	- Cannot rely on this alone to prevent movement of zebra mussels/veligers - May not meet temperature discharge requirements for Willow River
Screen on Intake Pipe	***No***	***No***	- Will NOT prevent movement of veligers - Recommended as part of most alternatives to prevent zebra mussel establishment in pipe intake and pump - Lower cost
Use of Shallow Wetlands	Maybe	Maybe	- Requires a flow path through wetland of ~1.0 km (~0.6 miles) - Limited options near Bass Lake - wetland complex to south ~0.5-0.8 km flow path but appears to be landlocked - No data on water quality of wetland downstream
Filtration System (Mechanical Filtration (AMIAD))	***Yes***	***No***	- Will likely require a shelter for equipment (land purchase/easement) - Filtration to 40 microns - Requires backwash discharge to lake - May require booster pump - No rental/portable options - Moderate to Expensive - More affordable filtration option
Filtration System (Phosphorus-Specific Disc Filtraiton System (Nexom))	Yes	No/Maybe	- Filtration to 5-10 microns - Phosphorus removal to 100 ug/L (however, documentation of systems acheiving 30 ug/L) - Can be installed inline with current pipe alignment underground or in shelter (land purchase/easement) - Requires backwash discharge to lake - May require booster pump - No rental/portable options - Very expensive
Filtration System (Phosphorus-Specific Sand Filtration (Nexom))	Maybe	Yes	- Phosphorus removal to 20 ug/L - Effective pore size should remove veligers but vendor could not guarantee removal of veligers to 40-50 microns - Will likely require a shelter for chemical storage/equipment (land purchase/easement) - Requires backwash discharge to lake - May require booster pump - No rental/portable options - Very expensive
Filtration System (Portable Bag Filter (Rain for Rent))	***Yes***	***No***	- Filtration to 25 microns - Rental/portable options (on skid) - Moderate Cost - most affordable filtration option - May require additional easement - Piping would need to be modified to accommodate temporary filtration - contractor installation - Not automated - need daily check and maintenance while in operation - May require booster pump
Chemical Treatment of Discharge (EarthtecQZ , Zequenox)	Yes (if contact time achieved)	No	- Both permitted for use by WiDNR - primarily for in-lake application, limits on dosing/addition of copper - May require a building for chemical storage and dosing equipment (land purchase/easement) - Requires significant contact time (8 hrs to 5 days) to achieve mortality (Zequenox does not achieve 100% mortality). Retention pond required for contact time (0.5 acres - 10.0 acres) (land purchase or easement) - Will likely require intensive monitoring during pumping - Very expensive

Feasibility Option	Meets Net Zero Transfer of Zebra Mussel (Veligers) Requirement	Meets Water Quality Discharge Requirement	Considerations
UV Treatment of Discharge	Yes (if contact time achieved)	No	- Requires high intensity/dosing to achieve mortality and 12 to 72 hour contact time - Retention/reactor required for contact time (land purchase/easement) - Very expensive - UV Effectiveness contingent on incoming water turbidity/solids - Veligers not killed instantly, but died within a few days - UV used on discharge pipes at dams with high dose/shorter contact times are used to prevent settlement/colonization of veligers on pump intake and equipment (but not necessarily about veliger mortality)
Infiltration of Discharge	***Yes***	***Yes***	- Requires purchase of land, ideally south of the existing forcemain and may require modifications to forcemain - Passive system - Beyond pump (intake screen), does not require new equipment - Expensive
Seasonal Pumping (November - April)	***Yes***	***Yes***	- May require a monitoring plan: Feb 2018 verified veligers not present and TP levels are very low in both the epilimnion and hypolimnion (<10 ug/L) - Passive system - Beyond pump (intake screen), does not require new equipment - Most affordable option
Groundwater - Shoreline Drain Tile System	***Yes***	***Yes***	- Increased pumping rate to achieve the same level of drawdown - Installation of shoreline draintile system - requires multiple easements, construction challenges - Likely requires a new pump, may be able to utilize existing forcemain - Passive system - Beyond pump, does not require new equipment - Expensive
Alum Treatment of Discharge	No	Yes	- Requires a building for chemical storage and dosing equipment (land purchase/easement) - Requires retention pond required for settling floc (0.5 acres) (land purchase or easement) - may need secondary pump for discharge depending on location - Will likely require intensive monitoring during operation - Floc removal from pond more intensive as no ability to connect to sanitary sewer - Very expensive
Water Quality Trading	No	Yes	- Need to find partners through a brokerage service - Complicated & Potentially Expensive - Annual reporting

Appendix F

Feasibility Level Opinions of Probable Cost

PREPARED BY: BARR ENGINEERING COMPANY		SHEET:	1	OF	1
		BY:	SC2	DATE:	4/26/2018
FEASIBILITY STUDY		CHECKED BY:	JAK2	DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST		APPROVED BY:		DATE:	
PROJECT:	Bass Lake Drawdown Feasibility Study	ISSUED:		DATE:	
LOCATION:	Town of St. Joseph	ISSUED:		DATE:	
PROJECT #:	49/56-1011	ISSUED:		DATE:	
OPINION OF COST - SUMMARY		ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
2018 Monitoring

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	Unit Cost	ITEM COST	NOTES
1	Equipment Purchase (Pump, Tubing, Plankton Net, Other Misc Supplies)	LS	1	$800.00	$800.00	1,2,3,4,5
2	Lab Costs (12 samples events, 24 samples, May-November) - Total Phosphorus	ea	24	$30.00	$720.00	1,2,3,4,5
3	Lab Costs (12 samples events, 12 samples, May-November) - Zebra Mussel Veligers	ea	12	$90.00	$1,080.00	1,2,3,4,5
4	Lab Costs (12 samples events, 12 samples, May-November) - Zebra Mussel Young of Year and Sizing	ea	12	$90.00	$1,080.00	1,2,3,4,5
5	Sample Collection Training	hr	6	$100.00	$600.00	1,2,3,4,5
	MONITORING SUBTOTAL				$4,300.00	
	CONTINGENCY (30%)				$1,300.00	
	ESTIMATED MONITORING COST				$5,600.00	

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] Assume sampling by BLRD residents
[5] Estimate costs are reported to nearest hundred dollars.

PREPARED BY: BARR ENGINEERING COMPANY

SHEET:	1	OF	1
BY:	KAD	DATE:	4/23/2018
CHECKED BY:	JAK2	DATE:	4/26/2018
APPROVED BY:		DATE:	
ISSUED:		DATE:	
ISSUED:		DATE:	
ISSUED:		DATE:	
ISSUED:		DATE:	

FEASIBILITY STUDY

ENGINEER'S OPINION OF PROBABLE PROJECT COST

PROJECT: Bass Lake Drawdown Feasibility Study

LOCATION: Town of St. Joseph

PROJECT #: 49/56-1011

OPINION OF COST - SUMMARY

Engineer's Opinion of Probable Project Cost

Bass Lake Drawdown Feasibility Study

Pump Rebuild/Intake Modification (Option A)

	Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	Unit Cost	ITEM COST	NOTES
	1	Pump rebuild	LS	1	$ 7,800.00	$ 7,800.00	1,2,4
	2	Chemical Treatment of Intake Pipe - EarthTecZQ	LS	1	$ 3,000.00	$3,000.00	1,2,4
Marine Construction Estimate	3	Barge Rental	Days	6	$ 1,600.00	$9,600.00	1,2,3,4
	4	Trucking	Days	1	$ 3,000.00	$3,000.00	1,2,3,4
	5	Dive Boat	Days	5	$ 475.00	$2,375.00	1,2,3,4
	6	Hydraulic Power Unit	Days	5	$ 250.00	$1,250.00	1,2,3,4
	7	Hydraulic Chainsaw	Days	5	$ 150.00	$750.00	1,2,3,4
	8	2018 three person team	Hrs	40	$ 415.00	$16,600.00	1,2,3,4
	9	2018 three person team - OT	Hrs	10	$ 540.00	$5,400.00	1,2,3,4
	10	Crane rental	Hrs	20	$ 450.00	$9,000.00	1,2,3,4
	11	Intake Screen Stand/Support	EA	1	$ 25,000.00	$25,000.00	1,2,4
	12	24" HDPE	LF	60	$60.00	$3,600.00	1,2,4
	13	Johnson T-18HCE Intake Screen	EA	1	$19,200.00	$19,200.00	1,2,4
	14	Johnson Hydroburst System	EA	1	$39,000.00	$39,000.00	1,2,4
	15	2" Hydroburst air line	LF	660	$10.00	$6,600.00	1,2,4
	16	Johnson Field Service	EA	1	$4,500.00	$4,500.00	1,2,4
	17	Controls/Electrical Connection (Hydroburst) to Existing Panel	EA	1	$25,000.00	$25,000.00	1,2,4
	18	Intake Screen Cover	EA	1	$5,000.00	$5,000.00	1,2,4
		CONSTRUCTION SUBTOTAL				$187,000.00	

Notes

[1] Unit Prices Based on Information Available at This Time, including quotes from vendors

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

[3] Estimate from Viking Marine Service includes modification for removing slotted HDPE intake pipe and replacing with solid.

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

PREPARED BY: BARR ENGINEERING COMPANY	SHEET:	1	OF	1
	BY:	KAD	DATE:	4/23/2018
FEASIBILITY STUDY	CHECKED BY:	JAK2	DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:		DATE:	
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED:		DATE:	
LOCATION: Town of St. Joseph	ISSUED:		DATE:	
PROJECT #: 49/56-1011	ISSUED:		DATE:	
OPINION OF COST - SUMMARY	ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Pump Rebuild/Intake Modification (Option B)

	Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	Unit Cost	ITEM COST	NOTES
	1	Pump rebuild	LS	1	$ 7,800.00	$ 7,800.00	1,2,4
	2	Chemical Treatment of Intake Pipe - EarthTecZQ	LS	1	$ 3,000.00	$3,000.00	1,2,4
Marine Construction Estimate	3	Barge Rental	Days	6	$ 1,600.00	$9,600.00	1,2,3,4
	4	Trucking	Days	1	$ 3,000.00	$3,000.00	1,2,3,4
	5	Dive Boat	Days	5	$ 475.00	$2,375.00	1,2,3,4
	6	Hydraulic Power Unit	Days	5	$ 250.00	$1,250.00	1,2,3,4
	7	Hydraulic Chainsaw	Days	5	$ 150.00	$750.00	1,2,3,4
	8	2018 three person team	Hrs	40	$ 415.00	$16,600.00	1,2,3,4
	9	2018 three person team - OT	Hrs	10	$ 540.00	$5,400.00	1,2,3,4
	10	Crane rental	Hrs	20	$ 450.00	$9,000.00	1,2,3,4
	11	Intake Screen Stand/Support	EA	1	$ 35,000.00	$35,000.00	1,2,4
	12	24" HDPE	LF	60	$60.00	$3,600.00	1,2,4
	13	Johnson T-18HCE Intake Screen	EA	1	$58,400.00	$58,400.00	1,2,4
	14	Johnson Hydroburst System	EA	1	$65,000.00	$65,000.00	1,2,4
	15	4" Hydroburst air line	LF	660	$15.00	$9,900.00	1,2,4
	16	Johnson Field Service	EA	1	$4,500.00	$4,500.00	1,2,4
	17	Controls/Electrical Connection (Hydroburst) to Existing Panel	EA	1	$25,000.00	$25,000.00	1,2,4
	18	Intake Screen Cover	EA	1	$5,000.00	$5,000.00	1,2,4
		CONSTRUCTION SUBTOTAL				$265,000.00	

Notes

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

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

[3] Estimate from Viking Marine Service includes modification for removing slotted HDPE intake pipe and replacing with solid.

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

BARR	PREPARED BY: BARR ENGINEERING COMPANY	SHEET:	1	OF	1
		BY:	KAD	DATE:	4/23/2018
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LOCATION:	Town of St. Joseph	ISSUED:		DATE:	
PROJECT #:	49/56-1011	ISSUED:		DATE:	
OPINION OF COST - SUMMARY		ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 1a: Intake Modification and Infiltration - Englehart

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
1	Mobilization/Demobilization (10%)	LS	1	$119,053.00	$119,053.00	1,2,3,4,7,8
2	Intake Modification and Pump Rebuild	LS	1	$187,000.00	$187,000.00	1,2,3,4,7,8
3	Manual Valve (18" HDPE)	Ea	2	$3,750.00	$7,500.00	1,2,3,4,7,8
4	18" HDPE Forcemain - Installed	LF	1,000	$60.00	$60,000.00	1,2,3,4,7,8
5	Excavation/Disposal	CY	22,234	$15.00	$333,510.00	1,2,3,4,5,6,7,8
6	Import clean sand for soil correction area	CY	12,438	$40.00	$497,520.00	1,2,3,4,7,8
7	Inlet Structure	Ea	1	$15,000.00	$15,000.00	1,2,3,4,7,8
8	Flow Distribution System (12" HDPE Perforated Heade	LF	1,200	$60.00	$72,000.00	1,2,3,4,7,8
9	Restoration	Ac	6	$3,000.00	$18,000.00	1,2,3,4,7,8
	CONSTRUCTION SUBTOTAL				$1,310,000.00	
	CONSTRUCTION CONTINGENCY (30%)				$393,000.00	
	ESTIMATED CONSTRUCTION COST				$1,703,000.00	
	PLANNING, ENGINEERING & DESIGN (30%)				$511,000.00	
	LAND PURCHASE (6.0 acres)	acre	6	$15,000.00	$90,000.00	
	ESTIMATED TOTAL PROJECT COST				$2,304,000.00	
	ESTIMATED ACCURACY RANGE	**-20%**			**$1,844,000.00**	
		50%			**$3,456,000.00**	

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] 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 +50%. 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.

[5] Assumes excavated volume can be used as required fill onsite

[6] Estimate assumes that projects will not be located on contaminated soil.

[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.

PREPARED BY: BARR ENGINEERING COMPANY	SHEET:	1	OF		1
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FEASIBILITY STUDY	CHECKED BY:	JAK2		DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:			DATE:	
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED:			DATE:	
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PROJECT #: 49/56-1011	ISSUED:			DATE:	
OPINION OF COST - SUMMARY	ISSUED:			DATE:	

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 1b: Intake Modification and Infiltration - Orl

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
1	Mobilization/Demobilization (10%)	LS	1	$95,015.60	$95,015.60	1,2,3,4,7,8
2	Intake Modification and Pump Rebuild	LS	1	$187,000.00	$187,000.00	1,2,3,4,7,8
3	Manual Valve (18" HDPE)	Ea	2	$3,750.00	$7,500.00	1,2,3,4,7,8
4	18" HDPE Forcemain - Installed	LF	200	$60.00	$12,000.00	1,2,3,4,7,8
5	Excavation/Disposal	CY	37,918	$12.00	$455,016.00	1,2,3,4,5,6,7,8
6	Import clean sand for soil correction area	CY	4,591	$40.00	$183,640.00	1,2,3,4,7,8
7	Inlet Structure	Ea	1	$15,000.00	$15,000.00	1,2,3,4,7,8
8	Distribution System (12" HDPE Perforated Header)	LF	1,200	$60.00	$72,000.00	1,2,3,4,7,8
9	Restoration	Ac	6	$3,000.00	$18,000.00	1,2,3,4,7,8
	CONSTRUCTION SUBTOTAL				$1,045,000.00	
	CONSTRUCTION CONTINGENCY (30%)				$314,000.00	
	ESTIMATED CONSTRUCTION COST				$1,359,000.00	
	PLANNING, ENGINEERING & DESIGN (30%)				$408,000.00	
	LAND PURCHASE (6.0 acres)	acre	6	$15,000.00	$90,000.00	
	ESTIMATED TOTAL PROJECT COST				$1,857,000.00	
	ESTIMATED ACCURACY RANGE	**-20%**			**$1,486,000.00**	
		50%			**$2,786,000.00**	

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. 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 +50%. 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.
5. Assumes excavated volume can be used as required fill onsite
6. Estimate assumes that projects will not be located on contaminated soil.
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.

