Report

Phase II - Lagoon Water Quality Improvement Evaluation

Scope ID: 00G003

LPL-682-00

Bay Beach Wildlife Sanctuary
Green Bay, Wisconsin

June 2001

Foth & Van Dyke
consultants · engineers · scientists

Bay Beach Wildlife Sanctuary
Phase II - Lagoon Water Quality Improvement Evaluation

Contents

Figures

Appendices

1 Executive Summary

Foth & Van Dyke was retained by the City of Green Bay to conduct a study of water quality improvement alternative for the Bay Beach Wildlife Sanctuary lagoons. The City received a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) which provided funding up to $10,000 for this project.

This evaluation and report focused on evaluation of alternatives to meet specific water quality goals. These goals were developed with WDNR to improve the water quality for the overall health of the water resource and enable a self sustaining warm water fishery to exist in the lagoon.

Water Quality Goals

Water quality goals were established through the cooperative input from the WDNR, Bay Beach Wildlife Sanctuary and Foth & Van Dyke water resource specialists. The intent of the water quality goals were set to establish a warm water fishery and improve general water quality. The goals were:

Dissolved Oxygen	>5.0 mg/l
Total Phosphorus	<100 ug/l
Chlorophyll a	<40 ug/l
Ammonia Nitrogen	<1.0 mg/l

Alternative Analysis

Alternatives were evaluated to increase the dissolved oxygen concentration by external aeration and removal of organic deposits that require oxygen for biological degradation. To meet the phosphorus goal, chemical treatment, removing waterfowl fecal deposits, and clean water addition were evaluated. Chlorophyll a will decrease with a lower phosphorus concentration but additional alternatives include chemical treatment, zebra mussels and barley straw for algae growth inhibition. Ammonia nitrogen will be reduced with the increase in dissolved oxygen and removal of fecal deposits. Costs for the most feasible options were developed and evaluated.

Cost and Impact Analysis

In-lake aeration was the most cost-effective alternative for oxygen addition. This alternative also reduces ammonia concentrations to meet water quality goals. The estimated capital cost for this alternative is $60,000 with annual operating costs of $2,500.

Fecal deposit removal was evaluated utilizing hydraulic removal methods with a settling pond for dewatering was the cost-effective alternative. This alternative will reduce oxygen demand from the deposits and reduce the phosphorus concentration contributed by the deposits. The estimated capital cost for this alternative is $500,000.

Water addition was evaluated to provide an fresh source of water, with a lower phosphorus content and thus reduce the phosphorus concentration in the lagoon. Water sources evaluated include the Fox River, Green Bay, Green Bay Metropolitan Sewerage District effluent, and shallow groundwater near the sanctuary. The least cost alternative is the shallow groundwater option. Soil testing will be required to determine the size of the groundwater collection trench and the estimated water availability. The estimated cost for the shallow groundwater alternative is $300,000 with annual operating costs of $6,000.

Recommendations and Implementation

The in-lake aeration system was recommended with implementation for the winter of 2001. Fecal deposit removal was recommended with implementation in the fall of 2001 and spring of 2002. Soil testing for shallow groundwater pumping was recommended for the fall of 2001 and implementation in the fall of 2002.

Lake Protection Grant funds were recommended for funding projects in 2001 and 2002. Other sources of funds and in-kind services will be needed to finance the entire project.

2 Introduction

The Bay Beach Wildlife Sanctuary lagoons are located in the City of Green Bay, Brown County, Wisconsin. The lagoons cover an area of 42 acres with the main lagoon having a surface area of 14.9 acres, a maximum depth of 12 feet, and an average depth of 4.1 feet.

In April 2000, the City of Green Bay was awarded a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) to evaluate alternatives for improving the water quality of the Bay Beach Wildlife Sanctuary lagoons.

2.1 Authorization

The City of Green Bay authorized the consulting firm of Foth & Van Dyke to complete Phase II of the lagoon study for the Wildlife Sanctuary, and to prepare a report identifying the results. The study resulted in a collaborative effort among Foth & Van Dyke, the Bay Beach Wildlife Sanctuary staff, and WDNR personnel.

2.2 Purpose

The purpose of the Phase II lake study was to address the following areas.

- Develop water quality goals which will allow a designated fishery to be maintained.
- Evaluate the appropriate methods for achieving the water quality goals.
- Evaluate costs and environmental impacts of the alternatives for improving water quality.
- Provide recommendations and an implementation plan for achieving the water quality goals.

The results of this study will be used to provide the City with a plan for achieving the water quality goals and ultimately restoring the lagoon to a healthy and fishable resource available for use to the community.

3 Existing Conditions

The Phase I report identified the existing conditions of the lagoon and the surrounding watershed. A summary of that study is presented below:

3.1 Water Quality

A water quality sampling program was implemented to determine the lake's water quality and trophic status. The Bay Beach lagoon can be described as highly eutrophic based on the high concentrations of phosphorus and algae in the water. Other parameters such as dissolved oxygen and water clarity were also typical of highly eutrophic lakes.

3.2 Fecal Deposits

Soft organic material, primarily from waterfowl fecal deposits in the lagoon, was noted up to 4 feet thick in some places. Based on fecal deposit measurements, it is estimated that the main lagoon contains over 39,000 cubic yards of material. The material contains significant amounts of organic matter, Biochemical Oxygen Demand (BOD), and phosphorus. The organic matter which is measured in the BOD analysis can reduce the dissolved oxygen concentrations in the lagoon. The phosphorus in the deposits are also reintroduced into the water column further promoting algae growth.

