Permit Application

Nagawicka Lake Restoration

Chapter 30 Permit Application

Project I.D.: 06D006

City of Delafield
Delafield, Wisconsin

Revised May 2008

Chapter 30 Permit Application
Revised May 2008
City of Delafield
Nagawicka Lake Restoration

Contents

Page

Tables

Figures

Appendices

1 Introduction

The city of Delafield, Wisconsin, is pursuing dredging and restoration within portions of Nagawicka Lake. Because of the important recreational value and aquatic habitat provided by the lake, various lake management issues have been raised by the community. These include the build-up of sedimentation and proliferation of invasive plant species, which result in diminution of aquatic habitat. The Nagawicka Lake restoration goals, as defined by the citizens of the community, include the following:

- Maintain and enhance aquatic habitat,
- Provide better public watercraft access for recreation,
- Maintain property values and the city tax base,
- Maintain adequate public safety and;
- Prevent/minimize further lake sedimentation.

As part of this project, removal of sediment is proposed in five selected areas within the lake as discussed in further detail in this Dredge Permit Application.

This report presents the requirements for Dredge Permit Application under Section 30.20 Wis. Stats. for dredging selected areas of Nagawicka Lake. Also included in this report is additional information necessary to comply with other state regulatory requirements including:

- Dredge Operating General Permit (WPDES Permit No. WI-0046558-3);

- Compliance with Wis. Stats. Chapter 289 and Wis. Admin. Code NR 504.04 performance standards;

- Compliance with Wis. Admin. Code NR 150 for Determining the Need for Environmental Impact Statement (EIS) resulting from a Type II Action.

The completed Dredge Application form and the WPDES General Permit Application form are provided in Appendix A. Also included within this report is a draft Environmental Analysis (EA) providing issue identification pursuant to Wis. Admin. Code NR 150.22 Type II actions. The draft EA is provided in Appendix B. As requested by the applicant (city of Delafield), the Wisconsin Department of Natural Resources (WDNR) will have responsibilities of certain portions of the EA as identified in the cover letter.

Separate from this application, yet an integral part of the overall project goals, is restoration of the lake shore. LJ Reas Consulting, Inc., is concurrently working with the city and the WDNR to develop concepts for lake shoreline restoration in selected areas. The permits and approvals for the shoreline restoration (if any) are separate from this application. However, since overall lake restoration is key to achieving the city's goals for this project, dredging of selected areas will be integral to the restoration plan including the use of aquatic vegetation to stabilize and maintain dredge channel slopes. These concepts are presented in more detail in this application.

2 Project Background

Nagawicka Lake is a 917-acre water body located in Sections 5, 8, 9, 16, 17, 20, and 21 of Township 7 North, Range 18 East, Waukesha County as shown in Figure 1. The lake's total tributary drainage area is approximately 45 square miles, of this, approximately 68% (percent) is rural land use and the remaining 32% is urban.

The volume of water in the lake is approximately 46,000 acre-feet. Inflow to the lake is primarily contributed by the Bark River and direct surface water run-off from surrounding areas. Total annual inflow to the lake is approximately 29,000 acre-feet. Outflow from the lake is controlled by two outlet structures; a gated dam, and a mill race located on the Bark River at the southwestern shore of the lake. Total annual outflow from the lake is also approximately 29,000 acre-feet. The outlet structures maintain an average lake depth of 36 feet. The water mean residence time in the lake is approximately 1.6 years.

Nagawicka Lake is a heavily-used recreational lake. There are over 500 privately-owned riparian residences on Nagawicka Lake. Annually, there are more than 7,750 boat launches at the Waukesha County Naga-Waukee Park and more than 3,000 boat launches at the city of Delafield Bleeker Street boat launch. The parking lots at each of the boat launches are often filled to capacity. Because of its heavy use, and as an important recreational resource for southeast Wisconsin, various lake quality issues have been raised by the community including siltation, proliferation of invasive aquatic plant growth, and impacts to ecologically sensitive areas. The Nagawicka Lake Restoration Project will address these issues by striving to improve aquatic habitat, by maintaining property values, and by enhancing recreational access to the lake.

A March 2001 Lake Management Plan for Nagawicka Lake, prepared by the Southeastern Wisconsin Regional Planning Commission (SEWRPC 2001), established the need for lake restoration and selective dredging. The SEWRPC report noted Nagawicka Lake ranks high on the WDNR recreational rating due to its proximity to large communities and good water quality. As such, maintaining this valuable asset to the community for recreation users and ecological habitat is critical.

2.1 History of Events

The city of Delafield, over the past 6 years, has developed a lake restoration plan which includes dredging portions of Nagawicka Lake and shoreline restoration. The city has completed an assessment of historical sediment data and submitted this information in the Preliminary Dredge Application pursuant to Wis. Admin. Code NR 347 (Foth & Van Dyke, 2006). The WDNR responded to the Preliminary Dredge Application in a letter dated June 1, 2006[1], requiring an additional sediment sample be collected and tested from the Bark River Inlet. The city of Delafield acknowledged the WDNR's request and described proposed additional testing in a letter to the WDNR dated June 21, 2006[1]. The additional testing completed in 2006 was provided in the Nagawicka Lake Restoration Chapter 30 Permit submitted to the WDNR in October 2006. The WDNR responded to the application in a letter dated March 8, 2007 requesting additional information. As per this request, the city conducted additional sediment sampling and elutriate testing as summarized in a letter to the WDNR dated November 19, 2007[1]. The city also sent a letter to the WDNR, dated February 18, 2008, describing the

[1] Letters provided in Appendix C of this report.

proposed dredge prism alignments. The WDNR responded back in a letter, dated March 18, 2008, regarding WDNR's position on the proposed dredge alignments. These letters, as well as follow-up communications, have been incorporated within this revised application.

2.2 Restoration and Prevention Goals

Shoreline restoration of selected areas will be included as part of the dredging of Nagawicka Lake. As previously presented, LJ Reas Consulting is currently developing the restoration plans. A detailed description of the restoration plans in the various dredge locations is provided in Appendix D.

The removal of sediment from the five restoration areas will create an opportunity for sediment stabilization and the reintroduction of native Wisconsin submergent vegetation. By revegetating the restored lakebed areas with native species, the lake bottom will be stabilized by its root systems, the disturbed areas will be covered with beneficial plant material (versus being left open to colonization by eurasian water milfoil (EWM) or other exotic and invasive species), and the fishery habitat will be improved. In general, the intent of dredging and restoration is to remove accumulated soft sediments and to restore the dredged areas to better ecological conditions than existed prior to dredging.

Both the fishery needs and the remaining substrate of the dredged areas will be the key factors determining which species of native plants will be chosen and how they will be planted. The restoration focus of the dredged channels will be to limit migration of the remaining sediment into the excavated areas. By revegetating the sloped base with cluster colonies of native species, the rooting systems of these plants will hold the lake bottom in place. The spaces between the colonies will allow for easy detection of EWM for the initial few years before the natives begin to spread outside their colonies. The dredged areas of the main lakebed will have a similar focus of stabilizing soft sediment areas through cluster colonies, but will focus more on the fishery needs of each specific area. It will be necessary to work closely with the WDNR fisheries and aquatic plant management staff to determine the specific plant species and densities to achieve these goals.

There are various planting methodologies for restoring vegetation to submerged areas. Each method is determined by the species used, the type of plant material used, and the composition of the sediment. It is anticipated that a variety of species will be used so as to increase the likely success of the revegetation colonies. Stem fragments, daughter plants, root crowns, tubers or winter buds, even seeds (usually dependent upon species) may be used as starter materials for aquatic plant cultures. Depending on the dredging method used in each area, it may be possible to save some existing plant communities to be disturbed or removed and replant them after the excess sediment is removed. The ability to do this cost effectively while removing any EWM strands is being evaluated.

An example of one specific planting technique in soft sediment areas is the weighted propagule method. Depending on the plant species used, a tuber, stem fragment, or root crown is placed in a small biodegradable net bag. Additional sediment, sand, or pea gravel is added to the bag to create a desired level of weight. The bags are then either dropped over the side of a boat or dropped down PVC tubing to the desired spot on the lakebed. There the weight of the bag pulls the propagule below the surface of the sediment where it is insulated from predation, disturbance, etc. There, the propagule begins to sprout and grow.

The city of Delafield and the Lake Welfare Committee (LWC) are committed to stopping the reinfestation of the restored areas by EWM. They feel strongly that a formal EWM monitoring and eradication program in the restored areas is critical to the success of the Nagawicka Lake Restoration Project as a whole. While there currently is an aquatic plant harvesting machine working on the lake, it may be necessary to utilize some level of chemical control. In order to safely and cost effectively merge the vegetation restoration with chemical control of the EWM, the city will need to work closely with the WDNR Aquatic Plant Manager in the area.

In addition, the city of Delafield has passed a stormwater ordinance to help control future sedimentation of the lake. A $2.2 million stormwater retention pond has been installed to catch the runoff from Highways 83 and I-94. A recent housing development on the west side of the lake has also installed retention ponds to intercept runoff into the lake. The USGS has also installed monitoring stations at the Bark River entrance and exit of the lake.

Upon completion of the restoration plans, the city will work with the WDNR to obtain the necessary permits and approvals associated with the restoration concepts.

2.3 Project Funding

The proposed dredging and restoration project will be financed with public funding. The estimated cost of the dredging component of the project is approximately $3,800,000. A project cost analysis is provided in Appendix E. The restoration planting cost is estimated at $130,000. The restoration cost estimate is provided in Appendix D. The city has a requirement that capital projects greater than $1,000,000 need to have a referendum to approve the project. It is anticipated that referendum voting would occur in late summer or fall of 2008. The city and LWC are presently identifying taxing contributions for the riparian owners.