PREPARED BY: BARR ENGINEERING COMPANY	SHEET:	1	OF	1
	BY:	KAD	DATE:	4/23/2018
FEASIBILITY STUDY	CHECKED BY:	JAK2	DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:		DATE:	
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED:		DATE:	
LOCATION: Town of St. Joseph	ISSUED:		DATE:	
PROJECT #: 49/56-1011	ISSUED:		DATE:	
OPINION OF COST - SUMMARY	ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 1: Intake Modification and Infiltration - Operation and Maintenance (Annual)

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
1	Intake Screen Cover Removal/System Prep	hr	8	$415.00	$3,320.00	1,2,3,4,5
2	Intake Screen Cover Replacement/System Shutdown	hr	8	$415.00	$3,320.00	1,2,3,4,5
3	Annual Electrical Service	LS	1	$144.00	$144.00	1,2,3,4,5
4	Electrical cost (HydroBurst)	kWH	1,045	$0.0358	$37.36	1,2,3,4,5
5	Electrical cost (Pump Operation)	kWH	38,435	$0.0358	$1,374.05	1,2,3,4,5
6	Inspection and Maintenance of Basin	hr	16	$100.00	$1,600.00	1,2,3,4,5
	O&M SUBTOTAL				$9,800.00	
	O&M CONTINGENCY (30%)				$2,900.00	
	ESTIMATED O&M COST				$12,700.00	

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] Assume pump operates 8 hours per day and burst sent every hour of pump operates (Compressor runs 2 hrs/day); 5 months of operation; all off-peak operation
[5] Estimate costs are reported to nearest hundred dollars.

PREPARED BY: BARR ENGINEERING COMPANY	SHEET: 1	OF 1
BARR	BY: KAD	DATE: 4/23/2018
FEASIBILITY STUDY	CHECKED BY: JAK2	DATE: 4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:	DATE:
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED:	DATE:
LOCATION: Town of St. Joseph	ISSUED:	DATE:
PROJECT #: 49/56-1011	ISSUED:	DATE:
OPINION OF COST - SUMMARY	ISSUED:	DATE:

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 2a: Intake Modification (Option A) and Seasonal Pumping

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	Unit Cost	ITEM COST	NOTES
1	Mobilization/Demobilization (10%)	LS	1	$18,700.00	$18,700.00	1,2,3,4,5,6
2	Intake Modification and Pump Rebuild	LS	1	$187,000.00	$187,000.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$206,000.00	
	CONSTRUCTION CONTINGENCY (30%)				$62,000.00	
	ESTIMATED CONSTRUCTION COST				$268,000.00	
	PLANNING, ENGINEERING & DESIGN (30%)				$80,000.00	
	ESTIMATED TOTAL PROJECT COST				$348,000.00	
	ESTIMATED ACCURACY RANGE	**-20%**			**$279,000.00**	
		50%			**$522,000.00**	

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] 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 +50%. 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.

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

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

PREPARED BY: BARR ENGINEERING COMPANY	SHEET: 1	OF	1
BARR	BY: KAD	DATE:	4/23/2018
FEASIBILITY STUDY	CHECKED BY: JAK2	DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:	DATE:	
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED:	DATE:	
LOCATION: Town of St. Joseph	ISSUED:	DATE:	
PROJECT #: 49/56-1011	ISSUED:	DATE:	
OPINION OF COST - SUMMARY	ISSUED:	DATE:	

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 2b: Intake Modification (Option B) and Seasonal Pumping

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	Unit Cost	ITEM COST	NOTES
1	Mobilization/Demobilization (10%)	LS	1	$26,500.00	$26,500.00	1,2,3,4,5,6
2	Intake Modification and Pump Rebuild	LS	1	$265,000.00	$265,000.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$292,000.00	
	CONSTRUCTION CONTINGENCY (30%)				$88,000.00	
	ESTIMATED CONSTRUCTION COST				$380,000.00	
	PLANNING, ENGINEERING & DESIGN (30%)				$114,000.00	
	ESTIMATED TOTAL PROJECT COST				$494,000.00	
	ESTIMATED ACCURACY RANGE	**-20%**			**$396,000.00**	
		50%			**$741,000.00**	

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] 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 +50%. 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.

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

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

PREPARED BY: BARR ENGINEERING COMPANY	SHEET: 1	OF 1
	BY: KAD	DATE: 4/23/2018
FEASIBILITY STUDY	CHECKED BY: JAK2	DATE: 4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:	DATE:
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED:	DATE:
LOCATION: Town of St. Joseph	ISSUED:	DATE:
PROJECT #: 49/56-1011	ISSUED:	DATE:
OPINION OF COST - SUMMARY	ISSUED:	DATE:

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 2a: Intake Modification and Seasonal Pumping - Operation and Maintenance (Annual)

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
1	Intake Screen Cover Removal/System Prep	hr	8	$415.00	$3,320.00	1,2,3,4,5,6
2	Intake Screen Cover Replacement/System Shutdown	hr	8	$415.00	$3,320.00	1,2,3,4,5,6
3	Annual Electrical Service	LS	1	$144.00	$144.00	1,2,3,4,5,6
4	Electrical cost (HydroBurst)	kWH	1045	0.03575	$37.36	1,2,3,4,5,6
5	Electrical cost (Pump Operation)	kWH	38435	0.03575	$1,374.05	1,2,3,4,5,6
6	Chemical Treatment of Intake Pipe - EarthTecZQ	LS	1	$ 3,000.00	$3,000.00	1,2,3,4,5,6
7	Lab Costs - Total Phosphorus (Hypolimnion)	ea	6	$30.00	$180.00	1,2,3,4,5,6
8	Lab Costs (6 samples) - Zebra Mussel Sizing (hypolimnion)	ea	6	$90.00	$540.00	1,2,3,4,5,6
	O&M SUBTOTAL				$12,000.00	
	O&M CONTINGENCY (30%)				$3,600.00	
	ESTIMATED O&M COST				$15,600.00	

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] Assume pump operates 8 hours per day and burst sent every hour of pump operates (Compressor runs 2 hrs/day); 5 months of operation; all off-peak operation

[5] Assume monthly sampling events for Total phopshorus and veligers for 6 months (1 prior to pump operation, 5 during pump operation) by BLRD residents; Reporting to WDNR by BLRD residents

[6] Estimate costs are reported to nearest hundred dollars.

PREPARED BY: BARR ENGINEERING COMPANY	SHEET:	1	OF	1
BARR	BY:	KAD	DATE:	4/23/2018
FEASIBILITY STUDY	CHECKED BY:	JAK2	DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:		DATE:	
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED:		DATE:	
LOCATION: Town of St. Joseph	ISSUED:		DATE:	
PROJECT #: 49/56-1011	ISSUED:		DATE:	
OPINION OF COST - SUMMARY	ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 2b: Intake Modification and Seasonal Pumping - Operation and Maintenance (Annual)

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
1	Intake Screen Cover Removal/System Prep	hr	8	$415.00	$3,320.00	1,2,3,4,5,6
2	Intake Screen Cover Replacement/System Shutdown	hr	8	$415.00	$3,320.00	1,2,3,4,5,6
3	Annual Electrical Service	LS	1	$144.00	$144.00	1,2,3,4,5,6
4	Electrical cost (HydroBurst)	kWH	4180	0.03575	$149.44	1,2,3,4,5,6
5	Electrical cost (Pump Operation)	kWH	38435	0.03575	$1,374.05	1,2,3,4,5,6
6	Chemical Treatment of Intake Pipe - EarthTecZQ	LS	1	$ 3,000.00	$3,000.00	1,2,3,4,5,6
7	Lab Costs - Total Phosphorus (Hypolimnion)	ea	6	$30.00	$180.00	1,2,3,4,5,6
8	Lab Costs (6 samples) - Zebra Mussel Sizing (hypolimnion)	ea	6	$90.00	$540.00	1,2,3,4,5,6
	O&M SUBTOTAL				$12,100.00	
	O&M CONTINGENCY (30%)				$3,600.00	
	ESTIMATED O&M COST				$15,700.00	

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] Assume pump operates 8 hours per day and burst sent every hour of pump operates (Compressor runs 2 hrs/day); 5 months of operation; all off-peak operation
[5] Assume monthly sampling events for Total phopshorus and veligers for 6 months (1 prior to pump operation, 5 during pump operation) by BLRD residents; Reporting to WDNR by BLRD residents
[6] Estimate costs are reported to nearest hundred dollars.

PREPARED BY: BARR ENGINEERING COMPANY		SHEET:	1	OF	1
		BY:	KAD	DATE:	4/23/2018
FEASIBILITY STUDY		CHECKED BY:	JAK2	DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST		APPROVED BY:		DATE:	
PROJECT:	Bass Lake Drawdown Feasibility Study	ISSUED:		DATE:	
LOCATION:	Town of St. Joseph	ISSUED:		DATE:	
PROJECT #:	49/56-1011	ISSUED:		DATE:	
OPINION OF COST - SUMMARY		ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 3a: Intake Screen, Filtration (AMIAD), and Seasonal Pumping

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	Unit Cost	ITEM COST	NOTES
1	Mobilization/Demobilization (10%)	LS	1	$59,369.92	$59,369.92	1,2,3,4,5,6
2	Intake Modification and Pump Rebuild	LS	1	$187,000.00	$187,000.00	1,2,3,4,5,6
3	Permanent Building Installation - 20' x 14' & Foundation	SF	280	$400.00	$112,000.00	1,2,3,4,5,6
4	Building Heater Installed	Each	1	$5,500.00	$5,500.00	1,2,3,4,5,6
5	18" Butterfly valves installed	Each	3	$3,750.00	$11,250.00	1,2,3,4,5,6
6	18" Flange	Each	2	$3,000.00	$6,000.00	1,2,3,4,5,6
7	18" HDPE Pipe installed	LF	40	$60.00	$2,400.00	1,2,3,4,5,6
8	Pipe Heat Trace	LS	1	$1,800.00	$1,800.00	1,2,3,4,5,6
9	AMIAD Omega 54000 filter - Installed	Each	1	$237,749.16	$237,749.16	1,2,3,4,5,6
10	6" Filter Flush line - Routed back to lake	LF	200	$25.00	$5,000.00	1,2,3,4,5,6
11	Controls/Electrical Connection to Existing Panel	LS	1	$25,000.00	$25,000.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$653,000.00	
	CONSTRUCTION CONTINGENCY (30%)				$196,000.00	
	ESTIMATED CONSTRUCTION COST				$849,000.00	
	PLANNING, ENGINEERING & DESIGN (30%)				$255,000.00	
	LAND EASEMENT	SF	280	$6.00	$1,680.00	
	ESTIMATED TOTAL PROJECT COST				$1,106,000.00	
	ESTIMATED ACCURACY RANGE	**-20%**			**$885,000.00**	
		50%			**$1,659,000.00**	

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] 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 +50%. 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.

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

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

PREPARED BY: BARR ENGINEERING COMPANY		SHEET:	1	OF	1
		BY:	KAD	DATE:	4/23/2018
FEASIBILITY STUDY		CHECKED BY:	JAK2	DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST		APPROVED BY:		DATE:	
PROJECT:	Bass Lake Drawdown Feasibility Study	ISSUED:		DATE:	
LOCATION:	Town of St. Joseph	ISSUED:		DATE:	
PROJECT #:	49/56-1011	ISSUED:		DATE:	
OPINION OF COST - SUMMARY		ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost

Bass Lake Drawdown Feasibility Study

Option 3a: Intake Screen, Filtration (Amiad), and Seasonal Pumping - Operation and Maintenance (Annual)

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
1	Intake Screen Cover Removal/System Prep	hr	8	$415.00	$3,320.00	1,2,3,4,5,6
2	Intake Screen Cover Replacement/System Shutdown	hr	8	$415.00	$3,320.00	1,2,3,4,5,6
3	Annual Electrical Service	LS	1	$144.00	$144.00	1,2,3,4,5,6
4	Electrical cost (HydroBurst)	kWH	1045	$0.036	$37.36	1,2,3,4,5,6
5	Electrical cost (Pump Operation)	kWH	38435	$0.036	$1,374.05	1,2,3,4,5,6
6	Electrical cost (Heat Trace and Building Heater) - OnPeak	kWH	4113	$0.135	$555.30	1,2,3,4,5,6
7	Electrical cost (Heat Trace and Building Heater) - OffPeak	kWH	2057	$0.036	$73.53	1,2,3,4,5,6
8	Lab Costs - Total Phosphorus (Hypolimnion)	ea	6	$30.00	$180.00	1,2,3,4,5,6
9	Filtration System Prep and Shutdown	hr	16	$100.00	$1,600.00	1,2,3,4,5,6
	O&M SUBTOTAL				$10,700.00	
	O&M CONTINGENCY (30%)				$3,300.00	
	ESTIMATED O&M COST				$14,000.00	

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] Assume pump operates 8 hours per day and burst sent every hour of pump operates (Compressor runs 2 hrs/day); 5 months of operation; all off-peak operation

[5] Assume monthly sampling events for Total phopshorus and veligers for 6 months (1 prior to pump operation, 5 during pump operation) by BLRD residents; Reporting to WDNR by BLRD residents

[6] Estimate costs are reported to nearest hundred dollars.

PREPARED BY: BARR ENGINEERING COMPANY	SHEET: 1 OF 1
BARR	BY: KAD DATE: 4/23/2018
FEASIBILITY STUDY	CHECKED BY: JAK2 DATE: 4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY: DATE:
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED: DATE:
LOCATION: Town of St. Joseph	ISSUED: DATE:
PROJECT #: 49/56-1011	ISSUED: DATE:
OPINION OF COST - SUMMARY	ISSUED: DATE:

Engineer's Opinion of Probable Project Cost
Bass Lake Drawdown Feasibility Study
Option 3b: Intake Screen, Filtration (Rain for Rent), and Seasonal Pumping

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	Unit Cost	ITEM COST	NOTES
1	Mobilization/Demobilization (10%)	LS	1	$48,535.00	$48,535.00	1,2,3,4,5,6
2	Intake Modification and Pump Rebuild	LS	1	$187,000.00	$187,000.00	1,2,3,4,5,6
3	Permanent Building Installation - 22' x 28' & Foundation	SF	616	$400.00	$246,400.00	1,2,3,4,5,6
4	Building Heater Installed	Each	1	$5,500.00	$5,500.00	1,2,3,4,5,6
5	18" Butterfly valves installed	Each	3	$3,750.00	$11,250.00	1,2,3,4,5,6
6	18" Flange	Each	2	$3,000.00	$6,000.00	1,2,3,4,5,6
7	18" HDPE Pipe installed	LF	40	$60.00	$2,400.00	1,2,3,4,5,6
8	Pipe Heat Trace	LS	1	$1,800.00	$1,800.00	1,2,3,4,5,6
9	Controls/Electrical Connection to Existing Panel	LS	1	$25,000.00	$25,000.00	1,2,3,4,5,6
	CONSTRUCTION SUBTOTAL				$534,000.00	
	CONSTRUCTION CONTINGENCY (30%)				$160,000.00	
	ESTIMATED CONSTRUCTION COST				$694,000.00	
	PLANNING, ENGINEERING & DESIGN (30%)				$208,000.00	
	LAND EASEMENT	SF	616	$6.00	$3,696.00	
	ESTIMATED TOTAL PROJECT COST				$906,000.00	
	ESTIMATED ACCURACY RANGE	**-20%**			**$725,000.00**	
		50%			**$1,359,000.00**	

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] 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 +50%. 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.

[5] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction. Does NOT include seasonal rental of filtration equipment/booster pump.