3.3 Watershed Analysis

The watershed associated with the lagoon is 283 acre in size. Less than 20% of the area is developed. Other land uses are forests and grasslands. The overall result is little impact from the watershed on the lagoon with an estimated 8 pounds per year of phosphorus contributed to the lagoon from the watershed.

3.4 Waterfowl Impacts

Large numbers of resident and migratory waterfowl use the lagoons for a resting area. Peak populations of over 7,000 Giant Canada geese and over 4,000 mallard ducks use the sanctuary with about ⅔ of the total waterfowl using the main lagoon. This results in approximately 57 tons of fecal matter including over 1,700 pounds of phosphorus being added each year by waterfowl. The phosphorus contribution from waterfowl is significantly greater than any other impact on the water quality of the lagoon. Waterfowl also damage vegetation along the shoreline which has led to erosion on the south side of the main lagoon.

4 Water Quality and Fishery Goals

A water quality evaluation for the Bay Beach main lagoon was completed as part of Phase I. The evaluation concluded that the water quality was highly eutrophic and the lagoon was not capable of supporting a warm water sport fishery. The limiting factors were lack of oxygen, high algae growth, and high ammonia concentrations.

4.1 Fishery Goals

Representatives from Bay Beach Wildlife Sanctuary, Wisconsin Department of Natural Resources, and Foth & Van Dyke met to discuss alternatives for establishing a fishery and the water quality necessary to support a fishery. There are three types of fisheries that could be implemented in the Bay Beach lagoon:

- Put and take early season trout fishery
- Put and take warm water fishery
- Self sustaining warm water fishery

Since the lagoon had a self sustaining warm water fishery at one time, the selected goal was to return the lagoon to a self sustaining warm water sport fishery with a secondary alternative for a put and take trout fishery.

4.2 Water Quality Goals

Water quality improvements must be made to achieve the goal of a self sustaining warm water fishery. The following goals were set by the same group involved in the fishery evaluation.

4.2.1 Phosphorus

A phosphorus concentration of 100 ug/l or less was established as a goal to improving water quality and allowing a warm water fishery development. Current phosphorus concentrations are 800 to 1,000 ug/l in the main lagoon. The phosphorus concentration goal would reduce algae growth and improve water clarity. Improved clarity will promote rooted aquatic plant development, which in turn will provide shelter for fish and food for waterfowl.

4.2.2 Dissolved Oxygen

A goal of 5 mg/l or greater of dissolved oxygen was recommended for sustaining a warm water fishery. In addition, if trout were stocked in spring, the dissolved oxygen level would need to be equal to or greater than 6 mg/l. Dissolved oxygen should be maintained at established goals throughout the winter.

4.2.3 Chlorophyll a

Chlorophyll a concentrations have ranged up to 280 ug/l. A goal of 40 ug/l was established which should be possible given the phosphorus reduction goals.

4.2.4 Ammonia Nitrogen

Ammonia, at certain water pH conditions, is a toxic compound to fish. An ammonia concentration of 1.0 mg/l or less was established for the lagoon. Ammonia concentrations are high only when dissolved oxygen is absent. Maintaining proper dissolved oxygen levels will minimize the impact of ammonia on the fishery.

5 Water Quality Improvement Alternatives

Numerous alternatives are available to improve water quality in the main Bay Beach lagoon. The water quality goals established in Section 4 will require more than one improvement to accomplish all the goals. In the following section, alternatives are identified and discussed for each of the water quality improvement goals.

5.1 Phosphorus Reduction

Phosphorus is present in the water column and in the sediment. The primary source of phosphorus is waterfowl defecation. Phosphorus can be reduced in the lagoon by removing sediment, chemically treating the water, provide a low phosphorus external water source for flushing the lagoon, and by reducing the source of phosphorus inputs. This report presents alternatives for reducing existing phosphorus levels but does not evaluate the methods for reducing the waterfowl population as a phosphorus source. A task force has been established by the personnel at the Bay Beach Wildlife Sanctuary to evaluate methods for reducing the waterfowl population at the Sanctuary.

5.1.1 Fecal Material Removal

Fecal material from waterfowl settles to the lagoon bottom. This material acts to remove dissolved oxygen from the lagoon and in addition the material decomposes and releases phosphorus and ammonia into the water column where both the phosphorus and nitrogen are available to algae for growth. Removing the fecal material will provide a positive benefit by removing a source of phosphorus, nitrogen and oxygen demand from the lagoon.

5.1.2 Chemical Treatment of Surface Water

Lakes and lagoons can be chemically treated to remove phosphorus. The most common chemical is aluminum sulfate (alum). The alum reacts with dissolved phosphorus to form a precipitate. The precipitate settles to the bottom of the lagoon and stays in a solid form which is not available to the algae. Alum can be added in a liquid form but will need to be mixed throughout the lagoon. This is typically done with a motor boat that discharges the alum all through the lagoon and mixes the alum with the water as the boat moves.

This chemical treatment procedure has been successful in several lakes and lagoons. It is most often used when the phosphorus influx has been removed and the chemical precipitation has the potential for a long term reduction of phosphorus from the surface water. This process may need to be repeated if the source of phosphorus is not sufficiently controlled and therefore is not a suitable alternative for this application.

