A

APPENDIX A

Public Participation Materials

Little Saint Germain Lake Protection & Rehabilitation District

Little Saint Germain Lake Management Planning Project

Planning Meeting

November 5, 2008

Tim Hoyman
Eddie Heath
Onterra LLC

Presentation Outline

- Native Aquatic Plants
- Evolution of Exotic Treatment Monitoring
- Little Saint Exotic Treatments
- Results of 2008 Treatment
- Proposed 2009 Treatments
- Thoughts and Conclusions
- Implementation Plan Creation

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Aquatic Plants

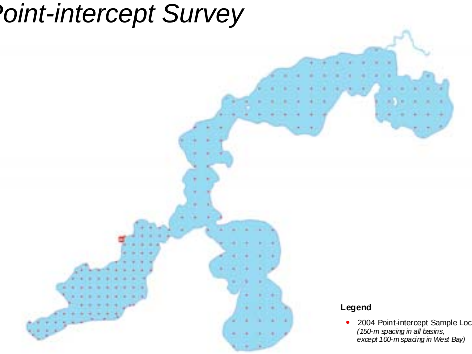
Comprehensive Plant Survey

- Surveys Completed in 2004 & 2008

1. **Point-Intercept Survey**
   - Systematic survey of all aquatic plants
2. **Community Mapping Survey**
   - Floating-leaf
   - Emergent

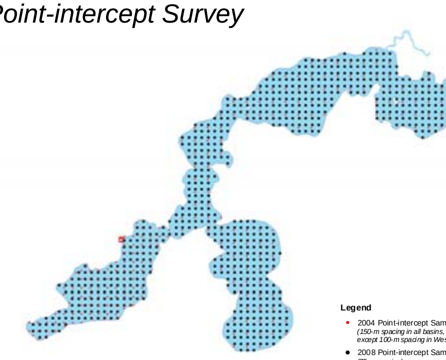
Onterra LLC

Point-intercept Survey

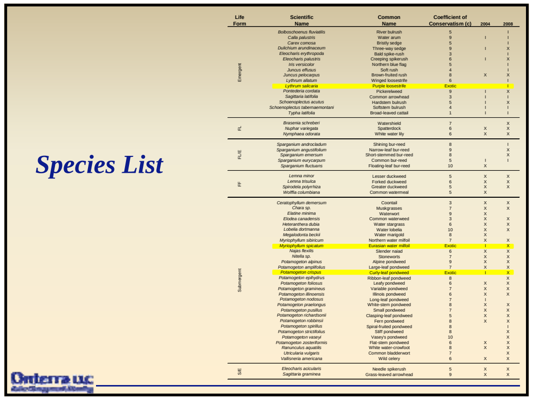


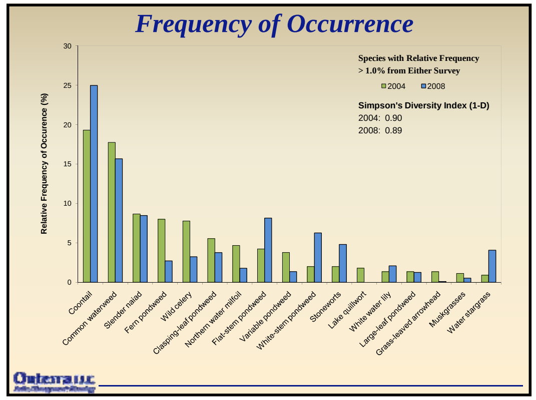
Onterra LLC

Point-intercept Survey

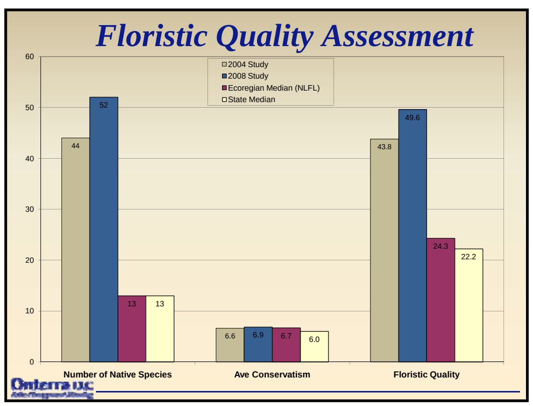


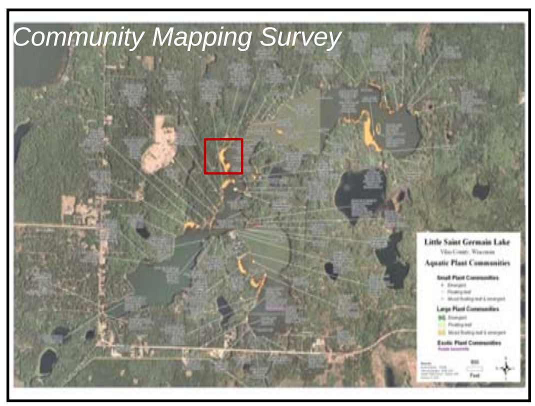
Onterra LLC

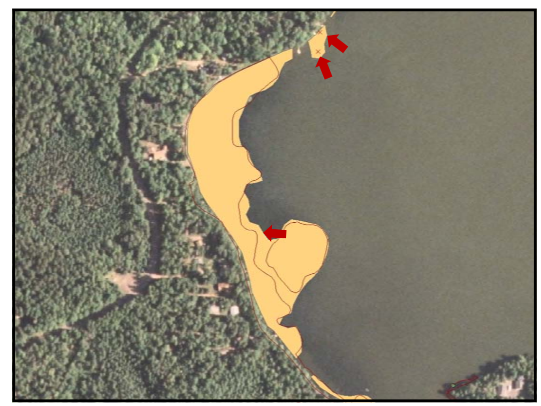

Species List
Onterra LLC


Frequency of Occurrence
Relative Frequency of Occurence (%)
Species with Relative Frequency > 1.0% from Either Survey
2004
2008
Simpson's Diversity Index (1-D)
2004: 0.90
2008: 0.89
Coontail
Common waterweed
Slender naiad
Fern pondweed
Wild celery
Clasping-leaf pondweed
Northern water milfoil
Flat-stem pondweed
Variable pondweed
White-stem pondweed
Stoneworts
Lake quillwort
White water lily
Large-leaf pondweed
Grass-leaved arrowhead
Muskgrasses
Water stargrass
Onterra LLC


Aquatic Plants
Wisconsin Ecoregions
Northern Lakes and Forests
Little Saint Germain Lake
North Central Hardwood Forests
Driftless Area
Southeastern Wisconsin Till Plains
Onterra LLC


Floristic Quality Assessment
2004 Study
2008 Study
Ecoregion Median (NLFL)
State Median
44
52
13
13
6.6
6.9
6.7
6.0
43.8
49.6
24.3
22.2
Number of Native Species
Ave Conservatism
Floristic Quality
Onterra LLC


Community Mapping Survey
Little Saint Germain Lake
Aquatic Plant Communities



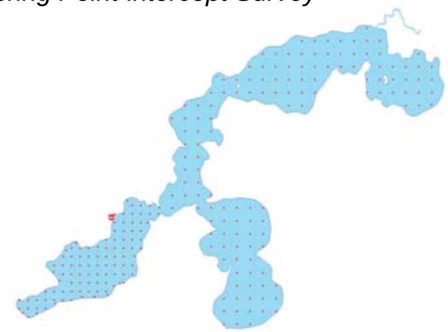
Aquatic Invasive Species Control Project

Evolution of Exotic Treatment Monitoring

2005 Spring P-I Used to Locate Exotics

- Supplemented by previous summer volunteer scuba survey data – some GPS
- Some scuba surveys completed in spring to refine treatment extents

Spring Point-intercept Survey



Evolution of Exotic Treatment Monitoring

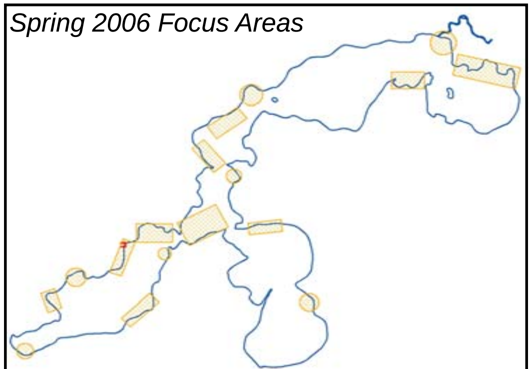
2005 Spring P-I Used to Locate Exotics

- Supplemented by previous summer volunteer scuba survey data – some GPS
- Some scuba surveys completed in spring to refine treatment extents

2006 Spring P-I & *Large* Focus Areas Used to Locate Exotics

- Supplemented by previous summer volunteer scuba survey data – some GPS
- Included some scuba and submersed video to refine treatment extents
- Concerns of treatment effectiveness – Onterra visits lake in mid Sept

Spring 2006 Focus Areas



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- Supplemented by previous summer volunteer scuba survey data – some GPS
- Included some scuba and submersed video to refine treatment extents
- Concerns of treatment effectiveness – Onterra visits lake in mid Sept

2007 Spring P-I & *Refined* Focus Areas Used to Locate Exotics

- Previous year's pro & volunteer surveys used to create refined focus areas
- Much submersible video used to refine treatment areas
- Volunteers trained to locate exotics for next spring's focus areas

Spring Point-Intercept Results

Table 6. Percent frequency of pretreatment surveys sample locations containing aquatic invasive species.

Year	EWM Frequency	CLP Frequency
2005	2%	4%
2006	0%	1%
2007	3%	3%

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Evolution of Exotic Treatment Monitoring

2005 Spring P-I Used to Locate Exotics

- Supplemented by previous summer volunteer scuba survey data – some GPS
- Some scuba surveys completed in spring to refine treatment extents

2006 Spring P-I & *Large* Focus Areas Used to Locate Exotics

- Supplemented by previous summer volunteer scuba survey data – some GPS
- Included some scuba and submersed video to refine treatment extents
- Concerns of treatment effectiveness – Onterra visits lake in mid Sept

2007 Spring P-I & *Refined* Focus Areas Used to Locate Exotics

- Previous year's pro & volunteer surveys used to create refined focus areas
- Much submersible video used to refine treatment areas
- Volunteers trained to mark exotics for next spring's focus areas

2008 Refined Focus Areas Used to Locate Exotics

- Short supply of volunteers & time lead to insufficient data collection in 2007
- Much submersible video used to refine treatment areas (very time consuming)
- Pre- and post treatment P-I data collected over treatment sites
- Summer volunteer surveys verified and refined by Onterra during early Sept

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Evolution of Exotic Treatment Monitoring

Spring surveys largely used to locate exotics and create treatment areas

Treatment success determined by a reduction in treatment acreage over the course of years

Summer surveys used to locate exotics and create treatment areas – refined in spring

Reduction in exotic density initially used to determine treatment success with reduction in acreage to follow

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Curly-leaf Pondweed

- Initial Success Criteria:
  - Based upon reduction in treatment area

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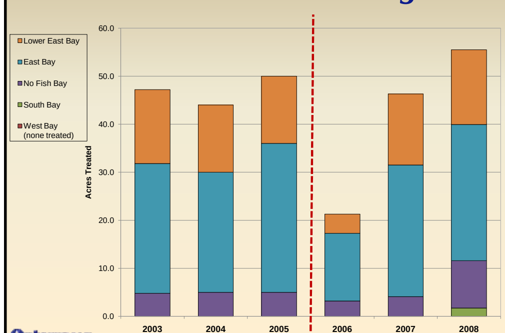
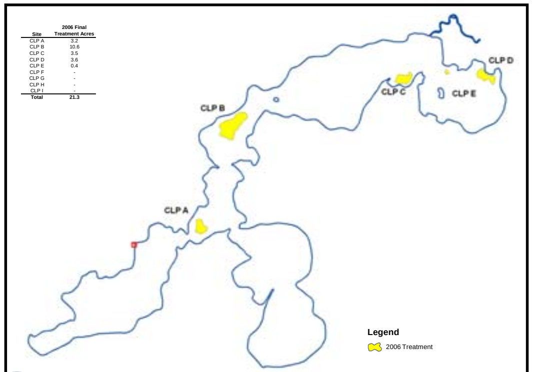
CLP Treatment Acreages



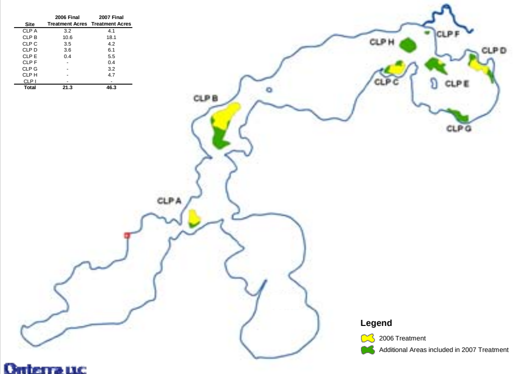
Onterra LLC

Site	2006 Final Treatment Acres
CLP A	3.2
CLP B	10.6
CLP C	3.5
CLP D	3.6
CLP E	0.4
CLP F	-
CLP G	-
CLP H	-
CLP I	-
Total	**21.3**



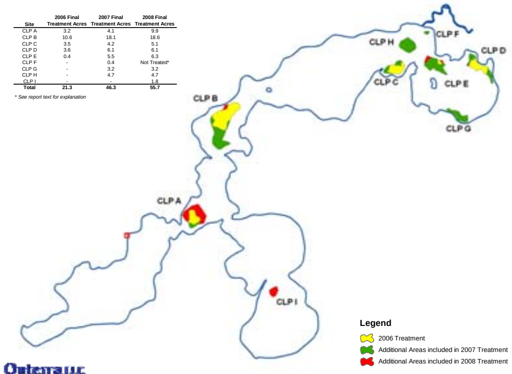
Onterra LLC

Site	2006 Final Treatment Acres	2007 Final Treatment Acres
CLP A	3.2	4.1
CLP B	10.6	18.1
CLP C	3.5	4.2
CLP D	3.6	6.1
CLP E	0.4	5.5
CLP F	-	0.4
CLP G	-	3.2
CLP H	-	4.7
CLP I	-	-
Total	**21.3**	**46.3**



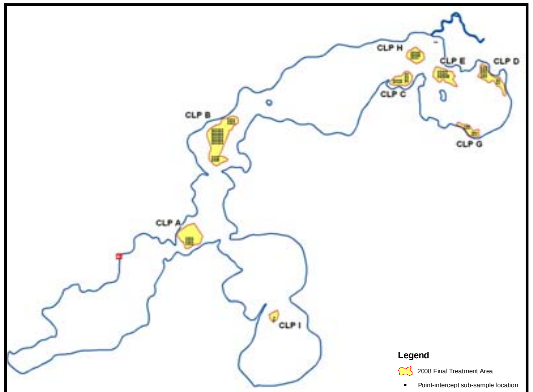
Site	2006 Final Treatment Acres	2007 Final Treatment Acres	2008 Final Treatment Acres
CLP A	3.2	4.1	9.9
CLP B	10.6	18.1	18.6
CLP C	3.5	4.2	5.1
CLP D	3.6	6.1	6.1
CLP E	0.4	5.5	6.3
CLP F	-	0.4	Not Treated*
CLP G	-	3.2	3.2
CLP H	-	4.7	4.7
CLP I	-	-	1.8
Total	**21.3**	**46.3**	**55.7**

** See report text for explanation*



Curly-leaf Pondweed

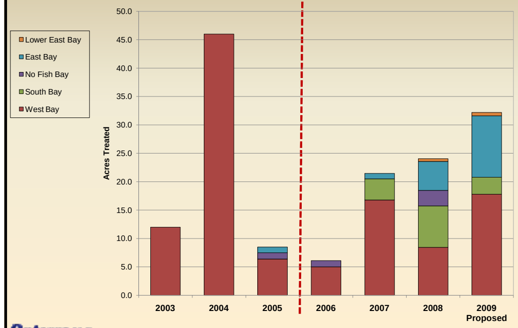
- Initial Success Criteria:
  - Based upon reduction in treatment area
- Current Success Criteria:
  - Using modified point-intercept survey to monitor treatment effectiveness
    - May 2008 (Pretreatment)
    - *May 2009 (Post Treatment)*

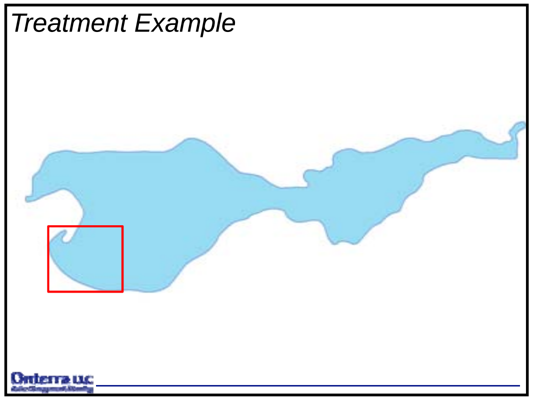


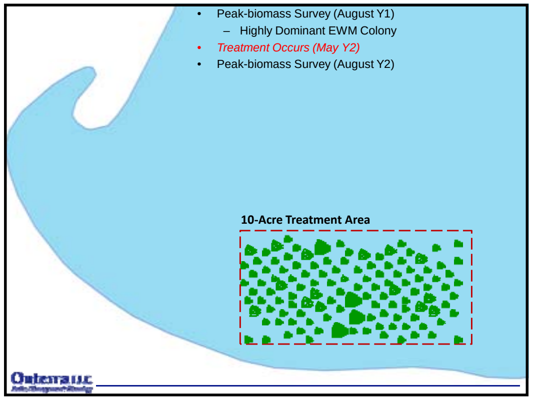
Eurasian Water Milfoil

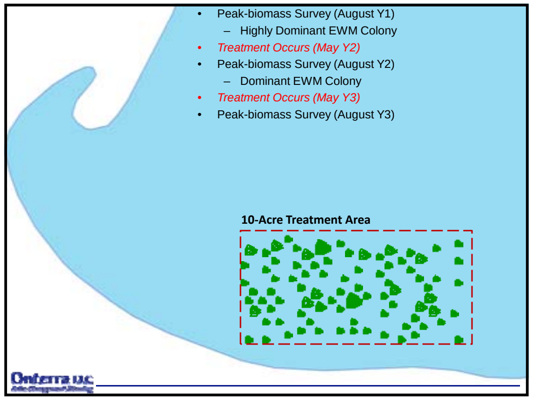
- Initial Success Criteria:
  - Based upon reduction in treatment area

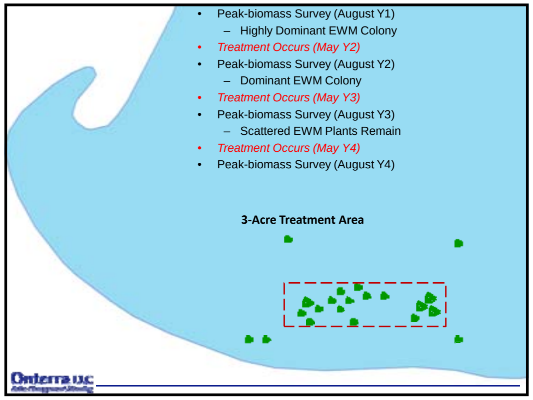
EWM Treatment Acreages

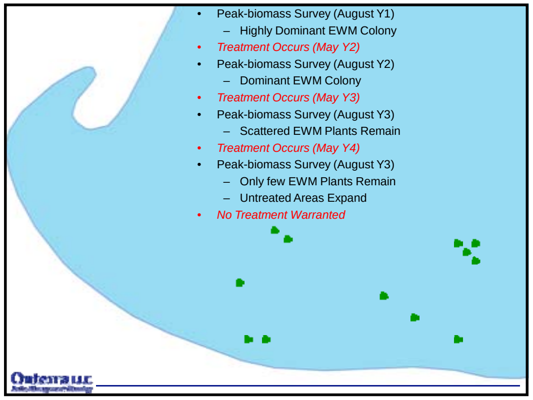


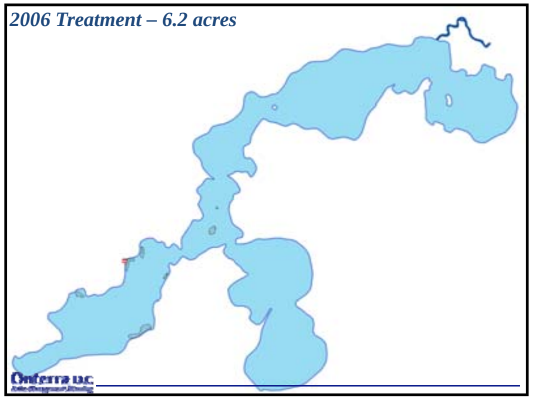

Treatment Example
Onterra LLC

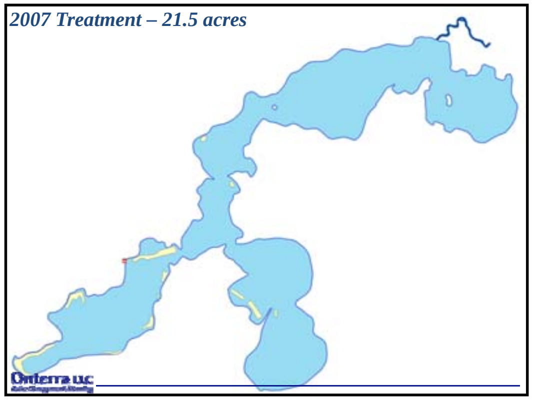

• Peak-biomass Survey (August Y1)
– Highly Dominant EWM Colony
• Treatment Occurs (May Y2)
• Peak-biomass Survey (August Y2)
10-Acre Treatment Area
Onterra LLC

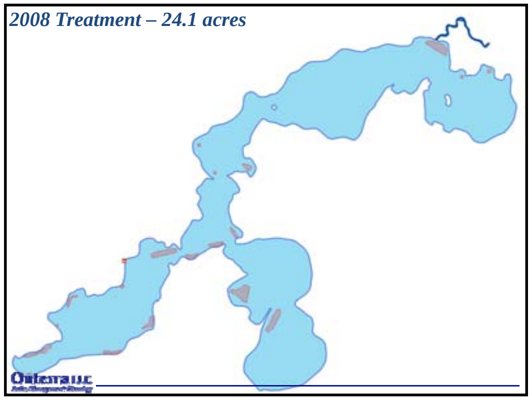

• Peak-biomass Survey (August Y1)
– Highly Dominant EWM Colony
• Treatment Occurs (May Y2)
• Peak-biomass Survey (August Y2)
– Dominant EWM Colony
• Treatment Occurs (May Y3)
• Peak-biomass Survey (August Y3)
10-Acre Treatment Area
Onterra LLC

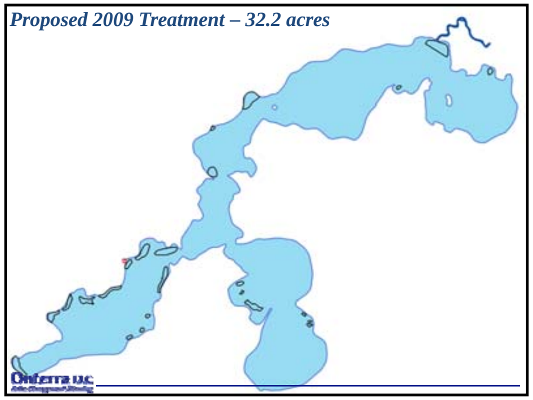

• Peak-biomass Survey (August Y1)
– Highly Dominant EWM Colony
• Treatment Occurs (May Y2)
• Peak-biomass Survey (August Y2)
– Dominant EWM Colony
• Treatment Occurs (May Y3)
• Peak-biomass Survey (August Y3)
– Scattered EWM Plants Remain
• Treatment Occurs (May Y4)
• Peak-biomass Survey (August Y4)
3-Acre Treatment Area
Onterra LLC

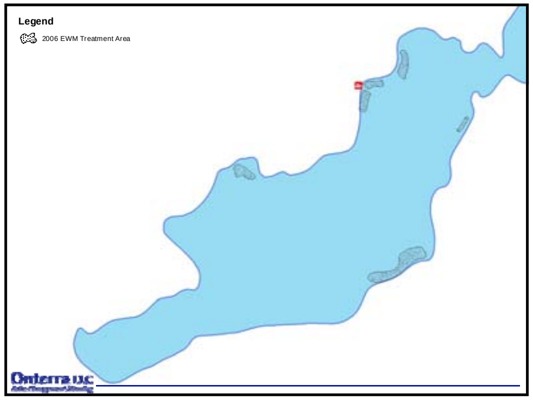

• Peak-biomass Survey (August Y1)
– Highly Dominant EWM Colony
• Treatment Occurs (May Y2)
• Peak-biomass Survey (August Y2)
– Dominant EWM Colony
• Treatment Occurs (May Y3)
• Peak-biomass Survey (August Y3)
– Scattered EWM Plants Remain
• Treatment Occurs (May Y4)
• Peak-biomass Survey (August Y3)
– Only few EWM Plants Remain
– Untreated Areas Expand
• No Treatment Warranted
Onterra LLC


2006 Treatment – 6.2 acres
Onterra LLC

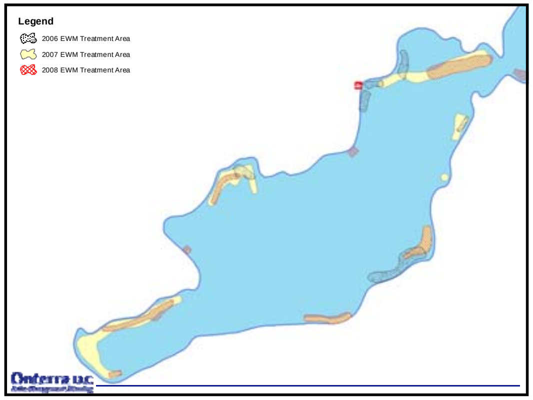

2007 Treatment – 21.5 acres
Onterra LLC


2008 Treatment – 24.1 acres
Onterra LLC


Proposed 2009 Treatment – 32.2 acres
Onterra LLC


Legend
2006 EWM Treatment Area
Onterra LLC


Legend
2006 EWM Treatment Area
2007 EWM Treatment Area
Onterra LLC

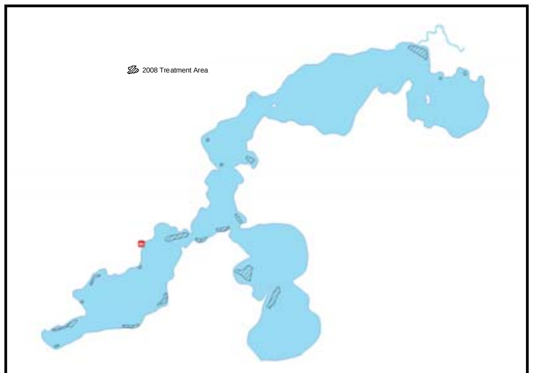

Legend
2006 EWM Treatment Area
2007 EWM Treatment Area
2008 EWM Treatment Area
Onterra LLC

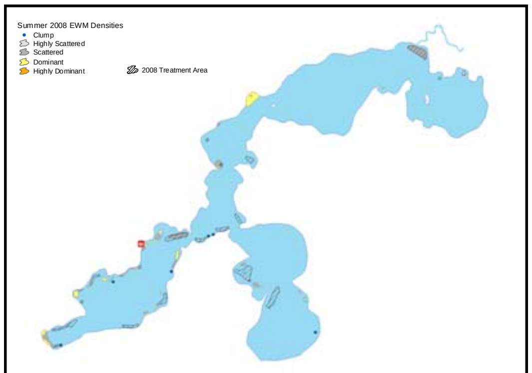
Eurasian Water Milfoil

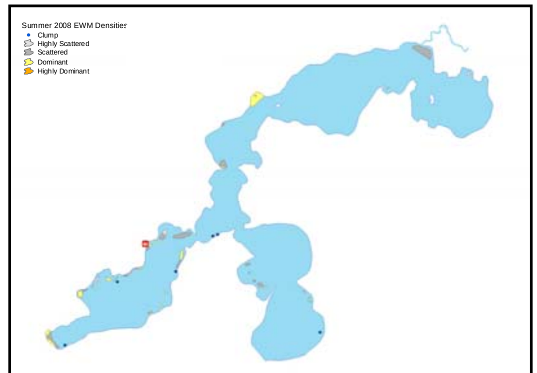
- Initial Success Criteria:
  - Based upon reduction in treatment area
- Current Success Criteria:
  - Using modified point-intercept survey to monitor treatment effectiveness
    - ~~*August 2007 (Pretreatment)*~~
    - May 2008 (Pretreatment)
    - August 2008 (Post Treatment)
    - *May 2009 (Post Treatment)*

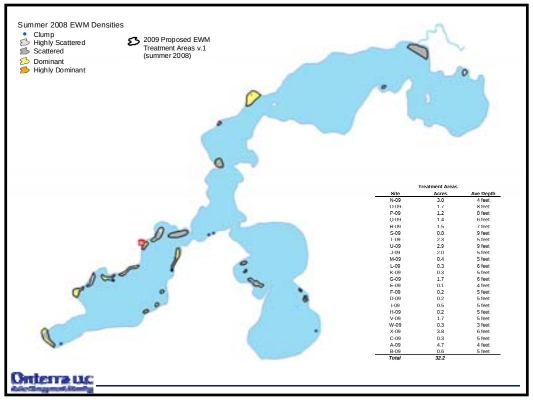
2008 EWM Treatment Monitoring Results

- Qualitative
- Quantitative



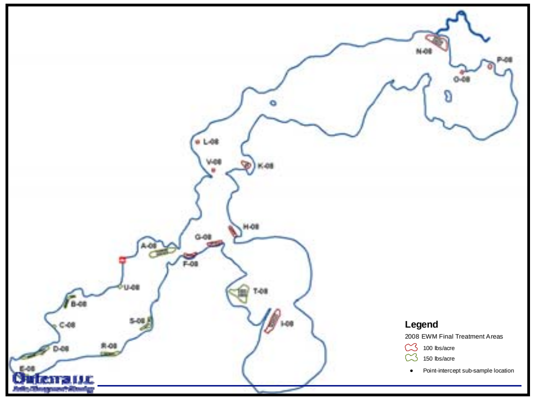


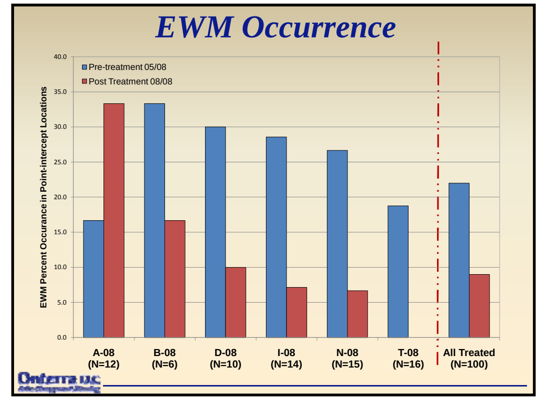


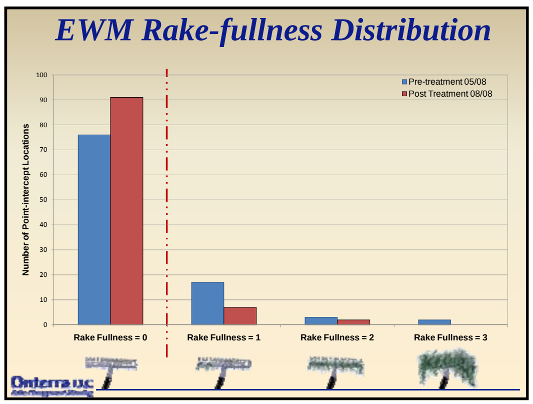


Treatment Areas

Site	Acres	Ave Depth
N-09	3.0	4 feet
O-09	1.7	8 feet
P-09	1.2	8 feet
Q-09	1.4	6 feet
R-09	1.5	7 feet
S-09	0.8	9 feet
T-09	2.3	5 feet
U-09	2.9	9 feet
J-09	2.0	5 feet
M-09	0.4	5 feet
L-09	0.3	6 feet
K-09	0.3	5 feet
G-09	1.7	6 feet
E-09	0.1	4 feet
F-09	0.2	5 feet
D-09	0.2	5 feet
I-09	0.5	5 feet
H-09	0.2	5 feet
V-09	1.7	5 feet
W-09	0.3	3 feet
X-09	3.8	6 feet
C-09	0.3	5 feet
A-09	4.7	4 feet
B-09	0.6	5 feet
Total	***32.2***	

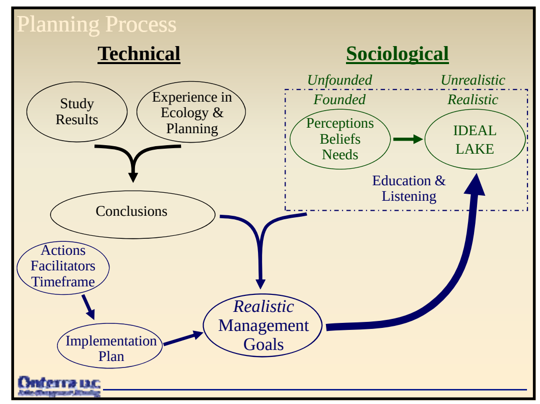






Thoughts & Conclusions

- Native plants have remained about the same
- We did not see a reduction in treatment acreage as originally anticipated
- Discovered our monitoring & survey techniques needed to change
  - Properly trained volunteers are critical
  - Survey timing is essential
- Ability to tune treatments is important
- Did we meet the original goals?



LITTLE ST. GERMAIN LAKE PROTECTION AND REHABILITATION DISTRICT SAINT GERMAIN, WI

Elected Commissioners
Ted Ritter, Chairman
Erv Stiemke, Treasurer
Lou Mirek, Secretary

Appointed Commissioners
Todd Wiese, Town of Saint Germain
Mary Platner, County of Vilas

http://littlesaint.org

Mr. Tim Hoyman
Onterra, LLC
135 South Broadway – Suite C
De Pere, WI 54115

December 19, 2008

Re. Draft Management Plan Comments

Dear Tim:

This is in response to your draft management plan sent to Little Saint Germain Lake Planning Committee members on December 1, 2008. The board of commissioners has also reviewed the Implementation Plan portion of the document in addition to committee members having reviewed the entire document. This response is a collection of input from all sources and has been reviewed and approved by the board of commissioners.

Board of Commissioners response to
Onterra draft December, 2008 Lake Management Plan

Background portion

- Pg 3, par 2: Although State and GLIFCC sources indicate the presence of Rusty crayfish in Little Saint Germain Lake, those sources are believed to be in error. Please consider removing any indication of the presence of this species.
- Pg 3, par 5: The initial five year control project and supporting grant funding ended during 2008. A new management plan needs to be adopted prior to management activities commencing in 2009.
- Pg 8, par 4: Regarding the purple loosestrife finding: We are okay with mentioning this species finding in the plan. We are also okay with not prescribing any response to it. The lake district will seek the guidance of the Vilas County AIS Coordinator in developing an appropriate management plan.
- Pg 23, final par: This language might be interpreted by some that “maintenance level” management of EWM and CLP have bean achieved, thereby reducing eligibility for ongoing grant funding. This concern is especially relevant considering how intensely competitive AIS grants have become. We request this be modified to not only acknowledge the significant accomplishments of the initial five years, but to also emphasize that continued aggressive management is needed with both species in order to achieve a “maintenance level” management program (“maintenance level” is as yet undefined by the State).

<u>Implementation Plan</u>

Management Goal 1: Maintain recreational access to Little Saint Germain Lake for shore land property owners and other lake users:

Management Action: Use mechanical harvesting to remove nuisance levels of native plants ……to maintain navigational access ……

- Navigational "access" implies that harvesting is done only for the benefit of specific lakefront property owners to enable access to open water. While this is sometimes the case, harvesting is also done to maintain recreational opportunities for all lake users. Various areas of Little Saint that are popular for fishing as well as water skiing and general boating are also prone to occasional nuisance level native plant growth. Lake users cannot fully enjoy the lake when vegetation becomes dense or tops out. The phrase "reduction of biomass to prevent anoxic conditions" does not adequately identify the other reasons that justify harvesting.
- We question if the plan should specify the maximum number of acres to be harvested in any one year. Annual growth conditions and other variable factors should dictate that decision.
- We prefer the plan include the ability to proceed with harvesting on an annual basis as follows:
  - District and harvesting contractor submits an advance permit application identifying <u>potential</u> harvest areas for the coming summer season
  - DNR issues <u>conditional</u> permit in advance of summer season
  - District and harvesting contractor, adjust harvesting plan during summer according to plant growth and presence of EWP/CLP
  - While harvesting of invasive plant colonies should be prohibited, the presence of a single invasive plant should not prohibit harvesting. Perhaps the plan could define at what point the presence of invasive plants does not prohibit harvesting or requires removal of the invasive plants prior to harvesting.
  - DNR considers revised harvesting plan and issues final permit with appropriate restrictions

Management Action: Use mechanical harvesting or limited chemical treatments to maintain lake access for residences on southwest shore of East Bay

- Caution need be taken in defining this action to avoid making it the responsibility of the District to always provide navigational access relief for the benefit of specific lakefront properties. The plan should enable discretion by either the District or individual property owners to pursue such relief. (While the District seems willing at this time to offer assistance to the property owners on the southwest shore of East Bay, it may not choose to so do in the future).
- "Further, if herbicide applications are necessary, their use on native plants will be mitigated through the creation of natural buffer areas along the shore lands for which they are applied."
  - Perhaps this could say that shore land mitigation will be considered and implemented if found to be an appropriate aspect of the desired aquatic plant control. Let's not assume in advance that shore land mitigation will always be justified
- "Regardless of the technique used …… no more than a 20 foot wide navigation lane will be cleared in any area and the shortest route possible will be used"
  - Why a restriction of 20 feet? Isn't 30 feet the maximum allowed navigation lane?

Management Goal 2: Maintain or Enhance Current Water Quality Conditions:

Management Action: Monitor water quality through WDNR Citizens Lake Monitoring Network

- No comments

Management Action: Conduct alum treatment within specified areas ……

- Consideration of an alum treatment is a lengthy process that has been underway for several years. It is possible that the District will seek State authorization for a 2009 treatment, but there are still numerous hurdles to clear before even applying for a permit. The District is working closely with both Barr Engineering and the WDNR. The description and action steps of this management action will be provided at a later date in the form of a detailed project proposal currently being prepared by Barr Engineering.

Management Goal 3: Control Aquatic Invasive Species within Little Saint Germain Lake

Management Action: Continue CBCW inspections

- While watercraft inspection activities at the public boat landing are ultimately the responsibility of the District, efforts on a town-wide level are coordinated by the Town Lakes Committee, on which the District has the option of maintaining two voting seats. The District needs to continue supporting the work of the Town Lakes Committee through solicitation of volunteer inspectors.

Management Action: Coordinate annual volunteer monitoring of aquatic invasive species within Little Saint Germain Lake.

- "In order to effectively continue …… fortify the volunteer base. ~~so the work does not fall upon the shoulders of only one or so volunteers".~~

Management Action: Control Eurasian water milfoil and curly-leaf pondweed infestations within Little Saint Germain Lake using herbicide applications.

- Reference is made to the "impossibility" of eradicating EWM & CLP. We request that this be changed to something like "highly unlikely given the current status of control technology and methodology"
- Considerable discussion of "trigger points" occurred at the planning meeting preceding development of this plan draft. Should the plan discuss "trigger points" to define at what points:
    - new plant colonies are subject to chemical treatment?
    - previously treated plant colonies no longer need treatment?
- The plan needs to address how to manage new sites that do not yet qualify for 2,4-d treatment. Ignoring new sites until they become large enough to be effectively managed with 2,4-d is not appropriate. Doing so is akin to acknowledging that South Bay will eventually become as populated with EWM colonies as West bay has become. Perhaps some new protocol should be developed for effective control (other than hand pulling) of single or low density plants.
- Consider clarifying the roles and expertise levels of volunteer lake plant monitors:
    - Casual observers who report suspicious findings to trained observers
    - Trained observers who evaluate findings of casual observers and then respond accordingly
- No reference is made to post-treatment chemical residual monitoring of either the water or sediments. Considering that this plan will take the District into its second round of five year chemical usage, should we be conducting water and/or sediment studies for long term chemical residue?
- The plan does not address a strategy for grant funded support over the course of the next five years. The board of commissioners feels it is wise to pursue five year funding in one grant application, but to also note in the plan that additional

funding might be needed if State requirements expand in a manner that causes costs to increase during the second five years.

Management Action: Monitor native and non-native aquatic plants on a lake wide basis in Little Saint Germain Lake

- No comments

Additional suggestions:

- Please consider adding a “Summary” or “Conclusions” section including an assessment of the benefits delivered over the initial five year plan.
- Please consider including the initial five year plan as an appendix. Perhaps the District (Erv) could also summarize projected vs. actual five year costs as well as a grant funding summary.

Tim, some of these suggestions will likely require further discussion. As a means of efficiency in moving this project forward as expeditiously as possible, please contact me at my Vilas County workplace for any needed follow-up.

Sincerely,

Ted Ritter

Ted Ritter, Chairman
Board of Commissioners

B

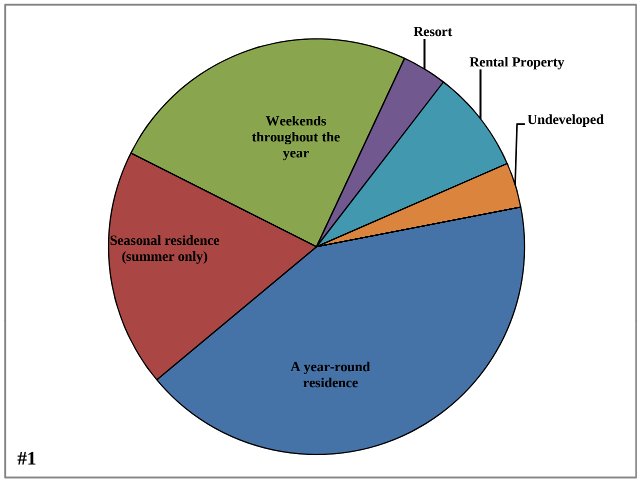
APPENDIX B

Stakeholder Survey Response Charts and Comments

Returned Surveys	204
Sent Surveys	418
Response Rate (%)	48.8

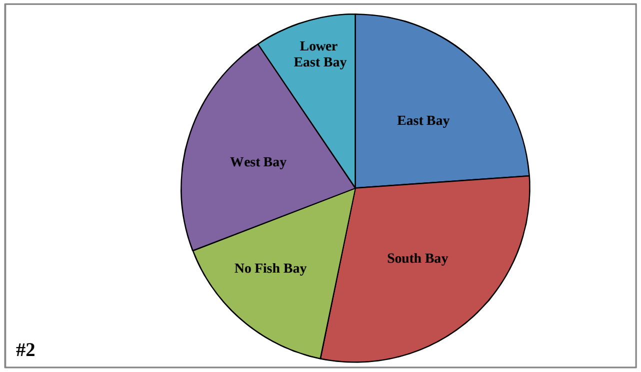
#1 What type of property do you own on Little Saint Germain Lake?

	Total	%
A year-round residence	84	*42.0*
Seasonal residence (summer only)	37	*18.5*
Weekends throughout the year	49	*24.5*
Resort	7	*3.5*
Rental Property	16	*8.0*
Undeveloped	7	*3.5*
Other	0	*0.0*
	200	



#2 On which bay is your Little Saint Germain Lake property located? .

	Total	%
East Bay	48	23.9
South Bay	59	29.4
No Fish Bay	32	15.9
West Bay	43	21.4
Lower East Bay	19	9.5
	201	

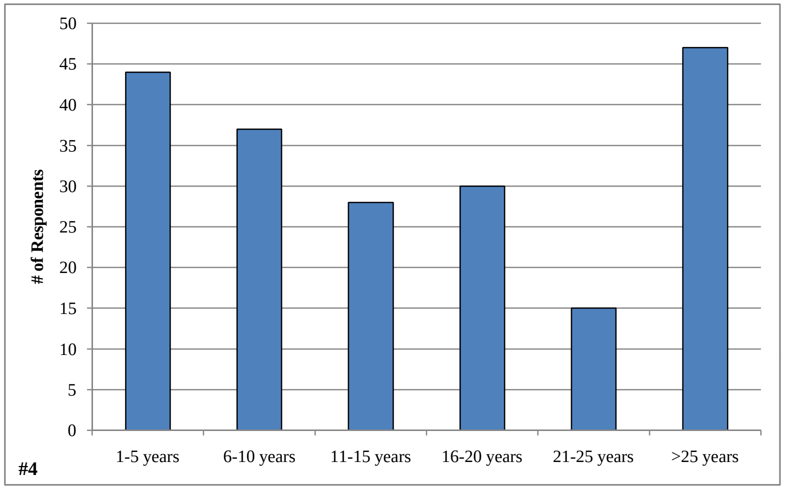


#3 If you are not a year-round resident, how many days each year is your property used by you or others?

Answered Question	128
Average	77.0
Standard deviation	50.8

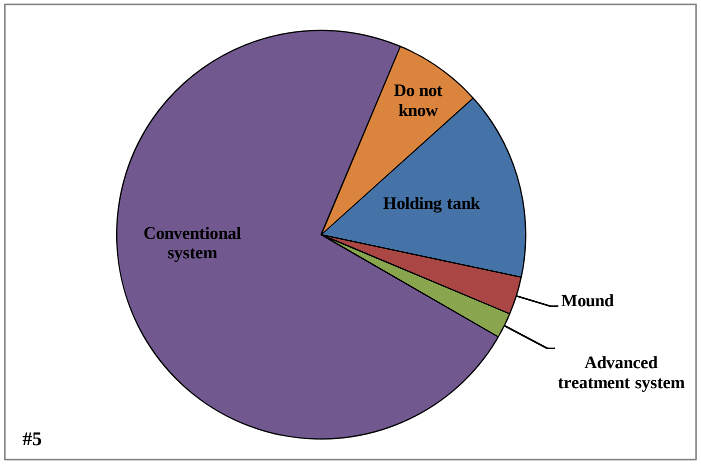
#4 How many years have you owned property on Little Saint Germain Lake?

	Total	%
1-5 years	44	*21.9*
6-10 years	37	*18.4*
11-15 years	28	*13.9*
16-20 years	30	*14.9*
21-25 years	15	*7.5*
>25 years	47	*23.4*
	201	



#5 What type of septic system does your property utilize?

	Total	%
Holding tank	30	*15.0*
Mound	6	*3.0*
Advanced treatment system	4	*2.0*
Conventional system	146	*73.0*
Municipal Sewer	0	*0.0*
Do not know	14	*7.0*
	200	

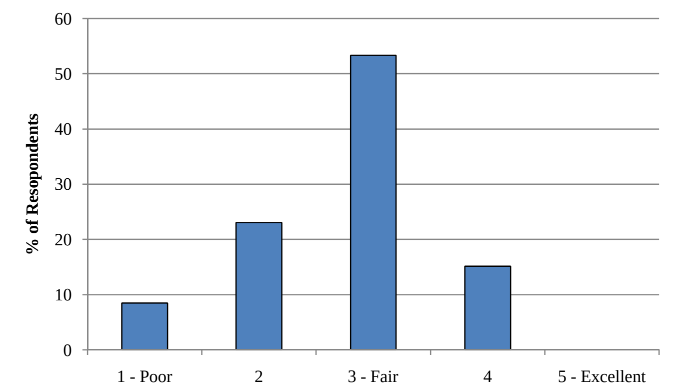


#6 Have you fished on Little Saint Germain Lake in the past 3 years?

	Total	%
Yes	165	*81.3*
No	38	*18.7*
	203	

#7 How would you describe the current quality of fishing on Little Saint Germain Lake?

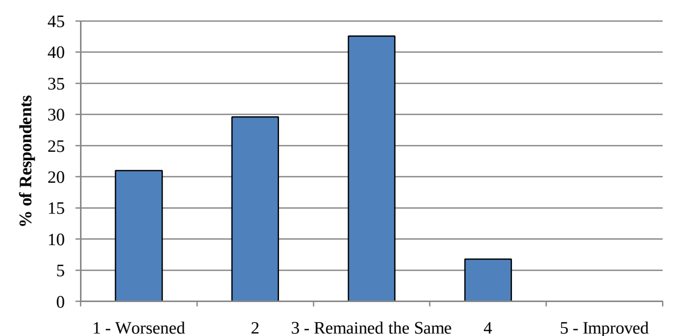
	Total	%
1 - Poor	14	*8.5*
2	38	*23.0*
3 - Fair	88	*53.3*
4	25	*15.2*
5 - Excellent	0	*0.0*
	165	



#7

#8 How has the quality of fishing changed on Little Saint Germain Lake since you obtained your property?

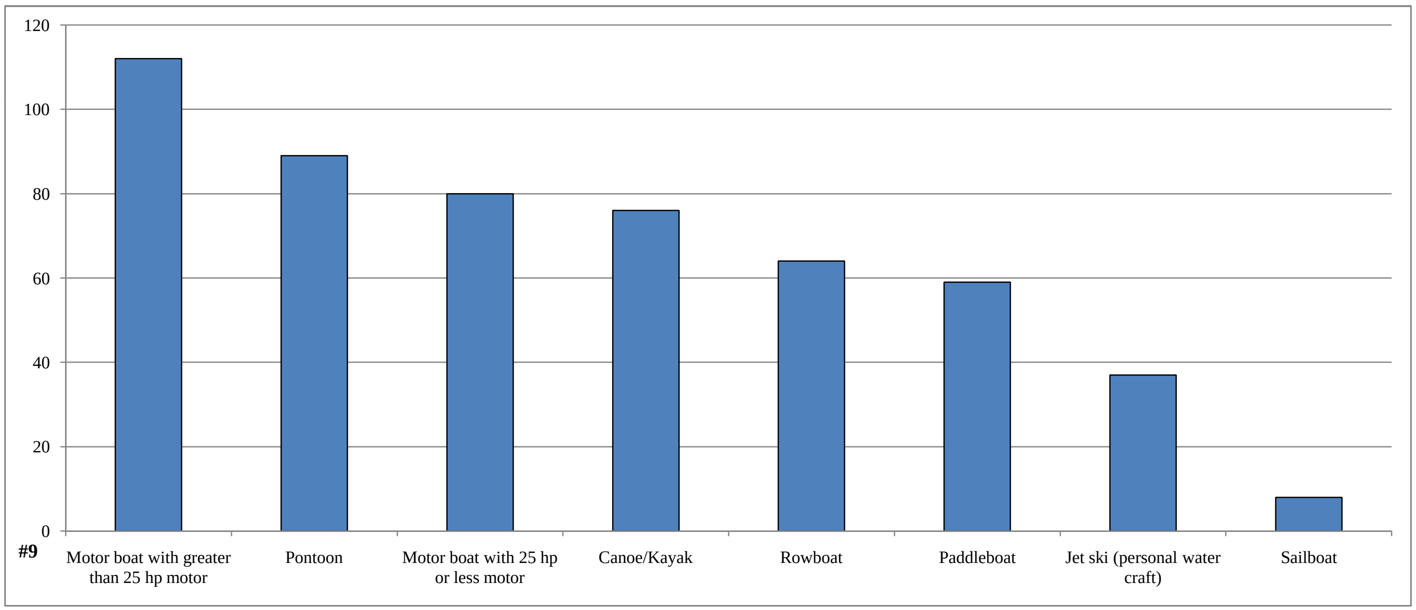
	Total	%
1 - Worsened	34	*21.0*
2	48	*29.6*
3 - Remained the Same	69	*42.6*
4	11	*6.8*
5 - Improved	0	*0.0*
	162	



#8

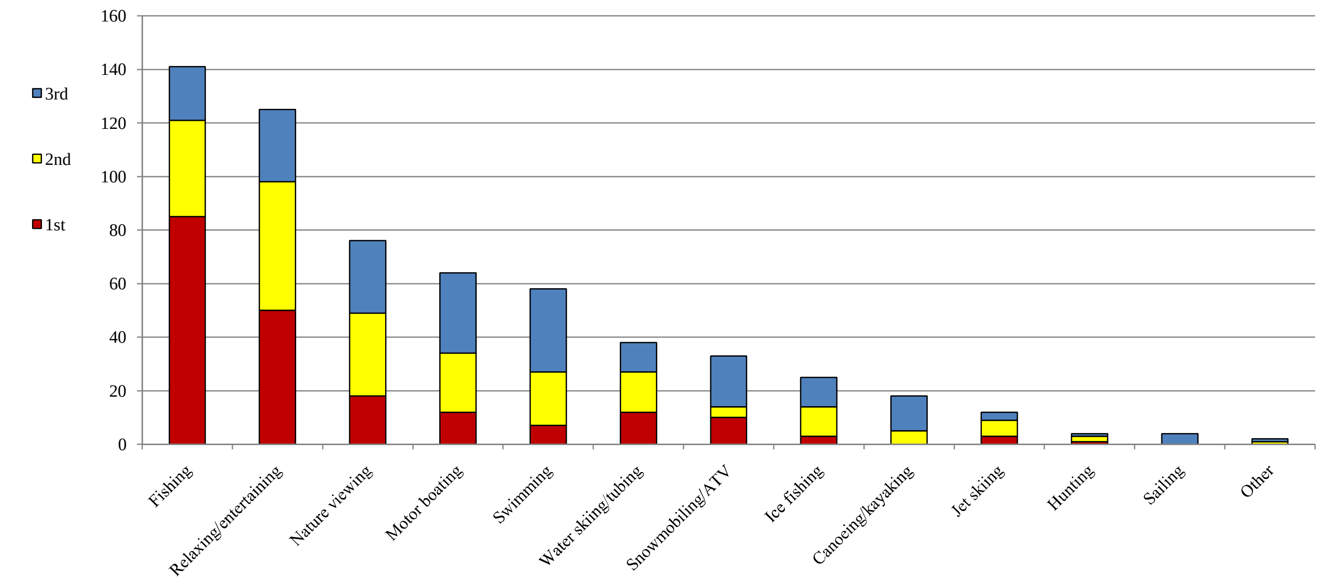
#9 What types of watercraft do you currently use on Little Saint Germain Lake?

	Total
Motor boat with greater than 25 hp motor	112
Pontoon	89
Motor boat with 25 hp or less motor	80
Canoe/Kayak	76
Rowboat	64
Paddleboat	59
Jet ski (personal water craft)	37
Sailboat	8
	525



#10 Please rank the activities below that are the most important or enjoyable to you on Little Saint Germain Lake?

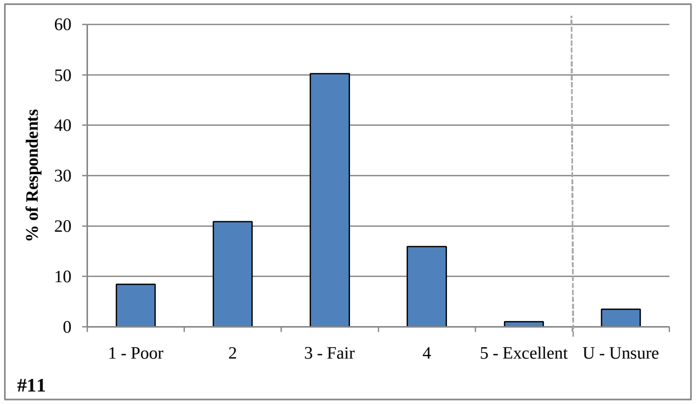
	1st	2nd	3rd	*% ranked*
Fishing	85	36	20	*23.4*
Relaxing/entertaining	50	48	27	*20.7*
Nature viewing	18	31	27	*12.6*
Motor boating	12	22	30	*10.6*
Swimming	7	20	31	*9.6*
Water skiing/tubing	12	15	11	*6.3*
Snowmobiling/ATV	10	4	19	*5.5*
Ice fishing	3	11	11	*4.1*
Canoeing/kayaking	0	5	13	*3.0*
Jet skiing	3	6	3	*2.0*
Hunting	1	2	1	*0.7*
Sailing	0	0	4	*0.7*
Other	0	1	1	*0.3*
	201	201	198	



#10

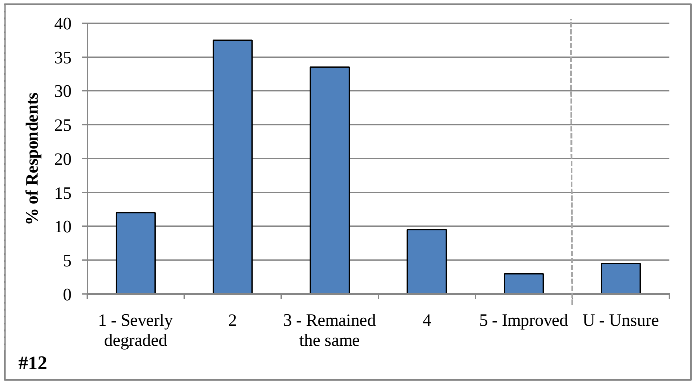
#11 How would you describe the current water quality of Little Saint Germain Lake?

	Total	%
1 - Poor	17	*8.5*
2	42	*20.9*
3 - Fair	101	*50.2*
4	32	*15.9*
5 - Excellent	2	*1.0*
U - Unsure	7	*3.5*
	201	



#12 How has the water quality changed in Little Saint Germain Lake since you obtained your property?

	Total	%
1 - Severly degraded	24	*12.0*
2	75	*37.5*
3 - Remained the same	67	*33.5*
4	19	*9.5*
5 - Improved	6	*3.0*
U - Unsure	9	*4.5*
	200	



#13 Are you aware of the impacts that the use of phosphorus-containing fertilizer on shoreland properties can have on your lake?

	Total	%
Yes	185	*93.4*
No	13	*6.6*
	198	

#14 Are you aware of aquatic invasive species on Little Saint Germain Lake?

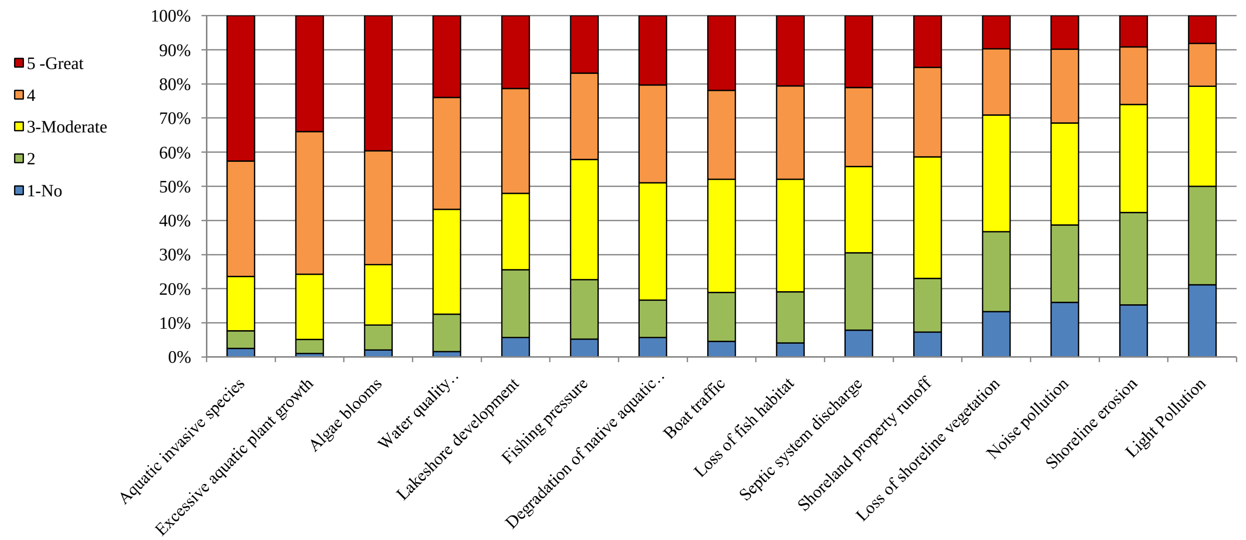
	Total	%
Yes	197	*98.5*
No	3	*1.5*
	200	

#15 Are you aware of aquatic invasive species in your lake?

	Total	%
Yes	176	*88.4*
No	23	*11.6*
	199	

#16 To what level do you believe each the following factors are negatively impacting Little Saint Germain Lake?

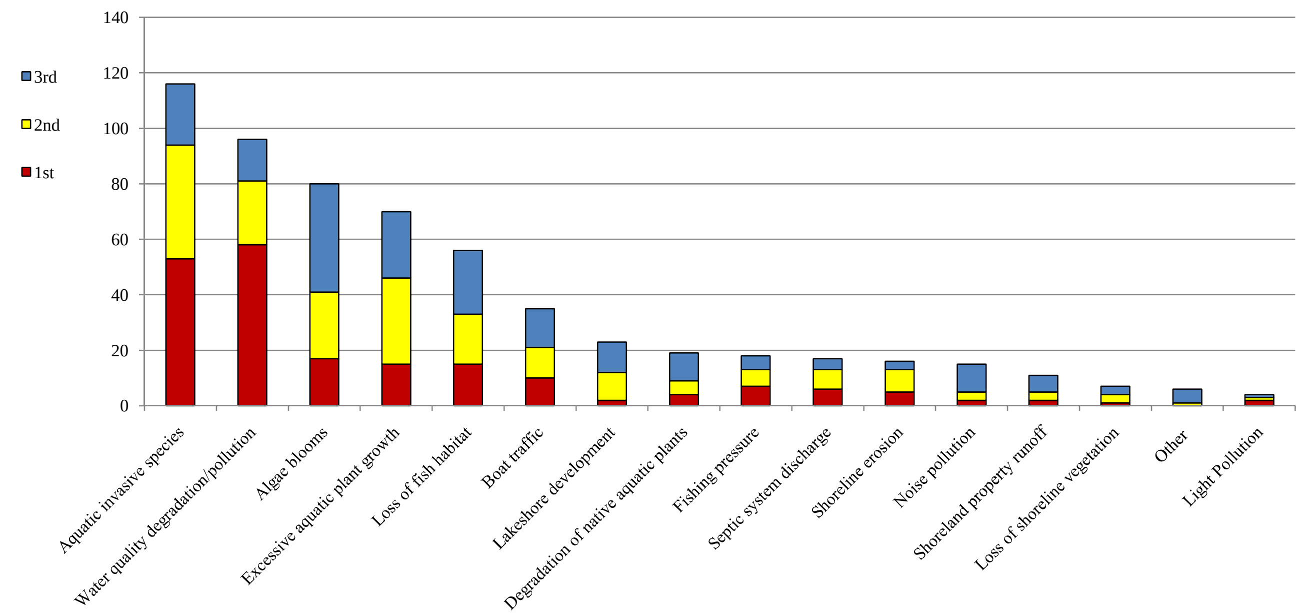
	1-No	2	3-Moderate	4	5 -Great	*Total*	*Average*
Aquatic invasive species	5	10	31	66	83	*195*	*4.1*
Excessive aquatic plant growth	2	8	37	81	66	*194*	*4.0*
Algae blooms	4	14	34	64	76	*192*	*4.0*
Water quality degradation/pollution	3	21	59	63	46	*192*	*3.7*
Lakeshore development	11	38	43	59	41	*192*	*3.6*
Fishing pressure	10	33	67	48	32	*190*	*3.5*
Degradation of native aquatic plants	11	21	66	55	39	*192*	*3.5*
Boat traffic	9	28	65	51	43	*196*	*3.5*
Loss of fish habitat	8	29	64	53	40	*194*	*3.5*
Septic system discharge	15	43	48	44	40	*190*	*3.3*
Shoreland property runoff	14	30	68	50	29	*191*	*3.3*
Loss of shoreline vegetation	26	46	67	38	19	*196*	*2.9*
Noise pollution	31	44	58	42	19	*194*	*2.9*
Shoreline erosion	30	53	62	33	18	*196*	*2.8*
Light Pollution	39	53	54	23	15	*184*	*2.6*
Other	0	0	0	0	0	*0*	*0.0*



#16

#17 From the list below, please rank your top three concerns regarding Little Saint Germain Lake?