3 Sediment Characteristics

3.1 Historical Sediment Deposition and Characteristics

Information compiled by SEWRPC as part of the lake management plan report (SEWRPC, 2001) indicates that near shore sediment thickness generally ranges from 15 inches to over 50 inches in the vicinity of the dredge locations as shown on Figure 2.

A Lake Watershed Study conducted by SEWRPC (SEWRPC, 1999), reported that lake sediments consist largely of muck. The breakdown of aquatic and terrestrial vegetation (leaves) is a significant source of muck in some areas of the lake, in particular, within the Northwest Channels. In 1992, four sites in Nagawicka Lake were analyzed by Swanson Environmental, Inc., for parameters including ammonia-nitrogen, nitrite-nitrogen, nitrate-nitrogen, total nitrogen, total organic carbon, arsenic and copper. The study suggested that the majority of nitrogen in lake sediments was associated with organic matter, and the net impact to benthic dwelling organisms due to nitrogen was not significant.

More recent studies have shown arsenic and copper concentrations are present in some lake sediments at low concentrations. The origin of arsenic in lake sediments is likely due to the sodium arsenate-based herbicides applied to Nagawicka Lake to control aquatic plant growth in the lake basin between 1950-1967. Sodium-arsenic has not been applied to the lake since 1967. Similarily, copper-sulfate based algicides were applied to a portion of the lake during the period from 1950-1992. Some of this copper is likely to be the origin of a portion of the copper concentrations sediments present in the lake, with the balance being from naturally occurring geologic sources.

The existence of low levels of pesticides in sediment samples previously collected by the city in 2004 is likely due to sediment loading to the lake from upland agricultural lands. The presence of metals, such as cadmium, lead, and zinc, is likely due to runoff from urban and/or agricultural lands and may be indicative of naturally occurring (background) concentrations of these constituents.

3.2 Historical Sediment Sampling and Analyses

Historical sediment sampling was performed at several locations in Nagawicka Lake as part of individual private dredging projects and during a previous Nagawicka Lake Restoration Study initiated by the city (Vierbicher, 2004).

A total of 20 private and nine city sediment samples from Nagawicka Lake have been previously analyzed. Of the total 29 samples, three were located in Zastrow's Bay, four in Bleeker Street Bay, 12 in the Northwest Channels, four in the Northeast Channels, and six in the West Channels. All of the samples were collected at the direction of the WDNR. Locations of the private and city samples are shown on Figure 3. Details of the sampling procedures are presented in the Preliminary Application (Foth & Van Dyke, 2006).

Results of the historical analytical testing show the vast majority of sediments have chemical concentration levels below Threshold Effect Concentration (TEC). Chemical concentrations greater than TEC were identified as arsenic, cadmium, copper, lead, zinc, dibenz(a,h)anthracene (DBA), 4-4'-DDE (DDE), aldrin, and endrin located in Bleeker Street Bay, Zastrow's Bay, the

Northwest Channels, and the Northeast Channels. The majority of the elevated concentrations were between the TEC and the Midpoint Effect Concentration (MEC). Table 3-1 presents a listing of those samples above the TEC (as compiled in the Preliminary Application) and the Foth 2006 supplemental testing.

In summary, the spatial distribution of the historical samples and chemical composition is indicative of lake sediment chemical composition. It can be expected that dredge sediments will have slightly elevated concentrations of metals and pesticides in some areas due to historical surrounding land uses and past lake vegetation control programs.

The previous sediment samples collected by the city were also analyzed for physical characteristics including grain-size distribution, percent solids, and moisture content. Nagawicka Lake sediments can generally be described as green to black highly organic silt or silty organics. The native lakebed consists primarily of gray clay. The sediments are highly organic, consisting of 5 to 23% solids, primarily characterized as sand, silty sand, or silt with P_{200} content (silt and clay fraction) ranging from approximately 9 to 92% with a mean of 64%. The West Channel area's have high levels of sand in the sediment compared to other areas. Bleeker Street Bay, Zastrow's Bay, and Northwest Channels areas generally have P_{200} content greater than 55%. Overall, the solids content appears to be higher in the West Channels areas compared to the other areas.

In summary, the physical characteristics of the sediments present in Bleeker Street Bay, Zastrow's Bay, and the Northwest Channels areas appear similar in composition, primarily fine grained having P_{200} content greater than 50%. The Northeast Channels and West Channels areas appear to have higher levels of sand with less than 50% P_{200}.

3.3 Supplemental Sediment Analyses

Supplemental sediment samples were collected by Foth & Van Dyke in response to WDNR's response to the Preliminary Application and the Chapter 30 Permit Application conducted in June 28, 2006 and October 10, 2007, respectively. The 2006 supplemental sample locations are shown on Figure 3. The 2007 supplemental elutriate analyses are summarized in a letter to the WDNR dated November 19, 2007, provided in Appendix C. The 2006 and 2007 supplemental sediment test results are discussed further in the following sections.

Table 3-1
Summary of Sediment Analytical Results Relative to Effect-Based Levels

Nagawicka Lake Chapter 30 Permit Application
City of Delafield

	Metals					PAH's									Pesticides		
Sample Location	Arsenic (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	Benzo(a) anthracene (mg/kg)	Benzo(a)p yrene (mg/kg)	Benzo(b) fluoranthene (mg/kg)	Benzo(g,h,i) perylene (mg/kg)	Chrysene (mg/kg)	Fluoranthene (mg/kg)	Phenanthrene (mg/kg)	Pyrene (mg/kg)	Dibenzo(a,h)a nthracene (mg/kg)	4,4'-DDE (mg/kg)	Aldrin (mg/kg)	Endrin (mg/kg)
City Samples																	
Bleeker Street Bay - Site V-1	--	--	**89.1**	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bleeker Street Bay - Site V-2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**0.0079**	--	--
Zastrow's Bay - Site V-6	--	--	**60.6**	--	--	--	--	--	--	--	--	--	--	--	**0.0073**	--	--
Zastrow's Bay - Site V-7	**11.1**	--	**68.3**	--	--	--	--	--	--	--	--	--	--	**4.7**	**0.012**	**0.051**	--
Northwest Channels - Site V-5	--	--	--	**40**	--	--	--	--	--	--	--	--	--	--	**0.012**	**0.044**	--
Northwest Channels - Site V-8	**15**	--	--	--	--	--	--	--	--	--	--	--	--	--	**0.011**	**0.035**	**0.012**
Northwest Channels - Site V-9	--	**1**	--	--	--	--	--	--	--	--	--	--	--	--	**0.023**	**0.059**	--
Private Dredge Samples																	
Northeast Channels - Site P-1 Gary Pratt (West)	**12.56**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Northeast Channels - Site P-1 Gary Pratt (Midpoint)	**12.33**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Northeast Channels - Site P-7 Nagawicka Shores Condos	--	**1.56**		**68.6**	**192**	--	--	--	--	--	--	--	--	--	--	--	--
Zastrow's Bay - Site P-2 Greg Farrow	**25.90**	--	**75.90**	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Northwest Channels -Site P-8 Nagashota Shores Association (#3 (1997))	**15**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
FVD Sediment Samples (2006)																	
Bark River Inlet - BRI(1-3)A	--	--	--	--	--	**0.174**	**0.304**	**0.318**	**0.279**	**0.311**	**0.861**	**0.32**	**0.269**	--	--	--	--
Bark River Inlet - BRI(1-3)B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WDNR Consesus-Based Effect Levels																	
TEC< X <MEC	9.8	0.99	32	36	120	0.108	0.15	0.24	0.17	0.166	0.423	0.204	0.195	0.033	0.0032	0.002	0.0022
MEC< X <PEC	21.4	3	91	83	290	0.579	0.8	6.82	1.685	0.728	1.327	0.687	0.858	0.084	0.017	0.041	0.1046
> PEC	33	5	150	130	460	1.05	1.45	13.4	3.2	1.29	2.23	1.17	1.52	0.135	0.031	0.08	0.207

< TEC = Not Shown (Level 1)
TEC< X <MEC = Threshold Effect Concentration = Effect level at which toxicity to benthic-dwelling organisms is predicted to be unlikely (Level 2).
MEC< X <PEC = Midpoint Effect Concentration = Concentration midway between the TEC and PEC concentrations (Level 3).
> PEC = Probable Effect Concentration = Effect level at which toxicity to benthic-dwelling organisms is predicted to be probable (Level 4).

Notes:
*BRI(1-3)A was a composite of the top 6.75-12.75 inches of 6 cores from three areas within the Bark River Inlet.
**BRI(1-3)B was a composite of the bottom 6.75-16.25 inches of 6 cores from three areas within the Bark River Inlet.

Prepared by: TMK1
Checked by: JOS1

3.3.1 2006 Bark River Supplemental Sample Analysis

3.3.1.1 Bark River Inlet Sample Analyses

The Bark River Inlet samples were collected in accordance with Wis. Admin. Code NR 347 requirements as outlined in the WDNR June 1, 2006 letter, and follow-up letter from Foth & Van Dyke dated June 21, 2006 (see Appendix C). A total of six samples were collected from the Bark River Inlet and composited into two sediment samples for chemical analysis, an upper strata sediment sample BRI(1-3)A and a lower strata sediment sample BRI(1-3)B. A detailed discussion of the sediment sampling procedures is provided in the Sample Collection Field Work Plan prepared by Foth & Van Dyke and provided in Appendix F. Copies of the 2006 laboratory data sheets are provided in Appendix G.