5.1.3 External Water Addition

Adding a significant amount of low phosphorus water from an external source can have a positive effect on the phosphorus concentration in the lagoon. The existing lagoon system has a long detention time and no regular discharge. Providing an external water source will reduce the detention time and maintain a higher water quality resource.

The amount of external source water needed varies significantly from one location to another. In general, a lake with a detention time of 14 days or longer will have algae that react in direct response to the amount of phosphorus in the water. If the detention time in the lagoon is 7 days or less, the amount of algae will be controlled by the reduction in detention time in addition to the reduction in the phosphorus concentration. The lagoon volume is estimated at 19 million gallons. The amount of external water needed to achieve a detention time of 7 days is about 1800 gallons per minute. The water addition alternative will also be evaluated at a detention time of about 21 days or 600 gpm.

Five external water sources were evaluated for discharging into the lagoon. The first source is a new high capacity groundwater well which is a good source of clean water. This alternative was eliminated due to the large amount of water needed from a well of this type and the limited aquifer capacity.

The Fox River or the waters of Green Bay are two additional potential sources of surface water. These water bodies have phosphorus concentrations below 100 ug/l which meets the water quality goals for the lagoon. A disadvantage of this water source is fish from these waters have consumption warnings. Establishing an urban fishery should also include being able to eat the fish that are caught. Both of these options will be evaluated for cost and other factors.

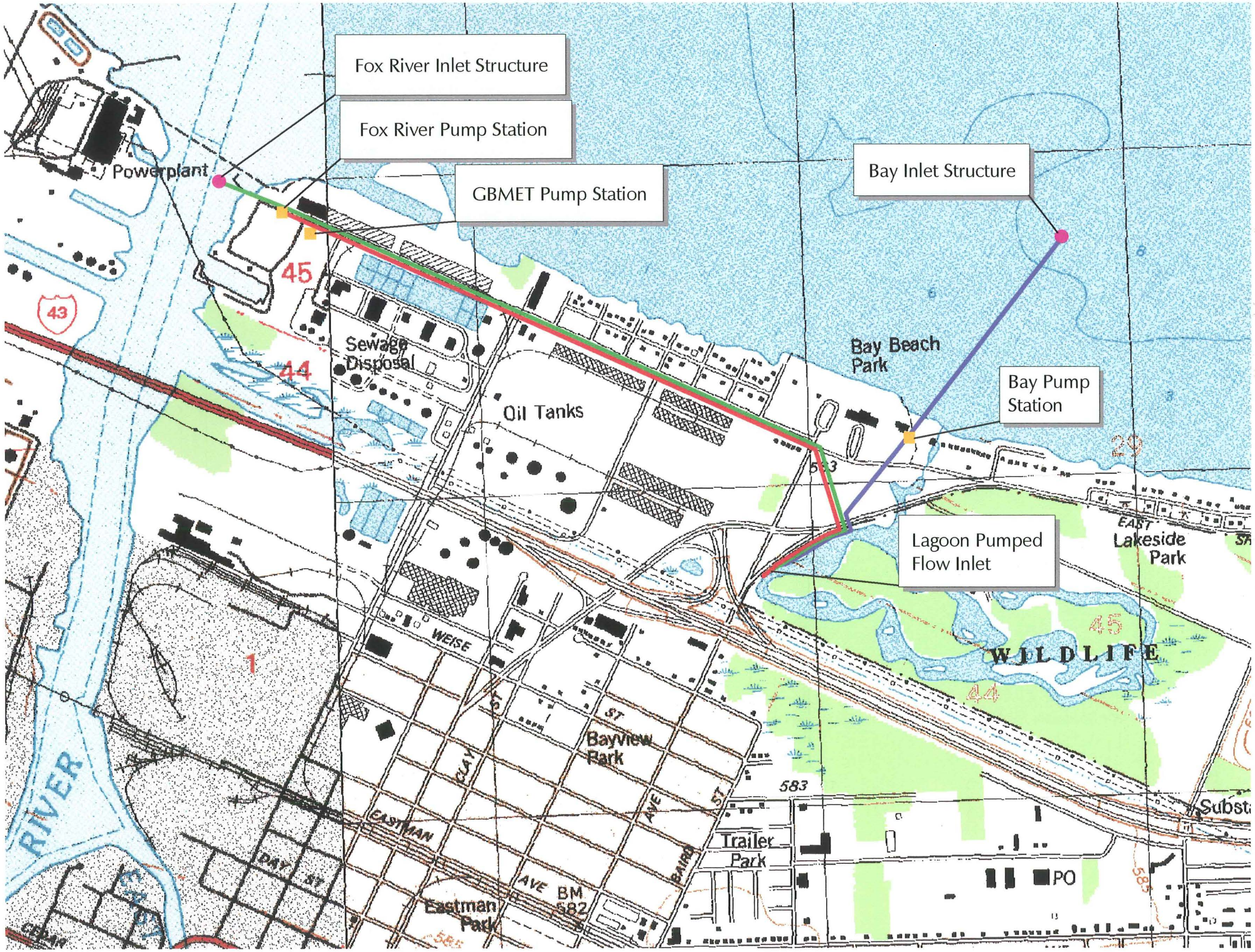
A fourth water source is treated water from the Green Bay Metropolitan Sewerage District. While this water is low in organic compounds, suspended solids and ammonia, the phosphorus concentration averages 300 ug/l. The advantage of this water source is it does not contain the potential contaminants and exotic species found in the Fox River and Green Bay. This alternative will be evaluated for cost and other factors.