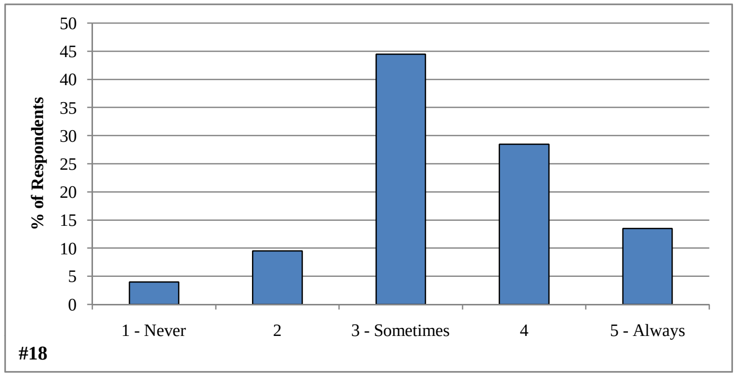
	1st	2nd	3rd	*% Ranked*
Aquatic invasive species	53	41	22	*19.8*
Water quality degradation/pollution	58	23	15	*16.4*
Algae blooms	17	24	39	*13.7*
Excessive aquatic plant growth	15	31	24	*12.0*
Loss of fish habitat	15	18	23	*9.6*
Boat traffic	10	11	14	*6.0*
Lakeshore development	2	10	11	*3.9*
Degradation of native aquatic plants	4	5	10	*3.2*
Fishing pressure	7	6	5	*3.1*
Septic system discharge	6	7	4	*2.9*
Shoreline erosion	5	8	3	*2.7*
Noise pollution	2	3	10	*2.6*
Shoreland property runoff	2	3	6	*1.9*
Loss of shoreline vegetation	1	3	3	*1.2*
Other	0	1	5	*1.0*
Light Pollution	2	1	1	*0.7*
	199	195	195	



#17

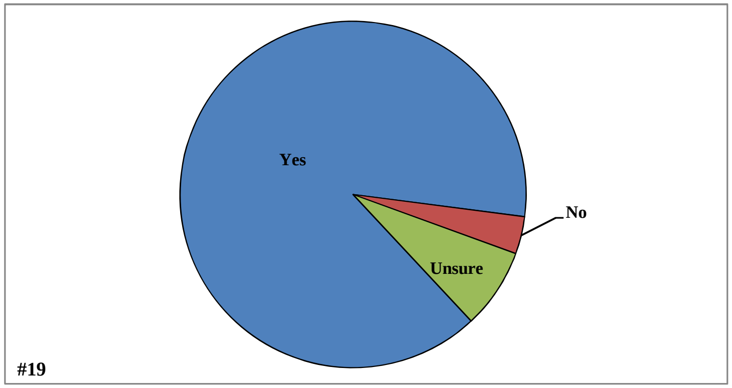
#18 How often does aquatic plant growth impact your enjoyment of Little Saint Germain Lake?

	Total	%
1 - Never	8	*4.0*
2	19	*9.5*
3 - Sometimes	89	*44.5*
4	57	*28.5*
5 - Always	27	*13.5*
	200	



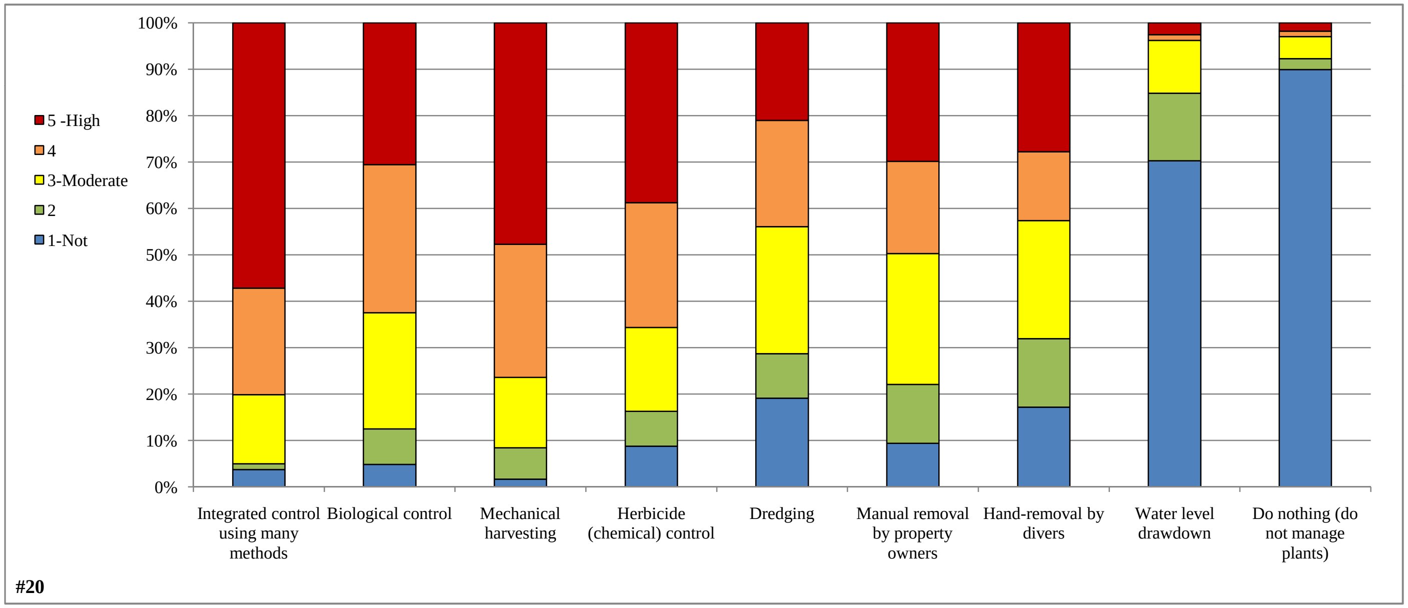
#19 Considering your answer to the question above, do you believe aquatic plant control is needed on Little Saint Germain Lake?

	Total	%
Yes	178	*89.0*
No	7	*3.5*
Unsure	15	*7.5*
	200	



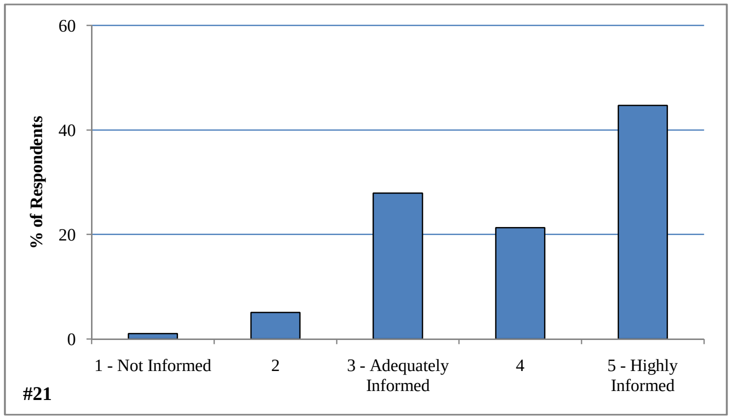
#20 What is your level of support for the responsible use of the following techniques on Little Saint Germain Lake?

	1-Not	2	3-Moderate	4	5 -High	*Total*	*Average*
Integrated control using many methods	6	2	24	37	92	*161*	*4.6*
Biological control	7	11	36	46	44	*144*	*4.3*
Mechanical harvesting	3	12	27	51	85	*178*	*4.3*
Herbicide (chemical) control	14	12	29	43	62	*160*	*4.1*
Dredging	30	15	43	36	33	*157*	*3.7*
Manual removal by property owners	17	23	51	36	54	*181*	*3.6*
Hand-removal by divers	29	25	43	25	47	*169*	*3.5*
Water level drawdown	111	23	18	2	4	*158*	*2.3*
Do nothing (do not manage plants)	152	4	8	2	3	*169*	*1.4*



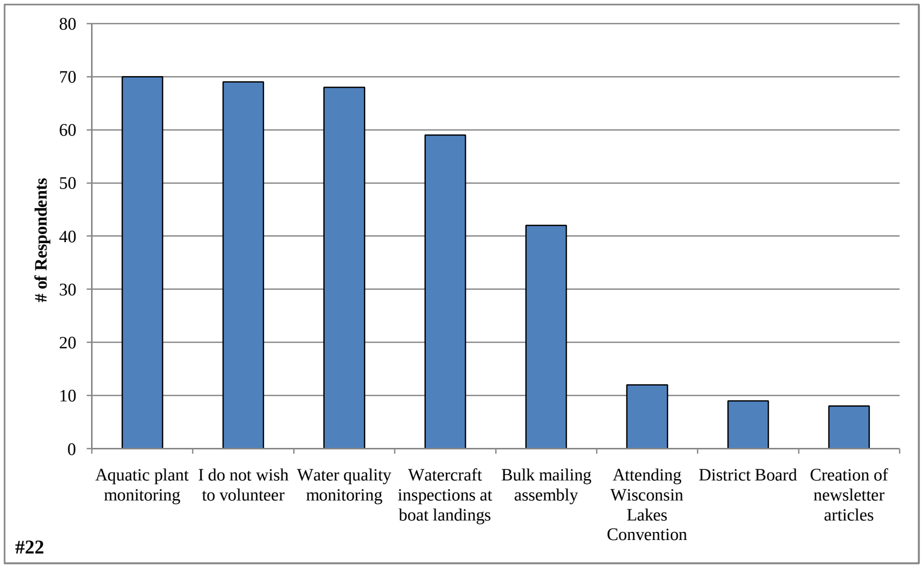
#21 Do you believe the Little Saint Germain Protection & Rehabilitation District has kept you adequately informed regarding issues with Little Saint Germain Lake and its management?

	Total	%
1 - Not Informed	2	*1.0*
2	10	*5.1*
3 - Adequately Informed	55	*27.9*
4	42	*21.3*
5 - Highly Informed	88	*44.7*
	197	



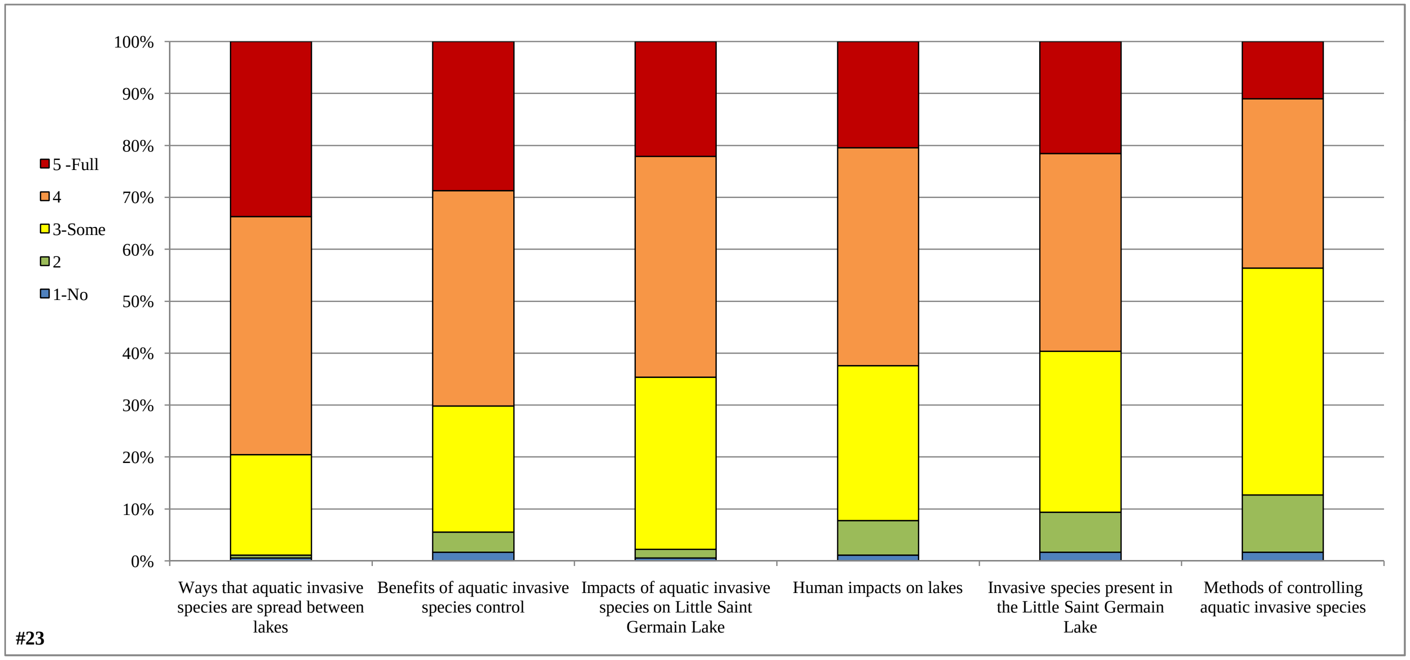
#22 Please circle the activities you would be willing to participate in if called upon.

	Total
Aquatic plant monitoring	70
I do not wish to volunteer	69
Water quality monitoring	68
Watercraft inspections at boat landings	59
Bulk mailing assembly	42
Attending Wisconsin Lakes Convention	12
District Board	9
Creation of newsletter articles	8
	337



#23 **Please describe your level of understanding of each of the following lake management issues.**

	1-No	2	3-Some	4	5 -Full	*Total*	*Average*
Ways that aquatic invasive species are spread between lakes	1	1	35	83	61	*181*	*4.1*
Benefits of aquatic invasive species control	3	7	44	75	52	*181*	*3.9*
Impacts of aquatic invasive species on Little Saint Germain Lake	1	3	60	77	40	*181*	*3.8*
Human impacts on lakes	2	12	54	76	37	*181*	*3.7*
Invasive species present in the Little Saint	3	14	56	69	39	*181*	*3.7*
Methods of controlling aquatic invasive species	3	20	79	59	20	*181*	*3.4*



Survey Number	Comments (including question 24)	Question Specific Comments
1		
2		#1g: church camp
3		
4		
5	Vegetation and sludge in East Bay prohibit use of piers/motors/canoes.Decreasing property values.Tried manual removal/herbicides to no avail.Aski Board's help.	#16p: sludge
6	Grateful for this pro-active approach. He/She has seen harm of our resources of milfoil, zebra mussels and rusty crayfish. Education of all people usi these resources.	
7	We have funded study after study. We have made progress on AIS but not enough. One yr ago Eagle River chain effort started and is now on DNR "fro burner" with increased treatment dosages, changes in treatment area and survey time, etc. Should LSG have rec'd this same "front burner" status. Regarding alge bloom, last year we were told alum treatment was going to be the answer. But as of Mem. Day meeting only a small area MAY BE treate onlyif MORE STUDIES are done. The number of rental vacancies and homes for sale indicate the word is out - LSG Lake is dying and very little other th "study it some more" is being done.	
8		
9	Thrilled that nature has ovecome man's interference. With South Bay being the shallowest, concerned that water draw down is increasing shoreli erosion.	
10		
11		
12		
13		
14		
15		
16		
17		
18	We have a lack of native weeds on the shoreline near the bank in the last 2 years on South Bay, may be its weed cutting or killing or poisoning the wee don't know?	
19		
20		#16p: Water level
21		
22	There are over 35 properties for sale on LSG. The most complaints of perspective buyers is water quality.	
23		
24		
25		
26		#16p: Water level
27		
28		#1g: 3 seasons - spring, summer and fa #10m: get away- peace/quiet
29	I have attended every annual meeting for the past 12 years. They are very informative and well presented. When I can finally retire I hope to help t District.	
30		
31		
32		
33	Largest change in 35+ years is downward spiral of quality fishing, some due to decrease stocking, possibly spearing prior to or during spawning. Invas plants have increased but feel the Lake District has done as good a job as can be expected and progress is evident.	
34		
35	Need to ensure water levels remain high. Less drain off thru dam is important.	
36		
37		
38		
39	You folks are doing a great job. Proactive but not offensive to residents and visitors. Keep up the good work!	
40	Thanks for all the efforts to maintain this great body of water.	#1g: seasonal thru out yr not only weekends
41		
42		
43		
44	How is this past winter's water aeration project working? Can Muskellunge Creek water quality be improved much is "million dollar" treatment plant r used? How about co-operative projects involving their lakeshore property owners? Thanks for those people working to make the District effective and our lake even better.	
45		
46	We have not caught a walleye from our pier in 10 years. I feel like the lake management has been very effective. One of the first problem areas was in front of my home. This has been managed and is much better. My home is in Lower East Bay.	#16p: spear fishing
47		
48		#16p: spear fishing
49	More homes have lawns which is adding harmful chemicals - fertilizer, weed killer, etc. Kudos to the LSG commission, they have done a wonderfuljob stewards of our lake.	
50	We need a police boat patrol. Too many skiers and jet skis come too close to piers and fishermen. Police or deputized volunteers that can issue citations may be helpful. Lake management is mssing this one and seems to focus on weeds when it should focus on both.	#16p: jet skis #17q: jet skis
51		#16p: jet skis
52	The lake gets drained too much. Need to keep water level up. Don't let people use lake water to water their lawns. Maybe dredge area between ea bay.	
53		
54		#16p: jet skis
55	Each spring water clarity is excellent but gets quickly clouded moving into summer. Cannot swim and enjoy. Appreciates our efforts but we should all p a special tax each year for ongoing aquatic invasive species problems. We should all equally contribute towards this problem.	
56		
57		#16p: wave runners
58	Major problem is transport of weeds by jet ski renters. It is impossible to clean inside of motor portion that water goes thru, therefore, it can transp weeds or seeds. Same happens with wet wells on boats. This can carry weed and other items from one lake to another.	
59	Many years ago chemical treatment approved by DNR resulted in catastrophic fish kills. Do not allow 'leading edge' techniques that have no long te demonstrated safety and efficacy.	
60		
61	Disappointed in the water quality relative to weedy botton (for swimming) and the green slime. This is a bigger issue in last 10+ yrs. I have not noticed any improvement from past attempts at fixing the problem. Strongly recommend more aggressive measures to get our lakes quality improved.	
62		
63	Keep up the good work - thanks to all who volunteer.	
64		
65		
66		
67		
68		
69	In favor of the Alum treatment that been proposed. Need information, are we going to do it or do Ihave to live in my sess pool (East Bay) forever?	
70		
71		
72	It would appear that Waldman, Black Bear, and other wealthy owners along the lake can do anything they want without DNR sanctions. Why?	

Survey Number	Comments (including question 24)	Question Specific Comments
73	1987 LSG - Class "A" musky lake. Presented statistics indicating LSG has far less stocking of muskies and walleye. LSG is understocked and ov fished. This will decrease our property values and revenue from summer tourism. Per annual reports property owners spend $1000 annually for fish stocking. Apparently this has no effect on musky or walleye population.	#16p: jet skis
74		
75	No healthylake=no owners,no renters=no income=no taxes. Tourism is decreasing in N. Wi. Every effort must be employed to keep water pristir otherwise, who wants to own or rent on a swamp.	
76	I am highly support of improving the water quality - including $ is improvement is likely.	
77	Thanks for all you work on this!	
78		
79	Reside in East Bay. Come June, shoreline is so disgustingly smelling of dead panfish, lake slop, big black buzzing flies and debris kicked up by the b traffic. Swimming is not an option. Debris from propellers (mainly weeds) ends up on our shoreline. We are vey optimistic on seeing results on our beautiful lake.	
80	Fishing is poor. It's pretty and enjoyable but, I think it's good we are going with bass. People are looking for the great north fish but we have lost that p of what we had.	
81		#1g: 1 week monthly
82		
83	We used to have beautiful, clear, lake water to look at, swim in, brag about. The past 6 years we have been embarrassed at the green, cloudy, we infested lake we have. We are considering selling due to the water quality and will find a cleaner lake to enjoy.	#10m: Viewing by pontoon
84	LSG was once regarded as an excellent walleye fishery. About 3-4 yrs ago; at the summer meeting, a fishery expert told us the fishing was dead. What happened and what can we do? As a whole, I have been improved with the action our lake association has taken. I hope this continues.	
85	The use of high speed boats is the cause of most of our problems.	
86		
87		
88		
89		
90	How will landowners be informed if swimming or water skiing has any short or long term risk.	#10m: Also, d, j, k
91		
92	Would be willing to participate financially on a pro-rated share to clean our lake. We believe it would benefit all lakefront owners.	
93		
94	We need to do something - can't just wait or do nothing.	
95	A few years ago there were great healthy weed beds on the NE section of South Bay and these weeds beds have been gone for the past few years There also used to be much better water quality in East Bay that is no longer there.	
96		
97		#17q: excess native weeds
98		
99		
100		
101	We have been impressed with Lake Assoc efforts to control AIS on LSG. You are responsible stewards of the dollars available/needed. "Light pollutic does exist. Ski resort with lights on after midnight. Part of the joy of northwoods is the peace of pitch dark - can there be a rule of "lights out" after a certain time of night that everyone could agree on?	
102		
103		
104	Concerned about current proposal to use a chemical applied once a year for two years - costly and could harm wildlife and fish. Heard of horror stories previous attempt that backfired. How frequently would this be done? We all want clear, clean water, but at what price?	
105		
106		
107	Should limit high horsepower speed/racing boats. Our lake is way too shallow in many areas for this type of craft. The churning action contributes to wat quality degradation, shore erosion and wildlife disruption.	#17q: utility workers mess
108		
109		
110	Been fishing on this lake since 1972 - fishing is the worst it has ever been. Bright lights on south shore of No Fish Bay.	
111	The elected commissioners have done an excellent job.	
112	Lakes are over managed. If left alone they will self correct. In 70's the weeds were so thick in front of Pride of the North. A path was cut. That conditi in later years corrected itself. I believe chemical treatments have ruined the weed structure and adversely affected the fishing.	#16p: jet skis
113		
114		
115		#16p: jet skis
116	Ted Ritter and others have done a great job informing us about all these problems and getting needed techniques implemented. We love the website.	#16p: jet skis
117	20 yrs ago walleyes were abundant and panfish larger. Put limit on motor size - grandfather currently owned - but replace with only new limits. No PWC, especially rentals - they don't follow rules. Consider user fee to defray costs of lake mgmt. A $10 sticker issued at launch by waterdcraft inspectors at boatlanding. Non-residents have huge impact on lake quality and fishing and need to contribute as most do not pay into the room tax.	#16p: lg HP motors/PWC
118		
119	I want to thank you for keeping our lake in great shape. Keep up the good work. Two major concerns: keep water level up and keep stocking the rig species of fish.	
120		
121		
122		
123		
124	Too much boat traffic. Weekly rentals are on vacation and on lake all day-everyday churning up the lake. This has to have an impact on our water quali Both the owners of weekly rentals and the town make too much money. Prop owners of weekly rentals should volunteer and pay addtl dues to Lake District.	#16p: Weekly rentals #17q: Weekly rentals
125		
126		
127		
128		
129	Our favorite game fish is Northern Pike. We used to catch countless northerns but for the past 3-4 yrs the numbers have dwindled to a few or none. V are concerned this will have a long term effect on the lake's overall fish population.	
130		
131		
132		#16p: jet skis
133	Over 16 yrs of ownership we have seen marked improvement in plant growth control. The algae bloom is still problematic.	
134		
135		
136	Thank commission for taking the bull by the horms to correct bad things happening to lake. Cannot wipe out all problems but can control them. Welcor to Aquatic Agriculture.	
137		
138		
139		
140		
141		
142	Though not on the lake much, is very interested in maintaining quality. Please keep me informed.	
143	Commissioners: Thank you for your continued good work. It is much appreciated.	
144	Have not been here long enough so I have not comment yet.	
145		

Survey Number	Comments (including question 24)	Question Specific Comments
146	Support efforts of last 5 yrs of mgmt. Don't agree with suspension of walleye stocking program. The club match from the hatchery made it a low $ impact and low rish insurance policy for the walleyes. If left uncheck, curly leaf pond weed is a huge problem. Thanks for the efforts to control this threat.	
147	Condos such as Black Bear put too much people density on lake and too much noise. Pole lights at home and resorts should have shield to av spot/flood light appearance from across lake. All jet skis should be banned - too noisy and fast and too dangerous when used by renters. Need quiet hours for fishing with a speed limit. Perhaps a speed limit on boats and a ban of jet skis before 10AM and after 6PM. Do not allow amplified music (resorts and bars). Something needs to be done quickly about weed control and the invasive species. LSG is more like Geneva or the Wis Dells than it is an up north experience it used to be.	#16p: jet skis #17q: jet skis
148		
149		
150	A time limit on water skiing and jet skis (9AM-5PM) should be in effect to allow time for fishermen to enjoy the lake.	
151	The District along with the Board have done an excellent job with all aspects of Lake Management. The many hours of work are appreciated.	
152	Would like to see this lake a "no wake lake"	#16p: jet skis/lg HP motors
153	Noise pollution - idiots renting at Elberts on West Bay and water skiing at 6AM. I understand the difficulties in controlling weed - work appreciated. La Committee needs to make contact with Elberts about 5:30AM skiing is not appreciated. This happens in July all the time. Is there a patrol effort or DNR branch available to issue ordinances?	
154	I support and applaud the Little St. Germain Assoc. for actually doing something to inform property owners and helping the lake.	#16p: fireworks all summer
155		
156		
157		
158	Fishing quality and numbers are drastically down.	
159		
160		
161	Many residents expect LSG Lake to be crystal clear. This has always been a stained lake. This will not change. Fishing has gone down hill past 5 y We do need weeds for fish habitat.	
162		
163	Vast areas of this lake have always been weedy. Sometimes we feel we're messing with "mother nature" too much when we try to permanently chan this.	
164	Our thanks to all whose efforts have focused knowledge and resources to address lake issues.	#16p: jet skis
165		#16p: gun powder fireworks
166	Since the tragic blunder of algae control by chemicals many years ago and the beginning of Indian spear fishing the quality of walleye fishing has be severly impacted and the size of panfish has gone down.	#16p: Indian spear fishing
167	A small group of people are doing a lot of work while most of us are doing nothing. I am very busy with other things. I volunteered and was asked once do something. The leaders could be more persistent in asking for volunteers.	
168	Would like to see "no wake" in West Bay and erosion control on the snowmobile ramp going up to Elberts.	#1g: condo
169	Drawing down lake water level has negative impact on our ability to use and enjoy the lake. Please maintain water level and aquatic invasive plant contr More boating and snowmobiling regulation would also have negative impacts on lake and business owners.	
170	Great mgmt of this lake and its invasive species over the past 3-4 yrs. Keep up good work. Main concern is excessive jet ski and boat traffic and lack courtesy or caring often by the visitors. Safety on lake in summer is a prime concern.	#16p: jet skis
171	Need to reduce algae bloom. Need to stock walleyes.	
172		
173		
174	Boats and jet skis too fast on West Bay to Hiller's Point. Speed riles up small rocks and shoreline now is small stones where it used to be great san beach. Jet skis should be banned on our section of this bay - too nosy, too fast and deteriorate shoreline. The swimming area now gets full of weeds - miserable swimming and water skiing. Fishing is fair for pan fish.	#16p: jet skis
175		
176	Noise pollution - leaf blowers are worse than jet skis. Light pollution - Black Bear uses way too many lights. So do several private cabins. Other: fertilizer and pavement issues cause runoff problems. We're happy to see the use of billboards and placemats with info about invasive species at local restaurants	#17q: low water recently
177	Concerned about clarity of lake. Top fisheries biologist in US lives in Eagle River - Lenord Pampel. He set up Milw Cty zoo aquarium and has ma honors and patented fish hatching knowledge. His research in raising fish is second to none. He has gone to schools, tribes and fish farmers. He should be contacted.	#16p: jet skis/too many rental units
178	Concerned about too many condos, skyrocketing taxes. Many for sale signs of property and possessions. Concern for decrease in boaters fishing. G prices may play a role but even more is the lake's deteriorations and woods deteriorations. There is so much muck that smells in front of our place - talk around town of sweage going into lake.	
179	16P - Muskellunge Creek and inflow of waters not in St. Germains control. Excessive development of off shore property. Tourism. Question 24 -Lake needs to be rehabbed - it's value has eroded. Current condition is unacceptable. Please provide what root causes and not cosmetic solutions are needed	#1g: 8 full weeks per year
180		
181		
182		
183	5-6 yrs ago algae/slime was bad and has improved since then but not like it used to be. Need to limit ground impact, i.e., condo development and control septic tanks and aquatic species control. People enjoying our lake is what it is all about. Thanks for you efforts in correcting the problems.	#16p: condos
184	As a realtor, I have had many potential buyers question me regarding our lake. It has impacted our ability to sell these properties. Neg impact on prope values.	
185	I would like to see East Bay have no controls on weeds to see what happens. I don't think there is a problem in this area. Use other methods in other bays. Could initiate a controlled comparison. Algae bloom does occur in this bay but has remained the same in the 15 yrs I have lived there.	
186	Beautiful lake. Too much development with large homes.	
187		
188	Keep up the good work	
189		
190	16 p. Unrestricted spearing of musky in winter by LDF tribe. Water skiing in evening and after dark times.	#16p: Jet ski
191		
192	In the past several years, the most detrimental aspect of ourlake is the algae in mid to late summer. It is so bad, youhate to use a boat much less ot activities - swimming, water skiing, fishing, etc.	#16p: tourist
193	Thank you for asking our opinions. Fertilizers should be illegal. We are in the "big woods" and there should be no reason what so ever to have a lawn t needs fertilizers.	
194	I support the efforts of the DNR to keep the lake healthy. There is tremendous progress regarding invasive species. Would help when up there. Thar for great work.	
195		
196		
197		#17q: jet skis
198	jet skis noise and proximity to pier	#16p: jet skis
199		
200		
201		
202		#16p: DWI
203	Don't live on lake, can't even see water. We just pay so idiots who live on the lake can enjoy it. People who live on the lake which is by choice should pay for its maintenance not people who live in a certain area. Besides all the problems with the lake are cause by the darn tourists.	
204	The control, mgmt, and treatment plan of AIS is absolutely mandatory. The 200 ft rule from shoreline for power boats needs to be enfored by local DNR and officials. This abuse has accelerated shoreline erosion, and at times swimmer safety. Thanks for LSG Protection and Rehab District for their efforts.	

C

APPENDIX C

December 2005 Project Update

INTRODUCTION

The following document is an update of activities completed as a part of the Little Saint Germain Lake Exotic Aquatic Species control project. It is essentially a summary of the past four years, but concentrates more on the efforts associated with the current project. The document is broken into three portions, the first dealing with the comprehensive survey which primarily focused on native plants, the second dealing with the surveys and treatments aimed at exotics, and the third outlining the general scope of work for the 2006 pretreatment surveys.

COMPREHENSIVE AQUATIC PLANT SURVEY – 2004

A comprehensive aquatic plant survey was completed on Little Saint Germain Lake August 25-27, 2004. The survey included two components, one being a point-intercept survey and the second being the mapping of aquatic plant communities based upon life-form. The intent of this survey was to establish a baseline set of data that represents the aquatic plant community of the lake before the invasive species program began. This, of course, should be considered a *close* approximation because the lake was treated for curly-leaf pondweed twice and Eurasian water milfoil four times before this survey was completed. The results discussed here will ultimately be compared with those of an identical study that will be completed during the summer of 2008.

The comprehensive plant survey was completed utilizing a point-intercept method as outlined by the Wisconsin Department of Natural Resources (WDNR). Based upon initial guidance by the WDNR concerning the surveys at Little St. Germain Lake, geographic information system software was utilized to produce point locations at a 150-meter resolution and resulted in 175 points being created for the entire lake. Examination of the layout indicated that only 13 points would be located within the littoral zone of West Bay because of the lake's depth (Z_{max}=53 feet) and sharp drop off. Please note that based upon earlier studies conducted by Onterra, the littoral zone of the lake is believed to extend to a depth of approximately 12-feet. In order to increase the points within West Bay, a 100-meter resolution was used to create point locations for that bay alone. This resulted in an additional 15 point being created within the bay's littoral zone. Twenty additional points were then added around the bay to increase the study's coverage even further primarily because of the know occurrence and proposed treatments of Eurasian water-milfoil.

The community map represents a snapshot of the important plant communities in the lake as they existed in during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads; and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

Data from the point-intercept survey is used to create a species list for the lake, determine the lake's aquatic plant diversity, and calculate the floristic quality of the lake. These results are helpful in determining the current health of the lake as well as tracking changes in the lake's aquatic plant community over time. Furthermore, these results can be compared between lakes with in the state and ecoregion (Figure 1) to create a better understanding of each lake's plant community and the ecosystem's condition as a whole.

Forty-six species of aquatic plants were located during the comprehensive survey (Table 1). Two of the species found in Little Saint Germain Lake are non-natives and are covered in more detail below. Using the entire dataset, it is found that Little Saint Germain Lake has a species diversity of 0.90. Although this diversity is the lower when compared to data collected during the same timeframe from other lakes within the Town of Saint Germain (Figure 2), it would still be considered quite high. For comparative purposes, a highly developed and eutrophic lake in south central Wisconsin, with tremendous exotics problems, has a diversity of 0.84. The occurrence analysis graph (Figure 3) indicates that by far the lake is dominated by coontail and common waterweed, while the remaining species are much more evenly disbursed. Diversity is a function of the evenness of distribution and the number of species in the lake. A lake with many species that is dominated by only a few will have a lower diversity than a lake with less species, but a more even distribution. Little Saint Germain is similar to the first lake described because it has many species, but it is heavily dominated by coontail and common waterweed. If those two species are removed from the calculation, which evens out the frequency of occurrence distribution considerably, the diversity of the lake increases to 0.97.

Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

Floristic Quality Assessment (FQA, Nichols 1999) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this case, the floristic quality of Little Saint Germain Lake is compared to lakes in the same town, ecoregion, and state.

The floristic quality of a lake is calculated using its species richness and average species conservatism. Species richness is simply the number of species that occur in the lake; for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (more pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality.

Median Value This is the value that roughly half of the data are smaller and half the data are larger. A median is used when a few data are so large or so small that it skews the average value to the point that it would not represent the population as a whole.

The floristic quality of Little Saint Germain Lake is very high when compared to the state and ecoregion medians (Figure 4). Furthermore, among the same lakes listed in Figure 1, it is the highest, just above Found Lake which has a value of 42.8. As described above, floristic quality uses the number of species and the average coefficient of conservatism within its calculation. The incredibly high number of species found in Little Saint Germain Lake, coupled with the moderate species conservatism, results in the high floristic quality of the lake. This is somewhat expected because larger lakes like Little Saint Germain tend to have more species within them, while lakes with developed shorelines and high recreational use, like Little Saint Germain, tend to have plant communities reflecting that disturbance.

Figure 1. Little Saint Germain Lake in relation to the ecoregions of Wisconsin. After Nichols 1999.

The community map for Little Saint Germain (Map 1) reflects the high diversity discussed above. There are many areas in each bay where diverse floating-leaf and emergent communities can be found. Each of these areas provides valuable fish and wildlife habitat important to the ecosystem both inside and outside of the lake.

Overall, the findings of the comprehensive survey indicate that the plant community of Little Saint Germain Lake is excellent. The efforts of the LSGLPRD and the WDNR in battling the spread and establishment of curly-leaf pondweed and Eurasian water milfoil are likely doing a great deal to protect this valuable resource.

Table 1. Little Saint Germain Species List. List compiled from data collected during 2004 comprehensive survey.

Life-Form	Scientific Name	Common Name	Coefficient of Conservatism
Emergent	*Juncus pelocarpus*	Brown-fruited rush	8
	*Calla palustris**	Water arum	9
	*Dulichium arundinaceum**	Three-way sedge	9
	*Eleocharis palustris**	Creeping spike-rush	6
	*Pontederia cordata**	Pickerelweed	9
	*Sagittaria latifolia**	Common arrowhead	3
	Schoenoplectus acutus[1]*	Hardstem bulrush	5
	Schoenoplectus tabernaemontani[2]*	Softstem bulrush	4
	*Typha latifolia**	Broad-leaved cattail	1
FF	*Lemna minor*	Lesser duckweed	5
	Lemna trisulca	Forked duckweed	6
	Spirodela polyrhiza	Greater duckweed	5
	Wolffia columbiana	Common watermeal	5
FL	*Nuphar variegata*	Spatterdock	6
	Nymphaea odorata	White water lily	6
FL/E	*Sparganium fluctuans*	Floating-leaf bur-reed	10
	*Sparganium eurycarpum**	Common bur-reed	5
Submergent	*Ceratophyllum demersum*	Coontail	3
	Chara sp.	Muskgrasses	7
	Elatine minima	Waterwort	9
	Elodea canadensis	Common waterweed	3
	Heteranthera dubia[3]	Water stargrass	6
	Isoetes lacustris	Lake quillwort	8
	Lobelia dortmanna	Water lobelia	10
	Megalodonta beckii[4]	Water marigold	8
	Myriophyllum sibiricum	Northern water milfoil	7
	Myriophyllum spicatum	Eurasian water milfoil	Exotic
	Myriophyllum tenellum	Dwarf water milfoil	10
	Najas flexilis	Slender naiad	6
	Nitella sp.	Stoneworts	7
	Potamogeton alpinus	Alpine pondweed	9
	Potamogeton amplifolius	Large-leaf pondweed	7
	Potamogeton crispus	Curly-leaf pondweed	Exotic
	Potamogeton foliosus	Leafy pondweed	6
	Potamogeton gramineus	Variable pondweed	7
	Potamogeton illinoensis	Illinois pondweed	6
	*Potamogeton nodosus**	Long-leaf pondweed	7
	Potamogeton praelongus	White-stem pondweed	8
	Potamogeton pusillus	Small pondweed	7
	Potamogeton richardsonii	Clasping-leaf pondweed	5
	Potamogeton robbinsii	Fern pondweed	8
	Potamogeton zosteriformis	Flat-stem pondweed	6
	Ranunculus aquatilis	White water-crowfoot	8
	Vallisneria americana	Wild celery	6
S/E	*Eleocharis acicularis*	Needle spike-rush	5
	Sagittaria graminea	Grass-leaved arrowhead	9

FF= Free Floating, FL = Floating Leaf, S/E = Submergent and Emergent
FL/E = Floating Leaf and Emergent, * = Incidental
[1]Formally known as *Scirpus acutus*
[2]Formally known as *Scirpus validus*
[3]Formally known as *Zosterella dubia*
[4]Formally known as *Bidens beckii*

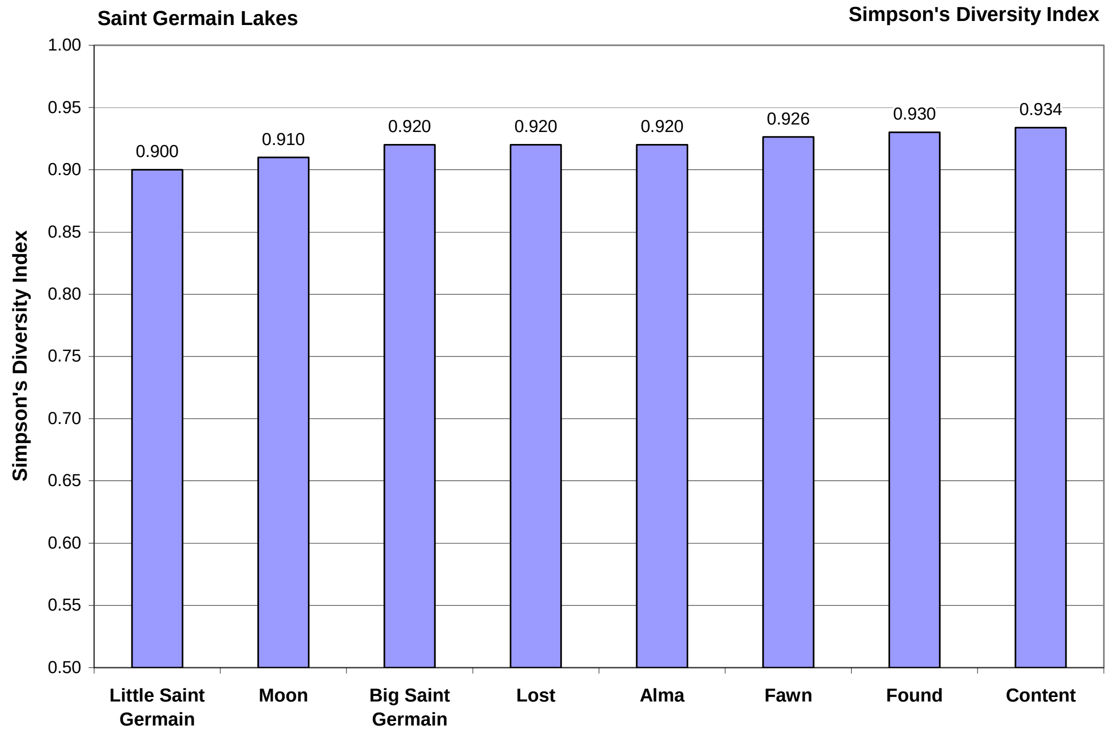


Figure 2. Species diversity of select Town of Saint Germain lakes. Developed with 2004 aquatic plant data collected by Onterra, LLC as a part of the Town of Saint Germain Aquatic Plant Management project.

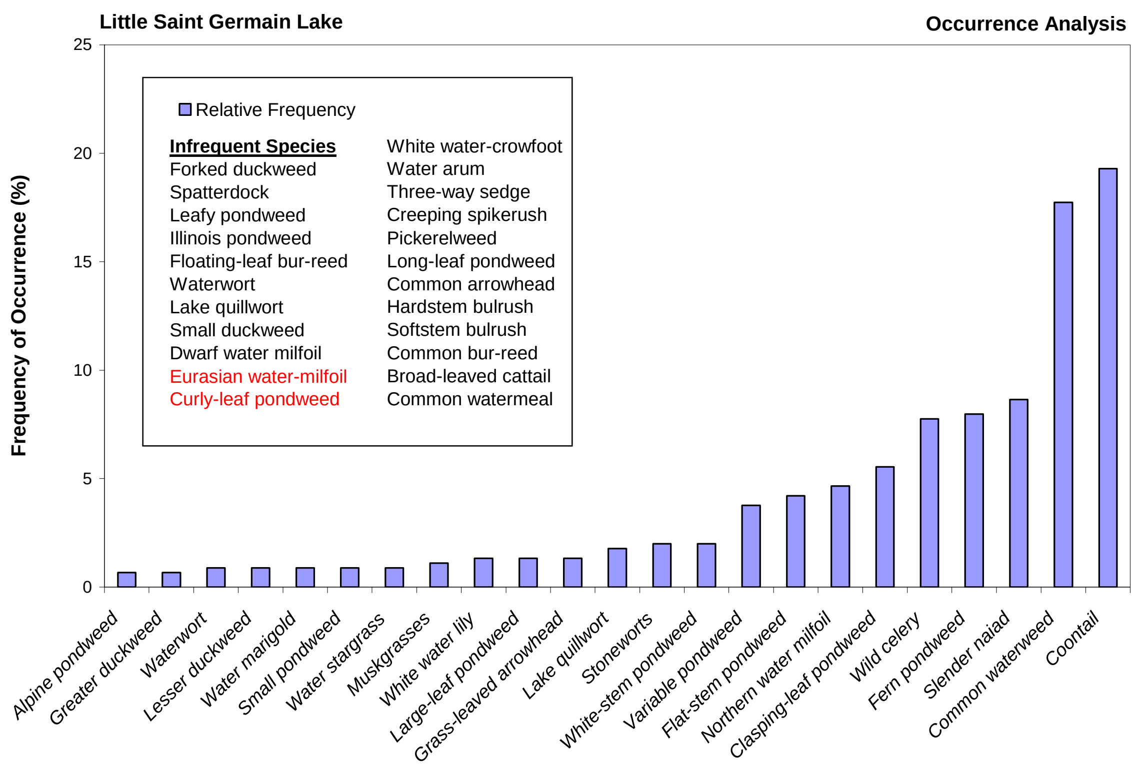


Figure 3. Little Saint Germain Lake occurrence analysis. Developed with 2004 aquatic plant data collected by Onterra, LLC.

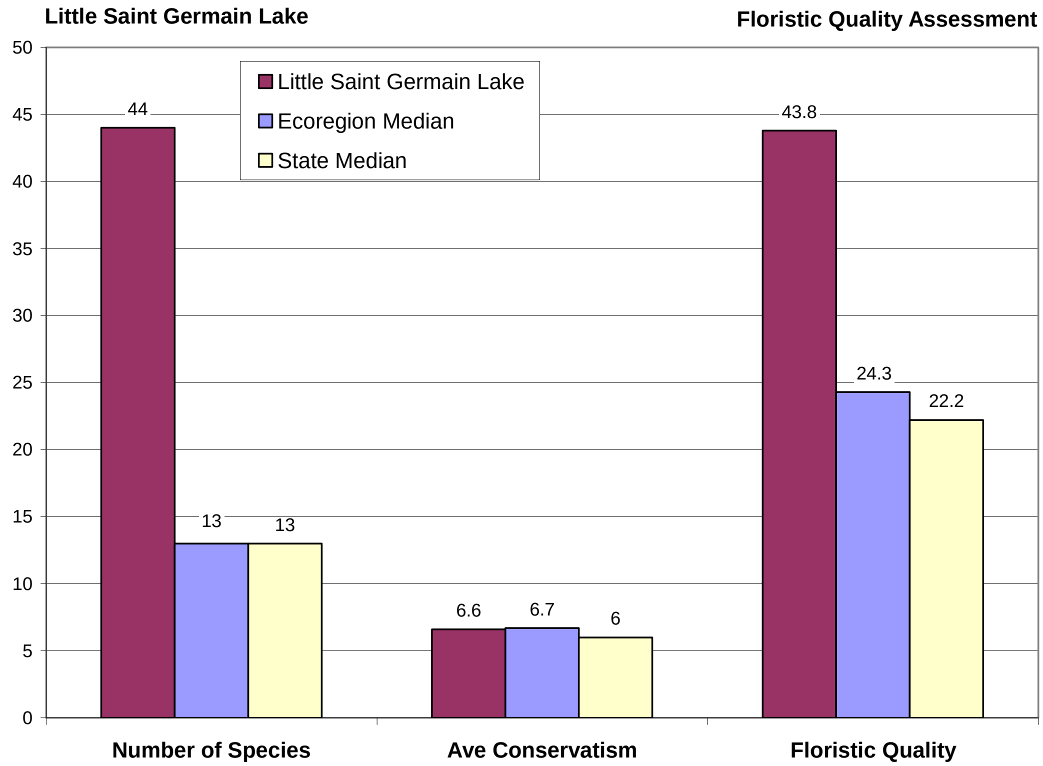


Figure 4. Little Saint Germain Lake Floristic Quality Assessment. Developed with 2004 aquatic plant data collected by Onterra, LLC using the methodology described in Nichols 1999.

BASELINE EXOTICS INFORMATION

Curly-leaf Pondweed

Curly-leaf pondweed (CLP) was discovered in Little Saint Germain Lake in the early summer of 2002. East and No Fish Bays were estimated to contain 50 acres of CLP forming dense surface mats and an additional 50 acres of CLP below the water's surface. GPS coordinates were taken by volunteers to serve as bounding coordinates for chemical application (Map 2). Also included on Map 2 are the sketched locations of the CLP infestations for that same time period based on the interpretation of the LSGLPRD. This report will refer to the labeling of the original five areas of CLP infestation (A-E) consistent with the sketched map. Chemical treatment was completed on May 14, 2003 by Cliff Schmidt of Schmidt Landscaping and Nursery, Inc. using the GPS points. Post treatment surveys were completed on May 30, July 3, and September 27, 2003 by LSGPRD volunteers with the help of conservationists from Vilas County. Although the treatment was considered to have a significant affect on the CLP beds, the September survey yielded new growth CLP in Area A. Volunteers using underwater cameras through the ice later discovered healthy CLP in the East Bay treatment areas as well.

Eurasian Water Milfoil

Floating EWM fragments were discovered near the West Bay public boat landing in May, 2003. Mark Hiller (see Appendix B for Mr. Hiller's survey summaries) organized volunteers to aid in SCUBA expeditions in May and June of 2003. These surveys indicated that there were numerous infestations of EWM in West Bay. GPS points were taken by volunteers and are shown in red on Map 3. Approximately 3 acres near the boat landing were treated on July 1, 2003 and later on August 4, 2003 a 30 foot wide perimeter strip of West Bay (approximately 9 acres) was also treated. Both treatments were observed to have good results.

CURRENT PROJECT EXOTICS SURVEYS

Curly-leaf pondweed Treatment	**May 14, 2003** 47.2 acres in No Fish and East Bays
Eurasian water milfoil Treatment	**July 1, 2003** 3 acres in West Bay
Eurasian water milfoil Treatment	**August 4, 2003** 9 acres in West Bay
Curly-leaf pondweed Treatment	**May 11, 2004** 44 acres in No Fish and East Bays

Curly-leaf Pondweed Survey 2004

A meander study was conducted on Little Saint Germain Lake on June 1-3, 2004. The entire littoral area of the lake was visually scoured in search of curly-leaf pondweed. In areas where CLP was previously located, numerous rake-tows were used in addition to the visual survey means. No rooted CLP plants were observed during the three day study. However, two floating CLP fragments were observed in West Bay.

Eurasian water milfoil Treatment	**July 1, 2004** 13 acres in West Bay

Eurasian water milfoil Treatment	**August 24, 2004** 33 acres in West Bay

2004 Comprehensive Survey

The comprehensive survey is described in detail above. It is listed here to maintain the understanding of the treatment timeline as it relates to the completion of the plant surveys.

2005 Pre-treatment Survey

A pre-treatment plant survey was completed on May 3-6, 2005 focusing primarily on CLP and EWM. A modified point-intercept survey using rake tows was used to locate and mark the extents of EWM and CLP to be used in management considerations. The survey corresponds with an opportune time to identify CLP. At this time of the year, EWM is quite immature and more difficult to discover. However, efforts were made to locate EWM at this time. The base resolutions from the 2004 Comprehensive Plant Survey were initially applied, and in most areas, reduced to allow more fine-scale detection of exotics. The points visited are located on Map 4 along with the CLP areas that will be referenced.

Due to West Bay's steep slopes and narrow littoral zone, a 50-meter resolution was applied to the entire bay. Although EWM was not discovered during the PI survey, SCUBA surveys completed by Onterra discovered a few plants near the boat landing. It was recommended that this area be included in the next EWM treatment. It is also noted that there was an abundance of northern water milfoil in West Bay during the time of the survey.

A 50-meter resolution was applied to the northern and southern thirds of No Fish Bay because of their proximity to historic infestations. The middle section of No Fish Bay was visited at a 100-meter resolution. The PI survey uncovered CLP to the east and west of Area A. Further examination using SCUBA showed submersed CLP extending to the east of Area A extending towards South Bay.

The northern half of South Bay was tightened to a 100-meter resolution in efforts to detect exotics coming in from No Fish Bay. After no exotics were found in the northern portion of the bay, a 150-meter resolution was applied to the rest of the bay. This survey was consistent with past surveys as no exotics were observed in South Bay.

Due to the size of East Bay the base resolution of 150-meter spacing was applied to areas that had not shown exotics in the past, but tightened considerably in areas known to be once infested. CLP was identified from the most southern portion of the bay. Area B was observed to be virtually free of CLP aside from a few scattered plants along the most northern extent of the area. Even with the addition of many points around Area C, no exotics were detected. Area D had a marked presence of CLP and the original boundaries still seem to best describe the current extent of the CLP infestation in this area. Although most of area E was free of CLP, numerous plants were located just to the east of the area.

A new area around Muskellunge Creek (Area F) was observed to be infested with both CLP and EWM. This area was recommended to be included in the next CLP treatment with hopes that the herbicide would also knock back the EWM.

Curly-leaf pondweed Treatment	**May 9, 2005** 50 acres in No Fish and East Bays

2005 June Field Visit

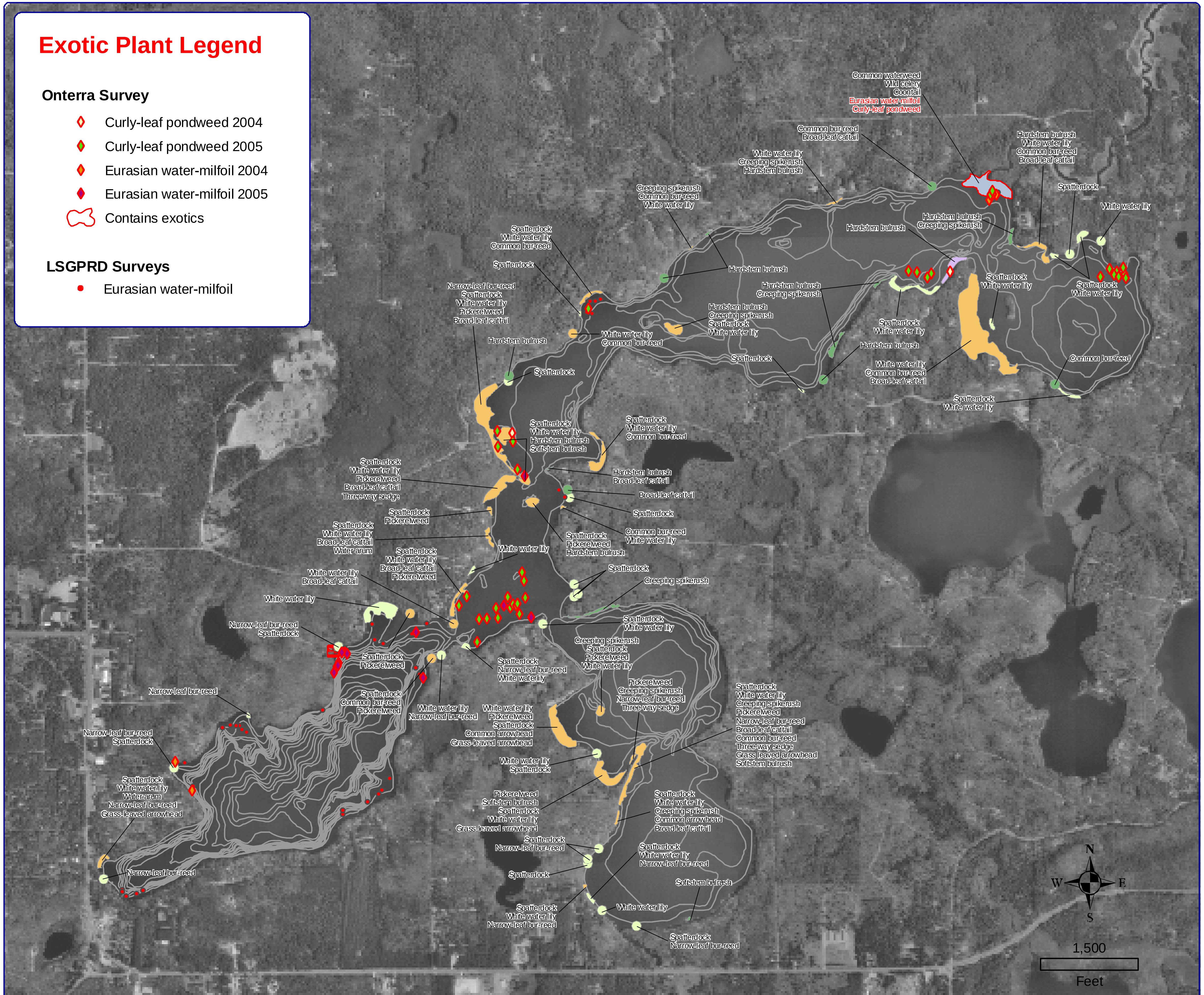
A field visit was conducted to verify the occurrence of EWM around the boat landing and to check on exotics around Area A (Map 4). Numerous occurrences of EWM were located near the boat landing and at the northwest edge of Area C. Fortunately, CLP was not observed in No Fish Bay. This suggests that perhaps chemical drift from Area A had an effect on the CLP located to its east.

Eurasian water milfoil Treatment	**July 13, 2005** 8.5 acres in West, No Fish, and East Bays

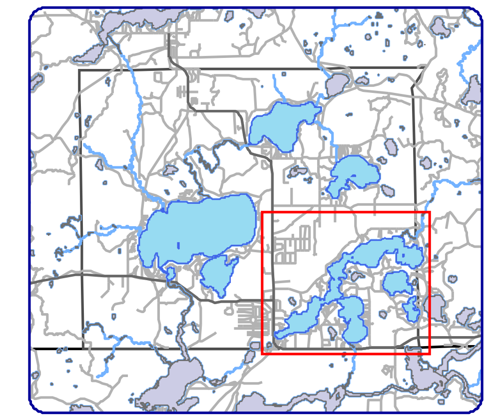
2006 PRETREATMENT SURVEY

Two types of surveys will be completed in the early spring of 2006 on Little Saint Germain Lake, a general survey that includes the entire lake and a more intense survey on known or suspected areas of exotic infestation. The general survey will be performed to systematically investigate the littoral area of Little Saint Germain Lake in search of exotic plants and will utilize the points outlined for the comprehensive aquatic plant survey (Appendix A). Native plant occurrences will also be noted, but are not the primary focus of the survey.

The primary intent of the pretreatment survey is to provide information to coordinate efficient exotic control treatments. Such an early period in the growing season does not lend itself useful in exploring for new colonies or infestations. These early season plants have limited biomass and are generally not high enough in the water column to be observed from the lake surface. In addition to the general survey, areas of known and suspected exotic plant locations will be searched with the intent of obtaining a better understanding of the colony boundaries (Map 5). Combining additional rake tows, submersed video, and scuba with GPS technology in these areas will allow for a precise understanding of the extents of the exotic plant communities.



Map 1
Little Saint Germain Lake
Vilas County, Wisconsin
Aquatic Plant Communities



Extent of large map shown in red.

Legend

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent
- Mixed Floating-leaf & Submergent

Large Plant Communities
- Emergent
- Floating-leaf
- Submergent
- Mixed Submergent & Emergent
- Mixed Floating-leaf & Emergent

Public Boat Landing

Sources:
Roads & Hydro: WDNR
Aquatic Plant Survey: Onterra, 2004
Map date: January 4, 2006

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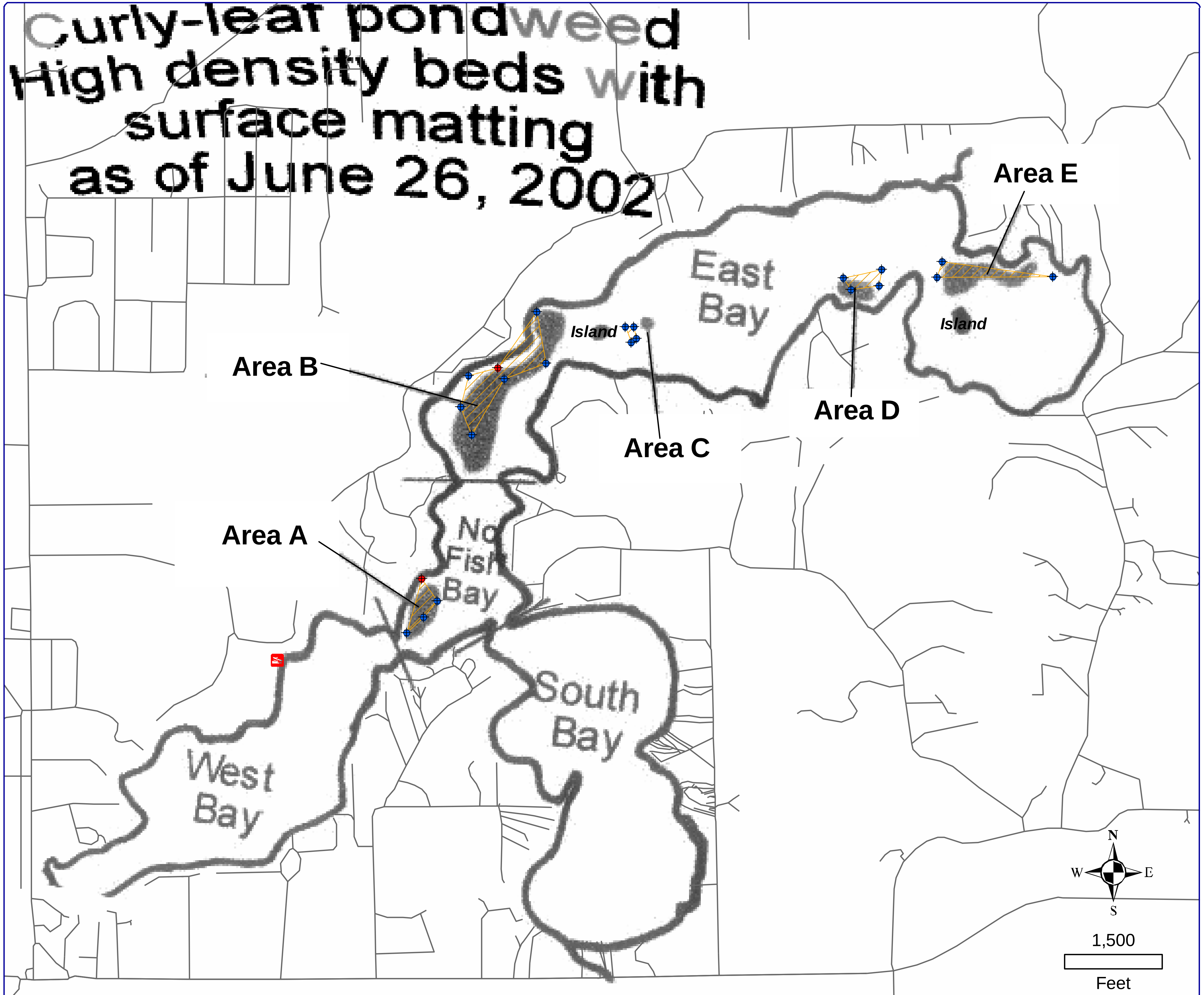
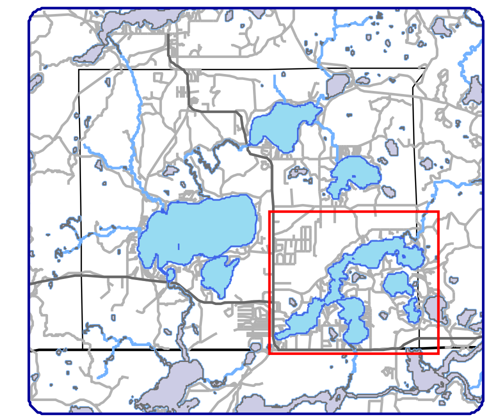


Map 2
Little Saint Germain Lake

Vilas County, Wisconsin

Baseline Curly-leaf Pondweed Findings



Extent of large map shown in red.

Legend

- LSGLPRD Bounding Coordinates: 6-26-2002
- LSGLPRD Bounding Coordinates: Adjusted for accuracy by Onterra with guidence from Mark Hiller.
- Curly-leaf Pondweed Area
- Public Boat Landing

Sources:
Sketched Map and GPS Data: LSGPRD
Roads: WDNR
Map Date: December 5, 2005

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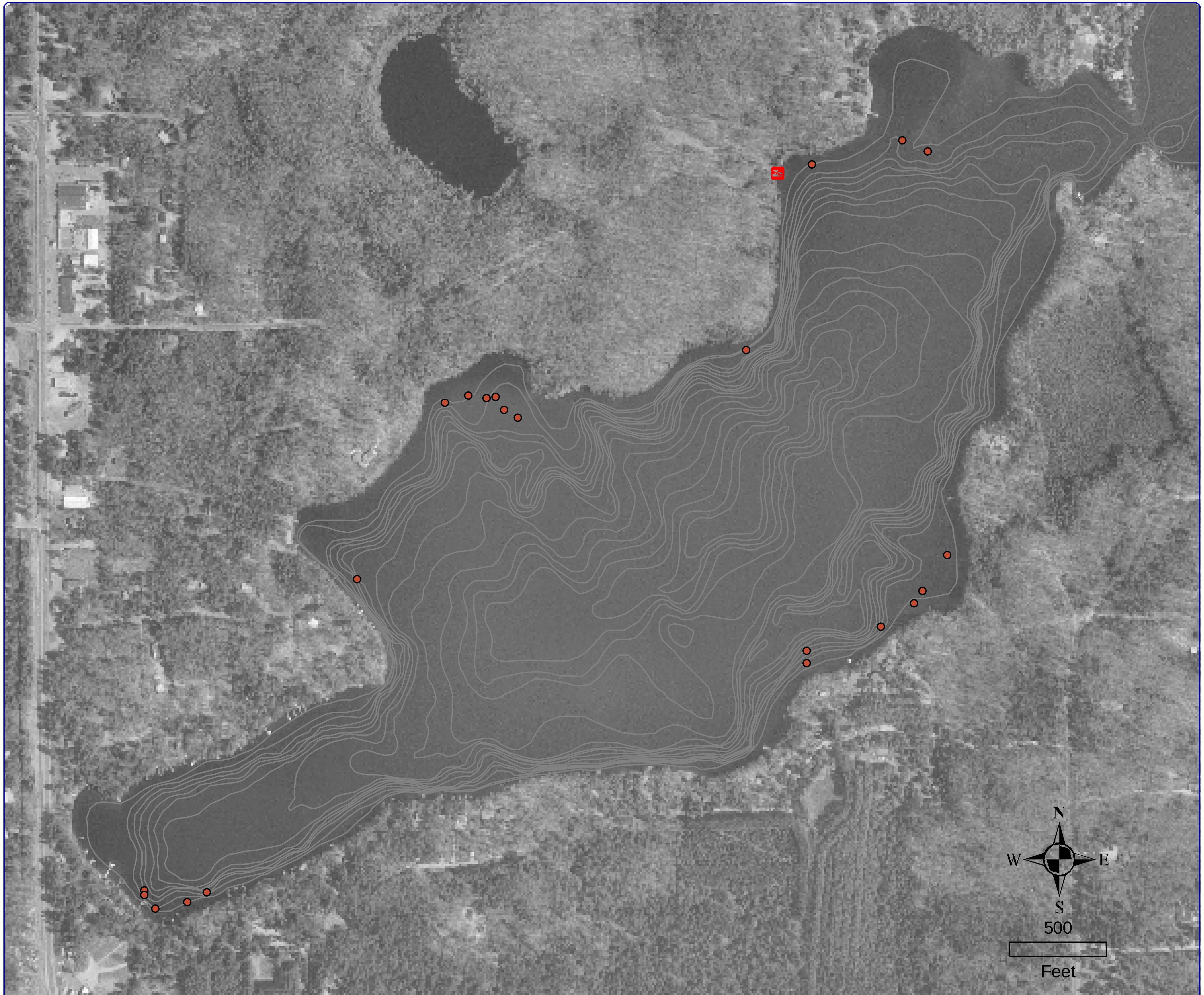
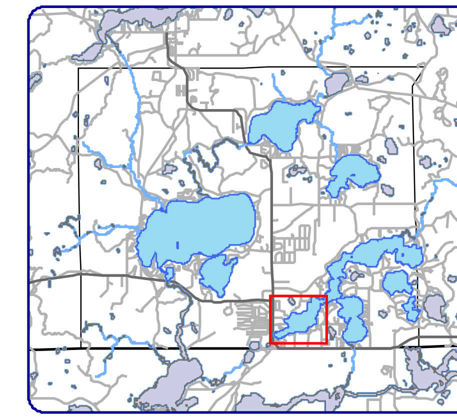


Map 3

Little Saint Germain Lake

Vilas County, Wisconsin

Baseline Eurasian Water Milfoil Findings



Extent of large map shown in red.

