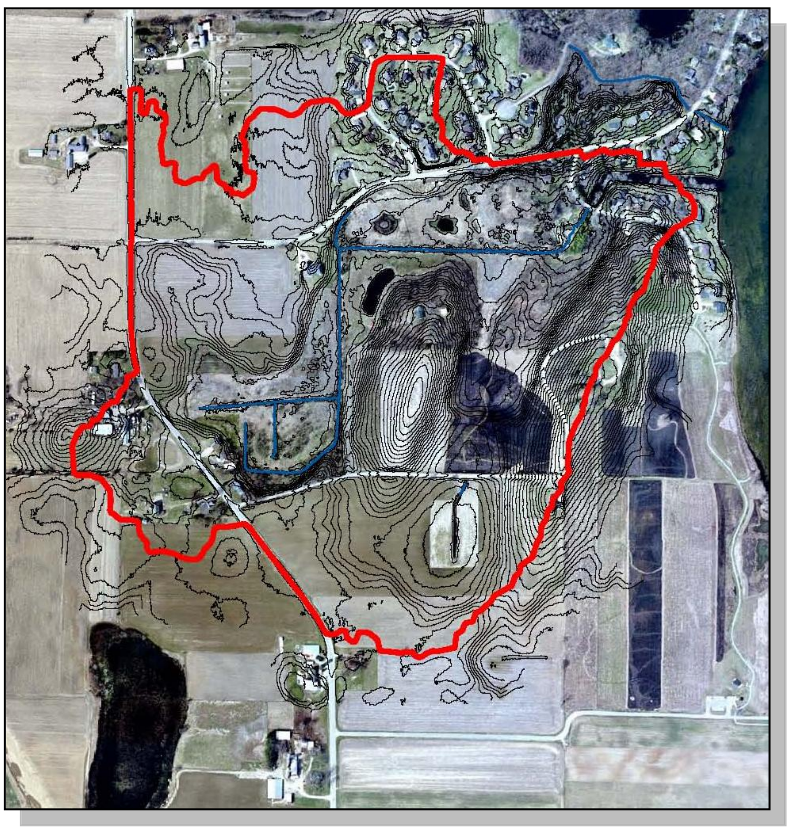
FINAL REPORT:

WATER QUALITY MONITORING AND EVALUATION OF POLLUTANT SOURCES WITHIN THE SOUTHWEST SUBWATERSHED OF ROCK LAKE

Rock Lake, Jefferson County, Wisconsin

Rock Lake Improvement Association, Inc.



Prepared in Cooperation With:

- Jefferson County Land and Water Conservation Department
- Underwater Habitat Investigations, LLC
- Hey and Associates, Inc.

Date: January 15, 2010

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INTRODUCTION

The Miljola Channel on the west side of Rock Lake has been experiencing excessive sediment deposition. The artificial navigation channel has been dredged several times during its history, only to fill back in a short period of time. In 2009 the Rock Lake Improvement Association began a monitoring project of the tributary stream that feeds the channel to identify the sources of the sediment (Figure 1). The study was conducted by Underwater Habitat Investigations, LLC, a private consultant, Patricia Cicero, from the Jefferson County Land and Water Conservation Department, and lake association volunteers. The purpose of the following report is as follows:

1. Summarize the water quality results of the 2009 stream sampling and their meanings.
2. Summarize the results of a stream inventory conducted by Hey and Associates to visually identify potential source s of sediment.
3. Calculate peak storm flows from the watershed.
4. Identify potential management alternatives for control of sediment inputs.
5. Develop recommendations for future action.

PROJECT BACKGROUND AND DESCRIPTION OF PROBLEM

In 1995, the subwatershed of Rock Lake was modeled by R.A. Smith and Associates, Inc. using the computer model WINHUSLE and reported as delivering 41 tons/year of sediment and 262 lbs/year of phosphorus into Rock Lake from upland erosion (R.A. Smith and Associates 1995). As a comparison, the model estimated 339 tons of sediment and 2,066 lbs of phosphorus flow into Rock Lake annually from rural lands in the watershed. The R.A. Smith and Associates report ranked 28 subwatersheds of Rock Lake in terms of sediment load per acre per year. There are 12 subwatersheds that have higher sediment load per acre than the Miljola subwatershed. It was noted in the R. A. Smith report that based on trophic modeling to back calculate the total phosphorus inputs to the lake from in-lake concentrations, the WINHUSLE modeling overestimated phosphorus loadings by 36%.

In recent years, the amount of sediment entering the channel from the drainage ditch was thought to be more than what was modeled – based on observations and the necessity to dredge sediment from the Miljola channel. Flooding events in 2007 and 2008 delivered a large amount of sediment to the channel, with the deepest deposits settling in the first 70 feet of the channel. The deepest sediment deposition was measured by landowners as 70 feet long by 50 feet wide by 6 feet deep. As a result, additional dredging of the channel occurred in 2009.

Testing by the Department of Natural Resources (WDNR) in June and July of 2008 found fluctuating levels of fecal coliform and e-coli counts. The e-coli ranged from 29 to 2,400 colonies per 100 ml. The fecal coliform ranged from 70 to 6,900 colonies per 100 ml.

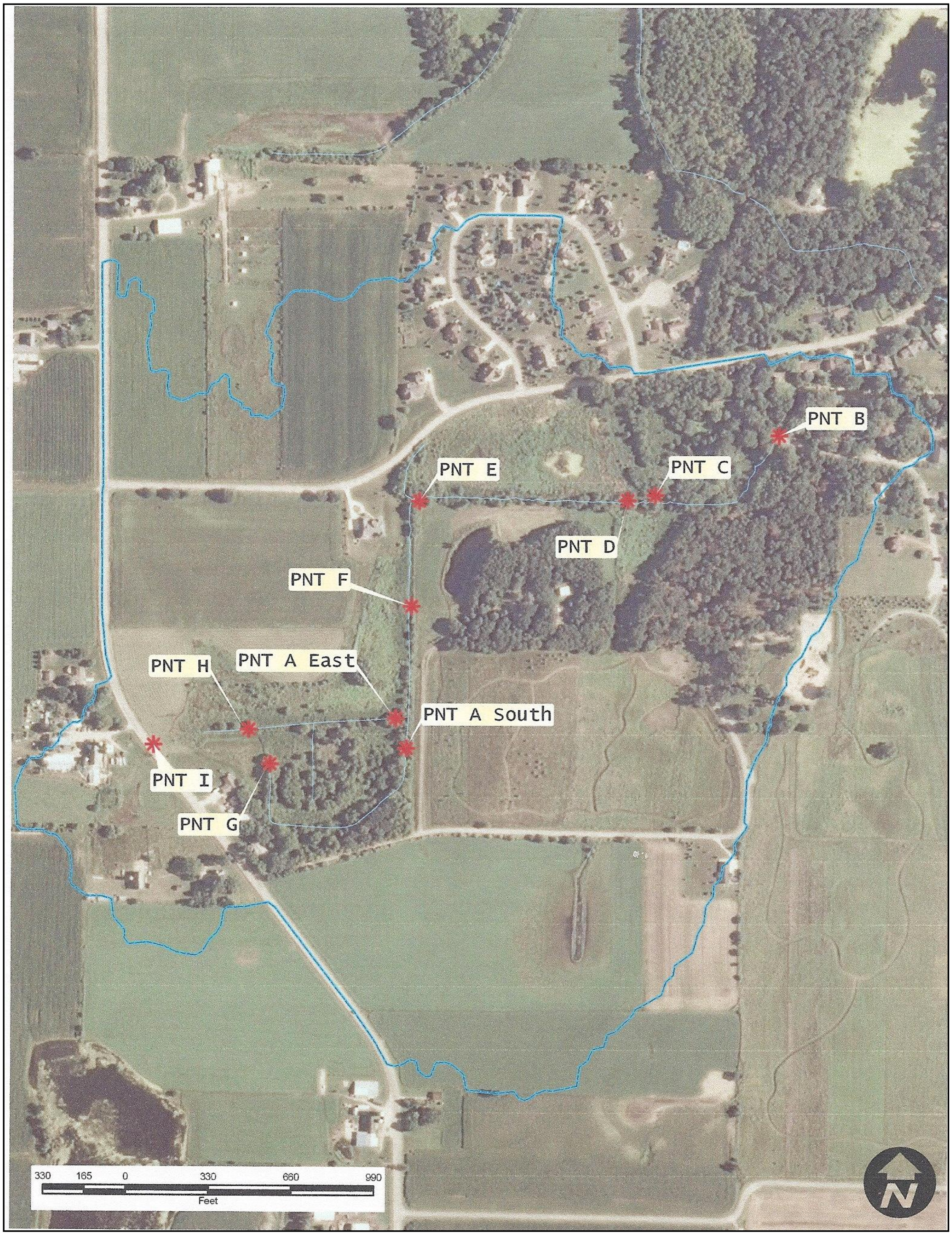

Figure 1
Study Area and Locations of Tributary Sampling Sites

PROJECT AREA

The Southwest Subwatershed drains 176.6 acres in the southwest corner of Rock Lake (Figure 1). This landscape is a mix of agriculture, parkland, wetlands, forest, and residential development (Table 1). The low gradient glaciated landscape of the subwatershed was ditched for agricultural drainage probably in the 1930s or 1940s. This drainage ditch (referred to as ditch or stream in this report) enters Rock Lake via a channel adjacent to Cedar Lane and Shorewood Hills Road (identified as the "Miljola channel" in this report).

Table 1
Land Uses in the Southwest Sub-watershed of Rock Lake

Land Use	Acreage	Percentage
Agriculture	59.20	33.5%
Grassland/Pasture (includes prairies)	36.34	20.6%
Forest	29.61	16.8%
Medium Density Urban (1/4 acre lots)	14.91	8.4%
Rural Residential (>1 acre lots)	13.59	7.7%
Wetland	10.81	6.1%
Roads	10.26	5.8%
Open water	1.89	1.1%
Total	**176.61**	**100%**

A portion of the subwatershed boundaries were field verified. As a result, there were some changes made to the watershed boundaries in the area of the Shorewood Meadows development.

PROJECT GOALS

Original Project Goals

Due to concerns over the amount of sediment, phosphorus, and bacteria in the stream/ditch, the Rock Lake Improvement Association applied for and received a Department of Natural Resources lake planning grant to perform sampling and analysis of the stream. Underwater Habitat Investigations, LLC (UHI) was hired to work on the project cooperatively with the Jefferson County Land and Water Conservation Department (LWCD) and the Rock Lake Improvement Association (RLIA).

The goal of the project was to monitor the stream and channel during both low flow and rainfall events to identify pollutant sources and loads. This includes assessing sources of fecal coliform and e-coli bacteria, phosphorus, and sediment. The health of the tributary was also assessed by performing fish and aquatic invertebrate sampling.

Amended Project Goals

After approximately 3 months of sampling and assessment in 2009, it was determined that the source of the sediment and nutrients is the bottom and sides of the drainage ditch. Underwater Habitat Investigations suggested that the remaining money in the grant should not be spent on additional base flow sampling or his time to perform the sampling. Instead, UHI recommended that the project move to the next level and include a preliminary engineering assessment to identify possible practices that would control the sediment and phosphorus delivery, and potentially the bacteria delivery also. With that advice, the RLIA requested and received a grant amendment to hire an engineering firm to do the following:

- Estimate watershed runoff volumes and peak flows for several storm events.
- Estimate stream hydraulic conditions (storm flow velocities) and sediment transport rates.
- Describe 2-3 management practices to improve sediment trapping. This description would include approximate sizes of the potential systems, ranges of possible costs, and discussion of feasibility. The feasibility discussion would include: potential upstream surface and ground water drainage impacts, long-term maintenance considerations, the most relevant storms to control for water quality and navigation objectives, and cost.
- Describe the conceptual engineering analysis, including concept drawings.
- Recommend next steps for developing preliminary and final engineering designs, including additional data needs and detailed engineering analyses needed.

HISTORY OF CHANNEL DREDGING

The Miljola channel was initially dredged for development most likely in 1957, based on aerial photos and newspaper ads for new “lake lots” available for development. The next known dredging of the channel took place in August 1998 with a hydraulic dredge on a barge. Approximately 6,000 cubic yards of sediment were removed from the channel. It is notable that half of what was removed was located in between the Cedar Lane road culvert and the bend of the channel (in the 1st 170 feet of the channel). The remaining 3,000 cubic yards was dredged from the bend of the Miljola channel to Rock Lake (approximately 700 feet). Therefore, the vast majority of sediment discharged in the Miljola channel from the stream is settling out within 170 feet of the road culvert. The dredged material removed in 1998 was placed in a WDNR approved disposal site upstream on farmland behind a berm adjacent to the drainage ditch.