The supplemental sediment testing results are provided in Table 3-2. Unlike other areas of the Lake, the Bark River Inlet area sediments showed low levels of several PAHs at concentrations between the TEC and MEC. Levels of pesticides, copper and arsenic above the threshold effects concentrations were not detected in the supplemental samples. The physical characteristics of the samples recovered from the Bark River Inlet, indicate the material is primarily fine graded having P_{200}.content great than 50%.

3.3.1.2 Elutriate Test Analyses

Carriage return water characteristics were evaluated from elutriate tests performed on a composite sediment sample. On June 28, 2006, Foth & Van Dyke collected six sediment samples from the Bark River Inlet, Northwest Channel, and West Channel areas at the locations shown on Figure 3. These samples were then composited into a single sample. Elutriate testing was conducted in accordance with U.S. Army Corp of Engineers procedures. Both total and dissolved effluent characteristics are presented in Table 3-3. Copies of the laboratory data sheets are provided in Appendix G.

It should be noted that the elutriate test method to estimate dissolved effluent characteristics was performed using a centrifugal method, as opposed to filtering, as indicated by the relative high suspended solids (170 mg/L). Therefore, the "dissolved" concentrations are higher than for a typical filtered sample.

3.3.2 2007 Supplemental Sample Analysis

The 2007 supplemental sampling was conducted by Foth pursuant to the WDNR's March 8, 2007 request for additional sediment characterization. Sample collection was conducted on October 10, 2007. A total of 12 samples were collected from the Bark River Inlet, Northeast Channels, Northwest Channels, and West Channels (3 from each to dredge areas). The 3 samples from each dredge area were then composited into a single sample for elutriate testing. In addition, a composite sample was also prepared from all 4 dredge areas. Elutriate testing was then conducted with polymer addition to establish water quality parameters at a total suspended solid (TSS) of 40 mg/L concentration. The polymer used in the tests was supplied by Soil Net, LLC, Madison, Wisconsin, and is on the Wisconsin Department of Transportation (WDOT) approval list.

Results of the tests indicate that 40 mg/L TSS can be achieved with polymer addition. Furthermore, it is noted that parameters of concern can also be controlled to below surface water discharge standards with polymer addition, suggesting a general WPDES permit standards can be met for surface water discharge. A detailed discussion of the sampling procedures and test results are provided in the letter to the WDNR, dated November 19, 2007, in Appendix C.

Table 3-2

Analytical Laboratory Data
2006 Sediment Samples - Bark River Inlet

Nagawicka Lake Chapter 30 Permit Application
City of Delafield

Analytical Parameter	Bark River Inlet - BRI(1-3)A*	Bark River Inlet - BRI(1-3)B**	TEC	MEC	PEC
Inorganics-Metals					
Arsenic (mg/kg)	4.9	2.94	9.80	21.40	33.00
Cadmium (mg/kg)	ND	N	0.99	3.00	5.00
Chromium (mg/kg)	22.6	14	43.00	76.50	110.00
Copper (mg/kg)	20.3	19.7	32.00	91.00	150.00
Lead (mg/kg)	19.4	27.2	36.00	83.00	130.00
Mercury (mg/kg)	0.442	7.76	NA	NA	NA
Nickel (mg/kg)	13.1	0.413	23.00	36.00	49.00
Zinc (mg/kg)	76.9	82.9	120.00	290.00	460.00
Inorganics-Nutrients					
Nitrate (mg/kg)	4.69	ND	NA	NA	NA
Nitrite (mg/kg)	ND	ND	NA	NA	NA
Ammonia-Nitrogen (mg/kg)	747	952	NA	NA	NA
Available Phosphorus (% by weight)	0.71	1.86	NA	NA	NA
Total Phosphorus (mg/kg)	988	772	NA	NA	NA
Total K-Nitrogen (mg/kg)	10300	17700	NA	NA	NA
Organics					
Total Organic Carbon	40000	61000	NA	NA	NA
1-Methylnaphthalene (mg/kg)	ND	ND	NA	NA	NA
2-Methylnaphthalene (mg/kg)	ND	ND	0.0202	0.111	0.201
Acenaphthene (mg/kg)	ND	ND	0.0067	0.048	0.089
Acenaphthylene (mg/kg)	ND	ND	0.0059	0.067	0.128
Anthracene (mg/kg)	ND	ND	0.0572	0.451	0.845
Benz(a)anthracene (mg/kg)	**0.174**	0.0294	0.108	0.579	1.05
Benzo(a)pyrene (mg/kg)	**0.304**	0.0554	0.15	0.8	1.45
Benzo(b)fluoranthene (mg/kg)	**0.318**	ND	0.24	6.82	13.4
Benzo(g,h,i)perylene (mg/kg)	**0.279**	0.051	0.17	1.685	3.2
Benzo(k)fluoranthene (mg/kg)	ND	0.0322	0.24	6.82	13.4
Chrysene (mg/kg)	**0.311**	ND	0.166	0.728	1.29
Dibenz(a,h)anthracene (mg/kg)	ND	ND	0.033	0.084	0.135
Fluoranthene (mg/kg)	**0.861**	0.18	0.423	1.327	2.23
Fluorene (mg/kg)	ND	ND	0.0774	0.307	0.536
Indeno(1,2,3-cd)pyrene (mg/kg)	0.182	ND	0.2	1.7	3.2
Naphthalene (mg/kg)	ND	ND	0.176	0.369	0.561
Phenanthrene (mg/kg)	**0.32**	0.0456	0.204	0.687	1.17
Pyrene (mg/kg)	**0.269**	0.129	0.195	0.858	1.52
Pesticides					
Chlordane (mg/kg)	ND	ND	0.0032	0.0106	0.018
Aldrin (mg/kg)	ND	ND	0.002	0.041	0.08
Endrin (mg/kg)	ND	ND	0.0022	0.1046	0.207
4,4'-DDT (mg/kg)	ND	ND	0.0042	0.0336	0.063
4,4'-DDE (mg/kg)	ND	ND	0.0032	0.017	0.031

NA = Not Applicable
ND = Not Detected

< TEC = Not Shown (Level 1)
TEC< X <MEC = Threshold Effect Concentration = Effect level at which toxicity to benthic-dwelling organisms is predicted to be unlikely (Level 2).
MEC< X <PEC = Midpoint Effect Concentration = Concentration midway between the TEC and PEC concentrations (Level 3).
> PEC = Probable Effect Concentration = Effect level at which toxicity to benthic-dwelling organisms is predicted to be probable (Level 4).

Notes:
*BRI(1-3)A was a composite of the top 6.75-12.75 inches of 6 cores from three areas within the Bark River Inlet.
**BRI(1-3)B was a composite of the bottom 6.75-16.25 inches of 6 cores from three areas within the Bark River Inlet.

Prepared by: TMK1
Checked by: JOS1

Table 3-3

Analytical Laboratory Data
2006 Elutriate Samples - Bark River Inlet

Nagawicka Lake Chapter 30 Permit Application
City of Delafield

Analytical Parameter	Filtered	Unfiltered
Pesticides		
Aldrin (ug/L)	<0.048	<0.50
Endrin (ug/L)	<0.048	<0.50
Chlordane-alpha (gama) (ug/L)	<0.048	<0.50
4,4'-DDE (ug/L)	<0.048	<0.50
4,4'-DDT (ug/L)	<0.048	<0.50
Metals		
Arsenic (ug/L)	24.1	808
Cadmium (ug/L)	<5.0	12.5 B
Chromium (ug/L)	20.1	1410
Copper (ug/L)	42.1	2800
Lead (ug/L)	27.6	3420
Manganese (ug/L)	522	44400
Mercury (ug/L)	0.084 B	21.3
Nickel (ug/L)	14.2 B	1060
Zinc (ug/L)	113	9430 C
Inorganics - Nutrients		
Nitrate-Nitrite (mg/L)	<0.10	<0.10
Ammonia Nitrogen (mg/L)	12.2 J	38.9 C
Total Phosphorus (mg/L)	0.59	75.9
Total K-Nitrogen (mg/L)	18.8	643
Total Suspended Solids (mg/L)	170	143000
pH (std units)	7.8	7.5
% solids (%)	NA	21.5
Organics		
Total Organic Carbon (mg/L)	14.2	44.1
Biochemical Oxygen Demand (mg/L)	13.1	347
1-Methylnaphthalene (ug/L)	<0.20	0.60 J
2-Methylnaphthalene (ug/L)	0.057 J	1.3
Acenaphthene (ug/L)	0.11 J	1.2
Acenaphthylene (ug/L)	<0.20	0.49 J
Anthracene (ug/L)	<0.20	1.3
Benzo(a)anthracene (ug/L)	0.028 J	6.5
Benzo(a)pyrene (ug/L)	<0.20	4.8
Benzo(b)fluoranthene (ug/L)	<0.20	9.1
Benzo(g,h,i)perylene (ug/L)	<0.20	7.9
Benzo(k)fluoranthene (ug/L)	0.026	3.6
Chrysene (ug/L)	0.036 J	9.1
Dibenzo(a,h)anthracene (ug/L)	<0.20	1.6
Fluoranthene (ug/L)	0.073 J	28
Fluorene (ug/L)	0.13 J	1.9
Indeno(1,2,3-cd)pyrene (ug/L)	<0.20	6.5
Naphthalene (ug/L)	0.084 J	1.9
Phenanthrene (ug/L)	0.44	10
Pyrene (ug/L)	0.060 J	13