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

PREPARED BY: BARR ENGINEERING COMPANY	SHEET:	1	OF	1
BARR	BY:	KAD	DATE:	4/23/2018
FEASIBILITY STUDY	CHECKED BY:	JAK2	DATE:	4/26/2018
ENGINEER'S OPINION OF PROBABLE PROJECT COST	APPROVED BY:		DATE:	
PROJECT: Bass Lake Drawdown Feasibility Study	ISSUED:		DATE:	
LOCATION: Town of St. Joseph	ISSUED:		DATE:	
PROJECT #: 49/56-1011	ISSUED:		DATE:	
OPINION OF COST - SUMMARY	ISSUED:		DATE:	

Engineer's Opinion of Probable Project Cost

Bass Lake Drawdown Feasibility Study

Option 3b: Intake Screen, Filtration (Rain for Rent), and Seasonal Pumping - Operation and Maintenance (Annual)

Cat. No.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST	NOTES
1	Intake Screen Cover Removal/System Prep	hr	8	$415.00	$3,320.00	1,2,3,4,5,6
2	Intake Screen Cover Replacement/System Shutdown	hr	8	$415.00	$3,320.00	1,2,3,4,5,6
3	Annual Electrical Service	LS	1	$144.00	$144.00	1,2,3,4,5,6
4	Electrical cost (HydroBurst)	kWH	1045	$0.036	$37.36	1,2,3,4,5,6
5	Electrical cost (Pump Operation)	kWH	38435	$0.036	$1,374.05	1,2,3,4,5,6
6	Electrical cost (Heat Trace and Building Heater) - OnPeak	kWH	4113	$0.135	$555.30	1,2,3,4,5,6
7	Electrical cost (Heat Trace and Building Heater) - OffPeak	kWH	2057	$0.036	$73.53	1,2,3,4,5,6
8	Electrical cost (Booster Pump Operation)	kWH	39270	$0.036	$1,403.90	1,2,3,4,5,6
9	Lab Costs - Total Phosphorus (Hypolimnion)	ea	6	$30.00	$180.00	1,2,3,4,5,6
10	Bag Filter BF200 ASME from - Rain for Rent (5 month rental)	Each	2	$14,899.50	$29,799.00	1,2,3,4,5,6
11	Pump Trash 6" DV150 Electric - Rain for Rent (5 month rental)	Each	1	$10,741.50	$10,741.50	1,2,3,4,5,6
12	Wire electrical Connection (trash pump/booster pump) to Existing Panel	Each	1	$4,000.00	$4,000.00	1,2,3,4,5,6
13	Unwire electrical Connection (trash pump/booster pump) to Existing Panel	Each	1	$4,000.00	$4,000.00	1,2,3,4,5,6
14	Hose 6"x20' HD Tank Truck Flanged 200# - Rain for Rent	Each	4	$1,501.50	$6,006.00	1,2,3,4,5,6
15	Filter Bag 25 Micron - Rain for Rent	50 Pack	100	$8.26	$826.00	1,2,3,4,5,6
16	Est. Devlivery Hauling - Rain for Rent	Each	1	$2,628.85	$2,628.85	1,2,3,4,5,6
17	Est. Pick-up Hauling - Rain for Rent	Each	1	$2,628.85	$2,628.85	1,2,3,4,5,6
18	Est. Install Labor	Each	1	$1,080.00	$1,080.00	1,2,3,4,5,6
19	Est. Removal Labor	Each	1	$1,080.00	$1,080.00	1,2,3,4,5,6
	O&M SUBTOTAL				$73,200.00	
	O&M CONTINGENCY (30%)				$22,000.00	
	ESTIMATED O&M COST				$95,200.00	

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] Assume pump operates 8 hours per day and burst sent every hour of pump operates (Compressor runs 2 hrs/day); 5 months of operation; all off-peak operation; Assumes daily replacementof bag filters in each unit (Each filter holds 16 bags) for 5 month operating period.

[5] Assume monthly sampling events for Total phopshorus and veligers for 6 months (1 prior to pump operation, 5 during pump operation) by BLRD residents; Reporting to WDNR by BLRD residents

[6] Estimate costs are reported to nearest hundred dollars.

Appendix G

American Engineering and Testing (AET) Soil Borings (April 2018)

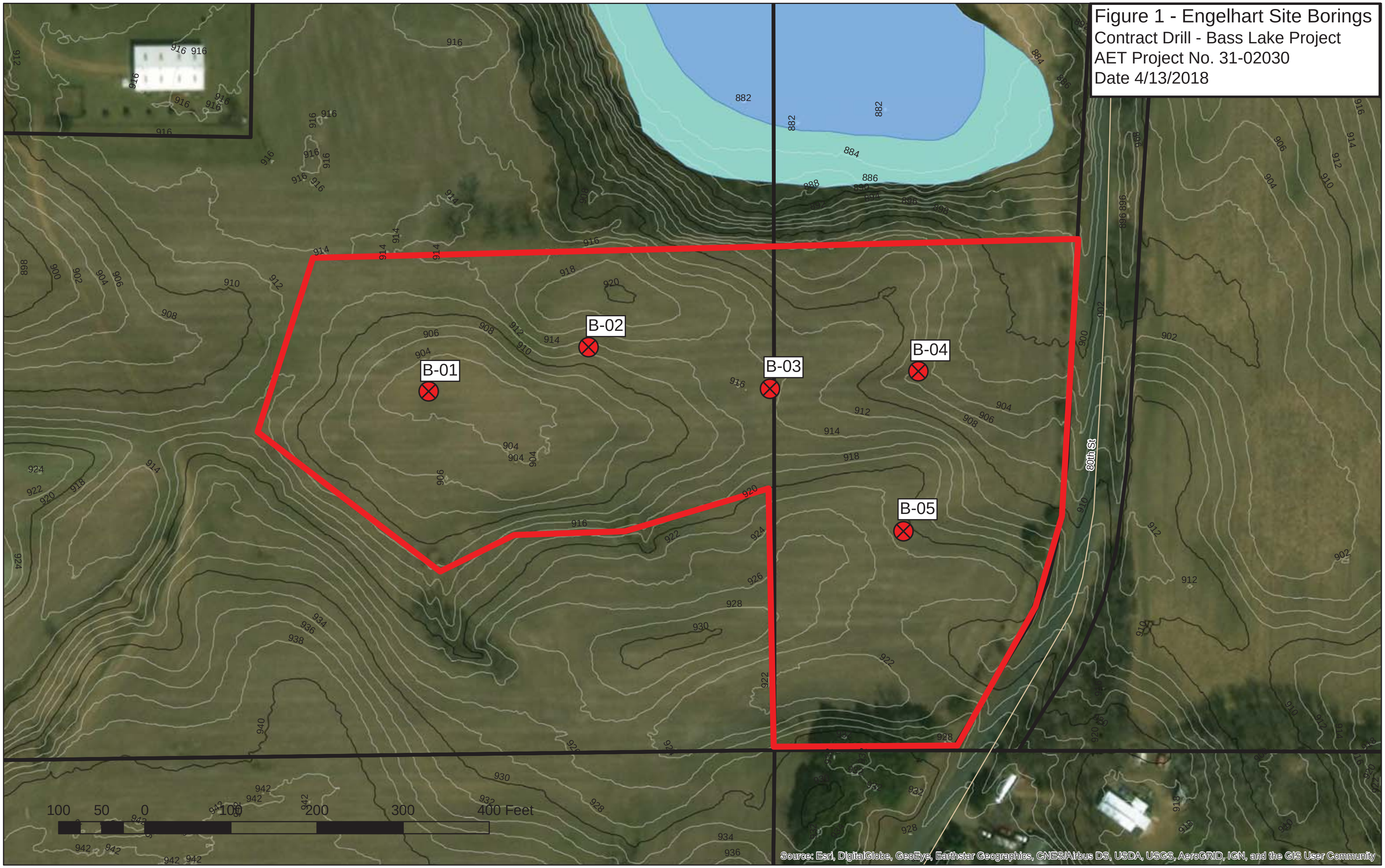


Figure 1 - Engelhart Site Borings
Contract Drill - Bass Lake Project
AET Project No. 31-02030
Date 4/13/2018

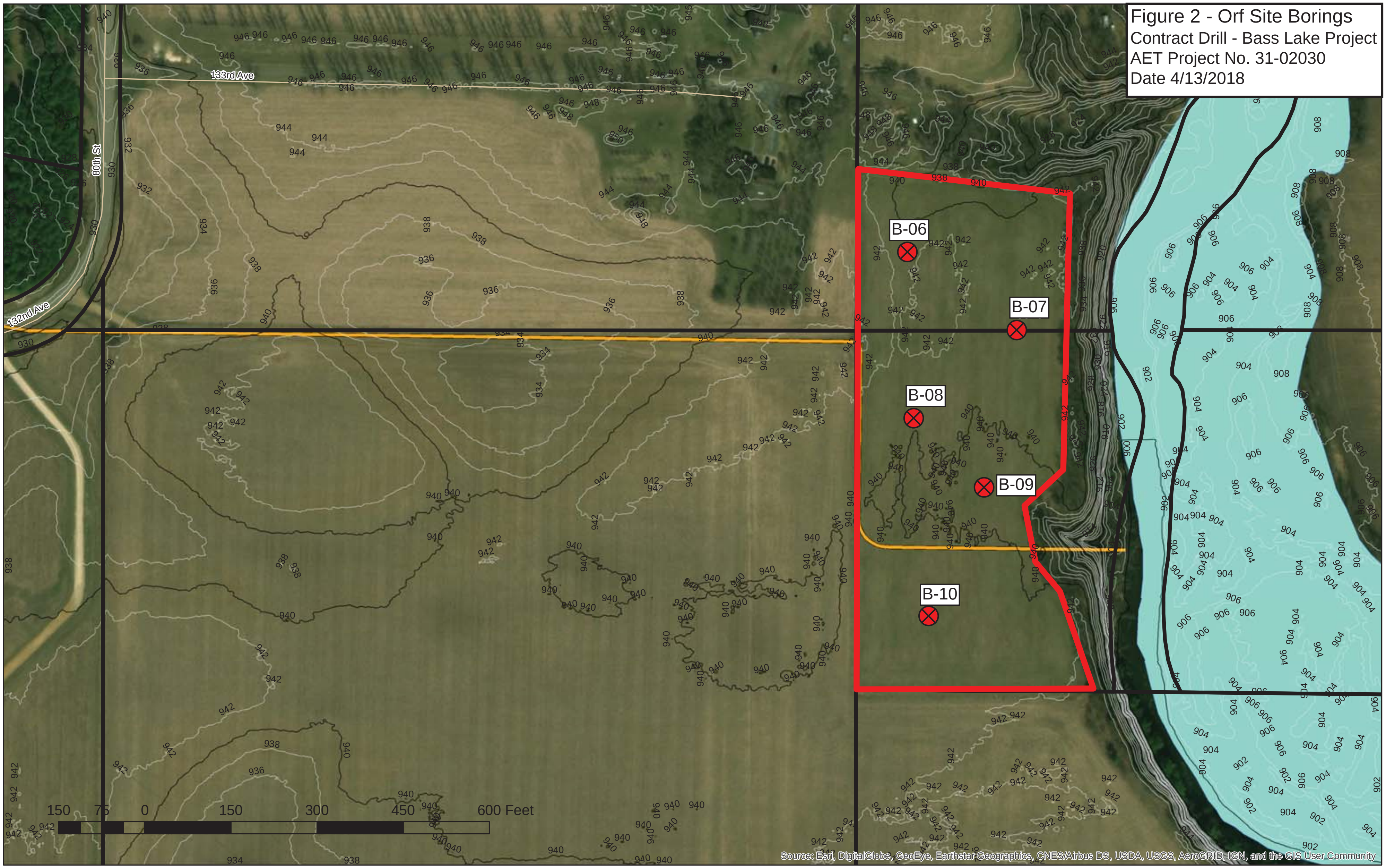


Figure 2 - Orf Site Borings
Contract Drill - Bass Lake Project
AET Project No. 31-02030
Date 4/13/2018
133rd Ave
80th St
132nd Ave
B-06
B-07
B-08
B-09
B-10
150 75 0 150 300 450 600 Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-01 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

DEPTH IN FEET	ELEV. FEET	Surface Elevation 903.5 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS WC	qp	LL	PL	%-#200
1	902.0	Sandy LEAN CLAY, dark brown, frozen, with trace roots (CL)	FINE ALLUVIUM		F/M	SS	20					
2–4	899.5	SILTY SAND, fine to coarse grained, a little gravel, dark brown, moist, loose (SM)	COARSE ALLUVIUM	10	M	SS	7					
4–6	897.5	SAND, fine to coarse grained, a little gravel, brown, moist, loose (SP)		6	M	SS	12					
6–8	895.5	SAND, fine to medium grained, a little gravel, brown, moist, very loose (SP)		3	M	SS	16					
8–14	889.5	Gravelly SAND, fine to medium grained, brown, moist, loose (SP)		6	M	SS	7	4				2
				8	M	SS	6					
				9	M	SS	3					
14–18	885.5	Gravelly SAND, fine to coarse grained, brown, moist, loose (SP)		10	M	SS	9					
				9	M	SS	13					
18–20	883.5	SAND, fine to medium grained, a little gravel, brown, moist, loose (SP)		8	M	SS	12					
20–24	879.5	SILTY GRAVEL with sand, dark brown, moist to waterbearing, very loose to loose (GM)		5	M	SS	13					
				3	W	SS	6					
24–26	877.5	SAND, fine to medium grained, brown, waterbearing, loose (SP)		5	W	SS	16					
26		*End of boring at 26.0 feet*										

DEPTH:	DRILLING METHOD
0-24.0'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
4/5/18	1450	26.0	24.0	23.6	None	22.2
4/5/18	1520	26.0	24.0	23.6	None	22.1

BORING COMPLETED: **4/5/18**

DR: **MH** LG: **GM** Rig: **67**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-02 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **913.0**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
	912.3	Sandy SILT with organics, a little gravel, dark brown, frozen (OL)	TOPSOIL									
1			COARSE ALLUVIUM		F/M	SS	13					
2	911.0	SILTY SAND with gravel, fine to medium grained, brown, moist, loose (SM)										
3				7	M	SS	16					
4		SAND, fine to medium grained, a little gravel, brown, moist, very loose to loose (SP)										
5				4	M	SS	18					
6	907.0	Gravelly SAND, fine to medium grained, brown, moist, loose (SP)										
7				6	M	SS	16					
8	905.0	SAND, fine to coarse grained, a little gravel, brown, moist, loose (SP)										
9				9	M	SS	6					
10	903.0	Gravelly SAND, fine to coarse grained, brown, moist, loose (SP)										
11				7	M	SS	10					
12	901.0	GRAVEL with sand, brown, moist, loose to medium dense (GP)										
13				8	M	SS	12					
14												
15				15	M	SS	6					
16	897.0	Gravelly SAND, fine to coarse grained, brown, moist, medium dense (SP)										
17				13	M	SS	14					
18												
19				16	M	SS	6					
20	893.0	SAND with gravel, fine to coarse grained, brown, moist, medium dense (SP)										
21				14	M	SS	10					
22	891.0	SAND, fine grained, brown, moist, medium dense (SP)										
23				20	M	SS	12					
24	889.0	No Recovery										
25			FINE ALLUVIUM	14	M	SS	0					
26	887.0	Sandy LEAN CLAY, brown, stiff (CL)										
27				15	M	SS	18					
28	885.0 / 884.8	SANDSTONE, sand, with gravel, fine grained, yellowish brown, moist, very dense, USCS classification: Sand (SP)	SANDSTONE	50/.2	M	SS	1					
		End of boring at 28.2 feet										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-28.0'	**3.25" HSA**	**4/5/18**	**1200**	**28.2**	**28.0**	**28.0**	**None**	**None**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **4/5/18**