Figure 5-1 shows the potential surface water sources and the associated pumping and piping facilities.

The fifth potential water source is a shallow groundwater source. If surface soils are permeable and are near a water source, the water can be obtained through a trench drain system and pumped to the lagoon. This alternative will be evaluated for cost and other factors.

FIGURE 5-1
SURFACE WATER ADDITION ALTERNATIVES

Bay Beach Wildlife Sanctuary
Brown County, Wisconsin



- Bay Water
- GBMET Water
- River Water
- Pump Station
- Inlet Structures

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

Source: U.S.G.S. 7.5-minute topographic quadrangle - Green Bay West, Green Bay East (1982).

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M:\00g003\apr\baybeach2.apr April 6, 2001 Drawn by: kpk1 Checked by: jjf1

5.2 Increase Dissolved Oxygen

Dissolved oxygen is limiting the ability of fish to survive in the lagoon. There are several means of adding oxygen to the lagoon. Oxygen can be transferred to water by pumping water from the lagoon to a cascade or spray system. The water is splashed and oxygen is transferred to the water. An alternative to this system is to pump air into the water. The air is diffused into the water, transferring oxygen. Foth & Van Dyke has analyzed both types of oxygen transfer systems and found it is less expensive to pump air into water. Adding dissolved oxygen by subsurface aeration will be evaluated for cost and other factors.

Another means of increasing the dissolved oxygen is to remove the biochemical oxygen demand (BOD) and ammonia from the water. This can be done by treating the lagoon water to remove the organic material and convert ammonia to nitrate. Low technology systems such as a recirculating sand filter or constructed wetlands need considerable land and must be operated well to be effective. These systems also work best in warmer weather and will provide minimal treatment in winter due to the cold lagoon water temperatures.

Providing aeration in the lagoon will accomplish the same function as a separate treatment system and will do so more cost effectively. Only lagoon aeration through a system which pumps air into water will be evaluated for oxygen improvement.

5.3 Algae Reduction (Chlorophyll a)

In addition to controlling the amount of phosphorus in the lagoon, there are alternatives for directly reducing the amount of algae in the lagoon. Copper sulfate can be used to kill algae and has proven to be an effective lake management tool. This option can have negative side effects if used in large quantities since copper can be toxic at higher concentrations.

There are also natural methods of algae reduction. One new method is the use of zebra mussels. These organisms filter algae out of the water as a food source. As an exotic species however, there may be negative qualities associated with the mussels such as the generation of high volumes of old shells and the associated removal costs. This option will not be evaluated further.

Another natural method that has had some success is the use of barley straw. This organic material contains a natural inhibitor which prevents algae from reproducing. Barley straw has been tried at wastewater lagoons in Wisconsin with mixed success. To implement this alternative, barley straw "logs" would need to be made and suspended across the lagoon. This is both labor intensive and an aesthetic problem that will interfere with the fishery. This alternative will not be evaluated further.

The large amounts of BOD and phosphorus in the waterfowl fecal material can contribute to the poor water quality in the lagoon. The BOD will remove oxygen from the lower water levels and the decaying fecal material will release phosphorus into the water which contributes to the excessive algae growth. Long term improvements to the water quality of the lagoon must address the impact the fecal material has on the water quality of the lagoon. Fecal material removal will be further evaluated in the cost and impact section of this report.

5.4 Ammonia Reduction

Ammonia is a natural nitrogen compound and is a product of biological decomposition. Ammonia remains in solution if the water is anoxic. If oxygen is available, bacteria convert ammonia to nitrate. Ammonia is toxic to fish and other organisms. The water quality will be improved if ammonia is eliminated from the lagoon. The method for accomplishing this is to provide aeration and keep the lagoon aerobic. If the aeration provided for dissolved oxygen is in operation, ammonia levels should be low. The fecal material removal will also reduce the source of nitrogen from the surface water. Ammonia reduction will be addressed in the evaluation of lagoon aeration and fecal material removal.

6 Cost and Impact Analysis

Section 5 identified alternatives for further evaluation. This section evaluates and develops capital costs and, where appropriate, operating costs for each alternative. The detail costs are shown in Appendix A.

6.1 Supplemental Oxygen (In Lake Aeration)

6.1.1 Fecal Material Removal

Removing the fecal material deposited from the waterfowl is an important part of improving the water quality. There are several methods of material removal including pumping the material as a slurry or excavating the material as a dry product. In either case, the material may be relatively high in nitrogen. The material will need to be tested to determine the nitrogen concentration and design the final disposal to avoid excessive nitrogen loading and the potential of groundwater infiltration by nitrogen from the fecal material.

Fecal material removal in slurry form will require a pump and auger system. The material will be pumped to a sedimentation pond where the material will dewater and the liquid will flow to a surface water. Bay Beach Wildlife Sanctuary owns land east of the visitor center that could be used for a sedimentation pond. The material will settle in the pond and be allowed to dry before final disposal. The Bay Beach Wildlife Sanctuary has about 60 acres of land available for soil spreading. If more land is needed, the material will need to be trucked and spread at a remote site. The cost for this alternative includes a hydraulic material removal system, a booster pump and pipeline, a sedimentation pond, and decant structure. Approximately 30,000 cubic yards of fecal material are estimated for removal from the main lagoon. The estimated cost for this alternative including engineering design work is $500,000

Fecal material removal in a solid form requires a dragline or backhoe to excavate the solids from the lagoon. The solids would be trucked to a suitable disposal area and spread. The estimated cost for this alternative including engineering design work is $720,000.