Legend

LSGLPRD Eurasian Water Milfoil Points: June, 2003

Public Boat Landing

GPS Data: LSGLPRD
Orthophotography: Vilas County
Bathymetry and Boat Landing: WDNR
Map Date: December 5, 2005

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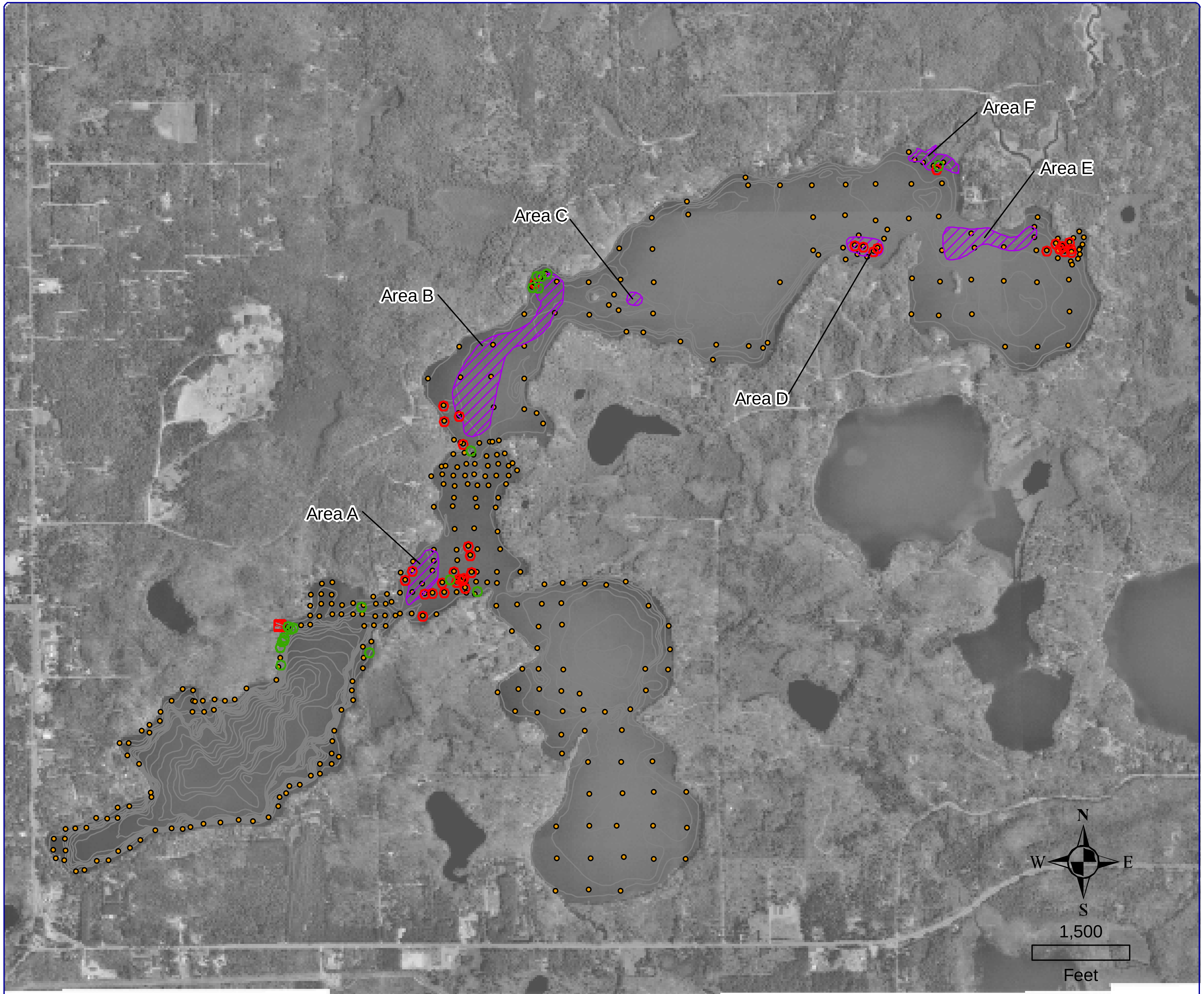
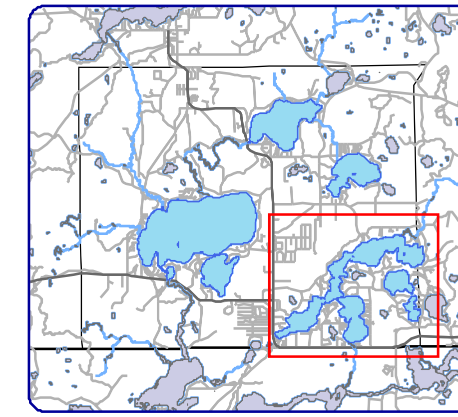


Map 4
Little Saint Germain Lake
Vilas County, Wisconsin
2005 Pre-treatment Survey Findings



Extent of large map shown in red.

Legend

- Eurasian Water Milfoil
- Curly-leaf Pondweed
- Areas from LSGLPRD Skeched Map
  "Area F" Added by Onterra, 2005
- Visited Pre-treatment Points
- Public Boat Landing

Sources:
GPS Data: Onterra, LLC
Orthophotography: Vilas County
Bathymetry and Boatlanding: WDNR
Map Date: December 5, 2005

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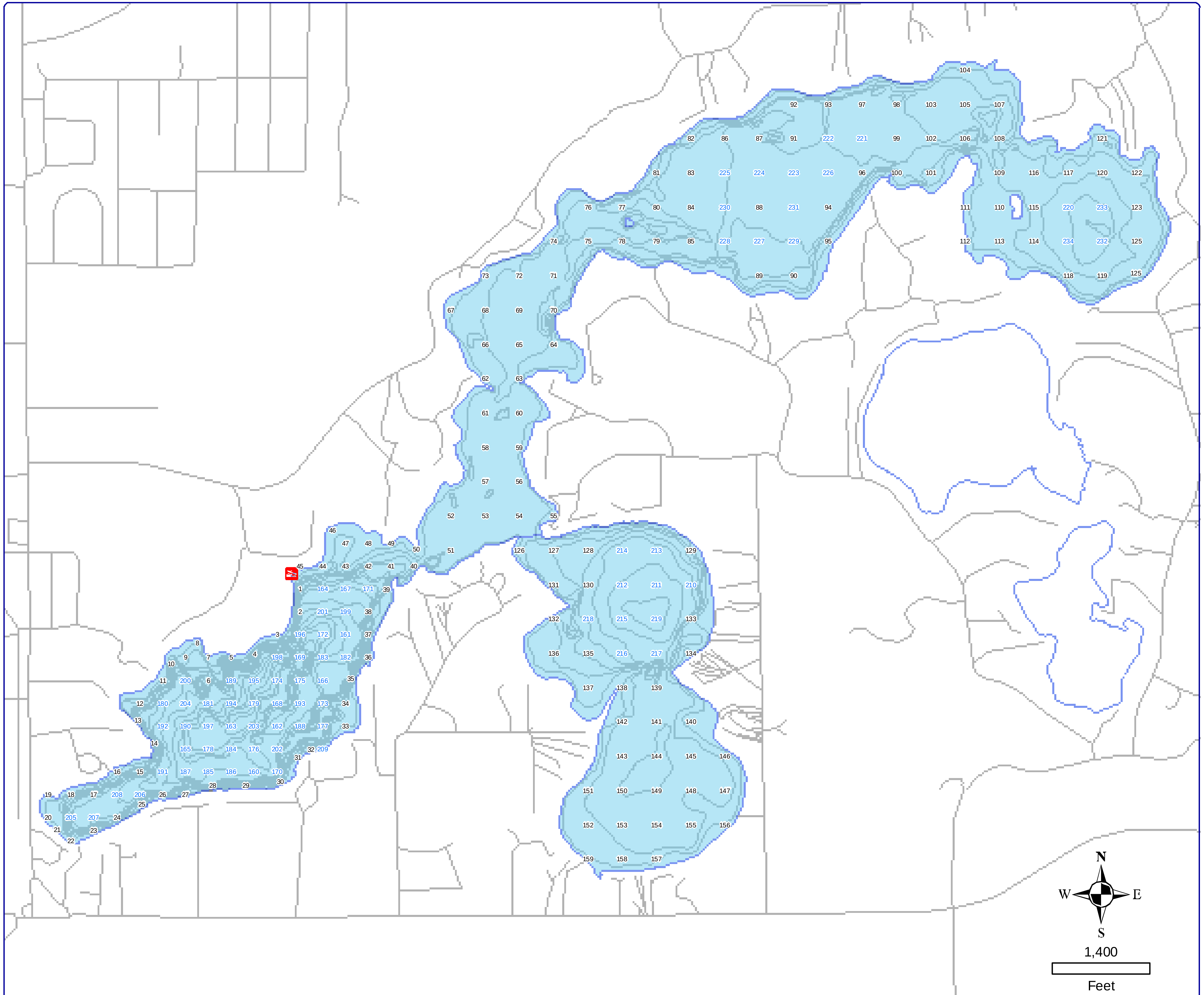
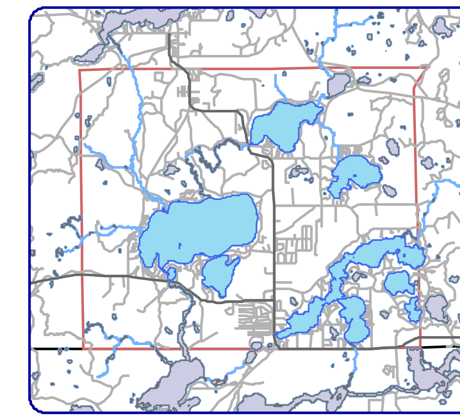


Appendix A

Little Saint Germain Lake

Vilas County, Wisconsin

Point-intercept Locations



Extent of large map shown in red.

Legend

Sampled Points

Points Not Sampled

Public Boat Landing

Sources:
Roads, Hydro, and Bathymetry: WDNR
Data Points: Onterra
Map Date: December 6, 2005

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D

APPENDIX D

March 2008 Project Update

INTRODUCTION

The following document is an update of activities completed as a part of the Little Saint Germain Lake Exotic Aquatic Species control project. It is essentially a summary of the past 2 years of the project, continuing to document the results of the project since the last update (January 2006). Management actions aimed at reducing lake-wide levels of curly-leaf pondweed (CLP) and Eurasian water milfoil (EWM) have been conducted on Little Saint Germain Lake since 2003 (Table 1). Previous to the 2005 field season, the Little Saint Germain Protection & Rehabilitation District (LSGPRD) received a Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species (AIS) grant to aid in the control of EWM and CLP within the lake. After the grant was awarded, Onterra was contracted to monitor and coordinate the treatments.

Table 1. Details of herbicide applications on invasive species in Little Saint Germain Lake.

Date	Target Species	Acres
May 14, 2003	CLP	47.2
July 1, 2003	EWM	3.0
August 4, 2003	EWM	9.0
May 11, 2004	CLP	44.0
July 1, 2004	EWM	13.0
August 24, 2004	EWM	33.0
May 9, 2005	CLP	50.0
July 13, 2005	EWM	8.5
May 12, 2006	EWM	6.2
May 13, 2006	CLP	21.3
May 10, 2007	EWM	21.5
May 11, 2007	CLP	41.6
May 25, 2007	CLP	4.7

SURVEY METHODS

The pretreatment survey on Little Saint Germain Lake consisted of two primary components. One of these components was a point-intercept survey of the entire lake to systematically investigate the littoral area in search of exotic plants. This survey utilizes the points outlined for the comprehensive aquatic plant survey. Because of the lifecycle of native plants, they should be at very low biomass (or not even started growing yet) during the spring survey. Native plant occurrences were noted, but were not the primary focus of the survey.

Such an early period in the growing season does not lend itself useful in exploring for new colonies or infestations, therefore *focus areas* were created by combining known locations of exotic plants from previous year's surveys and new occurrences located during the above mentioned point-intercept survey. Visiting these focus areas, the target exotic plant colony is mapped using sub-meter global positioning system (GPS) technology. The combination of additional rake tows, submersed video, and scuba methods were used to form an understanding of the extents of the exotic plant communities.

Professional Surveys

2006

On April 25 and May 3-5, 2006, field surveys took place to coordinate EWM and CLP treatments that would occur in mid-May. All areas previously treated for CLP were used as focus areas. In addition, a large colony that was detected by Ted Ritter (LSGPRD) during a previous visit was included as a focus area (Map 1, Site B). Based on the results of the pretreatment survey, 21.3 acres were treated on May 13, 2006 (Table 1, Map 1).

Using information provided by LSGPRD members, suspected locations of EWM were visited and professionally mapped by Onterra ecologists in 2005. These locations were used as focus areas for the 2006 treatment. Additional areas in No Fish Bay were added to the treatment plan after they were located during the pretreatment survey (Map 2). In total, 6.2 acres were treated on May 12, 2006 in No Fish and West Bays.

As a part of the Town of Saint Germain Lake Management Plan, volunteers on Little Saint Germain were trained to identify AIS and mark their occurrences. During an informal survey they completed in early-September, they found additional locations of EWM, including a few colonies in South Bay. Up until this time, EWM had not been located in South Bay. The findings of this survey raised concern by the volunteers about the seemingly lack of success that was associated with the 2006 EWM treatments. On September 11, 2006, Onterra ecologists visited Little Saint Germain Lake to better understand their concerns. From experience on other lakes in the region, 2006 was a "banner" year for EWM and the EWM on Little Saint Germain Lake was not an exception. Numerous EWM colonies were mapped within the lake during this field visit. However, many of these locations were not treated in 2006 suggesting that these occurrences largely consisted of untreated EWM.

During this late-summer field survey, the Muskellunge Creek inlet was searched for CLP based on accounts from LSGPRD members. At this time, a few healthy CLP plants were located in the creek. These findings are perplexing because the life cycle of CLP indicates that these plants should already have died back by this time.

2007

Pretreatment surveys were conducted on May 7-9, 2007. All sites treated for CLP in 2006 were used as focus areas. In addition, two sites were added previous to the field visit (Map 1, Sites G & F) based on advisement from LSGPRD members. These areas were used to gain a conditional permit from the WDNR. The results of these surveys indicated that the existing CLP colonies were much larger than previously mapped. Because of the increase in acreage requested to be treated, the WDNR had to adjust the conditional chemical application permits considerably. They were extremely helpful with the process and on May 11, 2007, 41.6 acres of CLP were treated on Little Saint Germain Lake (Table 1, Map 1). On May 22, 2007, Onterra ecologists made an additional site visit to map a CLP colony that was located by LSGPRD members while they were recreating on the lake. This 4.7 acre site (Map 1, Site H) was subsequently treated on May 25, 2007 (Table 1).

Eurasian water milfoil focus areas consisted of the surveyed locations from September 2006. After minor adjustments to these areas, 21.5 acres were treated on May 10, 2007 (Table 1, Map 2).

Volunteer Training Session

On July 19, 2007, two volunteers attended a training session held by Onterra ecologists. These individuals were already versed on invasive species identification; therefore the purpose of the training session was solely aimed at gaining familiarity with mapping techniques. Combining a land-based interactive demonstration with a practical example on Little Saint Germain Lake, volunteers were trained on how to collect GPS points in manner that would convey information about an exotic species colony. Volunteers were trained to use a Garmin GPSMap 76Cx, which was preloaded by Onterra with the 2007 CLP and EWM treatment areas. Volunteers were advised to use the GPS to visit the current year's treatment areas and check on the treatment results as well as map new occurrences of exotic species. In subsequent years, these individuals would collect these data in June for CLP and August for EWM. As stated above, LSGPRD members already conduct volunteer surveys as a part of the 'adopt a shoreline program' as outlined in the Town of Saint Germain management plan. A long term goal of the current project would be to train all these volunteers to collect meaningful GPS data. Teaching such a large group of volunteers, each containing differing levels of technological expertise, this task may take considerable time. Until that time, it is important to utilize their eyes to locate the EWM and then coordinate with the two trained individuals to map the locations, providing useful information to aid in the management of the lake.

CONCLUSIONS AND RECOMMENDATIONS

Little Saint Germain Lake continues to harbor populations of curly-leaf pondweed and Eurasian water milfoil. Now being in the final years of the current control project, attention has been given to empowering the Little Saint Germain Lake Protection and Rehabilitation District to perform significant facets of the management of Little Saint Germain Lake.

A portion of the pretreatment survey includes conducting a point-intercept survey of the entire lake in early May. The point-intercept survey was intended to provide a systematic way to look at the entire lake for AIS. However it has become apparent that this method is too *coarse scale* to provide the information for which it was intended (Table 2). It is suggested that the time used to complete these surveys may be better appropriated towards different aspects of the project. For example, monitoring activities could be completed that would bring this project more in line with recently devised protocols (see below).

Table 2. Percent frequency of pretreatment surveys sample locations containing aquatic invasive species.

Year	EWM Frequency	CLP Frequency
2005	2%	4%
2006	0%	1%
2007	3%	3%

The 2007 volunteer training session was held at the very-end of the time period available for mapping CLP, therefore allowing only minimal amount of volunteer data collection to be completed. Focus areas are created for 2008 based on all previously treated areas and two additional areas (Map 1, Sites I & J) provided by LSGPRD members. Because CLP primarily spreads from asexual reproductive structures called turions which can last in the sediment for a number of years, a continued commitment to this management strategy will be needed to reduce the turion base. Map 3 displays the 2003 CLP treatment areas, which remained largely the same through the 2005 CLP treatment. However, it is important to note two facts about Map 3. First, the map was hand drawn and may not accurately represent the actual areas treated. Secondly, new thought processes related to chemical drift have emerged since this map was constructed which indicate that chemical drift occurs at a much smaller scale than indicated on the map and the drifted chemical is at a concentration insufficient to cause mortality to the plants. Understanding this uncertainty, the map shows that majority of the 2008 focus areas have been treated, at least in part, since 2003.

A new approach to CLP management on Little Saint Germain Lake was initiated in 2006, utilizing sub-meter GPS technology to map CLP occurrence within the lake. Since 2006, only 40% of the proposed treatment areas have been treated more than once (Map 1) Although the previous methods of mapping CLP were not as technologically advanced as the approach taken in recent years, they most likely adequately represented the past treatment locations. A cursory look at this data may indicate that the CLP treatments on Little Saint Germain Lake are not decreasing the amount (density and acreage) of CLP in the lake, but without specific monitoring activities, this cannot be said with any degree of certainty.

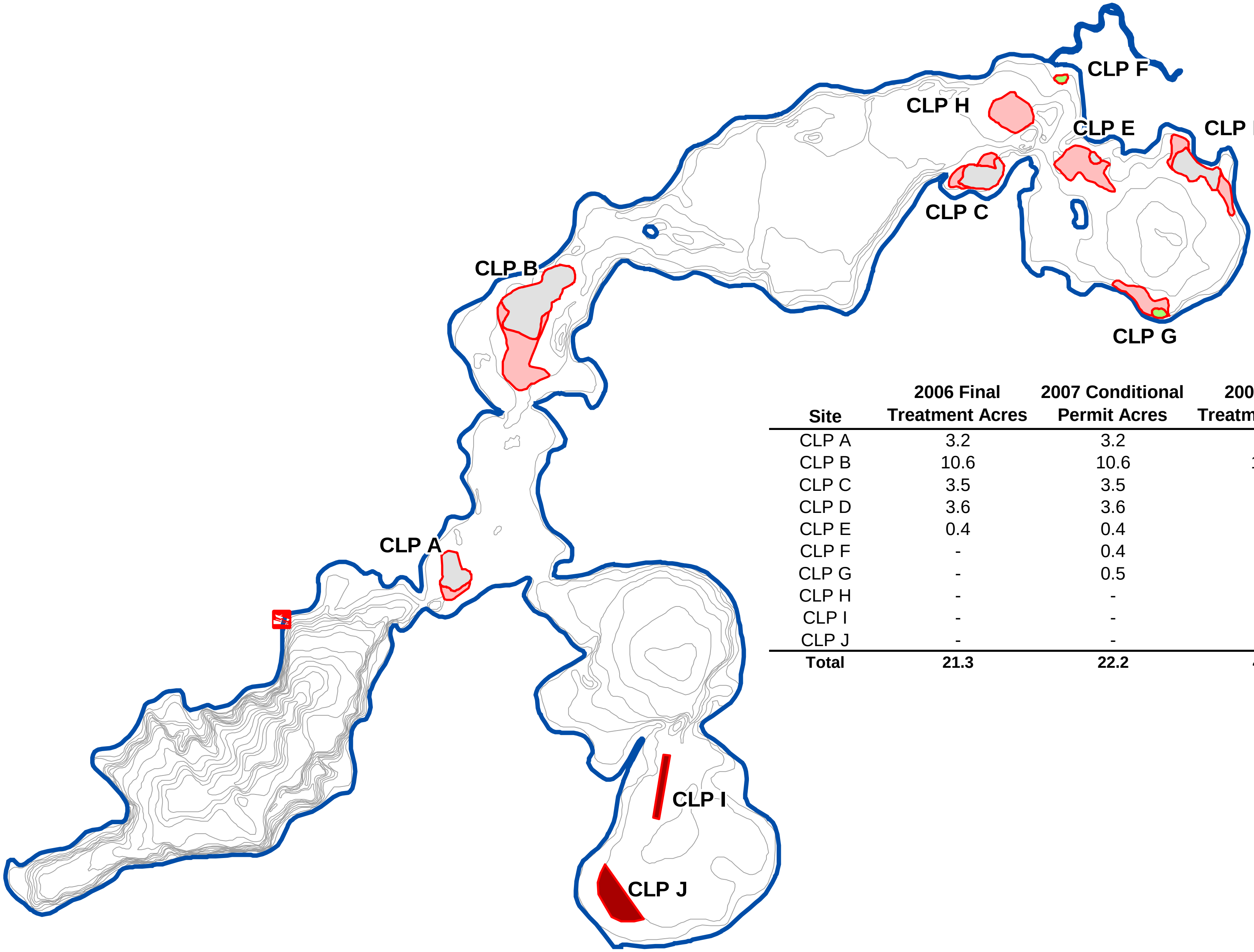
Determining the success or failure of chemical treatments on AIS is often a difficult task because the criteria used in determining success or failure is ambiguous. Most people involved with AIS management, whether professionals or laypersons, understand that the eradication of AIS from a lake, or even a specific area of a lake, is nearly, if not totally, impossible. Most understand that achieving control is the best criteria for success. Recent protocols have been established by the WDNR to gain a qualitative assessment of the treatments and it is proposed that these methods be utilized on Little Saint Germain Lake. This protocol outlines a modified point-intercept survey by which sub-sampling locations are placed 20 meters apart within the treatment areas. Data would be collected at these sample locations before and after the treatments indicating AIS presence and rake fullness. Table 3 outlines the number of point-intercept sample locations proposed for each treatment site. Post treatment sub-sampling would occur in early June for CLP and in August for EWM. The data collected during these surveys would be analyzed and included in the annual report of the 2008 treatments.

As stated above, the EWM treatments should also be monitored using the modified point-intercept method. Map 5 outlines the 2008 proposed EWM treatment strategy (these data are also displayed on Map 2). The majority of the treatment areas were constructed based on GPS locations marked by Tom Best, one of the volunteers trained in July. Additional areas (Map 5, Sites R, S, T, & U) were proposed for treatment based on anecdotal, but reliable, information from other LSGPRD members. Map 2 shows that many of the treatment areas in West Bay are remaining fragments of colonies from past treatments. An increased herbicide dose is recommended for future treatments within West Bay. The EWM in this part of the lake grows at an average depth of 7-9 feet, with plants observed growing out to 12 feet. Successes at 150 lbs/acre have been documented on lakes in this region that have EWM growing at similarly great water depths.

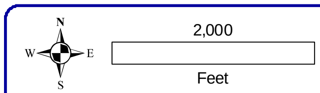
Table 3. CLP (Map 4) & EWM (Map 5) treatment areas with corresponding point-intercept sampling locations.

EWM Site	Acres	Sample Locations
A-08	1.1	4
B-08	0.2	1
C-08	0.1	0
D-08	0.9	4
E-08	0.2	1
F-08	0.5	2
G-08	0.7	3
H-08	0.9	4
I-08	1.2	5
J-08	0.4	2
K-08	2.4	10
L-08	1.3	5
M-08	0.1	0
N-08	2.5	10
O-08	0.3	1
P-08	0.3	1
Q-08	0.1	0
R-08	0.9	4
S-08	1.3	5
T-08	0.4	2
U-08	2.2	9
Total	**18**	**73**

CLP Site	Acres	Sample Locations
A-08	4.1	16
B-08	18.1	72
C-08	6.0	24
D-08	6.1	24
E-08	5.5	22
F-08	0.4	2
G-08	3.2	13
H-08	4.7	19
I-08	1.5	6
J-08	4.8	19
Total	**54.4**	**217**



Site	2006 Final Treatment Acres	2007 Conditional Permit Acres	2007 Final Treatment Acres	2008 Conditional Treatment Acres
CLP A	3.2	3.2	4.1	4.1
CLP B	10.6	10.6	18.1	18.1
CLP C	3.5	3.5	4.2	6.0
CLP D	3.6	3.6	6.1	6.1
CLP E	0.4	0.4	5.5	5.5
CLP F	-	0.4	0.4	0.4
CLP G	-	0.5	3.2	3.2
CLP H	-	-	4.7	4.7
CLP I	-	-	-	1.5
CLP J	-	-	-	4.8
Total	**21.3**	**22.2**	**46.3**	**54.4**



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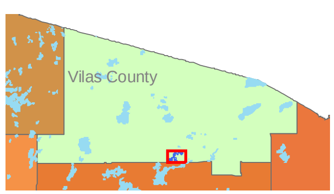
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Aquatic Plants: Onterra, 2006,2007
Bathymetry: WDNR
Map date: February 26, 2008



Extent of large map shown in red.

Legend

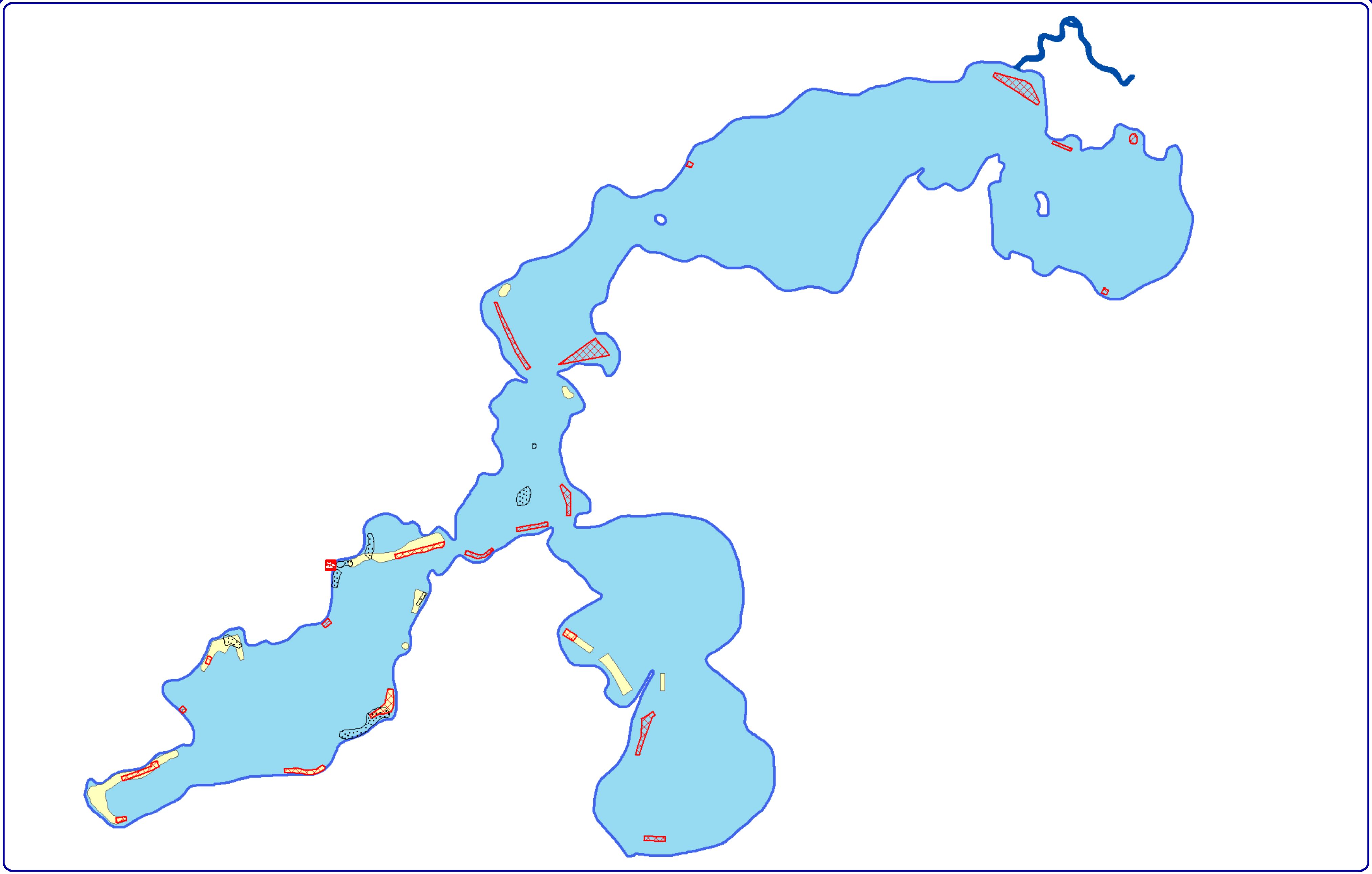
- 2006 Final Treatment Area
- Added for 2007 Conditional Permit
- Added for Final 2007 Treatment
- Added for 2008 Conditional Permit

Map 1

Little Saint Germain Lake

Vilas County, Wisconsin

2006-2008 CLP Treatment Areas



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2,000

Feet

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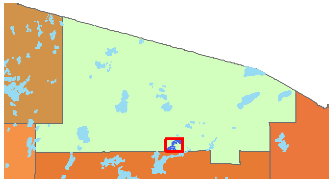
Sources:
Roads & Hydro: WDNR
Aquatic Plants: LSGPRD, 2007
Bathymetry: WDNR, Digitized by Onterra
Map date: February 25, 2008



Extent of large map shown in red.

Legend

2006 EWM Treatment Area (6.2 Acres)

2007 EWM Treatment Area (21.5 Acres)

2008 Proposed EWM Treatment Area (18.0 Acres)

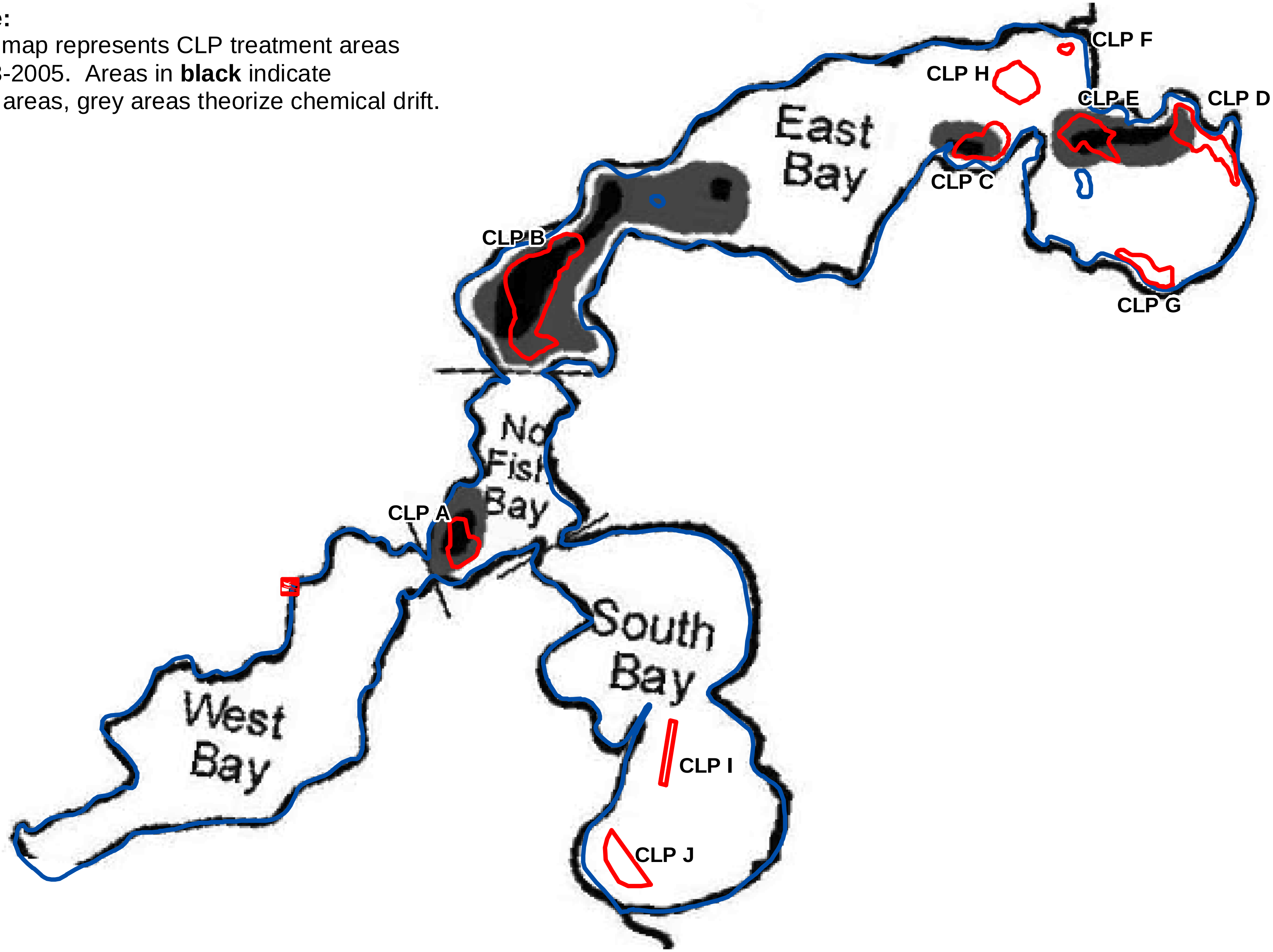
Map 2

Little Saint Germain Lake

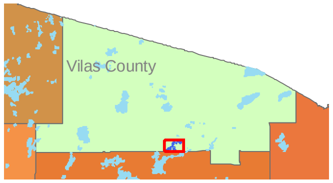
Vilas County, Wisconsin

2006-2008 EWM Treatment Areas

Map Note:
Sketched map represents CLP treatment areas from 2003-2005. Areas in **black** indicate treatment areas, grey areas theorize chemical drift.



2,000
Feet



Extent of large map shown in red.

Legend

2008 Proposed Treatment Area

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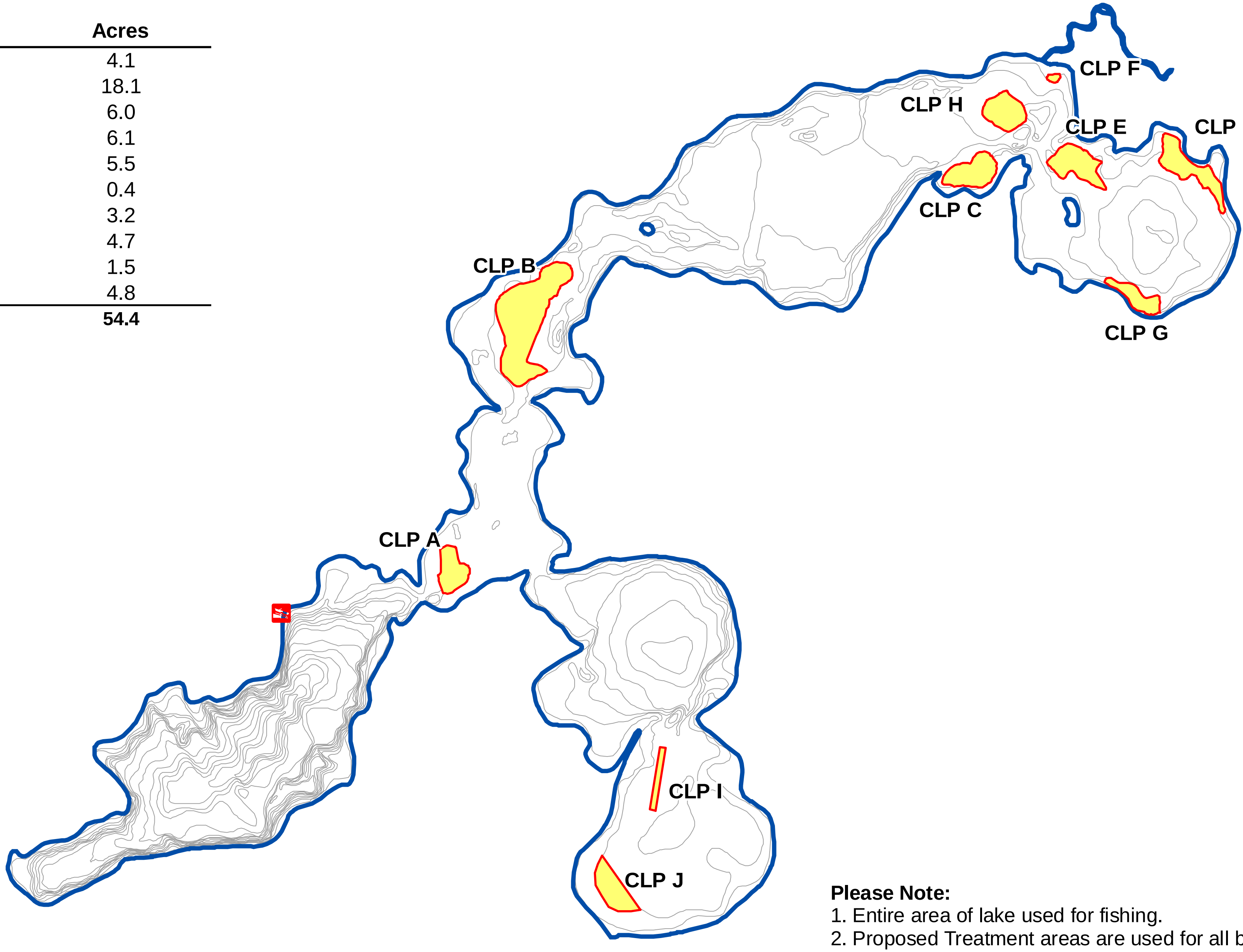
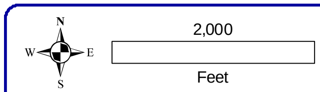
Sources:
Roads & Hydro: WDNR
Aquatic Plants: Onterra, 2006,2007
Sketched Map: LSGLPRD: 2003
Map date: February 26, 2008

Map 3
Little Saint Germain Lake
Vilas County, Wisconsin
Historic & 2008 Proposed CLP Treatment Areas

Site	Acres
CLP A	4.1
CLP B	18.1
CLP C	6.0
CLP D	6.1
CLP E	5.5
CLP F	0.4
CLP G	3.2
CLP H	4.7
CLP I	1.5
CLP J	4.8
Total	**54.4**



Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.



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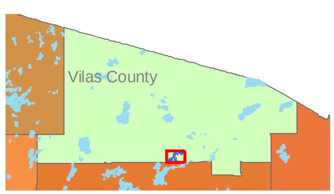
Sources:
Roads & Hydro: WDNR
Aquatic Plants: Onterra, 2006,2007
Bathymetry: WDNR
Map date: February 26, 2008



Extent of large map shown in red.

Legend

2007 Proposed Treatment Area

Map 4

Little Saint Germain Lake

Vilas County, Wisconsin

2008 Proposed CLP Treatment Areas

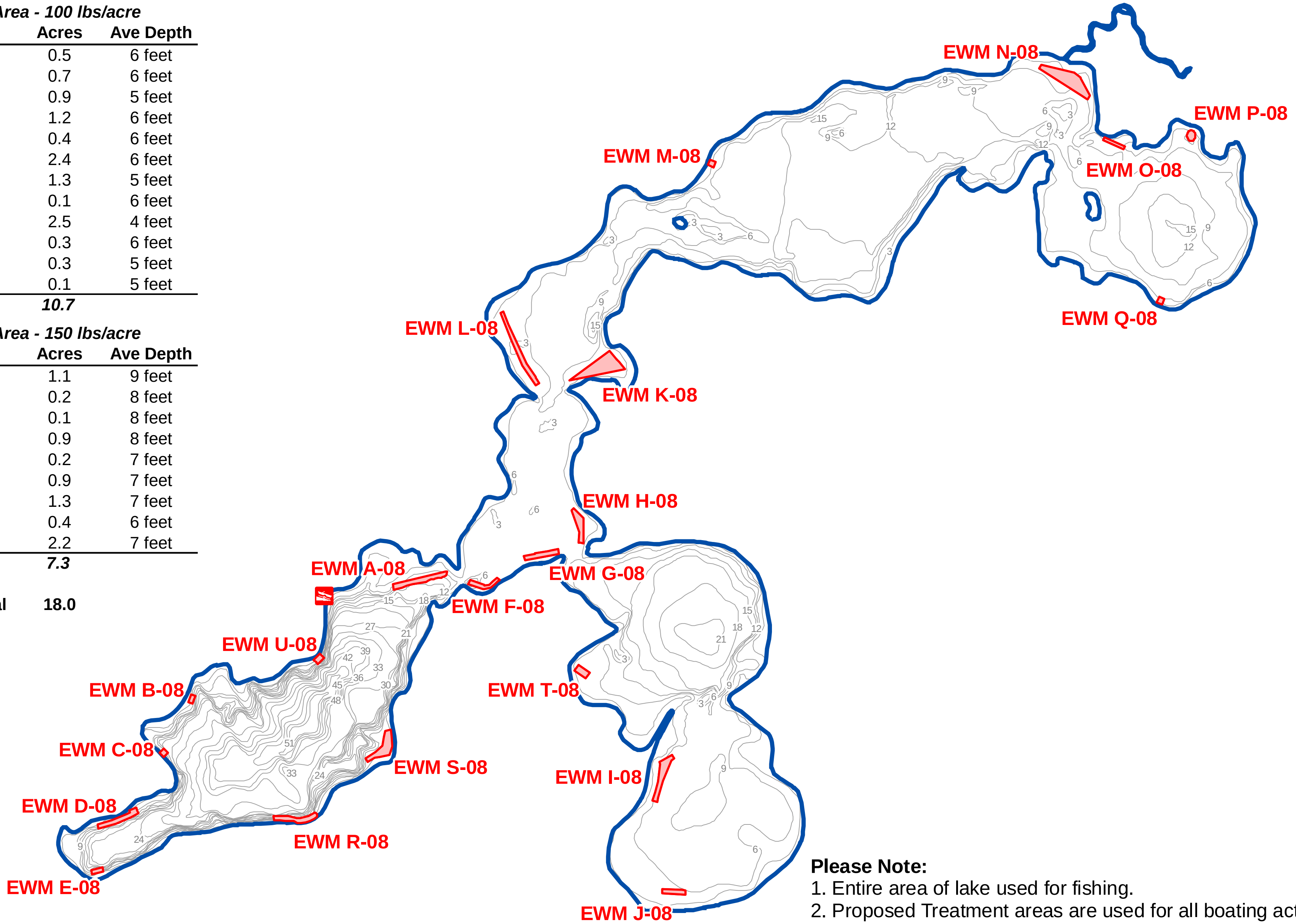
Treatment Area - 100 lbs/acre

Site	Acres	Ave Depth
F-08	0.5	6 feet
G-08	0.7	6 feet
H-08	0.9	5 feet
I-08	1.2	6 feet
J-08	0.4	6 feet
K-08	2.4	6 feet
L-08	1.3	5 feet
M-08	0.1	6 feet
N-08	2.5	4 feet
O-08	0.3	6 feet
P-08	0.3	5 feet
Q-08	0.1	5 feet
Subtotal	***10.7***	

Treatment Area - 150 lbs/acre

Site	Acres	Ave Depth
A-08	1.1	9 feet
B-08	0.2	8 feet
C-08	0.1	8 feet
D-08	0.9	8 feet
E-08	0.2	7 feet
R-08	0.9	7 feet
S-08	1.3	7 feet
T-08	0.4	6 feet
U-08	2.2	7 feet
Subtotal	***7.3***	

Grand Total **18.0**



Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.

N W E S

2,000
Feet

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Lake Management Planning
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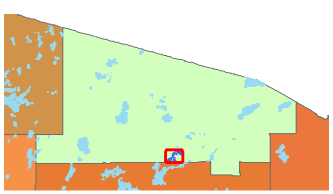
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Aquatic Plants: LSGPRD, 2007
Bathymetry: WDNR, Digitized by Onterra
Map date: February 28, 2008


Extent of large map shown in red.

Legend

2008 Proposed Treatment Area

Public Boat Landing

Map 5
Little Saint Germain Lake
Vilas County, Wisconsin
2008 Proposed EWM Treatment Areas

E

APPENDIX E

2008 Aquatic Plant Survey Data

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	Myriophyllum spicatum	Potamogeton crispus	Ceratophyllum demersum	Elodea canadensis	Potamogeton zosteriformis	Najas flexilis	Potamogeton praelongus	Nitella sp.	Heteranthera dubia	Potamogeton richardsonii	Vallisneria americana	Potamogeton robbinsii	Nymphaea odorata	Myriophyllum sibiricum	Lemna trisulca	Potamogeton gramineus	Potamogeton amplifolius	Potamogeton pusillus	Nuphar variegata	Lemna minor	Potamogeton strictifolius	Chara sp.	Schoenoplectus acutus	Spirodella polyrrhiza	Eleocharis palustris	Sparganium angustifolium	Brasenia schreberi	Pontederia cordata	Potamogeton illinoensis	Dulichium arundinaceum	Potamogeton foliosus	Ranunculus aquatilis	Sagittaria sp. (rosette)	Utricularia vulgaris	Potamogeton vaseyi	Eleocharis sp.	Eleocharis acicularis	Juncus pelocarpus	Lobelia dortmanna	Potamogeton epihydrus	Sagittaria graminea	Sparganium emersum (chlorocarpum)	Potamogeton alpinus
1	45.903086	-89.485915	4	M	P				1						1	1	1			1		1		1																										
2	45.902411	-89.485921	6	M	P					1						1	1																																	
3	45.903082	-89.484948				TOO DEEP																																												
4	45.902407	-89.484954				TOO DEEP																																												
5	45.901732	-89.484960				TOO DEEP																																												
6	45.903752	-89.483975				TOO DEEP																																												
7	45.903077	-89.483981				TOO DEEP																																												
8	45.902402	-89.483987				TOO DEEP																																												
9	45.901727	-89.483993				TOO DEEP																																												
10	45.903748	-89.483008	5	M	P		2		1							1	1			1																														
11	45.903073	-89.483014				TOO DEEP																																												
12	45.902398	-89.483020				TOO DEEP																																												
13	45.907119	-89.482010	10	M	P				1	1	2					1				2				1																										
14	45.904418	-89.482035	6	S	P					1												1						1																						
15	45.903743	-89.482041				TOO DEEP																																												
16	45.903068	-89.482047				TOO DEEP																																												
17	45.902393	-89.482054				TOO DEEP																																												
18	45.907114	-89.481043				TOO DEEP																																												
19	45.906439	-89.481049				TOO DEEP																																												
20	45.904414	-89.481068				TOO DEEP																																												
21	45.903739	-89.481074				TOO DEEP																																												
22	45.903064	-89.481080				TOO DEEP																																												
23	45.907785	-89.480069	8	M	P						1	1				1	1			2		1																												
24	45.907110	-89.480076				TOO DEEP																																												
25	45.906435	-89.480082				TOO DEEP																																												
26	45.905760	-89.480088				TOO DEEP																																												
27	45.905085	-89.480095	9	M	P																																													
28	45.904410	-89.480101				TOO DEEP																																												
29	45.903735	-89.480107				TOO DEEP																																												
30	45.908455	-89.479096				TOO DEEP																																												
31	45.907780	-89.479102				TOO DEEP																																												
32	45.907105	-89.479109				TOO DEEP																																												
33	45.906430	-89.479115				TOO DEEP																																												
34	45.905755	-89.479121				TOO DEEP																																												
35	45.905080	-89.479128				TOO DEEP																																												
36	45.904405	-89.479134				TOO DEEP																																												
37	45.903730	-89.479140				TOO DEEP																																												
38	45.909126	-89.478123	3	M	P					1	1					1	1							1																										
39	45.908451	-89.478129	9	M	P				3							1	1			1			1																											
40	45.907776	-89.478136				TOO DEEP																																												
41	45.907101	-89.478142				TOO DEEP																																												
42	45.906426	-89.478148				TOO DEEP																																												
43	45.905751	-89.478155				TOO DEEP																																												
44	45.905076	-89.478161				TOO DEEP																																												
45	45.904401	-89.478167				TOO DEEP																																												
46	45.903726	-89.478173				TOO DEEP																																												
47	45.908447	-89.477162	3	R	P																																	1												
48	45.907772	-89.477169	15		R																																													
49	45.907097	-89.477175				TOO DEEP																																												
50	45.906422	-89.477181				TOO DEEP																																												
51	45.905746	-89.477188				TOO DEEP																																												
52	45.905071	-89.477194				TOO DEEP																																												
53	45.904396	-89.477200				TOO DEEP																																												
54	45.903721	-89.477207				TOO DEEP																																												
55	45.908442	-89.476195				TOO DEEP																																												
56	45.907767	-89.476202				TOO DEEP																																												
57	45.907092	-89.476208				TOO DEEP																																												
58	45.906417	-89.476214				TOO DEEP																																												
59	45.905742	-89.476221				TOO DEEP																																												
60	45.905067	-89.476227				TOO DEEP																																												
61	45.904392	-89.476233				TOO DEEP																																												
62	45.903717	-89.476240				TOO DEEP																																												
63	45.908438	-89.475228				TOO DEEP																																												
64	45.907763	-89.475235				TOO DEEP																																												
65	45.907088	-89.475241				TOO DEEP																																												
66	45.906413	-89.475247				TOO DEEP																																												
67	45.905738	-89.475254				TOO DEEP																																												
68	45.905063	-89.475260				TOO DEEP																																												
69	45.904388	-89.475267				TOO DEEP																																												
70	45.903713	-89.475273				TOO DEEP																																												
71	45.909108	-89.474255				TOO DEEP																																												
72	45.908433	-89.474261				TOO DEEP																																												
73	45.907758	-89.474268				TOO DEEP																																												
74	45.907083	-89.474274				TOO DEEP																																												
75	45.906408	-89.474281				TOO DEEP																																												
76	45.905733	-89.474287				TOO DEEP																																												
77	45.905058	-89.474293				TOO DEEP																																												
78	45.904383	-89.474300				TOO DEEP																																												
79	45.903708	-89.474306	4	M	P							1				1	1																		1															
80	45.909104	-89.473288				TOO DEEP																																												
81	45.908429	-89.473294				TOO DEEP																																												
82	45.907754	-89.473301				TOO DEEP																																												
83	45.907079	-89.473307				TOO DEEP																																												
84	45.906404	-89.473314				TOO DEEP																																												
85	45.905729	-89.473320				TOO DEEP																																												
86	45.905054	-89.473326				TOO DEEP																																												
87	45.904379	-89.473333				TOO DEEP																																												

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	Myriophyllum spicatum	Potamogeton crispus	Ceratophyllum demersum	Elodea canadensis	Potamogeton zosteriformis	Najas flexilis	Potamogeton praelongus	Nitella sp.	Heteranthera dubia	Potamogeton richardsonii	Vallisneria americana	Potamogeton robbinsii	Nymphaea odorata	Myriophyllum sibiricum	Lemna trisulca	Potamogeton gramineus	Potamogeton amplifolius	Potamogeton pusillus	Nuphar variegata	Lemna minor	Potamogeton strictifolius	Chara sp.	Schoenoplectus acutus	Spirodella polyrrhiza	Eleocharis palustris	Sparganium angustifolium	Brasenia schreberi	Pontederia cordata	Potamogeton illinoensis	Dulichium arundinaceum	Potamogeton foliosus	Ranunculus aquatilis	Sagittaria sp. (rosette)	Utricularia vulgaris	Potamogeton vaseyi	Eleocharis sp.	Eleocharis acicularis	Juncus pelocarpus	Lobelia dortmanna	Potamogeton epihydrus	Sagittaria graminea	Sparganium emersum (chlorocarpum)	Potamogeton alpinus
88	45.903704	-89.473339	5	M	P				1	1												1						1																						
89	45.911799	-89.472296	11	M	P																			1			1																							
90	45.911124	-89.472302				TOO DEEP																																												
91	45.910449	-89.472308				TOO DEEP																																												
92	45.909774	-89.472315				TOO DEEP																																												
93	45.909099	-89.472321				TOO DEEP																																												
94	45.908424	-89.472327				TOO DEEP																																												
95	45.907749	-89.472334				TOO DEEP																																												
96	45.907074	-89.472340				TOO DEEP																																												
97	45.906399	-89.472347				TOO DEEP																																												
98	45.905724	-89.472353				TOO DEEP																																												
99	45.905049	-89.472359	5	M	P		2		1																																									
100	45.911795	-89.471328	9	M	P				1	1			1			1	1			1			1																											
101	45.911120	-89.471335				TOO DEEP																																												
102	45.910445	-89.471341				TOO DEEP																																												
103	45.909770	-89.471348				TOO DEEP																																												
104	45.909095	-89.471354				TOO DEEP																																												
105	45.908420	-89.471361				TOO DEEP																																												
106	45.907745	-89.471367				TOO DEEP																																												
107	45.907070	-89.471373				TOO DEEP																																												
108	45.906395	-89.471380				TOO DEEP																																												
109	45.905720	-89.471386				TOO DEEP																																												
110	45.905045	-89.471393	2	S	P				1	1		1										1																												
111	45.913140	-89.470349	5	M	P				3	1						1		1	1				1									1			1															
112	45.912465	-89.470355	4	M	P				1	1	1	1	2								1	1																												
113	45.911790	-89.470361				TOO DEEP																																												
114	45.911115	-89.470368				TOO DEEP																																												
115	45.910440	-89.470374				TOO DEEP																																												
116	45.909765	-89.470381				TOO DEEP																																												
117	45.909090	-89.470387				TOO DEEP																																												
118	45.908415	-89.470394				TOO DEEP																																												
119	45.907740	-89.470400				TOO DEEP																																												
120	45.907065	-89.470406				TOO DEEP																																												
121	45.906390	-89.470413	4	M	P				1	1		1					1			1		1		1				1																						
122	45.905715	-89.470419	6	R	P				1													1																												
123	45.913811	-89.469375	3	M	P					1															1								3																	
124	45.913136	-89.469382	4	M	P				1	1	1		1					1		1															1															
125	45.912461	-89.469388	4	M	P				1													1																												
126	45.911786	-89.469394				TOO DEEP																																												
127	45.911111	-89.469401				TOO DEEP																																												
128	45.910436	-89.469407				TOO DEEP																																												
129	45.909761	-89.469414				TOO DEEP																																												
130	45.909086	-89.469420				TOO DEEP																																												
131	45.908411	-89.469427				TOO DEEP																																												
132	45.907736	-89.469433				TOO DEEP																																												
133	45.907061	-89.469439	4	M	P																	1																												
134	45.906386	-89.469446				TOO DEEP																																												
135	45.905711	-89.469452				TOO DEEP																																												
136	45.913131	-89.468415	3	R	P																											1												1	1				
137	45.912456	-89.468421	4	M	P																																												
138	45.911781	-89.468427				TOO DEEP																																												
139	45.911106	-89.468434				TOO DEEP																																												
140	45.910431	-89.468440				TOO DEEP																																												
141	45.909756	-89.468447				TOO DEEP																																												
142	45.909081	-89.468453	6	M	P		1		1			1										1						1																						
143	45.908406	-89.468460				TOO DEEP																																												
144	45.912452	-89.467454	5	M	P		1					1								1																														1
145	45.911777	-89.467460				TOO DEEP																																												
146	45.911102	-89.467467	3	R	P												1					1																												
147	45.910427	-89.467473	4	S	P												1					1						1																						
148	45.913122	-89.466481	4	R	P				1																																									
149	45.912447	-89.466487				TOO DEEP										2																																		
150	45.911772	-89.466493	5	M	P				2	1						1	1										1																							
151	45.913793	-89.465507	3	M	P				1	2					1				1							1				1																				
152	45.912443	-89.465520	5	R	P					1		1																																						
153	45.914463	-89.464533	3	M	P				1			1					2																						1											
154	45.913788	-89.464540	4	M	P				1	2																																								
155	45.913113	-89.464546	5	M	P				1	1		1															1																							
156	45.912438	-89.464553	5	M	P																																													
157	45.922559	-89.463488	3	M	P				1	1									1						1																									
158	45.921884	-89.463495	3	M	P				2	1									1						1	1																								
159	45.915134	-89.463560	4	M	P					1		1					1																																	
160	45.914459	-89.463566	4	M	P				2	1						1																																		
161	45.913784	-89.463573	4	M	P				1																																									
162	45.913109	-89.463579	6	M	P				1			1																																						
163	45.912434	-89.463586	5	M	P				2	1		1			1	1																																		
164	45.922554	-89.462521	4	M	P				2	1																																								
165	45.921879	-89.462528	7	M	P				2	1																																								
166	45.921204	-89.462534	3	M	P				2																1																									
167	45.920529	-89.462541	4	M	P				3	1																																								
168	45.918504	-89.462560	3	M	P				1	2	1	1			1	1			1																						1								
169	45.917829	-89.462567	5	M	P				2	1						1																																		
170	45.917154	-89.462573	4	M	P				2	1			1		1		1							1																										
171	45.916479	-89.462580	6	M	P				3	1			1	1										1																										
172	45.915804	-89.462586	6	M	P				2	1		1																																						
173	45.915129	-89.462593	5	M	P				1																																									
174	45.914454	-89.462599	5	M	P				2	1																																								

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	*Myriophyllum spicatum*	*Potamogeton crispus*	*Ceratophyllum demersum*	*Elodea canadensis*	*Potamogeton zosteriformis*	*Najas flexilis*	*Potamogeton praelongus*	*Nitella sp.*	*Heteranthera dubia*	*Potamogeton richardsonii*	*Vallisneria americana*	*Potamogeton robbinsii*	*Nymphaea odorata*	*Myriophyllum sibiricum*	*Lemna trisulca*	*Potamogeton gramineus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Nuphar variegata*	*Lemna minor*	*Potamogeton strictifolius*	*Chara sp.*	*Schoenoplectus acutus*	*Spirodella polyrrhiza*	*Eleocharis palustris*	*Sparganium angustifolium*	*Brasenia schreberi*	*Pontederia cordata*	*Potamogeton illinoensis*	*Dulichium arundinaceum*	*Potamogeton foliosus*	*Ranunculus aquatilis*	*Sagittaria sp. (rosette)*	*Utricularia vulgaris*	*Potamogeton vaseyi*	*Eleocharis sp.*	*Eleocharis acicularis*	*Juncus pelocarpus*	*Lobelia dortmanna*	*Potamogeton epihydrus*	*Sagittaria graminea*	*Sparganium emersum (chlorocarpum)*	*Potamogeton alpinus*
175	45.913779	-89.462606	5	M	P					1		1																																						
176	45.913104	-89.462612	5	M	P							1																																						
177	45.923900	-89.461541	3	M	P					1						1																																		
178	45.923225	-89.461547	7	M	P				1	2				1																																				
179	45.922550	-89.461554	7	M	P				1	1				1																																				
180	45.921875	-89.461560	7	M	P																																													
181	45.921200	-89.461567	6	M	P				1																																									
182	45.920525	-89.461574	5	M	P				2	1																																								
183	45.919850	-89.461580	5	M	P				3	1																																								
184	45.919175	-89.461587				ON SHORE																																												
185	45.918500	-89.461593	3	M	P				2	1		1																																						
186	45.917825	-89.461600	4	M	P				2	1			1			1					1																													
187	45.917150	-89.461606	6	M	P				3	1		1			1									1																										
188	45.916475	-89.461613	5	M	P				3	1																																								
189	45.915800	-89.461619	6	M	P				1			1	1																																					
190	45.915125	-89.461626	6	M	P				1																																									
191	45.914450	-89.461632	4	M	P				2	1																																								
192	45.913775	-89.461639	5	M	P				1	2							1																																	
193	45.913100	-89.461645	5	M	P				1	2		1			1																																			
194	45.923895	-89.460574	6	M	P				1	3																																								
195	45.923220	-89.460580	7	M	P				1	3				1																																				
196	45.922545	-89.460587	7	M	P				1	1																																								
197	45.921870	-89.460593	8	M	P																																													
198	45.921195	-89.460600	7	M	P				3	1																																								
199	45.920520	-89.460606	7	M	P				2	1																																								
200	45.919845	-89.460613	6	M	P				1	1																																								
201	45.919170	-89.460619	7	R	P				2	1																																								
202	45.918495	-89.460626	5	M	P					1																																								
203	45.917820	-89.460633	4	M	P				1	1											1																													
204	45.917145	-89.460639	5	M	P				1	1		1									1																													
205	45.916470	-89.460646	5	M	P				2	1					1																																			
206	45.915795	-89.460652	5	M	P				1	1											1																													
207	45.915120	-89.460659	6	M	P				2	1																																								
208	45.914445	-89.460665	4	M	P				3	1			1		1																																			
209	45.913770	-89.460672	6	M	P							1																																						
210	45.923891	-89.459606	7	M	P				1	3				1																																				
211	45.923216	-89.459613	8	M	P				1	1																																								
212	45.922541	-89.459620	9	M	P				1																																									
213	45.921866	-89.459626	9	M	P																																													
214	45.921191	-89.459633	8	M	P					1																																								
215	45.920516	-89.459639	7	M	P				1	1				1																																				
216	45.919841	-89.459646	6	M	P				1			1																																						
217	45.919166	-89.459652	6	M	P										1																																			
218	45.918491	-89.459659	5	M	P																																													
219	45.917816	-89.459665	6	M	P				2					1							1																													
220	45.917141	-89.459672	4	M	P				1	1		1					2																																	
221	45.916466	-89.459679	3	M	P							1																															1						
222	45.915791	-89.459685	5	M	P							1			2																																			
223	45.915116	-89.459692	4	M	P				2	1		1																																						
224	45.914441	-89.459698	6	M	P				1																																									
225	45.913766	-89.459705	8	M	P																																													
226	45.913091	-89.459711	6	M	P					1		1																																						
227	45.912416	-89.459718	6	M	P				2	1																																								
228	45.924561	-89.458633	5	M	P					1		1			1																																			
229	45.923886	-89.458639	8	M	P				2	1				1																																				
230	45.923211	-89.458646	9	M	P																																													
231	45.922536	-89.458652	9	M	P																																													
232	45.921861	-89.458659	11	M	P																																													
233	45.921186	-89.458665	9	M	P									1																																				
234	45.920511	-89.458672	7	M	P					1				1																																				
235	45.918486	-89.458692	6	M	P				3				1		1																																			
236	45.914436	-89.458731	4	M	P				2	1																																								
237	45.913761	-89.458738	3	R	P																																													
238	45.913086	-89.458744	8	M	P				1			1																																						
239	45.912411	-89.458751	8	M	P					1																																								
240	45.911736	-89.458757				BOAT DOCK																																												
241	45.909711	-89.458777	3	S	P				1			1			1	1																							1				1							
242	45.909036	-89.458784	4	M	P				1	1			1	1																																				
243	45.908361	-89.458790	3	M	P				1	2	1			1					1	1					1																	1								
244	45.925232	-89.457659	4	M	P							2												1																										
245	45.924557	-89.457665	8	M	P				3	1				1																																				
246	45.923882	-89.457672	9	M	P				1																																									
247	45.923207	-89.457679	10	M	P																																													
248	45.922532	-89.457685	6	M	P																																													
249	45.921857	-89.457692				ON SHORE																																												
250	45.921182	-89.457698	5	R	P				2	1		1																																						
251	45.920507	-89.457705	4	M	P				3																																									
252	45.913081	-89.457777	8	M	P				1			1																																						
253	45.912406	-89.457784	10	M	P																																													
254	45.911731	-89.457790	9	M	P				1																																									
255	45.911056	-89.457797	3	M	P					1		1																																						
256	45.909706	-89.457810	6	M	P				1																																									
257	45.909031	-89.457817	5	M	P				1	1	1																																							
258	45.908356	-89.457823	6	M	P				2	1																																								
259	45.926577	-89.456678	5	M	P					2				1																																				
260	45.925902	-89.456685	8	M	P				2																																									
261	45.925227	-89.456692	9	M	P				1	1				1																																				