DR: **GM** LG: **MH** Rig: **67**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-03 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **914.5**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
0–0.8	913.7	Sandy SILT with organics, a little gravel, dark brown, frozen (OL)	TOPSOIL		F/M	SS	21					
0.8–4	910.5	Sandy LEAN CLAY, brown, soft to stiff (CL)	FINE ALLUVIUM	10	M	SS	4					
4–10	904.5	SAND, fine to medium grained, a little gravel, brown, moist, loose to medium dense (SP)	COARSE ALLUVIUM	15	M	SS	16					
				11	M	SS	14					
				10	M	SS	6					
10–12	902.5	SAND, fine to coarse grained, a little gravel, brown, moist, very loose (SP)		4	M	SS	5					
12–16	898.5	SAND with gravel, fine to medium grained, brown, moist, loose to medium dense (SP)		10	M	SS	6					
				17	M	SS	5					
16–18	896.5	GRAVEL with sand, brown, moist, loose (GP)		10	M	SS	7	2				2
18–22	892.5	Gravelly SAND, fine to coarse grained, brown, moist, medium dense (SP)		23	M	SS	6					
				22	M	SS	10					
22–26	888.5	SAND with gravel, fine to medium grained, brown, moist, medium dense (SP)		18	M	SS	8					
				14	M	SS	4					
26–30	884.5	SAND WITH SILT, fine grained, a little gravel, brown, moist, medium dense (SP-SM)		18	M	SS	6					
				16	M	SS	14					
30		*End of boring at 30.0 feet*										

DEPTH:	DRILLING METHOD
0-28.0'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
4/5/18	1000	30.0	28.0	30.0	None	None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

BORING COMPLETED: **4/5/18**

DR: **GM** LG: **MH** Rig: **67**

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-04 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **905.0**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
0–2.5	902.5	Sandy SILT with organics, dark brown, moist, very loose (OL)	TOPSOIL	4	M	SS	18					
2.5–6	899.0	LEAN CLAY, brown, soft to stiff (CL)	FINE ALLUVIUM	3	M	SS	22					
				9	M	SS	18					
6–8	897.0	SAND WITH SILT, fine to medium grained, a little gravel, brown, moist, medium dense (SP-SM)	COARSE ALLUVIUM	13	M	SS	18					
8–12	893.0	SAND, fine to medium grained, a little gravel, brown, moist, loose to medium dense (SP)		8	M	SS	18					
				11	M	SS	6					
12–18	887.0	SAND with gravel, fine to coarse grained, brown, moist, medium dense (SP)		12	M	SS	16					
				13	M	SS	12					
				13	M	SS	6					
18–26	879.0	SILTY SAND, fine grained, a little gravel, brown, most to waterbearing, loose to medium dense (SM)		11	M	SS	16					
				19	M-W	SS	14					
				8	W	SS	18					
				13	W	SS	18					
26		*End of boring at 26.0 feet*										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-24.0'	**3.25" HSA**							
		4/4/18	**1315**	**22.0**	**20.0**	**21.2**	**None**	**21.1**
		4/4/18	**1320**	**22.0**	**20.0**	**21.2**	**None**	**21.1**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **4/4/18**

DR: **GM** LG: **MH** Rig: **67**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-05 (p. 1 of 2)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **921.0**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS WC	qp	LL	PL	%-#200
1	919.5	SILT with organics, dark brown, frozen (OL)	TOPSOIL		F/M	SS	22					
2		SILTY CLAY, brown, firm (CL-ML)	FINE ALLUVIUM									
3				8	M	SS	18					
4	917.0	SAND WITH SILT, fine to medium grained, a little gravel, brown, moist, medium dense (SP-SM)	COARSE ALLUVIUM									
5				23	M	SS	8					
6	915.0	SAND WITH SILT and gravel, fine to medium grained, brown, moist, medium dense (SP-SM)										
7				14	M	SS	8					
8	913.0	SAND, fine to medium grained, brown, moist, loose to medium dense (SP)										
9				11	M	SS	14					
10												
11				8	M	SS	16					
12	909.0	SAND, fine to coarse grained, a little gravel, brown, moist, medium dense (SP)										
13				11	M	SS	10					
14												
15				12	M	SS	2					
16												
17				14	M	SS	2					
18												
19				14	M	SS	18					
20	901.0	Gravelly SAND, fine to coarse grained, brown, moist, medium dense (SP)										
21				12	M	SS	12					
22												
23				16	M	SS	12	2				2
24												
25	896.0	SAND, fine grained, a little gravel, yellowish brown, moist, dense (SP)		34	M	SS	10					
26												
27				37	M	SS	1					
28	893.0	SAND with gravel, fine to coarse grained, brown, moist, medium dense to dense (SP)										
29				20	M	SS	11					
30												
31	890.0			50	M	SS	8					

DEPTH: DRILLING METHOD	WATER LEVEL MEASUREMENTS						
	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-38.0' **3.25" HSA**	**4/4/18**	**1540**	**39.5**	**38.0**	**39.3**	**None**	**None**

BORING COMPLETED: **4/4/18**

DR: **GM** LG: **MH** Rig: **67**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030**   Log of Boring No. **B-05 (p. 2 of 2)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
33		SAND, fine grained, brown, moist, medium dense to dense (SP) *(continued)*		24	M	SS	20					
34												
35	886.0	SILTY SAND, fine grained, brown, moist, medium dense (SM)		20	M	SS	22					
36	885.0	LEAN CLAY, reddish brown, stiff (CL)	FINE ALLUVIUM									
37				12	M	SS	22					
38												
39	882.0	SANDSTONE, sand, with gravel, fine grained, yellowish brown, moist, very dense, USCS classification: Sand (SP)	SANDSTONE	59	M	SS	18					
	881.5	*End of boring at 39.5 feet*										

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-06 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **941.5**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
1	940.0	SILT with organics, dark brown, frozen (OL)	TOPSOIL		F/M	SS	19					
2	939.0	SILTY CLAY, brown, firm (CL-ML)	FINE ALLUVIUM									
3–4	937.5	SAND WITH SILT, fine to medium grained, a little gravel, brown, moist, medium dense (SP-SM)	COARSE ALLUVIUM	18	M	SS	17					
5		SAND with gravel, fine to coarse grained, brown, moist, loose to medium dense (SP)		24	M	SS	18	4				3
7				20	M	SS	17					
9				14	M	SS	6					
11–12	929.5			9	M	SS	15					
13–14	927.5	SAND, fine to medium grained, brown, moist, loose (SP)		10	M	SS	12					
15–16	925.5	Gravelly SAND, fine to coarse grained, brown, moist, medium dense (SP)		23	M	SS	14					
17		SAND with gravel, fine to coarse grained, brown, moist, loose to medium dense (SP)		10	M	SS	5					
19				7	M	SS	13					
21				13	M	SS	6					
23–24	917.5			9	M	SS	15					
25–27	914.5	SAND, fine to medium grained, light brown, moist, medium dense (SP)		19	M	SS	18					
27		SAND, fine to coarse grained, a little gravel, light brown, moist, loose to medium dense (SP)		11	M	SS	19					
29–30	911.5			7	M	SS	16					
		End of boring at 30.0 feet										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-28.0'	**3.25" HSA**	**4/5/18**	**1650**	**30.0**	**28.0**	**27.1**	**None**	**None**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **4/5/18**

DR: **MH** LG: **GM** Rig: **67**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-07 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **941.0**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
1	939.5	SILT with organics, dark brown, frozen (OL)	TOPSOIL		F/M	SS	19					
3	937.5	SILTY CLAY, brown, firm to stiff (CL-ML)	FINE ALLUVIUM	11	M	SS	15					
5		SAND with gravel, fine to coarse grained, brown, moist, medium dense to dense (SP)	COARSE ALLUVIUM	34	M	SS	13					
7	933.0			25	M	SS	16					
9		SAND, fine to medium grained, a little gravel, brown, moist, loose to medium dense (SP)		9	M	SS	16					
11				14	M	SS	18					
13	927.0			10	M	SS	18					
15	925.0	SILTY SAND with gravel, fine to medium grained, brown, moist, medium dense (SM)		26	M	SS	6					
17	923.0	SAND, fine to coarse grained, a little gravel, brown, moist, medium dense (SP)		13	M	SS	8					
19	921.0	SAND with gravel, fine to coarse grained, brown, moist, medium dense (SP)		12	M	SS	3					
21		SAND, fine to medium grained, a little gravel, brown, moist, medium dense (SP)		22	M	SS	8					
23	917.0			16	M	SS	11					
25		SAND with gravel, fine to coarse grained, brown, moist, medium dense (SP)		20	M	SS	14					
27	912.5			31	M	SS	8					
29	911.0	SANDSTONE, sand, fine to medium grained, yellowish white, moist, very dense, USCS classification: Sand (SP)	SANDSTONE	57	M	SS	18					
30		*End of boring at 30.0 feet*										

DEPTH:	DRILLING METHOD
0-28.0'	3.25" HSA

BORING COMPLETED: **4/6/18**

DR: **MH** LG: **GM** Rig: **67**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
4/5/18	1815	30.0	28.0	29.8	None	None
4/6/18	0730	30.0	28.0	29.8	None	None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-08 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **940.5**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
0–1	939.0	SILT with organics, dark brown, frozen (OL)	TOPSOIL		F/M	SS	19					
1–3	937.0	SILTY CLAY, brown, firm to stiff (CL-ML)	FINE ALLUVIUM	10	M	SS	16					
3–10	930.5	SAND with gravel, fine to coarse grained, brown, moist, loose to medium dense (SP)	COARSE ALLUVIUM	29	M	SS	20					
				24	M	SS	14					
				15	M	SS	14					
10–11	929.5	SAND, fine to medium grained, brown, moist, medium dense (SP)		14	M	SS	15					
11–16	924.5	Gravelly SAND, fine to coarse grained, brown, moist, medium dense (SP)		16	M	SS	14	4				4
				13	M	SS	16					
16–20	920.5	SAND, fine to medium grained, a little gravel, brown, moist, medium dense (SP)		19	M	SS	15					
				16	M	SS	18					
20–23	917.5	SAND, fine to medium grained, brown, moist, medium dense (SP)		20	M	SS	19	3				2
23–26	914.5	GRAVEL with sand, brown, moist, medium dense to very dense (GP)		22	M	SS	17					
				73/.9	M	SS	12					
26–28.5	912.0	SANDSTONE, sand, fine grained, yellow, moist, very dense, USCS classification: Sand (SP)	SANDSTONE	83	M	SS	17					
				58/.5	M	SS	6					
		End of boring at 28.5 feet										

DEPTH:	DRILLING METHOD
0-28.0'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
4/6/18	1010	28.5	28.0	28.4	None	None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

BORING COMPLETED: **4/6/18**

DR: **MH** LG: **GM** Rig: **67**

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-09 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **939.0**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
	938.5	SILT with organics, dark brown, frozen (OL)	TOPSOIL									
1	937.5	SILTY CLAY with organics, dark brown, frozen (OL)	FINE ALLUVIUM		F/M	SS	24					
2	937.0	Sandy LEAN CLAY, a little gravel, dark brown with brown mottling (CL)	COARSE ALLUVIUM									
3				12	M	SS	20					
4	934.5	SAND WITH SILT, fine to coarse grained, a little gravel, brown, moist, medium dense (SP-SM)	FINE ALLUVIUM									
5				6	M	SS	19					
6	933.0	SILTY CLAY, brown, firm (CL-ML)	COARSE ALLUVIUM									
7	932.0	SAND, fine to medium grained, a little gravel, brown, moist, medium dense (SP)		12	M	SS	13					
8												
9		SAND with gravel, fine to coarse grained, brown, moist, loose to medium dense (SP)		9	M	SS	14					
10												
11				16	M	SS	3					
12	927.0	SAND, fine to medium grained, a little gravel, brown, moist, medium dense (SP)										
13	926.0			14	M	SS	14					
14	925.0	SILTY SAND with gravel, fine to medium grained, dark brown, moist, medium dense, with laminations of clay (SM)	SANDSTONE									
15				57	M	SS	24					
16												
17		SANDSTONE, sand, fine grained, white, moist, dense to very dense, USCS classification: Sand (SP)		32	M	SS	21					
18	920.3			50/.2	M	SS	6					
		End of boring at 18.7 feet										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-18.0'	**3.25" HSA**	**4/6/18**	**1155**	**18.7**	**18.0**	**18.5**	**None**	**None**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **4/6/18**

DR: **MH** LG: **GM** Rig: **67**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **31-02030** Log of Boring No. **B-10 (p. 1 of 1)**

Project: **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

Surface Elevation **941.0**

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
1	939.5	SILT with organics, dark brown, frozen (OL)	TOPSOIL		F/M	SS	23					
2–3	938.0	SILTY CLAY with sand, brown, stiff (CL-ML)	FINE ALLUVIUM	20	M	SS	17					
3–4	937.0	Gravelly SAND, fine to coarse grained, brown, moist, medium dense (SP)	COARSE ALLUVIUM									
4–10	931.0	SAND with gravel, fine to medium grained, brown, moist, medium dense (SP)		26	M	SS	16					
				13	M	SS	13					
				12	M	SS	7					
10–12.5	928.5	SAND, fine to coarse grained, brown, moist, loose (SP)		8	M	SS	10					
12.5–15.4	925.6	SANDSTONE, sand, fine grained, yellow and white, moist, dense to very dense, USCS classification: Sand (SP)	SANDSTONE	48	M	SS	18					
				50/.2	M	SS	6					
				50/.4	M	SS	4					

End of boring at 15.4 feet

DEPTH:	DRILLING METHOD
0-14.0'	3.25" HSA

WATER LEVEL MEASUREMENTS

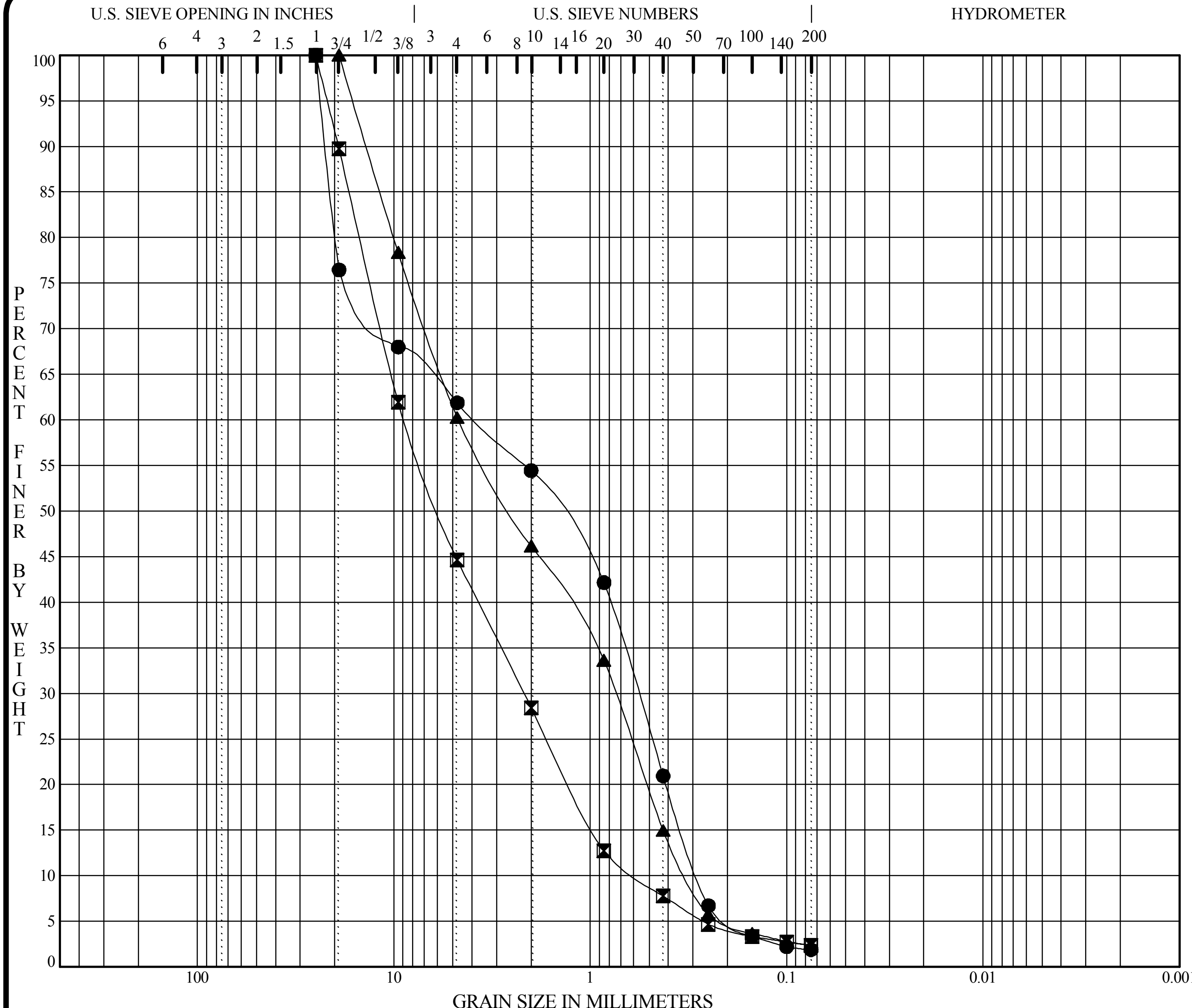
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
4/6/18	1330	15.4	15.0	15.1	None	None

