Dunes Lake Watershed Study—Phase II: LAKE PLANNING GRANT REPORT

Sponsor:	**Door County Soil & Water Conservation Department**
Project Period:	**October 1, 2008 – December 31, 2009**
Project Number:	**LPL-1259-09**

ABSTRACT

Empirical observations suggest that the lower reaches of Geisel Creek and Dunes Lake are experiencing accelerated eutrophication. These observations include increases in algae on bottom cobble and macrophytes in the lake, increases in algae on bottom cobble and macrophytes in the lake, increases in submerged macrophyte growth in the lake, a decrease in native clam numbers particularly near the outlet of Dunes Lake and in Shivering Sands Creek, and a large increase in coverage of duck weed on Geisel Creek. A multi-year study was developed by the Dunes Lake Partnership which is made up of several organization including The Nature Conservancy (TNC), The Door County Soil & Water Conservation Department (SWCD), and the Wisconsin Department of Natural Resources (WDNR). This study will assess current and historic water quality conditions and will attempt to identify the source or sources of the nutrients responsible for this eutrophication.

INTRODUCTION

Water quality continues to be a high priority for regions throughout the state of Wisconsin. Specifically, according to the *2009 Door County Citizen Survey Report* when County respondents were asked which County government service or operation was "very important" (the highest rating available in the survey), "Protecting ground and surface water quality" received the highest ranking of all listed County services. The protection of County water quality received 79% respondent selection of "very important". The survey illustrates that water quality protection continues to be a high priority for the people of the County.

Wetlands continue to be an important part of Door County in relation to surface water and groundwater. It is the mission of the Door County Soil & Water Conservation Department to protect and improve surface and ground water resources throughout Door County from non-point source pollution and maintain and acceptable state surface water quality standard.

Phase II of the Dunes Lake Watershed Study will be a continuation of watershed and lake water quality sampling and associated analysis. Phase II occurred during fall 2008 through the summer 2009. Phase I of sampling and analysis took place during the spring and summer months of 2008. Phase I of the project was made possible by donations from a local foundation and considered landowners.

PROJECT GOALS

Phase II goals included water sample collection and chemical analysis at various locations throughout the watershed. These locations include surface water and ground water samples. Samples were taken during thirteen (13) different events at six (6) separate locations during rain events, steady-state, pond-discharges,

and snow melt events. Rain events were defined as .25 inches of rain within 24 hours. Rain amounts were determined from the Agricultural Research Station's weather station as outlined on the NOAA's national weather services website (http://www.weather.gov/climate/xmacis.php?wfo=grb).

METHODS & MATERIALS

Water quality conditions will be assessed in Geisel Creek, several groundwater springs, Dunes Lake, and Shivering Sands Creek during the first two study years. Water sampling and chemical analysis were the primary focus of phases 1 and 2. Scheduled sampling events took place during the fall 2008 and spring 2009 over a period of five different months. Phase 2 samples were collected by the partnership and analyzed by the Wisconsin State Lab of Hygiene for dissolved reactive Phosphorous, total Phosphorous, total Kjeldahl Nitrogen, Nitrate + Nitrite-N, Ammonia-N, and total suspended solids. In-field analysis, using a hydro lab data sonde included pH, temperature, dissolved oxygen, and specific conductance. Additionally, a continuous recording YSI model 6600 V2 data sonde was deployed in Geisel Creek to monitor dissolved oxygen, pH, temperature, specific conductivity, chlorophyll, and rhodamine. This sonde was set to take a reading at 15 minute increments. This data sonde was donated for project use by the University of Wisconsin-Oshkosh. The data collected from this sonde is also included in the chemical analysis.

PHASE ACCOMPLISHMENTS *(please also refer to Appendix A)*

INPUTS TO DUNES LAKE

SURFACE WATER

- Surface water contributions to the Dunes Lake system are best characterized by samples taken at Highway 57, which captures a combination of runoff from agricultural and forested areas within the watershed.
- Non-nutrient sample analysis (steady state (SS) and rainfall (RF)) from surface water runoff samples collected at Highway 57 during 2008 are summarized below:

LAB ANALYSIS (mg/l unless noted)