In March 2005, dredging of a portion of the Miljola channel was done with a back hoe from Cedar Lane. Approximately 500 cubic yards of sediment were removed from the culvert to the extent of the back hoe’s reach. The dredged material was spread on conservation club land located outside of the subwatershed. In September 2007, landowners measured the depth of the sediment in the channel just downstream from the road culvert and found 2-3 feet of sediment. Therefore, 2-3 feet of sediment was deposited in 2.5 year. In the summer of 2008, the landowners reported that the area downstream from the road culvert had 6 feet of sediment. Therefore, 3-4 feet of sediment was deposited into the channel in 1 year. This increase of sediment deposition is more likely caused by the large and unprecedented precipitation events in the fall of 2007 and spring of 2008.

In August 2009, dredging was done again with a back hoe from Cedar Lane and from the land on both sides of the Miljola channel. Approximately 700 cubic yards of sediment were removed in the channel within 70 feet of the culvert. Sediment that was beyond 70 feet of the culvert was not dredged. The material taken out of the channel was spread on a farm field located outside of the subwatershed. A turbidity curtain was placed 30 feet from the culvert to prevent additional sediment from entering the rest of the channel. This curtain is anchored on the shoreline on both sides of the Miljola channel and extends to the bottom of the channel. A small portion of the top of the curtain is weighed down to allow water flow over the top of the curtain. The DNR permit for the turbidity curtain expires on August 17, 2012 and can be extended only once for an additional two years to August 17, 2014.

All of the dredging in the Miljola channel and material “disposal” was implemented under permits from the Wisconsin Department of Natural Resources (WDNR). Any future dredging in the channel will require permits from the WDNR.

WATER SAMPLING METHODS

Underwater Habitat Investigations led the sampling effort with support from the Land and Water Conservation Department and several RLIA board members.

Several stream sampling points were chosen for the project (Map 2). Some of these points were pipes that never had any water flow out of them: I is a road culvert, and D is a large metal pipe coming out of the stream bank. Samples were taken from May 2009 through October 2009. Only one storm event was sampled.

Parameters measured/sampled and the meter/method used are listed below:

- Flow (cfs) – water flow was measured with a Swoffer Model 2100 meter and March McBerny FlowMate.
- Water Level (ft) – water level was read from a stream gauge graduated to hundredths and marked at every foot and every tenth. The gauge was attached to a steel beam which was driven into the stream bottom upstream from the culvert (site B)
- Transparency (cm) – a 120 cm secchi transparency tube was used to measure the transparency or clarity of the water.
- pH – the ExStik pH Meter was used to measure pH. The instrument was calibrated according to the manufacturer’s directions. The YSI Model 63 was also used to measure pH.
- Conductivity (uS/cm) – The ExStik II Conductivity Meter was used to measure conductivity. The instrument was calibrated according to the manufacturer’s directions. The YSI Model 63 was also used to measure conductivity.
- Dissolved Oxygen (mg/l) – The Hach Portable LDO meter (HQ10) was used to measures dissolved oxygen and temperature. The YSI Model 52 was also used to measure DO.
- Temperature (°C) – Temperature was measured with the ExStik II Conductivity meter (°C) and the Hach Portable LDO meter (°F, then later converted to °C).
- Total Phosphorus (mg/l), Ammonia as Nitrogen (mg/l), Nitrate plus Nitrite (mg/l) – Water sample collected in a 250 ml bottle, preserved with sulfuric acid, tested with pH paper to ensure pH <2, put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking the sample.
- Total Suspended Solids (mg/l), Total Dissolved Solids (mg/l) – Water sample collected in quart bottle, put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking the sample.
- Fecal Coliform, E. coli (colonies/100ml) – water sample collected in 125 ml bottle (sealed by lab), put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking the sample.
- Chloride (mg/l), Sulfate (mg/l) - water sample collected in quart bottle, put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking sample.

- Total Phosphorus in Sediment (mg/kg) – sediment sample collected in 250 ml bottle, put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking sample.

WATER QUALITY DATA INTEROPERATION

Water quality samples were collected at several sites on tributary to identify sources of water pollutants in 2009. The location of the sampling site is shown in Figure 1. Parameters collected included:

- Water Level and Flow
- Dissolved oxygen
- Temperature
- Conductivity
- Ph
- Total phosphorus
- Ammonia nitrogen
- Nitrite/ Nitrate nitrogen
- Total suspended solids.
- Sediment load
- Bacteria

The following is a summary of the data and its meaning to the quality of the Miljola Channel and Rock Lake.

Water Level and Flow

The water level at Site B was recorded on every sampling date (Table 2). It ranged from 0.26 feet to 0.54 feet – a difference of only 0.28 feet, or 3.4 inches.

Table 2
Staff Gauge Readings at Sample Site B

Staff Gauge Reading in Feet by Given Date												
05/19/ 2009	06/02/ 2009	06/08/ 2009	06/16/ 2009	06/28/ 2009	07/10/ 2009	07/22/ 2009	07/28/ 2009	08/11/ 2009	08/19/ 2009	08/27/ 2009	10/1/ 2009	10/6/ 2009
0.52	0.47	0.54	0.44	0.44	0.36	0.44	0.35	0.39	0.34	0.36	0.35	0.37

Staff Gauge Reading in Feet by Given Date		
10/22/2009	10/23/ 2009 (AM)	10/23/ 2009 (PM)
0.38	0.56	0.55

It should be noted that the October 22 through 23, 2009 readings took place during a 2.14 inch rain event. The event did not produce a large rise in water level at Site B, upstream of the Cedar Lane road culvert. Given the size of the watershed, it would have been expected that a 2.14 inch rain event would have caused there to be more water at the discharge of the stream. This means that much of the rainwater infiltrated into the ground.

The water flow in cubic feet per second was also recorded (Table 3).

Table 3
Staff Gauge Readings at Sample Site B

Measured Flow in Cubic Feet per Second (cfs) by Date					
05/05/ 2009	**05/19/ 2009**	**06/02/ 2009**	**06/08/ 2009**	**6/28/ 2009**	**7/28/ 2009**
0.21	0.34	0.42	0.50	0.25	0.14

Figure 2 illustrates the relationship between the staff gauge readings and measured stream flow in cubic feet per second (cfs).

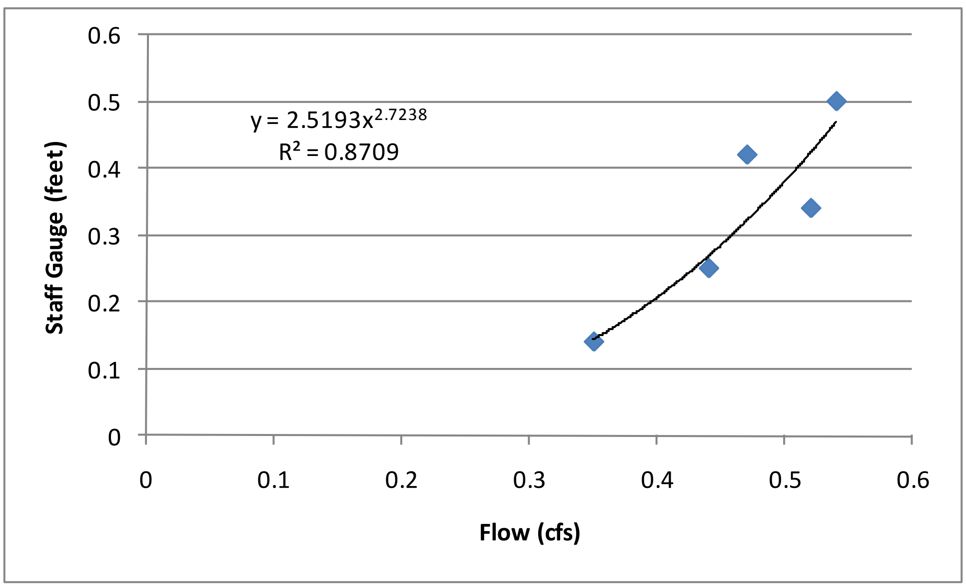

Figure 2
Relationship between staff Gauge Readings and Measured Flow

Dissolved Oxygen

Dissolved oxygen levels are one of the most important factors affecting aquatic life. Dissolved oxygen is required by all aquatic animals and affects the chemical form of many compounds in the water column and water-sediment interface. Most warm water fish species require oxygen concentrations above 3.0 milligrams per liter (mg/l) to survive. Cold-water species require higher oxygen levels and require 5.0 mg/l of dissolved oxygen for long-term survival.

A second concern about dissolved oxygen is that during periods of anoxia, when no oxygen is present chemicals in the soil and water can change form. One of most important concerns is the effects on phosphorus. Under anaerobic conditions phosphorus which is typically bound to soil particles or cations become soluble making them more available for rooted aquatic plant and algae growth.

The results of the dissolved oxygen sampling are summarized in Table 4. The results show that on none of the sampling dates did oxygen levels reach anoxic condition. On two dates at sampling site AS oxygen levels did drop below 3.0 mg/l, a level that would protect most aquatic life. This is not unusual below a wetland. Bacterial activity in wetland typically reduces dissolved oxygen levels below normal saturation. The stagnant conditions of the water at site AS prevents re-aeration of the stream flow. Downstream at sample site B, the inlet to the Miljola Channel and Rock Lake, oxygen levels were above 7.3 mg/l on all dates. Dissolved oxygen is not a concern in the study tributary.

Table 4
Results of Dissolved Oxygen Sampling (mg/l)

Site	Date											
	05/05 /2009	05/19 /2009	06/02 /2009	06/08 /2009	06/16 /2009	06/28 /2009	07/22 /2009	07/28 /2009	08/11 /2009	10/22 /2009	10/23 /2009	10/23 /2009
B	9.4	9.1	9.6	7.7	8.6	8.45	7.8	9.0	8.0	8.2	7.8	7.3
C		4.1									4.6	
E		7.8										
AE		6.9	8.0		7.1	6.97	5.5			8.8	3.4	
AS		5.8	4.0		2.9	3.31	3.1			2.8	6.0	
G			3.6		7.1							
H			7.0		4.4							
Channel					11.0							

Temperature

Stream temperature is a measure of the heat in the flowing water. Temperature is an important factor in determining instream dissolved oxygen. As water cools it has the ability to hold more dissolved oxygen. Warmer water holds less oxygen. Temperature is also an indication of the source of water feeding a stream. The temperature of groundwater in Wisconsin commonly remains fairly stable throughout the year at approximately 13 ^oC (55 ^oF) (WDNR, http://www.dnr.wisconsin.gov/org/water/dwg/gw/pubs/desk_b.pdf). Monitored stream temperatures is summarized in Table 5 and ranged from a high of 20 ^oC to low of 8.3 ^oC. The mean temperature at sample Site B at the bottom of the watershed was 12.3 ^oC (54.1 ^oF) for the 10 sample dates, indicating that the majority of flow entering Miljola Channel on the sampling dates was likely groundwater in origin.

Conductivity

Specific conductance is an indicator of the concentration of dissolved solids in the water column corrected for temperature. Dissolved solids include all anions and cations such as calcium, magnesium, iron, sodium, potassium, etc. Values of specific conductance are approximately two times the water hardness unless the water is receiving high concentrations of human-induced waste. High values of dissolved solids can disrupt electrolyte balances in aquatic organisms. In southern Wisconsin where our soils are underlying by limestone bedrock, high conductance, typically above 500 uS/cm, is an indicator of high groundwater inputs.

Table 5
Results of Temperature Sampling (°C)

Site	Date										
	05/05 /2009	05/19 /2009	06/02 /2009	06/16 /2009	06/28/ 2009	07/22 /2009	07/28 /2009	08/11 /2009	10/22 /2009	10/23 /2009	10/23 /2009
B	12.3	12	10.6	14.6	15	14.1	13.8	15.16	8.8	9.2	10.3
C		12.5								12.2	
D											
E		18.1									
F											
AE		20	10.0	16.7	19.3	17.2			8.8	9.4	
AS		20	11.1	15.2	16.6	14.6			8.3	8.7	
G			12.9	18.3							
H			11.3	16.4							
I											
Channel				21.7							

Table 6 summarizes the specific conductance results from the 2009 sampling. The results indicate that on most of the sampling dates the stream flow was dominated by groundwater discharges. Typically during large runoff events conductivity goes down. This is because rain water is low in dissolved solids and runoff that has limited contact time with the soil dilutes the groundwater dominated base flow that is high in conductivity. However in the Miljola Channel tributary most of the soils are well drained loam soils allowing large volumes of infiltration. It appears that during the monitored storms there was not have enough rainfall intensity to generate large volumes of runoff and that much of the rainfall infiltrated into the ground and entered the stream as groundwater interflow.