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	*Myriophyllum spicatum*	*Potamogeton crispus*	*Ceratophyllum demersum*	*Elodea canadensis*	*Potamogeton zosteriformis*	*Najas flexilis*	*Potamogeton praelongus*	*Nitella sp.*	*Heteranthera dubia*	*Potamogeton richardsonii*	*Vallisneria americana*	*Potamogeton robbinsii*	*Nymphaea odorata*	*Myriophyllum sibiricum*	*Lemna trisulca*	*Potamogeton gramineus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Nuphar variegata*	*Lemna minor*	*Potamogeton strictifolius*	*Chara sp.*	*Schoenoplectus acutus*	*Spirodela polyrrhiza*	*Eleocharis palustris*	*Sparganium angustifolium*	*Brasenia schreberi*	*Pontederia cordata*	*Potamogeton illinoensis*	*Dulichium arundinaceum*	*Potamogeton foliosus*	*Ranunculus aquatilis*	*Sagittaria sp. (rosette)*	*Utricularia vulgaris*	*Potamogeton vaseyi*	*Eleocharis sp.*	*Eleocharis acicularis*	*Juncus pelocarpus*	*Lobelia dortmanna*	*Potamogeton epihydrus*	*Sagittaria graminea*	*Sparganium emersum (chlorocarpum)*	*Potamogeton alpinus*
262	45.924552	-89.456698	11	M	P																																													
263	45.923877	-89.456705	9	M	P																																													
264	45.923202	-89.456711	6	M	P				1			1																																						
265	45.920502	-89.456738	4	M	P				2	1																																								
266	45.919827	-89.456744	3	M	P				1										1																															
267	45.913077	-89.456810	10						2	1				1																																				
268	45.912402	-89.456817	12	M	P																																													
269	45.911727	-89.456823	10	M	P				1																																									
270	45.911052	-89.456830	10	M	P				1	1		1			1																																			
271	45.910377	-89.456837	5	M	P				1			1					1																																	
272	45.909702	-89.456843	8	M	P				1		1																																							
273	45.909027	-89.456850	6	M	P				1				1							1																														
274	45.908352	-89.456856	7	M	P					1																																								
275	45.907677	-89.456863	4	M	P				1	1	1					1	1	1		1																														
276	45.907002	-89.456869	3	M	P				1	1									1		1													1													1		
277	45.902952	-89.456909	4	M	P				1	1	1							3																																
278	45.902277	-89.456916	4	M	P					1						1		2																																
279	45.901602	-89.456922	4	M	P				1		1							1																																
280	45.926572	-89.455711	4	M	P				2																																									
281	45.925897	-89.455718	9	M	P					1				1																																				
282	45.925222	-89.455724	10	M	P																																													
283	45.924547	-89.455731	10	M	P				1																																									
284	45.913747	-89.455837	3	S	P							1																																						
285	45.913072	-89.455843	12																																															
286	45.912397	-89.455850				TOO DEEP																																												
287	45.911722	-89.455856				TOO DEEP																																												
288	45.911047	-89.455863				TOO DEEP																																												
289	45.910372	-89.455870				TOO DEEP																																												
290	45.909697	-89.455876	12	M	P																																													
291	45.909022	-89.455883	12	M	P				1																																									
292	45.908347	-89.455889	11	M	P																																													
293	45.907672	-89.455896	5	M	P				2	1			1														1																							
294	45.906997	-89.455903	3	M	P				3	1	1																																							
295	45.906322	-89.455909	3	M	P				2	1	1				1				1		1						1																							
296	45.904297	-89.455929	2	S	P							1																																						
297	45.903622	-89.455935	4	M	P				2	1	1																																							
298	45.902947	-89.455942	5	M	P				1		3							1					1																											
299	45.902272	-89.455949	4	M	P				1		3							1																																
300	45.901597	-89.455955	5	M	P				1	1	2					1							1																											
301	45.900922	-89.455962	5	M	P				1	1	1		1			1		1		1																														
302	45.926568	-89.454744				ON SHORE																																												
303	45.925893	-89.454751	9	M	P																																													
304	45.925218	-89.454757	10	M	P																																													
305	45.913743	-89.454870				ON SHORE																																												
306	45.913068	-89.454876				TOO DEEP																																												
307	45.912393	-89.454883				TOO DEEP																																												
308	45.911718	-89.454889				TOO DEEP																																												
309	45.911043	-89.454896				TOO DEEP																																												
310	45.910368	-89.454903				TOO DEEP																																												
311	45.909693	-89.454909				TOO DEEP																																												
312	45.909018	-89.454916				TOO DEEP																																												
313	45.908343	-89.454922				TOO DEEP																																												
314	45.907668	-89.454929	3	M	P				1	1	1									1																														
315	45.906993	-89.454936	2	S	P				1						1																					1														
316	45.906318	-89.454942	2	S	P								1												1	1			1		1	1		1		1						1							
317	45.905643	-89.454949	3	S	P				1				1		1																								1										
318	45.904968	-89.454955	6	M	P				1		2					1		1																																
319	45.904293	-89.454962	5	M	P				1		2		1																																					
320	45.903618	-89.454969	6	M	P				1		3		1																																					
321	45.902943	-89.454975	5	M	P				3		1		1					1																																
322	45.902268	-89.454982	5	M	P			1	2		1		1																																					
323	45.901593	-89.454988	6	M	P				1		1		1																																					
324	45.900918	-89.454995	4	M	P				1	1	1		1										1																											
325	45.900243	-89.455002	3	S	P				1	1		1						1																																
326	45.926563	-89.453777	11	M	P																																													
327	45.925888	-89.453783	3	S	P																																													
328	45.925213	-89.453790	9	M	P					1				1																																				
329	45.924538	-89.453797	9	M	P																																													
330	45.913738	-89.453902	5	M	P				1						1																																			
331	45.913063	-89.453909				TOO DEEP																																												
332	45.912388	-89.453916				TOO DEEP																																												
333	45.911713	-89.453922				TOO DEEP																																												
334	45.911038	-89.453929				TOO DEEP																																												
335	45.910363	-89.453936				TOO DEEP																																												
336	45.909688	-89.453942				TOO DEEP																																												
337	45.909013	-89.453949				TOO DEEP																																												
338	45.908338	-89.453955	12	M	P																																													
339	45.907663	-89.453962	3	S	P					1	1	1						1						1					1			1																		
340	45.906988	-89.453969	5	M	P				1	2	1				1																																			
341	45.906313	-89.453975	4	M	P					2	1						1						1																											
342	45.905638	-89.453982	6	M	P				2		1		1					1					1																											
343	45.904963	-89.453989	5	M	P				1		1		2										1																											
344	45.904288	-89.453995	6	M	P				3		1		1																																					
345	45.903613	-89.454002	10	M	P				1				1					1																																
346	45.902938	-89.454008	10	M	P				2		1																																							
347	45.902263	-89.454015	5	M	P				1		1		1																																					
348	45.901588	-89.454022	5	M	P				1		1		1					1		1			1																											

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	Myriophyllum spicatum	Potamogeton crispus	Ceratophyllum demersum	Elodea canadensis	Potamogeton zosteriformis	Najas flexilis	Potamogeton praelongus	Nitella sp.	Heteranthera dubia	Potamogeton richardsonii	Vallisneria americana	Potamogeton robbinsii	Nymphaea odorata	Myriophyllum sibiricum	Lemna trisulca	Potamogeton gramineus	Potamogeton amplifolius	Potamogeton pusillus	Nuphar variegata	Lemna minor	Potamogeton strictifolius	Chara sp.	Schoenoplectus acutus	Spirodella polyrrhiza	Eleocharis palustris	Sparganium angustifolium	Brasenia schreberi	Pontederia cordata	Potamogeton illinoensis	Dulichium arundinaceum	Potamogeton foliosus	Ranunculus aquatilis	Sagittaria sp. (rosette)	Utricularia vulgaris	Potamogeton vaseyi	Eleocharis sp.	Eleocharis acicularis	Juncus pelocarpus	Lobelia dortmanna	Potamogeton epihydrus	Sagittaria graminea	Sparganium emersum (chlorocarpum)	Potamogeton alpinus
349	45.900913	-89.454028	4	M	P				1	1	1		1					1					1																												
350	45.900238	-89.454035	3	M	P						1																																								
351	45.927234	-89.452803	3	M	P							1					1																																		
352	45.926559	-89.452809	11	M	P																																														
353	45.925883	-89.452816	5	M	P					1		1		1	1																																				
354	45.925208	-89.452823	8	M	P					1				1																																					
355	45.924533	-89.452829	10	M	P																																														
356	45.913733	-89.452935	4	M	P																																														
357	45.913058	-89.452942				TOO DEEP																																													
358	45.912383	-89.452949				TOO DEEP																																													
359	45.911708	-89.452955				TOO DEEP																																													
360	45.911033	-89.452962				TOO DEEP																																													
361	45.910358	-89.452969				TOO DEEP																																													
362	45.909683	-89.452975				TOO DEEP																																													
363	45.909008	-89.452982				TOO DEEP																																													
364	45.908333	-89.452988	10	M	P				1		1		1						1																																
365	45.907658	-89.452995	5	M	P				1	2	1							1																																	
366	45.906983	-89.453002	5	M	P				3	1	1					1																																			
367	45.906308	-89.453008	6	M	P				2		1		1																																						
368	45.905633	-89.453015	5	M	P				3		1		1																																						
369	45.904958	-89.453022	9	M	P				1		2		1					1																																	
370	45.904283	-89.453028	8	M	P			1	2				1																																						
371	45.903608	-89.453035	11	M	P				1																																										
372	45.902933	-89.453042	10	M	P				1																																										
373	45.902258	-89.453048	5	M	P				2		1		1																																						
374	45.901583	-89.453055	4	M	P						2					1		1																																	
375	45.900908	-89.453061	7	M	P				1	1	1		1			1		1																																	
376	45.900233	-89.453068	3	S	P							1	1																																						
377	45.927904	-89.451829	8	M	P																																														
378	45.927229	-89.451835	10	M	P																																														
379	45.926554	-89.451842	11	M	P																																														
380	45.925879	-89.451849	9	M	P				1																																										
381	45.925204	-89.451855	3	M	P														1						1				1																						
382	45.924529	-89.451862	11	M	P					1																																									
383	45.913054	-89.451975				TOO DEEP																																													
384	45.912379	-89.451982				TOO DEEP																																													
385	45.911704	-89.451988				TOO DEEP																																													
386	45.911029	-89.451995				TOO DEEP																																													
387	45.910354	-89.452002				TOO DEEP																																													
388	45.909679	-89.452008				TOO DEEP																																													
389	45.909004	-89.452015				TOO DEEP																																													
390	45.908329	-89.452022				TOO DEEP																																													
391	45.907654	-89.452028	7	M	P				1		1																																								
392	45.906979	-89.452035	6	M	P				1			1	1																																						
393	45.906304	-89.452041	7	M	P				2		1		1								1																														
394	45.905629	-89.452048	8	M	P				2	1					1																																				
395	45.904954	-89.452055	10	M	P																																														
396	45.904279	-89.452061	10	M	P				3		1																																								
397	45.903604	-89.452068	9	M	P																																														
398	45.902929	-89.452075	10	M	P				2		1																																								
399	45.902254	-89.452081	5	M	P				3		1		1																																						
400	45.901579	-89.452088	4	M	P				2		1		1																																						
401	45.900904	-89.452095	5	M	P				1		2		1			1		1			1		1																												
402	45.928574	-89.450855	6	M	P				1			2			1		1																																		
403	45.927899	-89.450862	11	M	P																																														
404	45.927224	-89.450868	11	M	P																																														
405	45.926549	-89.450875	11	M	P																																														
406	45.925874	-89.450881	9	M	P																																														
407	45.925199	-89.450888	5	M	P				1																																										
408	45.924524	-89.450895	11	M	P																																														
409	45.913049	-89.451008	11	M	P																																														
410	45.912374	-89.451015				TOO DEEP																																													
411	45.911699	-89.451021				TOO DEEP																																													
412	45.911024	-89.451028				TOO DEEP																																													
413	45.910349	-89.451035				TOO DEEP																																													
414	45.909674	-89.451041				TOO DEEP																																													
415	45.908999	-89.451048				TOO DEEP						1																																							
416	45.908324	-89.451055				DOCK																																													
417	45.907649	-89.451061	3	M	P							1																																							
418	45.906974	-89.451068	6	M	P				1		1	1	1								1																														
419	45.906299	-89.451075	6	M	P				2		1	1	1																																						
420	45.905624	-89.451081	5	M	P																																														
421	45.904949	-89.451088	10	M	P				1																																										
422	45.904274	-89.451095	10	M	P				1																																										
423	45.903599	-89.451101	9	M	P				3		1		1																																						
424	45.902924	-89.451108	6	M	P				3		1		1																																						
425	45.902249	-89.451114	6	M	P				3		1		1																																						
426	45.901574	-89.451121	4	M	P				3		1		1			1		1																																	
427	45.900899	-89.451128	4	M	P						1	1			1																																				
428	45.929245	-89.449881	4	M	P							1			1		1																																		
429	45.928570	-89.449888	11	M	P																																														
430	45.927895	-89.449894	11	M	P																																														
431	45.927220	-89.449901	11	M	P																																														
432	45.926545	-89.449908				TOO DEEP																																													
433	45.925870	-89.449914	11	M	P																																														
434	45.925195	-89.449921	1	M	P																																														
435	45.924520	-89.449928	11	M	P																																														

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	*Myriophyllum spicatum*	*Potamogeton crispus*	*Ceratophyllum demersum*	*Elodea canadensis*	*Potamogeton zosteriformis*	*Najas flexilis*	*Potamogeton praelongus*	*Nitella sp.*	*Heteranthera dubia*	*Potamogeton richardsonii*	*Vallisneria americana*	*Potamogeton robbinsii*	*Nymphaea odorata*	*Myriophyllum sibiricum*	*Lemna trisulca*	*Potamogeton gramineus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Nuphar variegata*	*Lemna minor*	*Potamogeton strictifolius*	*Chara sp.*	*Schoenoplectus acutus*	*Spirodella polyrrhiza*	*Eleocharis palustris*	*Sparganium angustifolium*	*Brasenia schreberi*	*Pontederia cordata*	*Potamogeton illinoensis*	*Dulichium arundinaceum*	*Potamogeton foliosus*	*Ranunculus aquatilis*	*Sagittaria sp. (rosette)*	*Utricularia vulgaris*	*Potamogeton vaseyi*	*Eleocharis sp.*	*Eleocharis acicularis*	*Juncus pelocarpus*	*Lobelia dortmanna*	*Potamogeton epihydrus*	*Sagittaria graminea*	*Sparganium emersum (chlorocarpum)*	*Potamogeton alpinus*
436	45.923845	-89.449934	4	M	P							2			1																																		
437	45.912369	-89.450048	11	M	P				1	1																																								
438	45.911694	-89.450054				TOO DEEP																																												
439	45.911019	-89.450061				TOO DEEP																																												
440	45.910344	-89.450068	10	M	P																																													
441	45.909669	-89.450074	5	M	P		V		1	1		1	1							1																														
442	45.908994	-89.450081	7	M	P					2					1																																		
443	45.906969	-89.450101	4	M	P		1		1		2																																						
444	45.906294	-89.450108	6	M	P				1		1		1			1		1																1															
445	45.905619	-89.450114	3	M	P				1			1	1																																				
446	45.904944	-89.450121	4	M	P				3		1		1																																				
447	45.904269	-89.450128	6	M	P				3		1		1																																				
448	45.903594	-89.450134	4	M	P				2		1		1																																				
449	45.902919	-89.450141	6	M	P				3		1		1																																				
450	45.902244	-89.450148	6	M	P				1		1		2			1																																	
451	45.901569	-89.450154	4	M	P				1		1		1																																				
452	45.900894	-89.450161	4	M	P				1	1		1			1	1																																	
453	45.929240	-89.448914	11	M	P				1	1																																								
454	45.928565	-89.448920	12	M	P																																													
455	45.927890	-89.448927	12	M	P																																													
456	45.927215	-89.448934				TOO DEEP																																												
457	45.926540	-89.448940				TOO DEEP																																												
458	45.925865	-89.448947				TOO DEEP																																												
459	45.925190	-89.448954	12	M	P																																													
460	45.924515	-89.448960				TOO DEEP																																												
461	45.923840	-89.448967	4	M	P				1			1			1																																		
462	45.910340	-89.449101	3	M	P							1												1																									
463	45.906290	-89.449141	5	M	P				1	1	1		1			1	1			1																														
464	45.905615	-89.449147	3	M	P							1																																					
465	45.904940	-89.449154	4	M	P				1		1		1			1																																	
466	45.904265	-89.449161	6	M	P				1		2		1																																				
467	45.903590	-89.449167	4	M	P				2		1		1																																				
468	45.902915	-89.449174	5	M	P				3		1																																						
469	45.902240	-89.449181	4	M	P										1																																		
470	45.901565	-89.449187	3	M	P							1																																					
471	45.929235	-89.447946				TOO DEEP																																												
472	45.928560	-89.447953				TOO DEEP																																												
473	45.927885	-89.447960				TOO DEEP																																												
474	45.927210	-89.447966				TOO DEEP																																												
475	45.926535	-89.447973				TOO DEEP																																												
476	45.925860	-89.447980				TOO DEEP																																												
477	45.925185	-89.447986				TOO DEEP																																												
478	45.924510	-89.447993				TOO DEEP																																												
479	45.923835	-89.448000	11	M	P																																													
480	45.904260	-89.448194	5	M	P				1	1	1							1																															
481	45.903585	-89.448201	4	M	P				1		2										1																												
482	45.902910	-89.448207	5	M	P				2		1							1																															
483	45.902235	-89.448214	4	M	P				1		1	1			1		1																																
484	45.929231	-89.446979				TOO DEEP																																												
485	45.928556	-89.446986				TOO DEEP																																												
486	45.927881	-89.446992				TOO DEEP																																												
487	45.927206	-89.446999				TOO DEEP																																												
488	45.926531	-89.447006				TOO DEEP																																												
489	45.925856	-89.447012				TOO DEEP																																												
490	45.925181	-89.447019				TOO DEEP																																												
491	45.924506	-89.447026	12	M	P																																													
492	45.923831	-89.447033	11	M	P																																													
493	45.923156	-89.447039	9	M	P																																													
494	45.929901	-89.446005	11	M	P																																													
495	45.929226	-89.446012				TOO DEEP																																												
496	45.928551	-89.446018				TOO DEEP																																												
497	45.927876	-89.446025				TOO DEEP																																												
498	45.927201	-89.446032				TOO DEEP																																												
499	45.926526	-89.446039				TOO DEEP																																												
500	45.925851	-89.446045				TOO DEEP																																												
501	45.925176	-89.446052				TOO DEEP																																												
502	45.924501	-89.446059				TOO DEEP																																												
503	45.923826	-89.446065	11	M	P																																													
504	45.923151	-89.446072	6	M	P							1																																					
505	45.930571	-89.445031	10	M	P																																													
506	45.929896	-89.445038				TOO DEEP																																												
507	45.929221	-89.445044				TOO DEEP																																												
508	45.928546	-89.445051				TOO DEEP																																												
509	45.927871	-89.445058				TOO DEEP																																												
510	45.927196	-89.445065				TOO DEEP																																												
511	45.926521	-89.445071				TOO DEEP																																												
512	45.925846	-89.445078				TOO DEEP																																												
513	45.925171	-89.445085				TOO DEEP																																												
514	45.924496	-89.445091	12	M	P																																													
515	45.923821	-89.445098	11	M	P																																													
516	45.923146	-89.445105	4	M	P							2			1																																		
517	45.930566	-89.444064	11	M	P																																													
518	45.929891	-89.444070				TOO DEEP																																												
519	45.929217	-89.444077	12	M	P																																													
520	45.928542	-89.444084				TOO DEEP																																												
521	45.927866	-89.444091				TOO DEEP																																												
522	45.927191	-89.444097				TOO DEEP																																												

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	*Myriophyllum spicatum*	*Potamogeton crispus*	*Ceratophyllum demersum*	*Elodea canadensis*	*Potamogeton zosteriformis*	*Najas flexilis*	*Potamogeton praelongus*	*Nitella sp.*	*Heteranthera dubia*	*Potamogeton richardsonii*	*Vallisneria americana*	*Potamogeton robbinsii*	*Nymphaea odorata*	*Myriophyllum sibiricum*	*Lemna trisulca*	*Potamogeton gramineus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Nuphar variegata*	*Lemna minor*	*Potamogeton strictifolius*	*Chara sp.*	*Schoenoplectus acutus*	*Spirodela polyrrhiza*	*Eleocharis palustris*	*Sparganium angustifolium*	*Brasenia schreberi*	*Pontederia cordata*	*Potamogeton illinoensis*	*Dulichium arundinaceum*	*Potamogeton foliosus*	*Ranunculus aquatilis*	*Sagittaria sp. (rosette)*	*Utricularia vulgaris*	*Potamogeton vaseyi*	*Eleocharis sp.*	*Eleocharis acicularis*	*Juncus pelocarpus*	*Lobelia dortmanna*	*Potamogeton epihydrus*	*Sagittaria graminea*	*Sparganium emersum (chlorocarpum)*	*Potamogeton alpinus*
523	45.926516	-89.444104				TOO DEEP																																											
524	45.925841	-89.444111				TOO DEEP																																											
525	45.925166	-89.444117				TOO DEEP																																											
526	45.924491	-89.444124				TOO DEEP																																											
527	45.923816	-89.444131	11	M	P																																												
528	45.923141	-89.444138	9	M	P																																												
529	45.930562	-89.443096	4	M	P				1	2																																							
530	45.929887	-89.443103				TOO DEEP																																											
531	45.929212	-89.443110				TOO DEEP																																											
532	45.928537	-89.443116				TOO DEEP																																											
533	45.927862	-89.443123				TOO DEEP																																											
534	45.927187	-89.443130				TOO DEEP																																											
535	45.926512	-89.443137				TOO DEEP																																											
536	45.925837	-89.443143				TOO DEEP																																											
537	45.925162	-89.443150				TOO DEEP																																											
538	45.924487	-89.443157	10	M	P							1																																					
539	45.923812	-89.443164	6	M	P					2		1			1																																		
540	45.923137	-89.443170	7	M	P					1																																							
541	45.930557	-89.442129	10	M	P																																												
542	45.929882	-89.442136	12	M	P																																												
543	45.929207	-89.442142	12	M	P																																												
544	45.928532	-89.442149				TOO DEEP																																											
545	45.927857	-89.442156																																															
546	45.927182	-89.442163																																															
547	45.926507	-89.442169																																															
548	45.925832	-89.442176																																															
549	45.925157	-89.442183	4	M	P							1																																					
550	45.930552	-89.441162	12	M	P																																												
551	45.929877	-89.441168	11	M	P																																												
552	45.929202	-89.441175				TOO DEEP																																											
553	45.928527	-89.441182				TOO DEEP																																											
554	45.927852	-89.441189				TOO DEEP																																											
555	45.927177	-89.441195				TOO DEEP																																											
556	45.926502	-89.441202				TOO DEEP																																											
557	45.925827	-89.441209	3											1	1																																		
558	45.930548	-89.440194				TOO DEEP																																											
559	45.929873	-89.440201	11	M	P																																												
560	45.929198	-89.440208	12	M	P																																												
561	45.928523	-89.440215				TOO DEEP																																											
562	45.927848	-89.440221		R	P	TOO DEEP						1		1	1																																		
563	45.927173	-89.440228	4	M	P																																												
564	45.931218	-89.439220				ON SHORE																																											
565	45.930543	-89.439227	10	M	P																																												
566	45.929868	-89.439234	11	M	P																																												
567	45.929193	-89.439240	11	M	P																																												
568	45.928518	-89.439247	12	M	P																																												
569	45.927843	-89.439254				TOO DEEP																																											
570	45.930538	-89.438260	10	M	P																																												
571	45.929863	-89.438266	10	M	P																																												
572	45.929188	-89.438273	11	M	P																																												
573	45.928513	-89.438280	11	M	P																																												
574	45.927838	-89.438287	11	M	P																																												
575	45.927163	-89.438294	5	M	P									2																																			
576	45.930533	-89.437292	10	M	P																																												
577	45.929858	-89.437299	10	M	P																																												
578	45.929183	-89.437306	10	M	P																																												
579	45.928508	-89.437313	10	M	P									1																																			
580	45.927833	-89.437320	8	M	P									1																																			
581	45.927158	-89.437326	4	M	P			1						1											1																								
582	45.931204	-89.436318	2	M	P				1	1		1																																					
583	45.930529	-89.436325	9	M	P																																												
584	45.929854	-89.436332	9	M	P																																												
585	45.929179	-89.436339	1	M	P																																												
586	45.928504	-89.436345	10	M	P																																												
587	45.927829	-89.436352	7	M	P			1		1				1	1																																		
588	45.927154	-89.436359	7	M	P					1				1																																			
589	45.931199	-89.435351				BOAT																																											
590	45.930524	-89.435358	9	M	P																																												
591	45.929849	-89.435364	8	M	P																																												
592	45.929174	-89.435371	9	M	P																																												
593	45.928499	-89.435378	8	M	P				1					1																																			
594	45.927824	-89.435385	3	M	P							1			1	1													1																				
595	45.931194	-89.434383	6	M	P																																												
596	45.930519	-89.434390	8	M	P					1																																							
597	45.929844	-89.434397	9	M	P																																												
598	45.929169	-89.434404	9	M	P																																												
599	45.928494	-89.434411	6	M	P				1	1																																							
600	45.926469	-89.434431	2	M	P				1	1		1							1							1				1							1			1									
601	45.925794	-89.434438	2	M	P				1	2		1		1			1								1	1				1							1			1									
602	45.925119	-89.434445	2	M	P				1	1		1					1		1							1				1																1		1	
603	45.924444	-89.434452	1	M	P		1	1	1	1		1		1					1							1	1			1																			
604	45.931189	-89.433416	4	M	P				1	2																																							
605	45.930514	-89.433423	8	M	P																																												
606	45.929839	-89.433430	4	R	P																																												
607	45.929164	-89.433437	7	M	P																																												
608	45.928489	-89.433444	6	R	P																																												
609	45.927814	-89.433450	5	M	P				2								1																																

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	Myriophyllum spicatum	Potamogeton crispus	Ceratophyllum demersum	Elodea canadensis	Potamogeton zosteriformis	Najas flexilis	Potamogeton praelongus	Nitella sp.	Heteranthera dubia	Potamogeton richardsonii	Vallisneria americana	Potamogeton robbinsii	Nymphaea odorata	Myriophyllum sibiricum	Lemna trisulca	Potamogeton gramineus	Potamogeton amplifolius	Potamogeton pusillus	Nuphar variegata	Lemna minor	Potamogeton strictifolius	Chara sp.	Schoenoplectus acutus	Spirodella polyrrhiza	Eleocharis palustris	Sparganium angustifolium	Brasenia schreberi	Pontederia cordata	Potamogeton illinoensis	Dulichium arundinaceum	Potamogeton foliosus	Ranunculus aquatilis	Sagitaria sp. (rosette)	Utricularia vulgaris	Potamogeton vaseyi	Eleocharis sp.	Eleocharis acicularis	Juncus pelocarpus	Lobelia dortmanna	Potamogeton epihydrus	Sagittaria graminea	Sparganium emersum (chlorocarpum)	Potamogeton alpinus
610	45.927139	-89.433457	4	M	P				2										1																														
611	45.926464	-89.433464	4	M	P				3																																								
612	45.925789	-89.433471	4	M	P				3					1																																			
613	45.925114	-89.433478	3	M	P				3										1																														
614	45.924439	-89.433485	3	M	P				1	1				1	1		1		1		1										1																		
615	45.931184	-89.432449	4	M	P				2	1																																							
616	45.930509	-89.432456	6	M	P				1	1					1																																		
617	45.929834	-89.432462	6	M	P				1	1		1																																					
618	45.929159	-89.432469	7	M	P				1																																								
619	45.928484	-89.432476	8	M	P				1	1						1																																	
620	45.927809	-89.432483	7	M	P				1					1																																			
621	45.927134	-89.432490	5	M	P				2	1				1																																			
622	45.926459	-89.432497	4	M	P				1	1				1																																			
623	45.925784	-89.432504	4	M	P				1	1		1		1																																			
624	45.925109	-89.432511	4	M	P				1	3				1																																			
625	45.924434	-89.432518	4	M	P				2										1																														
626	45.929830	-89.431495				BOAT HOUSE																																												
627	45.929155	-89.431502	2	M	P				1																						1																		
628	45.928480	-89.431509	7	M	P				2	1																																							
629	45.927805	-89.431516	6	M	P				2					1																																			
630	45.927130	-89.431523	8	M	P					1																																							
631	45.926455	-89.431530	3	S	P				1					1																	1																		
632	45.925780	-89.431537				ON SHORE								1																																			
633	45.925105	-89.431543	7	M	P				1	3																																							
634	45.924430	-89.431550	6	M	P				1	2				1																																			
635	45.923755	-89.431557	5	M	P				1										1																														
636	45.928475	-89.430542	7	M	P				3					1																																			
637	45.927800	-89.430549	6	M	P				2	1				1																																			
638	45.927125	-89.430555	9	M	P																																												
639	45.926450	-89.430562	9	M	P																																												
640	45.925775	-89.430569	9	M	P																																												
641	45.925100	-89.430576	9	M	P																																												
642	45.924425	-89.430583	8	M	P																				1																								
643	45.923750	-89.430590	5	M	P				1			1																																					
644	45.928470	-89.429574	3	M	P				1	1							1		1										1																				
645	45.927795	-89.429581	5	M	P	CLP NEAR											1																																
646	45.927120	-89.429588	9	M	P				1	1																																							
647	45.926445	-89.429595	10	M	P																																												
648	45.925770	-89.429602	10	M	P																																												
649	45.925095	-89.429609	11	M	P																																												
650	45.924420	-89.429616	12	M	P																																												
651	45.923745	-89.429623	8	M	P				2					1																																			
652	45.927790	-89.428614	7	M	P																																												
653	45.927115	-89.428621	10	M	P																																												
654	45.926440	-89.428628				TOO DEEP																																											
655	45.925765	-89.428635				TOO DEEP																																											
656	45.925090	-89.428642				TOO DEEP																																											
657	45.924415	-89.428649				TOO DEEP																																											
658	45.923740	-89.428656	11	M	P																																												
659	45.923065	-89.428662	6	M	P				3	1				1																																			
660	45.928460	-89.427640	5	M	P				1																																								
661	45.927785	-89.427647	8	M	P																																												
662	45.927110	-89.427654	11	M	P																																												
663	45.926435	-89.427661				TOO DEEP																																											
664	45.925760	-89.427668				TOO DEEP																																											
665	45.925085	-89.427674				TOO DEEP																																											
666	45.924410	-89.427681				TOO DEEP																																											
667	45.923735	-89.427688				TOO DEEP																																											
668	45.923060	-89.427695	8	M	P																																												
669	45.922385	-89.427702	4	M	P				1	1																																							
670	45.929130	-89.426665	3	R	P							1																																					
671	45.928455	-89.426672	5	M	P				2																																								
672	45.927780	-89.426679	10	M	P				1																																								
673	45.927105	-89.426686	10	M	P																																												
674	45.926430	-89.426693	13	M	P																																												
675	45.925755	-89.426700				TOO DEEP																																											
676	45.925080	-89.426707				TOO DEEP																																											
677	45.924405	-89.426714				TOO DEEP																																											
678	45.923730	-89.426721	11	M	P																																												
679	45.923055	-89.426728	9	M	P																																												
680	45.927776	-89.425712	7	M	P				1																																								
681	45.927101	-89.425719	9	M	P																																												
682	45.926426	-89.425726	11	M	P																																												
683	45.925751	-89.425733	11	M	P																																												
684	45.925076	-89.425740	10	M	P					1																																							
685	45.924401	-89.425747	11	M	P																																												
686	45.923726	-89.425754	9	M	P																																												
687	45.923051	-89.425761	3	M	P																																												
688	45.927771	-89.424745	7	M	P				1																																								
689	45.927096	-89.424752	7	M	P																																												
690	45.926421	-89.424759	9	M	P																																												
691	45.925746	-89.424766	9	M	P																																												
692	45.925071	-89.424773	9	M	P																																												
693	45.924396	-89.424780	9	M	P																																												
694	45.923721	-89.424787	9	M	P																																												
695	45.927766	-89.423778	1	M	P																																												
696	45.926416	-89.423792	3	M	P							2																																					

Sampling point	Lattitude (Decimal degrees)	Longitudinal (Decimal degrees)	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rake pole (P) or rake rope (R)	Comments	*Myriophyllum spicatum*	*Potamogeton crispus*	*Ceratophyllum demersum*	*Elodea canadensis*	*Potamogeton zosteriformis*	*Najas flexilis*	*Potamogeton praelongus*	*Nitella sp.*	*Heteranthera dubia*	*Potamogeton richardsonii*	*Vallisneria americana*	*Potamogeton robbinsii*	*Nymphaea odorata*	*Myriophyllum sibiricum*	*Lemna trisulca*	*Potamogeton gramineus*	*Potamogeton amplifolius*	*Potamogeton pusillus*	*Nuphar variegata*	*Lemna minor*	*Potamogeton strictifolius*	*Chara sp.*	*Schoenoplectus acutus*	*Spirodella polyrrhiza*	*Eleocharis palustris*	*Sparganium angustifolium*	*Brasenia schreberi*	*Pontederia cordata*	*Potamogeton illinoensis*	*Dulichium arundianaceum*	*Potamogeton foliosus*	*Ranunculus aquatilis*	*Sagitaria sp. (rosette)*	*Utricularia vulgaris*	*Potamogeton vaseyi*	*Eleocharis sp.*	*Eleocharis acicularis*	*Juncus pelocarpus*	*Lobelia dortmanna*	*Potamogeton epihydrus*	*Sagittaria graminea*	*Sparganium emersum (chlorocarpum)*	*Potamogeton alpinus*
697	45.925741	-89.423799	8	M	P				1	1		1																																					
698	45.925066	-89.423806	8	M	P																																												
699	45.924391	-89.423812	6	R	P																																												
700																																																	
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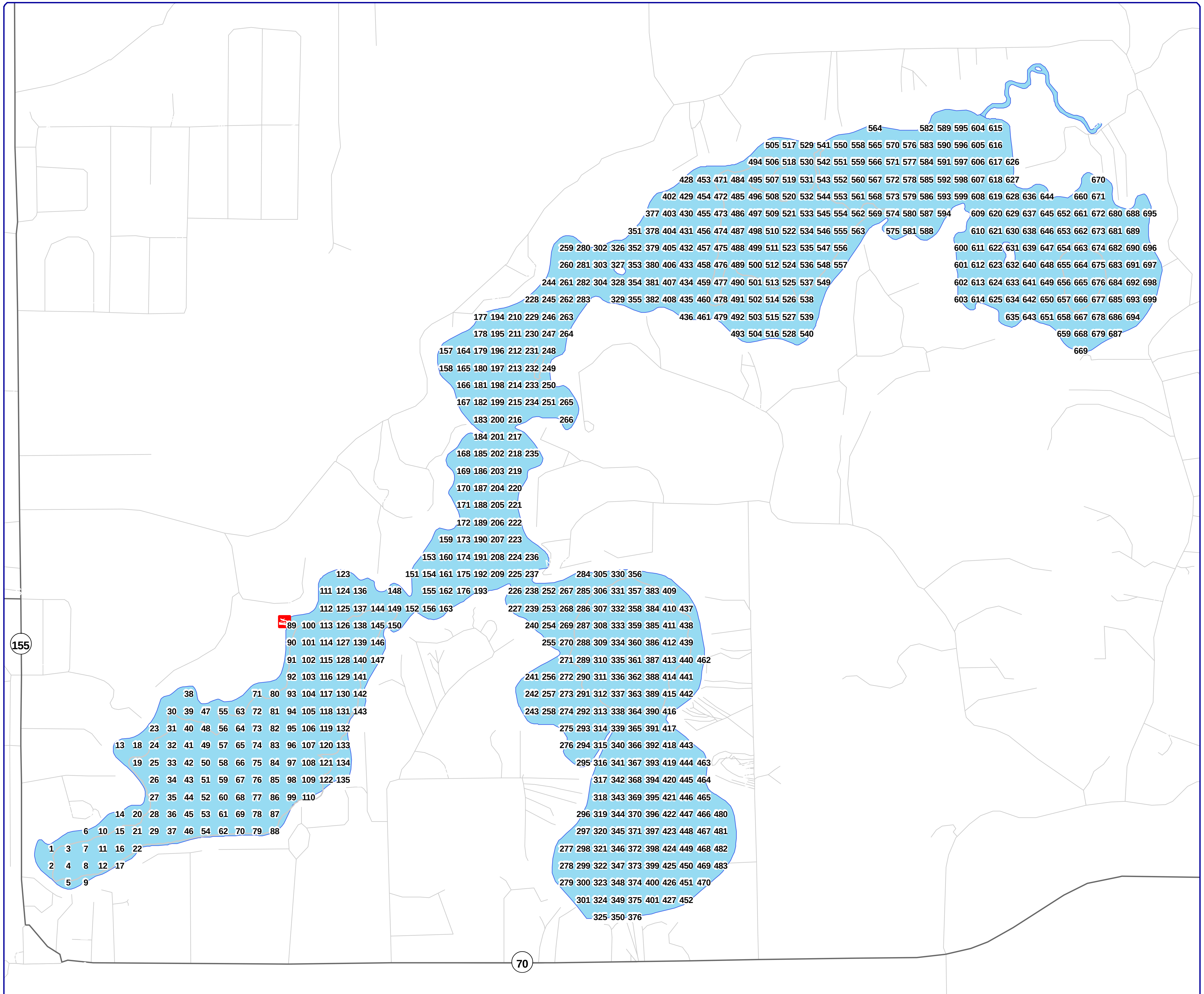
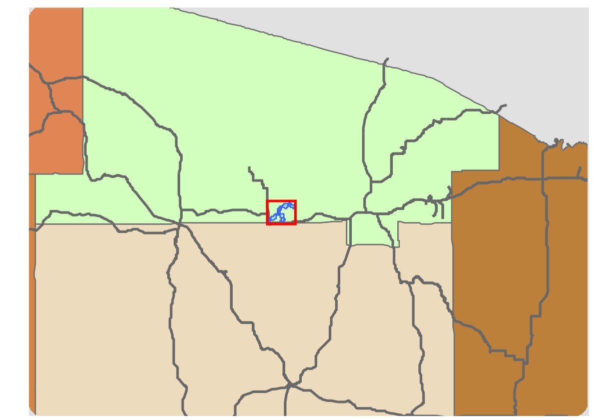


Appendix E

Little Saint Germain Lake

Vilas County, Wisconsin

2008 Point-intercept Sample Locations



Extent of large map shown in red.

Legend

Point-intercept Location

Boat Landing

Sources
Roads & Hydro: WDNR
Aquatic Plant Survey: Onterra, 2008
Map Date: November 25, 2008

N W E S

1,400
Feet

Onterra, LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

F

APPENDIX F

Hydrology, Water Quality, and Phosphorus Loading of Little St. Germain Lake, Vilas County, Wisconsin, 2000

USGS
science for a changing world

Hydrology, Water Quality, and Phosphorus Loading of Little St. Germain Lake, Vilas County, Wisconsin

Introduction

Little St. Germain Lake, which is in Vilas County, Wisconsin, just northeast of St. Germain (fig. 1), is one of 21 impoundments operated by Wisconsin Valley Improvement Company (WVIC) to provide storage for power and recreational use. The level of the lake, which was originally dammed in 1882, has been maintained by the WVIC at about 5 feet above its natural level since 1929, and it is annually drawn down about 1.5 feet from December through March. In the interest of protecting and improving the water quality of the lake, the Little St. Germain Lake Improvement Association was established in 1959. Later, the Little St. Germain Lake District was formed. The Wisconsin Department of Natural Resources (WDNR), in collaboration with the Lake District, did a study during 1983–85 to document the water quality of the lake and examine management alternatives (Wisconsin Department of Natural Resources, 1985). Results of the study indicated that, because of relatively high phosphorus loading to the lake, most of the lake was eutrophic (relatively productive), with the possible exception of the West Bay. The results also indicated monitoring of the lake should continue, and that actions should be taken to decrease nutrient loading to the lake by controlling erosion, fertilizer runoff, and leakage from septic systems.

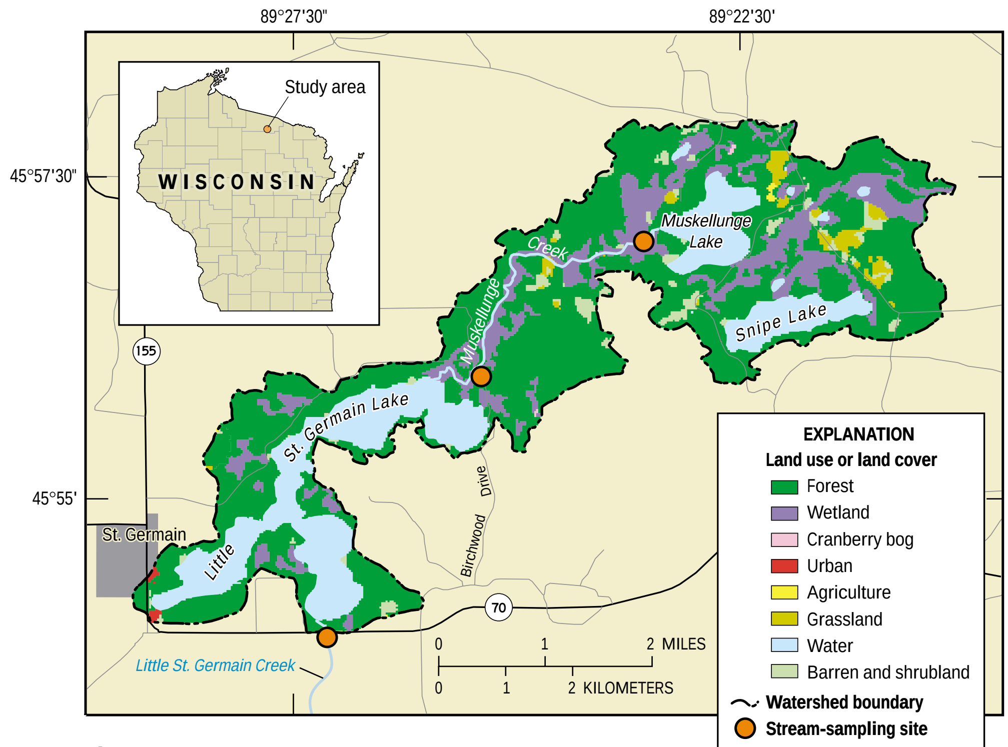


Figure 1. Location of Little St. Germain Lake, watershed characteristics, and location of stream-sampling sites.

The lake was monitored in detail again during 1991–94 by the U.S. Geological Survey (USGS) as part of a cooperative study with the Lake District. This study demonstrated water-quality variation among the basins of Little St. Germain Lake and extensive areas of winter anoxia (absence of oxygen). Further in-depth studies were then conducted during 1994–2000 to define the extent of winter anoxia, refine the hydrologic and phosphorus budgets of the lake, quantify the effects of annual drawdowns, and provide information needed to develop a comprehensive lake-management plan. This report presents the results of the studies since 1991.

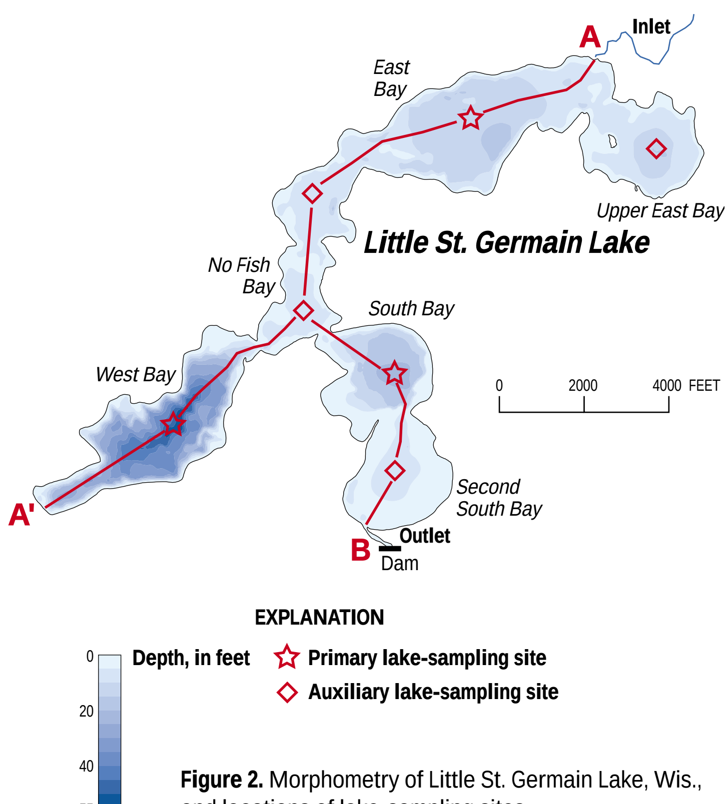


Figure 2. Morphometry of Little St. Germain Lake, Wis., and locations of lake-sampling sites.

The Lake and its Watershed

Little St. Germain Lake (fig. 1) is a multibasin lake with a total surface area of 977 acres and volume of 11,500 acre-feet. In this report, the lake is discussed in terms of six basins (fig. 2): Upper East Bay (119 acres, maximum depth—16 feet), East Bay (336 acres, 16 feet), No Fish Bay (69 acres, 10 feet), West Bay (213 acres, 53 feet), South Bay (122 acres, 22 feet), and Second South Bay (119 acres, 10 feet). The major tributary to the lake is Muskellunge Creek, which flows about 3 miles from shallow, eutrophic Muskellunge Lake into the north end of the East Bay. Outflow from the lake is to Little St. Germain Creek, which leaves the south side of the Second South Bay and flows about 1 mile before draining into the Wisconsin River.

The total watershed area of Little St. Germain Lake is 10 mi^2. The watershed is predominantly forest (68 percent), wetland (17 percent), and water (8 percent), although areas of low-density residential development are increasing (fig. 1). The soils in the watershed consist mainly of well-drained sand and sandy loams. These soils are thought to be naturally high in phosphorus content (Wisconsin Department of Natural Resources, 1985).

Data Collection—sites and techniques

Data used to describe the water quality of the lake were collected from April 1991 to January 2000; however, no data were collected from September 1994 to July 1996 and September 1997 to February 1999. Lake water-quality properties were generally measured five times per year (late winter, May, June, July, and August) at three sites: the centers of the East, West, and South Bays (fig. 2). At all sites, depth profiles of water temperature, dissolved oxygen, specific conductance, and pH were measured during each visit with a multiparameter instrument. Water samples were collected at these sites at either or both near surface (1 foot below the surface during open water or just below ice during ice cover) or near bottom (1 foot above bottom). Near-surface water samples were analyzed for concentrations of total phosphorus (an indicator of nutrient availability) and chlorophyll *a* (an indicator of the algal population). During ice-free periods, Secchi depths (an indicator of water clarity) also were measured. All water samples were analyzed by the Wisconsin State Laboratory of Hygiene.

Additional depth-profile measurements of temperature and oxygen were made at seven locations (the main sampling sites, the center of each of the other bays, and the western end of the East Bay; fig. 2) throughout the winter of 1996–97 to assess the extent and timing of anoxia. Profiles also were collected between these sites in March 1997 and 1999 to describe the spatial extent of anoxia (transects A–B and A'–B ; fig. 2).

Data collected during this study were published in two annual USGS data report series, the most recent of each being “Water Resources Data, Wisconsin—Water Year 1999” (Holmstrom and others, 2000) and “Water Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 1999” (U.S. Geological Survey, Wisconsin District Lake-Studies Team, 2000). Water levels at the dam on Little St. Germain Creek were monitored almost daily from 1991–99 by the WVIC (U.S. Geological Survey, Wisconsin District Lake-Studies Team, 2000).

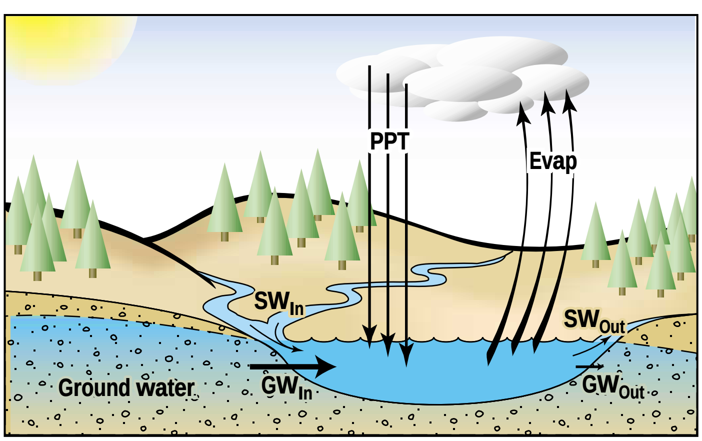


Figure 3. Schematic of the hydrologic budget of Little St. Germain Lake, Wis. Abbreviations are defined in the text.

Inflow to the lake was determined from measurements and water samples collected monthly in Muskellunge Creek at Birchwood Drive (fig. 1) during October 1996–September 1997 and December 1998–January 2000. During 1996–97, water samples were analyzed for total phosphorus concentration. During 1998–99, water temperature and dissolved oxygen also were measured, and the samples also were analyzed for dissolved phosphorus.

Surface-water outflow from the lake was estimated from water-elevation measurements made at the dam by WVIC. To better describe the outflow, additional flow measurements and water samples were collected monthly just below the dam from December 1998 through November 1999. Water samples were analyzed for total phosphorus. Measured flow at the dam indicated that low flows were underestimated and therefore those flows were adjusted accordingly.

Hydrology

The hydrology of Little St. Germain Lake can be described in terms of components of its water budget (fig. 3). The water budget for the lake may be represented by

$$\Delta S = (PPT + SW_{In} + GW_{In}) - (Evap + SW_{Out} + GW_{Out}), \quad (1)$$

where ΔS is the change in the volume of water stored in the lake during the period of interest and is equal to the sum of the volumes of water entering the lake minus the sum of the volumes of water leaving the lake. Water enters the lake as precipitation (PPT), surface-water inflow (SW_{In}), and ground-water inflow (GW_{In}). Water leaves the lake through evaporation (Evap), surface-water outflow (SW_{Out}), and ground-water outflow (GW_{Out}).

Each term in the water budget was computed for two different year-long periods: October 1996–September 1997 (1997) and December 1998–November 1999 (1999). Changes in lake volume were determined from water elevations monitored at the outlet dam (fig. 2) and the morphometry of the lake. Precipitation was measured by a weather observer in St. Germain. Surface-water inflow was estimated to equal the flow in Muskellunge Creek at Birchwood Drive. Flows were expected to change rather slowly and therefore daily inflows were estimated by linearly interpolating between monthly measurements. Evaporation from the lake was estimated on the basis of average monthly evaporation-pan data collected at Rainbow Flowage (about 10 miles southwest of the lake). Surface-water outflow consisted of flow past the dam into Little St. Germain Creek. Ground water seeps into and out of the bottom of Little St. Germain Lake. The monthly net ground-water flow (GW_{In} - GW_{Out}) was computed as the residual in the budget equation (eq. 1). These data did not allow ground-water inflow and ouflow to be computed independently; therefore, to estimate these components, ground-water inflow was assumed to be 50 percent more than net ground-water flow and ground-water outflow was assumed to be 50 percent less than net ground-water flow.

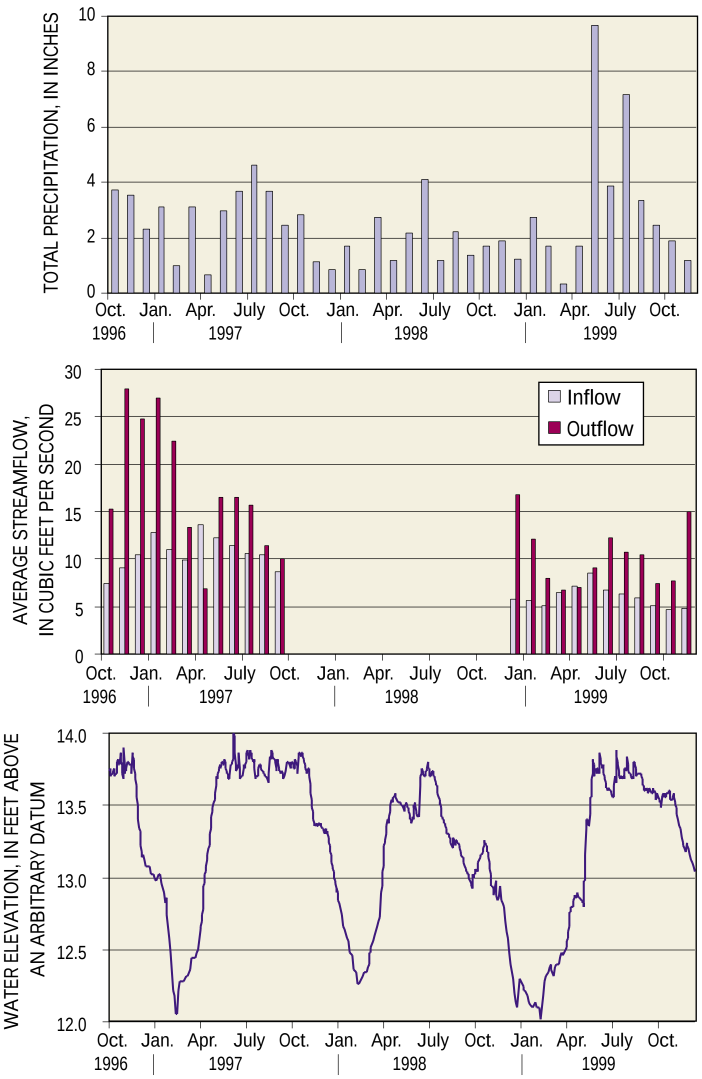


Figure 4. Monthly precipitation, inflow, outflow, and water elevation, Little St. Germain Lake, Wis.

Total monthly precipitation at St. Germain, monthly average surface-water inflow to and outflow from the lake, and water level of the lake are shown in figure 4. Total precipitation during 1997 (34.8 inches) was 4.4 inches less than in 1999 (39.2 inches). The average flow into the lake through Muskellunge Creek was 10.6 ft^3/s (cubic feet per second) in 1997 and 6.0 ft^3/s in 1999. The average flow out of the lake was 17.3 ft^3/s in 1997 and 10.6 ft^3/s in 1999. Inflow to the lake throughout 1997 was about 1.7 times that throughout 1999, even though there was less precipitation in 1997. This demonstrates that the flow in Muskellunge Creek is driven by long-term changes in precipitation rather than short-term fluctuations. Outflow from the lake in 1997 also was about 1.7 times that in 1999. In both years, outflow from the lake was about 1.7 times greater than that which came in from Muskellunge Creek. Evaporation from the lake was estimated to be 22.4 inches in both years.

Lake stage fluctuated from a minimum of 12.05 feet (relative to an arbitrary datum) to a maximum of 13.95 feet (fig. 4). The lake stage was relatively stable from May through mid November, lowered about 1.5 feet between mid November and early February, and remained relatively stable until mid March before again filling to its summer level. The lake stage at the end of 1997 was similar to that at the beginning of the period; however, the lake stage was about 0.65 foot higher at the end of 1999 than at the beginning of that study year.

After converting all of the hydrologic components in the budget equation (eq. 1) into acre-feet, there was a net ground-water input to Little St. Germain Lake of about 3,900 acre-feet in 1997 and 2,400 acre-feet in 1999 (fig. 5). After assuming the total ground-water input was 50 percent more than net ground-water flow (an assumption that needs further evaluation), the total ground-water input was estimated to be 5,800 acre-feet in 1997 and 3,500 acre-feet in 1999. Ground-water studies conducted by the WDNR indicate that most, if not all, of the ground water is expected to enter into the East Bay (Wisconsin Department of Natural Resources, 1985).

The complete hydrologic budget (fig. 5) indicated that the major source of water to the lake is from surface-water inflow from Muskellunge Creek; however, during years following extended dry periods (such as prior to 1999), direct precipitation and ground water can be nearly as important. The major loss of water from the lake is through the outlet.

Phosphorus Budget

Previous studies indicated that most of Little St. Germain Lake was eutrophic because of relatively high phosphorus loading to the lake (Wisconsin Department of Natural Resources, 1985). Therefore, to help define where the phosphorus originated, a detailed phosphorus budget was computed. Sources of phosphorus to the lake include precipitation, the inflowing stream, ground water, and

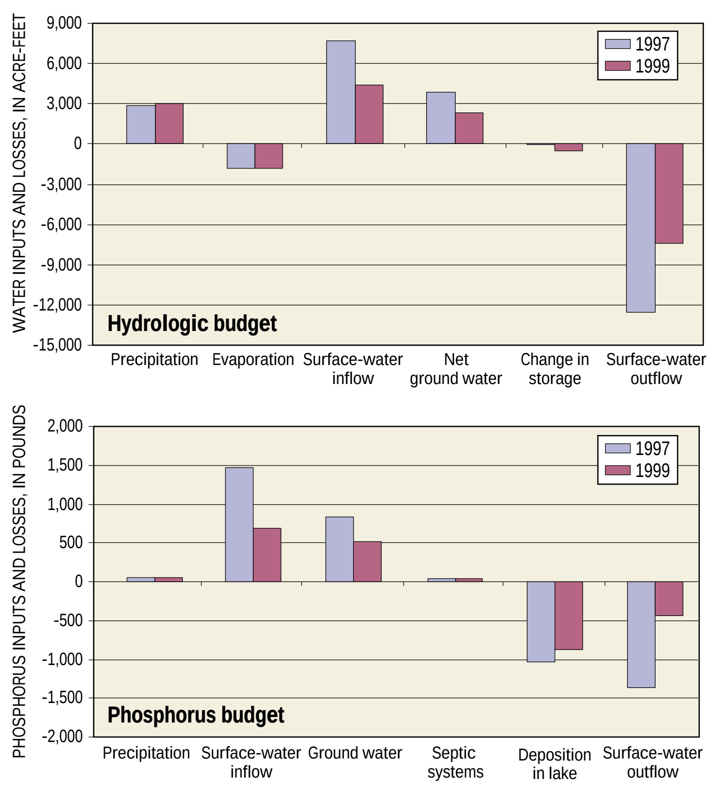


Figure 5. Hydrologic and phosphorus budgets of Little St. Germain Lake, Wis.

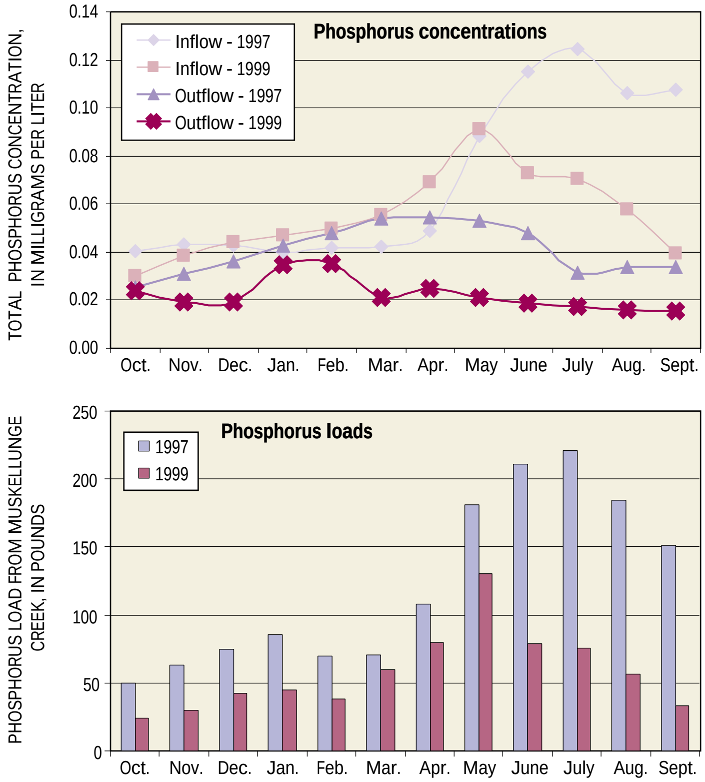


Figure 6. Phosphorus concentrations and loads in the inflow and outflow from Little St. Germain Lake, Wis., and phosphorus loads to the lake from Muskellunge Creek.

contributions from septic systems. Phosphorus concentration in precipitation was assumed to be 0.007 mg/L, a value found by Rose (1993) for northern Wisconsin. Therefore, direct precipitation contributes about 55 lbs of phosphorus per year to the lake (fig. 5).

Phosphorus concentrations in Muskellunge Creek inflow ranged from about 0.04 mg/L in winter to about 0.12 mg/L in July 1997 and about 0.09 mg/L in May 1999 (fig. 6). In 1999, about 30 percent of the phosphorus was in dissolved forms; however, the percentage in dissolved forms was not measured in 1997. Phosphorus concentrations were much higher in 1997 than in 1999, especially in mid to late summer. The high concentrations in 1997 may have been due to effects of beaver activity on Muskellunge Creek downstream from Muskellunge Lake. It is thought that ponding of water behind beaver dams resulted in a high release of phosphorus from the organic-rich wetland sediments that are not otherwise inundated with water. With this increased release of phosphorus from the sediments, a higher percentage of phosphorus would probably be in dissolved forms than was measured in 1999. Phosphorus concentrations in Muskellunge Creek, in both years, were high considering most of the watershed of Little St. Germain Lake is relatively pristine. The high concentrations are thought to be the result of leaching from the soils that are rich in phosphorus (Wisconsin Department of Natural Resources, 1985). Daily phosphorus concentrations were estimated by linearly interpolating between monthly measurements. The amount of phosphorus delivered to the lake was then computed by multiplying the daily phosphorus concentrations by the daily runoff volumes. The total input of phosphorus from stream inflow was estimated to be 1,500 and 700 pounds in 1997 and 1999, respectively (fig. 5). The difference between years was primarily due to the reduced flows in 1999, but decreased concentrations also contributed to the decreased loads in 1999.