DATE	TYPE	ALK	CALCIUM	HARDNS.	TSS	SO4
5/20/2008	SS	270	74	320	ND	19
7/2/2008	RF	320	82	350	8	2.5
7/30/2008	RF	270	67	290	20	7.3
8/7/2008	RF	300	85	340	5.5	6
	average	290	77	325	8.6	8.7
	range	270- 320	67-85	290-350	ND-20	2.5-19
	n	4	4	4	3	4

- Alkalinity, calcium and total hardness levels in samples collected reflect the dolomite nature of the bedrock in the area, and show surface water to be characterized as "Very Hard". The levels shown above reflect water hardness higher than that found in Clark Lake during the 2005/2006 Watershed Study performed by UWSP, with alkalinity, calcium and hardness in Clark Lake ranging from 184-204 mg/l, 83-124mg/l and 132-234 mg/l, respectively.
- Total suspended solids (TSS) in surface water contributions to Geisel Creek averaged about 8mg/l, while slightly above the 5mg/l average TSS level found in Logan creek during the 2005/2006 Study of Clark lake, should not be cause for concern for excess solids contribution to the lake system.
- Sulfate (SO4) levels in surface runoff averaged about 8mg/l, within the 10-20 mg/l typical in the NE region of the state (Shaw et al., 2000).
- Nutrient levels (mg/l) in surface water sampled (Steady State, Rainfall, pond discharge and Snowmelt sampling events) at Highway 57 during 2008 and 2009 are summarized below:

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.014	0.06	0.883	0.071	1.57
STD	0.021	0.0489	1.685	0.053	0.53

- About 75% of the total phosphorus in the samples taken was in bound or total form, with about 25% in the soluble form. These levels are in contrast with total phosphorus levels measured in Logan Creek during the 2005/2006 Study, which ranged from 0.004 to 0.032mg/l, averaging about 0.015mg/l. The somewhat higher total phosphorus levels in Geisel Creek suggest more significant contribution from agricultural runoff in terms of phosphorus than that found in the Clark Lake system.
- Three forms of nitrogen were sampled, with the more oxidized inorganic forms (nitrate (NO3) and nitrite (NO2) averaging almost 0.9 mg/l, with much lower levels of the reduced form (ammonia (NH3)) averaging 0.07mg/l, and the organically bound form (total kjhedahl nitrogen) averaging about 1.6 mg/l. total nitrogen levels of about 2.6mg/l are in contrast with TN levels in Logan creek of about 3.5 mg/l, and nitrate levels of about 3 mg/l. The higher nitrate levels in Logan Creek suggest higher groundwater contributions of nitrogen to Logan Creek at the point where samples were taken than found at Highway 57 sample point on Geisel Creek.

SEWAGE TREAMENT POND

Limited sampling of the pond contents is summarized below:

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.888	0.957	ND	0.082	1.79

- Phosphorus sampling suggests the majority of the phosphorus contribution to Geisel creek is in the total, or bound form, with total phosphorus levels about 1mg/l. Nitrogen levels generally reflect organic-bound forms of nitrogen with TKN averaging about 1.8 mg/l.

- The impact of pond discharges to Geisel Creek is captured in sampling performed at the Dunn and Haberli Roads sample points. The above data will be supplemented with data collected as part of the WPDES permit requirements in future reports.

GEISEL CREEK

- Other sample points on Geisel Creek include Dunn Road, which captures the influence of point source discharges from the sewage treatment ponds and Haberli Road, which includes groundwater contribution in addition to the surface runoff and pond discharge. The Haberli sampling point represents the major point source discharge to Dunes Lake.
- Non-nutrient sample analysis (steady state (SS) and rainfall (RF)) from surface water runoff samples collected at Dunn Road and Haberli Road sampling points during 2008 are summarized below

LAB ANALYSIS (mg/l unless noted)

DATE	TYPE	ALK	CALCIUM	HARDNS.	TSS	SO4
5/20/2008	SS	280	69	310	ND	19
7/2/2008	RF	330	80	350	270	17
7/30/2008	RF	220	54	230	5	12
	average	290	68	297	92	14.3
	range	220-330	54-80	230-350	ND-270	9.2-19
	n	4	3	3	3	4

LAB ANALYSIS (mg/l unless noted)

DATE	TYPE	ALK	CALCIUM	HARDNS.	TSS	SO4
5/20/2008	SS	270	66	300	3.5	19
6/12/2008	SS	690	15	270	4.5	13
7/2/2008	RF	290	71	320	8	13
7/17/2008	SS	270	69	310	22	18
7/30/2008	RF	270	65	290	2	12
8/14/2008	SS	260	66	300	1	20
9/5/2008	RF	270	62	280	1.5	19