Table 6
Results of Specific Conductance Sampling (uS/cm)

Site	Date											
	05/05 /2009	05/19 /2009	06/02 /2009	06/08 /2009	06/16 /2009	06/28 /2009	07/22 /2009	07/28 /2009	08/11 /2009	10/22 /2009	10/23 /2009	10/23 /2009
B	805, 816, 835	840, 1002	863, 909L, 1057, 1065	407	1009	828	926	482	1080	1052	1069	1054
C		744									983	
E		948										
AE			1034		1218	1098	1256			1232	1277	
AS			1054, 1266		1253	1057	1177			1219	1196	
G			897, 905		1170							
H			1106		1293							
Channel					555							

Ph

The pH is a measure of the hydrogen ion concentration on a scale from 0 to 14 standard units. A pH of 7 indicates neutral conditions. A pH above 7 indicates basic water; below 7 indicates acidic conditions. Most aquatic life requires a pH range between 6.5 and 9.0 to survive. Below a pH of 6.5 fish begin to become stressed. Low levels of pH can cause some toxic metals to become more soluble in water. When pH values rise to the range of 8.0 to 9.0, it may be indicative of rapid algae growth.

Table 7 summarizes the pH results from the 2009 sampling. All values were in the neutral range and high or low pH is not a concern in the study tributary.

Table 7
Results of pH Sampling

Site	Date											
	05/05 /2009	05/19 /2009	06/02 /2009	06/08 /2009	06/16 /2009	06/28 /2009	07/22 /2009	07/28 /2009	08/11 /2009	10/22 /2009	10/23 /2009	10/23 /2009
B	7.77	7.76	7.76	7.56	7.9	7.89	7.84	8.02	7.97	7.92	7.9	7.79
C		7.12									7.31	
E		7.74										
AE		7.59	7.5		7.50	7.65	7.37			7.95	7.75	
AS		7.50	7.51		7.35	7.42	7.29			7.74	7.61	
G			7.56		7.62							
H			7.25		7.13							
Channel					8.45							

Chloride

Chloride can be an indication of pollution because it is not common in Wisconsin soils or rocks, except in areas with limestone deposits. Jefferson County is located in an area of the state that contains higher concentrations (>10 mg/l) of chloride than in other areas. Sources of chloride are animal waste, potash fertilizer, septic systems, water softening salt, and road salt. Roads in the watershed (Hwy S and Cedar Lane) receive road salt in the winter. Chloride can inhibit plant growth, impair reproduction, and negatively impact the diversity of the in-stream organisms.

On July 28, 2009, the chloride concentration of the water upstream of the Cedar Lane road culvert (site B) was 70.1 mg/l. This amount is well below the U.S. Environmental Protection Agency recommendation for aquatic life which is a 4-day average chloride concentration of 230 mg/l occurring once every 3 years; and the USEPA secondary maximum contaminant level of 250 mg/l for chloride in drinking water (Mullaney 2009).

Total Phosphorus

Aquatic plants and algae require nutrients such as phosphorus, nitrogen, carbon, calcium, chlorides, iron, magnesium, sulfur, and silica for growth. In lakes where the supply of one or more of these nutrients is limited, plant and algae growth may also be limited. The two nutrients that most often limit and control the growth of plants are nitrogen and phosphorus. In nutrient limited lakes, if you add more nitrogen or phosphorus, you will get more plant or algae growth. Rock Lake has been shown to be phosphorus limited because the nitrogen to phosphorus ratio is approximately 55:1 (Marshall 1997). Lakes are phosphorus limited as long as the nitrogen to phosphorus ratio exceeds 15:1.

Table 8 summarizes statewide means and ranges of nitrogen and phosphorus concentrations from stream data collected for 240 streams as part of the study, *Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin* (Robertson, 2006).

Table 8
Results of Statewide Sampling of Total Phosphorus in Wisconsin Streams
(Source: USGS)

Statistic	Total Suspended Solids (mg/l)	Organic Nitrogen (TKN) (mg/l)	Nitrate/Nitrite (mg/l)	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Dissolved Phosphorus (SRP) (mg/l)
	Statewide Means (USGS, 2006)					
Mean	-	0.675	2.086	2.807	0.116	0.079
Median		0.563	1.048	1.695	0.085	0.050
Minimum	-	0.070	0.005	0.131	0.012	0.004
Maximum	-	2,350	20.550	21.260	1.641	1.495
Standard deviation	-	0.414	2.865	2.860	0.144	0.122

Table 9 summarizes the total phosphorus results from the 2009 Miljola tributary sampling. Total phosphorus concentrations ranged from 0.251 to 2.0 mg/l. All of the values exceeded the USGS statewide mean values, and three values exceeded the statewide maximum, indicating very high concentrations of phosphorus.

Table 9
Results of Total Phosphorus Sampling (mg/l)

Site	Date								
	06/02/2009	06/08/2009	06/16/2009	06/28/2009	07/22/2009	07/28/2009	10/22/2009	10/23/2009	10/23/2009
B	0.268	0.394	0.280	0.227	0.502	0.251	0.350	0.481	0.510
AE	1.150		1.060	0.813	1.440			1.200	
AS	0.287		0.333	0.267	0.278			0.297	
G	1.660*		2.380*						
H	1.560*		2.000*						

* Stagnant water conditions.

Table 10 summarizes the phosphorus loadings to Rock Lake based on the sampling data at sample site B. Loading is the total mass in pounds that enters the lake per day or per year. Multiplying the measured stream flow times the total phosphorus concentration you can estimate daily pounds of phosphorus that has entered the lake. Assuming that the sampling results represent a typical day, we can multiply the daily average by 365 days to get an estimate of annual loading. It need to be noted that none of the samples collected represent a large rainfall or runoff event, therefore these estimates should be considered low. The results in Table 10 indicate that at least 256 pound of total phosphorus per year entered Rock Lake in 2009 from the study tributary.

Table 10
Total Phosphorus Loadings to Rock Lake Based on Sampling at Site B (Channel Inlet)

Parameter	Sampling Date									Average	Annual Loading (lbs/year)
	06/02 /2009	06/08 /2009	06/16 /2009	06/28 /2009	07/22 /2009	07/28 /2009	10/22 /2009	10/23 /2009	10/28 /2009		
Flow (cfs)	0.420	0.500	0.290	0.250	0.290	0.140	0.190	0.490	0.474		
Total P (mg/l)	0.268	0.394	0.280	0.227	0.502	0.251	0.350	0.481	0.510	0.363	
Total P (lbs/day)	0.606	1.061	0.437	0.306	0.784	0.189	0.358	1.271	1.301	0.702	**256.065**

Phosphorus sampling in the stream upstream of the Cedar Lane culvert was performed in the past, mainly as part of the research for the Rock Lake Priority Lake project. Figure 3 shows the variation of total phosphorus measurements over time that ranges from 0.086 mg/l to 0.61 mg/l (within the range of statewide min/max values) and has an average value of 0.32 mg/l (greater than the statewide mean).

Ammonia Nitrogen

About three-fourths of the ammonia produced in the United States is used in fertilizers either as the compound itself or as ammonium salts such as sulfate and nitrate. Therefore ammonia is a potential indicator of pollution by agricultural runoff. NH_3 is the principal form of toxic ammonia. It has been reported toxic to fresh water organisms at concentrations ranging from 0.53 to 22.8 mg/L. Toxic levels are both pH and temperature dependent. Toxicity increases as pH decreases and as temperature decreases. Ammonia is a nutrient that can be used by rooted aquatic plants and algae.

Table 11 summarizes the ammonia results from the 2009 sampling. As can be seen from the sampling most values are relatively low, indicating that agricultural runoff of fertilizer is not a major issue.

Table 11
Results of Ammonia Sampling (mg/l)

Site	Date							
	06/02/2009	06/08/2009	06/28/2009	07/22/2009	07/28/2009	10/22/2009	10/23/2009	10/28/2009
B	0.058	0.125	ND	0.050	ND	0.032	0.09	0.095
AE	0.186		~~0.151*~~	0.195			0.332	
AS	0.300		~~0.321*~~	0.265			0.187	
G	1.24							
H	0.166							

*Lab Comment: matrix spike, QC exceeded

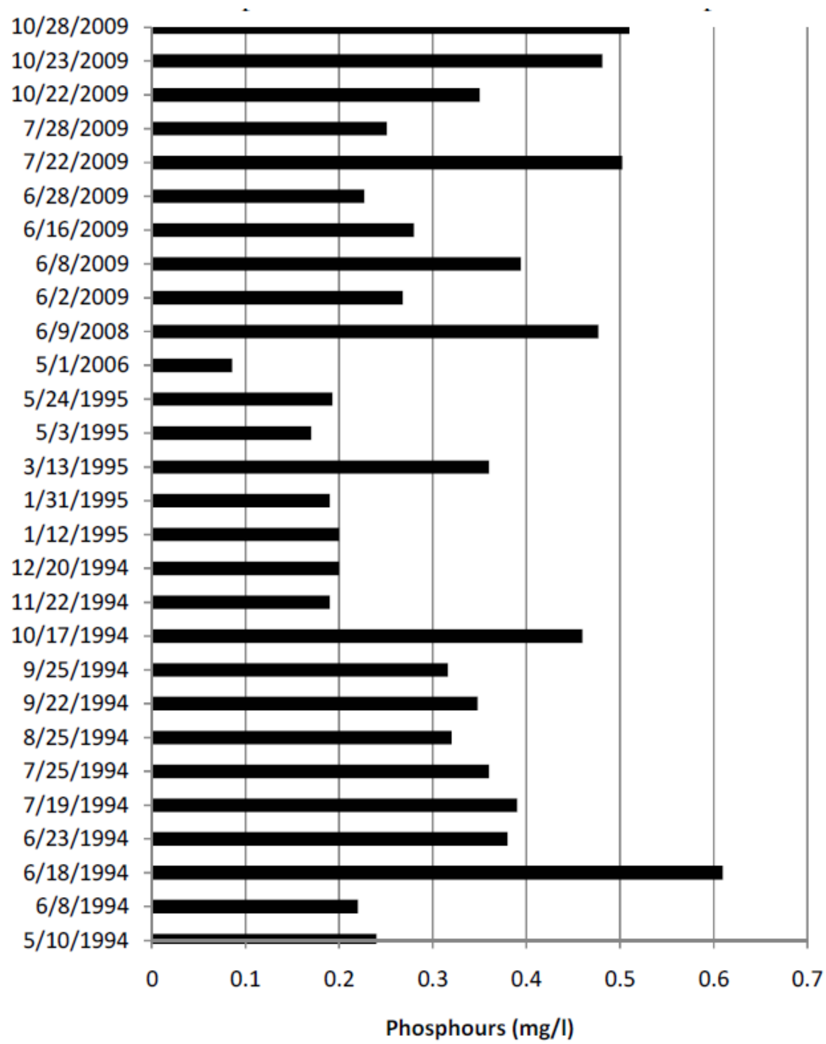

Figure 3
Historic Total Phosphorus Data Available from Ditch Upstream of Cedar Lane Road Culvert

Nitrite/Nitrate

State and Federal laws set the maximum allowable level of nitrate-nitrogen in public drinking water at 10 milligrams per liter (10 parts per million). Nitrate-contaminated water should never be fed to an infant less than 6 months of age. In young infants, ingestion of nitrate can reduce the blood's ability to carry oxygen. In severe cases it can cause a condition that doctors call methemoglobinemia also called "blue baby syndrome" because the infant's skin appears blue-gray or lavender in color. This skin color change is caused by a lack of oxygen in the blood. An infant suffering from "blue baby syndrome" needs immediate medical care because the condition can lead to coma and death if it is not treated promptly. Some scientific studies have also found evidence suggesting that women who drink nitrate contaminated water during pregnancy are more likely to have babies with birth defects. People who have heart or lung disease, certain inherited enzyme defects or cancer may be more sensitive to the toxic effects of nitrate than healthy individuals. Some researchers also suspect that consuming nitrate-contaminated water may increase the risk of certain types of cancer (WDNR Publication: PUB-DG-001 2006). This form of nitrogen at high levels and can contribute to nuisance algae blooms.

Table 12 summarizes the nitrite/nitrate results from the 2009 sampling. None of the values exceeds the state's drinking water standard. Fourteen of the seventeen samples exceeded the statewide means for nitrite/nitrate collected by USGS (Table 8), indicating elevated concentrations.