J Estimated result. Result less than the reporting limit.
B Estimated result. Result less than the reporting limit.
C Method blank contamination. The associated method blank contains the target analyte at a reportable level.
NE Not established
PAL - NR 140 Preventive Action Limit
ES - NR 140 Enforcement Standard

Prepared by: TMK1
Checked by: JOS1

Table 3-4

Sediment Physical Characteristics

Nagawicka Lake Chapter 30 Permit Application
City of Delafield

Area	Sample Location		Date Analyzed	% Solids	Total Organic Carbon (% dry wt.)[1]	Particle Size Distribution % Gravel	% Sand	% Silt	% Clay	P200 (%)	Visual Description
City Samples - Historical											
Bleeker Street Bay	V-1		3/19/2004	8.6	0.33	0	17.7	51.3	31.0	82.3	Dark green to black, fine-grained, high organic content overlying gray very fine-grained, lower organic content
	V-2		3/19/2004	17.5	0.61	0	39.6	41.9	18.5	60.4	Same as Above
	V-3		3/19/2004	16.6	0.21	0	19.1	49.6	31.3	80.9	Same as Above
	V-4		3/19/2004	6.4	1.50	0	44.2	35.7	20.1	55.8	Same as Above
Zastrow's Bay	V-6		3/19/2004	6.1	0.36	0	34.8	38.8	26.4	65.2	Green organics mixed with dark silt overlying gray clay/green organics overlying gray clay
	V-7		3/19/2004	5.2	1.40	0	26.7	51.3	22.0	73.3	Green organics overlying dark mix of organics and sil
Northwest Channels	V-5		3/19/2004	14.4	1.40	0	7.1	59.6	33.3	92.9	Black, coarser-grained, high organic content overlying gray clay
	V-8		3/19/2004	5.3	2.40	0	40.4	38.1	21.5	59.6	Green organics overlying gray clay
	V-9		3/19/2004	6.0	1.50	0	27.5	47.5	24.6	72.5	Same as Above
Private Dredging Samples - Historical											
Northeast Channels	P-1 Gary Pratt	East	1/9/1996	NV	68.80	0	50.0	35.0	15.0	50.0	No description available.
		West	1/10/1996	NV	48.20	0	91.0	3.0	6.0	9.0	No description available.
		Midpoint	1/11/1996	NV	60.40	0	57.0	25.0	18.0	43.0	No description available.
	P-7 Nagawicka Shores Condos		NA	NV	NV	NV	NV	NV	NV	NV	No description available.
Zastrow's Bay	P-2 Greg Farrow		NA	NV	NV	NV	NV	NV	NV	NV	No description available.
West Channels	P-4 Thomas Kelly	#1 (0-2')	NA	21.9	NV	NV	NV	NV	NV	NV	No description available.
		#2 (0-2')	NA	17.0	NV	NV	NV	NV	NV	NV	No description available.
		#3 (2-5')	NA	21.0	NV	NV	NV	NV	NV	NV	No description available.
	P-5 Mark Gurda	Core 1	7/20/2001	13.8	12.80	0	66.9	32.5	0.6	33.1	No description available.
		Core 2	7/20/2001	20.8	7.17	0	50.5	49.2	0.3	49.5	No description available.
		Core 3	7/20/2001	23.2	8.43	0	46.9	39.4	13.7	53.1	No description available.
Northwest Channels	P-3 Thomas Robak		NA	NV		NV	NV	NV	NV	NV	No description available.
	P-8 Nagashota Shores Association	#1 (1992)	5/28/1992	NV	0.10	0	10.0	88.0	2.0	90.0	No description available.
		#2 (1992)	5/28/1992	NV	0.10	0	21.0	68.0	11.0	79.0	No description available.
		#3 (1992)	5/28/1992	NV	0.03	0	31.0	67.0	2.0	69.0	No description available.
		#4 (1992)	5/28/1992	NV	0.02	0	8.0	66.0	26.0	92.0	No description available.
		#1 (1997)	NA	NV	NV	NV	NV	NV	NV	NV	No description available.
		#2 (1997)	NA	NV	NV	NV	NV	NV	NV	NV	No description available.
		#3 (1997)	NA	NV	NV	NV	NV	NV	NV	NV	No description available.
		#4 (1997)	NA	NV	NV	NV	NV	NV	NV	NV	No description available.
F&VD Samples (2006)											
	BRI (1-3)A		6/8/2006	NV	NV	0	32.3	39.7	28.0	67.7	No description available.
	BRI (1-3)B		6/8/2006	NV	NV	0	13.6	53.4	33.0	86.4	No description available.

NV = No Value
NA = Not Applicable

Prepared by: TMK1
Checked by: JOS1

[1] Total Organic Carbon values obtained by converting mg/kg to %, excluding values for P-1 which were given in % dry weight.

Note: No geotechnical data available for P-6 Michael Curley.

3.4 Summary of Sediment Chemical Characteristics

The results of the sediment analyses were compared to *WDNR Consensus-Based Sediment Quality Guidelines* to evaluate the quality of sediment. Three concentrations are defined in these guidelines based on the potential for long-term effects to benthic-dwelling organisms: Threshold Effect Concentration (TEC), Midpoint Effect Concentration (MEC), and Probable Effect Concentration (PEC). The TEC is the level of contamination that has an unlikely effect on benthic-dwelling organisms, and thus, the sediment can be considered clean. The PEC is the level of contamination that is likely to affect the health of benthic-dwelling organisms. The MEC is the midpoint between the TEC and PEC. From the three concentrations, four levels of affect are defined as follows:

- Level 1 < TEC
- Level 2; TEC > MEC
- Level 3; MEC > PEC
- Level 4 < PEC

Note that these guidelines apply only to in-water concentrations relative to benthic-dwelling organisms in sediment, and are not directly applicable for evaluation of upland disposal or beneficial use.

Results of historical analytical testing show the vast majority of sediment proposed to be removed is below the TEC (Level 1). Arsenic, cadmium, copper, lead, zinc, several PAH's and pesticides (DDE, aldrin and endrin) are above the TEC at several locations.

For those greater than Level 1, the majority of concentrations were between the TEC and MEC (Level 2). Sample locations V-5, V-7, and V-9 contained pesticides (DDE and aldrin) and P-2 contained arsenic between the MEC and PEC (Level 3). Location V-7 contained DBA above the PEC level (Level 4) which appears to be an isolated incident. The parameters relative to the various affect-based levels are summarized in Table 3-1.

Pesticide concentrations are likely due to agricultural and residential runoff. Arsenic and copper are constituents of herbicides and algicides historically used to control aquatic plant growth in certain parts of the lake. Sodium arsenate-based herbicides have not been applied on the lake since 1967. The major use of copper and sulfate-based algicides ceased in 1970 with a small final isolated use in 1989. There is no commercial production or known use of the PAHs within the Bark River watershed, though they can occur as a component of coal tars, shale oils, and soots and have been detected in gasoline engine exhaust, coke oven emissions, cigarette smoke, charcoal broiled meats, vegetation near heavily traveled roads, surface water, and soils near hazardous waste sites. PAHs generally adsorb strongly to soils and do not leach to groundwater.

3.5 Summary of Sediment Physical Characteristics

The previous sediment samples collected by the city were also analyzed for geotechnical characteristics at a qualified laboratory using the Wisc. Admin. Code NR 347 guidelines for urban lakes, which includes grain size, percent solids, and moisture content. In addition, visual descriptions of such characteristics as color, texture, grain size, and organic content were documented during sampling of the nine city samples. Some of the sediment samples collected at the private dredge sites were also tested for geotechnical characteristics, however, visual descriptions are not available for these samples. Table 3-4 presents a summary of the physical characteristics and geotechnical test results for the historical sediment samples.

Based on the visual descriptions, generally the sediment overlying the native lakebed is generally green to black highly organic silt or silty organics. The native lakebed consists primarily of gray clay. The sediment sampled is highly organic consisting of 5 to 23% solids. Fine-sand content ranges from 7 to 91% and P_{200} content ranges from 33% to 93%.

In summary, the physical characteristics of the sediments present in Zastrow's Bay, and the Northwest Channels areas appear similar in composition, primarily fine grained having P_{200} content greater than 55%. The Northeast Channels and West Channels areas appear to have higher levels of sand, less than 50% P_{200}.

4 Proposed Dredge Locations

The city of Delafield is planning to dredge five locations within Nagawicka Lake, as shown on Figure 3. Note that the city has agreed not to pursue dredging in Bleeker Street Bay and the Kettle Area as requested by the WDNR in a letter to the city dated March 8, 2007. The five locations were defined in order to achieve the goals discussed in Section 1 of this application, as follows:

- Maintain and enhance aquatic habitat,
- Provide better public watercraft access for recreation,
- Maintain property values and the city tax base,
- Maintain adequate public safety, and
- Prevent/minimize further lake sedimentation.

These goals were established during a multi-year process of discussing the overall Lake restoration with city officials, Lake Welfare Committee members and the riparian property owners.

A total of 264 riparian property owners will be directly affected by the dredging. A listing is provided in Appendix H. A copy of a notification letter will be sent to affected riparian owners at least 30 days prior to dredging and is provided in Appendix I. In addition, as requested by the WNDR, the city has prepared riparian easement agreements with property owners that would be affected by extended disturbance during dredging operations. Those agreements are also provided in Appendix I.