Phosphorus concentrations in ground water were not measured as part of this study, and those measured as part of other studies were quite variable. Therefore, a phosphorus concentration for ground water was estimated by use of equation 2:

$$[TP]_{GW} = \frac{(Q_{BW}*[TP]_{BW} - Q_{MLO}*[TP]_{MLO})}{(Q_{BW} - Q_{MLO})}\ . \qquad (2)$$

This equation is based on two assumptions: (1) during winter, biological and chemical processes have minimal effect on the water quality of Muskellunge Creek, and so changes in the concentration of phosphorus in Muskellunge Creek as it flows from Muskellunge Lake outlet (MLO) to Birchwood Drive (BW) are caused only by the addition of ground water, and (2) ground water entering Little St. Germain Lake has the same concentration as that entering Muskellunge Creek. Therefore, an estimate of the phosphorus concentration in ground water ($[TP]_{GW}$) can be obtained by the change in the phosphorus load (Q*[TP]) from MLO to BW divided by the increase in the flow of the creek ($Q_{BW} - Q_{MLO}$). Average phosphorus concentrations (from December 1999 and January 2000) increased from 0.035 mg/L at Muskellunge Lake Outlet to 0.045 mg/L at Birchwood Drive, while average streamflow increased by 2.1 ft^3/s. Therefore, an average phosphorus concentration of 0.053 mg/L was obtained for ground water after applying these values to equation 2 and resulted in an estimated total input of phosphorus from ground water of 835 and 512 pounds in 1997 and 1999, respectively (fig. 5). Most phosphorus contributed by ground water is expected to enter into the East Bay of the lake.

The input of phosphorus from septic systems (M) was estimated by use of equation 3 (Reckhow and others, 1980):

$$M = E_S * (\text{Number of Capita Years}) * (1 - S_R), \qquad (3)$$

where M is a function of an export coefficient, E_S, and a soil retention coefficient, S_R. In applying equation 3, it was assumed that the most likely value for E_S was 1.8 pounds of phosphorus per capita per year. The number of capita years was estimated to be 165 (only residents on the East and Upper East Bays were included: 90 full-year residents, 270 three-month residents, and 90 one-month residents), and the most likely value of S_R was 0.85. Only residents on these bays were included because past studies indicated that most of the ground water entered the lake through these areas (Wisconsin Department of Natural Resources, 1985). The total input from septic tanks was then computed to be 44 pounds per year. By applying low and high estimates for E_S (1.1 and 2.2 pounds of phosphorus per capita per year) and S_R (0.9 and 0.5), low and high estimates of phosphorus from septic systems were 18 and 182 pounds, respectively.

Phosphorus concentrations leaving the lake ranged from about 0.02 to 0.05 mg/L (fig. 6). Concentrations in 1997 were higher than in 1999, especially from March through June. The higher concentrations reflect higher phosphorus concentrations in the lake in 1997 than in 1999. Daily phosphorus concentrations were estimated by linearly interpolating between monthly measurements, and the amount of phosphorus removed from the lake was then computed by multiplying the daily phosphorus concentrations by the daily outflows. The total amount of phosphorus in stream outflow was estimated to be 1,370 and 440 pounds in 1997 and

1999, respectively (fig. 5). The greater load in 1997 was due to a combination of higher concentrations and flows in 1997 than in 1999.

The phosphorus budget (fig. 5) indicates that inflow from Muskellunge Creek was the major source of phosphorus to the lake (53–61 percent) and ground water was the secondary source (35–39 percent). The concentrations and volumes of ground water entering the lake, however, are based on several untested assumptions. Approximately 57 and 33 percent (1997 and 1999, respectively) of the total phosphorus input to the lake (2,410–1,310 pounds in 1997 and 1999, respectively) was exported through the outlet. The remaining 43 to 67 percent of the phosphorus input (1,400 and 870 pounds in 1997 and 1999, respectively) was deposited in the bed sediment of the lake or discharged with ground-water outflow.

Lake-Water Quality

Water quality in Little St. Germain Lake varied consistently among basins, except for a few water-quality characteristics that were similar throughout the lake but varied seasonally: specific conductance, which ranged from about 75 microsiemens per centimeter (µs/cm) in summer to about 90 µs/cm in winter; and pH, which ranged from about 7 in winter to about 8 in summer.

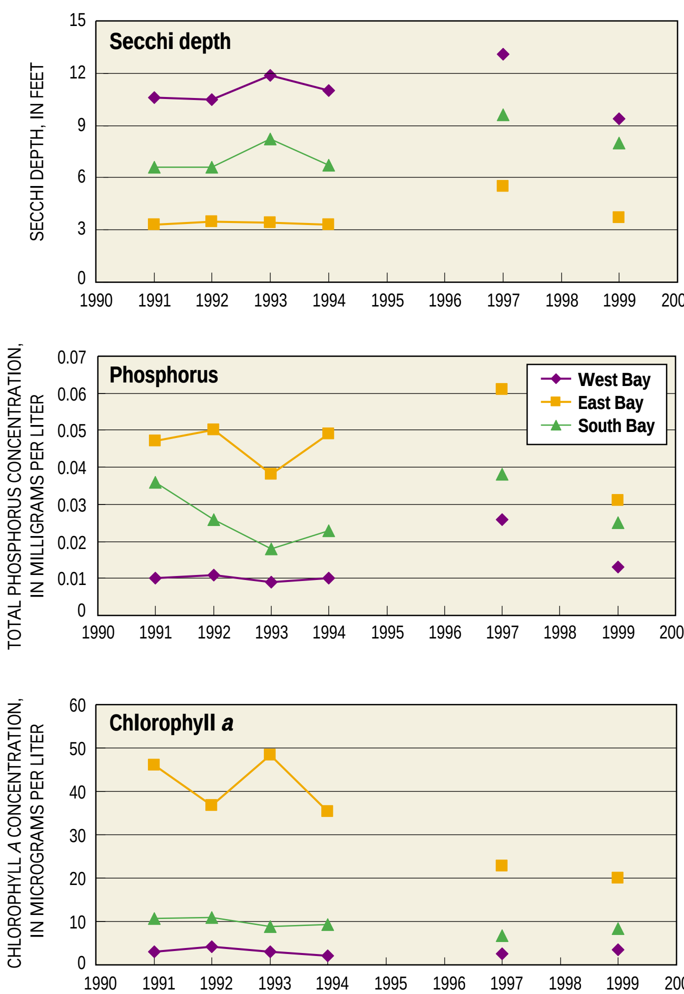


Figure 7. Average summer Secchi depth, and surface concentrations of phosphorus and chlorophyll *a* in the three main basins of Little St. Germain Lake, Wis., by year.

Water Clarity

Water clarity, the distribution of temperature and dissolved oxygen, and the concentrations of nutrients, were all consistently different among basins. The differences indicated that the West Bay generally had the best water quality and the East Bay had the poorest quality. Water clarity, based on Secchi depth readings, ranged from 7–15 feet in the West Bay (average summer clarities of 9–13 feet) to 4–14 feet in the South Bay (average summer clarities of 7–10 feet) to 2–8 feet in the East Bay (average summer clarities of 3–6 feet) (fig. 7). Clarity was usually the best in late summer in the West Bay; however, it was usually best in early summer in the East Bay.

Water Temperature and Dissolved Oxygen

Thermal stratification also differed among basins because of differences in their morphometries and limited circulation between basins. The West Bay, being relatively deep and having a relatively short length, became strongly stratified during summer, with bottom temperatures remaining around 8–9ºC. The South Bay, being moderately deep, became only weakly stratified during summer, and stratification was frequently broken down by wind mixing. Bottom temperatures in the South Bay gradually increased throughout the summer. Thermal stratification throughout the rest of the lake was very weak, with seldom more than 2 or 3ºC of stratification. During the winter, weak thermal stratification was also present throughout the lake.

Thermal stratification during summer, primarily in the West Bay, isolated the deepest water from surface interactions. Thus, as summer progressed, dissolved oxygen concentrations in water below the thermocline decreased as a consequence of decomposition of dead algae that settled from the surface and the biochemical oxygen demand of the sediment. Water below about 30 feet in the West Bay usually became anoxic in late June and stayed anoxic throughout summer. In the South Bay, the weak stratification resulted in only the deepest water becoming nearly, but almost never completely, anoxic.

Before freezing, most of the lake was nearly saturated with oxygen; however, after the lake froze and winter progressed, oxygen was quickly consumed, especially in the shallower basins. Although oxygen is consumed slowly during periods of low temperatures, extensive oxygen depletion occurred in every basin of the lake. Oxygen depletion was much more severe during winter than during summer because of the lack of oxygen transfer through the surface, as a result of ice cover. Changes in oxygen concentrations for the East and Upper East Bays of the lake are shown in figure 8. Other than the shallowest areas of the West and East Bays, the remaining parts of the lake can become almost completely depleted of oxygen by mid-February. To demonstrate the spatial extent of oxygen depletion, transects of temperature and oxygen profiles were collected from the inlet to the outlet (A–B; fig. 2) and from the West Bay to the outlet (A'–B; fig. 2) in March 1997 and March 1999 (fig. 9). Detailed transects were collected in March because this was near to when oxygen depletion was expected to be most severe. As figure 9 shows, anoxia occurred throughout each of the basins; and by mid-March only small areas of the lake would be habitable by most fish (areas with dissolved oxygen concentrations greater than about 2 mg/L). These habitable areas include water down to about 30 feet in the West Bay and down to about 5 feet in the East Bay.

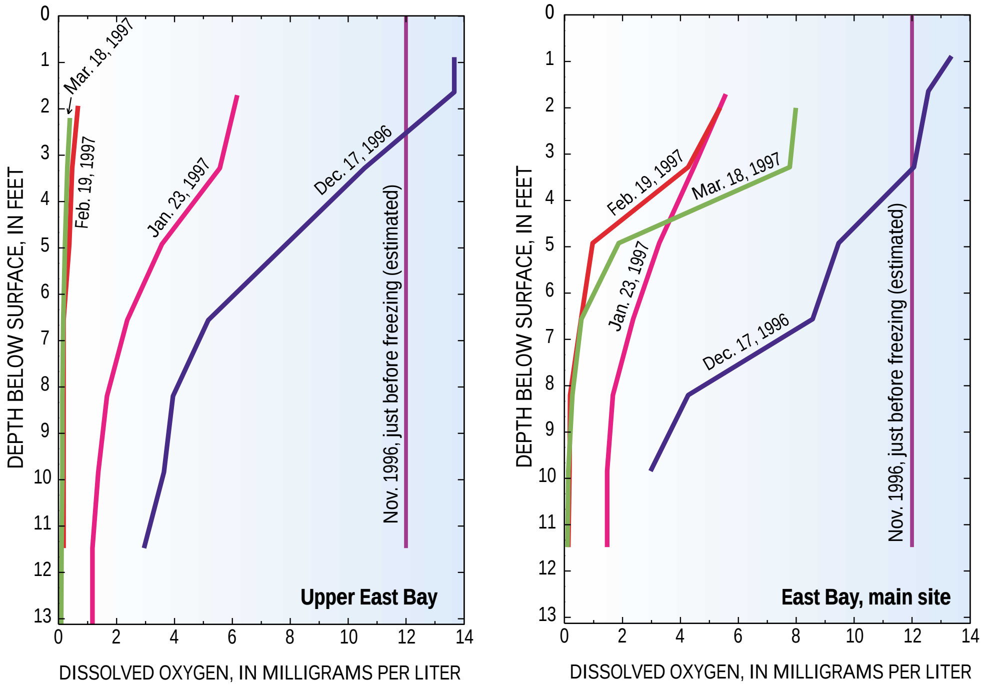


Figure 8. Oxygen distributions in the Upper East and East Bays of Little St. Germain Lake, Wis., during winter 1996–97.

Water entering from Muskellunge Creek can alleviate the extent of winter anoxia in the East Bay. Although dissolved oxygen concentrations in Muskellunge Creek may be low in midwinter (less than 6 mg/L in February 1999 and possibly much lower in other years), concentrations can be high later in winter (greater than 10 mg/L in March 1999). Dissolved oxygen concentrations in the middle of the East Bay were lower in February 1997 than they were later in March 1997 (fig. 8). This increase appears to be associated with cold, highly oxygenated water originating from Muskellunge Creek propagating across the basin (fig. 9). Dissolved oxygen concentrations in the Upper East Bay, which are not influenced by Muskellunge Creek inflow, did not increase from February to March. A detailed analysis of the flow in the lake demonstrated that the upper 3 feet of water (just below the ice) throughout the East Bay could be replaced by water from Muskellunge Creek in about 30 days.

Phosphorus Concentration

Phosphorus is one of the essential nutrients for plant and algal growth and is often the nutrient that limits this growth in midwestern lakes. High concentrations of phosphorus can cause high algal populations (blooms) and can therefore be a major cause of eutrophication (that is, accelerated aging and increased productivity) of lakes. Phosphorus concentrations were consistently highest in the East Bay (average summer concentrations of 0.031–0.061 mg/L), moderate in the South Bay (0.018–0.038 mg/L), and lowest in the West Bay (0.009–0.026 mg/L). These differences among basins appear to be directly related to the input of nutrients from both Muskellunge Creek and ground water and to differences in basin morphometry.

Phosphorus can be released from lake sediments, especially during periods of anoxia. Increased phosphorus concentrations just above the sediments were observed primarily in the West Bay during late summer, when the deep water was anoxic. Phosphorus concentrations reached 0.2–0.3 mg/L in late summer in the West Bay, but only 0.08–0.09 mg/L just above the sediments in the South Bay. The extensive anoxic area during winter, especially during 1997, resulted in phosphorus concentrations reaching 0.17 mg/L in the West Bay, but only 0.08 mg/L in the South Bay and 0.10 mg/L in the East Bay.

Chlorophyll *a* Concentration

Chlorophyll *a* is a photosynthetic pigment found in algae and other green plants. Its concentration, therefore, is commonly used as a measure of the density of the algal population of a lake. Concentrations greater thatn 15 µg/L are considered to be very high and usually associated with algal blooms. Differences in chlorophyll *a* concentrations among basins directly

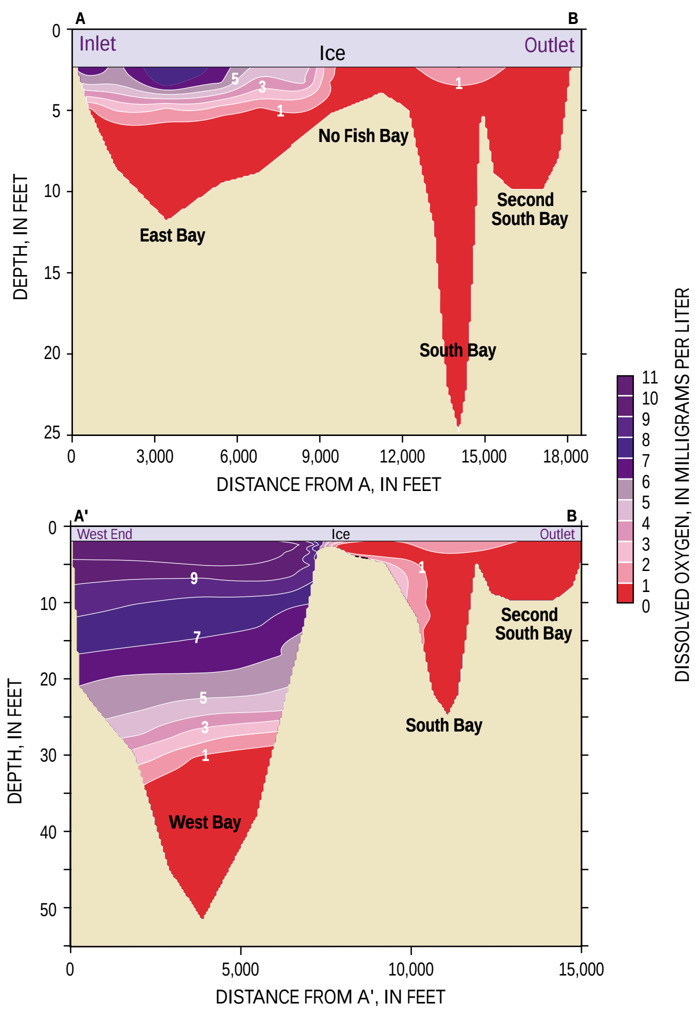


Figure 9. Distributions of dissolved oxygen in Little St. Germain Lake, Wis., March 18, 1997. (Trace of sections are shown in figure 2.)

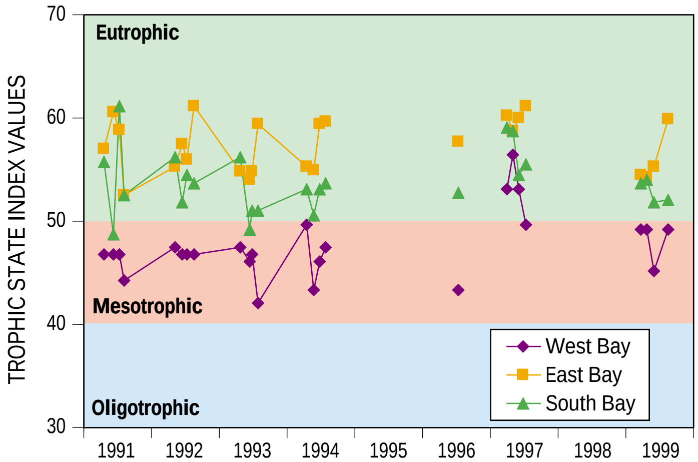


Figure 10. Trophic state indices based on surface total phosphorus concentrations in the West, East, and South Bays of Little St. Germain Lake, Wis., by year.

coincided with the differences in the phosphorus concentrations among basins. Concentrations were highest in the East Bay (average summer concentrations ranged from 20–48 µg/L), moderate in the South Bay (7–11 µg/L) and lowest in the West Bay (2–4 µg/L) (fig. 7). Concentrations were commonly greater than 15 µg/L in the East Bay and occasionally above 15 µg/L in the South Bay, but never observed above 15 µg/L in the West Bay.

Trophic State Indices

One method of classifying water quality or productivity of lakes is by computing water-quality indices (Trophic State Indices, or TSI's). These indices, based on near-surface concentrations of total phosphorus and chlorophyll *a* and on Secchi depths, were developed by Carlson (1977) and modified for Wisconsin lakes by Lillie and others (1993). Oligotrophic lakes (TSI's less than 40) typically have a limited supply of nutrients and are typically clear, algal populations and phosphorus concentrations are low, and the deepest water is likely to contain oxygen throughout the year. Mesotrophic lakes (TSI's between 40 and 50) typically have a moderate supply of nutrients, are prone to moderate algal blooms, and have occasional oxygen depletions at depth. Eutrophic lakes (TSI's greater than 50) are nutrient rich with correspondingly severe water-quality problems, such as frequent seasonal algal blooms, oxygen depletion in lower parts of the lakes, and poor clarity. Lakes with TSI's greater than 60 are considered hypereutrophic and usually have extensive algal blooms throughout summer. These three indices are related to each other in complex ways that differ seasonally and among lakes. All three of the indices indicated that the East Bay was eutrophic and often hypereutrophic during summer (average summer TSI based on surface phosphorus was 58, based on surface chlorophyll *a* was 60, and based on Secchi depth was 58). All three of the indices indicated that the South Bay was mesotrophic to eutrophic (average summer TSI based on surface phosphorus was 53, based on surface chlorophyll *a* was 51, and based on Secchi depth was 48). All three of the indices indicated that the West Bay was mesotrophic (average summer TSI based on surface phosphorus was 47, based on surface chlorophyll *a* was 43, and based on Secchi depth was 42).

Effects of Winter Drawdown

As mentioned previously, the WVIC controls the water level of the lake in accordance with their Federal Energy and Regulatory Commission license. Each winter the lake is drawn down about 1.5 feet. The drawdown is begun in November and completed in early February (fig. 4). In 1997, outflows from the lake were highest during November through February. Refilling then begins in early March and typically by May the water level is back to its normal summer elevation. Outflow from the lake in 1997 was lowest during March and April.

Effects on Nutrient Loading

Total phosphorus concentrations in the outflow generally increase from November through April (fig. 6). The average concentration increased 0.015 mg/L from November–February to March–April in 1997; however, there was no increase in 1999. Therefore, increased early-winter water removal associated with the drawdown may decrease the amount of nutrients that would be removed from the lake. If it is assumed that the drawdown resulted in 1,500 acre-feet of water (a 1.5-foot drawdown) being released in early winter instead of late winter, this would equate to about 65 pounds of phosphorus being retained in the lake in 1997 and no change in 1999. This amount represents about 0–3 percent of the total input of phosphorus. Therefore, the drawdown has only a small effect on the phosphorus budget for the lake as a whole.

Winter drawdown may, however, increase the phosphorus loading to the West Bay. During the drawdown period, water with a relatively low concentration of phosphorus flows from West Bay into No Fish Bay, whereas during refilling, water with a relatively high concentration of phosphorus flows from No Fish Bay into West Bay. To determine the effects of this process, the average drawdown for the 1991–99 period was examined.

During 1991–99, average drawdown was 1.57 feet, average time to achieve drawdown was 106 days, average precipitation during drawdown was 0.42 foot, and evaporation was considered to be negligible. Therefore, there was a net release of 1.99 feet of water from West Bay. If the average concentration of phosphorus in the water was 0.014 mg/L (the average near-surface concentration measured in the West Bay), there would be a net removal of 14.6 pounds of phosphorus from West Bay. During 1991–99, the average time to achieve refilling of the lake was 81 days, average precipitation during refilling was 0.46 foot, and average evaporation was estimated to be 0.18 foot. Therefore, there was a net inflow of 1.29 feet of water to West Bay. If the average concentration of phosphorus was 0.045 mg/L (the average near-surface concentration measured in the East Bay), there would be a net increase of 31.2 pounds of phosphorus to West Bay. Hence the net effect, on average, of the drawdown and refilling of the lake is a16.6-pound increase in phosphorus loading to West Bay. This amount is slightly more than that contributed by precipitation for the year (12.2 pounds). Therefore, although the drawdown contributes only a small amount of phosphorus to the West Bay, it may be a major source given the few other sources to this basin.

Effects on Dissolved Oxygen

The drawdown may also affect dissolved oxygen concentrations in the lake because oxygen concentrations decrease dramatically from November through April (fig. 8); therefore, more oxygen would be removed if more water was taken out earlier in the winter. The average concentration of dissolved oxygen in the South Bay decreased 7.2 mg/L from November–February (8.8 mg/L) to March–April (1.7 mg/L) in 1997. If it is assumed that the drawdown resulted in 1,500 acre-feet of water being released in early winter instead of late winter, this would equate to about 30,000 pounds of oxygen being released. This amount represents about 8 percent of the total dissolved oxygen in the entire lake when it freezes, or about 18 percent of the dissolved oxygen in East, No Fish, and South Bays combined, or about 44 percent of the dissolved oxygen in just the South Bays when the lake freezes. The smaller the amount of oxygen available for consumption by biochemical reactions, the sooner the concentrations will decrease below critical levels. Therefore, the drawdown can significantly decrease the length of time certain areas of the lake are habitable by fish.

Effects of Phosphorus Reductions

The total phosphorus input to the lake was estimated to be 2,410 and 1,310 pounds in 1997 and 1999, respectively. Most of this phosphorus is input into the East Bay and results in the water quality in this basin being significantly poorer than in other parts of the lake. One way to determine how much phosphorus loading would need to be reduced to improve the water quality of this basin is through the use of empirical models. These models relate phosphorus loading to measures describing lake-water quality (such as phosphorus and chlorophyll *a* concentrations and Secchi depth).

Several empirical models within the Wisconsin Lakes Modeling Suite (WiLMS; J. Panuska, Wisconsin Department of Natural Resources, written commun., 1999) relate hydrologic and phosphorus loading to in-lake phosphorus concentrations. Six of these models were applicable to the East Bay of Little St. Germain Lake. Therefore, the recent hydrologic and phosphorus loading to the lake (1997 and 1999) and various phosphorus-reduction scenarios were input into these models to predict phosphorus concentrations. The average phosphorus concentration predicted by the models for 1997 and 1999 was 0.051 mg/L, which is comparable to the measured lake concentration of about 0.046 mg/L. The models were then applied to various phosphorus-reduction scenarios: 50, 75, and 100 percent reduction in tributary loading, with all other sources maintained at their present levels. The models predicted that these reductions in tributary loading would cause the average phosphorus concentration in the East Bay to decrease by 0.012, 0.019, and 0.021 mg/L, respectively. Another empirical model, developed by Lillie and others (1993) and contained in WiLMS, relates in-lake phosphorus concentration to average summer Secchi depth. This model predicted that reductions in phosphorus concentrations of 0.012, 0.019, and 0.021 mg/L would be expected to increase the average summer Secchi depth by 0.7, 1.0, and 2.0 feet, respectively. Therefore, a total elimination of the phosphorus loading from Muskellunge Creek is predicted to increase the summer Secchi depth from 3.8 feet to about 5.8 feet. In addition to improving water clarity, the reduction in total phosphorus would be expected to decrease the frequency of blue-green algal blooms.

Because of the significant contributions of phosphorus to the lake estimated from ground water, even with tributary loading eliminated, the predicted phosphorus concentrations and Secchi depths still resulted in the East Bay being classified as a eutrophic system. As mentioned previously, however, estimates of ground-water inflow are considerably uncertain, and further studies would be needed to better quantify the importance of ground water to the lake.

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APPENDIX G

Barr Engineering Company Summary Report

Little St. Germain Lake Aluminum Sulfate Treatment Proposal

Prepared for
Little St. Germain Lake Protection and Rehabilitation District

March 2009

BARR

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Little St. Germain Lake Aluminum Sulfate Treatment Proposal

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1.0 Executive Summary

At the request of the Wisconsin Department of Natural Resources, an evaluation has been conducted to examine the need, expected benefits, and other potential consequences of using alum to treat the bottom sediments of Little St. Germain Lake. There has been extensive work conducted on Little St. Germain Lake, largely because water quality in the lake is in the eutrophic range and appears to have worsened over the last two decades. Seasonal trends in water quality show that degradation occurs during the summer when phosphorus contributions from inflows are lower but internal phosphorus loading is elevated. The degraded water quality has negative impacts on aesthetics, fish populations, and macrophytes leading to lower enjoyment of the lake by residents and others who use the lake for these purposes.

Recent studies have focused on methods to reduce external or internal phosphorus loads in order to improve water quality in the lake. A study conducted for the Little St. Germain Lake Protection and Rehabilitation District examined the feasibility of treating inflow from Muskellunge Creek with alum to improve water clarity in the lake. Muskellunge Creek, the main inlet to the lake, enters in the East Bay. Inflows from the creek do affect water quality but the majority of phosphorus loading occurs during the early part of the growing season and modeling results indicate that treating the inflow would provide limited benefit in late summer when water quality is usually the most degraded.

Due to the high cost of inflow alum treatment, an additional study was conducted to determine the benefit of applying alum directly to the lake to control internal phosphorus loading. Modeling showed that decreasing internal phosphorus loading would reduce surface water phosphorus in the lake by a greater amount than inflow treatment, especially in the later part of the summer.

Alum treatment was decided upon as the most economical solution to improve water quality based on the cost and expected benefits. Chemical modeling was conducted using a USGS program called PHREEQ to evaluate the effect of different alum doses on pH in the lake. Because of the low alkalinity of the lake, the dose needed to inhibit internal phosphorus loading would have to be split and applied for several successive years. It is recommended that the treatment be split into three equal phases (doses) to minimize the use of costly buffers. It is possible that two treatments (conducted in successive years) will be adequate to inhibit internal loading, however, sediment coring is recommended after the second treatment along with ongoing water quality monitoring to determine the potential need for the third treatment. This approach will also allow for adaptive management based on monitoring after the initial phase(s) of treatment. The alum dose and expected cost for alum application in each phase are shown in Table EX-1. Additional monitoring and contract bidding costs of $7,750 will be needed for each phase of treatment beyond the first treatment conducted in 2009.

Table EX-1. Alum dose and expected cost of treatment (per phase). Cost includes lime addition.

Treatment Zone	Alum Applied (gallons)
East	57250
Lower East	66690
Total	123940
Treatment cost per phase	**$ 202,000**

Potential effects of alum treatment on benthic invertebrates, fish, and macrophytes were considered in this proposal. A review of published studies on the potential effects of alum treatment show that effects on aquatic life are limited as long as the pH of lake water during treatment remains above 6. Due to the expected increase in water clarity, more lake bottom area will be available for plant colonization but studies have shown that the diversity or health of a macrophyte community increases with an increase in water clarity.

Post-treatment monitoring will be conducted to assess the effectiveness and longevity of the treatment with regard to controlling internal phosphorus loading and improving water quality in Little St. Germain Lake. It is expected that the water quality benefits of the alum treatment will last for a minimum of 10 years (case studies have demonstrated that improvement can last for approximately 5 to 20 years). It can be expected that the proposed alum treatment will have greater longevity compared to past treatments on other lakes because of improved alum dosing procedures.

2.0 Historical Conditions

Little St Germain Lake is located in Vilas County, WI in the town of St. Germain. The lake is highly sought after for recreational and other activities which include fishing, waterskiing, swimming, and boating.

2.1 Land Use

Settlers first arrived in the town of St. Germain in 1903. Since around that time, logging, recreation, and a small amount of farming and development have dominated the direct watershed areas around the lake. Current land uses are shown in Figure 1.

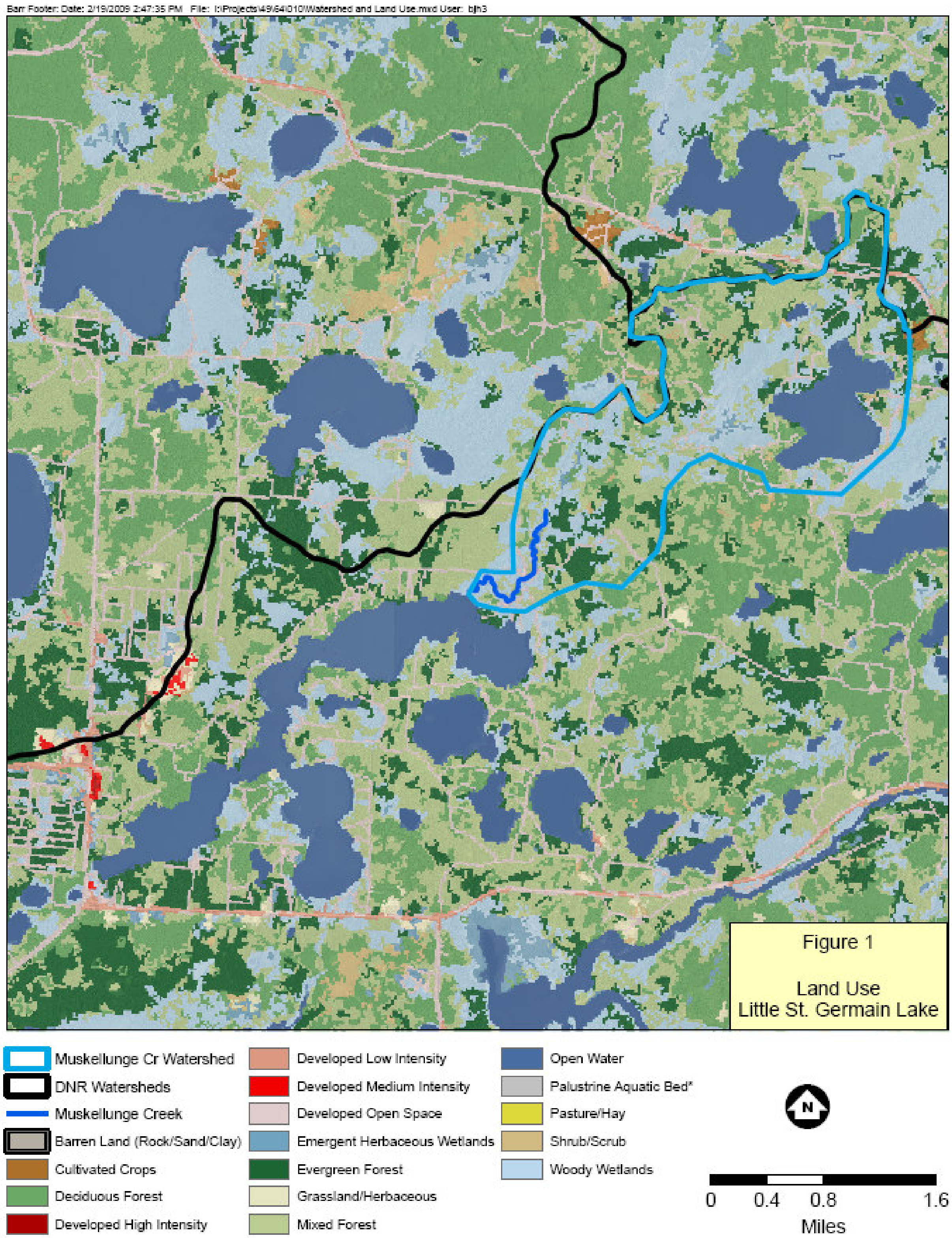
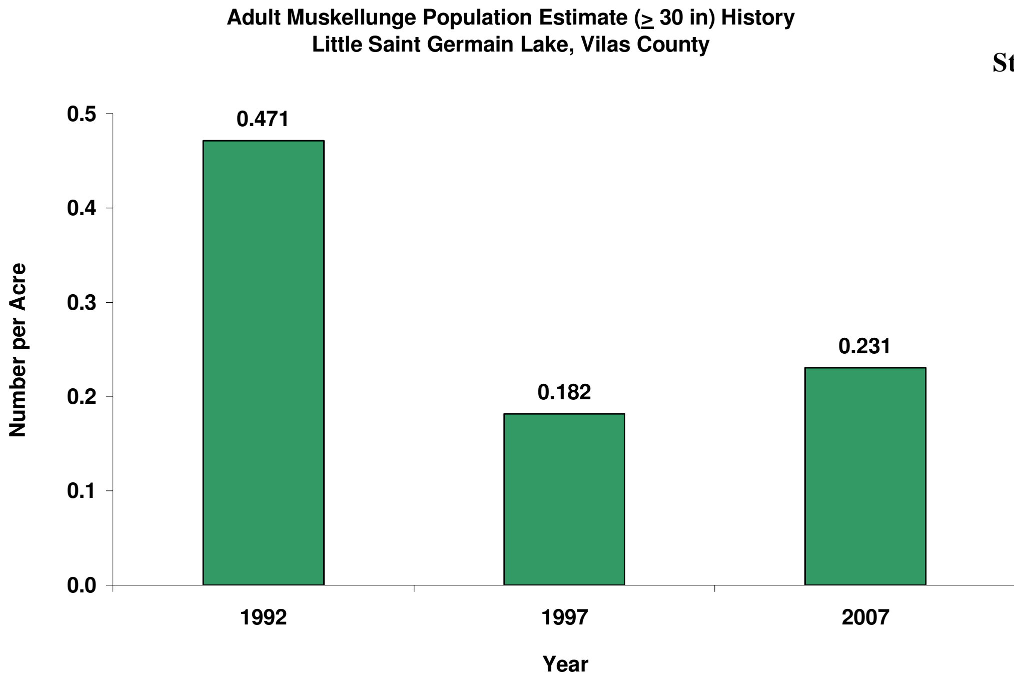


Figure 1. Land use and watershed areas around Little St. Germain Lake.

2.2 Fishery and Aquatic Habitat (Macrophytes)

2.2.1 Fish Data

Data for the Little St. Germain Lake fishery was provided by the WIDNR (Figure 2). When comparing 1992 to 1997 and 2007, the muskie population appears to have dropped in the lake. After 2000, however, the amount of fish stocked bi-yearly was reduced from approximately 2000 to 490.



Stocked Muskie

1990: 1900

1996: 2021

1998: 1774

2000: 1800

2002: 490

2004: 490

2006: 490

Figure 2. Muskellunge population and stocking data for Little St. Germain Lake.

2.2.2 Macrophyte Treatment Data

Little St. Germain Lake has populations of both Eurasian watermilfoil (EWM) and curlyleaf pondweed (CLP). Both of these plants can negatively affect the recreational and/or water quality of a lake. Both tend to dominate the aquatic plant community over time, lead to lower diversity within the system, interfere with recreation in shallower areas of a lake, and lower the overall aesthetics of a lake. CLP has an additional mode of impact whereby senescence of the plant in late June to early July can cause a release of phosphorus from plant tissue and also decrease oxygen in the water column during plant breakdown, potentially initiating or accelerating sediment phosphorus release.

Both CLP and EWM have been treated with herbicides beginning in 2003 (Table 1). Treatment of CLP occurs in the spring using Endothall while granular 2,4 D is used in both the spring and fall to manage the growth of EWM. All macrophyte treatment maps are shown in Appendix B. 2008 CLP treatment areas are mostly clustered within Lower East Bay with two areas immediately to the west of Lower East Bay. Only two small areas were treated for EWM in the Lower East Bay (0.5 acres total) and one larger area (3.8 acres) at the mouth of Muskellunge Creek, was treated in the East Bay.

Table 1. Herbicide treatment details for CLP and EWM in Little St. Germain Lake.

Treatment Date	Species	Chemical	Treated Area (Acres)
05/14/03	CLP	Liquid Endothall	42.7
07/01/03	EWM	Granular 2,4-D	3.0
08/04/03	EWM	Granular 2,4-D	9.0
05/11/04	CLP	Liquid Endothall	44.0
07/01/04	EWM	Granular 2,4-D	13.0
08/24/04	EWM	Granular 2,4-D	33.0
05/09/05	CLP	Liquid Endothall	50.0
07/13/05	EWM	Granular 2,4-D	8.5
05/12/06	EWM	Granular 2,4-D	6.2
05/13/06	CLP	Liquid Endothall	21.3
05/10/07	EWM	Granular 2,4-D	21.5
05/11/07	CLP	Liquid Endothall	41.6
05/27/07	CLP	Liquid Endothall	4.7
06/06/08	CLP	Liquid Endothall	54.4
06/07/08	EWM	Granular 2,4-D	24.0

CLP has been treated during years 2006 through 2008. In each successive year, larger areas of the lake needed treatment to manage CLP, indicating colonization of the lakebed may be increasing.

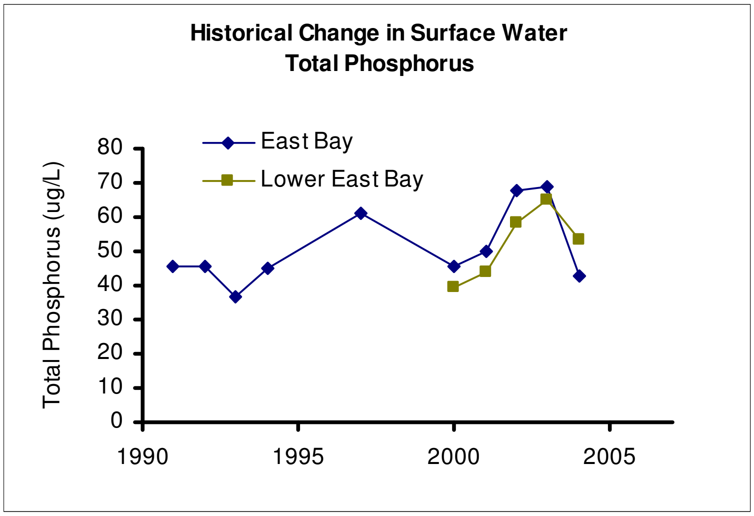
2.3 Nutrient Related Water Quality

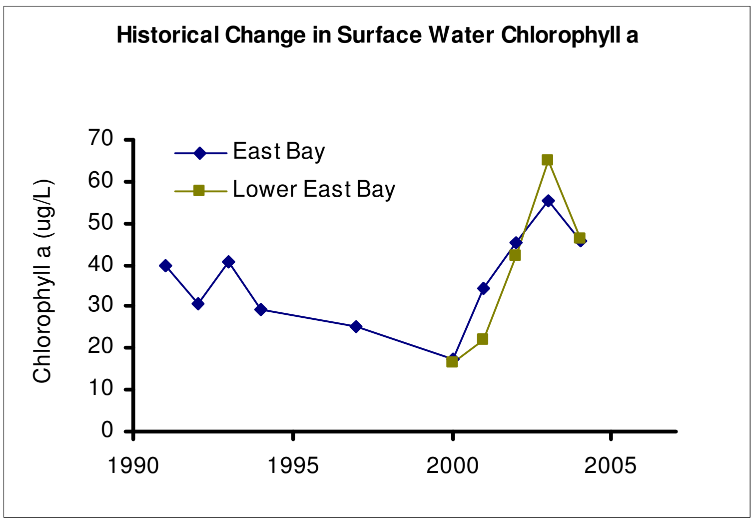
2.3.1 Historical Trends

Historical, nutrient related water quality data for Little St. Germain Lake are available for the Lower East and East Bays for a 7 and 16 year period, respectively. Total phosphorus, Secchi disc depth, and chlorophyll *a* growing season averages are shown in Figure 3 and were calculated using data from May through August for years with at least four data points that were representative of the entire season. The growing season averages typically included at least one measurement per month.

Annual average total phosphorus appears to have increased during the period of record, especially in the Lower East Bay. However, a drop in total phosphorus in 2004 (the final year for both data sets) was seen in East Bay and it was not substantially different from data collected during the early 1990s. Chlorophyll *a* reached a low during 2000 but more than tripled by 2003 in both bays and remained higher than all growing season means during the 1990s. Secchi disc depth was lower when comparing recent data from 2001 through 2006 to data collected in the late 1990s.

Historical averages for all data collected from West, East, South, and Lower East Bays were calculated to compare water quality spatially across the lake (Figure 4). Both East Bay and Lower East Bay were highest in total phosphorus and chlorophyll *a* for surface samples and had the lowest average Secchi disc depth of the four bays. This may appear counterintuitive given that internal loading can be observed for both the West and South Bays during the summer months. However, both of these bays are highly stratified and bottom phosphorus does not regularly reach the lake surface.





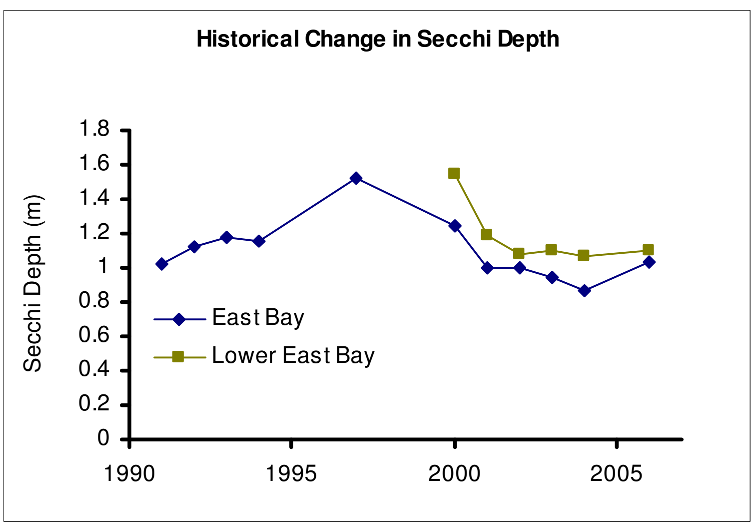


Figure 3. Historical changes in water quality at East Bay and Lower East Bay sites.

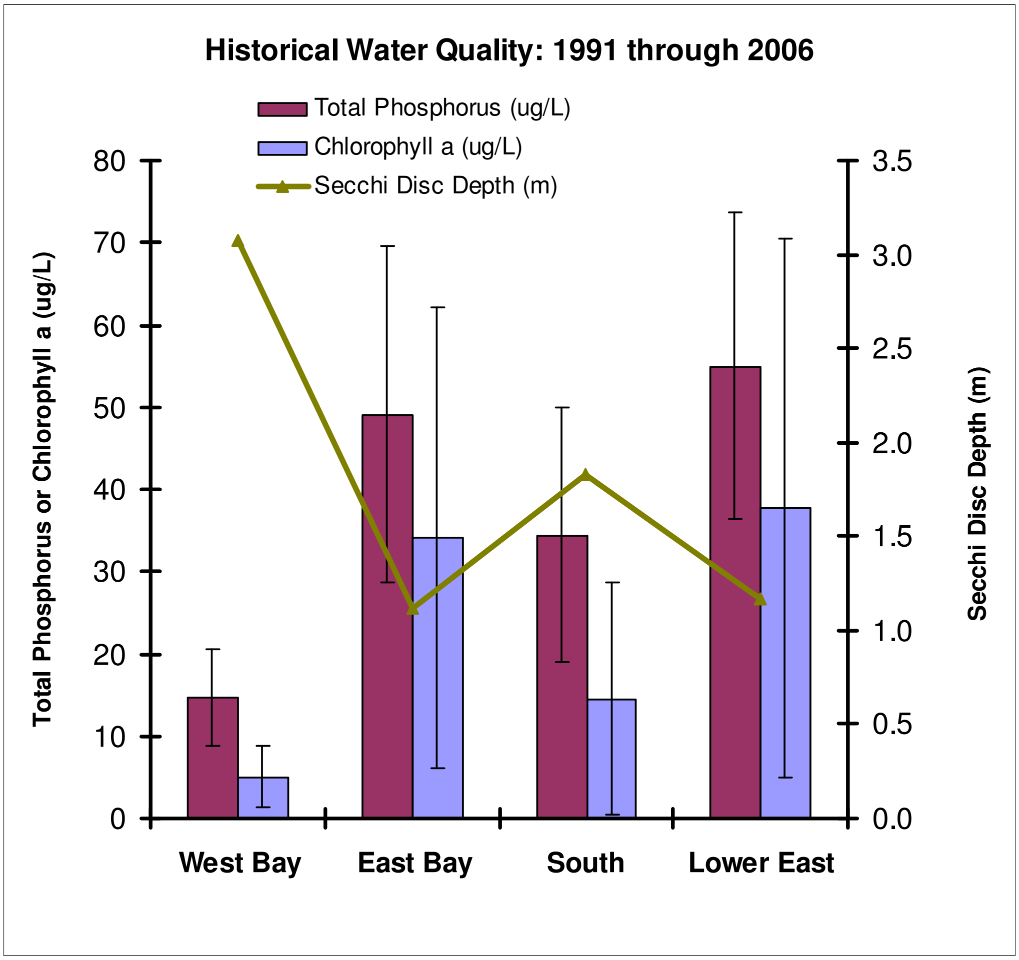


Figure 4. Average historical water quality at all monitoring locations in Little St. Germain Lake.

2.3.2 Seasonal Trends

To detect changes within a growing season, monthly averages for data from 2001 through 2003 were calculated and are shown in Figure 5. As the summer progresses, both total phosphorus and chlorophyll *a* increase, causing a corresponding decrease in water clarity. This trend is typical in lakes that are influenced by internal loading.

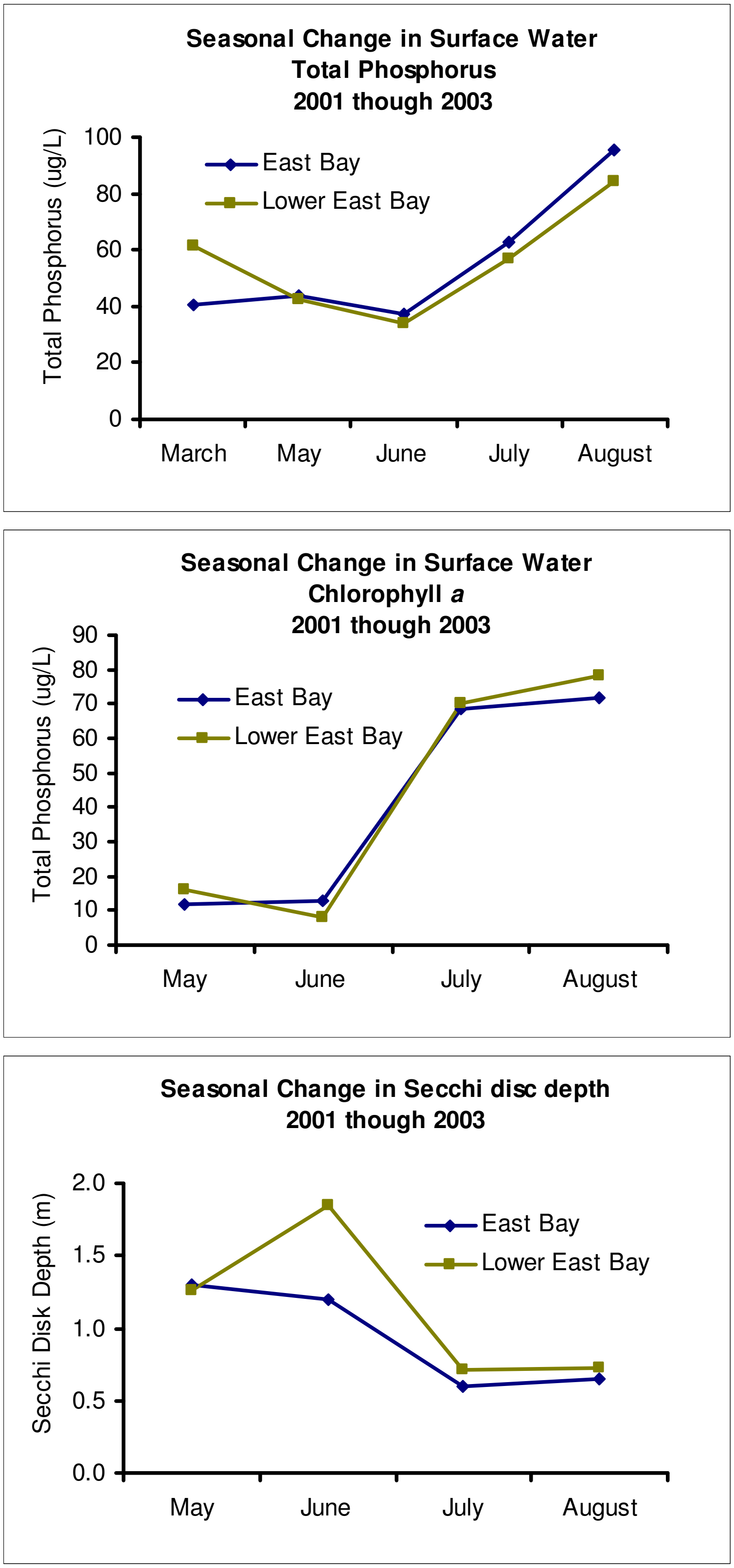


Figure 5. Seasonal changes in water quality in East Bay and Lower East Bay.

Evidence of internal phosphorus loading was seen during sampling in 2007 (Figure 6). Phosphorus concentrations reached over 0.4 mg/L near the bottom of East Bay but then decreased to less than 0.1 mg/L by the next sampling event, likely due to a mixing event. Concurrent with the decrease in bottom phosphorus was an increase in surface phosphorus in East Bay. Total phosphorus increased from approximately 0.05 mg/L in July to 0.087 mg/L by late August. Lower East Bay showed a similar trend although bottom water phosphorus data were not available. From these data it appears that phosphorus from the bottom waters was transported to the surface, decreasing water quality.

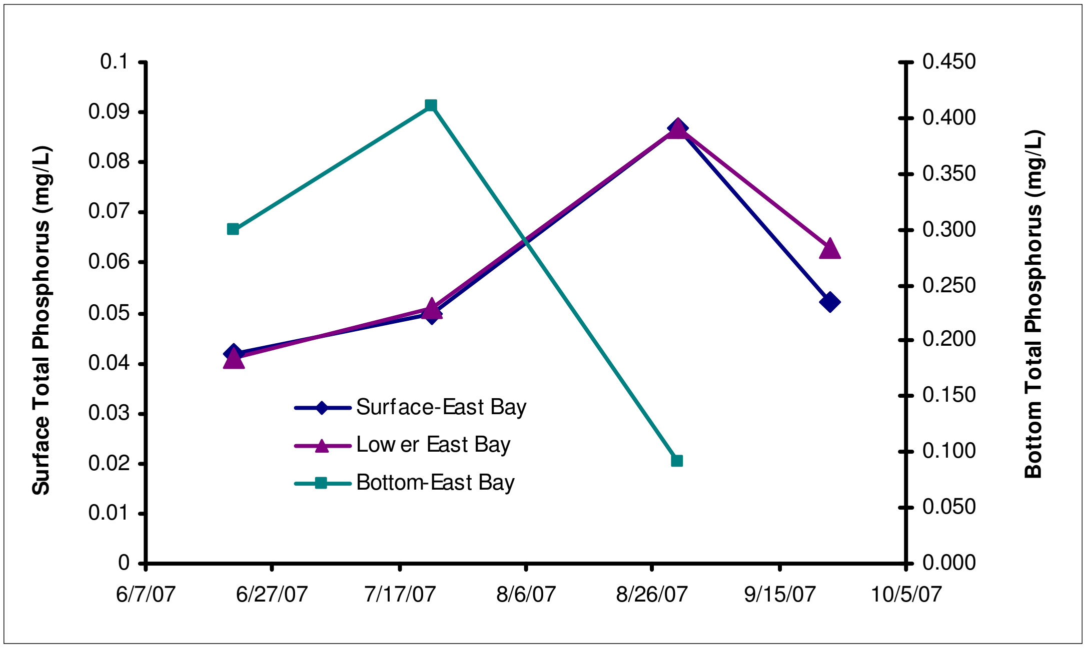


Figure 6. 2007 water column total phosphorus data for East Bay and Lower East Bay.

Data recently collected from Lower East Bay indicate that internal phosphorus loading appears to occur in areas of the lake that are generally thought of as mixed (Figure 7). Even though loading rates are likely lower in these areas when compared to the South and West Bays (based on the collected data), the water volume of these bays is smaller (less dilution) and the phosphorus is readily available for algal growth during the summer months. This is due to breakdown of stratification in these areas whereas loading in deeper areas of the lake may not impact the surface water significantly until turnover occurs in late fall.

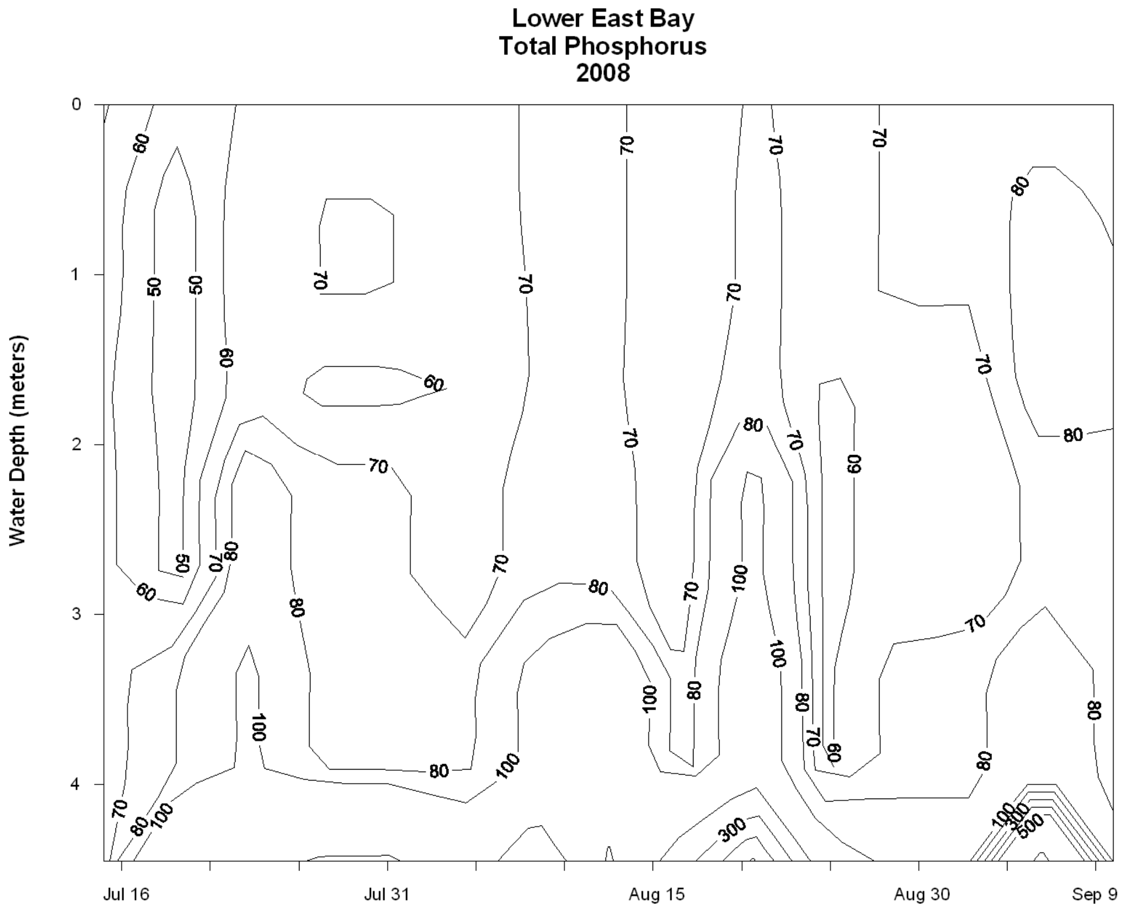


Figure 7. 2008 Lower East Bay water column total phosphorus isopleths data.

2.3.3 Overall Trends in Water Quality

Based on historical data, there appears to be a decline in water quality over the last two decades in Little St. Germain Lake. Overall the lake is eutrophic and water quality declines as the growing season moves into late summer. Water quality is poorest in East Bay and Lower East Bay but South Bay, strongly influenced by East Bay and Lower East Bay water quality, is also in the eutrophic range. Data indicate that internal phosphorus generation and mixing lead to higher surface water concentrations of total phosphorus in East Bay and Lower East Bay.

3.0 Management Options

Using all available data for Little St. Germain Lake, two options were investigated to reduce phosphorus levels in the lake. These options included external or internal phosphorus source loading reductions.

3.1 Inflow Alum Treatment

The feasibility of constructing and operating an alum treatment facility designed to remove phosphorus from Muskellunge Creek was evaluated (Barr, March 2007). The feasibility analysis was performed assuming that the facility would be constructed north east of the intersection of Birchwood Drive and Muskellunge Creek Road. The criteria for evaluation included capital and operation costs, physical constraints of the site, the capacity of the site to accommodate required treatment facility structures, and the expected in-lake phosphorus levels (East Bay) with a range of potential treatment facility designs and operating conditions. The findings of this study were as follows:

- Proper operation, performance, and cost effectiveness of the treatment facility will be constrained by the limited size of the site that is available for the construction of the facility and the large percentage of total flow volume in Muskellunge Creek that will need to be treated.

- A total of twelve alternative plant operating conditions were evaluated. The conditions evaluated include treatment of 50% (flows <6.6 cfs), 75% (flows <11.1 cfs), and 100% (flows <21 cfs) of Muskellunge Creek flows, alum doses of 3 and 6 mg/L as aluminum, and the use of baffle or mechanical mixing of alum and water.

- The cost of capital, engineering and design, and treatment system optimization is expected to range from $0.7 to $1.1 million if a mechanical mixer is used. Greater treatment performance is expected with the mechanical mixing system.

- Annual operation and maintenance costs were expected to range from $130,000 to $600,000, depending on the volume of stream flows treated and whether alum doses of 3 or 6 mg/L are used. (Note, this cost would be higher now due to higher prices for aluminum)

- Because the available treatment site is constrained by its size, treatment of stream flows less than 6.6 cfs was recommended.

- There are several physical and chemical constraints that may affect system performance or will require some operational adjustments. The use of a 6 mg/L dose may be constrained by the low alkalinity of Muskellunge Creek (expected to range from 35 to 60 mg/L as $CaCO_3$) and the potential to suppress the pH of water in the creek below 6.0. Hence, the lack of alkalinity in Muskellunge Creek may restrict the treatment system performance (because a lower dose will need to be used) or an alternative, higher cost coagulant (e.g., polyaluminum chloride) will need to be considered.

- Using a calibrated water quality model for the East Bay of Little St. Germain Lake and 2001 monitoring data collected by the USGS, it is estimated that average treatment season (mid-April through September) phosphorus levels would decline from 0.051 mg/L to somewhere within the range of 0.038 to 0.041 mg/L with the treatment of stream flows less than 6.6 cfs (Figure 8).

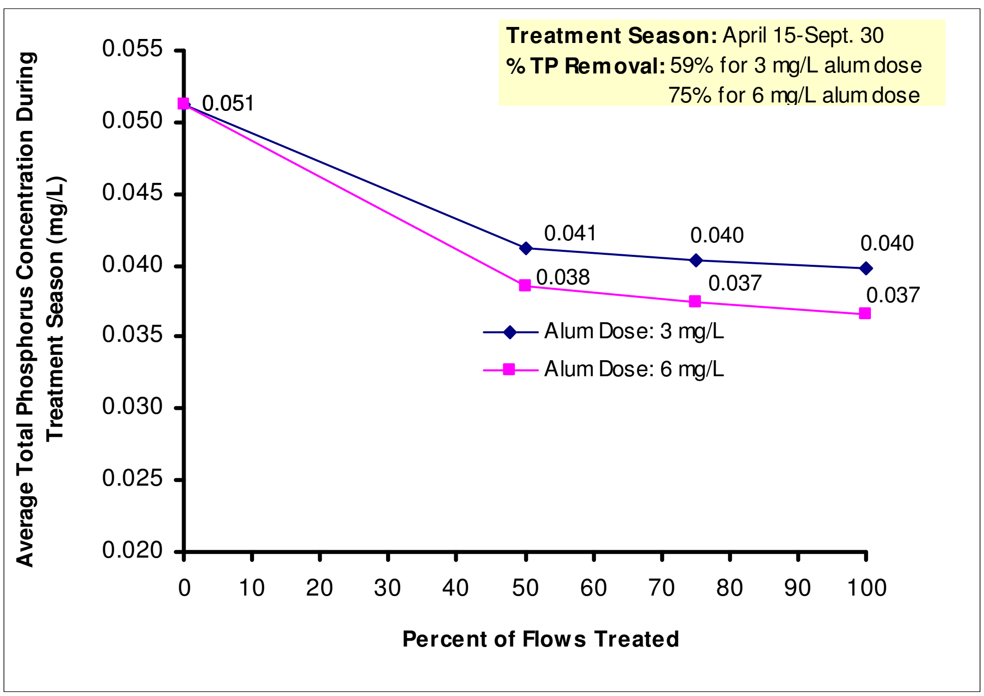


Figure 8. Expected phosphorus reductions from Muskellunge Creek using alum.

- The use of the calibrated lake model and the sediment studies conducted by the USGS and Barr indicate that phosphorus release from the sediments (internal loading) of the East Bay of Little St. Germain has a significant effect on phosphorus levels in the East Bay. If internal phosphorus loading were reduced by 90%, the average phosphorus level in the East Bay (mid-April through September) would have been 0.036 mg/L in 2001 (Figure 9).

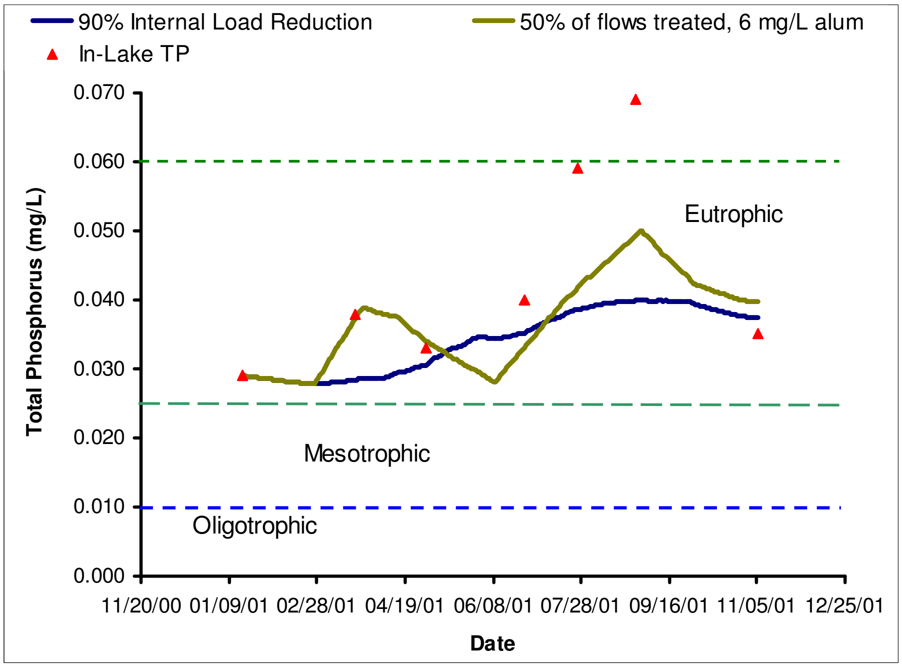


Figure 9. A comparison of total phosphorus in East Bay after inflow treatment and whole lake treatment using alum.

After assessing the in-lake and inflow data, the expected cost for a treatment facility, and the expected benefit to in-lake phosphorus levels, it was decided to further investigate the effect of internal phosphorus loading and the feasibility of in-lake alum treatment to improve water quality in Little St. Germain Lake.