Table 12
Results of Nitrite/Nitrate Sampling (mg/l)

Site	Date							
	06/02/ 2009	06/16/ 2009	06/28/ 2009	07/22/ 2009	07/28/ 2009	10/22/ 2009	10/23/ 2009	10/23/ 2009
B	3.49	3.51	3.77	2.51	3.93	2.83	5.09	6.06
AE		5.90	6.66	3.08			2.77	
AS		0.409	0.381	0.518			2.14	
G		ND						
H		4.10						

Transparency

Transparency is a measure of water clarity. Materials suspended and dissolved in the water will impact the clarity of the water. The more cloudy the water the less transparency it has. The results from the sampling in the ditch are presented in Table 13. The numbers in the table represent the distance one can see into the water column. The lower the transparency readings, the more turbid the water.

Table 13.
Transparency (cm) Measurements

Site	5/5/ 2009	5/19/ 2009	6/2/ 2009	6/8/ 2009	6/16/ 2009	6/28/ 2009	7/22/ 2009	7/28/ 2009	8/11/ 2009	10/22/ 2009	10/23/ 2009 am	10/23/ 2009 pm
B	110	120	77.6	66.4	87.6	115	ND*	77	42.8	67.8	45	35.4
C												
D												
E												
F												
AE		120	107		49.5	73	55.5			113.8	>120	
AS			>120		>120	>120	>120				>120	
G			>120		63							
H			>120		91.6							
I												

*An accurate reading was not obtained.

Table 14 shows the Wisconsin median and average transparency of streams and the data from the ditch. In May and June, the ditch transparency was greater than the average and median transparency of streams throughout WI. In July, the ditch transparency was close to WI stream norms. In August, the ditch transparency was much lower than the WI stream norms (based on one sample). For October, the median and average transparencies in the ditch were less than the WI stream norms. However, it should be noted that the October data was during a storm event, and transparencies decrease because more sediment is carried during storm events. The State minimum transparency for streams is 23.5 cm.

Table 14.
Median and Average Transparency (cm) for Wisconsin (Robertson 2006) and the Ditch

Month	WI Median Transparency	Ditch Median Transparency*	WI Average Transparency	Ditch Average Transparency*
May	105.0	120	89.8	116.7
June	88.5	107	79.6	96.7
July	90.0	77	82.9	84.2
August	>120	42.8	92.9	42.8
October	>120	90.8	107.9	83.7

*Transparencies that were >120 were assumed to be 120 for the median and mean calculations.

Sediment Load Sampling

Soil erosion by water is the process where material is dislodged from the surface of the land and transported by water to a receiving body such as a stream. Once material is detached, it can be transported by the energy of the water. As particle size and weight of the material increases, so does the velocity needed to transport it. The material transported through the stream is its stream load. Stream load is composed of dissolved or solution load, suspended load, and bed load.

Dissolved Solids

Dissolved load comes primarily from groundwater seepage into the stream. Ions in solution also come from the solution of materials that line the channel. The most common chemical constituents of dissolved solids are calcium, phosphates, nitrates, sodium, potassium and chloride, which are found in nutrient runoff, general stormwater runoff, and runoff from road de-icing salts. The chemicals may be cations, anions, molecules or agglomerations on the order of 1000 or fewer molecules, so long as a soluble micro-granule is formed. The technical definition of dissolved solids is that the solids must be small enough to survive filtration through a sieve size of two micrometers (um).

On July 28, 2009, the total dissolved solids of the water upstream of the Cedar Lane road culvert (site B) was 566 mg/l.

Total Suspended Solids

Suspended load is comprised of sediment suspended in the water and transported through the stream. Turbulent flow suspends clay and silt in the stream. Suspended load comes from material eroded from the surface bordering the channel and deposited in the stream, as well as erosion of the channel itself.

Total suspended solids is a measure of the amount of suspended material in the water column. It is related to water clarity and turbidity. TSS is composed of two components – nonvolatile suspended solids and volatile suspended solids. Volatile suspended solids (VSS) refers to the organically derived portion of TSS related to algal and bacteria biomass while non-volatile suspended solids are inorganic solids. High TSS values are associated with poor water clarity and can be harmful to many aspects of the lake ecosystem, including the plant and fish communities. High turbidity caused by suspended solids can shade out aquatic plants resulting in their reduction or disappearance from the littoral zone. Aquatic plants provide habitat for many fish species, stabilization of the lake bottom, and refuges for algae grazing zooplankton. Suspended solids can also inhibit successful predation by sight-feeding fish or settle out and smother fish eggs. TSS above 40 mg/l cause cloudy water conditions and levels above 100 mg/l can damage aquatic life. Suspended solids that are discharged to lakes can settle accumulating sediment on the bottom of the lake.

Table 15 summarizes the total suspended solids results from the 2009 sampling.

Table 15
Results of Total Suspended Solids Sampling (mg/l)

Site	Date								
	06/02/2009	06/8/2009	06/16/2009	06/28/2009	07/22/2009	07/28/2009	10/22/2009	10/23/2009	10/23/2009
B	16	31	35	~~15~~*	85	23	34	80	114
AE	16		52	~~15~~*	31			3	
AS	6		4	~~4~~*	22			ND	
G			57						
H			88						

* Lab comment: Holding time exceeded by 2 days

Table 16 summarizes the total suspended solids loadings to Rock Lake based on the sampling data at sample site B. Assuming that the sampling results represent a typical day, we see that at least 35,756 pounds of suspended solids entered the Miljola Channel and Rock Lake in 2009. Like phosphorus, It need to be noted that none of the samples collected represent a large rainfall or runoff event, therefore these estimates should be considered low.

Table 16
Total Suspended Solids Loadings to Rock Lake Based on Sampling at Site B (Channel Inlet)

Parameter	Sampling Date									Mean	Annual Loading (lbs/yr)
	06/02/2009	06/08/2009	06/16/2009	06/28/2009	07/22/2009	07/28/2009	10/22/2009	10/23/2009	10/28/2009		
Flow cfs	0.420	0.500	0.290	0.250	0.290	0.140	0.190	0.490	0.474		
TSS (mg/l)	16.00	31.00	35.00	15.00	85.00	23.00	34.00	80.00	114.0	48.111	
TSS (lbs/day)	36.20	83.51	54.67	20.20	132.8	17.38	34.76	211.3	290.9	97.961	35,755.68

Bed Load

Bed load, sometimes referred to as traction load, is the material that is transported by sliding, rolling, and saltating (skipping) along the bed of a stream (Figure 4). Particles comprising bed load can range in size from sand to boulders. The movement of bed load is responsible for bedforms that change in time and space along a stream bed.

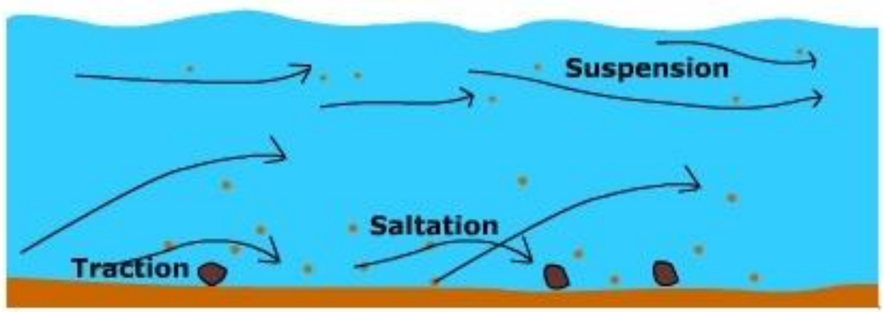

Figure 4
Illustration of Suspended and Bed Load in a Flowing Stream

Particles along a stream bed begin to move when the shear stress exerted by the flowing water exceeds a critical value. The critical shear stress depends on a combination of the particle diameter, the slope of the stream channel, the difference between the density of individual particles and that of water (particle buoyancy), and the degree to which the particles are packed together. As a result, particles of different mineralogical composition and size will have different critical shear stresses. Heavy minerals can be concentrated in stream beds because they are left behind, while lighter particles move around them. Likewise, small particles may move while large particles of the same mineral or rock type are left in place. Water density is proportional to the suspended load being carried. Muddy water high in suspended sediment will, therefore, increase the particle buoyancy and thereby reduce the critical shear stress required to move particles of a given size and composition.

The shear stress exerted by the flowing water, which is proportional to both water depth and stream channel slope, also controls the movement of bed load. Large or heavy particles that have high critical shear stress values may move as bed load when the water is unusually deep during infrequent floods and remain stationary between those times.

Once a particle begins to move, the current above the bed may be strong enough to lift it off the bed and into the flowing water. When the entire weight of a particle is borne by water instead of other particles beneath it, that particle ceases to be part of the bed load and becomes part of the suspended load. Conversely, if the current slows, a particle may fall out of suspension and become part of the bed load. The distinction between bed load and suspended load in a stream can, therefore, change continuously through time.

Bed load mass can be measured using a device called a “Helley-Smith Sampler”. The Helley-Smith sampler was designed by the United States Geological Survey (USGS) to conduct stream bed load studies. By design, the Helley-Smith sampler is intended to collect sediment particles that are moving along the bottom, or close to the bottom, by rolling, sliding, or bouncing (actually, those particles moving within 0.25 ft. of the bed). The device consists of a 3- by 3-inch rectangular funnel fitted with a catch bag made of 0.25 mm opening nylon mesh that is attached to the flared end of the sampler (Figure 5). It is placed on the channel bottom for a fixed time period and the amount of sediment collected in the bag is then measured.

Figure 5
Photograph of "Helley-Smith" Stream Bed Load Sampler

On November 13, 2009 Hey and Associates conducted a bed load sample at sample site B the inlet to the Miljola Channel. On this date the staff gauge reading at the site was 0.38 and flow was measured using a Marsh-McBirney, Inc. FlowMate flow meter at 0.46 cfs. During a five minute period 0.225 pounds (3.6 oz) of bed load material was collected. The material was all peat. If we assumed that this value represented a typical day and multiply it by 365 days we get an annual loading level of **23,652 pounds per year**. This value should be considered a low estimate of bed load as the one sample was collected during a period of very little flow and does not represent the quantity of material that is likely moving during storm events or higher base flow. Additional sampling would be required to accurately estimate the real bed loading to the channel and lake.

On May 19, 2009, a sediment sample was taken upstream of the Cedar Lane road culvert (site B). The phosphorus concentration in the sediment was measured to be 1,410 mg/kg.

Underwater Habitat Investigations, Land and Water Conservation Department, Hey and Associates, Inc., and the Rock Lake Improvement Association all agree that the bulk of sediment that is entering the Miljola Channel is from stream bed erosion. The bed load sampling on November 13, 2009 illustrated that material is moving along the bottom of the channel. The characteristic of the sediment that is accumulating in the Miljola Channel is mostly peat. While additional sampling should be conducted to better document the annual inputs to the channel and lake, management for sediment control should focus primarily on controlling stream bed and bank erosion.

Fecal Bacteria

The presence of fecal bacteria in aquatic environments may indicate that the water has been contaminated with the fecal material of man or other animals. Fecal bacteria can enter rivers through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from human sewage. If high numbers of fecal coliform bacteria are found in a sample of stream water, one may conclude that there has been recent fecal contamination. Two test for fecal bacteria are available; fecal coliform and E-Coli.

Fecal Coliform Bacteria

Fecal coliform bacteria, members of the family *Enterobacteriacae*, which include *Escherichia coli* , *Citrobacter*, *Enterobacter* and *Klebsiella* species, are often used as indicators. These gram negative bacilli (rod shaped bacteria) are found in the digestive tracts of all warm-blooded animals. Most are not pathogenic. However, because they are eliminated with feces, they are sometimes associated with pathogens such as *Vibrio cholera* bacteria or a form of *Hepatitus* virus that is found in the digestive tract. Total coliform bacteria counts are sometimes used to test for water contamination also. These organisms are less precise as fecal contamination indicators because many can live and reproduce in soil and water, without having a human host. Recreational standards for fecal coliform bacteria are as follows:

Coliform Standards (in colonies per 100 ml):

Total body contact (swimming)……………………….200 FC

Partial body contact (boating) ………………………1000 FC

Table 17 summarizes the fecal coliform results from the 2009 sampling. As can be seen many of the values are above the state recreational use standards and indicate the presence of fecal bacteria.

Table 17
Results of Fecal Coliform Sampling (colonies per 100 ml)

Site	Date								
	05/19/ 2009	06/02/ 2009	06/08/ 2009	06/16/ 2009	06/28/ 2009	07/22/ 2009	10/22/ 2009	10/23/ 2009	10/23/ 2009
B	60	860	3,600	340	2,000	6,800	310	450	320
F	<10								
AE		210		610	950	4,500		410	
AS	140	140		180	5,300	1,630		310	
G		150		1,500					
H		5,800		50					

E-coli Bacteria

E-coli (*Escherichia coli)* are a specific form of the fecal coliform group. E-coli which live the intestines of warm blooded animals have been associated with making humans sick through ingestion. The U. S. Environmental Protection Agency (USEPA) has recommended that E-coli be used to measure the safety of public beaches. The USEPA requires that beaches be posted with an advisory sign informing the public of increased health risk when a water sample exceeds 235 colony-forming units of E. coli per 100 milliliters of water. The sampling shows values above the recreational standard on 7 of the sampling dates, indicating a source of fecal bacteria (Table 18).