4.1 Water Depth, Sediment Thickness and Vegetation Survey

Through discussions with the various project stakeholders, and the results of the vegetation survey, the primary concern was related to dredging in areas where the water depth is less than three feet and diverse native plant species and fish habitat are present. Dredging in deeper water (i.e., > 3 feet water depth) was not identified as a constraint in other areas. As such, the city's plan is to dredge non-sensitive areas having water depths greater than 3 feet to attain a 5 foot channel water depth. As a result of past discussions with the WDNR and dredging constraints listed in the March 8, 2007 letter, the city has substantially modified the original dredge plan submitted with the Preliminary Application.

Several water depth, sedimentation and vegetation surveys have been completed in the proposed dredge areas over the past 3 years. These surveys have been used to establish the dredge alignments and channel dimension based upon water depth, sediment thickness, and plant species. The most recent aquatic plant survey within the dredge areas was conducted with the LWC and WDNR representatives in August 2006. Summary notes compiled from this survey are provided in Appendix J. In response to the March 8, 2007 WDNR comments, Foth conducted further detailed water depth and sediment profile survey within the proposed dredge alignments. This work was completed to develop accurate dredge prisms and volumes. Foth conducted a total of 129 survey transects through the proposed dredge areas. At each transect location, 5 points were surveyed for top of water, top of sediment and top of hardpan. Location of the 2007 survey transects is shown on Figure 4. A summary table of this survey information is provided in Appendix K. The typical procedure used for measuring the water depth and soft sediment thickness is described below:

> Once the survey boat stabilized at a survey location, the water depth and distance from the vessel deck to the top of soft sediment was measured using a survey rod attached to a 6" diameter metal plate. The plate was used to find the top of soft sediment as probing with only a rod would make it difficult to determine the top of soft sediment. Next, the thickness of the soft sediment was measured by pushing a probing rod with a 1/2" steel end (without a steel plate) into the sediment until refusal. This second step is referred to as "poling".

Based upon those measurements, the dredge prisms were developed for each dredge area as shown on Figures 5A through 13A. Water depth within each channel alignment is provided on Figures 5B through 13B.

The majority of poling that aligns with the channels show refusal below the channel bottom target elevation of 884.5 feet. Recognize that poling refusal does not imply native "hard pan".

Given the mechanical limitation of hydraulic dredging, hard pan dredging will not occur. During dredging, if hard pan is encountered above the target elevation, the dredge cutter head will adjust vertically thereby not penetrating the hard pan material. Only in the Bark River sediment trap is native hard pan expected to be encountered above the base target elevation of 883.0—probably no more than 3 to 6 inches. This may be conducted using mechanical dredging such as a crane with a clamshell bucket.

4.2 Dredge Areas and Prisms

The following Table 4-1 summarizes the dredge areas and associated dredge prism volumes for the proposed dredge locations within Nagawicka Lake.

Table 4-1
Dredge Prism Volumes

Dredge Location	Approx. Dredge Plan Area (acres)	Approx. Dredge Prism Volume (cy)(1)	Dredge Volume(2) with Overcut Allowance and Pier Adjustment
West Channels	5.1	13,632	16,485
Northwest Channels	12.8	37,000	44,678
Northeast Channels	1.6	3,542	4,277
Bark River Inlet	4.9	27,818	33,590
Zastrow's Bay	2.2	6,741	8,146
Total	**26.6**	**88,753**	**107,176**

(1) In-situ lake sediment volume or dredge prism. Upland disposal volume, after dewatering, will be substantially less than the dredge prism volume.
(2) Assume a 0.5 ft. overcut allowance to establish target elevation and 5% additional volume for dredging by piers not shown on the 2005 orthophoto base map.

Prepared by: MJP1
Checked by: JOS1

The areas to be dredged were substantially reduced since submittal of the Preliminary Application to account for input received from the WDNR related to water depth and the presence of submergent native vegetation and fish habitat. The dredge channel areas and volumes were generally determined using the following criteria:

- A minimum 5-foot wide setback from the shoreline,

- Maximum side slope of the dredge cut of 4H : 1V (Horizon to Vertical) to maintain stability, and

- Post-dredge water depth of 5 feet, channel bottom target elevation of 884.5 MSL. Within the sedimentation trap at the Bark River Inlet, the post dredge water depth will be 6.5 feet deep, having a bottom elevation established at 883.0 MSL. Note: With the exception of the Bark River sediment trap, hard pan encountered above the target elevation will reduce post-dredge water depth.

- A minimum of 25 foot channel bottom width, where applicable.

These criteria define the channel alignment within each dredge area as shown on Figures 5 through 13. Typical post dredge channel cross-sections are shown on Figure 20. Where applicable, the channel width for navigation was established at 25 feet. However, based upon either physical or environmental constraints, channel width will be less in certain locations.

Also presented on Figures 5 through 13 are detailed cross-sections through the channels. Dredging will require pier removal. The majority of the piers are temporary, seasonal docks which can be pulled from the lake rapidly and replaced after dredging. Permanent piers will be allowed to remain in place with dredging conducted no closer than 10 feet. The costs associated with pier removal and replacement will be the riparians' responsibility. The LWC and the city have notified the community that dock removal will be necessary for this project and have received property owner support of this need. Recognize that the ortho map is dated spring of 2005, as such, not all current piers may be shown. Therefore, dredge alignment may be slightly altered (see *Typical* section on Figure 20) based upon a pre-dredge pier survey which will be conducted prior to dredging.

The dredge volumes presented in Table 4-1 include an over dredge allowance to account for constructability limitations of hydraulic dredging. Experience with other dredge projects indicates that the target elevations can be established within a 0.5 foot cut allowance. Therefore, for permitting purposes, a 0.5 foot overcut tolerance has been included in the dredge quantities listed in Table 4-1. To account for changes in dredge alignments due to piers not identified on the current planimetric map, a 5% dredge volume contingency has been included as listed in Table 4-1.

<u>West Channels</u> – The dredge alignments in the West Channels are shown on Figures 5A and 6A. The dredge alignment for the West Channel (south) shown on Figure 5A was revised based upon WDNR's sensitive area definition. Water depths in the West Channels range from less than 0.5 feet to 2.5 feet in the southern portion of the West Channel to 1 to 2.5 feet in the north portion of the West Channel. (Figures 5B and 6B.)

The specific need for dredging of the West Channels is to provide better access for safe navigation for boaters. In the southern channel area as shown on Figure 5A, in order to comply with the WDNR requirement, the limit of the channel will not extend further than 150 feet into the lake. The channel bottom will be 25 feet wide. In the northern portion of the dredge alignment, the dredge prism shows a bottom width of 34 feet--this is to accommodate riparian piers that extend through that area. As such, the dredge prism needed to be extended to allow for unimpeded navigation through the channel (i.e. the channel width extends 25 feet beyond the end of the piers in that area.). A significant proportion of the sediment in the West Channels is composed of a very organic muck resulting from the decomposition of organic matter such as leaves and other vegetation. Furthermore, it has been noted by the WDNR that a significant growth of eurasion water milfoil will be eradicated by dredging this area.

This dredging work would meet the first four goals listed above in the beginning of Section 4. Alternative methods such as navigational buoys, extension or relocation of piers would not meet any of the goals listed above as defined by the citizens of the community. Pier extensions, although temporary, may alleviate water access problems by homeowners. This is not a viable long term solution for lake access by homeowners as sediment accumulation will continue resulting in the need to move piers further out into the lake.

Based upon the proposed dredge alignment for the West Channel areas, it is estimated that approximately 16,485 cubic yards (cy) (including 0.5 foot overcut and pier contingency) of sediment will be removed.

<u>Northwest Channels</u> – The dredge alignments in the Northwest Channels are shown on Figures 7 through 9. As required by the WDNR in their letter dated March 8, 2007, areas have been eliminated from the dredge alignment west of parcel 0750029 and south of parcel 0750024. The width of the dredge channel along parcels 07511106 and 0751004 has been adjusted to maintain 5-foot buffers to wetland areas. Furthermore, the channel alignments have been modified to maintain as much distance as practicable to existing wetland areas by moving the channel alignments closer to the developed shore side. The LWC believes that dredging of the east channel between parcels 0750059 and 0750058 and 0750085 is absolutely necessary for water craft navigation. Even with dredging, the channel west of parcels 0750059 and 0750058 and the developed shore side, the channel width will be too narrow for adequate water craft passage thereby causing a choke point and safety hazard. Also the LWC believes dredging of 4 channels between parcels 750999001 as shown on Figures 8A and 9A is needed to provide adequate channel passage for riparian owners. Without these channels being dredged, Northwest Channels access for riparians will be limited to locations north and south. During summer months, this could result in boat congestion and potentially be a safety hazard.

Conditions in the Northwest Channels are similar to the West Channels, with water depths ranging from less than 1.5 to 3.0 feet, with substantially lesser depths in many locations. (See Figures 7B, 8B, and 9B.) At several locations, the water depth is very shallow (less than 6 inches) because of excessive sediment accumulation. When water levels are naturally lower in the fall, a shoreline mudflat is exposed, and, in the winter, these mudflats freeze down to 6 to 12 inches. In the spring, when water levels rise back to normal, the blocks of sediment-laden ice float out into the channels, melt, and deposit their sediment load into the channels.

Dredging the Northwest Channels will provide benefits similar to the West Channel dredging such as improved boater safety due to increased water depth and bottom channel width, an improved environment for reestablishment of native Wisconsin submergent vegetation, an improved fishery habitat, and will also alleviate the problem of sediment transport into the channel by the above described process.