9/14/2008	SS	260	62	280	1.8	20
10/8/2008	RF	250	60	270	2.5	21
	average	312	59	294	5.2	17
	range	250-690	15-71	270-320	22-Jan	13-21
	n	10	9	10	9	10

- Levels of alkalinity, calcium hardness, total hardness, total suspended solids and sulfate are not significantly different from levels measured at the Highway 57 sample point.
- Nutrient levels (mg/l) in surface water sampled (Steady State, Rainfall, pond discharge and Snowmelt sampling events) at Dunn Road during 2008 and 2009 are summarized below:

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.208	0.291	0.574	0.051	1.87
STD	0.272	0.278	0.524	0.044	0.64

- Total and dissolved phosphorus levels show a significant increase from the HWY 57 sample point, likely reflecting the input from the pond discharges.
- Ammonia and TKN levels are similar to those measured at the HWY 57 point, with NO3/NO2 levels about 50 % higher at Dunn Road than at HWY 57.
- Nutrient levels (mg/l) in surface water sampled (Steady State, Rainfall, pond discharge and Snowmelt sampling events) at Haberli Road during 2008 and 2009 are summarized below:

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.029	0.053	2.29	0.031	0.74
STD	0.049	0.059	1.16	0.036	0.43

- Total and dissolved phosphorus results (see above) at Haberli road show a significant drop (about 80%) from levels measured at Dunn Road, suggesting either significant assimilation between the Dunn and Haberli Road sample points (unlikely given the short distance and lack of significant biological growth in stream length), or (more likely) dilution with groundwater containing lower levels of phosphorus.
- Nitrate/nitrite levels between the two sample points increased about four fold, with ammonia levels relatively consistent and lower levels of TKN measured at Haberli road. The increase in NO3/NO2 is consistent with groundwater contribution - see later discussion on groundwater nitrogen levels.

GROUNDWATER

- Groundwater represents a significant source of water to the Dunes Lake system, and as such, was part of the sampling effort. Free-flowing springs are found up gradient of Dunes Lake (Haberli ditch (combination of groundwater and surface water)), (Northwest and west springs) and NE of the Lake (east spring), which contribute water to the lake year-round. Samples taken from these locations were analyzed for non-nutrient and nutrient parameters.
- Non-nutrient sample analysis (steady state (SS) and rainfall (RF)) from groundwater sample locations are summarized (averages and ranges, respectively) below:

SAMPLE POINT: Haberli Ditch, #4

ALK	CALCIUM	HARDNS.	TSS	SO4
260	63	276	1.9	15
250-280	61-67	270-280	1-2.5	21-12

SAMPLE POINT: Northwest Spring, #5

ALK	CALCIUM	HARDNS.	TSS	SO4
253	63	276	3	10.8
240-260	53-69	250-300	ND-6	9.6-12

SAMPLE POINT: West Side Spring, #6

ALK	CALCIUM	HARDNS.	TSS	SO4
257	67	288	2	12
220-280	56-72	240-310	1.8-2.3	ND-16

SAMPLE POINT: East Side Spring, #7

ALK	CALCIUM	HARDNS.	TSS	SO4
253	59	268	4	13
240-260	50-63	240-280	ND-6.5	3.2 - 21

- Groundwater quality reflects hard, alkaline water after passage through dolomitic bedrock.
- Nutrient levels (mg/l) in groundwater sampled (Steady State, Rainfall, pond discharge and Snowmelt sampling events) during 2008 and 2009 are summarized below:

HABERLI DITCH

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.012	0.054	2.3	ND	0.46
STD	0.007	0.084	0.6	ND	0.13

NORTHWEST SPRING

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.02	0.03	9.9	>ND	0.72
STD	0.045	0.045	1.6	>ND	1.06

WEST SPRING

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.009	0.014	8.94	>ND	0.29
STD	0.002	0.003	1.61	>ND	0.15

EAST SPRING

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.009	0.035	3.73	>ND	0.56
STD	0.01	0.042	0.59	>ND	0.55

- Dissolved phosphorus levels ranged from 9 to 20 ppb and total phosphorus levels ranged from 14 to 54 ppb across all sample points.
- Significant differences were observed across the four groundwater sampling points for NO2/NO3, with the Northwest and west spring about 9-10 mg/l and Haberli Ditch and east spring averaging between 2and 3.7 mg/l. Ammonia was at or slightly above detection in all groundwater samples, with TKN ranging from 0.3 to 0.7 mg/l.
- The 'typical" groundwater quality of relatively low phosphorus and higher NO2/NO3 is the basis for the observation of groundwater contribution to Geisel creek between Dunn and Haberli roads. That same stretch of creek is generally gaining in volume throughout the year, reflecting groundwater contribution.