Table 18
Results of E-coli Sampling (colonies per 100 ml)

(Site	Date								
	05/19/ 2009	**06/2/ 2009**	**06/8/ 2009**	**06/16/ 2009**	**06/28/ 2009**	**07/22/ 2009**	**10/22/ 2009**	**10/23/ 2009**	**10/23/ 2009**
B	48	**1,120**	**3,610**	**326**	**4,710**	**6,100**	230	**550**	**350**
F	3								
AE	185	130		345	**1,203**	**3,800**		**460**	
AS	55	96		210	1,986	1,700		460	
G		70		613					
H		5,210		77					

One of the goals of the grant project was to discover the source of e-coli and fecal coliform bacteria. The sampling that was planned and implemented did not result in identifying the source. This is because the bacteria levels were very variable at all of the sampling points and therefore did not indicate a possible pollutant location. Possible bacteria sources could be one or more of the following: leakage from septic systems into the groundwater, leakage from a manure storage into the groundwater, contaminated sediment from previous runoff events from agricultural fields spread with animal waste, contributions of bacteria associated with organic wetland soils, and wildlife in the area.

The one manure storage structure in the watershed was properly closed in early December 2009. The storage had a concrete floor and clay side-walls. A Natural Resources Conservation Service engineer designed and inspected the closure which consisted of removing any remaining manure, breaking up the concrete floor, removing all contaminated soils, and filling the hole with clean fill. Therefore, if this storage was a source, then it will no longer be a source in the future.

During sampling events, there were several sightings and evidence of wildlife in the area. These include deer, waterfowl, and groundhogs.

LWCD staff had a discussion with Sharon Kluender from the State Lab of Hygiene about bacteria and tests that could reveal a source of bacteria. She suggested a series of tests that could possibly help with source testing (human vs animal) that include: antibiotics, bacteriodes spp., bifidobacteria, hormones, pharmaceuticals/personal care products, rhodococcus coprophilus, 11 sterols, and male specific RNA coliphage. She recommended that these tests should be done together (instead of picking a subset). Again, she was quick to point out that the testing could be implemented, and there could still be uncertainty in the results.

Storm Sampling

On October 22 and 23, 2009, a small storm event was sampled. The storm event produced 2.14 inches of rain (as measured from a volunteer's rain gauge). Total rain amounts measured by a local resident were measured as follows:

- 10-22-09, 1:30 pm = 0.71 inches of total rain
- 10-23-09, 7:00 am = 1.82 inches of total rain
- 10-23-09, 4:00 pm = 2.14 inches of total rain

Rainfall officially measured using a NOAA approved rain gauge at the City of Lake Mills Wastewater treatment plan was:

- 7 am Oct 22, 2009 until 7 am Oct 23, 2009 = 1.23 inches
- 7 am Oct 23, 2009 until 7 am Oct 24, 2009 = 0.25 inches
- Total for two days = 1.48 inches

Measurements taken during the storm event at Site B are contained in Table 19 and 20.

Table 19.
Water Quality Measurements at Site B during a Storm Event

Site B	Water Level (ft)	Temp (^{o}C)	Clarity (cm)	Conductivity (uS/cm)	D.O. (mg/l)	Total P (mg/l)	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	TSS (mg/l)
10/22 10:50 AM	0.38	8.8	67.8	1052	8.2	0.35	0.032	2.83	34
10/23 9:50 AM	0.56	9.2	45.0	1069	7.8	0.481	0.09	5.09	80
10/23 2:00 PM	0.55	10.3	35.4	1054	7.3	0.51	0.095	6.06	114

Table 20
Bacteria measurements at Site B during a storm event

Site B	E-Coli (colonies/100ml)	Fecal Coliform (colonies/100ml)
10/22/2009, 10:50 AM	230	310
10/23/2009, 9:50 AM	550	450
10/23/2009, 2:00 PM	350	320

The following can be said about the results:

- Conductivity levels suggest that the stream flow consists of mostly groundwater. Therefore, much of the rainfall during this event was mainly infiltrated through the ground and not delivered as runoff.
- The water level did not increase very much during the storm given the size of the watershed. Therefore, much of the rainfall is infiltrating into the ground instead of being delivered to the stream via surface runoff.
- Sediment delivery increases with increased flow. Because the flow is mostly groundwater, it is probably the case that the sediment in the stream originates in the channel of the stream.
- Bacteria levels increased with flow and then decreased again when the flow decreased.

HABITAT SAMPLING

On August 21, 2009, UHI and the LWCD surveyed the stream for fish and aquatic insects. Because of the shallow stream depth and very narrow channel, dip nets were used instead of electroshocking gear or seines. Six sites along the length of the stream were sampled (see Figure 6).

No fish were found at any of the sites. In terms of the insects, amphipods were the dominant organism. Water striders were also present.

The amphipod's (also called scud – Gammarus psuedolimneus) body shape and side-swimming behavior enables it to not be washed downstream in currents. It eats decaying plants and animals. Amphipods are semi-tolerant of pollutants and their presence often indicate the presence of ground water.

Water striders live on the water surface and therefore breathe from the atmosphere instead of the water as do most fish, crustaceans and other aquatic insects. They can walk on water and they eat plants and insects. Water striders are not water quality indicators because they are air breathers and will not be affected by pollutants that lower dissolved oxygen in the water.

STREAM CHANNEL AND SEDIMENT SURVEY

On August 21, 2009, UHI and LWCD surveyed the stream bottom at six locations along the length of the stream (Figure 6). Characteristics found at each sampling point are recorded in Table 21. Sediment depths along the channel profile were also measured at site 5 and 6 (Figures 7 & 8). During the survey (and on other sampling days) the dark peat (or muck) sediment was observed flowing above the bottom of the stream (bed load). The dark peat/muck sediment is characteristic of wetland soils, such as Houghton muck which is the wetland soil surrounding the stream/ditch.

Given the sediment profiles (Figures 7 & 8), an estimate of sediment that is located in the stream channel and has the potential to be delivered downstream during storm events can be determined. Based on field observations, an estimate was made as to the length of stream that contains sediment in the bottom of the channel. The estimated amount of sediment in the stream channel bottom alone is 9,200 cubic yards.

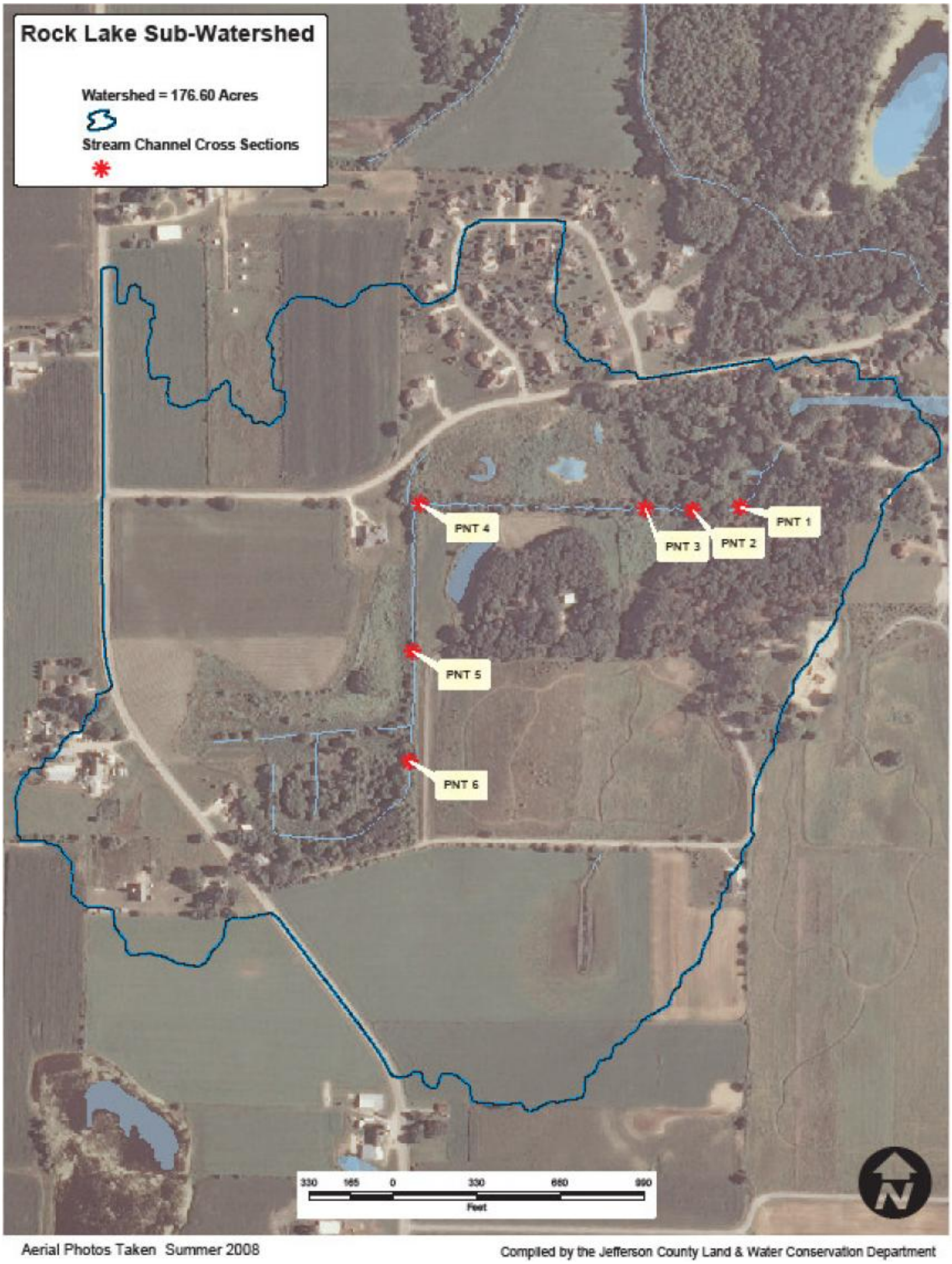

Figure 6
Locations of Habitat Sampling

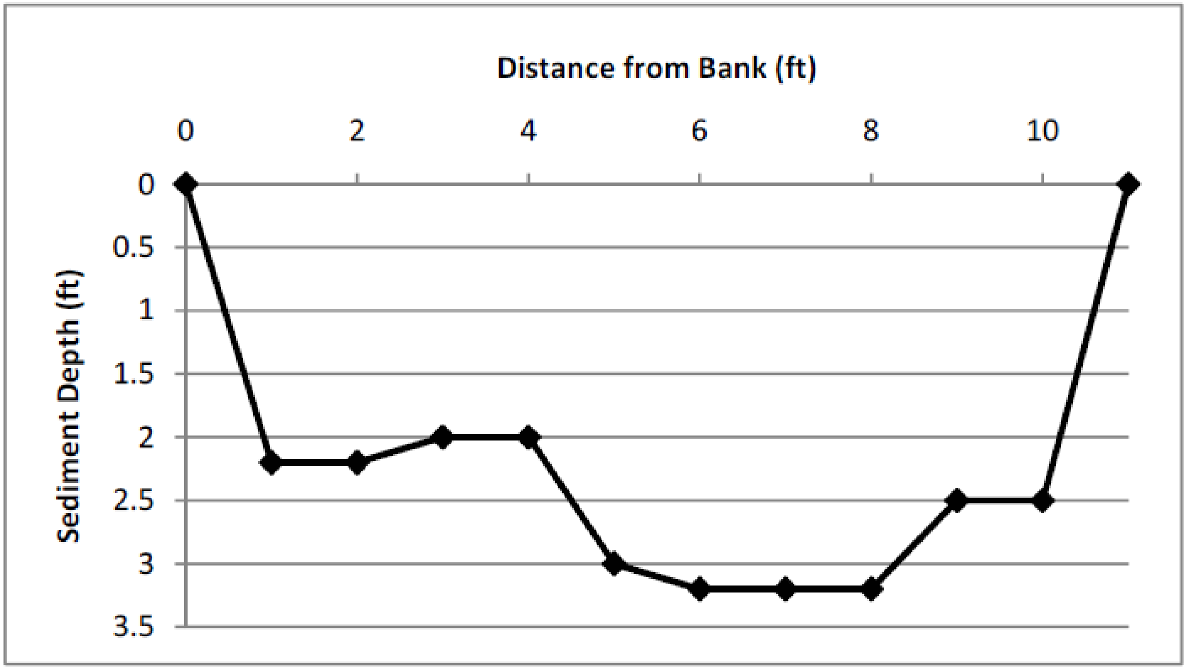

Figure 7
Sediment Depths at Site 5 (see Figure 5)