From this analysis, the slurry material removal alternative is less costly and is the recommended approach for material removal. The cost estimate assumes that material will be contained and spread on city property as necessary.

6.1.2 External Water Addition

Cost estimates were developed for the external water addition alternative. Specific water addition alternatives are described in detail below.

6.1.2.1 Fox River Source

Water from the Fox River can be used for water addition and flushing of the main lagoon. The distance from the Fox River to the lagoon is about 7,500 feet. Costs include a chemical feed system for the water inlet to prevent plugging by zebra mussels and a pumping system. The estimated cost for a system to provide about 600 gpm is $1,060,000. If a flow of 1,800 gpm is used, the cost increases to $1,360,000. Annual operation and maintenance costs for the two options are estimated at $11,000 and $33,000 respectively. The operation and maintenance of the system includes power for pumping, chemicals for disinfection, and maintenance of equipment.

6.1.2.2 Bay of Green Bay Source

Water from the Bay of Green Bay can be used for water addition and flushing of the main lagoon. The distance from the Green Bay to the lagoon is about 2,200 feet. However, the intake must be located deep enough to avoid ice damage. The distance needed to reach this depth is an additional 2,200 feet. This underwater pipe will be installed using a directional drilling technique. Costs include a chemical feed system for the water inlet to prevent plugging by zebra mussels and a pumping system. The estimated cost for a system to provide about 600 gpm is $1,150,000. If a flow of 1,800 gpm is used, the cost increases to $1,382,000. Annual operation and maintenance costs for the two options are estimated at $11,000 and $33,000 respectively. The operation and maintenance of the system includes power for pumping, chemicals for disinfection, and maintenance of equipment.

6.1.2.3 GBMSD Effluent Source

Water from the GBMSD effluent pipe can be used for water addition and flushing of the main lagoon. The distance from GBMSD to the lagoon is about 7,500 feet. The estimated cost for a system to provide about 600 gpm is $795,000. If a flow of 1,800 gpm is used, the cost increases to $1,060,000. Annual operation and maintenance costs for the two options are estimated at $6,000 and $15,000 respectively. The operation and maintenance of the system includes power for pumping and maintenance of equipment. The lower cost for this option reflects the lack of a chemical disinfection system for zebra mussels since GBMSD already provides disinfection.

6.1.2.4 Shallow Groundwater Source

This alternative was estimated assuming 2,000 feet of trench drain terminating at a pumping station. The trench drain would be approximately 10 feet deep and have a perforated pipe at the bottom of the trench. The trench above the pipe would be backfilled with gravel and filter fabric to encourage water to reach the perforated pipe. The trench drain and pumping station were assumed to be located near the entrance to the Bay Beach amusement park. The force main to the lagoon was approximately 1,600 feet long. The estimated cost for this system is $300,000. Operation and maintenance costs for this alternative are estimated at $6,000 for pumping and equipment maintenance.

The flow rate that can be expected from a system of this type will depend on the soil permeability and the length of trench. Since the shallow trench system can be significantly less expensive than the other water sources, it is recommended to pursue this option by conducting more detailed soil analysis. The estimated cost for conducting a soil analysis is estimated at $20,000.

6.2 Supplemental Oxygen (In Lake Aeration)

The entire lagoon becomes anoxic in winter and remains anoxic in summer at depths below 3 feet. Subsurface aeration, which pumps air into the water, is the recommended approach to providing adequate oxygen for maintaining a fishery.

The aeration equipment will consist of a blower mounted in a small building. The building will provide weather protection for the blower and reduce the sound made by the equipment. The blower will discharge to three separate air lines that will be buried along shore until they extend into the water. The air lines will be weighted to sink in the water and terminate at the deepest parts of the lagoon.

The cost for the aeration alternative includes blower equipment, piping, a building, electrical equipment, site work, and engineering. The estimated cost for supplemental oxygen addition is $60,000. The annual operating cost is estimated at $2,000.

7 Recommendations and Implementation

7.1 Recommendations for Phosphorus Reduction

7.1.1 Remove Fecal Material

Material deposited from waterfowl defecation contain large amounts of phosphorus, nitrogen and oxygen demanding organic material. Approximately 39,000 cubic yards of material resides at the bottom of the lagoon. The material will have a negative impact on the water quality if it remains in the lagoon. For this reason it is recommended to remove most of the fecal material (up to 30,000 cubic yards) from the lagoon. The most cost-effective approach for material removal is to pump the material to a settling basin located on the east end of the Bay Beach Wildlife Sanctuary property with subsequent land spreading.

7.1.2 Soil Testing for Shallow Groundwater Pumping

The existing lagoon system has a long detention time since there is a small watershed and no normal outlet for the lagoons. Adding water will provide flushing to reduce the concentrations of phosphorus and nitrogen. A most cost-effective approach is to construct groundwater collection trenches and pump the water to the lagoon. The water will flow around the lagoon system and discharge to the nearby storm sewer.

The design of a collection trench for shallow groundwater depends on the soil type and groundwater levels. Foth & Van Dyke recommends an engineering phase of this work be conducted to evaluate soil conditions for use as a trench drain. If the testing shows that the trench is a viable option, plans can be developed to proceed with design and construction.