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

BORING COMPLETED: **4/6/18**

DR: **MH** LG: **GM** Rig: **67**

AET_CORP W-ELEV 31-02030 - CONTRACT DRILL SW - ST. JOSEPH.GPJ AET+CPT+WELL.GDT 4/13/18



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
● B-01	9.0'	**Gravelly sand, f to m grained (SP)**	**4**				**0.30**	**13.5**
⊠ B-03	17.0'	**Gravel with sand (GP)**	**2**				**0.93**	**15.2**
▲ B-05	23.0'	**Gravelly sand, f to c grained (SP)**	**2**				**0.37**	**14.7**

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-01	9.0'	**25.00**	**3.82**	**0.571**	**0.2826**	**38.1**	**60.0**	**1.9**	
⊠ B-03	17.0'	**25.00**	**8.79**	**2.177**	**0.5798**	**55.4**	**42.3**	**2.3**	
▲ B-05	23.0'	**19.00**	**4.68**	**0.743**	**0.3192**	**39.7**	**57.9**	**2.3**	

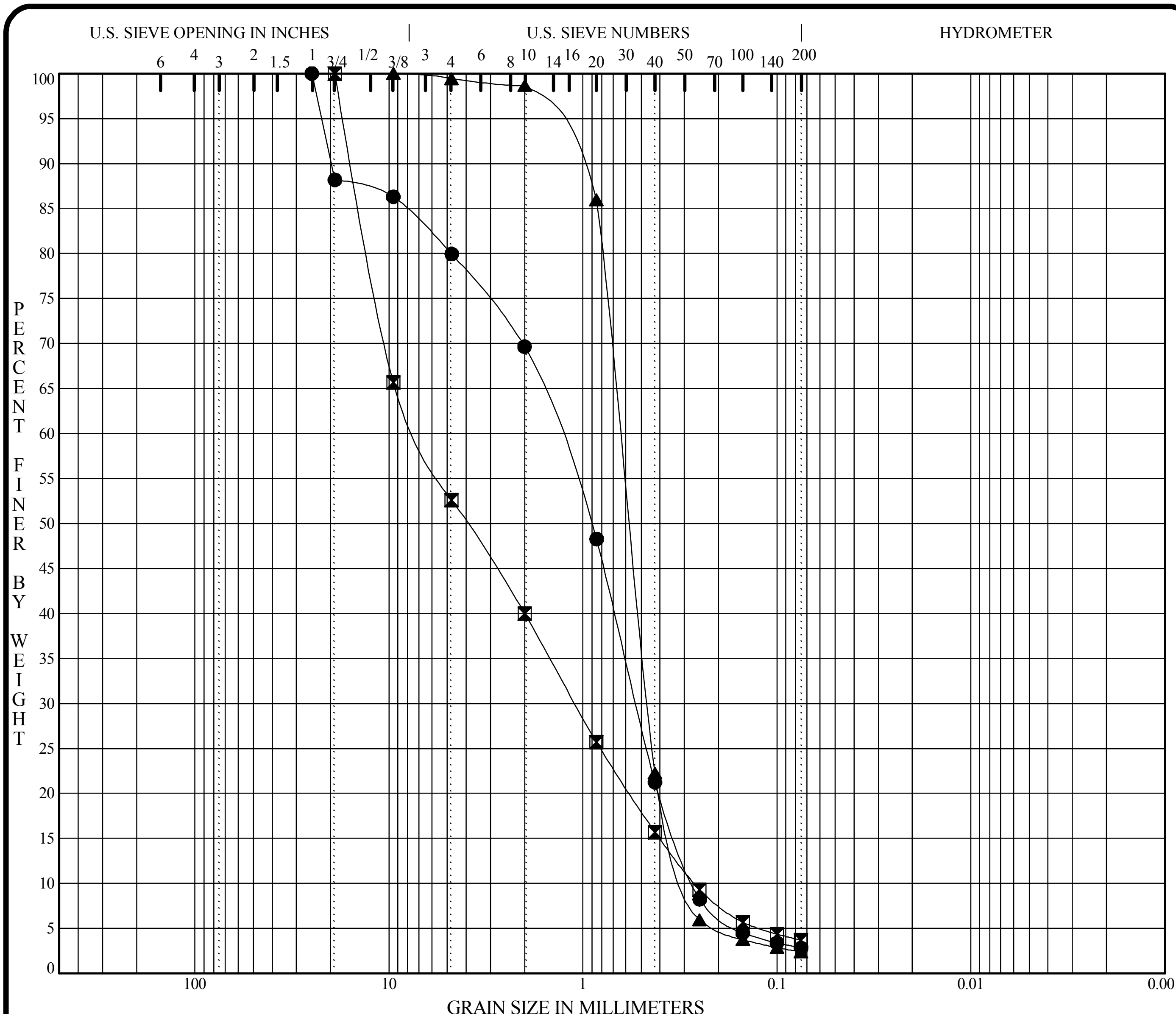
PROJECT **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

AET JOB NO. **31-02030**

DATE **4/4/18**

AMERICAN ENGINEERING TESTING, INC.

GRADATION CURVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
● B-06	5.0'	**Sand with gravel, f to c grained (SP)**	**4**				**0.78**	**5.1**
⧗ B-08	13.0'	**Gravelly sand, f to c grained (SP)**	**4**				**0.65**	**26.5**
▲ B-08	21.0'	**Sand, f to m grained (SP)**	**3**				**1.17**	**2.2**

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-06	5.0'	**25.00**	**1.36**	**0.532**	**0.2687**	**20.1**	**77.1**	**2.8**	
⧗ B-08	13.0'	**19.00**	**7.03**	**1.100**	**0.2649**	**47.4**	**48.9**	**3.7**	
▲ B-08	21.0'	**9.50**	**0.64**	**0.462**	**0.2852**	**0.6**	**97.0**	**2.4**	

PROJECT **Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin**

AET JOB NO. **31-02030**
DATE **4/6/18**

AMERICAN ENGINEERING TESTING, INC.

GRADATION CURVES

Wis. Dept. of Safety and Professional Services
Division of Safety and Buildings

SOIL EVALUATION - STORM

in accordance with SPS 382.365 and 385, Wis. Adm. Code

Attach complete site plan on paper not less than 8 1/2 x 11 inches in size. Plan must include, but not limited to: vertical and horizontal reference point (BM), direction and percent slope, scale or dimensions, north arrow, and BM referenced to nearest road.

Please print all information.

Personal information you provide may be used for secondary purposes (Privacy Law, s. 15.04 (1) (m)).

County: St. Croix
Parcel I.D.:
Reviewed by: Date:

Property Owner: c/o Town of St. Joseph
Property Location: Govt. Lot *** 1/4 *** 1/4 S *** T 30 N R 19W E (or) W
Property Owner's Mailing Address: 1337 County Road V
Lot #: Block #: Subd. Name or CSM#:
City: Hudson | State: WI | Zip Code: 54016 | Phone Number: (715) 549-6235
☐ City ☐ Village ☒ Town: St. Joseph
Nearest Road: 80th St. & 133rd Ave

Drainage area ________ ☐ sq. ft. ☐ acres
Optional:
Test Site Suitable for (check all that apply)
☐ Irrigation ☐ Bioretention trench ☐ Trench(es)
☐ Rain garden ☐ Grassed swale ☐ Reuse
☐ Infiltration trench ☐ SDS (> 15' wide) ☐ Other ________

Hydraulic Application Test Method:
☒ Morphological Evaluation
☐ Double-Ring Infiltrometer
☐ Other (specify) ________

B-01 Obs. # ☒ Boring ☐ Pit Ground surface elev. 903.5 ft. Depth to limiting factor 265 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-18	7.5YR 3/3	---	c	0, m	m, vfr	a, w	<5	0.07
2	18-48	7.5YR 3/3	---	ls	0, sg	m, lo	g, w	~20	1.63
3	48-96	7.5YR 4/3	---	s gr	0, sg	m, lo	g, w	10-20	3.60
4	96-168	7.5YR 4/3	---	s vgr	0, sg	m, lo	g, w	30-45	3.60
5	168-216	7.5YR 4/3	---	s vgr	0, sg	m, lo	g, w	~55	3.60
6	216-240	7.5YR 5/4	---	s	0, sg	m, lo	a, w	~10	3.60
7	240-288	7.5YR 3/3	---	s xgr	0, sg	m, lo	g, w	~70	3.60

B-01 Cont Obs. # ☒ Boring ☐ Pit Ground surface elev. ________ ft. Depth to limiting factor ________ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
8	288-312	7.5YR 4/3	---	s	0, sg	m, lo	---	<5	3.60
			GW encountered ~22.1'						

CST/PSS Name (Please Print): Blake E. Snyder
Signature: Blake Snyder
CST/PSS Number: 1323667
Address: 1837 County Highway OO, Chippewa Falls WI 54729
Date Evaluation Conducted: April 4 through 6, 2018
Telephone Number: (715) 861-5045

Property Owner c/o Town of St. Joseph   Parcel ID # ______   Page 2 of 7

B-02   Obs. #   ■ Boring ☐ Pit   Ground surface elev. 913.0 ft.   Depth to limiting factor 336 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-8	7.5YR 3/3	---	sil	0, m	m, vfr	a, w	~5	0.13
2	8-24	7.5YR 3/4	---	ls	0, sg	m, lo	g, w	~20	1.63
3	24-72	7.5YR 4/4	---	s	0, sg	m, lo	a, w	0-5	3.60
4	72-96	7.5YR 4/4	---	s vgr	0, sg	m, lo	g, w	~50	3.60
5	96-120	7.5YR 4/3	---	s gr	0, sg	m, lo	a, w	~20	3.60
6	120-192	7.5YR 4/3	---	s xgr	0, sg	m, lo	g, w	60-70	3.60
7	192-240	7.5YR 4/3	---	s vgr	0, sg	m, lo	g, w	40-55	3.60

B-02 Cont   Obs. #   ☐ Boring ☐ Pit   Ground surface elev. ______ ft.   Depth to limiting factor ______ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
8	240-264	7.5YR 4/3	---	s gr	0, sg	m, lo	a, w	20-40	3.60
9	264-288	7.5YR 5/3	---	s*	0, sg	m, lo	---	<5	0.50*
10	288-312	---	-No sample recovery-	---	---	---	---	---	---
11	312-336	7.5YR 5/6	---	c	0, m	m, fi	a, w	<5	0.07
12	336-338	7.5YR 6/4	-Sandstone-	**	**	**	---	**	**

B-03   Obs. #   ■ Boring ☐ Pit   Ground surface elev. 914.5 ft.   Depth to limiting factor >360 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-11	7.5YR 2.5/2	---	sil	0, m	m, vfr	a, w	~5	0.13
2	11-48	5YR 4/3	---	c	0, m	m, fr	a, w	<5	0.07
3	48-144	7.5YR 4/4	---	s	0, sg	m, lo	g, w	~15	3.60
4	144-192	7.5YR 5/3	---	s gr	0, sg	m, lo	g, w	~25	3.60
5	192-264	7.5YR 4/3	---	s xgr	0, sg	m, lo	g, w	55-75	3.60
6	264-312	7.5YR 4/3	---	s gr	0, sg	m, lo	a, w	30	3.60
7	312-360	7.5YR 5/3	---	s*	0, sg	m, lo	---	~5	0.50*

B-04   Obs. #   ☒ Boring ☐ Pit   Ground surface elev. 905.0 ft.   Depth to limiting factor 253 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-30	7.5YR 2.5/3	---	sil	0, m	m, fr	g, w	<5	0.13
2	30-72	5YR 4/3	---	c	0, m	m, fr	a, w	<5	0.07
3	72-144	7.5YR 4/4	---	s	0, sg	m, lo	g, w	5-15	3.60
4	144-216	7.5YR 5/3	---	s gr	0, sg	m, lo	a, w	25-35	3.60
5	216-312	7.5YR 4/4	---	ls*	0, m	m, lo	---	~5	0.50*
			GW encountered ~21.1'						

B-05   Obs. #   ☒ Boring ☐ Pit   Ground surface elev. 921.0 ft.   Depth to limiting factor 468 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-18	7.5YR 3/3	---	sil	0, m	m, vfr	g, w	<5	0.13
2	18-48	7.5YR 4/3	---	c	0, m	m, fr	a, w	<5	0.07
3	48-96	7.5YR 4/3	---	s	0, sg	m, lo	g, w	10-20	3.60
4	96-144	7.5YR 4/3	---	s	0, sg	m, lo	g, w	<5	3.60
5	144-240	7.5YR 4/3	---	s gr	0, sg	m, lo	g, w	~25	3.60
6	240-300	7.5YR 5/4	---	s vgr	0, sg	m, lo	a, w	45-55	3.60
7	300-336	7.5YR 7/6	---	s*	0, sg	m, lo	a, w	~5	0.50*

B-05 Cont   Obs. #   ☐ Boring ☐ Pit   Ground surface elev. ____ ft.   Depth to limiting factor ____ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
8	336-372	7.5YR 4/3	---	s vgr	0, sg	m, lo	a, w	30-40	3.60
9	372-408	7.5YR 4/4	---	s*	0, sg	m, lo	g, w	<5	0.50*
10	408-432	7.5YR 4/4	---	ls*	0, sg	m, lo	a, w	<5	0.50*
11	432-468	5YR 4/6	---	c	0, m	m, fi	a, w	<5	0.07
12	468-480	7.5YR 5/6	-Sandstone-	**	**	**	---	**	**

Property Owner c/o Town of St. Joseph   Parcel ID # ____   Page 4 of 7

B-06   Obs. #   ☐ Boring ☐ Pit   Ground surface elev. 941.5 ft.   Depth to limiting factor >360 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-18	7.5YR 3/3	---	sil	0, m	m, vfr	g, w	<5	0.13
2	18-30	7.5YR 4/3	---	c	0, m	m, fr	g, w	<5	0.07
3	30-144	7.5YR 4/4	---	s	0, sg	m, lo	a, w	15-30	3.60
4	144-168	7.5YR 6/3	---	s	0, sg	m, lo	a, w	<5	3.60
5	168-192	7.5YR 4/4	---	s vgr	0, sg	m, lo	g, w	~60	3.60
6	192-288	7.5YR 4/4	---	s gr	0, sg	m, lo	a, w	15-30	3.60
7	288-324	7.5YR 6/3	---	s	0, sg	m, lo	g, w	<5	3.60

B-06 Cont   Obs. #   ☐ Boring ☐ Pit   Ground surface elev. ____ ft.   Depth to limiting factor ____ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
8	324-360	7.5YR 4/3	---	s gr	0, sg	m, lo	---	15-25	3.60