DUNES LAKE SYSTEM

- Inputs to Dunes Lake have been previously described. The Dunes Lake sample point represents the discharge from upper Dunes Lake, representing the majority of the water body and lower Dunes Lake, a smaller, deeper portion of the lake.
- Non-nutrient sample analysis (steady state (SS) and rainfall (RF)) from surface water runoff samples collected at the Dunes Lake sampling point during 2008 are summarized (average and range, respectively) below.

DUNES LAKE

ALK	CALCIUM	HARDNS.	TSS	SO4
243	51	255	1	9.8
220-260	42-60	240-280	ND-1.5	3.0-16

- Alkalinity and total hardness levels were generally higher than Clark Lake (2005/2006 study, 184-204mg/l and 132-234 mg/l, respectively) perhaps suggesting that Dunes Lake has more groundwater contribution than Clark Lake. Calcium hardness levels (on the other hand) tended to be higher in Clark Lake (83-124mg/l) than Dunes Lake, suggesting either a differential bedrock composition or relatively higher rates of calcium deposition in Dunes Lake. Since calcium is an effective bonding agent for phosphorus, and given the higher levels of phosphorus in the inlet to Dunes Lake than Clark Lake, calcium-phosphate deposition may be responsible for the difference in calcium hardness between the two lakes.
- Sulfate levels tended to be slightly higher in Clark Lake (14-16.7mg/l) than Dunes Lake.
- Nutrient levels (mg/l) in Dunes Lake (Steady State, Rainfall, pond discharge and Snowmelt sampling events) during 2008 and 2009 are summarized below:

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.0017	0.026	0.334	0.176	1.54
STD	0.0038	0.029	0.519	0.403	2.18

- Dissolved and total phosphorus levels (1.7 and 26ppb, respectively) represents measurable PO4 assimilation across Dunes Lake, as compared with levels measured at Haberli road (29 and 53 ppb, respectively).
- Nitrogen assimilation across Dunes Lake is evident by reduced total nitrogen species (2.05 vs. 3.07mg/l) as compared with Haberli Road, with NO2/NO3 levels decreasing across the lake, and ammonia and TKN levels increasing across the lake.

LAKE DISCHARGE

- Non-nutrient sample analysis (steady state (SS) and rainfall (RF)) from surface water runoff samples collected at the discharge from Dunes Lake (Shivering Sands sampling point during 2008 are summarized (average and range, respectively) below.

SAMPLE POINT: Shivering Sands Creek, #9

ALK	CALCIUM	HARDNS.	TSS	SO4
244	52	257	3.4	10
230-260	43-62	240-290	ND-9	7.9-15

- Sample results are very similar to those results from the Dunes Lake samples.
- Nutrient levels (mg/l) in the discharge from Dunes Lake (Steady State, Rainfall, pond discharge and Snowmelt sampling events) during 2008 and 2009 are summarized below:

	D-PO4	T-PO4	NO2/NO3	NH3	Kjh-N
Mean	0.0031	0.025	0.26	0.05	0.94
STD	0.0036	0.013	0.56	0.09	0.24

- Dissolved phosphorus levels are similar as Dunes Lake (1.7 vs. 3 ppb) with total phosphorus levels (25ppb vs. 26ppb) the same as Dunes Lake.
- Total nitrogen at the discharge is about 1.3mg/l, reflecting a further decrease from the 2.1mg/l level measured in the Lake, with the largest decrease in TKN.

END NOTES

The Dunes Lake Watershed Study currently consists of four phases. This report only outlines study findings during Phase II. Please note that the information in this report represents only a fraction of the overall project. Data continues to be analyzed as more information is learned during phase III and IV of the study.

A more comprehensive, final report/lake management plan to come upon completion of entire project.

APPENDIX A:
SUMMARY OF CHEMICAL ANALYSIS

JUNE 30, 2010