7.1.3 Erosion Protection

The erosion on the south shore of the lagoon should be protected with rip-rap. Approximately 900 feet of eroded shoreline needs to be protected.

7.2 Recommendations for Increased Dissolved Oxygen

7.2.1 Install In-Lake Aeration

The Phase I report identified anoxic conditions in the lagoon below three feet in summer and over the entire water column in winter. Ammonia levels were also high in the anoxic zones which may lead to toxicity to aquatic organisms. The existing dissolved oxygen concentration does not meet the water quality goal of 5 mg/l needed for a warm water fishery. Providing aeration to the lagoon will raise the dissolved oxygen concentration, eliminate anoxic conditions, and reduce ammonia levels below the toxic range. The cost analysis showed in-lake aeration to be less costly than other types of aeration. In-lake aeration should be installed at several locations in the lagoon and operated throughout the year. Figure 7-1 shows the recommended plan for Bay Beach Wildlife Sanctuary.

7.3 Implementation

7.3.1 Obtain Lake Protection Grant

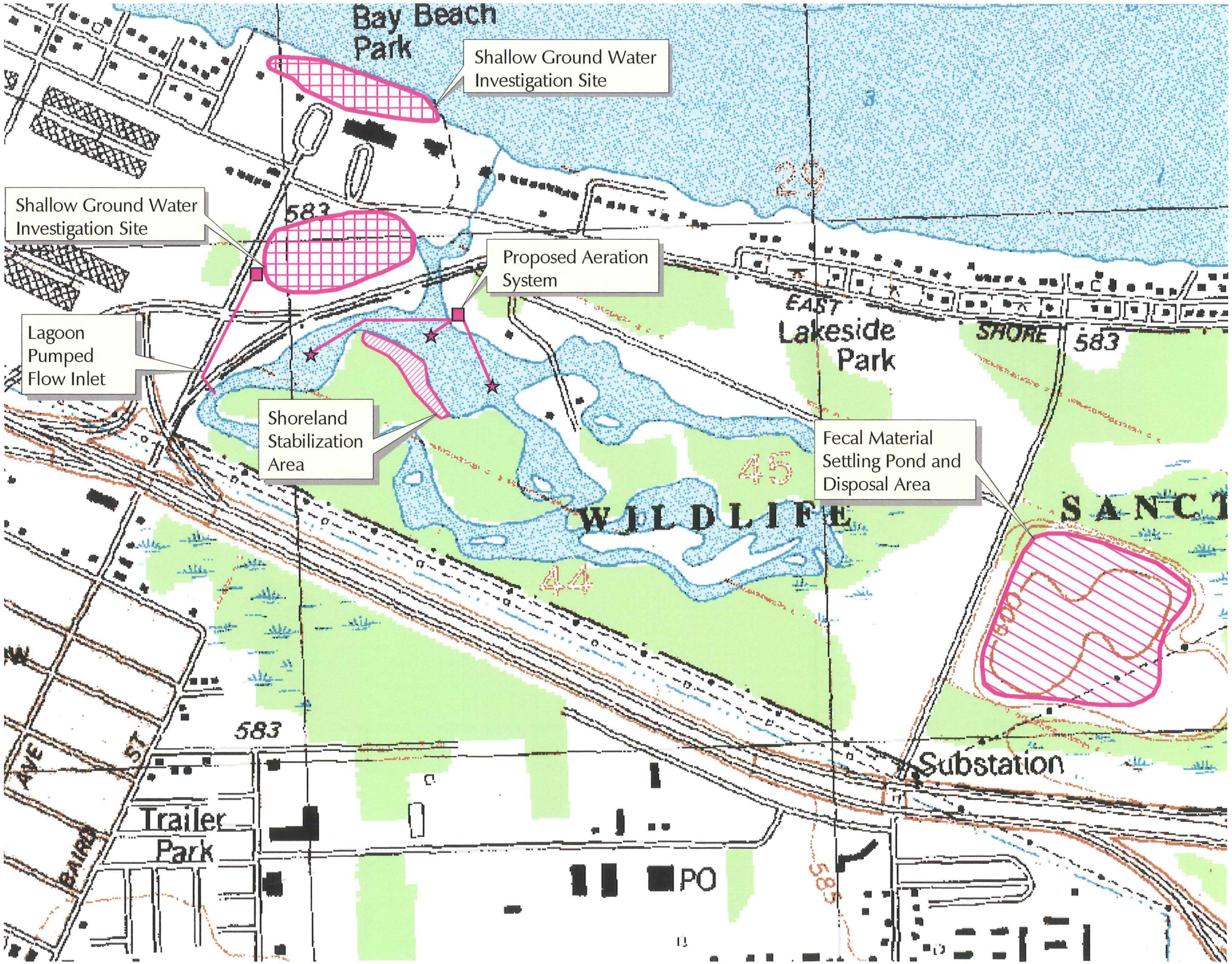
A WDNR funded program for lake improvement construction projects is available. It is recommended that Bay Beach Wildlife Sanctuary apply for a Lake Protection Grant to cover a portion of the recommended action items. This application should be submitted for the May 1, 2001 grant application deadline.