3.2 In-Lake Alum Treatment

To better quantify internal phosphorus loading, and expected costs and potential benefits of treating the lake sediments with alum in Little St. Germain Lake, sediment cores were collected at 26 locations in the lake in June 2007. Sediment was analyzed to determine the spatial distribution of phosphorus (mobile, aluminum-bound, and organic) for different regions of the lake and corresponding potential phosphorus release rates and appropriate alum doses were estimated,. The distribution of phosphorus (mobile fraction) is shown in Figure 10. Overall, the concentration of sediment phosphorus in the lake was high, even when compared to lakes in urban areas, and there is a high potential for internal phosphorus loading to affect water quality in the lake. The sediment data indicate that the highest phosphorus was in West Bay, followed by South Bay, Lower East Bay, East Bay, and then No Fish Bay.

Although there is a potential for internal phosphorus loading to affect phosphorus levels in the water column of each bay, factors such and dissolved oxygen levels, bathymetry, the volume of each bay, stratification, and the rate of transport of phosphorus from the lake bottom, determine whether high sediment phosphorus actually results in high phosphorus in the surface water (and hence high algal growth).

Water quality models were developed to evaluate the expected change in phosphorus in East Bay, Lower East Bay, and South Bay with alum treatment. A model was not developed for West Bay because water monitoring data collected in 2007 indicate that the potential for phosphorus transport to the surface of this bay to be minimal, and phosphorus levels are relatively low in the summer.

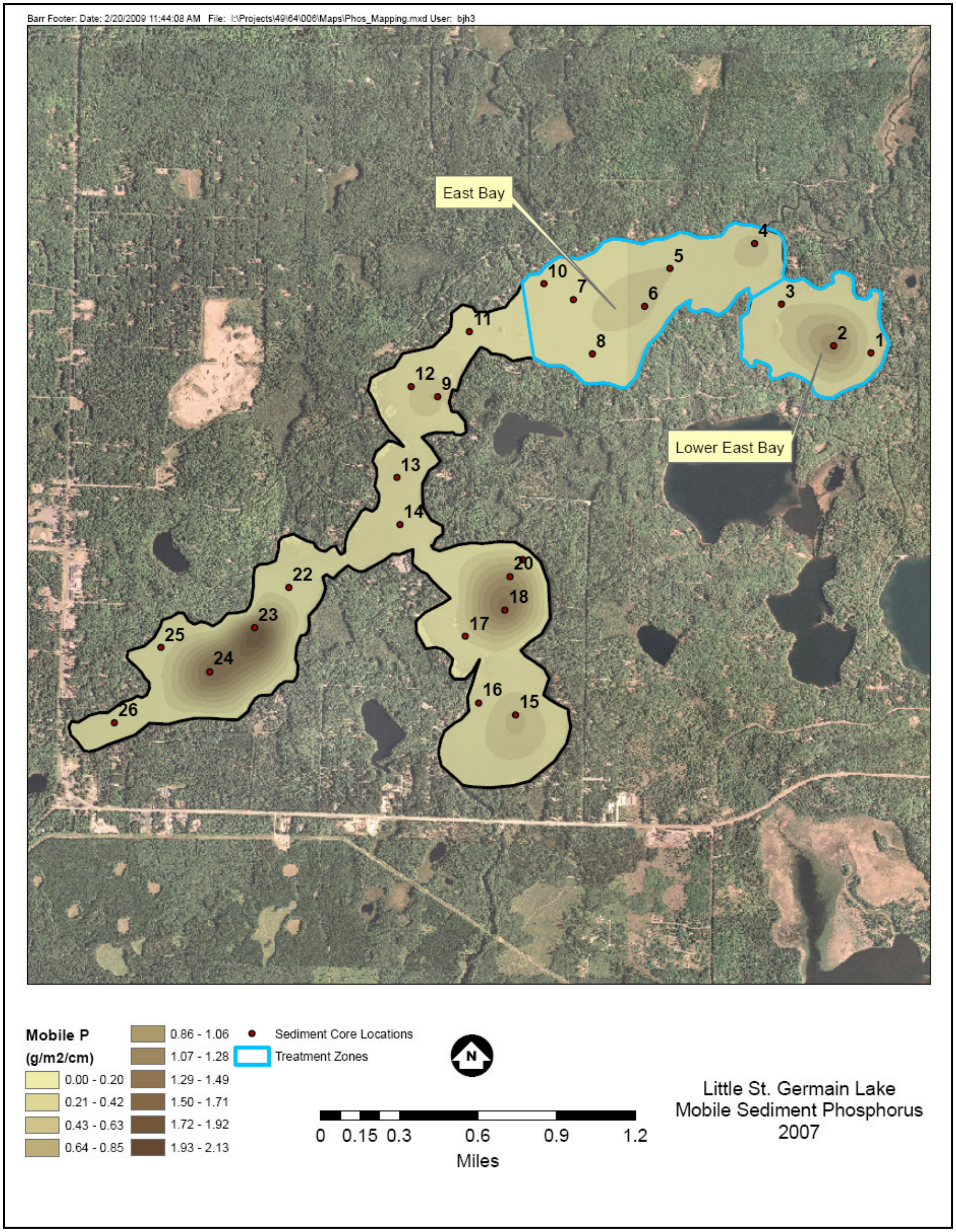


Figure 10. Sediment mobile phosphorus in Little St. Germain Lake.

The results of the modeling work, provided in Table 2, indicate that there will be a significant water clarity benefit to East Bay and Lower East Bay as well as South Bay (water from East Bay affects South Bay phosphorus levels) if East Bay and Lower East Bay are treated with alum at the doses prescribed (see Section 5). The additional benefit of treating South Bay, in addition to East Bay and Lower East Bay, should be weighed against the additional cost of treating South Bay. The primary benefit of treating South Bay with alum will be a reduction in spring to early summer algal blooms and reduced potential and magnitude for late summer blooms.

This study recommended treatment of East Bay and Lower East Bay because it was expected that the water quality improvement in South Bay would be adequate with only the treatment of the upper two bays.

Table 2. Expected Improvement in Total Phosphorus, Chlorophyll a, and Secchi Disc Depth (June through August) with Alum Treatment.

	East Bay/Lower East Bay			South Bay(2)		
Alum Treated Area	**Total Phosphorus (ug/L)**	**Chlorophyll *a* (ug/L)**	**Secchi disc depth (ft/m)**	**Total Phosphorus (ug/L)**	**Chlorophyll *a* (ug/L)**	**Secchi disc depth (ft)**
No Treatment	62	38	2.8/0.9	46	19	4.3/1.3
East/Lower East Bay Only: **Proposed Option**(1)	33	15	4.2/1.3	28	10	6.1/1.9
South Bay Only	62	38	2.8/0.9	35	13	5.2/1.6
South Bay and East Lower East	33	15	4.2/1.3	19	6	7.6/2.3

(1)Average of modeling results for 2001, 2002, and 2007. Average for June through August period.
(2)Average of modeling results for the year 2002.

4.0 In-Lake Alum Treatment: Dosing, Benefits and Potential for Adverse Effects

Alum has been used to reduce phosphorus in lakes for approximately four decades (Landner 1970, Kennedy et al. 1987, Welch and Cooke 1998, Reitzel et al. 2003, Huser et al. 2009). Numerous studies have been conducted on both the benefits and potential drawbacks to using alum for phosphorus reduction in surface water.

4.1 Alum Dosing

Historically, dosing of alum was based on lake water alkalinity in order to avoid toxicity effects from aluminum (Kennedy and Cooke 1982). The alkalinity-based method was used as a “rule of thumb” because aluminum acts as a weak acid and reduces lake water pH once the available alkalinity is consumed. The alkalinity-based method, however, lacks any relationship to phosphorus control, the issue of concern. In most cases this dosing method restricted the amount of alum that was applied, leading to an under-dosing of the lake. This was especially true for shallow and/or soft water lakes where there is less buffering capacity.

More recently, sediment phosphorus release rates along with expected treatment longevity had been used in alum dose calculations (Kennedy et al. 1987). This is an improvement because it focuses on the phosphorus released from sediments that may eventually become available for algal uptake. Use of internal phorphorus release rates alone, however, may overestimate, or more likely, underestimate the amount of aluminum needed to inactive phorsphorus available for release from the sediment. Another drawback to this method is that the entire mobile phosphorus pool may not be released during the experimental time frame. That is, the internal P release measured will yield a rate of phosphorus released from the sediment, but not necessarily the total mass of P available for release over the long term.

Another reason under-dosing may have occurred with the internal loading method is due to the fact that sediments previously treated with alum have shown that the phorphorus sorption capacity of aluminum is significantly lower than the previously assumed stoichiometric ratio of 1 (Kennedy and Cooke 1982; Kennedy 1987). In Washington and Wisconsin alum-treated lake sediments, the aluminum to phosphorus ratios (Al:Al-P) ranged from 5:1 to 11:1 (by weight), respectively (Rydin and Welch 1999; Rydin et al. 2000). The ratio ranged from 4.4 to 12 in alum-treated lakes in

Minnesota (Huser 2009). Basically this means that lakes treated with alum under the assumption of a 1 to 1 binding ratio for aluminum and phosphorus were under-dosed by up to a factor of 12.

An advanced method developed by Rydin and Welch (1999) focuses on the conversion of sediment mobile phosphorus to aluminum bound phosphorus by adding alum directly to sediments in laboratory experiments. For complete removal of mobile phosphorus, an aluminum to aluminum bound phosphorus ratio of 100:1 was recommended with a treatment depth of four centimeters. Although both were mentioned in the study, this method did not account for the variability of mobile phosphorus by sediment depth or organic bound phosphorus release.

Another important factor for dosing alum to control internal phosphorus loading is the sediment depth distribution of mobile phosphorus. This depth has varied in different studies; Rydin and Welch (1998) found excess mobile P in the top 4 cm of sediment, James and Barko (2003) reported elevated levels in the top 30 cm, and Pilgrim et al. (2007) found a range of 4 to 7 cm. According to Pilgrim et al., the mobile phosphorus method could be improved by relating mobile phosphorus in the sediment with expected internal release rate of P after treatment. Thus a net reduction of P released to the water column from conversion of mobile phosphorus to aluminum bound phosphorus could be calculated. A method to incorporate expected breakdown of organic phosphorus in the dosing method was also included by Pilgrim et al. (2007).

The method used in this study to calculate alum doses for Little St. Germain Lake is a combination of the Rydin and Welch and Pilgrim et al. methods. Dosing is based on the reduction of mobile and organic phosphorus in the sediment and the final dose is then calculated based on the desired internal phosphorus loading rate. The alum dosing results for Little St. Germain Lake are explained in more detail in Section 5.

4.2 Case Studies

As noted above, the best method to determine the amount of aluminum needed to control internal phosphorus loading in lakes is based on mobile phosphorus levels in sediment. However, this method has only recently been developed and therefore, nearly all lakes with long term data sets were dosed based on alkalinity (buffering capacity) or internal phosphorus loading rates.

Deep lakes have shown better results when compared to shallow lakes in cases where aluminum has been added to control internal phosphorus loading. Because shallow lakes have low buffering capacity (primarily because of lower water volume) and internal phosphorus loading rates can be difficult to estimate, these lakes generally receive much lower alum doses compared to deep lakes.

Longevity can also be limited in shallow systems because the same mass of internal load generally has a greater impact in a shallow lake. Thus, dosing for shallow lakes is particularly important because even a small residual internal phosphorus loading rate after treatment can limit effectiveness.

4.2.1 Deep (Dimictic) Lakes

In a study conducted by Welch and Cooke (1998), water quality data collected from 12 alum-treated, dimictic lakes was analyzed before and after alum application to determine the longevity of treatment. Total phosphorus (surface), chlorophyll *a*, and internal loading were reduced and control lasted from 4 to 20 years. Internal loading reduction averaged 80% of pre-treatment levels during these years in lakes where monitoring was conducted.

Little published data exist for lakes where alum was dosed based on sediment mobile phosphorus. However, Huser et al. (2009) showed that in Lake Calhoun (Minneapolis, MN), a sharp reduction in surface total phosphorus occurred during the first four years after treatment (2002-2005). Secchi depth increased from approximately 10 to 20 feet and internal loading was reduced by over 90%. Two of the lakes in this study were not dosed using sediment phosphorus content (Cedar Lake and Lake of the Isles). Cedar Lake has shown positive treatment effectiveness through the 10 years of data that the study summarized. Although this lake has two relatively deep bays (up to 40 feet), it is polymictic during some years.

Other alum treated lakes described in Cooke et al. (2005) and Huser (1999) include Mirror and Shadow Lakes (WI, 13 year treatment effectiveness), Lake Morey (VT, at least 12 year treatment effectiveness), West Twin Lake (OH, 18 year treatment effectiveness), and Medical Lake (WA, ~20 year treatment effectiveness).

4.2.2 Shallow (Polymictic) Lakes

There are no peer-reviewed water quality studies for shallow lakes in which alum was dosed and applied based on mobile phosphorus. All cases listed below were dosed on alkalinity or, at best, using an estimate of internal phosphorus loading rates.

Surface total phosphorus and chlorophyll *a* were reduced by an average of 40% from 5 to 11 years after treatment in six out of nine alum treated, polymictic lakes (Welch and Cooke 1998). Three of the polymictic lakes in this study showed little to no improvement after treatment. It was hypothesized that macrophytes caused either uneven floc distribution or in two cases, where effectiveness was not as long as expected, large amounts of phosphorus were transported through plant tissue via senescence and decay. However, a number of the other lakes in the study with positive results also had substantial macrophyte coverage. It is more likely that these lakes, because they were shallow and most had low alkalinity, were under-dosed with respect to phosphorus in the sediment. Because of the low buffering capacity in shallow lakes (due to low water volume), most shallow lakes have been severely under-dosed using older, non-sediment based alum dosing methods.

Huser et al. (2009) showed that treatment effectiveness lasted approximately five years in Lake of the Isles (Minneapolis, MN), a shallow lake. Again, however, alum dosing was not based on sediment mobile phosphorus and sediment data showed that a large pool of mobile phosphorus remained in the sediment after alum treatment (Huser 2009).

4.3 Potential Toxicity and pH Effects

The toxicology of aluminum has been studied extensively. Most of the work on aluminum toxicity has centered on the effect of acid rain, low pH, and the subsequent increase in aluminum toxicity due to acidification. A broad summary of the toxicity literature by Pilgrim and Brezonik (2005) suggested that the potential for aluminum toxicity to invertebrates, zooplakton, and fish is negligible if pH is maintained above 6.0 but not significantly higher than 8.5. This is largely due to the fact that within this pH range aluminum is bound to hydroxide as $Al(OH)_3$ and the reactivity of aluminum is reduced.

Generally, studies have shown short-term, initial impacts from alum treatment on phytoplankton, zooplankton and benthic species. These effects are mainly due to physical properties of the aluminum floc once it has entered the water. However, due to the increase in water quality following treatment; abundance and diversity generally increase.

Lakes Harriet and Calhoun (Minneapolis, MN) were treated with alum in 2001 and provide an example of in-lake aluminum concentrations after treatment. Lake Harriet, treated in early May 2001, had elevated total aluminum concentrations in the surface water shortly after treatment up to 0.298 $mg \cdot L^{-1}$ (Figure 11). By June, surface concentration was back near the pre-treatment condition. Lake Calhoun was treated in the autumn of 2001, but no aluminum sampling was conducted immediately after treatment. By the early spring of 2002, however, aluminum concentrations were low and comparable to pre-treatment levels, even in the water just above the alum treated sediment. By June of 2003, both lakes had total aluminum concentrations slightly below pre-treatment levels throughout the water column. It was hypothesized that organic matter, which can act as a carrier of aluminum, was lower (i.e., less algae) and hence less aluminum was held in the water column.

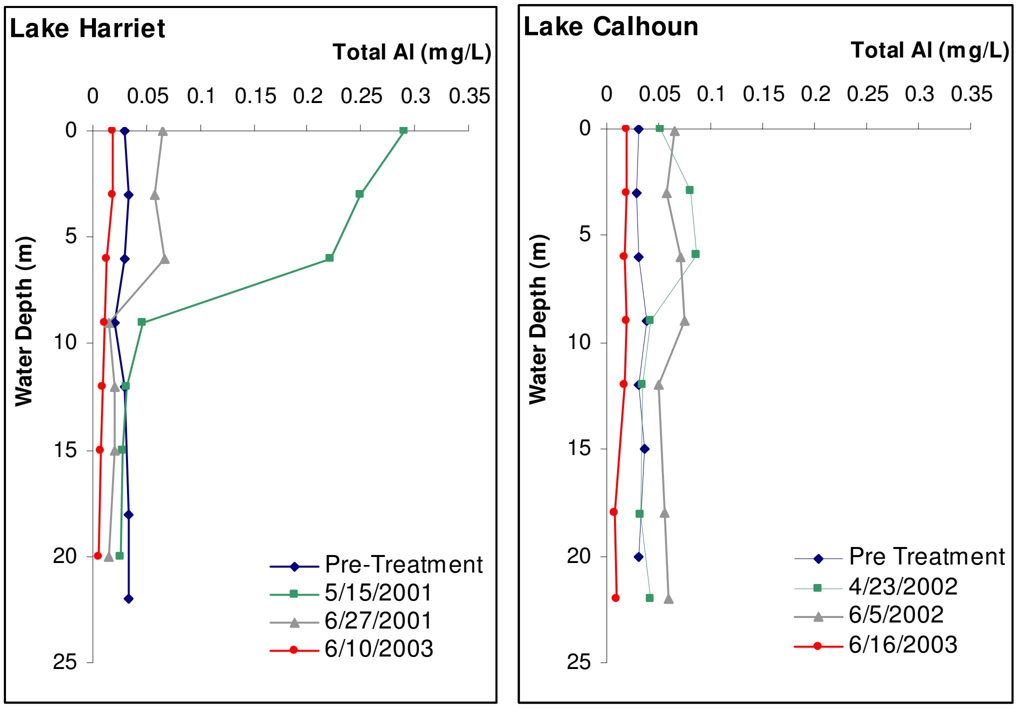


Figure 11. Water column concentrations of aluminum in two lakes before and after alum treatment.

4.3.1 Fish

When aluminum is highly soluble (at low pH) it can interfere with fish respiratory function. Therefore, as long as lake pH remains above 6 (aluminum solubility is minimum near pH 6.3) during an alum treatment, fish mortality is not expected to occur. Monitoring of two alum treatments in Minneapolis in 2001, conducted directly behind the application barge, showed the operator was able to maintain pH levels well above 6 and no fish mortality was observed directly after treatment or in the following days (Mike Perneil, Mpls. Park and Rec. Board, personal communication). Zero mortality of trout between pH 6 and 10 was seen in an experiment using alum-treated sludge from a wastewater facility (Ramamoorthy 1988). This was expected as aluminum is in the particulate phase within this pH range and in the presence of solids.

Bioaccumulation of aluminum in rainbow trout after alum treatment was examined in Medical Lake, Washington (Buergel and Soltero 1983). 12.2 mg Al/L (~120 g Al/m^2) was added during treatment and no physiological stress, gill hyperplasia, or retardation of growth was detected. Aluminum in gill tissues in a nearby hatchery (not affected by alum treatment) was higher than that detected in Medical Lake.

In some cases exposure to continuously elevated levels of aluminum hydroxide can produce long-term, chronic effects in fish. Kane and Rabeni (1987) showed that smallmouth bass had significantly reduced activity after a continuous exposure to $Al(OH)_3$ over 30 days. However, during an alum treatment, the $Al(OH)_3$ floc settles out of the water column (usually within hours) and continued exposure would not be expected.

Fisheries data from the past 20 years were obtained from the MN DNR for four of the lakes in the Minneapolis Chain of Lakes (the Chain): Lake Calhoun, Lake Harriet, Lake of the Isles, and Cedar Lake (Table 1). Data were also obtained for Lake Nokomis; a nearby, non-alum treated lake within the same system. All four of the lakes in the Chain have been treated with alum at different times in the past:

- Lake of the Isles (1996)
- Cedar Lake (1996-97)
- Lake Harriet (2001)
- Lake Calhoun (2001)

Lake Nokomis has not been treated with alum, but did have a common carp removal as part of its management. Approximately 5,000 lbs of carp were removed from the lake in January 2001. Harvesting of macrophytes (mainly Eurasian watermilfoil and curlyleaf pondweed) occurs in all five lakes.

Data for the predatory fish species, northern pike, muskie, and tiger (hybrid) muskie, were compared for each lake. Data is in pounds of fish per set (i.e. gill net) and each survey event employed anywhere from 2 to 9 gill nets. This surveying method is more useful for a qualitative analysis when looking at large predatory fish because the number of large fish caught is typically small and does not generally provide statistically meaningful data. Northern pike and muskie/tiger muskie were observed in all lakes before and after alum treatments. Based on available data there was no evidence of population changes due to alum treatment in any of the lakes (see Appendix A).

It should be noted the Chain is nicknamed such because the lakes are connected via shallow channels/waterways that allow fish to migrate from one lake to another. Fish that were stocked in one lake were captured in another lake on several occasions. Also, field crews observed dead muskies or tiger muskies on various lakes on several occasions during the fish surveys. When examined closely, most of these dead fish showed evidence of severe injury from recreational fishing.

4.3.2 Benthic Invertebrates

Bottom dwelling, benthic organisms have not been affected greatly by previous lake alum treatments except that diversity increases in some cases (Conner et al. 1989; Narf 1989). The increase in diversity was attributed to more oxygen in the deep water due to lower settling of algal matter and increased quality of habitat. In Liberty Lake, WA, alum treatment appeared to negate toxic effects of a previous rotenone treatment, as crayfish, absent previous to alum treatment, were found 5 days after treatment (Funk et al. 1982).

It can be concluded from the peer-reviewed literature regarding whole-lake alum treatments that the potential for adverse effects with alum treatment only occurs when there is a significant accumulation of alum floc (i.e., a physical disturbance of habitat). The literature also indicates that alum is not toxic to benthic invertebrates when pH is above 6.0, while notable toxicity is apparent near pH 5.0 (Gensemer and Playle, 1999; Pilgrim and Brezonik, 2005). Lamb and Bailey, 1981, studied the effect of alum floc on benthic invertebrates in a laboratory setting to determine if proposed whole lake alum treatments would have adverse effects on benthic invertebrates. They reported significant mortality of a chironomid (aquatic insect) in chronic laboratory tests only with very high alum doses of 80 to 480 milligrams per liter. The authors suggested that observed mortality was potentially due to aluminum toxicity but they also noted that there was significant alum floc accumulation and the chironomids were using the floc as habitat by burrowing within the floc. It was noted that heavy aluminum floc was likely causing stress and mortality for tests with higher alum doses. This study also demonstrated that there were minimal chronic effects with an alum dose of 10 milligrams per liter (as Al) and that there were no acute effects even at doses as high as 960 milligrams per liter.

As part of a district-wide evaluation of wetland health, the Ramsey Washington Metro Watershed District (Ramsey County, Minnesota) performed benthic invertebrate and water quality monitoring of a wetland (T-31) that is downstream of an in-line alum treatment facility. The alum treatment facility has been operating from spring though the fall of each year since 1998. During that time the concentration of aluminum entering the wetland has averaged from 1 to 6 milligrams per liter of aluminum. Aluminum was enriched in the wetland sediment, indicating that aluminum that entered the wetland also deposited as alum floc in the wetland. Benthic invertebrate monitoring results and IBI (index of biotic integrity) analysis for the T-31 wetland revealed that the wetland had similar quality to the high quality reference (unimpacted) wetlands in the study. The conclusion of this study was that the deposition of aluminum floc in this wetland had not adversely affected the biota of the wetland. Based upon the alum dosing suggested for Little St. Germain Lake (4.7 mg/L of aluminum), levels are comparable for the T-31 wetland and alum application to Little St. Germain Lake.

A study was conducted on a wetland/settling pond and a lake downstream of an in-line treatment system (continuous alum dosing) in Eagan, Minnesota (Twin Cities Metropolitan Area). This study found no effects on the benthic invertebrate community downstream of the alum treatment system with the accumulation of 10 cm of alum floc (Pilgrim and Brezonik, 2005). However, the benthic invertebrate community was nearly eliminated with over 1 foot (approximately 35 cm) of alum floc accumulation. The alum floc had an aluminum content of 200 milligrams per gram of dry sediment, roughly 10 times the background concentration. The authors hypothesized that the loss of the invertebrate community was largely due to the physical disruption of suitable habitat and the creation of severe anaerobic conditions below the floc layer. The potential for significant alum floc accumulation to disrupt benthic invertebrate communities also has been documented for an experimental treatment system on the Cuyahoga River (Barbiero et al., 1988).

Finally, a study on the Lake Morey (VT) alum treatment did show an initial decrease in the condition factor for yellow perch and benthic invertebrate habitat but the decline was temporary and there was a long term benefit to biotic populations (Smeltzer et al. 1999).

Overall it appears that under certain conditions and treatment circumstances (e.g., pH below 6.0 and very heavy alum floc accumulation-approximately one foot or greater), negative impacts to the benthic community can occur with alum treatment. However, if pH is carefully controlled and floc is not excessively deep (floc accumulation will not be more than 1-2 cm with this treatment), adverse effects are not likely to occur. Over the long-term, benthic species seem to benefit as abundance and diversity are generally greater after treatment.

4.3.3 Potential Combined Effects Between Endothall, 2,4-D, and Alum

There were no data or published reports on the combined effects of using the herbicides Endothall and 2,4-D and alum. However, because changes in the local environment can stress living species in general, it is recommended that alum treatment occur at least two weeks after any late summer or early fall herbicide treatment.

One potential indirect effect of combining herbicide and alum treatments in the same area could be dissolved oxygen depletion. As macrophytes die back due to herbicide application, decomposition of the plant material decreases oxygen in the water column. Alum (it forms aluminum hydroxide once applied to the lake water) causes settling of particulate matter from the water column to the sediment as it flocculates and settles. If algal biomass is high in the water column at the time of treatment, alum treatment will cause the algal matter to settle out of the water column. Degradation of the settled algal matter, along with decomposing macrophyte matter, may cause areas of dissolved oxygen depletion, potentially stressing fish and benthic invertebrates. Although this process has not been documented (at least in peer-reviewed literature), it is a potential risk if both herbicide application and alum treatment are conducted

4.4 Effects on Macrophytes

Submerged macrophytes in surface waters are dependent upon light and nutrients for growth. An increase in water clarity will increase the amount of sediment surface available to colonization by macrophytes. It is generally assumed that plant rooting depth in lakes is equal to the average summer Secchi disc depth. This also assumes that some other factor is not limiting the depth or area of macrophyte growth (e.g. fetch, fish, sediment substrate, etc.). Based on these assumptions and the morphology of each basin, the potential increase in lake surface area that could be colonized due to increased water clarity is shown in Table 3.

Table 3. Expected changes in lake surface area for macrophyte rooting depth after alum treatment.

	Average Secchi Depth (feet)	Current Macrophyte Rooting Area (acres)	Proposed Secchi Depth (feet)	Proposed Macrophyte Rooting Area (acres)	Potential Increase in Rooting Area (acres)
East Bay	7.6	65.3	9	80.5	15.2
Lower East Bay	7.6	70.3	9	91.2	20.9

The expected increase in water clarity may increase the potential rooting area for macrophytes by 15.2 acres in East Bay and 20.9 acres in Lower East Bay. However, as stated above, other factors may limit colonization including fetch and sediment type and composition.

Previous work has shown that the health of a macrophyte community improves with increasing water clarity. Diversity is generally higher in systems with higher water clarity and a greater number of high value species are usually present. Madsen et al. (2004) showed that as the light extinction coefficient increased (clarity decreased) in two northern Minnesota lakes, aquatic macrophyte diversity declined. Rybicki and Landwehr (2007) saw an increase in native species (with respect to invasive species) and plant community diversity increased when water quality increased between 1985 and 2001 in the Potomac Estuary. Macrophyte diversity and density increased after water clarity increased due to fish removal in a large, shallow wetland (Schrage and Downing 2004).

4.5 Aeration and Alum

Aeration of lake water is designed to increase the limit the impacts from oxygen by adding air or compressed oxygen to the water column. The main purpose of the aeration systems installed in Little St. Germain is to prevent low oxygen conditions from negatively impacting the fishery. The systems are run from approximately December until ice-out.

There are a number of case studies where alum and aeration were used to improve water quality. Medical Lake (WA state) showed improved water quality after alum application and aeration for at least 20 years (Huser 1999). Powderhorn Lake, a small stormwater pond with a deep hole, was treated with alum in 2003 and has an aeration system. No evidence of interference between the aerator and the aluminum floc has been seen in the lake and the water quality has improved. Both of these aeration systems were designed to increase dissolved oxygen to improve the fishery in each lake.

Because aeration systems are designed to increase oxygen in the water column, there should be minimal effect on the alum treatment in Little St. Germain Lake. Once applied, alum forms aluminum hydroxide, sinks down to the sediment surface, and mixes with the surficial sediment layers. There may be some floc re-distribution when the aeration systems are installed but the aluminum-phosphorus bond will not be affected.

5.0 Alum Treatment Plan

5.1 Problem Definition

Water quality in East Bay and Lower East Bay is poor, especially when compared with other areas of the lake. Water quality conditions worsen towards the middle of the summer and continue to decline until the fall. Phosphorus loading from the sediment is contributing to the poor water quality in these bays and thus, a reduction of internal loading is expected to increase water quality, especially in the mid to late summer months.

5.2 Goals and Objectives

The goal with this alum treatment is to reduce mid and late summer algal blooms and to have a more stable, consistent, and improved lake clarity from spring through fall. This goal can be achieved by reducing internal phosphorus loading by 90% in both East Bay and Lower East Bay.

5.3 Treatment Plan

The treatment plan involves developing an alum dose to control internal phosphorus loading, timing of the application, and sequencing. A risk assessment for the treatment is also presented below.

5.3.1 Dosing and cost

The total alum dose is based on sediment content and depth distribution of mobile phosphorus in Little St. Germain Lake. The maximum amount that can be applied during treatment is limited by the alkalinity (or buffering capacity) of the lake water. Because aluminum is slightly acidic, dosing must be calculated so the lake water pH does not drop below pH 6.

For Little St. Germain Lake, alum dosing was based on using an aluminum to mobile phosphorus ratio of 75:1, an average sediment treatment depth of 6 cm, and a 90% reduction of internal phosphorus load. Treatment depth was determined by analyzing the depth distribution of excess phosphorus in the sediment of the lake (see example in Figure 12).

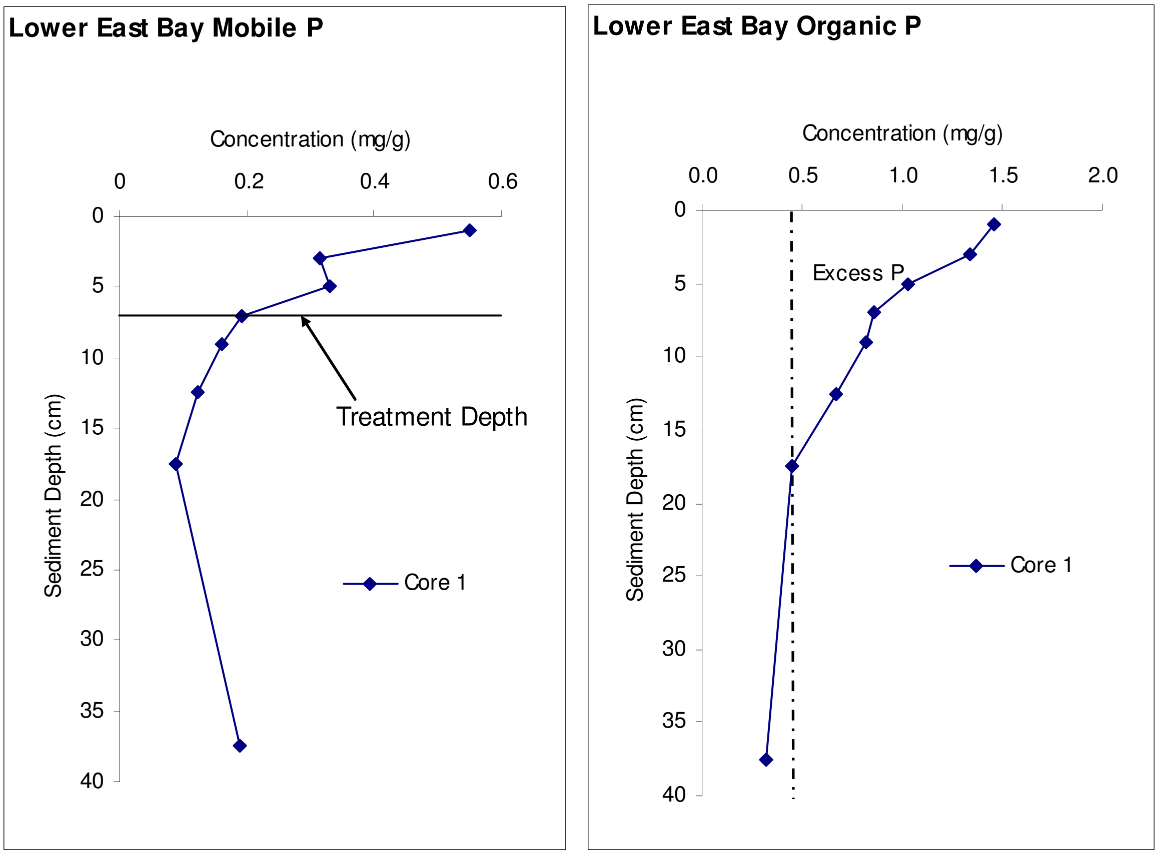


Figure 12. Examples of alum dose calculation parameters for mobile and organic phosphorus.

In addition, alum dosing incorporated organic-phosphorus degradation in the sediment. As organic phosphorus is broken down through microbial activity, it contributes directly to the mobile phosphorus fraction and, over time, labile organic matter will contribute to internal phosphorus loading. The amount of alum needed to bind this future source of mobile phosphorus was calculated by determining the amount of excess labile organic phosphorus and estimating the conversion to mobile phosphorus using annual degradation rates of 1.5 to 2% over a 10 year period.

Because the use of this alum dosing method generally results in higher alum doses over traditional methods, multiple phases for treatment are usually recommended for shallow lakes or lakes with low buffering capacity. This is done both to save cost by using the natural buffering capacity of the lake water and to improve phosphorus contact with aluminum through multiple smaller doses instead of one large dose. For Little St. Germain Lake, alum will need to be applied in annual phases (once per year) for two to three successive years.

Applying alum in phases provides flexibility and an adaptive management approach. After each phase of treatment, sediment and water monitoring are conducted to re-evaluate the need for further treatments. If monitoring results indicate that sediment treatment and water quality goals are being met before the entire alum dose is applied, the final phase of treatment could be reduced or postponed.

Based on the mobile phosphorus content of the sediments collected from East Bay and Lower East Bay in 2007, the total amount of alum that will be added for each bay is 740 gal/acre(East Bay) and 1620 gal/acre (Lower East Bay). The average alum dose across the entire area (East Bay and Lower East Bay) is 1048 gallons per acre (Table 4).

Table 4. Total alum doses required to convert mobile phosphorus to aluminum bound phosphorus in the East and Lower East Bays (based upon a total of three phases).

Treatment Zone	Alum Dose* (gal/acre)
East	740.0
Lower East	1620
Total	1048

*Based on total lake area

Due to the relatively low alkalinity (48 mg/L) in Little St. Germain surface waters, the amount of alum applied per treatment must be adjusted to prevent pH depression below 6. Based on water chemistry data and the water volume in each bay, eight treatments (without any buffer) would be needed to add enough aluminum to the sediment and not suppress pH below 6.0. Because this is not feasible, several options were considered so that more aluminum could be added without exceeding pH guidelines. The options included the use of a buffered solution of sodium aluminate, use of polyaluminum chloride, or the addition of lime in conjunction with alum treatment. Treatment costs for sodium aluminate and polyaluminum chloride were at least 50% greater than any other option and were not considered further. The least expensive and most feasible option involves adding straight alum to East Bay and alum with lime to buffer the treatment in Lower East Bay.

Lime has been added to lakes over the past few decades to control internal phosphorus loading but the effects have been short lived (Cooke et al. 2005), mainly due to the fact that calcium bound phosphorus formation is most effective at a pH greater than 9. Because the pH in Little St. Germain Lake is not generally sustained at or above 9, especially above the sediment surface where the lime would settle to, no additional impact to internal phosphorus loading is considered with its application.

Alum and lime would be applied in up to three phases in the lake over a three year period. The estimated cost per treatment phase for the application of alum will be $202,000 (Table 5). It should be noted that this cost estimate is based on historically high aluminum prices due to substantial cost increases during 2008. Contract rates for alum have increased approximately 45% since 2007 when the original feasibility study for the alum treatment was conducted.

Table 5. Recommended alum treatment option for East Bay and Lower East Bay. Cost includes lime.

Treatment Zone	Alum Applied (gallons)
East	57250
Lower East	66690
Total	123940
Treatment cost per phase	**$ 202,000**

Additional cost for treatment monitoring and contractor bidding and supervision will be $7,750 for each additional phase of treatment beyond the first application. For example, the total cost of the phase two treatment would be approximately $209,750 including the application itself, treatment monitoring, contract bidding, and contractor supervision costs.

5.3.2 Timing

Alum treatment should occur during the fall to avoid fish spawning concerns, low dissolved oxygen conditions, and impacts to recreational users. Treatment should also occur at least two weeks after any planned herbicide treatment in the fall. Dissolved oxygen monitoring should be conducted prior to alum treatment to determine if oxygen depletion after herbicide treatment is a concern.

Additional water column samples should also be collected and analyzed immediately before treatment. Surface and bottom water samples should be collected from each bay and analyzed for pH, ions and alkalinity. The results will be used to modify the alum dose, if necessary, to maintain a pH of 6 or greater.

Due to potential horizontal drift of the aluminum floc in the lake water, requirements will be placed on the contractor stipulating a maximum wind velocity threshold for treatment. In addition, treatment will not be allowed if substantial precipitation is expected to occur immediately prior to, during, or shortly after the application.

5.3.3 Application Sequencing

An approximate breakdown of the alum treatment schedule is below.

Day 1:

- Treatment should begin from the far eastern end of Lower East Bay and move to the Lower East Bay/East Bay border. Only a portion of the required alum dose for this phase should be applied. The remainder will be applied after lime application.

Day1/Day 2

- An application of lime should then be conducted at the Lower East Bay.

Day 3/4

- Alum treatment should then continue from the eastern end of the East Bay in a southward direction.

Day 4 or 5

- The Lower East Bay should be treated with the second portion of the alum dose in the same manner that the first dose was applied.

Sequencing the alum treatment in this manner will allow greater fish movement during the alum application and will also allow the lime addition to buffer the alum treatment in Lower East Bay.

5.4 Risk Assessment

Section four of this report discussed potential for fish and benthic invertebrate toxicity along with possible changes in macrophyte growth patterns. This section covers risks associated directly with water quality improvement and alum treatment.

5.4.1 No treatment option

If no treatment of the East and Lower East Bays is chosen, average summer total phosphorus, chlorophyll *a*, and Secchi disc depth are expected to remain within the range seen since 2000 (Table 6). Annual increases in late summer total phosphorus levels will continue to degrade water quality in the lake. Phosphorus in the water of East Bay and Lower East Bay will continue to negatively impact South Bay water quality as well.

5.4.2 Lower than expected performance

Because alum treatment of Little St. Germain was designed based on sediment mobile phosphorus, it is not expected that internal loading will substantially contribute to excess phosphorus in the water column of the treated bays. However, due to low alkalinity in the water column, the total alum dose required to convert mobile phosphorus to aluminum bound phosphorus in the sediment will need to be split and applied in separate phases. It is possible that lower than expected results will occur until the final alum treatment is complete and all mobile phosphorus is converted to aluminum bound phosphorus.

Treatment effectiveness will appear to be lower in years with high precipitation and elevated external phosphorus loading relative to average or dry years. However, internal phosphorus loading will remain low, even in wet years.

5.4.3 Expected performance and longevity

After all phases of alum treatment are complete for East Bay and Lower East Bay, average summer water clarity will increase by approximately 1.4 feet and total phosphorus and chlorophyll *a* will decrease by 29 µg/L and 23 µg/L, respectively. Improvements in water quality are also expected in South Bay (Table 6).

Table 6. Expected increases in water quality for East Bay, Lower East Bay, and South Bay after alum treatment.

Alum Treated Area	East Bay/Lower East Bay			South Bay[2]		
	Total Phosphorus (ug/L)	**Chloropyll *a* (ug/L)**	**Secchi disc depth (ft/m)**	**Total Phosphorus (ug/L)**	**Chloropyll *a* (ug/L)**	**Secchi disc depth (ft/m)**
No Treatment	62	38	2.8/0.9	46	19	4.3/1.3
East/Lower East Bay Only: **Proposed Option**[1]	33	15	4.2/1.3	28	10	6.1/1.9

(1)Average of modeling results for 2001, 2002, and 2007. Average for June through August period.
(2)Average of modeling results for the year 2002.

Treatment longevity is a function of multiple factors, including:

- The amount of mobile sediment phosphorus remaining after treatment
- The deposition rate of new sediment in each bay
- The concentration of different phosphorus fractions in newly deposited sediment

- The physical and chemical properties (e.g. dissolved oxygen) of the lake water after treatment

- The guidelines used to determine treatment effectiveness

As new sediment accumulates in each bay, internal phosphorus loading will eventually return due to new phosphorus entering the system. Because there are no data on sediment deposition rates or the fraction of phosphorus in newly deposited sediment, a precise longevity estimate is difficult to calculate. In addition, sedimentation rates can be expected to drop after treatment, due to lower algal production and settling to the sediment. Based on previous treatments with alum, and the fact that this treatment dose was calculated based on mobile sediment phosphorus, longevity is expected to be at least 10 years from the initial application.

5.5 Treatment Effectiveness Monitoring Program

Sufficient pre-treatment data exist so that post treatment monitoring can determine the effectiveness of alum treatment in Little St. Germain Lake. Both water column and sediment data should be collected after alum application to monitor the effectiveness of treatment and to determine if alum was applied by the contractor as required. Monitoring of pH will also be conducted during the treatment.

5.5.1 Monitoring of pH

During the treatment application, pH will be monitored to make sure that it does not drop below 6. Monitoring will need to be conducted for each phase of the treatment.

5.5.2 Sediment Cores

Sediment cores should be collected from the same locations determined during the 2007 sediment monitoring program. Approximately 10 sediment cores will be collected and analyzed for mobile and aluminum bound phosphorus fractions, as well as aluminum, to determine if the coverage of the alum application was completed properly and how much mobile phosphorus in the sediment was converted to aluminum bound phosphorus. Aluminum and phosphorus distribution maps will be created so this can be seen graphically as well.

5.5.3 Water Quality Monitoring

Water quality monitoring in the lake should continue to be conducted as it was before treatment to assess the treatments impact on surface water quality and longevity of the treatment effects. Additional monitoring in the Lower East Bay, similar to that conducted in 2008, should be conducted after treatment to assess the treatment effectiveness to reduce internal phosphorus loading to the water column.

6.0 Summary

Water quality in Little St. Germain Lake is in the eutrophic range and appears to have worsened over the last two decades. The East and Lower East Bays are especially problematic with higher phosphorus and chlorophyll *a* and lower Secchi disc depth than either South Bay or West Bay. Seasonal trends in water quality show that degradation occurs during the summer when phosphorus contributions from inflows are lower but internal phosphorus loading is elevated. The degraded water quality has negative impacts on aesthetics leading to lower enjoyment of the lake by residents and others who use the lake for these purposes.

Two options were studied to improve lake water quality in Little St. Germain Lake: inflow alum treatment and whole lake alum treatment. Modeling of the two different options showed that applying alum to the lake would improve water quality to a greater degree than treating the inflows with alum, and for a lower cost.

Based on sediment analysis and lake modeling, an alum dose was calculated to improve water quality in the lake. Applying the required alum and reducing internal phosphorus loading from the sediment will have the following benefits:

- An average decrease in phosphorus and chlorophyll *a* in the surface water of the East/Lower East Bays by 29 µg/l and 23 µg/L, respectively. The reduction in algal growth will lead to an average increase in Secchi disc depth of approximately 1.4 feet.
- An average decrease in phosphorus and chlorophyll *a* in the surface water of South Bay 18 µg/L and 9 µg/L and an average increase in Secchi disc depth of 1.8 feet.

Due to the low buffering capacity of the lake water, it is recommended that the alum treatment be split into three phases and that lime be used to buffer the treatment in Lower East Bay. Applying alum in phases reduces the need for more costly buffered aluminum compounds to prevent pH depression during treatment and allows for an adaptive management approach. The need for the third and final treatment phase will be based upon mobile phosphorus reduction (goal is 90 % reduction) in the lake sediment, and lake water clarity improvement after the second phase of treatment. It is recommended that water clarity be evaluated on an ongoing basis to determine the need for a potential third phase of alum treatment.

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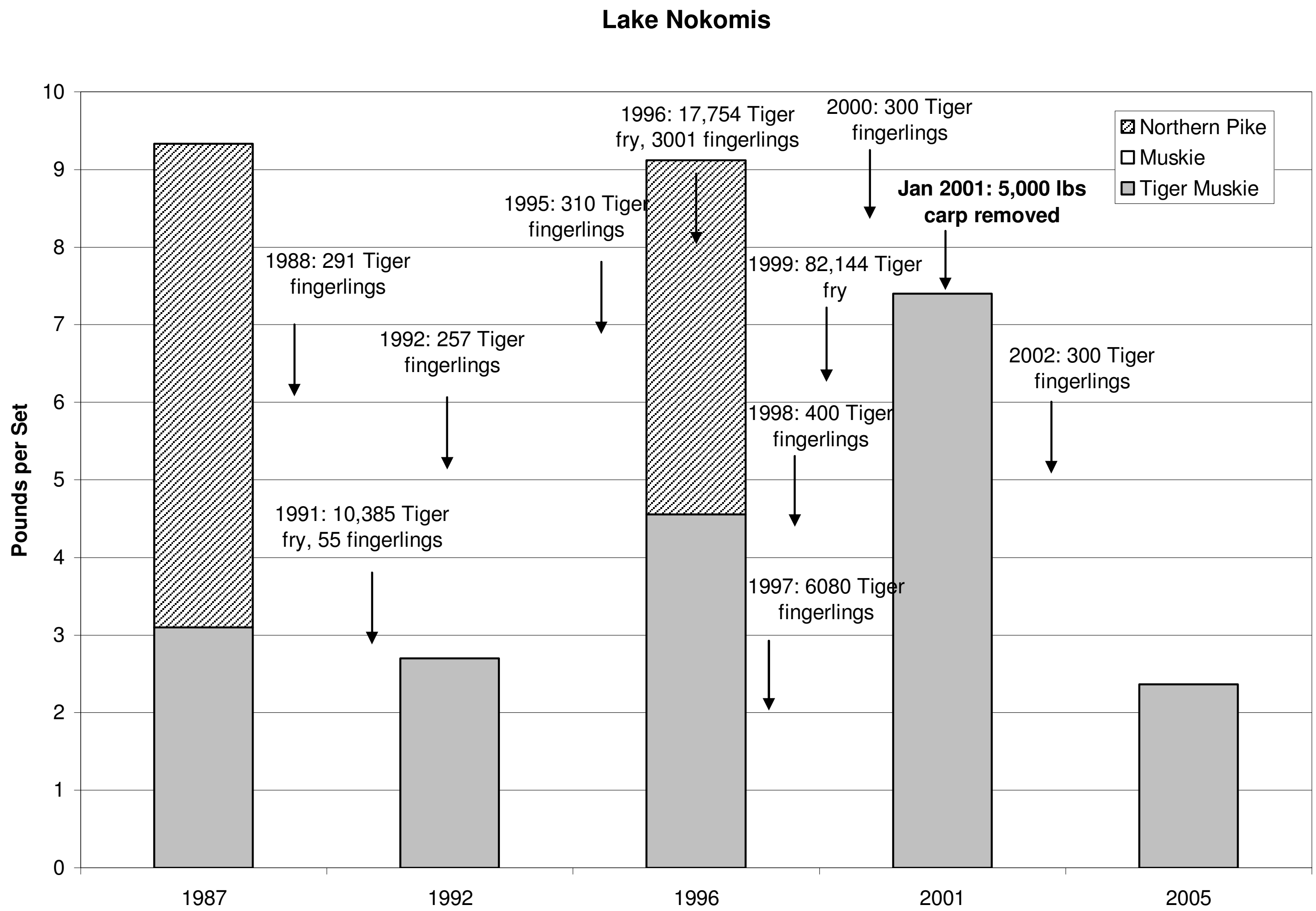
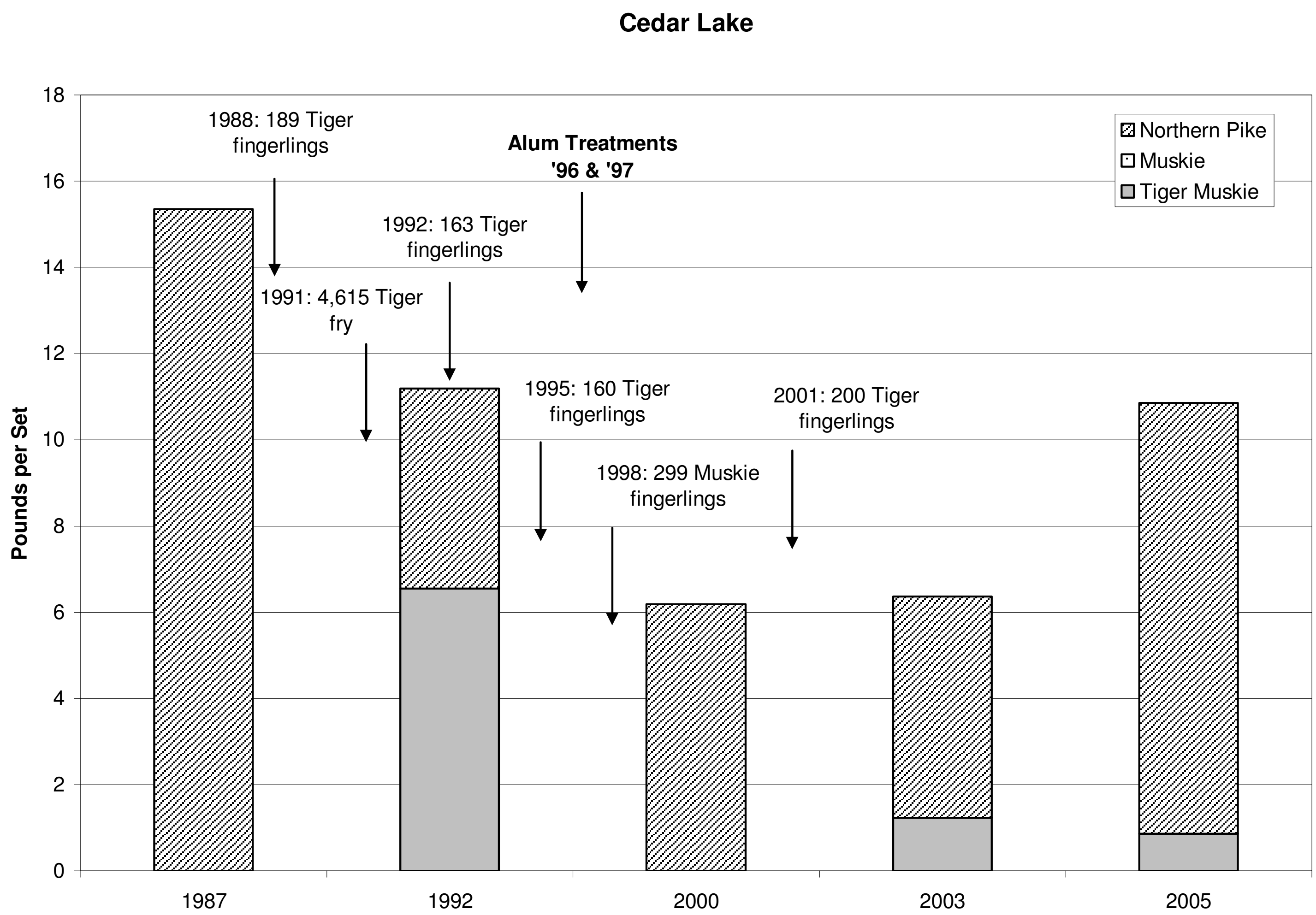
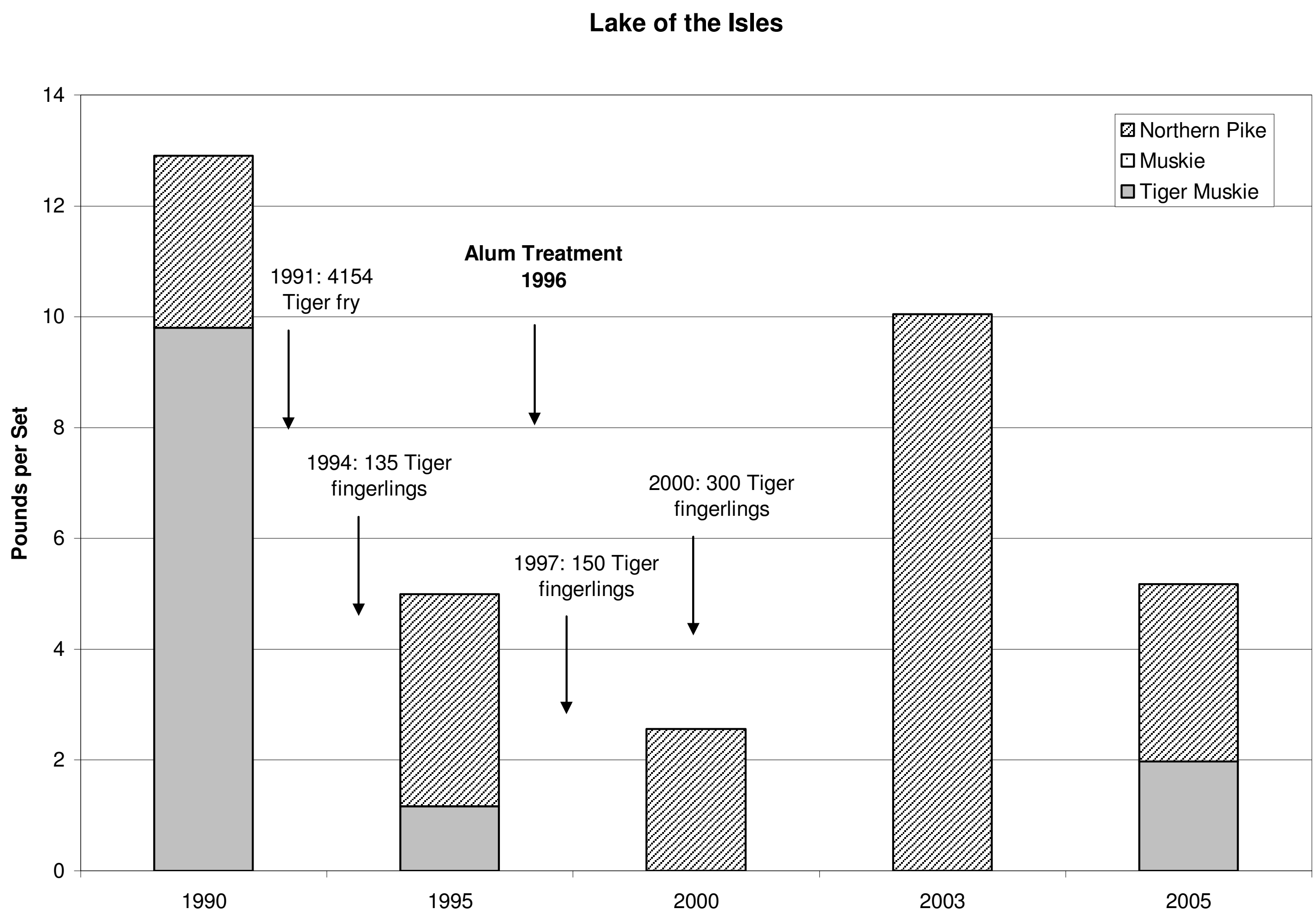
Appendices

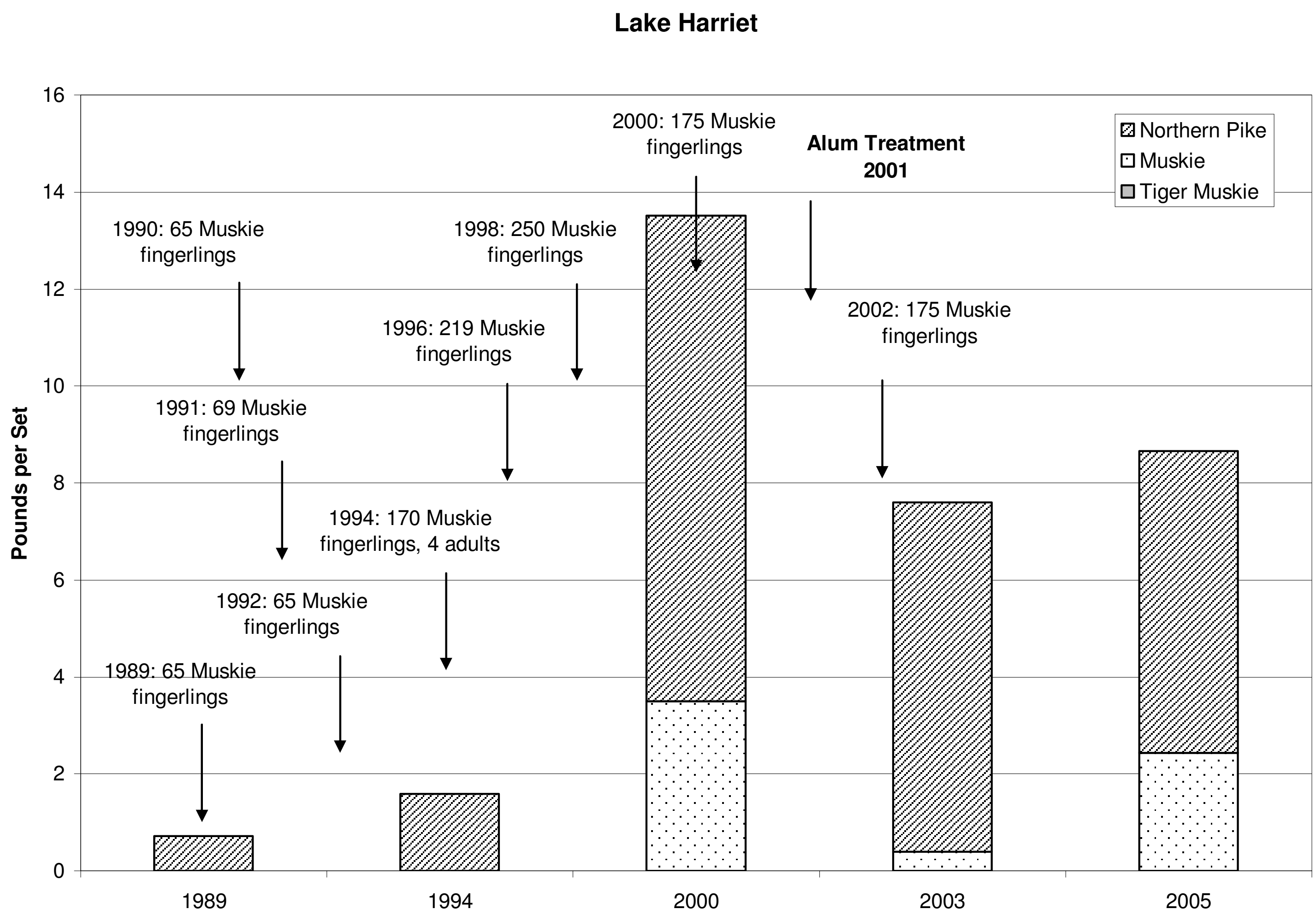
Appendix A-Fisheries Data

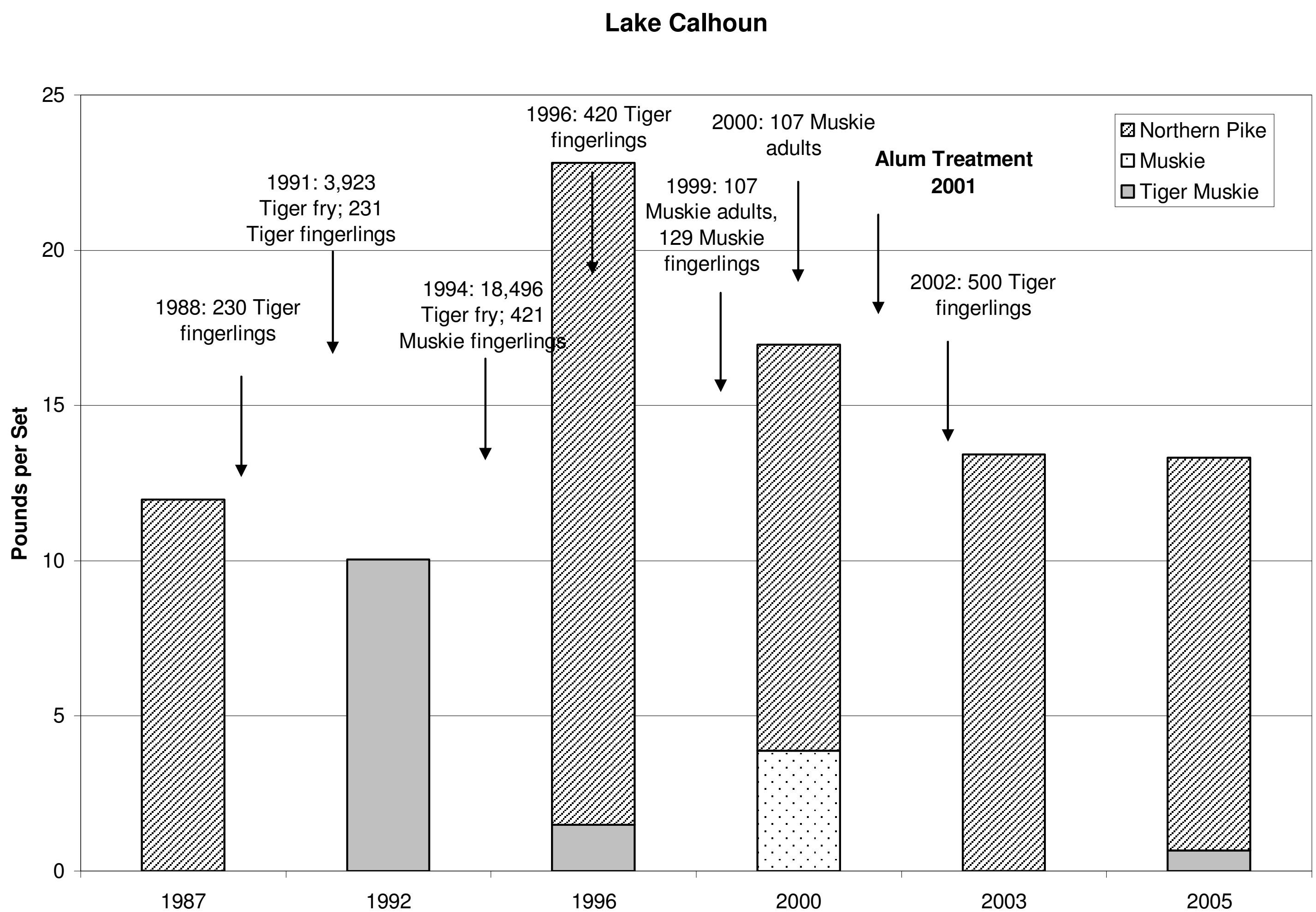
Minneapolis Chain of Lakes Data



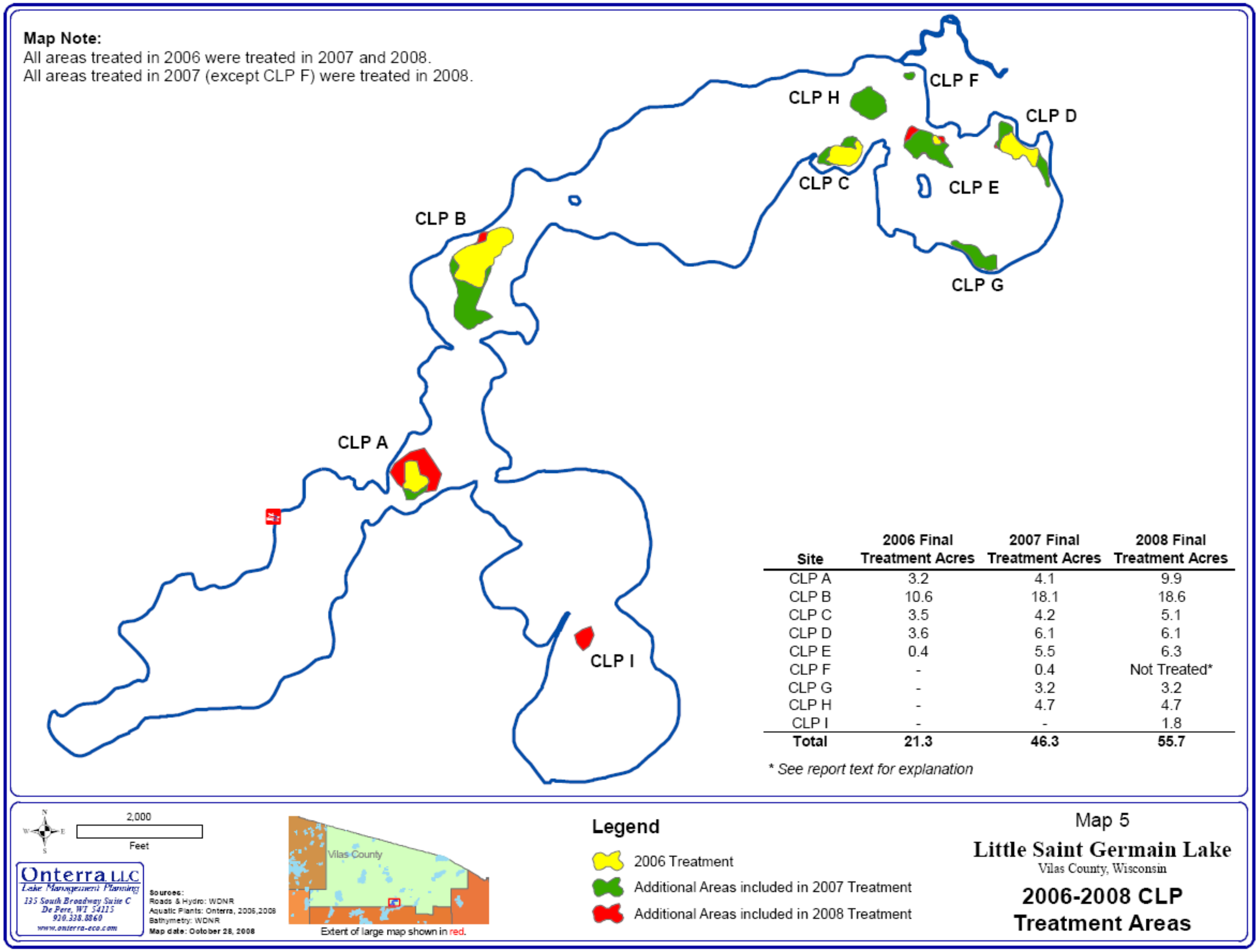

Cedar Lake
Pounds per Set
18
16
14
12
10
8
6
4
2
0
1987
1992
2000
2003
2005
Northern Pike
Muskie
Tiger Muskie
1988: 189 Tiger fingerlings
Alum Treatments '96 & '97
1992: 163 Tiger fingerlings
1991: 4,615 Tiger fry
1995: 160 Tiger fingerlings
2001: 200 Tiger fingerlings
1998: 299 Muskie fingerlings