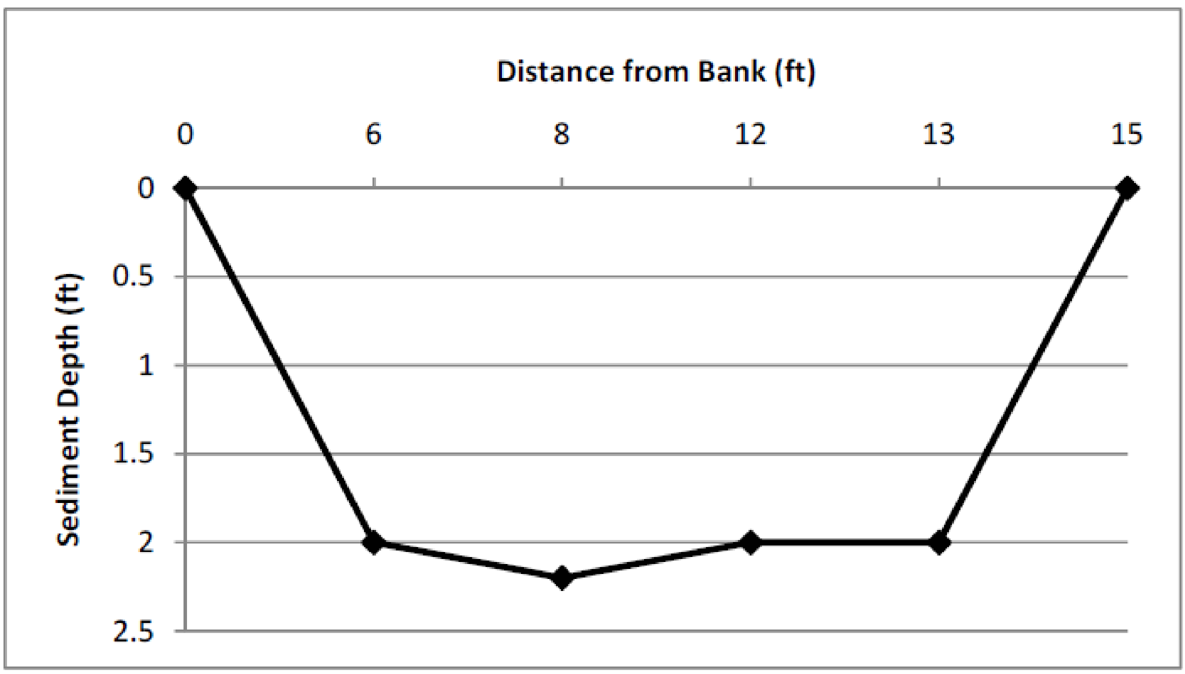

Figure 8
Sediment Depths at Site 6 (see Figure 5)

Table 21.
Stream Channel Characteristics

Site	Substrate	Channel Width (ft)	Average water Depth (ft)	Comments
1	Sand	3’	0.25	
2	Gravel, rubble	4’	0.25	
3	Mostly muck	4’	0.33	Bank erosion
4	~1” muck over sand	2.5’	0.25	Bank erosion
5	Muck	11’		Dredge spoils on west bank, eroding and poorly vegetated
6	Muck	15’	0.33	Heavily shaded with eroding banks

Field observations indicate that the section of the ditch that contains the most sediment in its channel is located upstream of Site 4, where the stream makes a 90 degree turn to run north-south (Figure 5).

It is important to note that the observations on August 21, 2009 are different than the observations made by Hey and Associates on November 13, 2009 in terms of stream channel substrate. The differences are in Reach 1 and 2. In August, the channel substrate was characterized by sand and an area with gravel and rubble. In November, the channel substrate was characterized by peat (muck). This highlights the dynamic nature of this stream and again the sediment flow occurring in the stream.

SEDIMENT AND PHOSPHORUS LOADING

The Wisconsin Lake Modeling Suite (WiLMS) is a model that can estimate phosphorus loading rates from the stream. The results from the WiLMS model with current land uses are in Table 22. It is the case that the WiLMS model is conservative when it comes to estimating phosphorus loading from wetland areas. Because of the presence of a wetland soil (Houghton muck) along the ditch, it is possible that the area surrounding the ditch contain wetlands.

Table 22.
Estimated Annual Phosphorus Loading from the Stream

Parameter	Low	Most Likely	High
Phosphorus Loading (lb/yr)	37.5	79.3	146.7

Table 23 reports the various estimates of sediment and phosphorus loading from the stream.

Table 23.
Estimates of Sediment and Phosphorus Loading

Parameter	WINHUSLE 1995	WiLMS 2009	Bed Load 2009
Estimated Sediment (tons/yr)	41		11.8
Estimated Phosphorus (lbs/yr)	262	37.5 - 146.7	33.3*

*The phosphorus loading was calculated given the sediment load delivery and the analysis of the amount of phosphorus contained in the sediment (1,410 mg/kg).

Caution needs to be used when comparing the estimated loadings in Table 23. It was noted in the R. A. Smith report, that based on trophic modeling to back calculate the total phosphorus inputs to the lake from in-lake concentrations, the WINHUSLE modeling overestimated phosphorus loadings by 36%. Both the WINHULSE and WiLMS models estimate surface runoff and do not estimate channel erosion. It also needs to be noted that the estimate of bed load is based on a single sample collected during base flow and is likely an underestimate of the annual loading of sediment and phosphorus.

RESULTS OF A STREAM INVENTORY CONDUCTED BY HEY AND ASSOCIATES

On November 13, 2009 Dr. Neal O'Reilly of Hey and Associates conducted a survey of the Miljola Channel tributary to identify obvious source of soil erosion. Soil erosion can be generated by wind erosion, water erosion, and stream ban erosion. Each erosion type has its own unique signature that can be observed in the field. The following is a brief overview the three erosion types:

Wind erosion

Wind erosion is caused by strong wind blowing across flat un-vegetated fields picking up dry soil and moving them distances from a few feet to several miles.

Water Erosion

When rain comes down in torrents there is not enough time for the water to soak through soil and the run off cause's erosion.

- Splash erosion is caused impact of the rain drops on bare soil. The raindrops beat hard on the surface of the soil. The flowing mud splashes as high as 60 cm and about 150 cm away.

- Sheet erosion occurs with the uniform removal of a thin layer or 'sheet' of soil. Sloping land with shallow, loose topsoil overlying compact subsoil is the most susceptible. It can be detected by the muddy color of the run-off from the fields.

- Rill erosion is an intermediary stage between sheet erosion and gully erosion. It involves the removal of soil by rainwater runoff through small finger-like channels.

- Channel or gully erosion occurs when the volume of concentrated run off increases and attains more velocity. The rills enlarge into gullies. It often starts along bullock cart tracks, cattle trails and burrows of animals. At an advance stage, gullies result in ravines, very deep cuts several feet deep.

Stream Bank Erosion

During large storms, streams carry higher velocities of flow that act to move sediment particles from the bed and bank.

The Miljola Channel tributary stream channel is an artificial agricultural drainage ditch. Based on field observations the trapezoidal channel was cut 6 to 10 feet below the original land surface to lower the groundwater table and provide outlets for drain tiles (Figure 9). Bank heights vary from one side of the channel to next by as much as 2 to 4 feet. Based on the predominant soil type (Houghton muck), the original valley was likely a large wetland where water flowed towards the lake as slow moving sheet flow. The artificial channel today provides an efficient system to move water from the watershed to the lake.

The soils in the watershed fall into two groups (USDA, 1979);

- Upland well drained loam soils including Fox silt loam (FsA), Matherton silt loam (MnA), St Charles silt loam (SbA), Boyer loamy sand (BoC), Rotamer loam (RtD2) and Kidder loam (KfC2).
- Lowland poorly drained (hydric) soils including Houghton muck (Ht) and Wacousta silty clay (Wa).

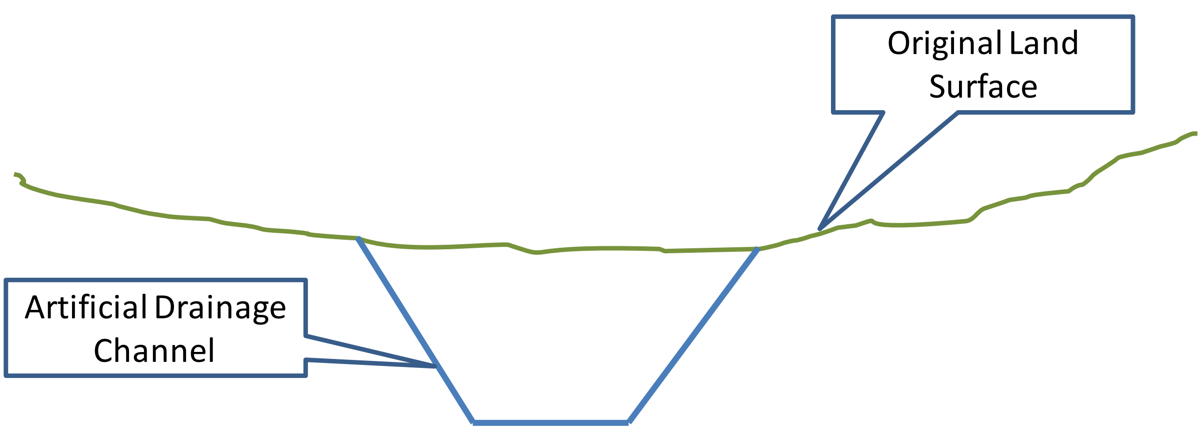

Figure 9
Typical Cross-Section of Miljola Channel Tributary Channel

The soils in the watershed are illustrated in Figure 10.

The bottom of the drainage channel has been dug mostly into the Houghton muck (Ht). Houghton muck is an organic layer made up of black to very brown decomposed plant matter typically 72 inches thick underline by clay. The soil is made up of decomposed wetland vegetation and is laid down in flat layers at the bottom of valley floors. The soil is classified by the Natural Resources Conservation Service, as having from an engineering prospective of low strength. The soil when exposed is easily eroded.

The Miljola Channel tributary stream can be divided into four distinct reaches illustrated in Figure 11.

- Reach 1 – is characterized by a channel with organic peat bed and banks about 2 to 5 feet high and side vegetation of reed canary grass.

- Reach 2 – is characterized by a much deeper channel with 4 to 6 foot high banks, a clay bottom and side vegetation of trees and shrubs. In this reach down cutting of the channel has stopped and erosion is cutting on the channel banks.

- Reach 3 - is characterized by very step banks 8 to 10 feet high, a bed and lower bank made up of peat and side vegetation of a mixture of reed canary grass and occasional shrubs. This section of channel is both down cutting and eroding into the toe of the banks.

- Reach 4 - is characterized by lower banks 3 to 5 feet high made up of all peat and stagnant water. The area appears to be a wetland that was drained for framing but was abandoned do to too wet of conditions.