The project funding should be directed to four areas; installation of in-lake aeration equipment, fecal material removal, shoreline protection, and technical evaluation of shallow groundwater collection. The funds from the grant should be used to purchase and install the aeration system. It is anticipated that the aeration system should be in place for the winter of 2001-2002. The Wildlife Sanctuary will need to include the operation and maintenance cost for the aeration system in their annual budget.

Grant funds should also be used for fecal material removal. The cost of this project phase will exceed the ability of the Lake Protection Grant. The Bay Beach Wildlife Sanctuary will need to obtain funding for this phase of the project from other sources in addition to the Lake Protection Grant. If funding is obtained, the fecal material removal can be done in the fall of 2001 or in the summer of 2002.

Lake Protection Grant funds should be used to develop the technical approach for shallow groundwater pumping to supply water to the lagoon. This work should be done in the fall of 2001 to develop design parameters and revised costs for this alternative. This should be complete in time to submit an application for a Lake Protection Grant in May 2002. Construction of a water supply system to the lagoon could be completed in the fall of 2002 or spring of 2003.

FIGURE 7-1
RECOMMENDED PLAN
Bay Beach Wildlife Sanctuary
Brown County, Wisconsin



- ■ Blower Structure
- ★ Aeration Sites

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

Source: U.S.G.S. 7.5-minute topographic quadrangle - School Hill (1973).
Classification derived from LANDSAT Thematic Mapper (TM) satellite imagery from 1991, 1992, and 1993.
The classification has been smoothed to a one acre minimum mapping unit (4 contiguous pixels) from the original 30-meter pixel size.
Wetlands less than one acre and open water pixels were not smoothed.
Classification was done by the Wisconsin DNR - Geo Services Section.
Watershed delineation done by Foth and Van Dyke, 2000.

0 200 400 600 800 1000 Feet

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M:\00g003\apr\baybeach2.apr April 30, 2001 Drawn by: kpk1 Checked by: pak

Appendix A

Cost Estimates

BAY BEACH WILDLIFE SANCTUARY
WATER ADDITION

FOX RIVER - 7 DAY DETENTION TIME IN LAGOON

ITEM DESCRIPTION	Quantity	Unit	Unit Cost	Cost
Inlet Structure	1	ea	$10,000	$10,000
Suction Piping	600	lf	$200	$120,000
Chlorination System Equipment	1	ea	$26,000	$26,000
Sodium Bisulfite Feed Equipmen	1	ea	$26,000	$26,000
Chlorination System Piping	1	ea	$4,000	$4,000
Chemical Feed Building	1	ea	$40,000	$40,000
Pump	1	ea	$11,000	$11,000
Wet Well	1	ea	$13,000	$13,000
Forcemain Piping - Bored	5750	lf	$100	$575,000
Forcemain Piping - Trenched	1750	lf	$70	$122,500
Pump Mechanical Installation	1	ea	$13,000	$13,000
Pump Electrical & Instrumentati	1	ea	$13,000	$13,000
Land	0.1	acres	$40,000	$4,000
Earth Berm at Effluent Structure	1	ea	$6,000	$6,000
Total Construction				$983,500
Technical, Legal, Contingency				$393,400
Total Capital Cost				$1,376,900

BAY BEACH WILDLIFE SANCTUARY
WATER ADDITION

FOX RIVER - 21 DAY DETENTION TIME IN LAGOON

ITEM DESCRIPTION	Quantity	Unit	Unit Cost	Cost
Inlet Structure	1	ea	$10,000	$10,000
Suction Piping	600	lf	$160	$96,000
Chlorination System Equipment	1	ea	$26,000	$26,000
Sodium Bisulfite Feed Equipmen	1	ea	$26,000	$26,000
Chlorination System Piping	1	ea	$4,000	$4,000
Chemical Feed Building	1	ea	$40,000	$40,000
Pump	1	ea	$11,000	$11,000
Wet Well	1	ea	$13,000	$13,000
Forcemain Piping - Bored	5750	lf	$75	$431,250
Forcemain Piping - Trenched	1750	lf	$45	$78,750
Pump Mechanical Installation	1	ea	$13,000	$13,000
Pump Electrical & Instrumentati	1	ea	$13,000	$13,000
Land	0.1	acres	$40,000	$4,000
Earth Berm at Effluent Structure	1	ea	$6,000	$6,000
Total Construction				$772,000
Technical, Legal, Contingency				$308,800
Total Capital Cost				$1,080,800

BAY BEACH WILDLIFE SANCTUARY
WATER ADDITION

GREEN BAY - 7 DAY DETENTION TIME IN LAGOON

ITEM DESCRIPTION	Quantity	Unit	Unit Cost	Cost
Inlet Structure	1	ea	$10,000	$10,000
Suction Piping	2200	lf	$300	$660,000
Chlorination System Equipment	1	ea	$26,000	$26,000
Sodium Bisulfite Feed Equipmen	1	ea	$26,000	$26,000
Chlorination System Piping	1	ea	$16,000	$16,000
Chemical Feed Building	1	ea	$40,000	$40,000
Pump	1	ea	$11,000	$11,000
Wet Well	1	ea	$13,000	$13,000
Forcemain Piping - Bored	200	lf	$100	$20,000
Forcemain Piping - Trenched	2000	lf	$70	$140,000
Pump Mechanical Installation	1	ea	$13,000	$13,000
Pump Electrical & Instrumentati	1	ea	$13,000	$13,000
Land	0.1	acres	$40,000	$4,000
Earth Berm at Effluent Structure	1	ea	$6,000	$6,000
Total Construction				$998,000
Technical, Legal, Contingency				$399,200
Total Capital Cost				$1,397,200