Lake of the Isles
Pounds per Set
14
12
10
8
6
4
2
0
1990
1995
2000
2003
2005
Northern Pike
Muskie
Tiger Muskie
1991: 4154 Tiger fry
Alum Treatment 1996
1994: 135 Tiger fingerlings
1997: 150 Tiger fingerlings
2000: 300 Tiger fingerlings


Lake Harriet
Pounds per Set
16
14
12
10
8
6
4
2
0
1989
1994
2000
2003
2005
Northern Pike
Muskie
Tiger Muskie
1989: 65 Muskie fingerlings
1990: 65 Muskie fingerlings
1991: 69 Muskie fingerlings
1992: 65 Muskie fingerlings
1994: 170 Muskie fingerlings, 4 adults
1996: 219 Muskie fingerlings
1998: 250 Muskie fingerlings
2000: 175 Muskie fingerlings
Alum Treatment 2001
2002: 175 Muskie fingerlings

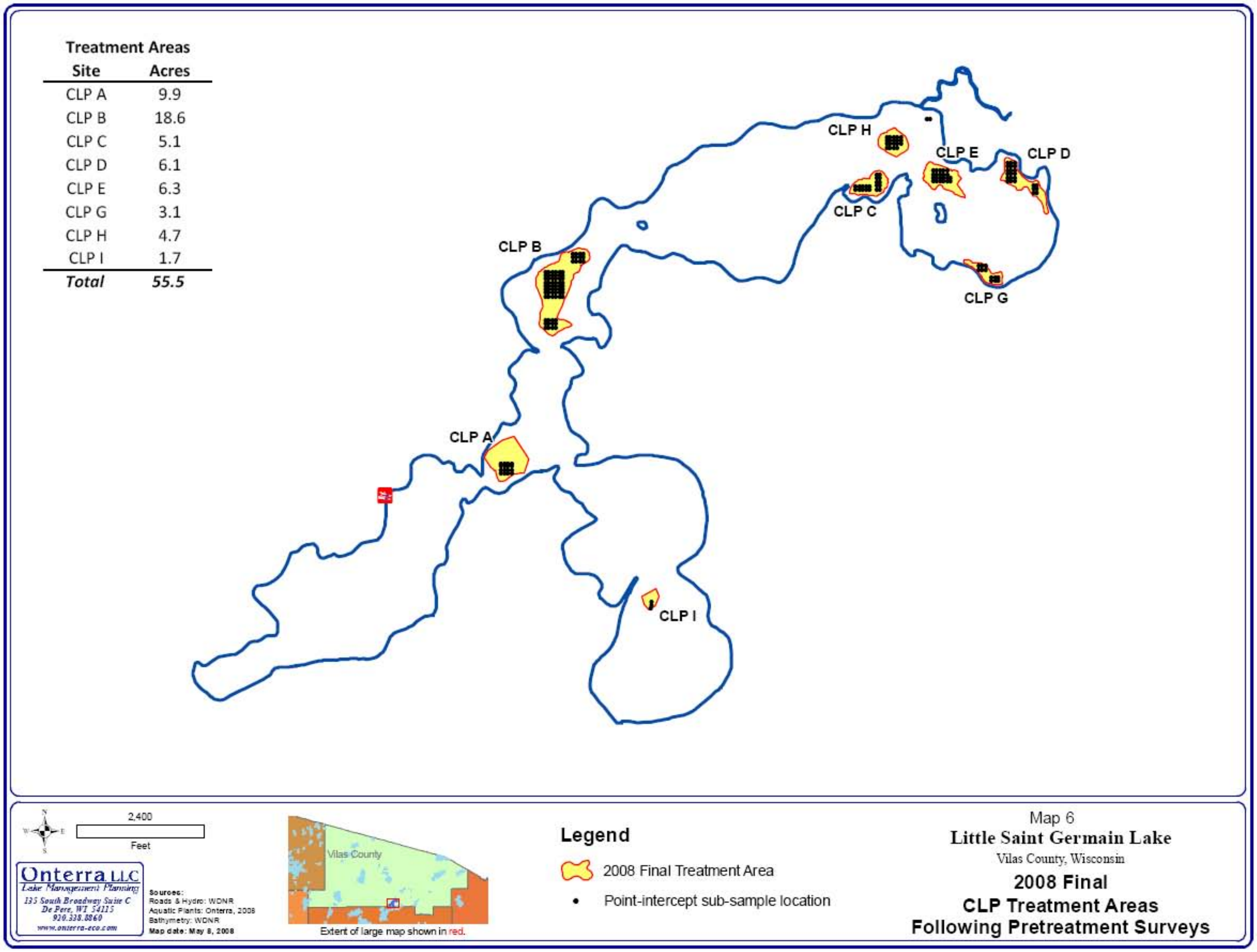

Lake Calhoun
Pounds per Set
25
20
15
10
5
0
1987
1992
1996
2000
2003
2005
Northern Pike
Muskie
Tiger Muskie
1988: 230 Tiger fingerlings
1991: 3,923 Tiger fry; 231 Tiger fingerlings
1994: 18,496 Tiger fry; 421 Muskie fingerlings
1996: 420 Tiger fingerlings
1999: 107 Muskie adults, 129 Muskie fingerlings
2000: 107 Muskie adults
Alum Treatment 2001
2002: 500 Tiger fingerlings

Appendix B-Macrophyte Maps



Site	2006 Final Treatment Acres	2007 Final Treatment Acres	2008 Final Treatment Acres
CLP A	3.2	4.1	9.9
CLP B	10.6	18.1	18.6
CLP C	3.5	4.2	5.1
CLP D	3.6	6.1	6.1
CLP E	0.4	5.5	6.3
CLP F	-	0.4	Not Treated*
CLP G	-	3.2	3.2
CLP H	-	4.7	4.7
CLP I	-	-	1.8
Total	**21.3**	**46.3**	**55.7**

** See report text for explanation*



Treatment Areas

Site	Acres
CLP A	9.9
CLP B	18.6
CLP C	5.1
CLP D	6.1
CLP E	6.3
CLP G	3.1
CLP H	4.7
CLP I	1.7
Total	***55.5***

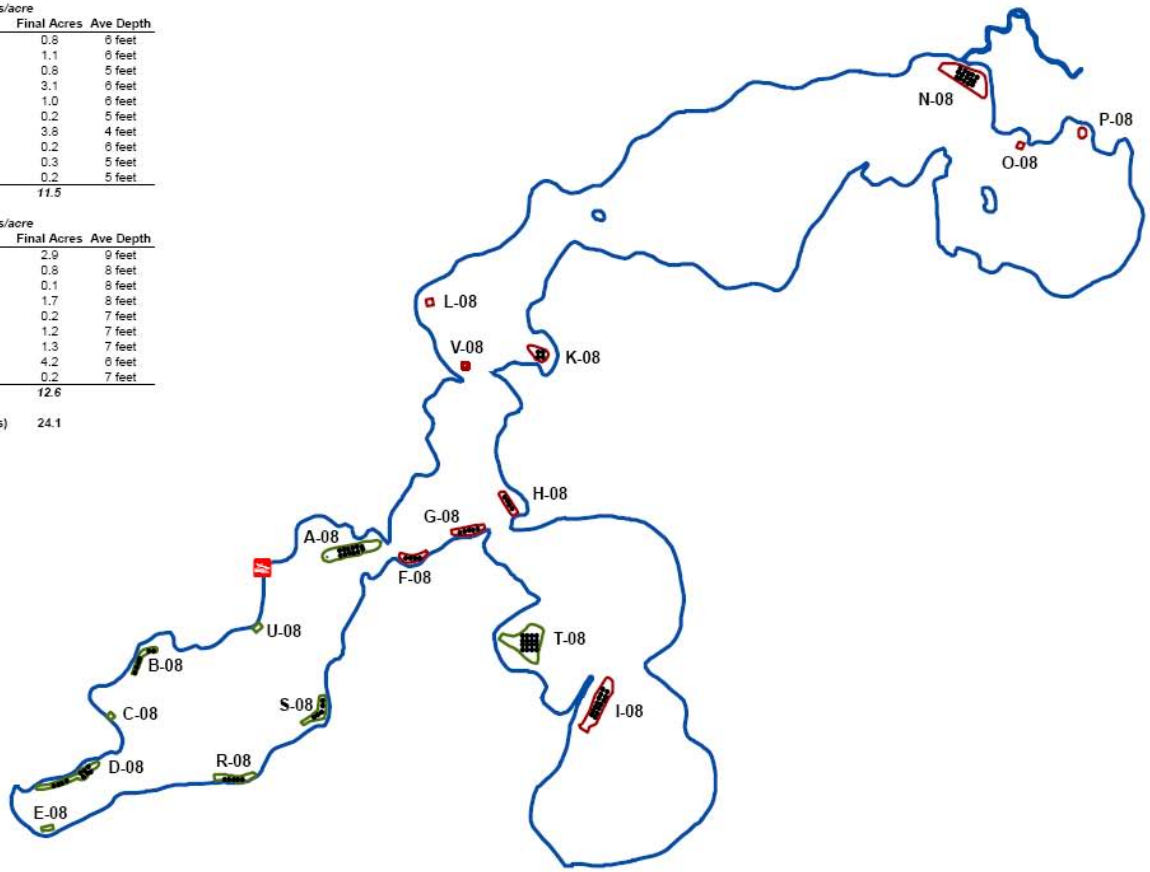
Treatment Area - 100 lbs/acre

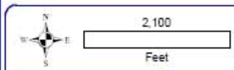
Site	Final Acres	Ave Depth
F-08	0.8	6 feet
G-08	1.1	6 feet
H-08	0.8	5 feet
I-08	3.1	6 feet
K-08	1.0	6 feet
L-08	0.2	5 feet
N-08	3.8	4 feet
O-08	0.2	6 feet
P-08	0.3	5 feet
V-08	0.2	5 feet
Subtotal	***11.5***	

Treatment Area - 150 lbs/acre

Site	Final Acres	Ave Depth
A-08	2.9	9 feet
B-08	0.8	8 feet
C-08	0.1	8 feet
D-08	1.7	8 feet
E-08	0.2	7 feet
R-08	1.2	7 feet
S-08	1.3	7 feet
T-08	4.2	6 feet
U-08	0.2	7 feet
Subtotal	***12.6***	

Grand Total (Final Acres) 24.1





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Sources:
Roads & Hydro: WDNR
Aquatic Plants: LSGPRD, 2007
Bathymetry: WDNR, Digitized by Onterra
Map date: June 4, 2008

Extent of large map shown in red.

Legend

2008 EWM Final Treatment Areas

- 100 lbs/acre
- 150 lbs/acre
- Point-intercept sub-sample location

Map 7

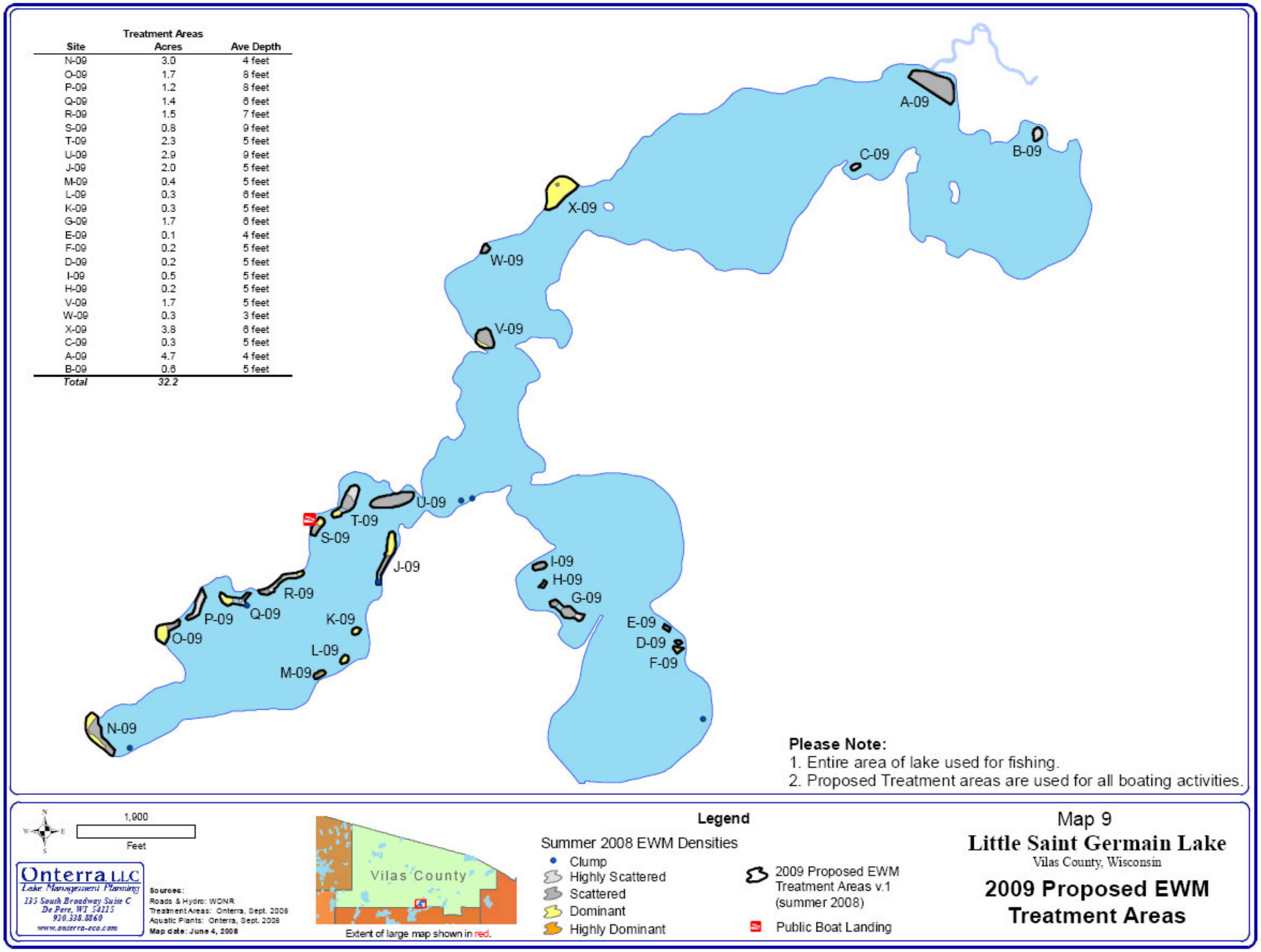
Little Saint Germain Lake

Vilas County, Wisconsin

2008 Final
EWM Treatment Areas

Treatment Areas

Site	Acres	Ave Depth
N-09	3.0	4 feet
O-09	1.7	8 feet
P-09	1.2	8 feet
Q-09	1.4	6 feet
R-09	1.5	7 feet
S-09	0.8	9 feet
T-09	2.3	5 feet
U-09	2.9	9 feet
J-09	2.0	5 feet
M-09	0.4	5 feet
L-09	0.3	6 feet
K-09	0.3	5 feet
G-09	1.7	6 feet
E-09	0.1	4 feet
F-09	0.2	5 feet
D-09	0.2	5 feet
I-09	0.5	5 feet
H-09	0.2	5 feet
V-09	1.7	5 feet
W-09	0.3	3 feet
X-09	3.8	6 feet
C-09	0.3	5 feet
A-09	4.7	4 feet
B-09	0.6	5 feet
Total	*32.2*	



H

APPENDIX H

2009 Treatment Report

INTRODUCTION

Herbicide treatments of Eurasian water milfoil (EWM) and curly-leaf pondweed (CLP) were completed on Little Saint Germain Lake during May 2009. This report discusses the methods used to evaluate the treatment and the criteria used to determine if it was successful beginning with the summer 2008 survey (summer pretreatment) completed during August 2008. The report goes on to discuss the condition of the EWM in the treatment areas in the spring before the 2009 treatment (spring pretreatment) and then in August 2009 (summer post treatment) following the herbicide application. Similar to past years, the peak biomass survey was completed in August 2009 to gather information used in creating the 2010 proposed treatment areas, which are discussed near the end of the report. Once agreed upon by the Little Saint Germain Lake Protection and Rehabilitation District (LSGPRD) and the Wisconsin Department of Natural Resources (WDNR), the proposed treatment areas will be used to obtain a conditional treatment permit for the May 2010 treatment.

TREATMENT MONITORING

Determining the success or failure of chemical treatments on AIS is often a difficult task because the criteria used in determining success or failure is ambiguous. Most people involved with AIS management, whether professionals or laypersons, understand that the eradication of AIS from a lake, or even a specific area of a lake, is nearly, if not totally, impossible. Most understand that achieving control is the best criteria for success. Two different methods of evaluation were used to understand the level of control that was achieved by the chemical treatment. A qualitative assessment was determined for each treatment site by collecting spatial data with a sub-meter Global Positioning System (GPS), in addition to, comparing detailed notes from the pre- and post treatment observations.

Previous to the 2005 field season, the LSGPRD received a WDNR Aquatic Invasive Species (AIS) grant to aid in the control of EWM and CLP within the lake. After the grant was awarded, Onterra was contracted to monitor and coordinate the treatments. The project was initially set up by conducting a point-intercept survey of the entire lake in early May. The point-intercept survey was intended to provide a systematic method to search the entire lake for AIS. However it became apparent that this method is too *coarse scale* to provide the information for which it was intended. After discussions with the LSGPRD, it was agreed that the time used to complete these surveys may be better appropriated to bring the project more in line with recently devised protocols.

Starting in May 2008, quantitative monitoring of the treatments were completed following protocols disbursed by the Wisconsin Department of Natural Resources (WDNR) in April 2007. This protocol calls for the monitoring of target plants (EWM and CLP) and native plants before and after treatments. The methodology is specifically designed for EWM treatments and includes pretreatment surveys being completed the summer before treatment and the spring of the treatment. Post treatment surveys are completed the summer following treatment and in some case, carried out for multiple summers after the treatment.

The monitoring of CLP treatments differs slightly, as quantitative sampling would be conducted the spring previous to the treatment (pretreatment) and the spring following the treatment (post treatment). Because of CLP'slife cycle, a post treatment survey a few weeks following the treatment would not differentiate if a reduction in CLP occurrence could be attributed to the herbicide application or the natural die-off of the species. For this reason, the 2009 CLP treatment will not be discussed in terms of treatment effectiveness, as the post treatment data will not be collected until the spring of 2010. However, the 2008 CLP treatment will be discussed as quantitative data is available between spring 2008 (pretreatment) and spring 2009 (post treatment). Cost coverage for the spring 2008 CLP pretreatment survey is included in the 2005 AIS grant and the 2009 CLP post treatment survey within the February 2009 AIS grant.

During the February 2009 WDNR grant cycle, the LSGPRD received partial funding for a four-year AIS Control and Prevention Project aimed at reducing EWM and CLP within the lake. During the following grant cycle (August 2009), the LSGPRD secured the remaining funds needed to carry-out the multi-year project. The four-year project covers the 2009-2012 treatments of EWM and CLP. As stated above, the 2008 CLP treatment will also be evaluated within this report.

Quantitative data was collected during the summer of 2008 on Little Saint Germain Lake, but with the uncertainty of grant funds, point-intercept collections were aimed solely at monitoring the 2008 treatment areas. Only 41 of those locations are useable to evaluate the 2009 treatment (Table 2) as there was not much overlap in sites treated in 2008 and 2009. In total, 187 sub-sample locations were visited in August 2009 to serve as the 2010 pretreatment survey for EWM. At all locations, EWM presence and rake fullness were documented as well as water depth and substrate type. Native plant abundances were also determined at each plot during those surveys.

As outlined within the August 2009 AIS Established Population Control Grant application, the treatments within the four-year project would be monitored through the combined efforts of professionals and volunteers. A group of volunteers would work to monitor the lake for existing and new aquatic invasive species, while professional staff from Onterra would complete surveys to determine prospective treatment areas and complete quantitative sampling. Volunteers would scout Little Saint Germain Lake in late July or early August in search of EWM to supplement and enhance surveys completed by Onterra staff during August. The results of the surveys would be used to create the prospective treatment areas for the following year.

Statistical Analysis of Pre- and Post Treatment Survey Data

Scientists often rely on the use of statistical analysis to understand whether the observed differences in nature are merely a product of chance or can be attributed to a particular factor. In the case of the pre- and post treatment monitoring surveys completed on Little Saint Germain Lake, the particular factor we are concerned with is the herbicide treatment. The desired result is a decrease in AIS within the treatment areas. The amount of AIS within a treatment site is measured with the sub-sampling surveys and expressed in terms of percent frequency of occurrence. AIS frequency is the percentage of sub-sampling sites that contain AIS relative to the total sub-sampling sites.. For example if a treatment site has 20 sub-sampling locations and 5 of those locations contained EWM, then the EWM frequency would be 25%.

As a part of the treatment monitoring, the sub-sampling sites are visited before and after the treatments to produce the pre- and post treatment data. By comparing those data, we can see if there is more, less, or the same amount of AIS before and after the treatment. As mentioned above, the desired result is to have less AIS after treatment. If there is a difference between the pre- and post treatment data, statistical analysis is used to determine if the difference is sufficient to be attributed to the treatment or if the difference may have occurred randomly. If the difference is sufficient, it is considered to be *significantly different*, if it is not sufficient, it is considered to be *insignificantly different*. In the end, a significant difference can be attributed to some factor, while an insignificant difference can only be attributed to random chance.

With guidance from WDNR Integrated Sciences, a Chi-square distribution analysis (alpha = 0.05) was used to determine if the quantitative data collected before the treatment are statically different from the data collected after the treatment. The alpha value is set such that we consider the results statistically significant when the test is 95% confident that the results are truly different and non-random.

The number of sub-sample sites within a treatment area must be considered when evaluating the treatment impacts on that particular site. A higher sample size (N), leads to more credible results and conclusions. In general, sites containing less than 6 sub-sample locations are not considered sufficient for analysis; however, those data are considered valuable when pooled (combined) with the other sub-sample sites within the lake for the lake-wide analysis. A 20-meter spacing (resolution) between sub-sample locations is considered the closest that hand-held GPS technology can effectively allow. Additionally, as mentioned above, only those sites that were sampled in both 2008 and 2009 were used in the analysis.

The caveat to all of this is that we assume that the differences observed were caused by the herbicide treatment, but truly, without having comparable data from a non-treatment site (control group), this cannot be absolutely certain. For example, was the reduction in EWM caused by inter-annual variations caused by competitive dynamics between species, fluctuating water levels, natural plant cycles, or changes due to climatic conditions? Without a true experimental design that uses a control site (the monitoring of an area that was not treated) we cannot absolutely answer that question. In the end, it is impractical to take the risk of not treating a colony of AIS within a lake just to make sure that the results of the studies are scientifically sound; therefore making the educated-assumption that the difference is caused by the herbicide treatment is reasonable.

Pretreatment Survey – 05/08/09 and 05/11/09

One aspect of this survey was to refine the treatment areas used in the conditional permit to more accurately and effectively coordinate the control effort. These areas were accepted by the LSGPRD and the WDNR, and considered the *final* treatment areas. These data were then provided to the herbicide applicator.

During this survey, quantitative data were also collected to understand the efficacy of the CLP treatment. The data collected would serve as a post treatment survey to evaluate the previous year's treatment in addition to serving as a pretreatment survey for the upcoming treatment

The weather conditions on the first day of the survey were sunny with light wind. The second day was partly cloudy and windy. Viewing the EWM on Little Saint Germain Lake from the surface was relatively effortless because of the clarity of the water at this time of the year. An aqua scope and submersible video camera were used to aid in the survey. The ambient air temperature was 48°F and 65°F, respectively. The surface water temperature was approximately 52°F and 57°F, respectively.

Curly-leaf Pondweed

In 2008, 55.5 acres were treated with Aquathol-K at 1.5 ppm to control CLP. These areas served as the proposed 2009 treatment areas for which a conditional herbicide application permit was submitted. During the surveys, a submersible camera was used almost exclusively to locate CLP as it was quite early in the plant's growth at that time of year.

For the most part, CLP density was observed to significantly less within all of the sites – especially in Site A. CLP sites G and H were removed as almost no plants were observed within the proposed treatment areas after being transected numerous times using submersed video and rake tows (Map 1). In total, 46.4 acres were treated to control CLP in 2009.

Eurasian Water Milfoil

A conditional permit containing 32.2 acres was created for the 2009 treatment (Map 2). As stated above, the project was designed to have professionals monitor the treatments and refine the mapping of new occurrences based on data collected by LSGPRD volunteers. Along with reducing the costs associated with hiring professionals, these activities instill ownership within the project and a better understanding of how well the treatments are working.

The 2009 treatment areas were created after revisiting the 2008 treatment sites and the GPS locations marked by volunteer LSGPRD members. After the conditional permit was created, additional EWM occurrences were found by district members. Since the conditional permit was already submitted, it was determined not to revised the conditional permit, but simply integrated the additional areas into the *focus areas* that would be visited by Onterra staff during the 2009 spring pretreatment survey.

After the spring survey, the acreage of EWM warranting treatment increased approximately 8 acres to 40.2 acres (Map1) Two conditional treatment sites in East Bay, totaling about one acre, were removed because little to no EWM was observed. The district decided to take an aggressive approach and treat all the areas that warranted treatment.

Post Treatment & Peak biomass EWM Survey – 09/02/09

During this survey, all EWM treatment areas were visited to determine the efficacy of the chemical application. The conditions were mostly sunny with a slight breeze. At this time of year the EWM is at peak growth and the plants have nearly reached the surface, making viewing the plant optimal. All point-intercept sample locations were revisited and data were collected in the same manner as during the pretreatment survey. Native plant occurrences were also documented at the sub-sample locations during this survey for comparison with past and future summer surveys.

As outlined within the Little Saint Germain Comprehensive Plant Management Plan (Draft), success of the herbicide treatments would be evaluated in multiple ways. Qualitatively, a successful treatment on a particular site would include a reduction of EWM density as demonstrated by a decrease in density rating (e.g. highly dominant to dominant). In terms of a treatment as a whole, at least 75% of the acreage treated that year would decrease by one level of density as described above for an individual site.

Quantitatively, a successful treatment on a specific site would include a significant reduction in EWM frequency following the treatments as exhibited by at least a 50% decrease in EWM frequency based upon the sub-sampling. In other words, if the EWM frequency of occurrence before the treatment was 80%, the post treatment frequency would need to be 40% or lower for the treatment to be considered a success for that particular site. Evaluation of the treatment-wide effectiveness would follow the same criteria based upon pooled sub-sample data from all treatment sites. Further, there would be a noticeable decrease in rake fullness ratings within the fullness categories of 2 and 3. Preferably, there would be no rake tows exhibiting a fullness of 2 or 3 during the post treatment surveys.

During this field survey, a peak biomass EWM survey was conducted to provide an accurate account of all EWM locations within the lake to aid in coordinating the 2009 management actions. These recommendations are provided within this section.

South Bay

Site D-09 There was no EWM found within the southern portion of this treatment area which before the treatment contained a highly dominant EWM colony and a scattered EWM area (Maps 2 and 3). Additionally, the northern part of the treatment area that was dominant before the treatment is now reduced to a scattered density, but the colony expanded in size since the 2008 peak biomass survey (Maps 2 and 3). This small scattered colony is recommended for treatment in 2010 (Map 4, D-10).

Sites G-09, H-09, and I-09 Before the treatment, the bay that contained these treatment sites contained a few scattered EWM colonies. Only a few single EWM plants were found within this bay after the treatment (Map 3). For the most part, the remaining EWM was located at the margins or just outside of the 2009 treatment areas. At this time, there is not enough EWM found to warrant repeat treatment in these areas during 2010.

Site Y-09 In the spring of 2009, this site, was added to the treatment permit because several clumps of EWM were found during the pretreatment survey(Map 2). After the treatment, little to no EWM was observed within most of the site, except for a small scattered colony at the extreme northern part of the site (Map 3). The new colony is proposed for treatment in 2010 (Map 4, F-10).

West Bay

Site J-09 Little to no treatment affect was observed within this site. The density of EWM has remained largely the same from last year, buthas spread to the south of this site along the shore (Maps 2 and 3). This site is recommended for treatment in 2010 including the southern expansion (Map 4, H-10).

Sites K-09 and L-09 The treatments had little or no affect on the EWM within either of these sites. The density remained the same and the EWM colonies in between K-09 and L-09 have coalesced into one large colony, in addition to EWM spreading to the south of L-09 (Maps 2 and 3). This area of scattered and dominant EWM is recommended for treatment in 2010 (Map 4, I-10).

Sites M-09 Only a few single EWM plants remained after the treatment within an area that contained dominant and highly dominant EWM during August 2008 (Maps 2and 3). This site is not recommended for treatment in 2010 but will remain a focus area as EWM occurrences encroaching from the northeast may form a single colony warranting treatment

Site N-09 A decrease in EWM density was observed within the near shore portions of this treatment site where it was found to be dominant in 2008 (Maps 2 and 3). After the treatment most of N-09 was found to contain scattered EWM occurrences (Map 3). Additionally, there was a highly scattered colony with an area of dominant EWM found along the north shore of this bay to the east of N-09 (Map 3). Site N-09 and this new found colony are proposed to be treated as a single site in 2010 (Map 4, J-09)

Sites O-09, P-09, and R-09 Numerous scattered and dominant areas of EWM span along the shoreline between Site 0-09 and R-09. Overall the 2009 treatments successfully impacted the density of EWM within these sites. Again the EWM in this area will be targeted by three treatment sites (Map 4: K-10, L-10, and M-10). Particular attention will be paid in this area during the spring 2010 pretreatment survey as it may be more appropriate to treat the entire area as a single site if EWM expansion continues.

Site S-09 The treatment had little effect on the EWM within this site. In 2008, there were three separate colonies delineated in front of main public access location for the lake. During the August post treatment survey, it was found that EWM growth had *filled in* the areas between the colonies (Map 3). This site is proposed to be retreated in 2010 (Map 4 M-10).

Site U-09 EWM decreased one density rating from scattered to highly scattered after the treatment (Maps 2 and 3). EWM expanded slightly from August 2008 toward the shore (Map 3). This site is proposed for treatment again in 2010 including the shoreward expansion (Map 4, O-10).

East Bay

Site V-09 The EWM at this site was impacted, but only slight reductions in density were observed (Maps 2 and 3). This area is proposed to be retreated to further impact the EWM within this area (Map 4, Site P-10)

Sites W-09and X-09 No EWM was observed within these sites after the treatment and neither is recommended for treatment in 2010 (Map 3 and Map 4).

Site A-09 The size of the EWM colony was reduced from 3.7 acres to 0.9 acres after the treatment (Maps 2 and 3). Although the size of the colony has been reduced, the density remains scattered and is recommended for treatment next year (Map 4, A-10).

Site Z-09 Several plants were observed at this site before the treatment during the spring of 2009 and no plants found following the treatment (Maps 2 and 3). Site Z-09 is not recommended for treatment in 2010.

CONCLUSIONS AND RECOMMENDATIONS

Curly-leaf Pondweed

After the pretreatment survey, approximately 9 acres were removed from the proposed treatment areas. This marked the first occasion since professional involvement began where CLP treatment acreage was reduced. A cursory look at this data may indicate that the CLP treatments on Little Saint Germain Lake are not successful since there has been an increase in the amount of CLP treated each year since 2006. Because CLP primarily spreads from asexual reproductive structures called turions which can last in the sediment for a number of years, a continued commitment to this management strategy will be needed to reduce the turion base.

In 2008, many of these areas have would been treated for their second or third time, likely approaching the point when the depletion of the turion base can be detected, as manifested by the decrease in the number of plants that sprout each spring from this reproductive structure. The reduction in acreage requiring treatment in 2009 likely indicates this phenomenon.

Table 1 displays the quantitative data monitoring the 2008 herbicide treatment. Before the 2008 treatment, 14 of the 185 sub-sample locations contained CLP and 18 contained CLP during the spring following the treatment. Because the CLP infestation in Little Saint Germain is sparse, significant differences are impossible to detect. Actually, except for CLP C, none of the results including the treatment-wide results are statistically significant and difference could be a result of random variation.

Table 1. CLP occurrence in point-intercept locations displayed by treatment site.

Site	Sample Locations(N)	2008 CLP Occurrence	2009 CLP Occurrence
CLP A	16	0	0
CLP B	72	8	7
CLP C	20	0	5
CLP D	24	1	2
CLP E	21	5	3
CLP F	2	0	0
CLP G	11	0	1
CLP H	19	0	0
Total	**185**	**14**	**18**

While great strides are being made on the known occurrences of CLP, it is important that LSGPRD volunteers scour the lake in early to mid June of each year to mark new CLP occurrences. These locations would be transferred to Onterra for inclusion within the following year's focus areas to be visited during the spring pretreatment survey.

Eurasian Water Milfoil

Before the treatment on Little Saint Germain Lake, 15.6% of the point-intercept locations contained EWM and 13.3% contained EWM after the treatment, indicating an insignificant 14.7% ((13.3 – 15.6) / 15.6 x 100%) reduction in EWM occurrence. However, this quantitative data is based on only 5 of the 20 sites treated in 2009 (Table 2) and it cannot be assumed these results reflect the lake-wide treatment effects. Each of the sites that contained more than six point-intercept subsample locations were analyzed separately, but none of the sites were statistically significant. In other words it cannot be said for certain if a change in EWM occurrence is due to the treatment or if the difference may have occurred randomly.

Table 2. EWM occurrence in point-intercept locations displayed by treatment site.

Site	Sample Locations (N)	2008 EWM Occurrence	2009 EWM Occurrence
A-09	9	1	1
H-09	12	0	0
P-09	6	1	2
U-09	12	4	2
Y-09	2	1	1
Total	**41**	**7**	**6**

A rake fullness rating of 1-3 was used to determine abundance of EWM at each location. Figure 1 displays the number of point-intercept locations exhibiting each of the rake fullness ratings within the fore-noted treatment areas on Little Saint Germain Lake. The figure shows that there was little change comparing the rake fullness ratings between 2008 and 2009.

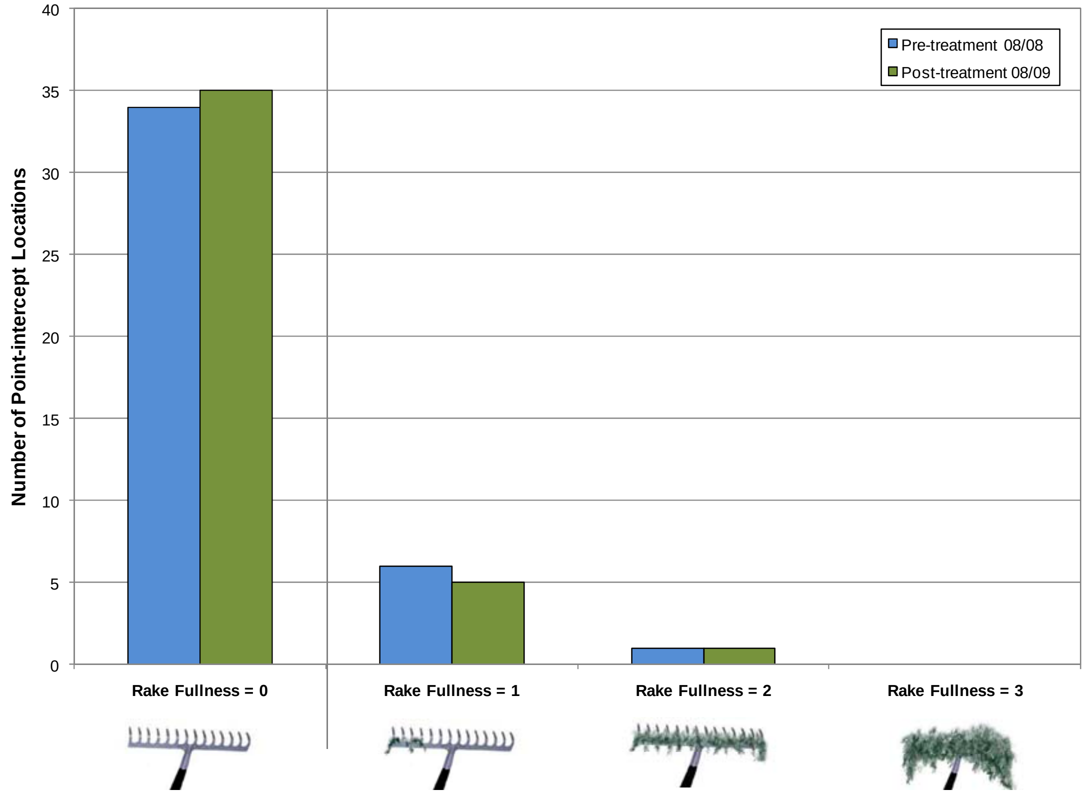


Figure 1. EWM rake fullness distribution within treated areas on Little Saint Germain Lake.

Native Plants

Although it is never the intent of the treatments to impact native species, it is important to remember that these non-target impacts can only be considered in the context of the areas treated and not on a *lake-wide* basis. In other words, the impact of the treatments on a non-target species in the treatment areas cannot be extrapolated to the entire population of that plant within the lake, unless the plant species is only found in locations where there is EWM. The same cannot be said for EWM, because by targeting nearly all EWM within the lake, it is intentionally being impacted on a lake-wide basis. One may claim that an impact to non-target natives may leave a 'hole' where pioneer infestations of EWM can take hold. The herbicide used in 2009 (2,4-D) is broad-leaf (dicot) specific and as long as a particular treatment site is not dominated by broad-leaf natives, native monocots, of which most aquatic plants are, will provide ample competition to compete against the non-native threat.

Native plant frequencies were monitored on Little Saint Germain Lake within the treatment sites listed in Table 2 during the 2008 summer pretreatment survey and the 2009 summer post treatment survey (Figure 2). Please note that Figure 2 is displaying the difference between frequency of occurrence determined during the summer of 2008 and the summer of 2009 for each native plant listed and <u>not</u> a percent change in frequency. For example, coontail occurred in approximately 91.1% of the plots during the summer of 2008 and 62.2% during the summer of 2009. Therefore, the chart indicates a negative difference (decrease) of approximately

28.9(62.2% – 91.1%) and <u>not</u> a percent change. If percent change was calculated, we would see in this example that coontail decreased by 31.7% ((62.2 – 91.1) / 91.1 x 100%).

Four plants were found to have a statistically significant decline within the five treatment areas where data is available (Figure 2). As mentioned above, 2,4-D is dicot-specific, so the decline of the monocot species, large-leaf pondweed, small pondweed, and white-stem pondweed are not likely from the treatment. Coontail was the only dicot that showed a significant decline (Figure 2). Herbicide application occurred in May before the majority of native plants should be actively growing in order to target EWM specifically, but it is possible that coontail could have been affected by the herbicide. However, coontail does not truly root to the sediment and is easily moved about the lake in masses; therefore, differences in coontail frequency between surveys may be the result of wind direction during the days preceding the surveys. There were two species that had a statistically significant increase in occurrence, clasping-leaf pondweed (monocot) and the macroalgae group of stoneworts (Figure 2).

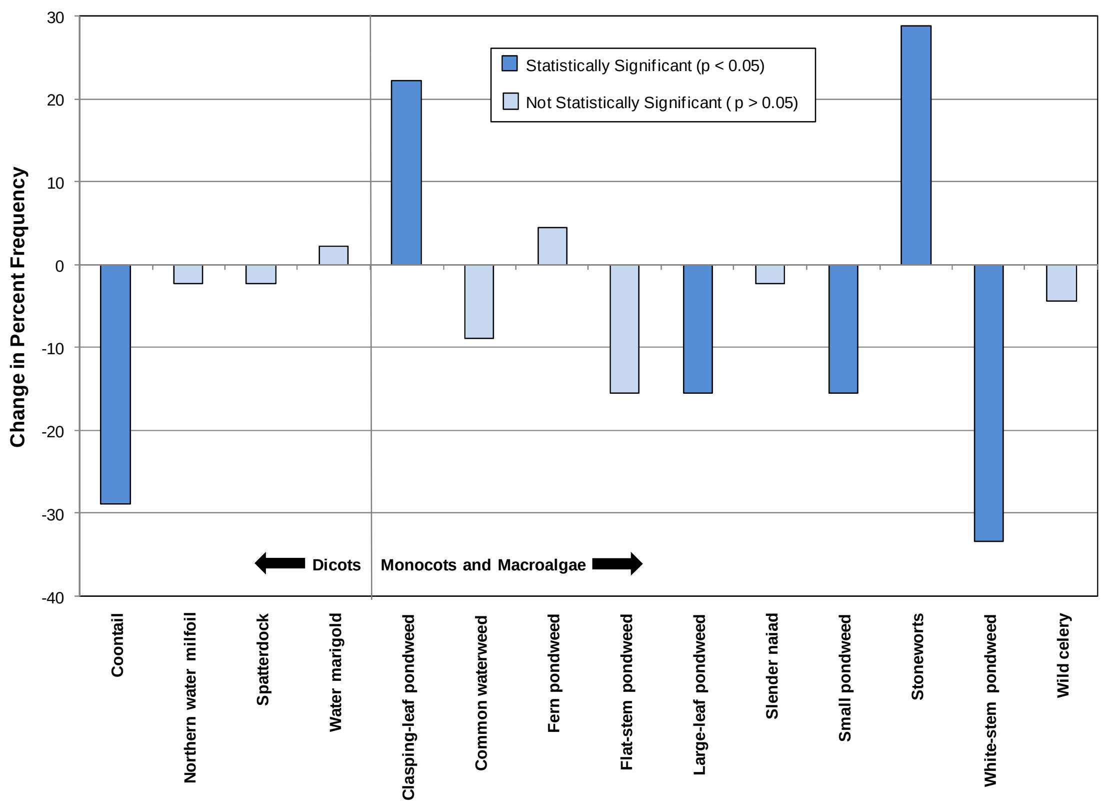


Figure 2. Native plant change in percent frequency from 2008 to 2009 on Little Saint Germain Lake.

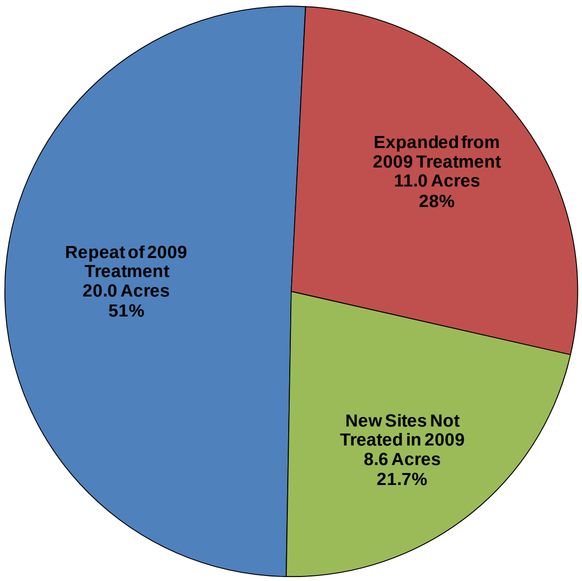


Figure 4. Common acreage comparison between 2009 treatment and proposed treatment for 2010.

Thirteen of the 20 sites treated in 2009 require repeat treatment, resulting in 51% of the 2010 treatment being common to areas treated during May 2009 (Map 4). Also, approximately 28% of the proposed 2010 treatment acreage is comprised by expanded areas of EWM during the 2009 growing season. The majority of this expansion is contained within the sites in West Bay (Map 4). Approximately 8.6 acres of newly proposed treatment areas are completely independent from previously treated areas (Figure 3); which occur in East, No Fish, and South Bays. Please note that all the new treatment areas, except C-10, were discovered during the 2008 peak biomass survey or earlier, as opposed to being newly discovered during this year. However, the EWM density of these areas has increased and now warrant treatment.

Slightly less than 75% of the treatment areas were reduced by at least one density rating after the 2009 treatment; which is just shy of meeting the qualitative success criteria discussed in the post treatment survey section. Also the qualitative analysis revealed that there was not a significant reduction in EWM occurrence within the five treatment sites that contained usable quantitative data.

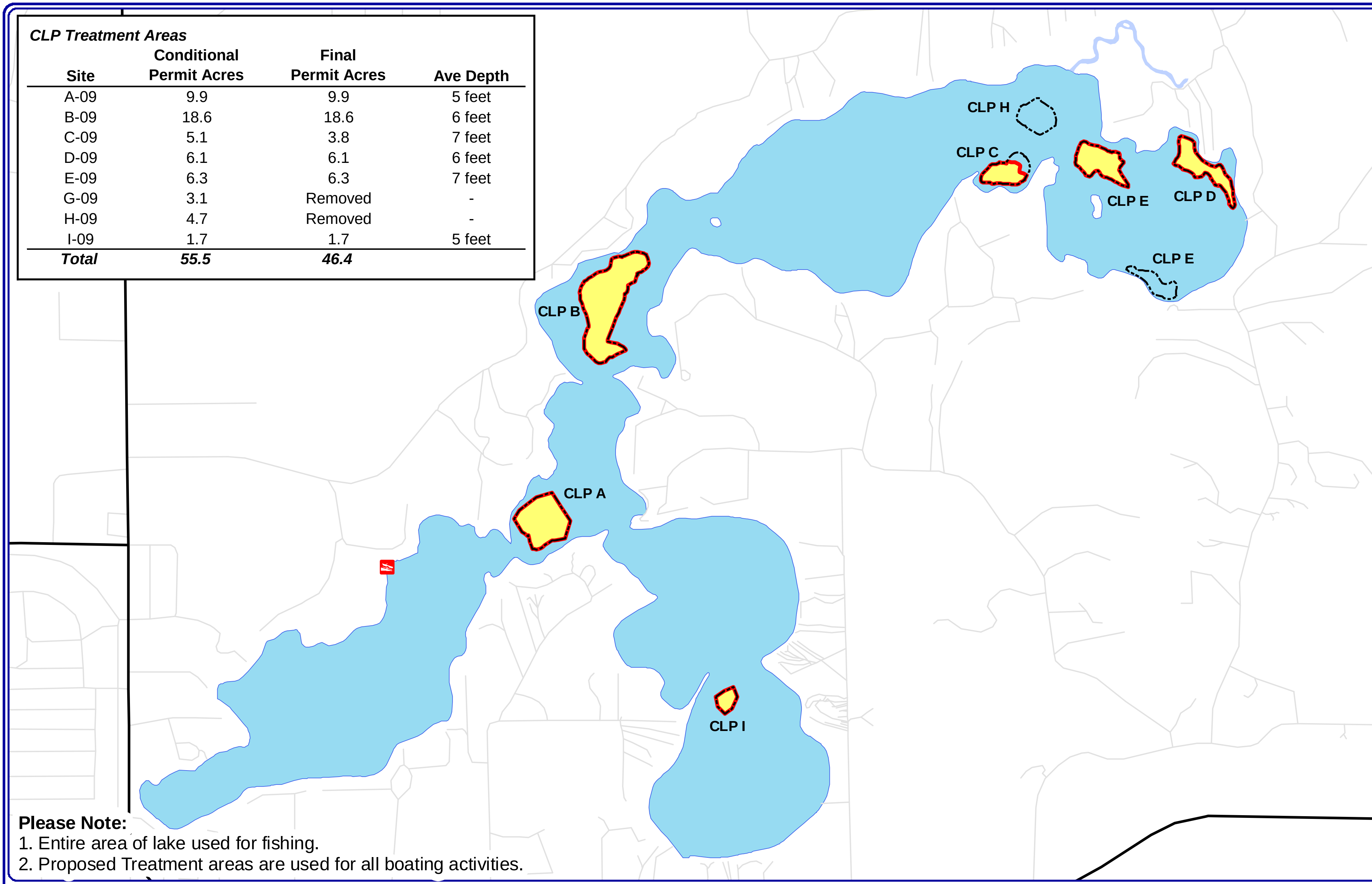
The reality is that the LSGPRD is in line to retreat many of the 2009 treatment areas in 2010, most of which are in West Bay, likely due to the deeper water and steep slopes. Retreating areas is not uncommon in EWM management as dense areas often require multiple years of the treatment to drastically decrease the site's density. One explanation for this may be the fact that the colony rebounds after treatment through germination of existing stock within the sediment's seed bank and/or through the propagation of new plants through dormant root crowns. As the area is repetitively treated, the source for new plants is depleted and the colony cannot rebound. This is much like using repeated, annual treatments to reduce the turion (reproductive structure) bank which is common in the management of CLP. In the situation of CLP, we expect to treat the same area annually over 3 to 5 years in order to deplete the turion bank held in the sediment.

Impacts resulting from the 2009 treatments that were not detectable during the 2009 summer surveys *may* become apparent during the 2010 spring and summer surveys. In some lakes, surveys completed the summer following treatment indicated poor treatment efficacy, but when the sites are reassessed the following year, treatment impacts can be seen in the form of reduced biomass. In cases such as this, the EWM may be injured to the point that it can survive the growing season following treatment, but not the following winter because the plant did not have the ability to build energy reserves in its root crown. As a result, the plant is unable to produce foliage the following spring and perishes. This would be analogous to a squirrel being injured during the summer. That squirrel may have the ability to feed itself while food supplies are high, but not the ability to gather and store food for the winter. As a result, the squirrel would survive the summer, but not make it through the winter or following spring when food is not as plentiful.

As mentioned earlier, the steep slopes, particularly in West Bay of Little Saint Germain Lake, are likely a primary factor reducing the efficacy of the treatments. The target herbicide concentration may be met in some parts of the treatment area and not others due to increased water volume with depth. Although the validity of the following statement is unknown, it is also theorized that either the granular formulation itself or the dissolved chemical may move downhill, outside of the area in which it was intended. The proposed treatment for 2010 includes increasing the treatment dose of Navigate from 150 lbs/acre to 200 lbs/acre within these areas in West Bay (Map 4). Of particular concern is the area by the boat landing, site N-10, because this is a high navigation area which increases the potential of EWM fragments to be spread to other areas by boat traffic. All other treatment areas are recommended to be treated at 150/lbs/acre.

CLP Treatment Areas

Site	Conditional Permit Acres	Final Permit Acres	Ave Depth
A-09	9.9	9.9	5 feet
B-09	18.6	18.6	6 feet
C-09	5.1	3.8	7 feet
D-09	6.1	6.1	6 feet
E-09	6.3	6.3	7 feet
G-09	3.1	Removed	-
H-09	4.7	Removed	-
I-09	1.7	1.7	5 feet
Total	***55.5***	***46.4***	



Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.

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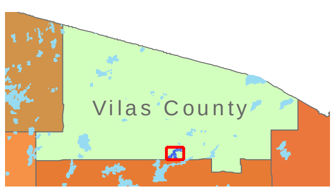
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Aquatic Plant Surveys: Onterra 2008-09
Map date: February 4, 2010



Extent of large map shown in red.

Legend

2008 CLP Treatment Area

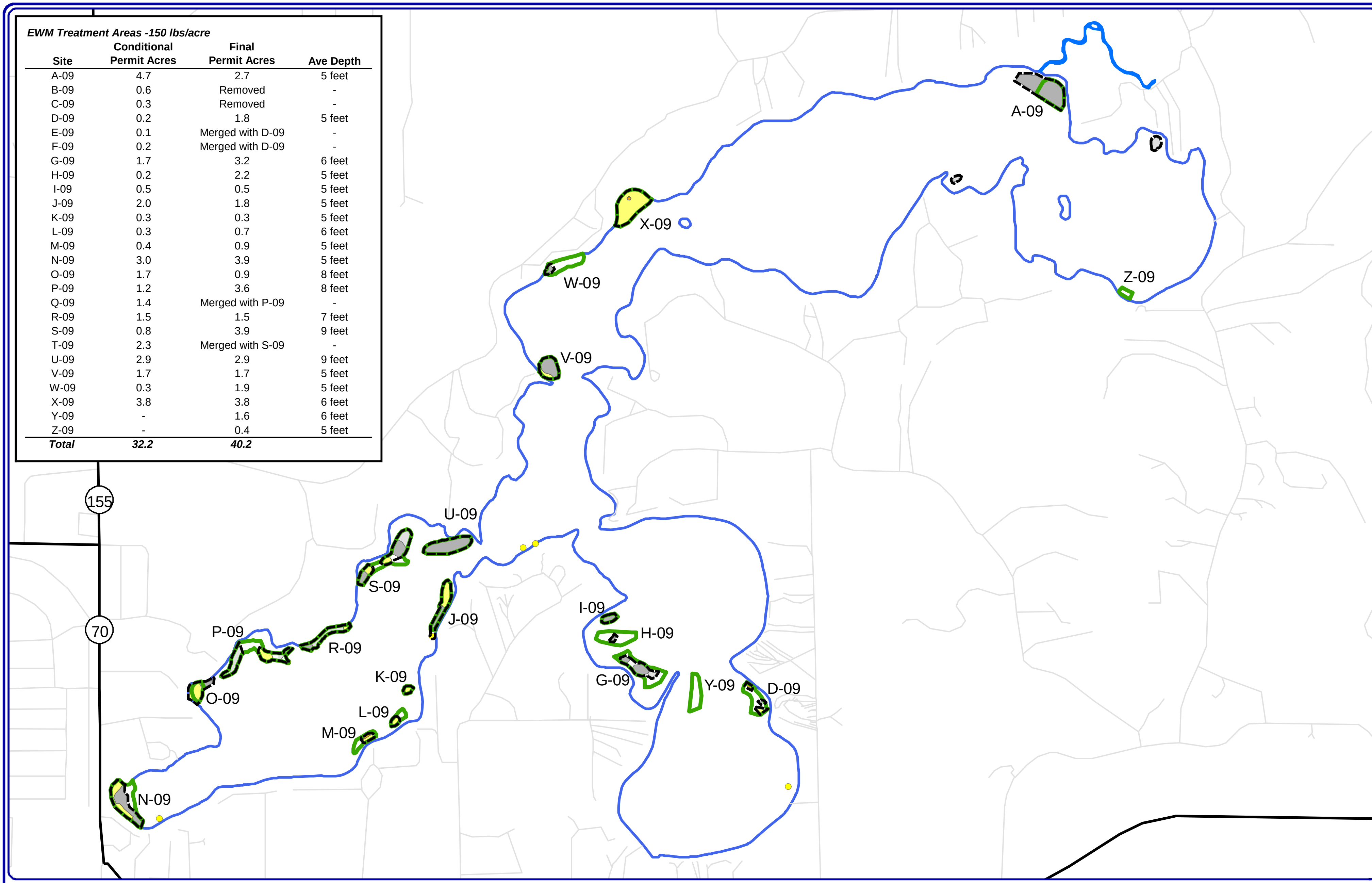
2009 CLP Treatment Area

Map 1
Little Saint Germain Lake
Vilas County, Wisconsin

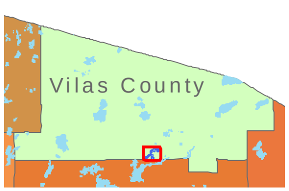
2008 and 2009 Treatment Areas

EWM Treatment Areas -150 lbs/acre

Site	Conditional Permit Acres	Final Permit Acres	Ave Depth
A-09	4.7	2.7	5 feet
B-09	0.6	Removed	-
C-09	0.3	Removed	-
D-09	0.2	1.8	5 feet
E-09	0.1	Merged with D-09	-
F-09	0.2	Merged with D-09	-
G-09	1.7	3.2	6 feet
H-09	0.2	2.2	5 feet
I-09	0.5	0.5	5 feet
J-09	2.0	1.8	5 feet
K-09	0.3	0.3	5 feet
L-09	0.3	0.7	6 feet
M-09	0.4	0.9	5 feet
N-09	3.0	3.9	5 feet
O-09	1.7	0.9	8 feet
P-09	1.2	3.6	8 feet
Q-09	1.4	Merged with P-09	-
R-09	1.5	1.5	7 feet
S-09	0.8	3.9	9 feet
T-09	2.3	Merged with S-09	-
U-09	2.9	2.9	9 feet
V-09	1.7	1.7	5 feet
W-09	0.3	1.9	5 feet
X-09	3.8	3.8	6 feet
Y-09	-	1.6	6 feet
Z-09	-	0.4	5 feet
Total	***32.2***	***40.2***	



1,900
Feet



Extent of large map shown in red.

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Sources:
Roads & Hydro: WDNR
Aquatic Plants Surveys: Onterra 2008-09
Map date: December 1, 2009

Legend

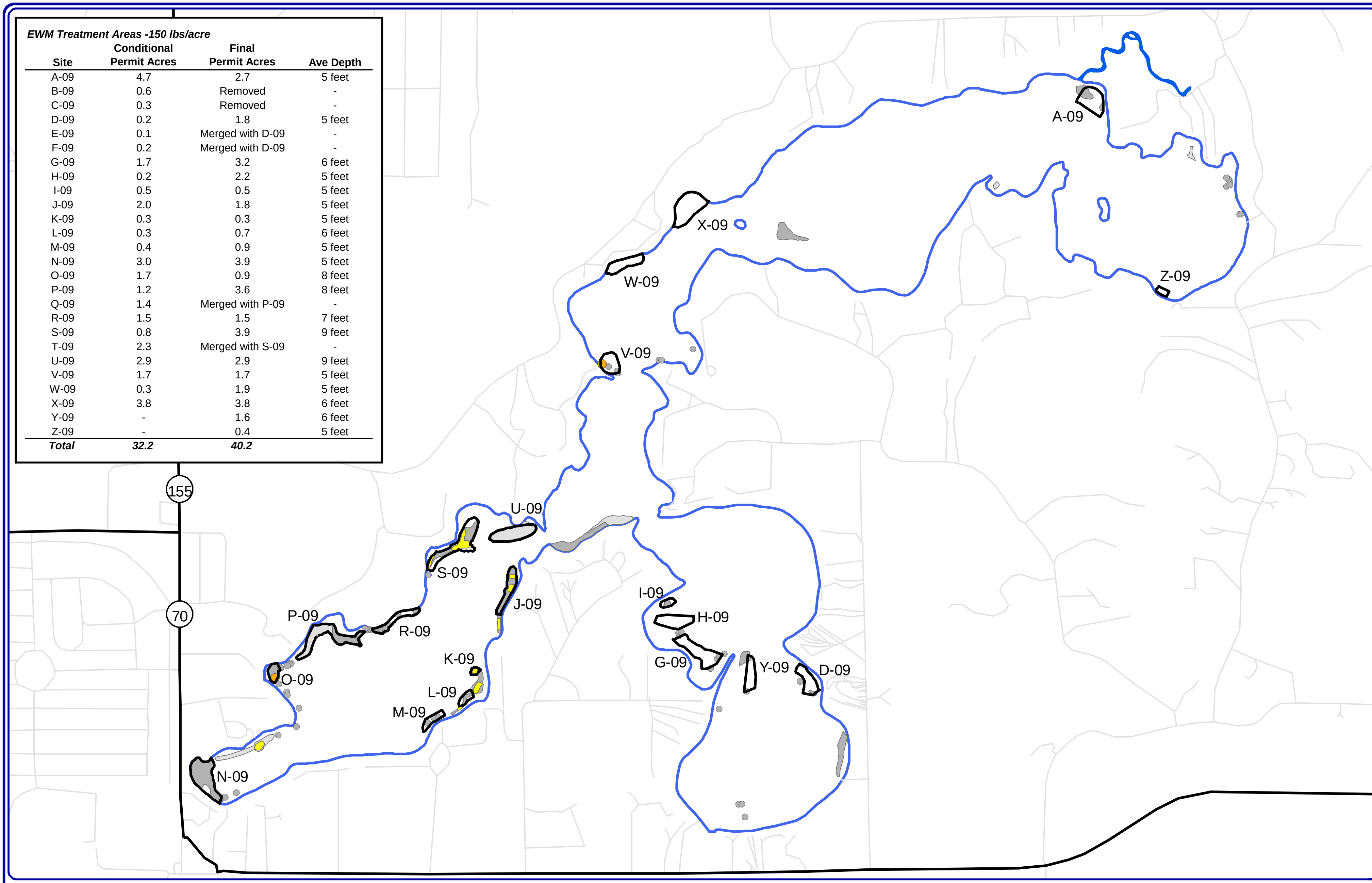
EWM Survey Results (Aug 2008)
- Clumps of Plants
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting *(none found)*
- 2009 Final EWM Treatment Areas
- 2009 Proposed EWM Treatment Areas
- Public Boat Landing

Map 2
Little Saint Germain Lake
Vilas County, Wisconsin

2008 EWM Densities and 2009 Treatment Areas

EWM Treatment Areas -150 lbs/acre

Site	Conditional Permit Acres	Final Permit Acres	Ave Depth
A-09	4.7	2.7	5 feet
B-09	0.6	Removed	-
C-09	0.3	Removed	-
D-09	0.2	1.8	5 feet
E-09	0.1	Merged with D-09	-
F-09	0.2	Merged with D-09	-
G-09	1.7	3.2	6 feet
H-09	0.2	2.2	5 feet
I-09	0.5	0.5	5 feet
J-09	2.0	1.8	5 feet
K-09	0.3	0.3	5 feet
L-09	0.3	0.7	6 feet
M-09	0.4	0.9	5 feet
N-09	3.0	3.9	5 feet
O-09	1.7	0.9	8 feet
P-09	1.2	3.6	8 feet
Q-09	1.4	Merged with P-09	-
R-09	1.5	1.5	7 feet
S-09	0.8	3.9	9 feet
T-09	2.3	Merged with S-09	-
U-09	2.9	2.9	9 feet
V-09	1.7	1.7	5 feet
W-09	0.3	1.9	5 feet
X-09	3.8	3.8	6 feet
Y-09	-	1.6	6 feet
Z-09	-	0.4	5 feet
Total	***32.2***	***40.2***	



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1,900
Feet

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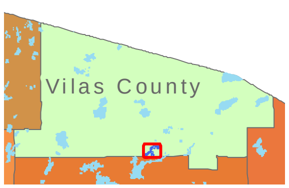
Sources:
Roads & Hydro: WDNR
Aquatic Plants Surveys: Onterra 2008-09
Map date: December 8, 2009



Extent of large map shown in red.