During the field survey peat material was observed moving along the bottom in reaches 1 through 3. Springs were observed at several locations. The bottoms of the banks along the entire stream were eroded and had exposed peat material. There were limited signs of rill or gully erosion on the upper banks of the channel. Few gullies were observed coming off the upland agricultural fields. The few gullies observed were in stream reach No. 3. Photograph 15 in Appendix A of this report illustrated one of the few gullies. **Based on the field observations, a single bed load sample, and that the majority of the material historically dreaded material from the Miljola channel is peat, it appears that bed and bank erosion of peat material is the largest source of sediment from the watershed to the Miljola Channel.**

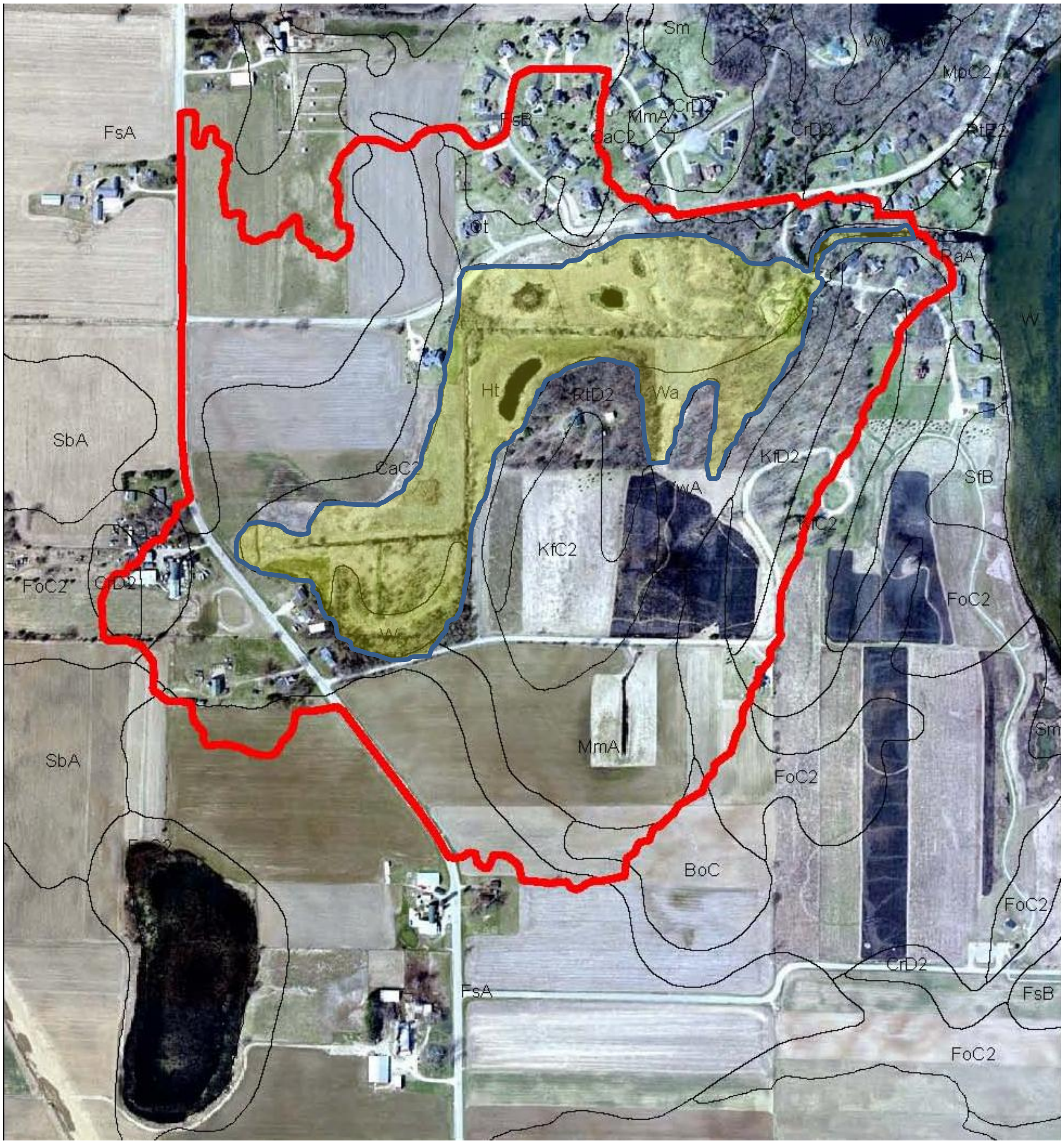

Figure 10
Soils Miljola Channel Tributary Watershed
(Areas in yellow indicate Hydric soils)

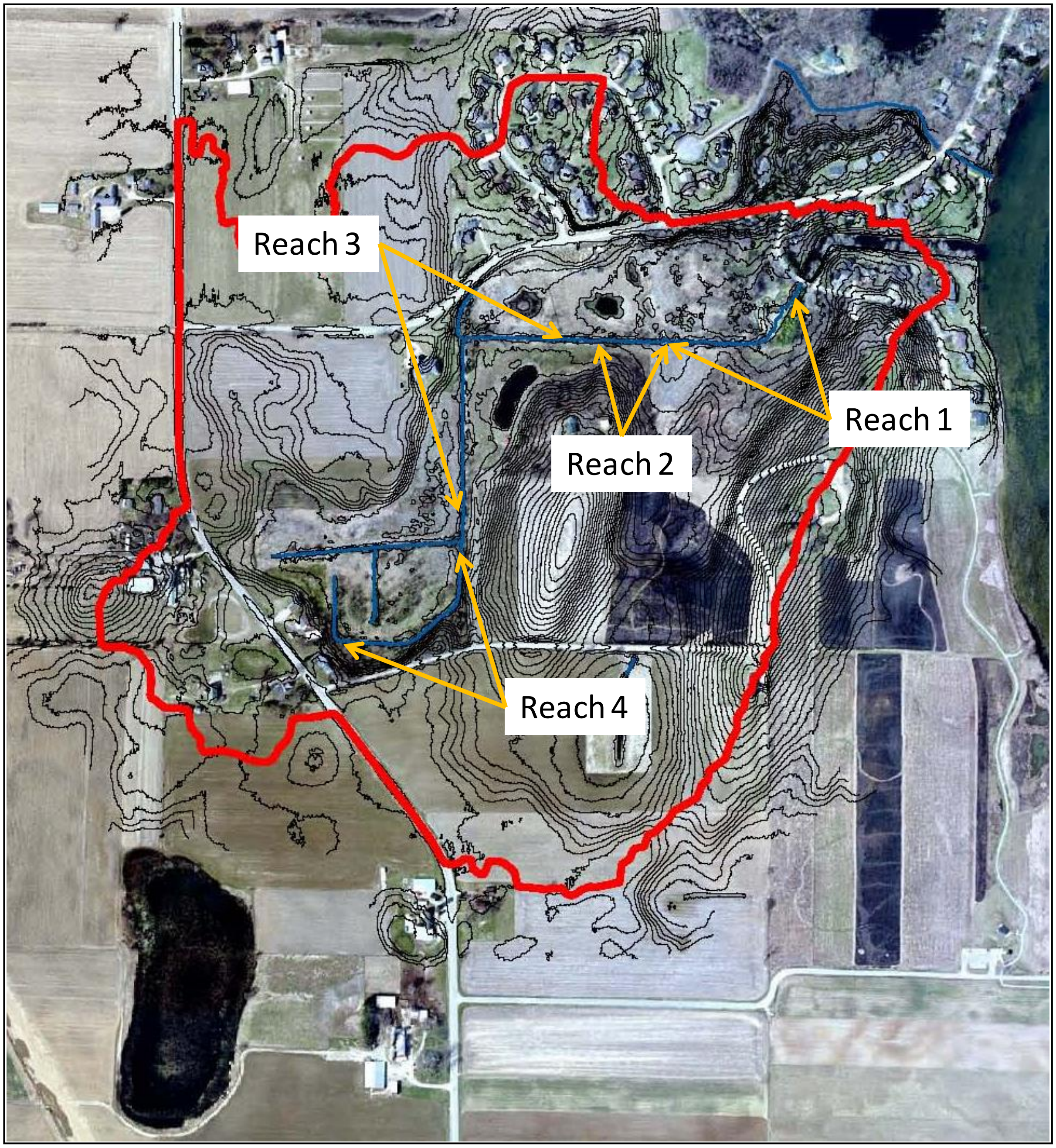

Figure 11
Stream Reaches

CALCULATED PEAK STORM FLOWS FROM THE WATERSHED

Peak flows from the Miljola Channel tributary watershed were calculated utilizing the methods outlined in the Natural Resources Conservation Service (NRCS) TR-55, *Urban Hydrology for Small Watersheds* methodology. The methodology considers the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. Table 24 summarizes the results of the hydrological modeling for a series of rainfall events for Southern Wisconsin based on 24-hours rainfall amounts provided by the Southeastern Wisconsin Regional Planning Commission.

Table 24
Calculated Peak Storm Flows in Cubic Feet per Second (cfs)
Miljola Channel Tributary Outlet

Storm Frequency	2-year	5-year	10-year	25-year	50-year	100-year
24-hour Rainfall	2.57	3.14	3.62	4.41	5.11	5.88
Peak Flow (cfs)	120.12	186.28	247.25	352.69	449.92	560.33

The above peak flows can be used to develop the final design criteria for management practices. Most management practices are designed to treat water between the 2-year and 10-year storm events. However, all management practices need to be designed with bypass opportunities or emergency spillways that can withstand flows up to the 100-year frequency to prevent catastrophic failure of the practice which could allow years of accumulated sediment to move downstream.

CONCLUSIONS

Underwater Habitat Investigations, Land and Water Conservation Department, Hey and Associates, Inc., and the Rock Lake Improvement Association are all in agreement that a solution should be identified and implemented to control the sediment, nutrients, and bacteria being delivered from the ditch to the Miljola channel.

Source of Sediment and Phosphorus

Underwater Habitat Investigations, Land and Water Conservation Department, and Hey and Associates all agree that the “source” of sediment is the sediment that is contained in the bottom and sides of the stream/ditch. Based on channel profiles of the sediment in the stream, the estimated amount of loose material currently sitting in the bottom of the stream channel is 9,200 cubic yards. This represents the quantity of sediment that can be easily moved by future storms. The stream banks are predominantly peat, providing a source of new material to the channel during erosive storm events. Based on a single bed load sample, the estimated annual bed load of sediment is 23,652 pounds/year. Storm events will increase the sediment and nutrient delivery of the stream which is evidenced in the one storm event sampled and the sediment deposited in the Miljola channel during the record-setting precipitation events between Fall 2007 and Spring 2008.

Prior to starting this grant project, it was known that the sediment delivery to the channel was a problem because of the continued necessity to dredge the channel. This project has revealed the source of the sediment which will continue to be delivered to the channel as bed load and during storm events.

Source of Bacteria

Bacteria levels in the stream have been variable. The source of the bacteria still remains a mystery. The LWCD and RLIA recommend that additional bacterial sampling be done to identify the source of the bacteria.

Work could be done to rule out one of the possible source of bacteria: septic systems. The majority of the septic systems in the watershed received permits from the Jefferson County Zoning and Planning Department when their systems were built. These permit holders also report to the Zoning Department when they complete the required pumping every 3 years. There are 2 septic systems in the watershed that pre-date the law that required a construction permit and maintenance. A request could be made to the Zoning Department to ask the owners of these systems if an inspection can be done to insure that the systems are functioning correctly. These inspections would not cost anything to the RLIA and could be performed prior to spending more money on bacteria sampling and analysis.

POTENTIAL MANAGEMENT ALTERNATIVES FOR CONTROL OF SEDIMENT INPUTS

As discussed above, the largest source of soil erosion in the Miljola Channel tributary watershed appears to be stream bed and lower bank erosion. Chemical sampling indicated that nitrogen, total phosphorus and fecal bacteria levels were high. The goal of any management strategy should be to control stream bank and bed erosion and trap nitrogen, phosphorus and bacteria.

Management alternatives fall into the following groups:

- Practices to prevent stream bank erosion
    - bank stabilization
    - ditch plugs
- Practices that trap and filter sediment, nutrients, and bacteria
    - wetland restoration
    - sedimentation basin
    - chemical treatment using alum
    - sand filters

Stream Bank Stabilization

Stream bank stabilization can take many forms. The purpose of most bank stabilization projects is to armor the banks with non-erosive materials such as rock, geotextile fabrics or vegetation. The following is an outline of various stream bank stabilizations methods recommended for various bank conditions by the Association of Illinois Soil and Water Conservation Districts:

1. For Streams that only require minor spot treatments:

   - **Willow Posts** – Dormant Willow Posts are inserted into the streambank with the bottoms submerged below water level. Posts regenerate into willow trees while roots and branches armor the stream bank.

   - **Vegetation** – Many types of vegetation can be used, ie: prairie grasses, shrubs, etc. along with erosion netting.

2. Stream that have stopped getting deeper, but are widening and/or meandering trying to establish and build a new floodplain.

   - **Bendway Weirs** are a series of low rock structures angled upstream on the outside bend. As water passes over the top of the bendway weir, it is directed at right angles to the crest of the weir. By using a series of bendway weirs, water flow is redirected through the eroding bend by each weir.

   - **Stream Barbs** are different from bendway weirs in that they are angled more aggressively upstream and have a sloped crest diverting stream flow away from highly erodible streambank areas.

3. Streams that have eroding (or eroded) channel bottoms and if left untreated, the problem will continue to move upstream.

   - **Rock Riffles** are a series of low rock dams that slow the velocity and “stair step” water down a steep grade so that bank and bottom erosion are controlled.

4. Stream where the channel is beginning to stabilize and floodplain development is near completion. Minimal protection may need to be installed to aid the establishment of vegetation that will prevent excessive widening and/or meandering of the stream.

   - **Stone Toe Protection** is the placement of stone (peaked), parallel to the bank, providing protection for the toe and stabilizing the lower portion of the bank allowing vegetation to establish above the stone.