Alternatives to dredging such as navigation buoys and relocation or extension of piers would have no beneficial results for the issues described above for the Northwest Channels and would not provide a means to accomplish the goals set forth by the citizens of the community. Furthermore, pier extension in the channel areas will further restrict boat navigation resulting in safety hazards.

Using the above dimensions results in an estimated total dredge volume in the Northwest Channels of 44,678 cy (including a 0.5 foot overcut and 5% pier contingency).

Northeast Channels – The Northeast channels are labeled as NE1 through NE5, as shown on Figure 10A. Due to shallow water depth, dredging is proposed in all five channels following the criteria listed previously. As identified in the WDNR March 8, 2007 comment letter, the area previously identified as channel NE4 was removed from the dredging plan. In the remainder of the Northeast Channels, due to the narrow existing channel widths and in order to maintain a 5 foot buffer from shore, channel bottom widths will range from 4 to 12 feet.

The Northeast Channels require dredging due to shallow water depth caused by accumulated sediment. The existing channels are very narrow at some locations, therefore magnifying the impact of the shallow water depths on safe navigation for boaters. Existing water depth in those channels ranges from less than 1.0 feet to 3.0 feet as shown on Figure 10B. The estimated dredge volume for the Northeast Channels is 4,277 cy (including 0.5 foot overcut and 5% pier contingency).

Dredging the Northeast Channels will provide improved boater safety due to increased water depth and bottom channel width, an improved environment for re-establishment of native Wisconsin submergent vegetation, and improved fishery habitat.

Alternatives to dredging such as navigation buoys and relocation or extension of piers would have no beneficial results for the issues described above for the Northeast Channels and would not provide a means to accomplish the goals set forth by the citizens of the community. Furthermore, pier extension will restrict boat navigation in the channels causing a safety hazard.

Bark River Inlet Area – The Bark River Inlet area is divided into four sub-areas, as shown on Figure 11A, and described below:

- Bark River (mouth of river)
- Bark River sediment trap (in the lake at the river mouth)
- Lake Drive (shoreline located north of the river mouth)
- Sylvester Drive (shoreline located south of the river mouth)

The Lake Drive dredge channel, as identified in the March 8, 2007 letter, suggested that water depth greater than 3.5 feet, as such, the WDNR concluded this area should not be dredged. Refinement of the dredge prism in this area based on additional survey information collected during the fall of 2007 shows pre-dredge water depth generally ranging from 0.5 to 3.0 feet; as such, dredging will be performed along Lake Drive as shown on Figure 11B. Because the dredge area along Lake Drive is not within a sensitive area, dredging can be conducted to provide better water craft access and navigation.

Dredging criteria within the Bark River Inlet and the north and south shorelines are the same as for the West and Northwest Channels (5 feet shoreline setback, 4V:1H sideslopes, 25 feet wide dredge channel bottom, and 5 feet post-dredge water depth).

A sedimentation trap has been designed at the Bark River Inlet to the lake to reduce future sediment loading to the lake. The design basis for the sedimentation trap is to collect the larger fractions of soil particles that pass into Nagawicka Lake from the Bark River, thereby, reducing uncontrolled particle deposition across the lake. Collecting sediment at this location not only reduces overall particulate loading to the lake, but also allows for effective future maintenance dredging of the sediment trap. The bottom target elevation for the sediment trap will be established at elevation 883.0, resulting in a post-dredge water depth of 6.5 feet. Based upon the calculations provided in Appendix L, the sediment trap will have capacity to store sediments for 7 to 14 years based upon a 100% to 50% deposition efficiency, respectively. Dredging the sediment trap could result in small amount of hard pan removal, if present above elevation 883.0 feet, which will then be conducted using a mechanical method such as a crane with clamshell bucket. The designed sediment trap provides the city the best configuration that balances dredging configuration versus sediment collection efficiency.

Alternatives to dredging, such as navigation buoys and relocation or extension of piers would have no beneficial results for the issues described above for the Bark River Inlet area and would not provide a means to accomplish the goals set forth by the citizens of the community. Pier extension will not alleviate near shore accumulation of sediment. Extending piers further into the lake to allow homeowners access would result in increased safety hazard for boaters.

<u>Zastrow's Bay</u> – Zastrow's Bay is divided into three sub-areas, as shown on Figures 12A and 13A, and described below:

- ZB1 (northwest inlet),
- ZB2 (northeast inlet), and
- ZB3 (south inlet).

The proposed dredging within Zastrow's Bay has also been modified to account for vegetation and water depth information. In general, for ZB1 and ZB2, shoreline dredge channels are proposed in areas where the water depth is less than 3 feet, as shown on Figure 12B. Areas in the middle of these inlets where native vegetation and deeper water are present will remain undredged. In the March 8, 2007 letter, the WDNR noted that water depths in ZB3 (southern inlet) were greater than 3 feet, and therefore, dredging should not be conducted. The city and LWC believe dredging in this area is needed to provide safe lake access to riparian owners.

Considering this area is outside of a sensitive area, dredging in water depths greater than 3.0 feet meets the city and LWC goals. The combined Zastrow's Bay dredge prisms are estimated at 8,146 cy (including 0.5 foot overcut and 5% pier contingency).

Dredging of the Zastrow's Bay area will provide improved boater safety due to increased water depth, an improved environment for reestablishment of native Wisconsin submergent vegetation, and improved fishery habitat.

Alternatives to dredging such as navigation buoys and relocation or extension of piers would have no beneficial results for the issues described above for the Zastrow's Bay area and would not provide a means to accomplish the goals set forth by the citizens of the community. Pier extension is not practical in Zastrow's Bay. The extension of piers will result in increased hazards for watercraft.

5 Channel Dredging

5.1 Dredge Operations

Nagawicka Lake sediment dredging will be conducted using hydraulic methods. If hard pan or hard material is encountered during the Bark River sedimentation trap excavation, the contractor may employ a mechanical process such as clamshell bucket. The proposed dredge alignments for the five dredge areas within Nagawicka Lake are shown on Figures 5 through 13. The dredging will affect 264 riparian owners as listed in Appendix H. A notification letter, provided in Appendix I, will be sent to the property owners 30 days prior to commencement of dredging operations.

Using hydraulic dredging, sediment can be quickly removed thereby reducing lake inaccessibility for riparian owners. The total quantity of sediment to be removed, including overcut, is estimated at 107,176 cy. Assuming the contractor will employ one dredge, operating at 50% efficiency, dredging can remove approximately 960 cy per day, requiring approximately 112 dredge days, operating 24 hours per day/5 days per week. The sediment process design calculations are provided in Appendix L. Based upon dredge production rates and to minimize impacts to sensitive lake aquatics such as fish spawning cycles, the project is being planned for a 2 year period, beginning in 2009. An overall project timeline is shown on Figure 22.

Hydraulic dredging will be accomplished using a cutterhead or auger-style dredge that will pump a dredge slurry to an upland disposal site. Using this method, truck transport and the associated roadway traffic are eliminated. The hydraulic dredge cuts the soft sediments to the designated elevation. The sediment is then pumped as a slurry to the dewatering site. Dredging to the desired cut invert is accomplished using a series of passes. A face cut lift of approximately 80% of the dredge pump diameter (e.g. .80 x 8" dredge = 6.4") is commonly used by the contractor. As such, a series of passes may be required at some locations to achieve the desired dredge cut elevation.

Hydraulic systems have the advantage of high production capacity resulting in lower costs and minimal re-suspension of solids. The best management practices that will be used during dredging to reduce soft sediment re-suspension will include:

- Reducing cutterhead/auger rotation speed,
- Reducing swing speed of cutterhead or advance of auger, and
- Reducing or eliminating cut force undercutting by using a maximum lift thickness of 80%.

Because of the distance between the dewatering site from some of the dredge areas, a booster pump station may be required. Typically, booster pump locations are located every 3,000 to 5,000 feet depending on factors such as type of dredge, dredge material characteristics, and change in elevation between the dredge and dewatering locations.

Figure 14 shows conceptual pipeline routes from the lake to the dewatering site. The locations of the pipeline routes are based on minimizing disturbance of environmentally sensitive areas and maintaining riparian access to the lake from their property. While these pipeline routes present feasible and logical layouts, the successful dredging contractor may have a more efficient approach that still meets the project goals.)

The pipeline routes are planned as Stage 1 and Stage 2. The Stage 1 plan will require the main header bisect the lake mid point. This stage will allow dredging of the West Channels first, followed by the south one-half of the Northwest Channels, and finally Zastrow's Bay. Stage 2 dredging will require relocating the main header which bisects the lake to the north. Stage 2 dredging will then commence with the northern one-half of the Northwest Channel, progressing to the Northeast Channels, followed by the Bark River Inlet and finally to the northern inlets of Zastrow's Bay (if needed). Using this staged approach will minimize accessibility problems with riparian property owners.

The main header pipe bisecting the lake will be submerged 10 to 20 feet to allow recreational boaters to traverse the lake. The submerged pipeline will be marked in accordance with WDNR and U.S. Coast Guard standards as provided in details on Figure 20.

Upland piping from the shoreline staging area located in Zastrow's Bay to the dewatering site is shown on Figure 16. Influent piping will follow one of two routes. The primary influent/effluent pipeline route will be positioned on the Jim Lang property (parcel 0755996) crossing under Lake Road to Hirschman Lane. From Hirschman Lane, the pipeline will enter the Lake County LLC property on the west side which abuts to the city property off Oakwood Road. Easement agreements with the Lang and Lake County properties are provided in Appendix I. The alternative pipeline route follows Ridley Drive to Price Road, east to Nagawicka Lake Road then south to Hirschman Lane. The primary route will have less impact to property owners and a more direct route to the dewatering area. The primary route will cross through 5 private driveways. At the driveways, the pipes will either be installed through existing culverts or be trenched below the driveway if the culverts are of insufficient size. At the Lake Road junction, the pipes will be trenched below the road grade allowing uncongested use of this road. The alternate route is less desirable because of multiple transects over existing driveways. Effluent piping will follow the influent pipe route.