BAY BEACH WILDLIFE SANCTUARY
WATER ADDITION

GREEN BAY - 21 DAY DETENTION TIME IN LAGOON

ITEM DESCRIPTION	Quantity	Unit	Unit Cost	Cost
Inlet Structure	1	ea	$10,000	$10,000
Suction Piping	2200	lf	$250	$550,000
Chlorination System Equipment	1	ea	$26,000	$26,000
Sodium Bisulfite Feed Equipmen	1	ea	$26,000	$26,000
Chlorination System Piping	1	ea	$16,000	$16,000
Chemical Feed Building	1	ea	$40,000	$40,000
Pump	1	ea	$11,000	$11,000
Wet Well	1	ea	$13,000	$13,000
Forcemain Piping - Bored	200	lf	$75	$15,000
Forcemain Piping - Trenched	2000	lf	$45	$90,000
Pump Mechanical Installation	1	ea	$13,000	$13,000
Pump Electrical & Instrumentati	1	ea	$13,000	$13,000
Land	0.1	acres	$40,000	$4,000
Earth Berm at Effluent Structure	1	ea	$6,000	$6,000
Total Construction				$833,000
Technical, Legal, Contingency				$333,200
Total Capital Cost				$1,166,200

BAY BEACH WILDLIFE SANCTUARY
WATER ADDITION

GBMSD - 7 DAY DETENTION TIME IN LAGOON

ITEM DESCRIPTION	Quantity	Unit	Unit Cost	Cost
Inlet Structure	1	ea	$0	$0
Suction Piping	0	sf	$0	$0
Chlorination System Equipment	0	ea	$0	$0
Sodium Bisulfite Feed Equipmen	0	ea	$0	$0
Chlorination System Piping	0	ea	$0	$0
Chemical Feed Building	0	ea	$0	$0
Pump	1	ea	$13,000	$13,000
Wet Well	1	ea	$13,000	$13,000
Forcemain Piping - Bored	5750	lf	$100	$575,000
Forcemain Piping - Trenched	1750	lf	$70	$122,500
Pump Mechanical Installation	1	ea	$13,000	$13,000
Pump Electrical & Instrumentati	1	ea	$13,000	$13,000
Land	0.1	acres	$40,000	$4,000
Earth Berm at Effluent Structure	1	ea	$6,000	$6,000
Total Construction				$759,500
Technical, Legal, Contingency				$303,800
Total Capital Cost				$1,063,300

BAY BEACH WILDLIFE SANCTUARY
WATER ADDITION

GBMSD - 21 DAY DETENTION TIME IN LAGOON

ITEM DESCRIPTION	Quantity	Unit	Unit Cost	Cost
Inlet Structure	0	ea	$0	$0
Suction Piping	0	sf	$0	$0
Chlorination System Equipment	0	ea	$0	$0
Sodium Bisulfite Feed Equipmen	0	ea	$0	$0
Chlorination System Piping	0	ea	$0	$0
Chemical Feed Building	0	ea	$0	$0
Pump	1	ea	$11,000	$11,000
Wet Well	1	ea	$13,000	$13,000
Forcemain Piping - Bored	5750	lf	$75	$431,250
Forcemain Piping - Trenched	1750	lf	$45	$78,750
Pump Mechanical Installation	1	ea	$13,000	$13,000
Pump Electrical & Instrumentati	1	ea	$13,000	$13,000
Land	0.1	acres	$40,000	$4,000
Earth Berm at Effluent Structure	1	ea	$6,000	$6,000
Total Construction				$570,000
Technical, Legal, Contingency				$228,000
Total Capital Cost				$798,000

BAY BEACH WILDLIFE SANCTUARY
WATER ADDITION

SHALLOW GROUNDWATER TRENCH - 21 DAY DETENTION TIME IN LAGOON

ITEM DESCRIPTION	Quantity	Unit	Unit Cost	Cost
Inlet Structure	0	ea	$10,000	$0
Suction Piping	2000	lf	$40	$80,000
Chlorination System Equipment	0	ea	$26,000	$0
Sodium Bisulfite Feed Equipmen	0	ea	$26,000	$0
Chlorination System Piping	0	ea	$16,000	$0
Chemical Feed Building	0	ea	$40,000	$0
Pump	1	ea	$11,000	$11,000
Wet Well	1	ea	$13,000	$13,000
Forcemain Piping - Bored	200	lf	$75	$15,000
Forcemain Piping - Trenched	1500	lf	$45	$67,500
Pump Mechanical Installation	1	ea	$13,000	$13,000
Pump Electrical & Instrumentati	1	ea	$13,000	$13,000
Land	0	acres	$40,000	$0
Earth Berm at Effluent Structure	1	ea	$6,000	$6,000
Total Construction				$218,500
Technical, Legal, Contingency				$87,400
Total Capital Cost				$305,900

BAY BEACH WILDLIFE SANCTUARY
SHALLOW GROUNDWATER TRENCH ENGINEERING

ITEM DESCRIPTION	Quantity	Unit	Unit Cost	Cost
Soil Borings	12	ea	$1,200	$14,400
Test Trench Construction	1	ea	$3,000	$3,000
Pump Test	1	ea	$2,000	$2,000
Engineering	1	ea	$12,000	$12,000
Total				$31,400

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