B-07   Obs. #   ☒ Boring ☐ Pit   Ground surface elev. 941.0 ft.   Depth to limiting factor 342 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-18	7.5YR 3/3	---	sil	0, m	m, vfr	g, w	<5	0.13
2	18-42	7.5YR 4/3	---	c	0, m	m, fr	a, w	<5	0.07
3	42-96	7.5YR 4/6	---	s gr	0, sg	m, lo	g, w	15-25	3.60
4	96-168	7.5YR 4/3	---	s	0, sg	m, lo	a, w	~5	3.60
5	168-192	7.5YR 4/3	---	ls gr	0, sg	m, lo	g, w	~20	1.63
6	192-240	7.5YR 4/3	---	s gr	0, sg	m, lo	g, w	20-40	3.60
7	240-288	7.5YR 5/4	---	s	0, sg	m, lo	g, w	~15	3.60

Property Owner c/o Town of St. Joseph Parcel ID # ______

B-07 Cont Obs. # ☐ Boring ☐ Pit Ground surface elev. ______ ft. Depth to limiting factor ______ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
8	288-342	7.5YR 4/4	---	s vgr	0, sg	m, lo	a, w	30-40	3.60
9	342-360	7.5YR 8/3	-Sandstone-	**	**	**	---	**	**

B-08 Obs. # ☒ Boring ☐ Pit Ground surface elev. 940.5 ft. Depth to limiting factor 312 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-18	7.5YR 3/3	---	sil	0, m	m, vfr	g, w	<5	0.13
2	18-42	7.5YR 3/4	---	c	0, m	m, fr	a, w	<5	0.07
3	42-120	7.5YR 4/4	---	s gr	0, sg	m, lo	g, w	~30	3.60
4	120-132	7.5YR 5/4	---	s	0, sg	m, lo	a, w	<5	3.60
5	132-192	7.5YR 4/3	---	s vgr	0, sg	m, lo	a, w	40-60	3.60
6	192-276	7.5YR 5/4	---	s	0, sg	m, lo	a, w	0-10	3.60
7	276-312	7.5YR 4/2	---	s xgr	0, sg	m, lo	a, w	60-75	3.60

B-08 Cont Obs. # ☐ Boring ☐ Pit Ground surface elev. ______ ft. Depth to limiting factor ______ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
8	312-360	10YR 6/8	-Sandstone-	**	**	**	---	**	**

Property Owner c/o Town of St. Joseph Parcel ID # ______ Page 6 of 7

B-09 Obs. # ■ Boring ☐ Pit Ground surface elev. 939.0 ft. Depth to limiting factor 18 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-6	7.5YR 3/3	---	sil	0, m	m, vfr	g, w	<5	0.13
2	6-18	7.5YR /3/	---	c	0, m	m, fr	g, w	<5	0.07
3	18-24	7.5YR 3/3	c, 2, f, 7.5YR 4/4	c	0, m	m, fr	a, w	~5	0.07
4	24-54	7.5YR 4/3	---	s	0, sg	m, lo	a, w	~15	3.60
5	54-72	7.5YR 4/3	---	c	0, m	m, fi	a, w	<5	0.07
6	72-84	7.5YR 4/4	---	s	0, sg	m, lo	g, w	~5	3.60
7	84-144	7.5YR 4/4	---	s gr	0, sg	m, lo	g, w	25-35	3.60

B-09 Cont Obs. # ☐ Boring ☐ Pit Ground surface elev. ______ ft. Depth to limiting factor ______ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
8	144-156	7.5YR 4/4	---	s	0, sg	m, lo	a, w	~10	3.60
9	156-168	7.5YR 3/3	---	ls	0, sg	m, lo	a, w	~20	1.63
10	168-224	7.5YR 8/2	-Sandstone-	**	**	**	---	**	**

B-10 Obs. # ■ Boring ☐ Pit Ground surface elev. 941.0 ft. Depth to limiting factor 150 in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr
1	0-18	7.5YR 3/3	---	sil	0, m	m, vfr	g, w	<5	0.13
2	18-36	7.5YR 3/4	---	c	0, m	m, fr	a, w	<5	0.07
3	36-48	7.5YR 4/3	---	s vgr	0, sg	m, lo	g, w	~50	3.60
4	48-120	7.5YR 4/4	---	s gr	0, sg	m, lo	g, w	15-25	3.60
5	120-150	7.5YR 4/4	---	s	0, sg	m, lo	a, w	~5	3.60
6	150-185	10YR 7/6	-Sandstone-	**	**	**	---	**	**

Property Owner c/o Town of St. Joseph Parcel ID # ____________ Page 7 of 7

Obs. # ☐ Boring ☐ Pit Ground surface elev. ______ ft. Depth to limiting factor ______ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr

Obs. # ☐ Boring ☐ Pit Ground surface elev. ______ ft. Depth to limiting factor ______ in.

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.	Hydraulic App. Rate Inches/Hr

Test Results and/or Summary Comments

The installation of monitoring wells for additional groundwater measurements was beyond our scope of services.

* Per Wisconsin DSPS, the sandy loam infiltration rate is used for fine sand & loamy fine sand soil textures. These layers are marked by an asterisk in the texture and hydraulic app rate columns.

**Sandstone encountered

*** B-01, B-02, B-03 - SE 1/4 of the SE 1/4 of Section 26

*** B-04, B-05 - SW 1/4 of the SW 1/4 of Section 25

*** B-06, B-07 - NW 1/4 of the SE 1/4 of Section 25

*** B-08, B-09, B-10 - SW 1/4 of the SE 1/4 of Section 25

Appendix H

Project Team Meeting #2 Presentation (4/27/2018)

Bass Lake Drawdown Feasibility Study

Team Meeting #2

4/27/2018

Jen Koehler PE and Karen Chandler PE, Barr Engineering Company

Review Agenda

- Recap of past meeting – review goals and selection of 4 options
- Discuss feasibility level evaluation of 4 options
- Discussion/recommendations
- Outline next steps/schedule

Recap of Last Meeting: Project Goals

- Discussed project goals
  - Determine feasibility of modifications to the existing pumping system to:
    - Meet phosphorus discharge requirements
    - Filter or otherwise prevent Zebra Mussels from entering the Willow River
    - Effectively maintain lake levels
    - Estimate the potential impact of hypolimnetic withdrawal on Bass Lake water quality

Recap of Last Meeting: Four Feasibility Alternatives

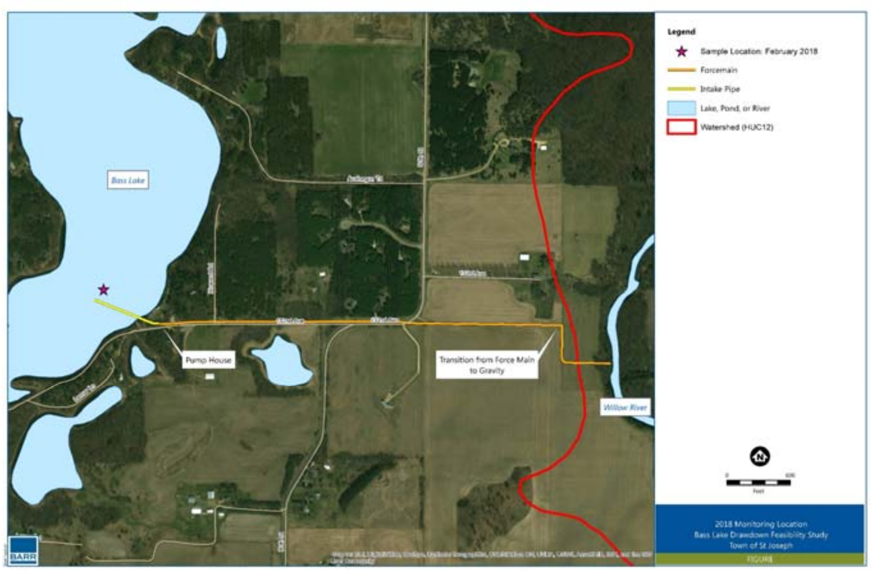
- **Option 1:** Modify Pump Intake (screen), Pump to Infiltration Outside the Bass Lake Groundwatershed
- **Option 2:** Modify Pump Intake (screen), Seasonally (November – April) pump to reduce lake levels
- **Option 3:** Modify Pump Intake (screen), Mechanical Filtration (AMIAD) and Portable Bag Filtration, and Seasonal Pumping for Total Phosphorus (November – June)
- **Option 4:** Shoreline Drain Tile System

Original WDNR Permit – Pumping Rate

The Bass Lake Rehabilitation District filed a request with the Department on May 30, 1997, for a permit to install a pumping system to lower the current high water level of Bass Lake (approximately at 888.5 MSL). The lake level will be stabilized at elevation 886 MSL. Water will be pumped from Bass Lake to the Willow River at a maximum rate of 4.5 cubic feet per second. The pumping will not exceed 2 million gallons per day for any 30 day period, therein eliminating the need for a diversion permit persuant to Sec. 30.18 Wis. Stats. The project is comprised of three main

- **Will allow for 2.0 MGD (*1.0 MGD during off peak*)**
- **Open to flexible pump start (885.0?)**
- **Restarting of pumping will require Chapter 30 permit (Chapter 30.18)**

2018 Monitoring Program – BLRD led



2018 Monitoring Program – BLRD

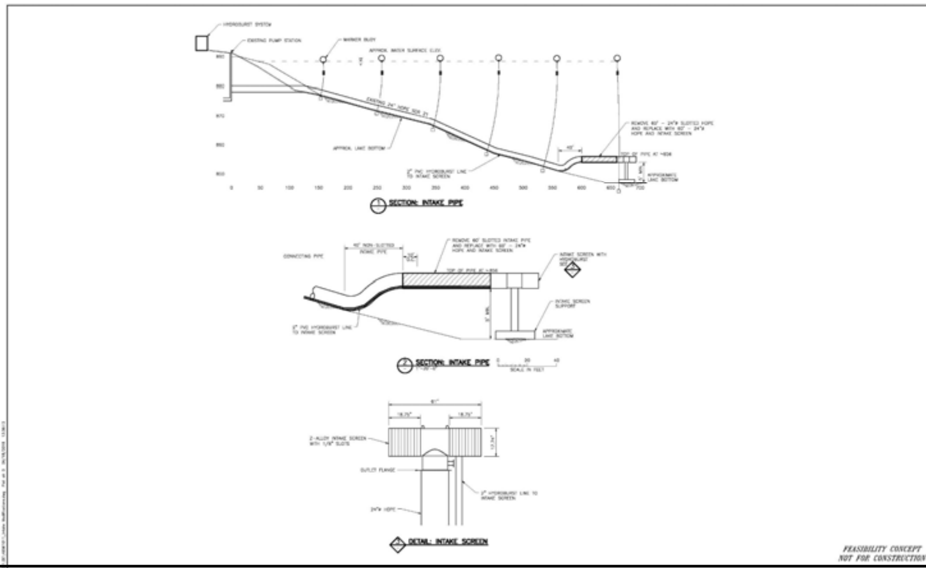
- Begin after ice-out (soon)
- Lake Level - Biweekly (every two weeks)
- Water quality monitoring – biweekly (May-Sept), monthly (October, November) over the pump intake location:
  - Dissolved oxygen and temperature, along the profile of the lake
  - Total Phosphorus (Low-Level method due to the low concentrations in the lake) at the surface and at the pump intake depth (~856 ft MSL)
- Zebra mussel veliger sampling (corresponding with water quality monitoring events) at pump intake (water temperatures reach 50 degrees F)

2018 Monitoring Program - Costs

- BLRD owns temp/DO meter
- Required equipment purchase: Pump, tubing, plankton net, other miscellaneous equipment
- Sampling training

Option	Equipment Purchase	Lab Costs	Sampling Training	*Total 2018 Monitoring Cost*
2018 Monitoring	$1000	$2,400	$800	***$4,200***

Pump Intake Modification and Pump Rebuild



Pump Intake Modification and Pump Rebuild

- ***Condition of the intake pipe – Are there zebra mussels established in the intake pipe?***
  - Televising not possible (due to submerged conditions)
  - Divers can only inspect a few feet into intake pipe
  - Jetting/mechanical not possible/effective (due to submerged conditions and access)
  - Chemical treatment is a possibility

Pump Intake Modification and Pump Rebuild

- Chemical treatment w/ Earthtech QZ
  - Earthtec QZ approved for use in WI
  - Dosing for volume in wet well and intake pipe
    - 5-day contact time to achieve 100% mortality
  - Application during intake modification
  - Would require a permit from WDNR (NR 107 permit) and performed by a licensed applicator
- Alternative: Replace 600 ft of 24" HDPE (~$30,000-$40,000)

BARR

Pump Intake Modification and Pump Rebuild

- ***Pump rebuild***
  - Replace motor
  - Replace bearings, seals, and O-rings
- ***Intake screen (Johnson Intake Screens)***
  - Standard screen slot size is 0.125" opening (~3 mm)
    - If screen needs to be reduced to 0.5 mm openings, the cost of the screen will be more than double
  - Automatic air backwash system (HydroBurst)
  - Z-alloy material to prevent zebra mussel establishment on the screen
- ***Upgrades to Electrical Panel may be needed***
  - Given the age and set-up of the existing electrical panel, may not have enough capacity/space for additional equipment. A new panel may be required.

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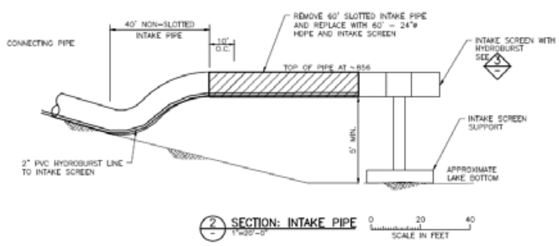
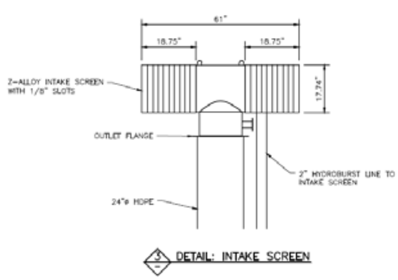
Intake Screen – Johnson Intake Screens

Z-Alloy materials repel Zebra mussels, resists biofouling and minimizes corrosion