During dredging, sediment will be transported to the upland dewatering site via a slurry pipeline. Solids content within the slurry is typically near 8%. At the dewatering site, the slurry will be dispensed into geotextile bags where decant water will be released at an anticipated rate of 400,000 to 430,000 gpd. The expected percent solids of the sediment contained in the geotextile bags will be in the rate of 30% to 38%. The decant water from the geotextile bags will be collected and pumped back to the lake--under the condition contained in the project's WPDES Permit. A geomembrane liner will be placed below the geotextile bags and will prevent infiltration of lake water into the subsoil. Additional water will be collected as the sediment in the bags consolidates over time. The pumped slurry will be managed by the contractor in a manner to promote rapid dewatering in the bags with the use of WDNR approved polymers.

During dredging operations, the city will implement a Dredge Contingency and Spill Prevention Plan as presented in Appendix M. This plan outlines potential spill incidents and response procedures, as well as notification procedures.

A mechanical dredging using a crane with clamshell bucket may be used for hard material removal in the Bark River Inlet sediment trap. The sediment trap having a target elevation established at 883.0 feet may require 4 to 6 inches of hard material removal, estimated at 2,000 to 3,000 in-situ cubic yards. This material will be deposited in a barge and transported to the shoreline staging area. At the shoreline staging area, the material will be removed from the barge and placed in trucks for transporting to the dewatering site and integrated into site development plan.

Proposed technical specifications for the dredging contractor are provided in Appendix N.

5.2 Shoreline Staging Area Requirements

The proposed shoreline staging area for dredging is located in Zastrow's Bay as shown on Figure 15.

The shoreline staging area will be positioned on the existing bituminous paved public access area to Zastrow's Bay. The staging area will measure approximately 3,000 square feet (sq ft). During dredging operations, the staging area will support the booster pump station and generators, and will provide an area for equipment storage for supporting dredging operations. A temporary 40-foot dock will be constructed by the contractor for service boat docking. Surrounding the shoreline service area will be a temporary chain-link fence to prevent unauthorized access.

Expected equipment to be used within the staging area may include the following:

- Temporary docks for service boat(s),
- Diesel generators for booster pumps,
- Pipe fusing equipment,
- Security fencing around the site,
- Portable toilets, and
- Storage for small equipment/tools.

At the staging area, stormwater and erosion control best management practices will be implemented to minimize siltation of the lake during operations. These controls will include silt fencing installed both upland and in the water surrounding the staging areas. In addition, preventive practices by the contractor will be implemented such as regular removal of solids accumulation on roads by sweeping or other methods.

Because the Ridley Road staging area is a pre-existing developed area with bituminous paving, it is an ideal location for supporting dredge activities, including pipeline assembly, booster pump assembly and operations, and small equipment storage. This area, measuring approximately 3,000 sq ft, has an existing bituminous surface and no new area for staging area s development is required. As such, a Wis. Statues Chapter 30 Permit for disturbance of more than 10,000 sq ft within 75 feet of the ordinary high water mark is not needed.

The city has easement agreements for those riparian owners surrounding the Zastrow's Bay (east inlet) that will have extended property use impacts by the dredging operation. These agreements are provided in Appendix I.

6 Upland Sediment Dewatering and Disposal

The proposed upland sediment disposal site property, owned by the city, is located off Oakwood Road on the east side of the lake as shown on Figure 16. This property measures approximately 36 acres. The city's intent to use this property for dewatering is noted in a letter provided in Appendix I. Of the 36 acres, approximately 5 acres will be used for sediment dewatering and approximately 10 acres will be used for an operations management area used for equipment and material storage, maintenance activities, contractor office trailer, and other construction support activities.

The city's future plan for this parcel is development into a city park. The park features could include general recreation areas, baseball/soccer fields, hiking trails, and general green space. The city's plan is to beneficially use the dewatered sediment to achieve the design grading plan for this property when the park is developed. Currently, the city has not finalized a site development plan for this property. To prevent sediment contact with public or wildlife after site grading, the city will cover the sediments with 12-inch layer of clean on-site soil and apply 3-inches of topsoil, seed fertilizer, and mulch.

Alternatively, the city may sell the dewatered sediments to a third party landscaper or nursery. An assessment made by the city's consultant determined the market value of sediment for topsoil amendment is presently approximately $1.00 per cy. Given the low levels of parameters of concern in the sediments (Table 3-1), it is believed that upon mixing with on-site topsoil, the sediment will qualify for beneficial reuse. If the city pursues beneficial use and sale of the sediment, dewatered samples will be collected for additional analytical testing. The city will notify the WDNR if any off-site beneficial use is planned, and will then develop a testing plan.

Prior to construction, *Diggers Hotline* will be contacted to identify utilities within the upland management sites and pipeline routes. If a conflict arises with utilities and the sediment management sites or pipeline routes, the city will require the contractor to modify the design/operations as needed to avoid conflicts with potential utilities.

6.1 Property Characterization

The city's property is currently zoned general agricultural and is presently used for row crop production. The site topography gently slopes toward the southeast. Higher elevations are present near the west/west central portion of the site. Land use surrounding the site is primarily agriculture and residential.

The USDA soil survey indicates the soils at the site are predominately Casco Loam (CeC2 and CeD2), Fox Silt Loam (FsB and FsC2) and St. Charles Silt Loam (SeA and SeB). The "A" horizon of these soil units are silt loams underlain by "B" horizon soils which are comprised of clay and silt loams. The "C" horizon soils transition to coarser sands and gravels. Given these soil types, it is likely to expect moderate to rapid surface water infiltration.

Four soil samples were obtained by Foth, on June 28, 2006, to establish background chemical composition and to identify soil physical characteristics at the proposed dewatering/disposal site. The locations of the samples collected from the property are shown on Figure 3. The samples were collected from the upper "A" horizon soil unit and tested for the parameters listed under Table 6-1.

In addition, the four samples were tested for physical characterization including grain-size distribution, moisture content and organic content. Based upon the test results, the surficial soils ("A" horizon) are predominantly fine grained having more than 88% passing the P_{200} sieve. The analytical and physical test results are presented in Appendix G.

Table 6-1

Analytical Laboratory Data
Soil Samples from Proposed Upland Dewatering/Disposal Site

Nagawicka Lake Chapter 30 Permit Application
City of Delafield

Analytical Parameter	Hirschman Lane[1] HL(1-4)A	Hirschman Lane HL(1-4)B	Hirschman Lane North - HLN(1-2)A	Hirschman Lane North - HLN(1-2)B
Total Solids (% by weight)	81.1	83.9	80.5	79.9
Moisture Content (% by weight)	18.9	16.1	19.5	20.1
Organic Content (% by weight)	3.95	NA	3.72	NA
Grain Size Distribution				
% Cobbles	0	0	0	0
% Gravel	0	1.3	0	0.5
% Sand	11.8	24.4	4.3	12.2
% Silt	57.8	40.9	65.8	46.9
% Clay	30.4	33.4	29.9	40.4
P_{200} (%)	88.2	74.3	95.7	87.3
Metals				
Arsenic (mg/kg dry)	4.96	NA	5.96	NA
Copper (mg/kg dry)	10.6	NA	11.7	NA
Lead (mg/kg dry)	11.7	NA	10.7	NA
Zinc (mg/kg dry)	51.4	NA	50.7	NA
Pesticides				
4,4'-DDD (mg/kg dry)	ND	NA	ND	NA
4,4'-DDE (mg/kg dry)	ND	NA	ND	NA
4,4'-DDT (mg/kg dry)	ND	NA	ND	NA
Aldrin (mg/kg dry)	ND	NA	ND	NA
Chlordane (mg/kg dry)	ND	NA	ND	NA
Dieldrin (mg/kg dry)	ND	NA	ND	NA
Endrin (mg/kg dry)	ND	NA	ND	NA
Heptachlor (mg/kg dry)	ND	NA	ND	NA
Lindane (mg/kg dry)	ND	NA	ND	NA
Toxaphene (mg/kg dry)	ND	NA	ND	NA

NA = Not Analyzed
ND = Non-Detect

Notes:
HL(1-4)A was a composite of the top 0.65-1.3 feet (Soil Horizon A - Topsoil) of 4 borings from the Hirschman Lane proposed disposal site.
HL(1-4)B was a composite of the bottom 1.1-1.85 feet (Soil Horizon B) of 4 borings from the Hirschman Lane proposed disposal site.
HLN(1-2)A was a composite of the top 1.1-1.2 feet (Soil Horizon A - Topsoil) of 2 borings from the Hirschman Lane North proposed disposal site.
HLN(1-2)B was a composite of the bottom 0.8-1.5 feet (Soil Horizon B) of 2 borings from the Hirschman Lane North proposed disposal site.
[1] City's property designated as Hirschman Lane

Prepared by: TMK1
Checked by: JOS1

6.1.1 Wis. Admin. Code NR 504 Performance Standards

As part of the selection of the city's property as the dewatering site, the requirements of Wis. Admin. Code NR 504(4) was reviewed to demonstrate that the proposed sediment dewatering would meet the required performance standards. The performance standards are described below:

Wis. Admin. Code NR 504.04(a): A significant adverse impact on wetlands.