Legend

EWM Survey Results (Sept 2009)

- Clumps of Plants
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant *(none found)*
- Surface Matting *(none found)*
- 2009 Final EWM Treatment Areas
- Public Boat Landing

Map 3
Little Saint Germain Lake
Vilas County, Wisconsin

2009 Treatment Areas and Post Treatment EWM Densities

2010 Proposed Treatment Areas

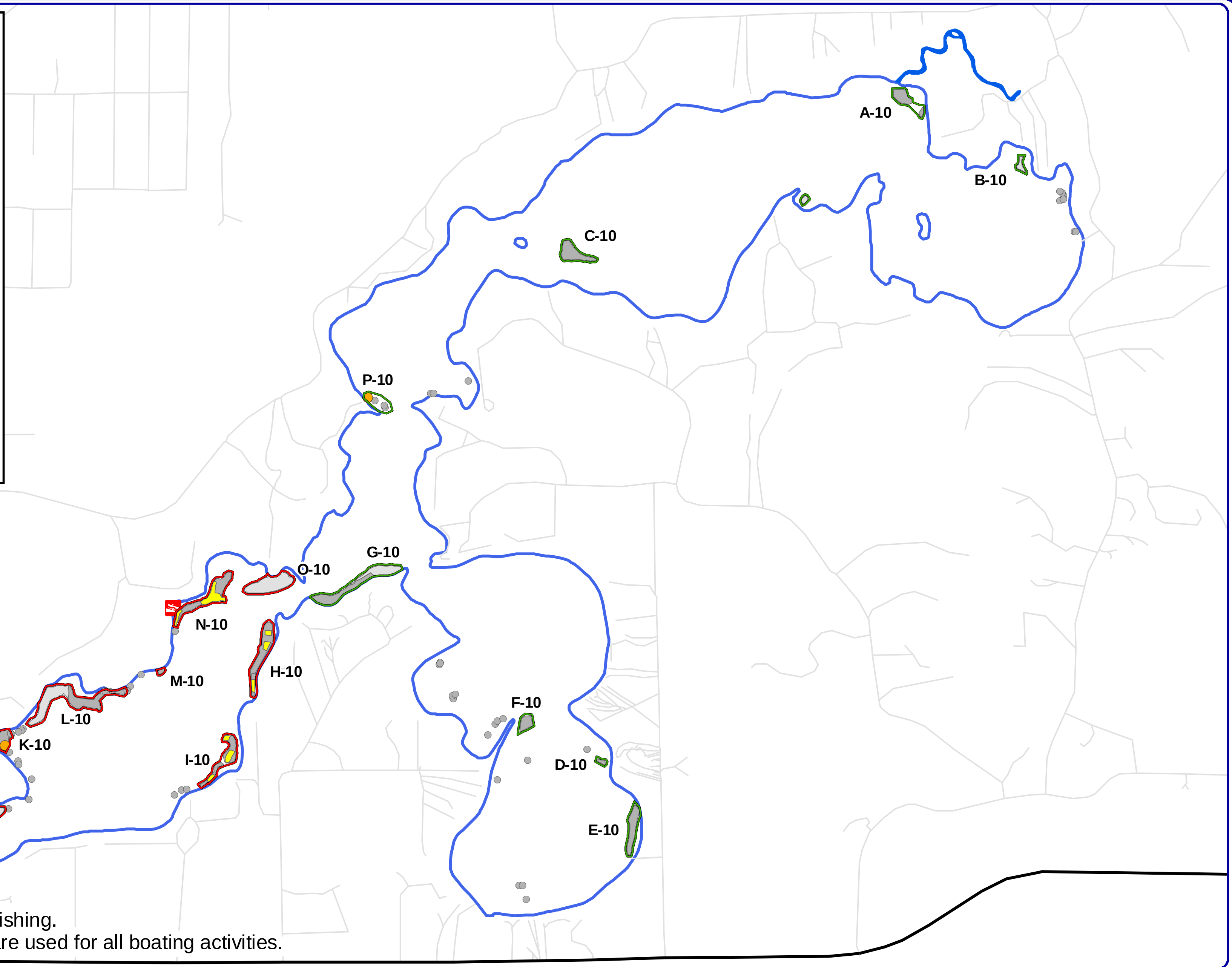
Treatment Areas - 150 lbs/acre

Site	Acres	Ave Depth
A-10	1.8	5
B-10	0.5	4
C-10	2.0	5
D-10	0.3	4
E-10	1.9	3
F-10	1.0	4
G-10	3.9	5
P-10	1.5	5
Q-10	0.3	5
Sub Total	**13.2**	

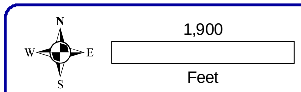
Treatment Areas - 200 lbs/acre

Site	Acres	Ave Depth
H-10	3.2	4
I-10	2.5	5
J-10	6.8	5
K-10	1.2	8
L-10	5.7	8
M-10	0.2	5
N-10	3.6	6
O-10	3.2	5
Sub Total	**26.4**	

Grand Total ***39.6***



Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.



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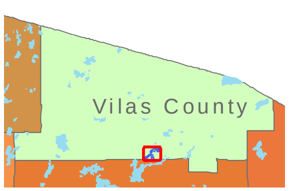
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Aquatic Plants Surveys: Onterra 2009
Map date: December 8, 2009



Extent of large map shown in red.

EWM Survey Results (Sept 2009)
- Few or Single Plants
- Small Plant Colony
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant *(none found)*
- Surface Matting *(none found)*

2010 Proposed EWM Treatment Areas
- 150 lbs/acre
- 200 lbs/acre
- Public Boat Landing

Map 4
Little Saint Germain Lake
Vilas County, Wisconsin

2010 Proposed Eurasian Water Milfoil Treatment Areas

APPENDIX I

Muskellunge Retention Regulation Memorandum – Steve Gilbert, WDNR

State of Wisconsin

CORRESPONDENCE/MEMORANDUM

DATE: June 18, 2009 FILE REF: 3600

TO: Mike Vogelsang, Area Fisheries Supervisor, Woodruff

FROM: Steve Gilbert, Fisheries Biologist, Woodruff

SUBJECT: 2010 WDNR Fisheries Rule Development Proposal

Title: Muskellunge Regulation Retention - 45 inch minimum size limit

1. **Author:** Steve Gilbert, Fisheries Biologist – Vilas County

2. **Waterbody:** Little Saint Germain Lake, Vilas County (T40N R08E Sec 35)

3. **Proposal:** Muskellunge Regulation Retention - 45 inch minimum size limit

4. Statement of management objectives:

There is a lack of trophy fishing regulations for muskellunge in the Northern Region. Vilas County has over 200 lakes that contain muskellunge (WDNR 1995), more than any other county in Wisconsin. Only 12 (10 at 40 inch and 2 at 45 inch minimum) of these have special regulations for muskellunge. Preliminary evaluations of our 40-inch minimum waters indicate this regulation has not significantly increased the numbers of fish greater than 40 inches in length when compared to a 34 inch minimum size limit (Margeneau 2000). Little Saint Germain Lake has the potential to produce true trophy muskellunge if afforded more conservative protection than a 40 inch minimum size limit.

The Goal of this regulation is to increase the RSD40 to 25, RSD45 to 10 and the RSD50 to 1 by 2018. Since this regulation went into effect in 2002 the RSD 40 goal has been reached and we are approaching the RSD45 goal.

5. Description of Fishery Status:

Little Saint Germain Lake is 957 acres, eutrophic, and has a maximum depth of 53 feet. It is a drainage lake and the outlet stream flows into the Rainbow Flowage (Upper Wisconsin River drainage). The outlet has a small dam on it that is operated by the Wisconsin Valley Improvement Company. The lake is located near the town of Saint Germain and 93.5% of its 14.5 miles of shoreline are privately owned (Black et al. 1963). There is a WDNR landing located on the northwest shore that provides the only public access to the lake.

The lake has a history as a moderate density muskellunge fishery with trophy potential. Smallmouth bass, largemouth bass, walleye, and northern pike are the other gamefish species present. The panfish fishery currently consists of abundant numbers of yellow perch, bluegill, and black crappie. West Bay, the only deep bay of the lake, has historically supported a cisco fishery.

Muskellunge Fishery

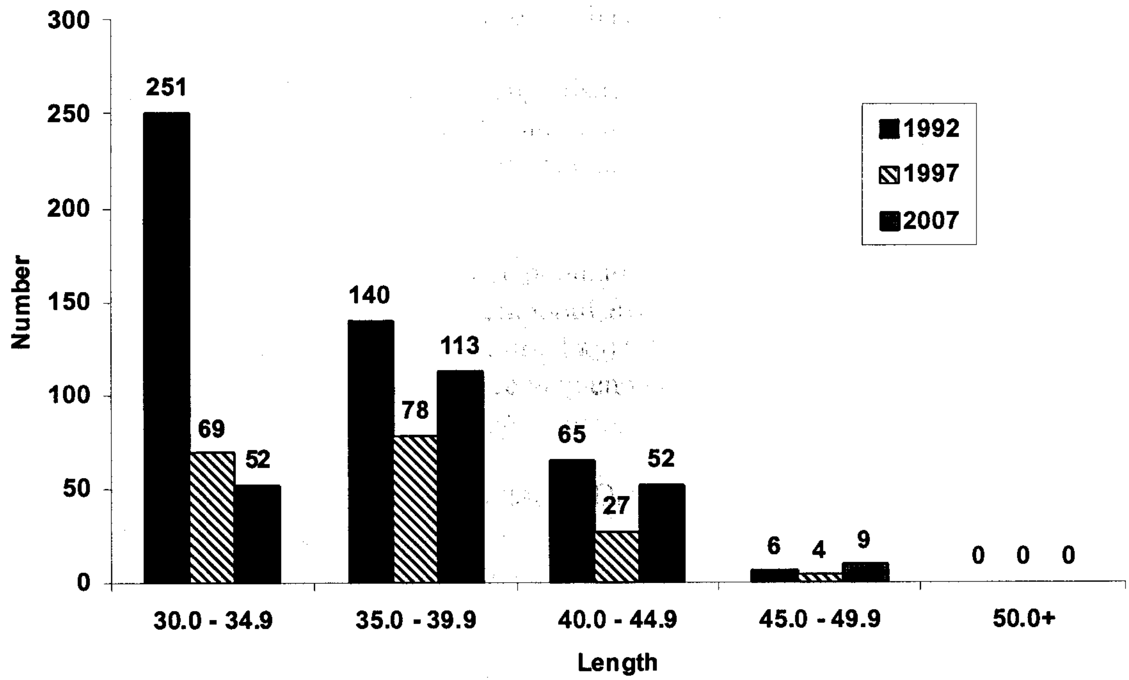
Little Saint Germain has a long history as a popular muskellunge fishery. Regular stocking since the 1930's has maintained the fishery. During the 1980's the lake was stocked almost every year with fall fingerlings at a rate of two to three per acre. This high level of stocking resulted in the high muskellunge population density of the early 90's dominated by fish less than 35 inches in length.

Since 2000, fingerling has been reduced to 0.5 fish per acre every other year. This reduction in stocking is part of our goal to maintain the number of muskellunge present at a level that can support a trophy fishery given the current forage base, harvest, and natural mortality.

In 2007 and 2008 a survey of the muskellunge fishery was conducted on Little Saint Germain Lake to evaluate the results of the 45 inch minimum length limit. Over the two years 145 muskellunge were captured using fyke nets. The largest fish captured was a 48.9 inch long female.

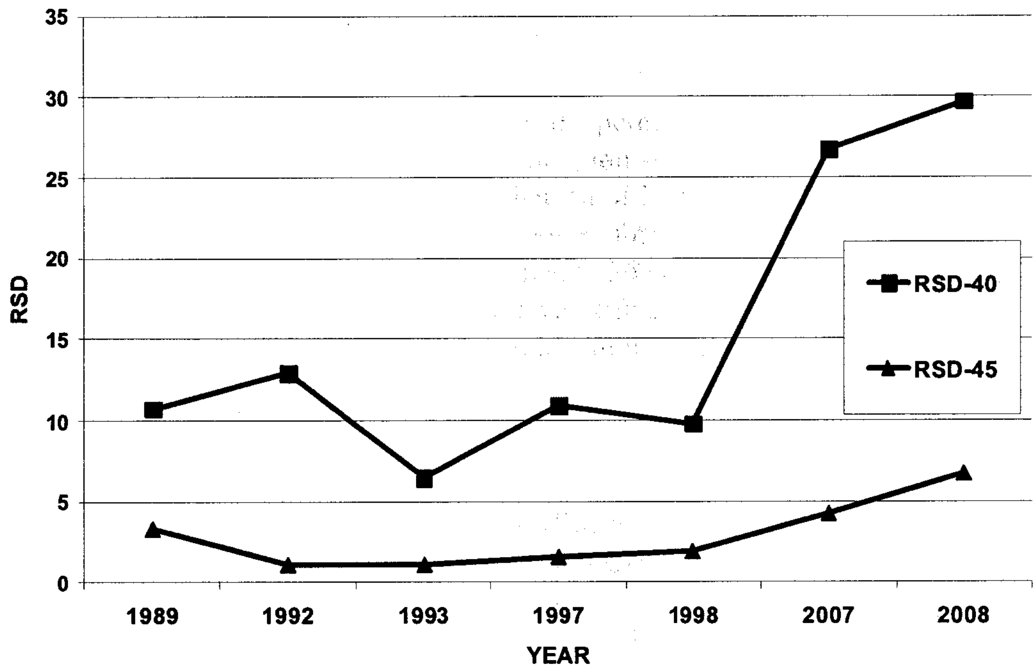
Based on this survey the adult muskellunge population (fish ≥ 30) has increased since the 1997 estimate from .18 to .23 fish/acre. The number of fish over 40 and 45 inches has increased significantly (Figure 1.). We have not captured a fish over 50 inches in length yet but the 45 minimum length limit has not been in place long enough to grow significant numbers of fish of this size.

Figure 1. Historical Muskellunge Population Distribution by Length Group for Little Saint Germain Lake, Vilas County.



Relative stock density (RSD), a measure of the percentage of fish over a set length in a fishery, is a good indicator of actual muskellunge population size structure (Hanson 1986). RSD 34 and 40 values calculated for 2008 using a **stock length of 20** inches, were 92 and 30 respectively (figure 2.). These RSD values are above those reported for other northern Wisconsin muskellunge waters (Margenau 2000, Hanson 1986). RSD 45 values were not calculated for these other lakes, but Little Saint Germain Lake had a value in 2008 of 7. RSD 50 was 0 but this is expected given the limited protection of the 45 inch length limit and the fact that it has only been in place since 2002.

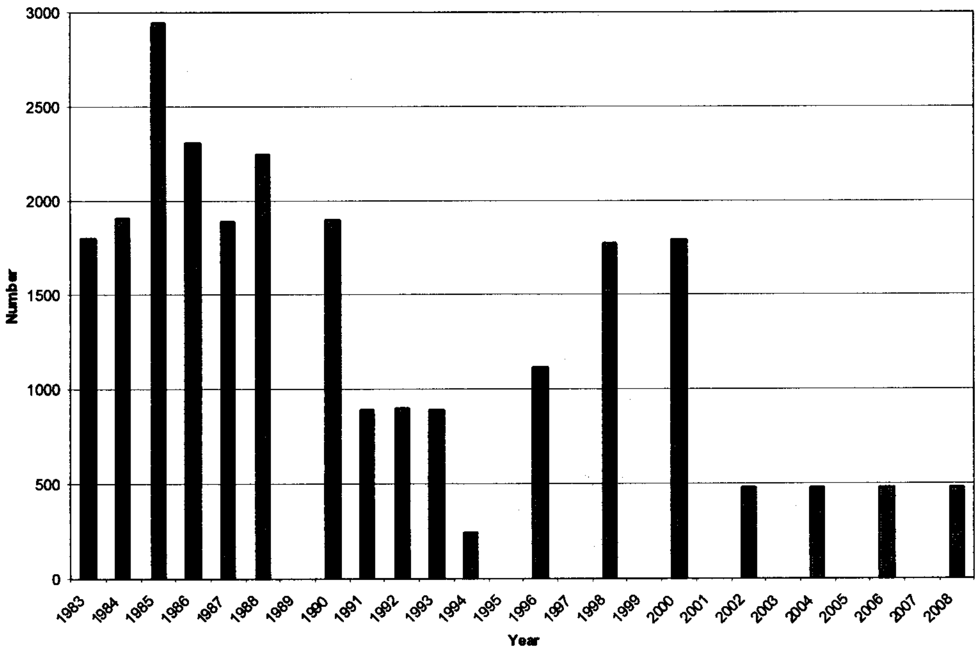
Figure 2. RSD History of Muskellunge (Stock Length > 20.0 inches) from Spring Netting Surveys of Little Saint Germain Lake, Vilas County.



Muskellunge Recruitment

Currently the muskellunge population of Little Saint Germain Lake is maintained through stocking (figure 3). The lake is currently stocked in even numbered years with large fingerling muskellunge at a rate of 0.5 fish per acre. Spring netting and fall electrofishing surveys indicate that there is limited natural recruitment occurring in some years.

Figure 3. Muskellunge Large Fingerling Stocking History for Little Saint Germain Lake, Vilas County (1983 to 2008).



Muskellunge Harvest

The last creel survey of Little Saint Germain Lake was conducted in 1997. At this time the muskellunge regulation on the lake was a 34 inch minimum length and 1 fish bag limit. Based on the results of the survey, anglers caught an estimated 658 and harvested 39 muskellunge for the entire season. This harvest is based on 3 fish reported to the creel clerk as harvested. Only two of these fish were measured and they were 36.0 and 38.3 inches in length. Catch and harvest rates of anglers specifically seeking muskellunge were 70.0 and 588.2 hours per fish respectively. Anglers spent 23,405 hours (23.9 hrs/acre) specifically fishing for muskellunge in 1997 on Little Saint Germain Lake.

Little Saint Germain Lake is in the ceded territory and significant tribal harvest of muskellunge does occur. Since 2001, tribal members have speared an average of 3.5 muskellunge a year (range 0 to 8) during the spring spearing season. There is also a fair amount of tribal winter ice spearing for muskellunge on this lake in some years.

6. Justification of Selected Regulation:

The current 45 inch minimum size limit has increased the numbers of muskellunge 40 inches or greater in length present in Little Saint Germain Lake. This lake has the size, growth rate, and forage base to produce significant numbers of trophy muskellunge. There is also a significant segment of the angling public that would like to see greater opportunities to catch larger muskellunge. In 1999 a survey was conducted by the Wisconsin department of natural resources of 1,400 anglers who fish muskellunge in Wisconsin (Margenau 2004). The survey found that 62% of anglers felt that a trophy muskellunge was a fish 50 inches or longer in length.

Maintaining the muskellunge regulation at the 45 inch minimum will continue to provide an additional quality angling opportunity in Vilas County.

Future plans call for monitoring muskellunge recruitment each fall. A Muskellunge population estimate and creel survey should be conducted on little Saint Germain Lake every 10 to 15 years to evaluate any changes.

References

Black, John J., Andrews, L. M. and C. W. Threinen. 1963. Surface water resources of Vilas County. Wisconsin Conservation Department, Madison, Wisconsin. 316 pages.

Hanson, David A. 1986. Population characteristics and angler use of muskellunge in eight northern Wisconsin lakes. Am. Fish. Soc. Spec. Publ. 15:238-248.

Margenau, Terry L. and Steven P. AveLallemant. 2000. Effects of a 40-inch minimum length limit on muskellunge in Wisconsin. N. Amer. J. Fish Mgt. 20:986-993.

Margenau, Terry L. and Jordan B. Petchenik. 2004. Social aspects of muskellunge management in Wisconsin. N. Amer. J. Fish Mgt. 24:82-93.

Wisconsin Muskellunge Waters. 1995. Wisconsin department of natural resources. Publication RS-919-96.

7. Public Comment:

At the 2001 spring Vilas County conservation congress hearing the 45 inch minimum (with a 10 year sunset clause) was submitted to be voted on. It passed locally by a 60 to 0 vote and statewide 2,176 to 924. The Little Saint Germain Lake District has reviewed this proposal in the past and approves of retaining this regulation.

This regulation change should cause no conflicts with tribal harvest. Tribal members have speared the lake in the past on a regular basis. Increasing the muskellunge population of Little Saint Germain Lake will have no negative impacts on annual tribal muskellunge or walleye harvest.

8. Previous Action:

Prior to 2002 the muskellunge fishing regulations on Little Saint Germain Lake followed the general inland rules for the state. In 2002, the current 45 inch minimum size limit was placed on the lake. Currently only one other lake in Vilas County has a 45 inch minimum length regulation and none have a 50 inch minimum.

If no action is taken the length limit will revert back to the standard statewide regulation of a 34 inch minimum and one fish bag limit. The Little Saint Germain Lake muskellunge fishery would revert back to a moderate density fishery and few musky greater than 40 inches in length will be caught.

9. Draft Question:
Little Saint Germain Lake Muskellunge Regulation – Retain and make permanent the minimum length limit of 45 inches.

The current 45 inch minimum size limit has been in effect on this lake for 8 years and has significantly increased the number of fish longer than 40 and 45 inches in length. This lake has the potential to grow trophy muskellunge if given additional protection from harvest. It is recommended that the muskellunge regulation on this lake be retained at a 45 inch minimum length limit. This regulation should improve muskellunge catch rates, increase numbers of adults, and provide an opportunity to catch larger fish. The Little Saint Germain Lake District has reviewed this proposal in the past and approves of retaining this regulation.

Do you favor retaining and making permanent the minimum length limit of 45 inches for muskellunge on Little Saint Germain Lake in Vilas County?

Revised: SJG 7/28/09

J

APPENDIX J

Panfish Survey – Wisconsin Valley Improvement Company

WISCONSIN VALLEY IMPROVEMENT COMPANY
FISHERIES INFORMATION SHEET

LAKE: LITTLE ST. GERMAIN **COUNTY:** VILAS **YEAR:** 2004

Wisconsin Valley Improvement Company (WVIC) and the Wisconsin DNR conducted a panfish survey of Little St. Germain in September 2004. Little St. Germain has a surface area of 980 acres, 15 miles of shoreline and a maximum depth of 53 feet in West Bay. The shoreline is predominately sand and gravel, with scattered areas of rock and muck. Dense aquatic plant beds are common in the shallow bays. The survey design focused on sampling panfish (bluegill, pumpkinseed and black crappie) with fyke-nets, which were fished for 4 days. The purpose of the survey was to determine the population characteristics of panfish and the diversity of other fish species present.

Bluegill

Density – A total of 6,048 bluegill was collected which equals a density of 126 fish per net per day (CPE). This is a very high density compared to larger lakes and reservoirs in the area, but comparable to some area lakes of similar size, such as Pickerel (204 CPE) and Squirrel (80 CPE). In larger reservoirs such as, Rainbow, Willow and Rice Reservoirs and the Sugar Camp Chain, bluegill densities are 5 to 12 fish per net per day, however bluegills from 8 to 10 inches are common in these reservoirs.

Length Frequency & Age - Bluegill size ranged from 3.2 to 7.7 inches, with a mean length of 5.6 inches. The age of bluegills ranged from 1 to 6 years, with age 5 fish (5 to 7 inches) the most abundant followed by Age 3 fish. Age 5 fish would have been spawned in 1999 and Age 3 fish in 2001. Mean length-at-age was below the regional mean for all ages except Age 1. This means bluegills for all ages except age 1 are growing at a slower rate when compared to bluegill throughout the region. This is generally indicative of an over abundance of bluegill and/or lack of predation to maintain a more balanced fishery. The general lack of bluegill greater than 8 inches is probably related to angler harvest. In the last (1997) WDNR creel survey it was estimated that anglers harvested 12,125 bluegill. Of these fish 55% were less than 7 inches in length.

Pumpkinseed

Density – A total of 2,122 pumpkinseed was collected which equals a density of 44 fish per net per day. This is also a very high density compared to some area lakes of similar size, such as Pickerel (33 CPE) and Squirrel (13 CPE) and compared to larger lakes and reservoirs in the area. For example, in Rainbow, Willow and Rice Reservoirs and the Sugar Camp Chain, pumpkinseed densities are 2 to 5 CPE, however pumpkinseeds from 6 to 8 inches are common in these reservoirs.

Length Frequency & Age – Pumpkinseed size ranged from 3.3 to 7.3 inches, with a mean length of 5.3 inches. The age of pumpkinseeds ranged from 2 to 6 years, with age 3 fish (4 to 6 inches) the most abundant with no Age 1 fish collected. Age 3 fish would have been spawned in 2001. Mean length-at-age was less than the regional mean for all ages. This means pumpkinseeds are growing at a slower rate when compared to pumpkinseed throughout the region. Like bluegill, this is also indicative of an over abundance of pumpkinseed and/or lack of predation to maintain a more balanced fishery.

Black Crappie

Density – A total of 452 black crappie was collected which equals a density of 9 fish per net per day. This is moderate density and comparable to some area lakes of similar size, such as Pickerel (11 CPE) and Squirrel (13 CPE) and similar to larger lakes and reservoirs in the area. For example, in Rainbow, Willow and Rice Reservoirs and the Sugar Camp Chain, black crappie densities generally range from 7 to 13 CPE and fish from 10 to 14 inches are common.

Length Frequency & Age – Black crappie size ranged from 4 to 10.8 inches, with a mean length of 7.3 inches. The age of black crappie ranged from 1 to 6 years, with ages 3 and 4 fish (6.5 to10 inches) the most abundant. Age 3 and 4 fish would have been spawned in 2001 and 2000, respectively. Mean length-at-age was less than the regional mean for all ages.

This means black crappie are growing at a slower than average rate when compared to black crappie throughout the region. There does not appear to be an over abundance of black crappie and the scarcity of individuals greater than 10 inches may be a function of harvest. Once they reach 5 inches anglers start harvesting them. In 1998 a WDNR survey estimated that anglers harvested 19,245 (19.6/acre) black crappie from the lake in that single year.

Other Species

A total of 13 species of fish was collected including the three panfish species and the bluegill x pumpkinseed hybrid:

White Sucker	Bluegill
Black Bullhead	Psd x Bgl hybrid
Yellow Bullhead	Largemouth Bass
Northern Pike	Black Crappie
Muskellunge	Yellow Perch
Rock Bass	Walleye
Pumpkinseed	

Yellow bullheads were very abundant with 2,031 fish collected. Many fish over 12 inches were captured with the largest measuring 14.5 inches in total length. Bullheads remain a major part of this fishery, but are not sought out by anglers even though they are above average in size. In the 1997 creel survey only 162 were harvested.

Other common species were northern pike, walleye and yellow perch. Eighty-eight walleye were collected and exhibited good size distribution from 8.4 inches to 29.3 inches. Eleven walleye had fin clips from previous DNR walleye surveys. These marked fish were between 19.6 and 23.8 inches. Eleven musky were also collected which ranged from 11.2 to 45 inches. All musky except for the 11.2 inch fish were greater than 30 inches with three fish exceeding 40 inches. Eighteen largemouth bass were collected that ranged from 5.2 to 18.6 inches.

K

APPENDIX K

Barr Engineering Company Proposed Alum Treatment Plan

Barr Engineering Company
4700 West 77th Street • Minneapolis, MN 55435-4803
Phone: 952-832-2600 • Fax: 952-832-2601 • www.barr.com *An EEO Employer*

Minneapolis, MN • Hibbing, MN • Duluth, MN • Ann Arbor, MI • Jefferson City, MO • Bismarck, ND

Memorandum

To: Ted Ritter: President of the Little St. Germain Protection and Rehabilitation District

From: Keith Pilgrim

Subject: Proposed Alum/Sodium Aluminate Treatment Additional Information Request by the Wisconsin Department of Natural Resources

Date: February 5, 2010

Project: 49/64 1001

Additional information on the proposed alum/sodium aluminate application planned for the fall of 2010 is being provided in this memorandum to answer questions posed by the Wisconsin DNR in a letter dated October 7, 2009. The Wisconsin DNR questions addressed in this memorandum are summarized below:

(1) A final treatment plan which should define the chemicals that will be used, how applied, at what rates, and a timeline.
(2) More detailed information on the predicted response of the lake (water clarity, chlorophyll, and TP) to alum treatment- seasonal (monthly) averages and variability, rather than long term average conditions – as well as predicted pH and aluminum concentration in water and sediments during and after treatment in order to evaluate toxicity risk. Amount of floc deposition (depth) should also be estimated.
(3) A detailed pre and post treatment monitoring plan, which should include the following (pH, DO, Al(OH)3, nutrients, Chlorophyll a, water clarity, and mobile P in sediments).
(4) A contingency plan, which should include performance bonding to cover cost associated with unintended impacts to fisheries or water quality.

Treatment Plan

The final treatment plan includes the simultaneous application of a mixture of alum and sodium aluminuate. Treatment will be conducted such that 1 gallon of sodium aluminate is applied for every 2 gallons of alum applied. One contractor, Sweetwater Technology, Inc. has the capability to deliver alum and sodium aluminuate in this matter. The application areas are shown in the attached Figure 1. The treatment includes the East Bay (249 acres) and the Lower East Bay (79 acres). Treatment will be conducted within the confines identified in Figure 1. Treatment will be conducted up to the five foot contour (e.g., at depths greater than 5 feet). The East Bay treatment dose is 27 grams of aluminum per square meter of lake surface. The Lower East Bay Treatment is 50 grams of aluminum per square meter of lake surface. These doses are reduced from originally prescribed alum doses (see Barr Engineering, December 2007) due to the increase in cost of aluminum since the publication of this document, and the need to reduce the overall dose to avoid pH effects with treatment. Overall, these doses were reduced by 34 to 48 percent to accommodate anticipated higher costs and avoid pH effects. A summary of treatment statistics is provided in Table 1-X. It is expected that application will take three to five days to conduct.

The geochemical modeling program called PHREEQC (developed by the USGS) was used to determine the pH response in the lake water column with alum/sodium aluminate application at the rates described above. The model input file is provided as an attachment to this document. The file also provides initial conditions, inputs, and model assumptions. In summary, it was assumed that the lake chemistry at the time of treatment will include alkalinity of 40 milligrams per liter as calcium carbonate, pH of 7.7, and partial pressure of carbon dioxide elevated compared to atmospheric carbon dioxide (this parameter was used to set the starting pH at 7.7). The model was run assuming that the lake is open to the atmosphere. This is a reasonable assumption given the shallow depth of the lake and the timing of the treatment (fall turnover with completely mixed conditions).

The result of the modeling exercise was used to identify the maximum alum and sodium aluminate that can be added to the lake and not suppress pH to below 6.0 and to avoid elevating positively charge aluminum species (the toxic form of aluminum) to levels that would be toxic (see Figure 1 and Figure 2). Work conducted by Pilgrim and Brezonik (Pilgrim, K.M and P.B. Brezonik. 2005. Evaluation of the potential adverse effects of lake inflow treatment with alum. Lake and Reservoir Management. 21(1): 78-88) showed that chemical equilibrium models such as PHREEQC are good predictors of aluminum solubility and speciation in natural waters. The model results indicate that with the prescribed doses, pH will be approximately 7.2 in the East Bay and 6.5 in the Lower East Bay after treatment. Total aluminum is expected to approximately 300 micrograms per liter in the East Bay and 50 micrograms per liter in the Lower East Bay after treatment. Positively charged aluminum species (Al^{+3}, $AlOH^{+2}$, and $Al(OH)_2^{+}$) are expected to be less than 5 microgram per liter for both bays. Numerous aquatic toxicity studies have demonstrated that aluminum is not toxic under the pH conditions expected with prescribed treatment doses (see Pilgrim and Brezonik and the extensive list of references provided by Barr as part of the March 2009 submittal). Floc accumulation is expected to be less than 1 centimeter.

Treatment Response

Barr has provided several studies that show the anticipated effect of alum or alum/sodium aluminate treatment, including seasonal variation and effects on chlorophyll a, with the proposed application. Graphs from these studies are provided as an attachment. The original alum dose was calculated using dosing methods developed by Pilgrim et. al,, 2007 (Pilgrim, K.M., B.J. Huser and P.L. Brezonik. 2007. A method for comparative evaluation of whole-lake and inflow alum treatment. Water Res. 41: 1215-1224.). The dose was designed to be a 75:1 dose, meaning, 75 grams of aluminum is added to form 1 gram of aluminum bound phosphorus. The sediment treatment depth of 6 centimeters was chosen because phosphorus (mobile phosphorus) was elevated above this depth. Treatment was designed to reduce mobile phosphorus to background levels identified below 6 centimeters. The 75:1 dose is considered to be high by some, but it is likely the appropriate dose. It should be noted that phosphorus levels in the lake sediments are not extremely high, however, they have a significant effect on lake water quality because of the lake's shallow depth and low volume. It is expected that the treatment response with the reduced doses described above will be similar to the previously calculated response (see attachment), but the longevity may be reduced and re-application may need to occur sooner than originally anticipated. If the contractor bid is significantly less than the anticipated application cost of $333,000, or if funds are available, additional treatment of either the East or Lower East should be considered for 2011 in order to apply the full dose as originally prescribed.

Post Monitoring Plan

Water monitoring

- Once a month staring in April 2011 and through October 2011.
- Locations: Deep hole in East and Lower East Bay and the South Bay, and at the mouth of Muskellunge Creek.
- Parmeters:
    - 1 Meter Profile (Muskellunge Creek grab only): total phosphorus, dissolved oxygen, pH, temperature.
    - 2 Meter Surface Composite (creek grab only): total aluminum, chlorophyll a (not needed for Muskellunge Creek)

Sediment

- 5 cores total from the East and Lower East Bay in fall 2011 or fall 2012 (if an application occurs in 2011)
- Cores to be analyzed for mobile and aluminum bound phosphorus and total aluminum at 2 centimeter increments to a depth of 20 centimeters.

Contingency Plan

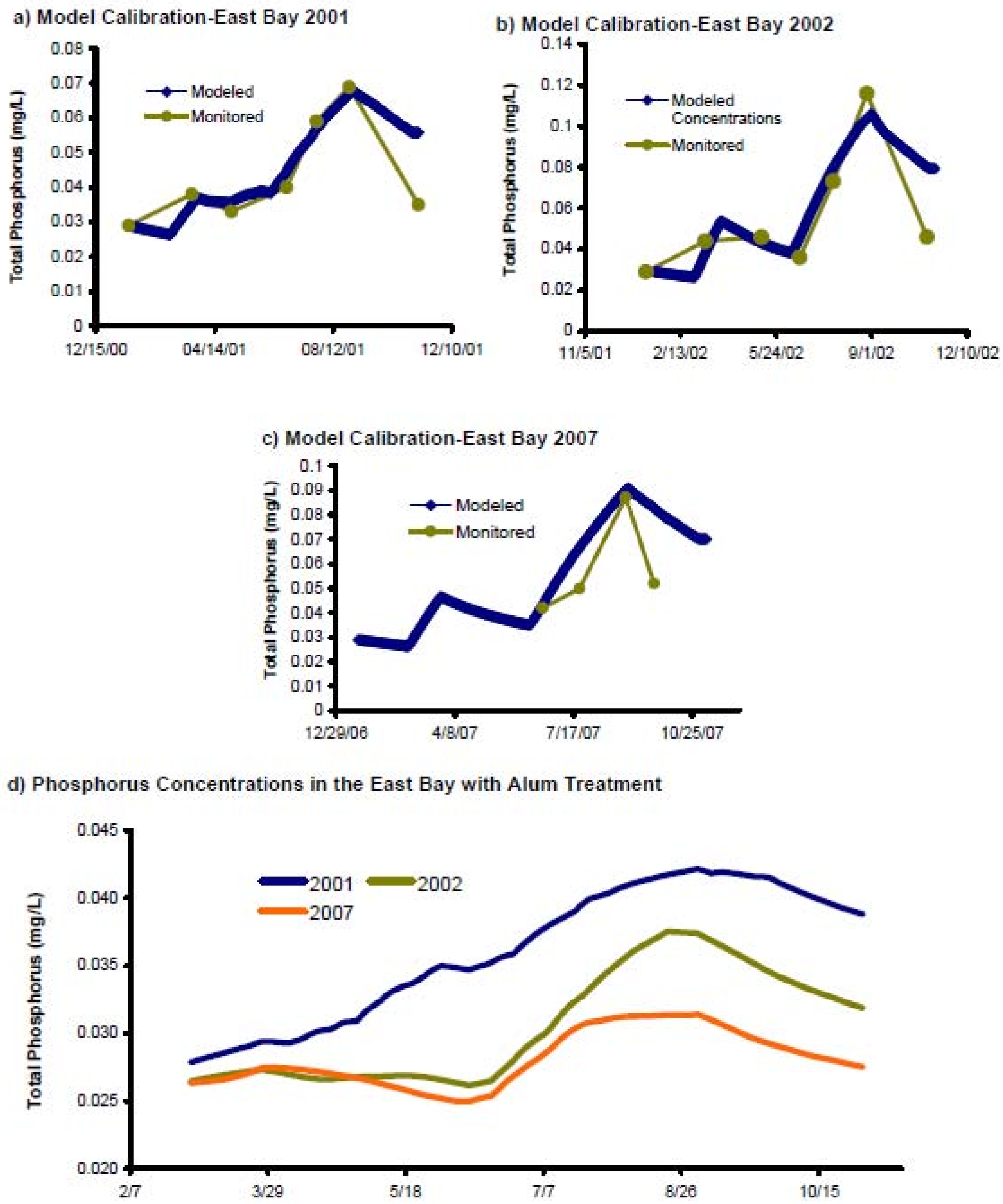
As part of the conditions of the contract documents the contractor will be required to bond for any damages of the treatment, including measureable fish effects. The damage value will be assessed as part of contract document development. (TED, I have to discuss with my colleague Brian Huser about this, and we will need to talk to the WDNR about what metrics will be used to determine damages—eg. will they have to do a fish survey immediately after the treatment to determine effects, and how much difference can the survey be from past surveys to be considered a damage, what is the maximum damage amount, is it related to fish restocking)

During the treatment pH will be monitored constantly and alkalinity measured frequently by Barr Engineering staff. The effect of the treatment on lake pH will be continually reassessed with respect to the expected pH endpoint. The PHREEQC model will be loaded on a laptop and used to periodically reexamine the effect of the treatment on pH and alkalinity in the lake. If the whole lake (each bay) pH begins to approach pH 6.0 and it appears that the pH will drop below 6.0 with additional applications, the treatment will be terminated.

PHREEQC Chemistry Model Input File

```
SOLUTION 1
    temp      15
    pH        7.7
    pe        0
    redox     pe
    units     ppm
    density   1
    Alkalinity 0 charge
    Al        0
    S(6)      2.3
    Ca        12
    Mg        3.8
    K         0.81
    Na        2.4
    Cl        1.9
    C(4)      27
    -water    1 # kg


REACTION 1
    NaAl(OH)4  0.72
    Al2(SO4)3  0.28
    0.00053 moles in 53 steps

EQUILIBRIUM_PHASES 1
    Al(OH)3(a) 0 0
    CO2(g)    -3.4 0

SELECTED_OUTPUT
    -file                 selected.out
    -totals               Al
    -molalities           Al(OH)2+  Al+3  AlOH+2  Al(OH)4-
    -equilibrium_phases   Al(OH)3(a)

END
```

Figure 9. East Bay water quality model calibration (a,b,c) and the expected total phosphorus concentration in the East Bay (d) with alum treatment.



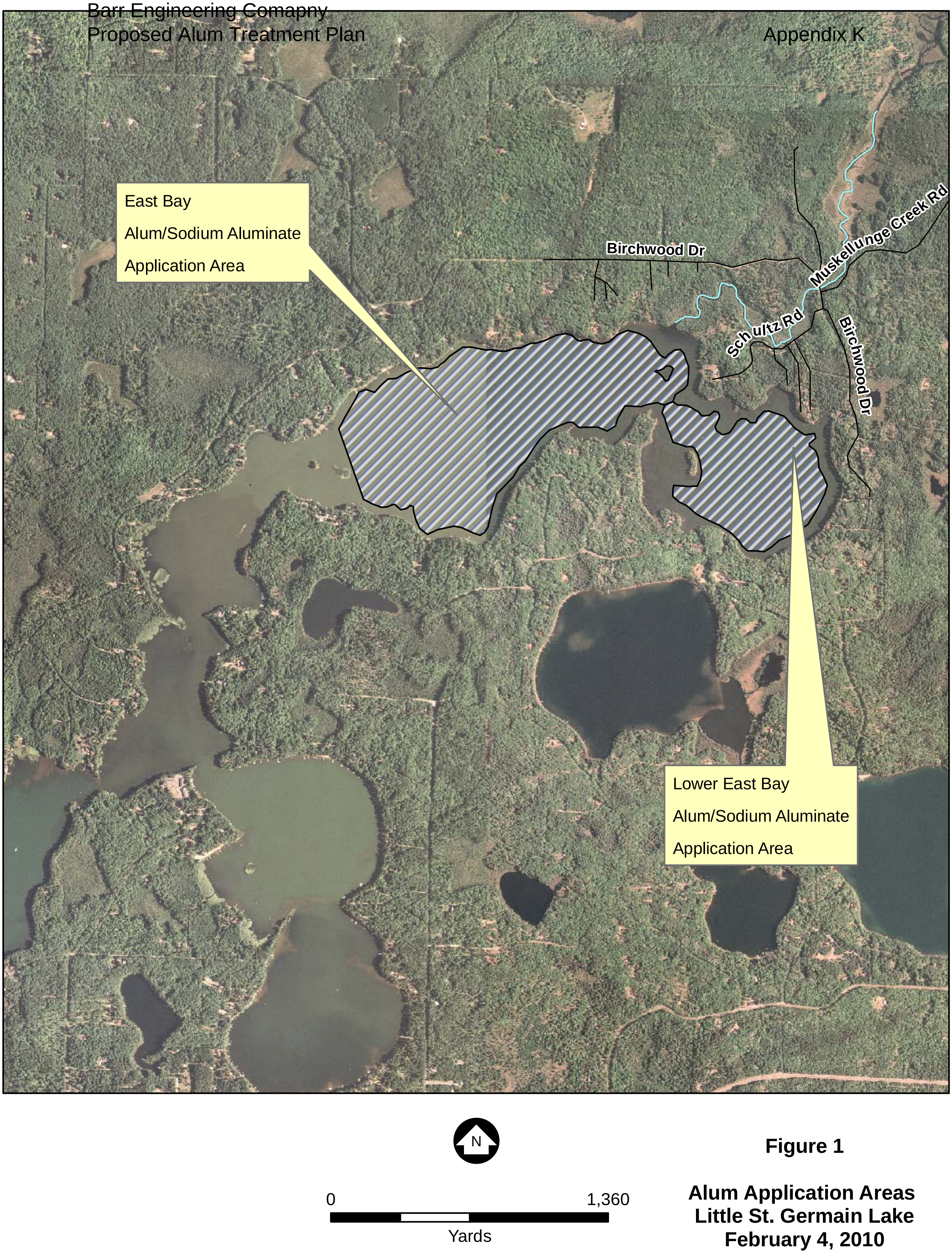


Figure 1

Alum Application Areas
Little St. Germain Lake
February 4, 2010

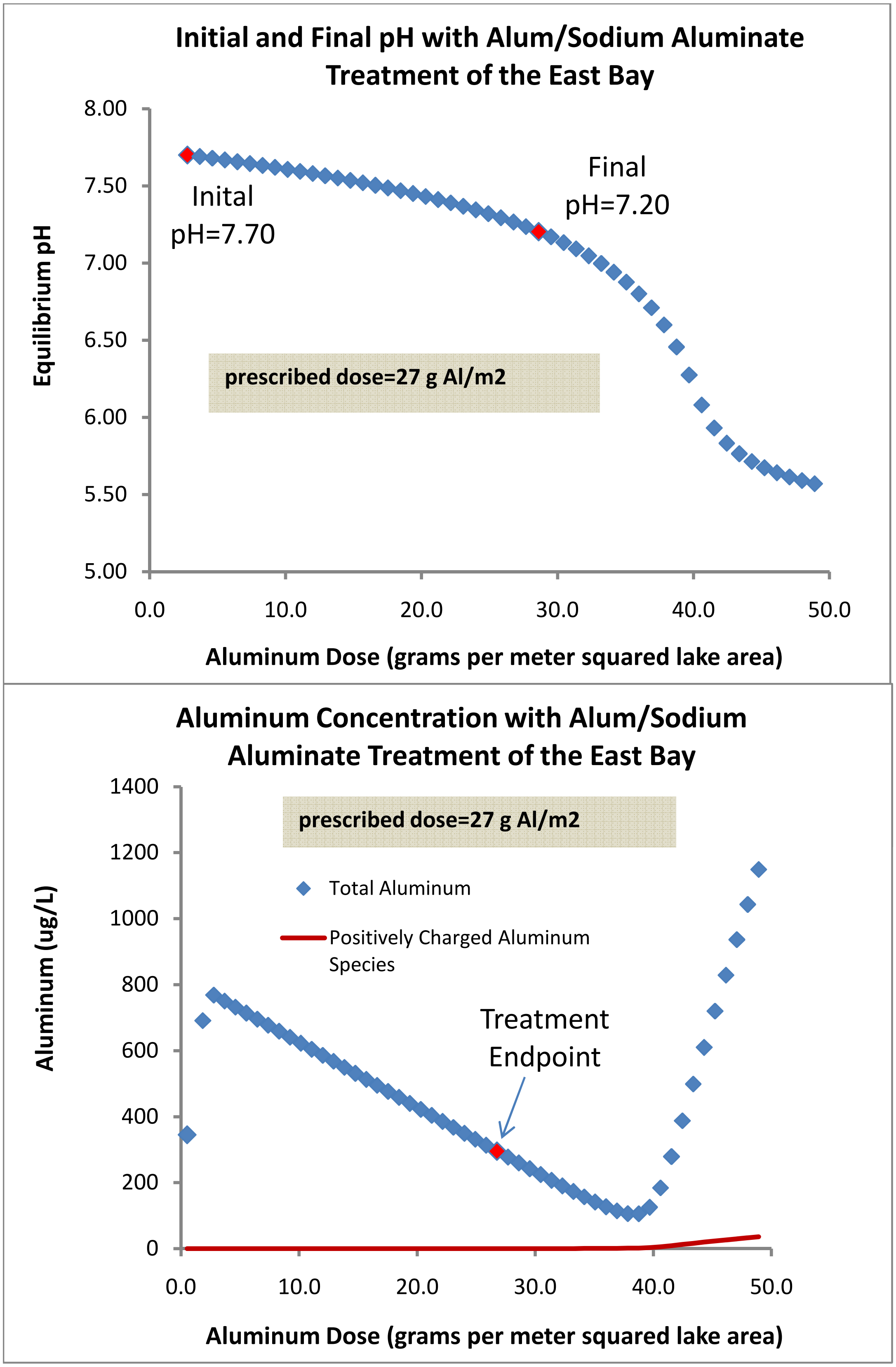
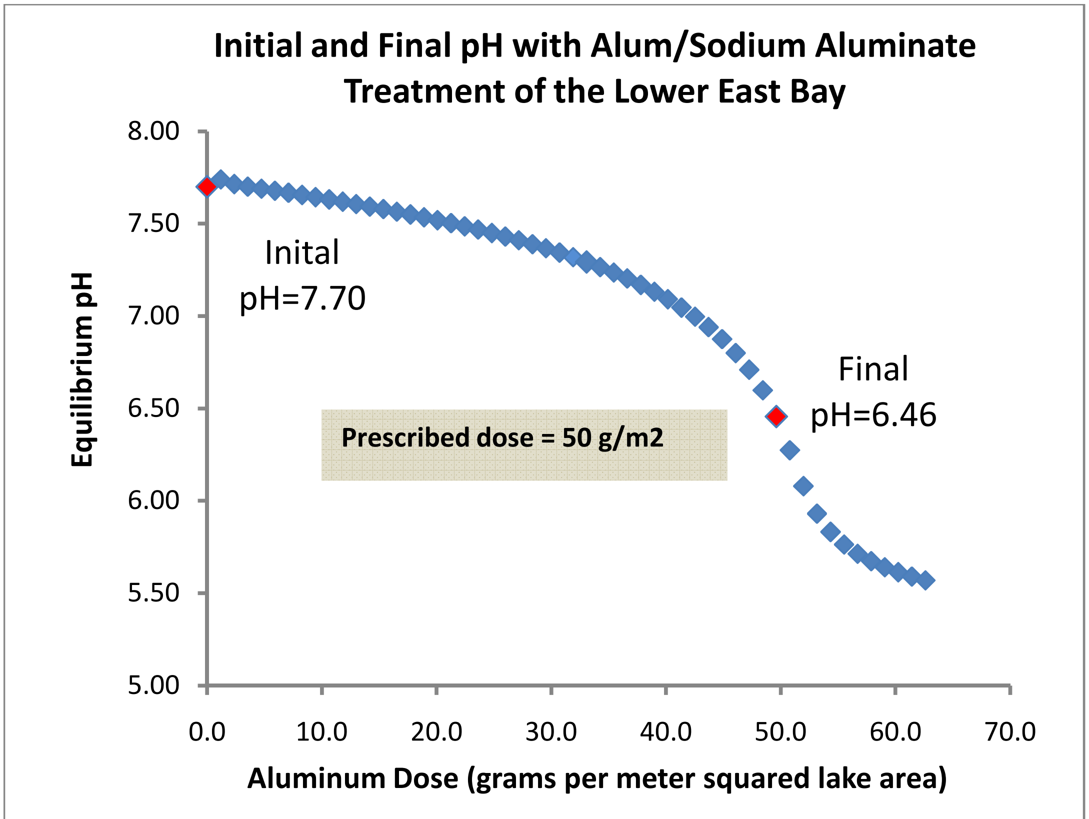


Figure 2. Effect of the prescribed alum/sodium aluminate application on pH and aluminum levels in the lake column of the the East Bay. Alumium is provided as total and a sum of the positively charged aluminum species (Al^{+3}, $Al(OH)^{+2}$, and $Al(OH)_2^{+}$). Model conditions assume starting pH of 7.7, temperature of 15°C, partial pressure of CO_2 of -3.4 (log form) and alkalinity of 40 mg/L as $CaCO_3$.



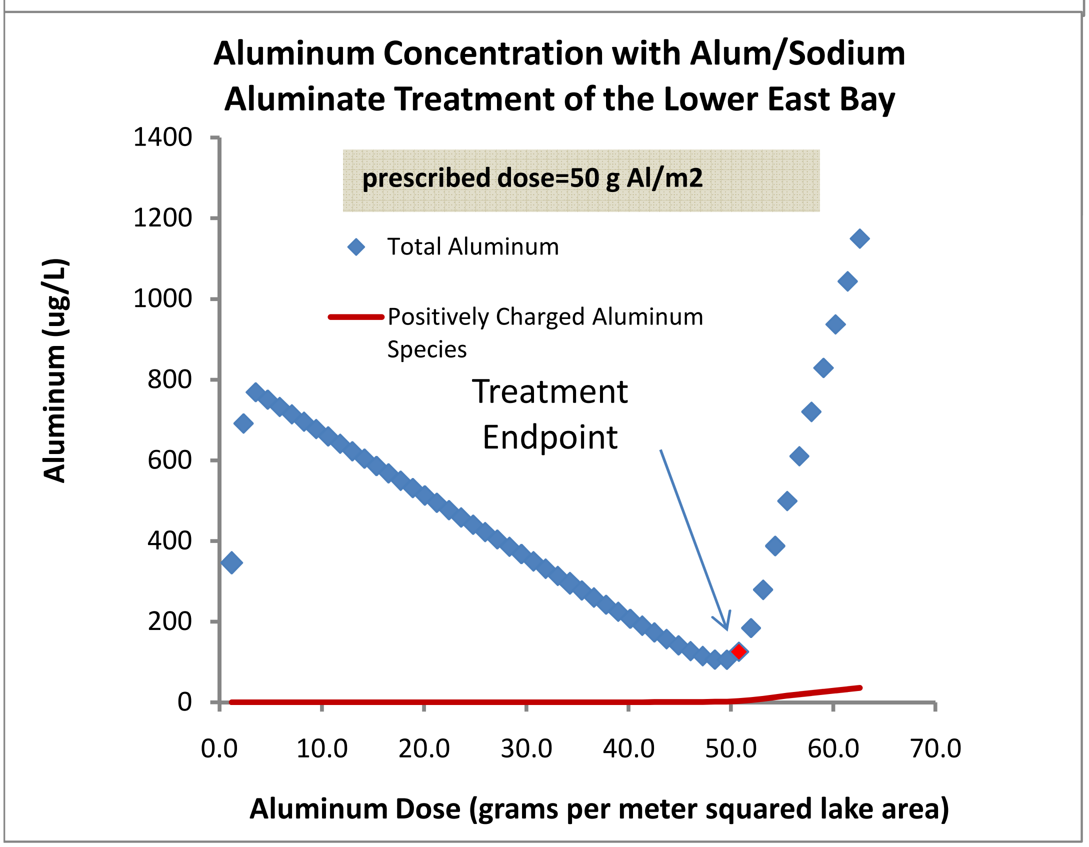


Figure 3. Effect of the prescribed alum/sodium aluminate application on pH and aluminum levels in the lake column of the the Lower East Bay. Alumium is provided as total and a sum of the positively charged aluminum species (Al^{+3}, $Al(OH)^{+2}$, and $Al(OH)_2{}^{+}$). Model conditions assume starting pH of 7.7, temperature of 15°C, partial pressure of CO_2 of -3.4 (log form) and alkalinity of 40 mg/L as $CaCO_3$.

Table 1. Alum and soldium aluminate dosing information.

Alum Sodium Aluminate Mixture (2:1)

Treatment Location	Gallons Sodium Aluminate	Gallons Alum	Gallons/ac (Sodium Aluminate)	Gallons/ac (Alum)	Ratio (Gallons Alum to Gallons of Sodium Aluminate)	Check (Kg Aluminum)	Grams Al/m2
East	26500	53500	106	215	2.0	26969	27
Lower East	15000	30000	197	395	2.0	15203	49

Cost

Treatment Location	Gallons Sodium Aluminate	Gallons Alum	Total Application Cost	Mobilization	Total Cost Both Bays
East	$132,500	$73,830	$206,330	$10,000	$332,730
Lower East	$75,000	$41,400	$116,400		

Properties

Unit	Aluminate Solution	Alum Solution
lbs/gal	12.1	11.1
%Al by Weight	10.4	4.4
Kg Al per gallon	0.57	0.22
	Na*Al(OH)4	Al2(SO4)3
Molecular Weight	118	342

FOR MODELING

Treatment Location	Aluminate (as Kg Al)	Alum (as Kg Al)
East	15,108	11,861
Lower East	8,552	6,651

Treatment Location	Sodium Aluminate (kg as Na*Al(OH)4)	Alum (kg as Al2(SO4)3)	Mass Based Ratio (alum to sodium aluminate)
East	66029	75119	1.1
Lower East	37375	42123	1.1

Treatment Location	Sodium Aluminate (moles)	Alum (moles)	Moles alum to total moles of alum and sodium aluminate	Moles sodium aluminuate to total moles of alum and sodium aluminate
East	559565	219645	0.28	0.72
Lower East	316735	123165	0.28	0.72

Treatment Location	Bay Volume (L)	Sodium Aluminate (molal as Na*Al(OH)4)	Alum (molal as Al2(SO4)3)	Total Molal	mg/L as Al
East	2732721695	0.000205	0.0000804	0.00029	9.9
Lower East	1059068877	0.00030	0.00012	0.00042	14.4

L

APPENDIX L

Aquatic Plant Management Strategy – WDNR Northern Region

AQUATIC PLANT MANAGEMENT STRATEGY

Northern Region WDNR
Summer, 2007

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

ISSUES

- Protect desirable native aquatic plants.
- Reduce the risk that invasive species replace desirable native aquatic plants.
- Promote "whole lake" management plans
- Limit the number of permits to control native aquatic plants.

BACKGROUND

As a general rule, the Northern Region has historically taken a protective approach to allow removal of native aquatic plants by harvesting or by chemical herbicide treatment. This approach has prevented lakes in the Northern Wisconsin from large-scale loss of native aquatic plants that represent naturally occurring high quality vegetation. Naturally occurring native plants provide a *diversity of habitat* that *helps maintain water quality*, helps *sustain the fishing* quality known for Northern Wisconsin, supports common lakeshore wildlife from loons to frogs, and helps to provide the *aesthetics* that collectively create the "up-north" appeal of the northwoods lake resources.

In Northern Wisconsin lakes, an inventory of aquatic plants may often find 30 different species or more, whereas a similar survey of a Southern Wisconsin lake may often discover less than half that many species. Historically, similar species diversity was present in Southern Wisconsin, but has been lost gradually over time from stresses brought on by cultural land use changes (such as increased development, and intensive agriculture). Another point to note is that while there may be a greater variety of aquatic vegetation in Northern Wisconsin lakes, the vegetation itself is often *less dense*. This is because northern lakes have not suffered as greatly from nutrients and runoff as have many waters in Southern Wisconsin.

The newest threat to native plants in Northern Wisconsin is from invasive species of aquatic plants. The most common include Eurasian Water Milfoil (EWM) and CurlyLeaf Pondweed (CLP). These species are described as *opportunistic invaders*. This means that these "invaders" benefit where an opening occurs from removal of plants, and without competition from other plants may successfully become established in a lake. Removal of native vegetation not only diminishes the natural qualities of a lake, it *may increase the risk that an invasive species can successfully invade onto the site where native plants have been removed*. There it may more easily establish itself without the native plants to compete against. This concept is easily observed on land where bared soil is quickly taken over by replacement species (often weeds) that crowd in and establish themselves as new occupants of the site. While not a providing a certain guarantee against invasive plants, protecting and allowing the native plants to remain may reduce the success of an invasive species becoming established on a lake. Once established, the invasive species cause far more inconvenience for all lake users, riparian and others included; can change many of the natural features of a lake; and often lead to *expensive annual control plans*. Native vegetation may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.

To the extent we can maintain the normal growth of native vegetation, Northern Wisconsin lakes can continue to offer the water resource appeal and benefits they've historically provided. A regional position on removal of aquatic plants that carefully recognizes how native aquatic plants benefit lakes in Northern Region can help prevent a gradual decline in the overall quality and recreational benefits that make these lakes attractive to people and still provide abundant fish, wildlife, and northwoods appeal.

GOALS OF STRATEGY:

1. Preserve native species diversity which, in turn, fosters natural habitat for fish and other aquatic species, from frogs to birds.
2. Prevent openings for invasive species to become established in the absence of the native species.
3. Concentrate on a" whole-lake approach" for control of aquatic plants, thereby fostering systematic documentation of conditions and specific targeting of invasive species as they exist.
4. Prohibit removal of wild rice. WDNR – Northern Region will not issue permits to remove wild rice unless a request is subjected to the full consultation process via the Voigt Tribal Task Force. We intend to discourage applications for removal of this ecologically and culturally important native plant.
5. To be consistent with our WDNR Water Division Goals (work reduction/disinvestment), established in 2005, to "not issue permits for chemical or large scale mechanical control of native aquatic plants – develop general permits as appropriate or inform applicants of exempted activities." This process is similar to work done in other WDNR Regions, although not formalized as such.

BASIS OF STRATEGY IN STATE STATUTE AND ADMINISTRATIVE CODE

State Statute 23.24 (2)(c) states:

"The requirements promulgated under par. (a) 4. may specify any of the following:

1. The **quantity** of aquatic plants that may be managed under an aquatic plant management permit.
2. The **species** of aquatic plants that may be managed under an aquatic plant management permit.
3. The **areas** in which aquatic plants may be managed under an aquatic plant management permit.
4. The **methods** that may be used to manage aquatic plants under an aquatic plant management permit.
5. The **times** during which aquatic plants may be managed under an aquatic plant management permit.
6. The **allowable methods** for disposing or using aquatic

plants that are removed or controlled under an aquatic plant management permit.

7. The requirements for plans that the department may require under sub. (3) (b). "

State Statute 23.24(3)(b) states:
"The department may require that an application for an aquatic plant management permit contain a plan for the department's approval as to how the aquatic plants will be introduced, removed, or controlled."

Wisconsin Administrative Code NR 109.04(3)(a) states:
"The department may require that an application for an aquatic plant management permit contain an aquatic plant management plan that describes how the aquatic plants will be introduced, controlled, removed or disposed. Requirements for an aquatic plant management plan shall be made in writing stating the reason for the plan requirement. In deciding whether to require a plan, the department shall consider the potential for effects on protection and development of diverse and stable communities of native aquatic plants, for conflict with goals of other written ecological or lake management plans, for cumulative impacts and effect on the ecological values in the body of water, and the long-term sustainability of beneficial water use activities."

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

APPROACH

1. After January 1, 2009* no individual permits for control of native aquatic plants will be issued. Treatment of native species may be allowed under the auspices of an approved lake management plan, and only if the plan clearly documents "impairment of navigation" and/or "nuisance conditions". Until January 1, 2009, individual permits will be issued to previous permit holders, only with adequate documentation of "impairment of navigation" and/or "nuisance conditions". No new individual permits will be issued during the interim.

2. Control of aquatic plants (if allowed) in documented sensitive areas will follow the conditions specified in the report.

3. Invasive species must be controlled under an approved lake management plan, with two exceptions (these exceptions are designed to allow sufficient time for lake associations to form and subsequently submit an approved lake management plan):
   a. Newly-discovered infestations. If found on a lake with an approved lake management plan, the invasive species can be controlled via an amendment to the approved plan. If found on a lake without an approved management plan, the invasive species can be controlled under the WDNR's Rapid Response protocol (see definition), and the lake owners will be encouraged to form a lake association and subsequently submit a lake management plan for WNDR review and approval.
   b. Individuals holding past permits for control of *invasive* aquatic plants and/or "mixed stands" of native and invasive species will be allowed to treat via individual permit until January 1, 2009 if "impairment of navigation" and/or "nuisance conditions" is adequately documented, unless there is an approved lake management plan for the lake in question.

4. Control of invasive species or "mixed stands" of invasive and native plants will follow current best management practices approved by the Department and contain an explanation of the strategy to be used. Established stands of invasive plants will generally use a control strategy based on Spring treatment. (typically, a water temperature of less than 60 degrees Fahrenheit, or approximately May 31st, annually).

5. Manual removal (see attached definition) is allowed (Admin. Code NR 109.06).

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* *Exceptions to the Jan. 1, 2009 deadline will be considered only on a very limited basis and will be intended to address unique situations that do not fall within the intent of this approach.*

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

DOCUMENTATION OF IMPAIRED NAVIGATION AND/OR NUISANCE CONDITIONS

Navigation channels can be of two types:

- Common use navigation channel. This is a common navigation route for the general lake user. It often is off shore and connects areas that boaters commonly would navigate to or across, and should be of public benefit.

- Individual riparian access lane. This is an access lane to shore that normally is used by an individual riparian shore owner.

Severe impairment or nuisance will generally mean vegetation grows thickly and forms mats on the water surface. Before issuance of a permit to use a regulated control method, a riparian will be asked to document the problem and show what efforts or adaptations have been made to use the site. (This is currently required in NR 107 and on the application form, but the following helps provide a specific description of what impairments exist from native plants).

Documentation of *impairment of navigation* by native plants must include:

a. Specific locations of navigation routes (preferably with GPS coordinates)
b. Specific dimensions in length, width, and depth
c. Specific times when plants cause the problem and how long the problem persists
d. Adaptations or alternatives that have been considered by the lake shore user to avoid or lessen the problem
e. The species of plant or plants creating the nuisance (documented with samples or a from a Site inspection)

Documentation of the *nuisance* must include:

a. Specific periods of time when plants cause the problem, e.g. when does the problem start and when does it go away.
b. Photos of the nuisance are encouraged to help show what uses are limited and to show the severity of the problem.
c. Examples of specific activities that would normally be done where native plants occur naturally on a site but can not occur because native plants have become a nuisance.

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

DEFINITIONS

Manual removal:	Removal by hand or hand-held devices without the use or aid of external or auxiliary power. Manual removal cannot exceed 30 ft. in width and can only be done where the shore is being used for a dock or swim raft. The 30 ft. wide removal zone cannot be moved, relocated, or expanded with the intent to gradually increase the area of plants removed. Wild rice may not be removed under this waiver.
Native aquatic plants:	Aquatic plants that are indigenous to the waters of this state.
Invasive aquatic plants:	Non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.
Sensitive area:	Defined under s. NR 107.05(3)(i) (sensitive areas are areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or lifestage requirements, or offering water quality or erosion control benefits to the body of water).
Rapid Response protocol:	This is an internal WDNR document designed to provide guidance for grants awarded under NR 198.30 (Early Detection and Rapid Response Projects). These projects are intended to control pioneer infestations of aquatic invasive species before they become established.