BARR

Pump Intake Modification and Pump Rebuild





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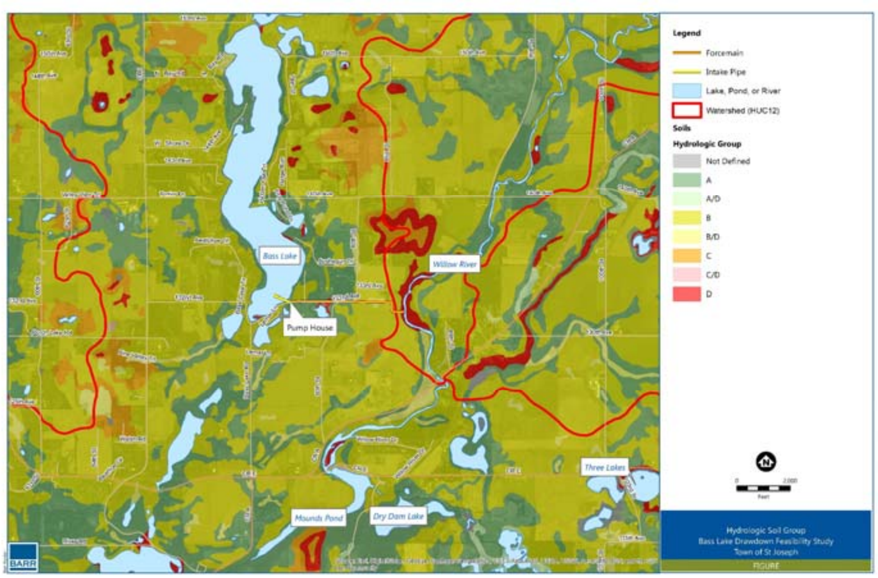
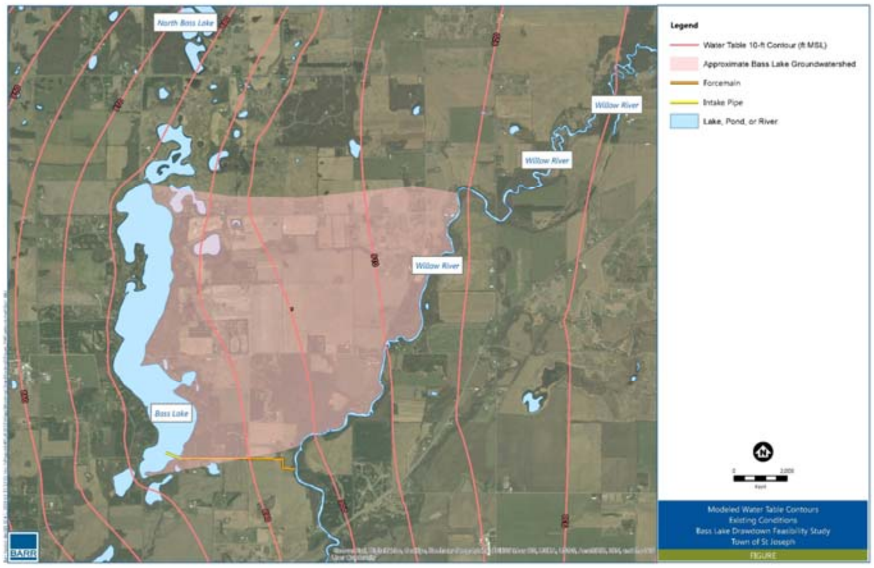
Pump Intake Modification and Pump Rebuild

- **NR107 Chemical Aquatic (Invasive Plant/Animal) Control Application Permit/WPDES General Permit for discharging a Pollutant due to Activities to Control Detrimental or Invasive Aquatic Animals (WI-0064564-2)** - for compliance with provisions of chapter 283, Wisconsin Statutes: Required for chemical treatment of Bass Lake intake pipe/wet well for control of zebra mussels (if used)
- **Chapter 30 permit** – for placement of Intake/Outfall in water and support base on lake bottom - Applicable statutes and codes include Section 30.12, Wis. Stats. and Chapter NR 329, Wis. Adm. Code.
  - Bass Lake classified as Area of Special Natural Resource Interest (ANSRI) and Outstanding and Exceptional Resource Waters.

Option1: Infiltration (Zebra Mussels/Phosphorus)



Option1: Infiltration (Zebra Mussels/Phosphorus)



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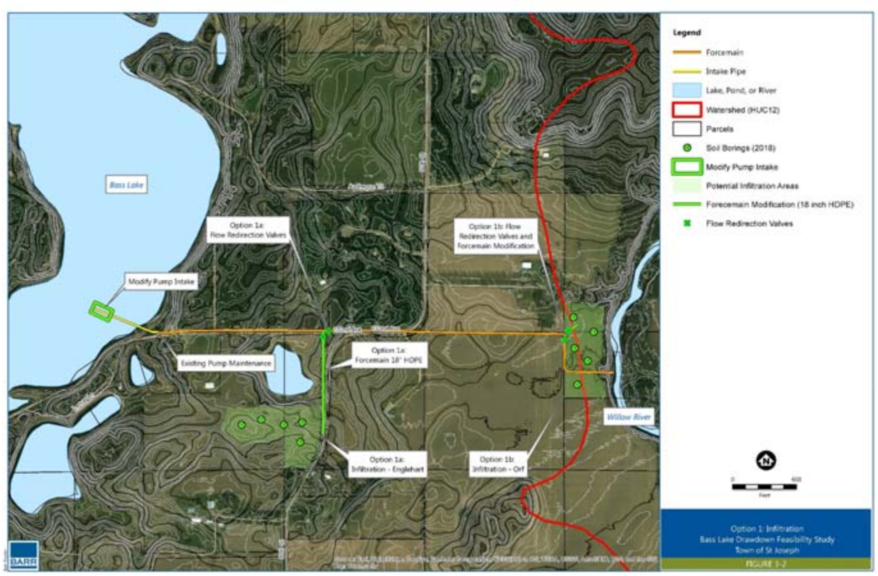
Option1: Infiltration (Zebra Mussels/Phosphorus)



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Soil Boring (AET) Results: Englehart Property (1a)

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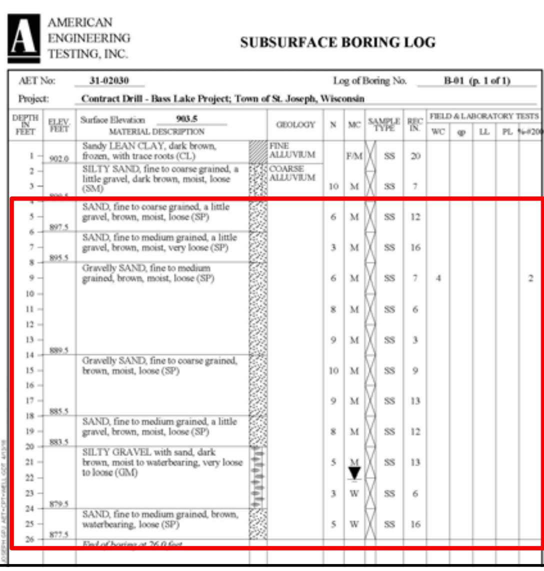
Soil Boring (AET) Results: Englehart Property (1a)



AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: 31-02030 | Log of Boring No. B-01 (p. 1 of 1)

Project: Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin

Surface Elevation 903.5

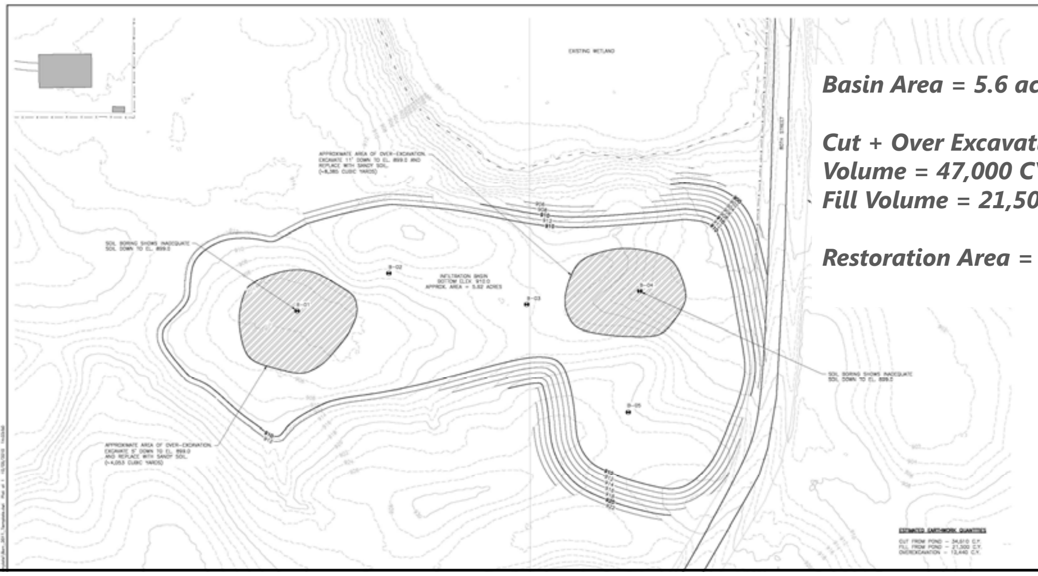
DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	φ	LL	PL	%-#200
1	902.0	Sandy LEAN CLAY, dark brown, frozen, with trace roots (CL)	FINE ALLUVIUM		F/M	SS	20					
2–3	899.5	SILTY SAND, fine to coarse grained, a little gravel, dark brown, moist, loose (SM)	COARSE ALLUVIUM	10	M	SS	7					
4–6	897.5	SAND, fine to coarse grained, a little gravel, brown, moist, loose (SP)		6	M	SS	12					
6–8	895.5	SAND, fine to medium grained, a little gravel, brown, moist, very loose (SP)		3	M	SS	16					
8–14	889.5	Gravelly SAND, fine to medium grained, brown, moist, loose (SP)		6	M	SS	7	4				2
				8	M	SS	6					
				9	M	SS	3					
14–18	885.5	Gravelly SAND, fine to coarse grained, brown, moist, loose (SP)		10	M	SS	9					
				9	M	SS	13					
18–20	883.5	SAND, fine to medium grained, a little gravel, brown, moist, loose (SP)		8	M	SS	12					
20–24	879.5	SILTY GRAVEL with sand, dark brown, moist to waterbearing, very loose to loose (GM)		5	M	SS	13					
				3	W	SS	6					
24–26	877.5	SAND, fine to medium grained, brown, waterbearing, loose (SP)		5	W	SS	16					

End of boring at 26.0 feet

- Most borings indicate needing to excavate several feet of material to expose sand (SP)
  - Basin bottom elevation target ~910 ft MSL
  - Two locations requiring additional correction
- Sand (SP) = 3.6 inch/hr

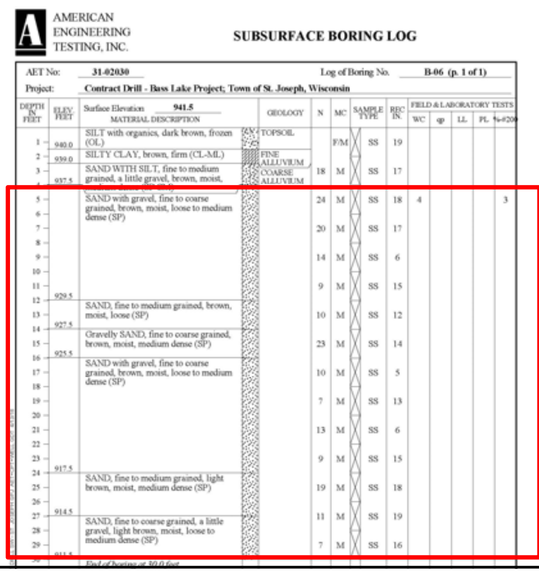
BARR

Soil Boring (AET) Grading: Englehart Property (1a)



Soil Boring (AET) Results: Orf Property (1b)

Soil Boring (AET) Results: Orf Property (1b)



AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: 31-02030 Log of Boring No. B-06 (p. 1 of 1)

Project: Contract Drill - Bass Lake Project; Town of St. Joseph, Wisconsin

Surface Elevation 941.5

DEPTH IN FEET	ELEV. FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	qp	LL	PL	%-#200
1	940.0	SILT with organics, dark brown, frozen (OL)	TOPSOIL		F/M	SS	19					
2	939.0	SILTY CLAY, brown, firm (CL-ML)	FINE ALLUVIUM									
3	937.5	SAND WITH SILT, fine to medium grained, a little gravel, brown, moist, medium dense (SP-SM)	COARSE ALLUVIUM	18	M	SS	17					
5		SAND with gravel, fine to coarse grained, brown, moist, loose to medium dense (SP)		24	M	SS	18	4				3
7				20	M	SS	17					
9				14	M	SS	6					
11				9	M	SS	15					
12	929.5											
13		SAND, fine to medium grained, brown, moist, loose (SP)		10	M	SS	12					
14	927.5											
15		Gravelly SAND, fine to coarse grained, brown, moist, medium dense (SP)		23	M	SS	14					
16	925.5											
17		SAND with gravel, fine to coarse grained, brown, moist, loose to medium dense (SP)		10	M	SS	5					
19				7	M	SS	13					
21				13	M	SS	6					
23				9	M	SS	15					
24	917.5											
25		SAND, fine to medium grained, light brown, moist, medium dense (SP)		19	M	SS	18					
27	914.5	SAND, fine to coarse grained, a little gravel, light brown, moist, loose to medium dense (SP)		11	M	SS	19					
29				7	M	SS	16					
30	911.5	End of boring at 30.0 feet										

- Most borings indicate needing to excavate several feet of material to expose sand (SP)
  - Basin bottom elevation target ~937 ft MSL
  - One location requiring additional correction
- Sand (SP) = 3.6 inch/hr

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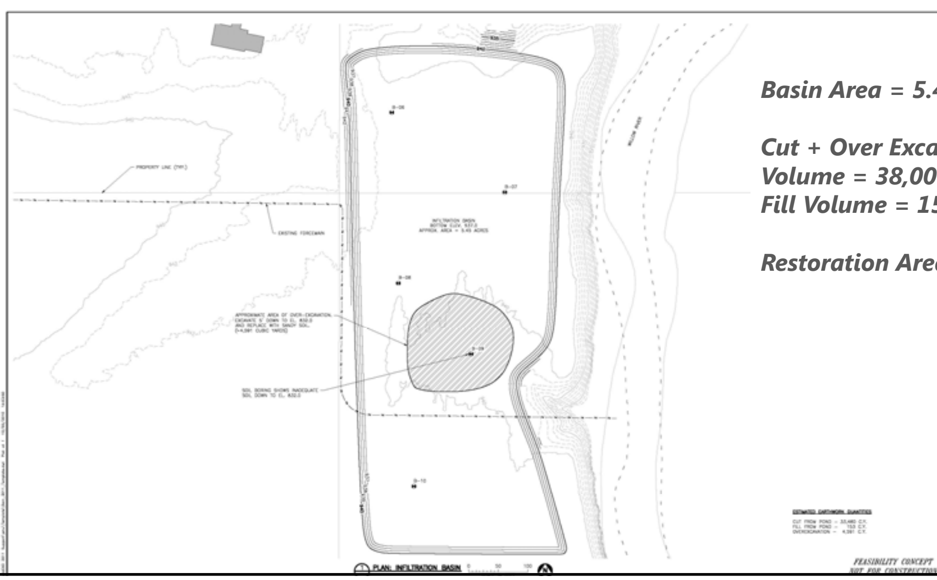
Soil Boring (AET) Grading: Orf Property (1b)



Basin Area = 5.4 acres

Cut + Over Excavation Volume = 38,000 CY
Fill Volume = 150 CY

Restoration Area = 6 acres

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Option1: Infiltration – Design Standards

Stormwater Approach (Wisconsin Stormwater Manual)

- Design based on 50% of in-situ infiltration rate
  - 3.6*(0.5) = 1.8 in/hr
- Drawdown not less than 6 hours, not more than 48-72
- Pumping 1.0 MGD/8hours per day:
  - ***Basin area of 5.0 acres can accommodate pumping rate, "dry" for 16 hours***
  - ***Basin area of 2.5 acres will be wet during pumping, "dry" for 16 hours***
  - Basin area of 0.8 acres will be wet for 24 hour – no "dry" period (not recommended)

Wastewater Approach (EPA/MPCA Rapid Infiltration System Guidance)

- Design based on 10% of in-situ infiltration rate
  - 3.6*(0.1) = 0.36 in/hr
- Requires several basins, cycle loading through each
  - 1/3 loading, 2/3 dry
- Pumping 1.0 MGD/8hours per day:
  - ***Minimum area = 12.5 acres***

Option1: Infiltration – Other Considerations

- Requires Land Purchase
- Cannot infiltrate during winter months – paired with seasonal pumping if winter operation needed
  - Valves could provide flexibility
- Additional soil testing needed before final design
  - Borings & In-situ field testing of infiltration
- Distribution of inflow evenly across basin important
- Groundwater mounding could be possible and may result in some water returning to Bass Lake
  - At Engelhart property – lateral movement of water to wetland to the north (1 – 7 ft of mounding, 0-30% of pumped volume could return to Bass Lake)
  - At Orf property - lateral movement of water to bluff along Willow River leading to seeps/slope stability issues (1 – 5 ft of mounding, 0-20% of pumped volume could return to Bass Lake)
- Stormwater runoff will need to be routed around these basins