The proposed dewatering facility is not located within any wetland areas. The properties have been used for agricultural production over the last 100 years. A review of the WDNR state wetland inventory map shows no wetland areas present within the proposed sites.

Wis. Admin. Code NR 504.04(b): Endangered or threatened species.

The proposed site has been used over 100 years for agricultural production; as such, no endangered or threatened species are expected within the proposed disposal area.

Furthermore, review of the lake and watershed inventory for Nagawicka Lake (SEWRPC, March 1999) shows that the proposed dewatering site is outside of Class 1, high-value habitat areas; as such, the presence of threatened or endangered species in this area would be very remote.

Wis. Admin. Code NR 504.04(c): A detrimental effect on any surface water.

The proposed dewatering facility has been designed to collect hydraulic dredge decant water and return the water to the lake under a WPDES permit. No surface waters surrounding the dewatering/disposal site would be affected by the dredge operations. Locations of surrounding surface water features are shown on Figures 1 and 3. The major surrounding surface water features include the Bark River and Nagawicka Lake. Best management practices will be applied to all areas of disturbance so as to minimize construction stormwater impacts to receiving waters.

Wis. Admin. Code NR 504.04(d): A detrimental effect on groundwater quality.

The design of the sediment dewatering process will allow collection of all of the decant water from the geotextile bags. The decant water (effluent) will be pumped back to the lake. Because the geotextile bags will be placed in an area underlain with a low permeable geomembrane liner, infiltration to the groundwater table will be prevented.

Review of properties surrounding the sediment dewatering facility shows 15 properties abut the city's property. Given this information and the type of properties surrounding the site, there are possibly 12 private groundwater wells within 200 feet of the dewatering facility. Bedrock is around 150 to 200 feet deep in the areas surrounding Nagawicka Lake. Groundwater in the vicinity of the site is estimated to be approximately 25 to 50 feet below ground surface. The groundwater contours across the area are shown on Figure 21.

The city presently plans to maintain the sediment on-site as landscaping material. The sediment will be covered with 12-inches of on-site soil followed by 3-inches topsoil. To ensure groundwater protection to surrounding properties, the city will install monitoring wells to evaluate groundwater quality. The city will develop this plan upon dredge permit approval with input from the WDNR.

Wis. Admin. Code NR 504.04(e): The migration and concentration of explosive gases.

The sediments that will be dredged do not contain putresible material that would lead to the development of explosive methane gas. As such, sediment dredging operations are not anticipated to cause issues with explosive gases.

Wis. Admin. Code NR 504.04(f): The emission of any hazardous air contaminant.

The sediment material as excavated from the lakebed does not contain hazardous substances or materials that would volatilize. As such, emissions of any hazardous air contaminants are not anticipated to occur.

6.2 Containment Facility Design

6.2.1 Dewatering

Figure 17 illustrates the dewatering facility layout at the sediment management site. The design concepts for this facility include:

- An approximate 200,000 sq ft dewatering pad having perimeter containment berms constructed 2 feet high with 3:1 (H:V) slopes along the east and south sides. The dewatering pad will include a PVC liner system consisting of the following (from bottom to top):
  - A clean smooth subgrade have oversize materials removed;
  - 30-mil PVC liner;
  - 6 oz/sy non-woven geotextile protection layer. Geotextile strength calculations demonstrate that the 6 oz/yd^2 geotextile will have adequate strength based upon drainage stone having a median particle size of 3/8-inch;
  - 12 inches of granular cover soil having a maximum particle size of 1 inch and a median particle size of 3/8-inch;

- Sediment screening equipment to remove oversize material greater than 1.5 in. size from the sediment that could cause damage to the geotextile bags.

- A sediment dewatering system consisting of geotextile dewatering tubes approximately 20 feet in diameter and approximately 120 feet long. Using a bag capacity of 1,200 cy, 89 bags will be required for dewatering assuming a dredge volume of approximately 107,000 cy. Carriage water will be pumped into the geotextile tubes and allowed to drain. As the sediments consolidate, water will drain from the tubes into the underlying granular drainage layer and be collected in the perimeter trenches. Sediments will be held in the tubes until the solids content is approximately 30 percent. The geotextile average size opening (AOS) calculations based upon the sediment characteristics are provided in Appendix L. The calculations show that a minimum 8 oz/yd^2 geotextile fabric will be needed to allow for effective water release and to minimize clogging.

- A decant water collection system consisting of gravel trenches containing perforated piping to transmit decant water to the collection sump. The dewatering pad will slope to the collection sump at a minimum of 0.5%.

- A decant water collection sump for pumping effluent back to the lake. The collection sump contains a 60-inch diameter perforated HDPE sump riser pipe to allow extraction of decant water by the effluent booster pump. The collection sump will contain a 275 to 300 gpm pump for pumping to a booster station (if needed) or directly to the lake. The pump sizing calculations are provided in Appendix L.

The design of the sediment management site is shown on Figures 16, 17, and 18. The dewatering site was designed based upon expected solids and decant water loading. The 5-acre dewatering pad will have adequate capacity to manage expected decant water and sediment volumes. Based upon the design calculations provided in Appendix L, the dewatered sediment volume is expected to be approximately 67,000 to 49,000 cy, assuming 30 to 38% solids, respectively.

6.2.2 Solids Management

Upon dewatering, it is expected that approximately 49,000 to 67,000 cy of solids would be managed at the dewatering site. The city is currently evaluating alternatives for long term management of the solids including:

- Incorporation into the park development plan for landscaping.
- Sale to third parties for topsoil amendment,

Sediment that is retained on site for landscaping will be covered with 12-inches of on-site existing soils followed by 3-inches of topsoil. The city will install monitoring wells to gauge groundwater quality changes (if any) as a result of sediment storage and on-site use. If the city considers sale to a third party, the city will collect additional dewatered samples and test for parameter of concerns upon agreement with the WDNR.

7 Documentation and Monitoring

7.1 Pre-and-Post Dredge Documentation

The selected dredge contractor will be required to conduct pre-and post-dredge bathymetric surveys to verify dredge alignment and for dredge quality determination for payment.

Construction observation and documentation will be directed by the city during dredging to ensure substantial compliance with the contract specifications and permit conditions.

7.2 WPDES Monitoring

Return decant water will be monitored as required under the WPDES Permit for the project. Provided in Appendix A is the application for a Dredging Operation General WPDES Permit (WPDES Permit No. WI-0046558-3).

Hydraulic dredging is planned for all of the areas to be dredged, with the possible exception of the Bark River sediment trap which could be excavated using a mechanical method. As presented in Section 5, decant water will be returned to the lake via discharge pipelines.

Through the permitting process, the WDNR will establish monitoring and/or effluent limits as deemed appropriate. The general permit starts with the monitoring requirements presented in Table 7-1.

Table 7-1
WPDES General Permit Monitoring Requirements for Dredging Projects

Parameter	Limit Type	Limit and Units	Sample Frequency	Sample Type
Flow	--	MGD	Daily	Measure or Estimate
Total Suspended Solids	Daily Max	40 mg/l	Weekly	Grab

Grab Sample - A grab sample means a single sample collected at one moment of time or a combination of several smaller samples of equal volume collected in less than a two-minute period.

Flow Volume - Estimate means a reasonable approximation of the average daily flow based on a water balance, an uncalibrated weir, calculations from the velocity and cross section of the discharge, intake water meter readings, discharge water meter readings, or any other method approved by the WDNR.

7.3 Dewatering Site Monitoring

If the city chooses to maintain the sediments on the city's property for grading and landscaping purposes, the city will install groundwater monitoring wells to determine changes (if any) to groundwater quality. The city will work with the WDNR to develop the monitoring plan upon issuance of the Chapter 30 Permit.

8 References

Foth & Van Dyke and Associates, Inc., April 2006, Nagawicka Lake Restoration, *Preliminary Dredge Application and Sampling Plan*

Southeastern Wisconsin Regional Planning Commission, March 1999, *Lake and Watershed Inventory for Nagawicka Lake*

Southeastern Wisconsin Regional Planning Commission, March 2001, *Lake Management Plan for Nagawicka Lake*

U.S. Army Corps of Engineers, January 2003, *Evaluation of Dredged Material Proposed for Disposal at Island, Nearshore, or Upland Confined Disposal Facilities -- Testing Manual, Publication ERDC/EL TR-03-1*

Vierbicher Associates, Inc., August 2004, *Draft Lake Restoration Study,* Nagawicka Lake, City of Delafield, Wisconsin

Wisconsin Department of Natural Resources, December 2003, *Consensus Based Sediment Quality Guidelines Recommendations for Use & Application, Interim Guidance, Publication No. WT-732-2003*

Wisconsin Department of Natural Resources, December 2003, *Guidance for Applying the Sediment Sampling and Analysis Requirements of Chapter 347, Wisc. Admin. Code, Publication WT-778-2003*

Wisconsin Department of Natural Resources, February 2004, *The State of Wisconsin Approval Process for Dredging of Commercial Parks Guidance for Applicants and WDNR Staff Publication No. PUB-FH-061-2004*

Wisconsin Department of Natural Resources, February 2004, Letter dated February 23, 2004 from Heidi Bunk to Joseph Dorava, P.E., of Vierbicher Associates, Inc., regarding *sediment sampling for Nagawicka Lake*

Wisconsin Department of Natural Resources, *General Permit to Discharge Under the Wisconsin Pollutant Discharge Elimination System for Carriage and/or Interstitial Water Resulting from Dredging Operations;* WPDES Permit No. WI-0046558-3, April 1, 2006