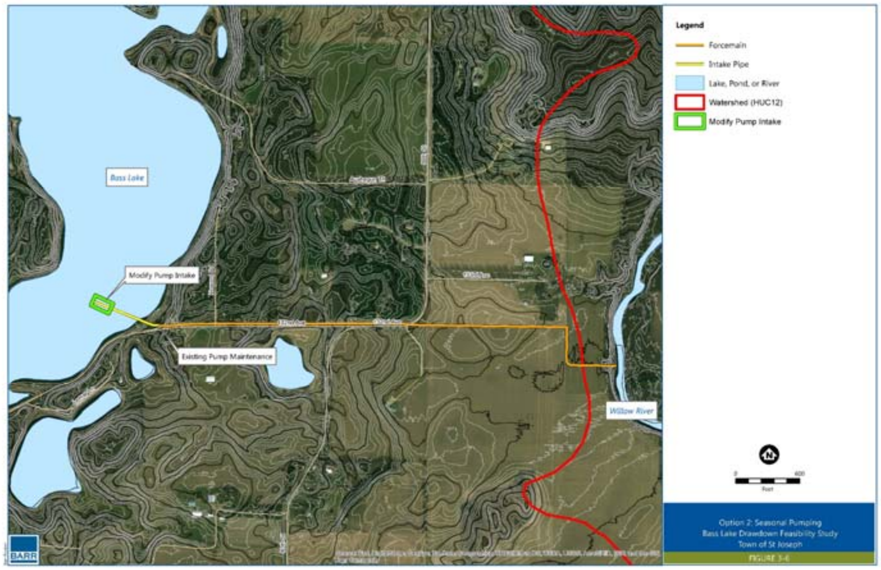
Option 1: Infiltration – Permitting

- **Chapter 283 Permit/Storm Water Associated with Land Disturbing Construction Activity (WI-S067831-5)** – for compliance with provisions of chapter 283, Wisconsin Statutes and chapters NR151 and NR216 of Wisconsin Administrative Code: Required for land disturbing activity affecting one (1) acre of more of land or pit/trench dewatering discharge from a construction site
- **Infiltration System – Wastewater Permit?? Stormwater Permit??**

Option 1: Infiltration – Costs

Option	Estimated Land/ Easement Purchase Cost	Estimated Construction Cost	Engineering & Design Cost	*Total Project Cost (-20%/+50%)*	*Annual Operation & Maintenance Cost*
Option 1a: Intake Modification and Infiltration at Englehart Property	$90,000	$1,708,000	$512,000	***$2,310,000 ($1,848,000 - $3,465,000)***	***$12,700***
Option 1b: Intake Modification and Infiltration at Orf Property	$90,000	$1,365,000	$410,000	***$1,865,000 ($1,492,000 - $2,798,000)***	***$12,700***

Option 2: Seasonal Pumping (Zebra Mussels/Phosphorus)



Seasonal Pumping: Water Quality & Discharge Restrictions

- Zero sum transfer of zebra mussels
  - Feb 2018 – veligers absent
  - Potential presence: May - September
- Discharge from Bass Lake must meet: 39 µg/L
    - Epilimnion TP Concentrations: 12 to 20 µg/L (long-term record)
    - Epilimnion TP concentration: 5.8 µg/L (February 2018)
    - Hypolimnion TP Concentrations (at intake): 31 - 107 µg/L (2017 summer)
    - Hypolimnion TP Concentration (at intake): 8.2 µg/L (February 2018)
  - Potential Elevated Hypolimnion TP: July – September/October

Option 2: Seasonal Pumping

- Includes intake modification
- Focus on pumping **November through April**
  - Zebra Mussel Veligers absent
  - Water quality should be below 39 ug/L
- Requires sampling (monthly?) before/during pumping
  - Temp, DO, Total Phosphorus, Veligers
- May also require chemical treatment of wet well/intake pipe before pumping

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Option 2: Seasonal Pumping – Costs

Option	Estimated Land/ Easement Purchase Cost	Estimated Construction Cost	Engineering & Design Cost	*Total Project Cost (-20%/+50%)*	*Annual Operation & Maintenance Cost*
Option 2: Intake Modification and Seasonal Pumping	$0	$273,000	$82,000	***$355,000 ($284,000 - $533,000)***	***$15,600***

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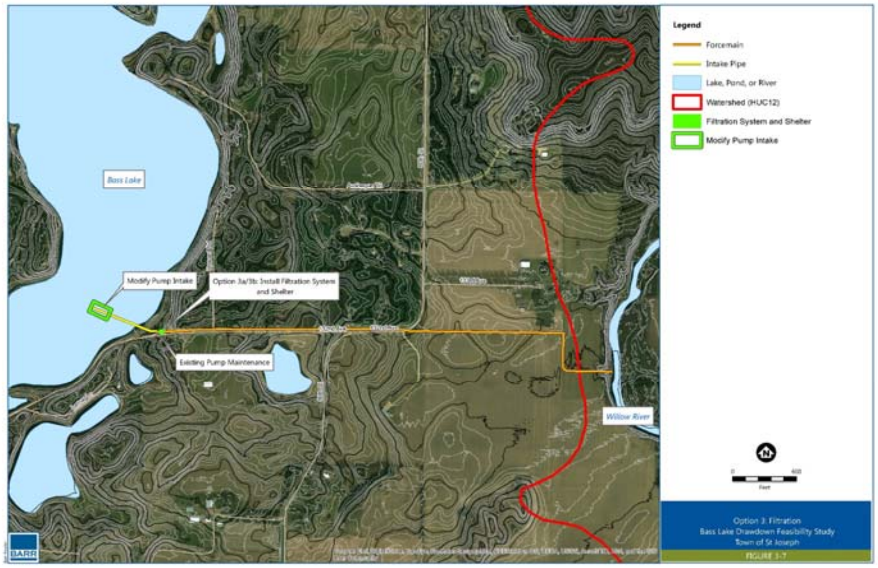
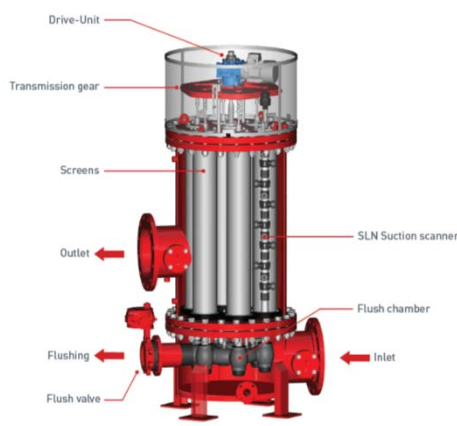
Option 3: Filtration & Seasonal Pumping (Zebra Mussels/Phosphorus)

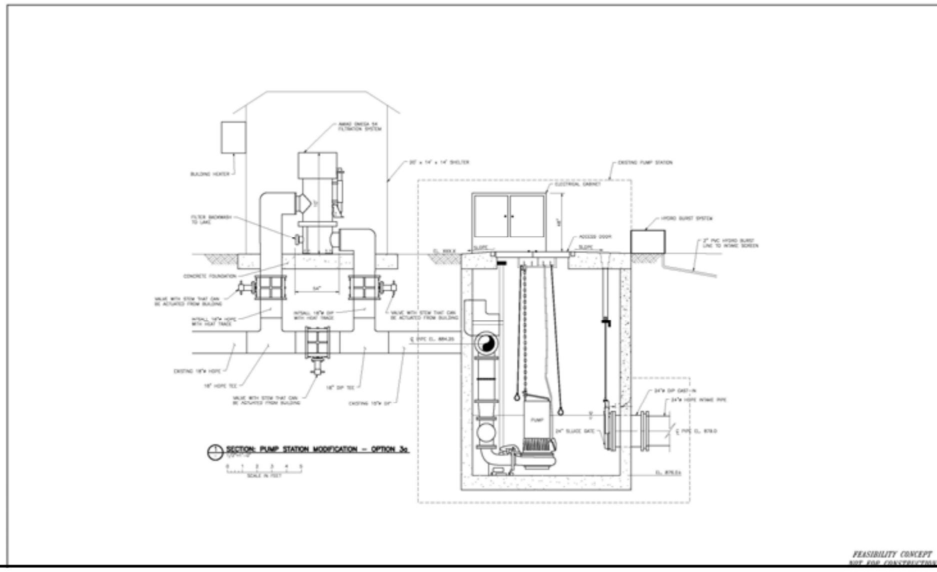


Option 3a: Filtration – AMIAD Omega 54000 Mechanical Filtration



- 40 µm removal
- Purchase and permanent installation
- No booster pump anticipated
- Automatic backwash (to lake)
- “Hands off” Operation

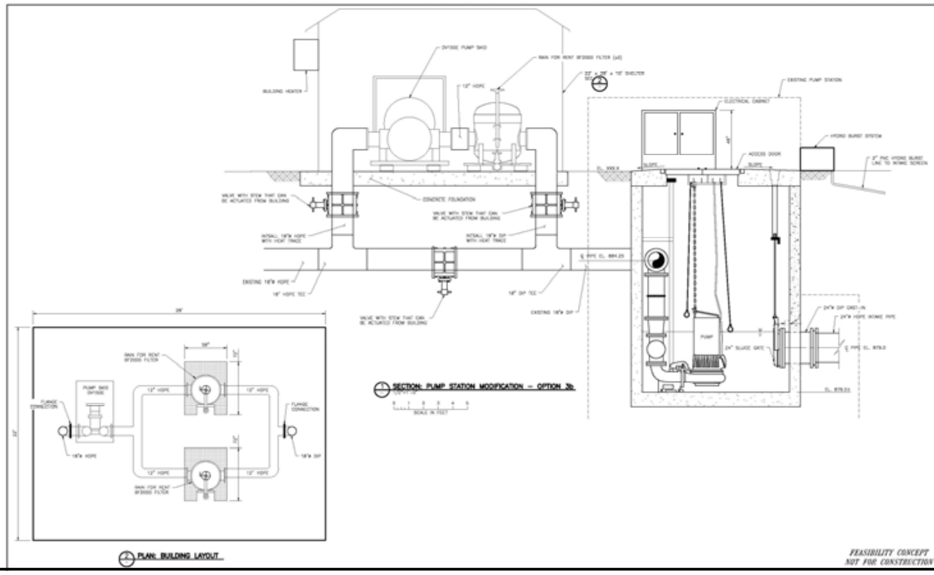
Option 3a: Filtration - Mechanical Filtration System AMIAD Omega 54000



Option 3b: Filtration - Rain-for-Rent Bag Filtration System

- 25 µm removal
- Some permanent installation/rental of temporary equipment
- Booster pump needed
- Bag filter – manual inspection (daily, potentially more frequently) and replacing bags as needed
- Very “Hands on” Operation

Option 3b: Filtration - Mechanical Filtration System Rain for Rent Bag Filtration System



Option 3: Filtration – Other Considerations

- Requires shelter/insulation for winter operation
- Does not address phosphorus removal so must be paired with seasonal pumping for water quality – **November – June operation**
- Additional easement may be needed
- Level of Operation and Maintenance
  – AMIAD (3a) automated, backwash to lake
  – Rain-for-Rent (3b) very hands on/manual maintenance, safety concerns

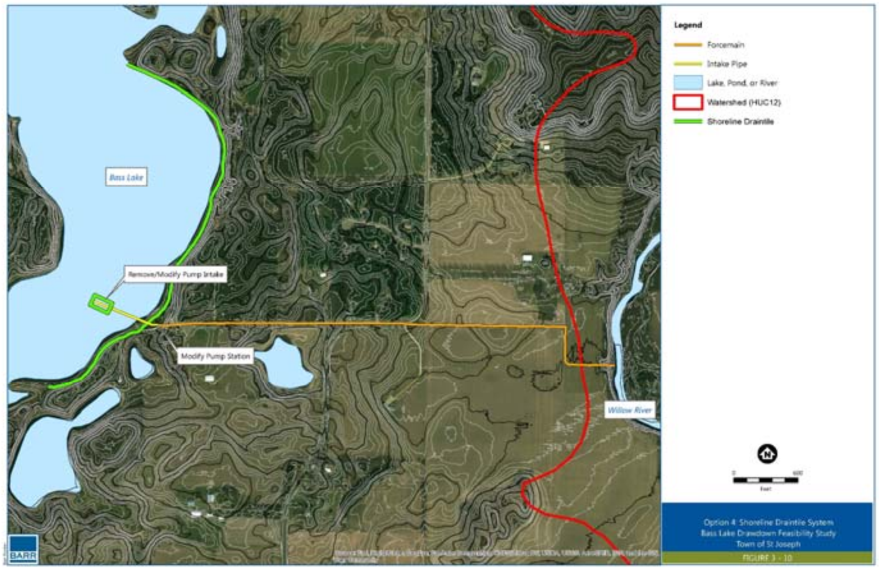
Option 3: Filtration – Permitting

- **Chapter 283 Permit/Storm Water Associated with Land Disturbing Construction Activity (WI-S067831-5)** – for compliance with provisions of chapter 283, Wisconsin Statutes and chapters NR151 and NR216 of Wisconsin Administrative Code: Required for land disturbing activity affecting one (1) acre of more of land or pit/trench dewatering discharge from a construction site
- **Town permits for shelter?**

Option 3: Filtration – Costs

Option	Estimated Land/ Easement Purchase Cost	Estimated Construction Cost	Engineering & Design Cost	*Total Project Cost (-20%/+50%)*	*Annual Operation & Maintenance Cost*
Option 3a: Intake Modification and AMIAD Filtration	$1,680	$854,000	$256,000	***$1,112,000 ($890,000 - $1,668,000)***	***$14,000***
Option 3b: Intake Modification and Rain for Rent Filtration	$3,696	$699,000	$210,000	***$913,000 ($890,000 -$1,668,000)***	***$95,200***

Option 4: Shoreline Drain Tile System



Option 4: Shoreline Drain Tile System

- **Constructability Concerns = Not Feasible**
  - Comparison of shoreline drain tile system (~4700 ft) against topography, system would have to be ~10 ft from water edge to minimize conflicts (still several conflicts with steep slopes)
  - Access to construct challenging/impossible at some locations (or from the water)
  - Depth of excavation for draintile results in wide trench that would impact steep slopes (slope stability and restoration concerns)
  - Dewatering needed to excavate the trench and if the soils are saturated sand, the trench walls could collapse
  - Require restoration of approximately one mile of shoreline
  - Easements from 8 property owners

Cost Summary

Option	Total Project Cost (-20%/+50%)	Annual Operation & Maintenance Cost
2018 Monitoring	$4,200	
Option 1a: Infiltration @ Englehart	$2,310,000 ($1,848,000 - $3,465,000)	$12,700
Option 1b: Infiltration @ Orf	$1,865,000 ($1,492,000 - $2,798,000)	$12,700
Option 2: Seasonal Pumping	$355,000 ($284,000 - $533,000)	$15,600
Option 3a: AMIAD Filtration	$1,112,000 ($890,000 - $1,668,000)	$14,000
Option 3b: Rain for Rent Filtration	$913,000 ($890,000 -$1,668,000)	$95,200
Option 4: Shoreline Draintile System	Determined to not be feasible – no cost estimate developed	

BARR

Discussion and Recommendations

1. 2018 Monitoring
2. Seasonal Pumping (including Intake Modification and Pump Maintenance)
3. AMIAD or Infiltration?

BARR

Schedule

task			est. completion date
1.0	data gathering and review		March 2, 2018
2.0	development and evaluation of options		April 27, 2018
3.0	meetings and project management	▪ kick-off meeting ▪ feasibility team meeting #1 ▪ feasibility team meeting #2 ▪ **town board meeting**	February 16, 2018 March 16, 2018 April 27, 2018 **May 10, 2018**
4.0	feasibility report	▪ **draft feasibility report** ▪ final feasibility report	**May 1, 2018** June 1, 2018

Appendix I

Town of St Joseph Board Meeting Presentation (5/10/2018)