Traditional” methods of controlling stream bank erosion rely on large quantities of riprap and /or a variety of concrete and steel structures. These methods typically cost $50 to $300 per foot of linear bank treated. Methods such as willow posts, vegetation, bendway weirs, stream barbs, and rock riffles can be installed for $15 to $25 per linear foot with limited use of materials and maintenance.

The Miljola Channel tributary stream is approximately 4,000 feet long. Since the entire length of the stream is showing some signs of bed and bank erosion, the cost of stabilizing the entire stream would be between $60,000 to $1,200,000 depending on the method used. These costs do not include the cost of land purchase and/or acquisition of easements.

A review of historic aerial photographs (1957, 1963, 1996, 2000, and 2004) indicates that the stream is not widening or meandering. Therefore, bendway weirs and stream barbs are not necessary.

Stream bed and bank erosion is moderate throughout the stream channel length. The use of Stone toe protection (also called “riprap”) would be cost prohibitive to armor the entire length of the stream and would cause considerable disturbance to the existing banks during installation. Toe protection could be feasible for small sections of the stream that has more severe erosion and good access for construction equipment.

Willow posts, vegetation, and stone toe protection could all address erosion happening on the bank of the stream/ditch. It is important to note that these practices will not address the sediment that is present on the bottom of the ditch channel.

Ditch Plugs

Wisconsin Wetland Association’s Wetland Restoration Handbook for Wisconsin Landowners, 2nd Edition (2004) by Alice L. Thompson and Charles S. Luthin describes what a ditch plugging is. “*Many wetland sites have a ditch or several ditches that drain the wetland. The quickest and least expensive option for reversing the harmful effect of the ditch is to plug it at the lowest point. By pushing an earthen plug into the ditch, the drainage stops and water backs up in the wetland. Current recommendations are to plug at least 150 feet of ditch if the soils are organic and 100 feet if soils are mineral. The plug should rise 33 percent above grade for organic soils and 20 percent above grade for mineral soils to allow for soil settling. A gentle slope with at least an 8:1 ratio, where for every 8 feet of width the level goes up a foot, is best. In some instances ditch plugs require periodic extensive maintenance to ensure that they remain functional.*”

Ditch plugs will result in water backing up behind the structures. Before they could be installed a hydraulic analysis of the impacts on local surface and groundwater levels would need to be conducted. To conduct this analysis more detailed topographic information of elevations adjacent to the stream will be needed along with a tile survey to determine the locations of local drain tiles.

Ditch plugs can be constructed from a variety of materials, including rock, wood, steel, and concrete. Figure 12 illustrates a typical ditch plug constructed from rock. Cost can range from $500 to $2,500 per plug. The Miljola Channel tributary stream as stated above is about 4,000 feet in length and is in organic soil, therefore requiring 150 feet long plugs. Four to five plugs may be needed to control the entire length of the stream. The cost of ditch plugs would be between $2,000 and $12,500 depending on the materials used and construction methods. These costs do not include the cost of land purchase and/or acquisition of easements.

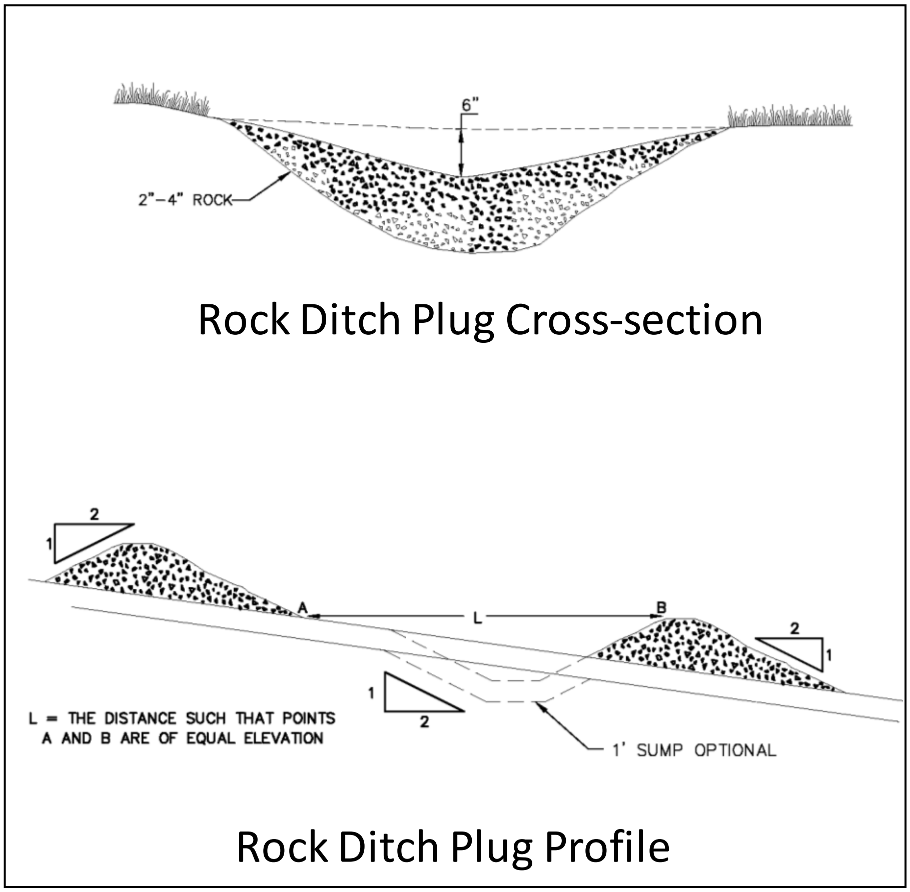

Figure 12
Ditch Plug Concept Drawing
(Source: Hey and Associates, Inc.)

Wetland Restoration

Constructed wetlands are water quality treatment practices that incorporate wetland plants in a shallow pool. Figure 13 illustrates a typical concept drawing for a constructed treatment wetland. As stormwater runoff flows through the wetland, pollutant removal is achieved by settling and biological uptake. While natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, are designed to encourage sheet flow through the system, and typically have less biodiversity than natural wetlands both in terms of plant and animal life. There are several design variations of the stormwater wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland. Typical pollutant removal efficiencies for constructed wetlands are shown in Table 25.

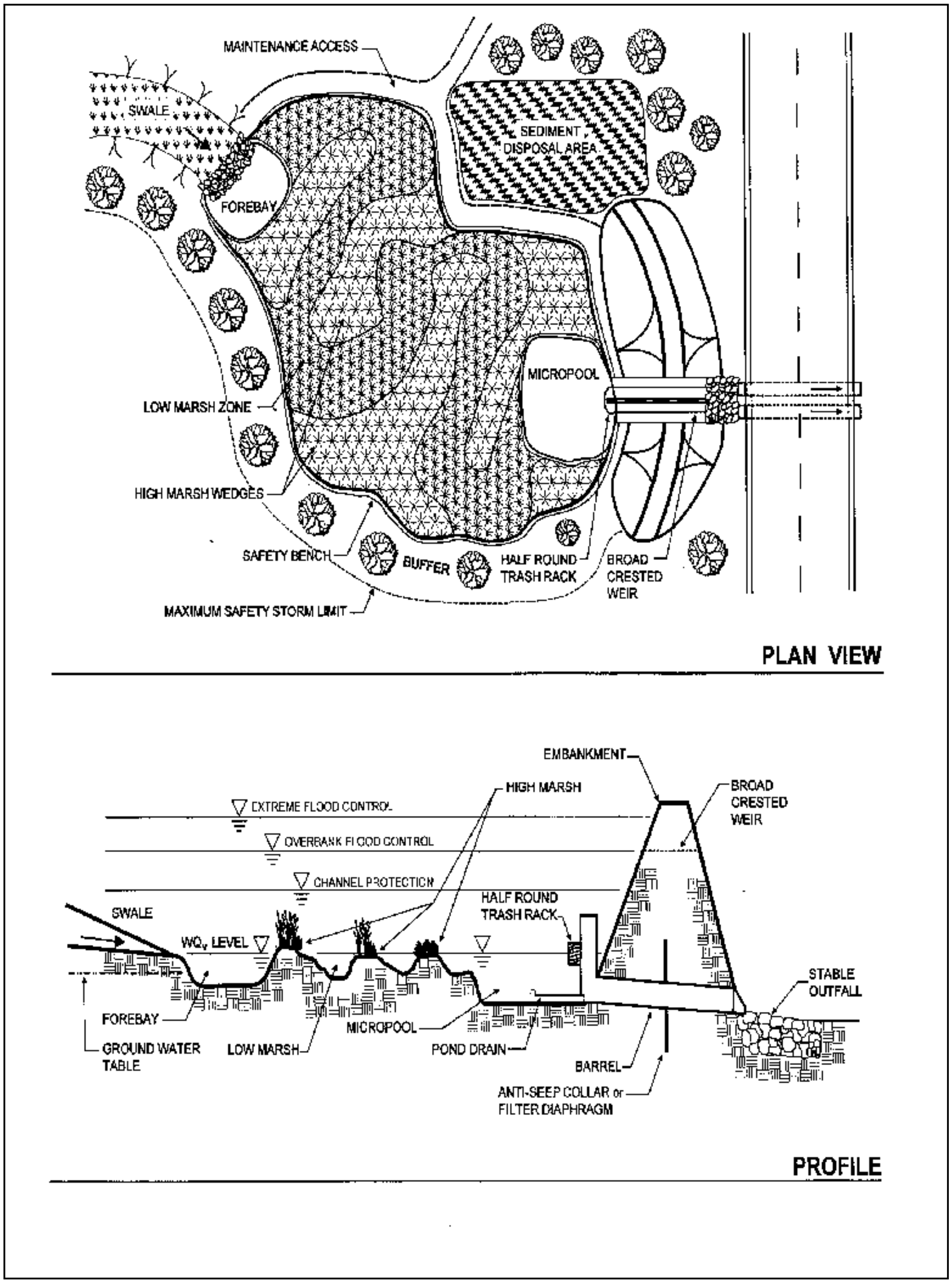

Figure 13
Treatment Wetland Concept Drawing
(Source: Center for Watershed Technology)

Table 25
Typical Pollutant Removal Rates of Wetlands (%) (Winer, 2000)

Pollutant	Stormwater Treatment Practice Design Variation			
	Shallow Marsh	ED Wetland	Pond/Wetland System	Submerged Gravel Wetland
Total Suspended Solids	83	69	71	83
Total Phosphorus	43	39	56	64
Total Nitrogen	26	56	19	19
Nitrite/nitrate	73	35	40	81
Copper	33	NA	58	21
Bacteria	76	NA	NA	78

NA: Data not available

- Shallow Marsh – is a marsh designed for shallow surface flow between 6 and 12 inches deep.
- ED Wetland – is similar to the shallow marsh but has longer residence times. The ED stands for "extended detention".
- Pond/Wetland System - is a combination of a wet detention pond to remove solids, followed by a wetland treatment system to remove soluble pollutants.
- Submerged Gravel Wetland – is a wetland treatment system with the plants grown in a gravel bed, the flow of water is through the gravel and roots of the plants not across the wetland surface.

Constructed wetland act in a passive manner and require little annual maintenance. The wetland areas provide other benefits such as open space, wildlife habitat and aesthetics. The treatment practice consumes large geographic areas of land. Typically wetland treatment systems need to be built in low topographical areas to allow water to drain into and out of them by gravity. These areas are typically natural wetlands that need to be disturbed in the construction process. Permitting of constructed wetlands in Wisconsin is very difficult.

To work effectively constructed wetlands need to consume about 3% to 5% of the land that drains to them. The Miljola Channel tributary watershed is approximately 180 acres in size, therefore, a treatment wetland or series of wetlands would need to total approximately 5.6 to 9.4 acres in size. Cost of constructed wetlands can be $57,100 for a 1 acre-foot facility, $289,000 for a 10 acre-foot facility (Brown and Schueler, 1997). Using these costs a constructed wetland to treat the entire Miljola Channel tributary watershed would be between $319,769 and $2,716,600. Annual maintenance costs are similar to wet detention basins, about three to five percent of the capital cost, or $9,600 to $136,000 depending on the design of the wetland. These costs do not include the cost of land purchase and/or acquisition of easements.

Sedimentation Basin

Sediment basins, also known as wet detention ponds, are impoundments that have a permanent pool of water and also have the capacity to temporarily store stormwater runoff until it is released in a safe manner. The capacity to hold runoff and release it at a lower rate than incoming flows has made detention ponds a popular practice for flood control and stormwater management. Ponds with a properly designed permanent pool can trap sediment and prevent it from being scoured off the bottom by future storms. Figure 14 illustrated a concept drawing of a typical wet detention pond. Dry detention ponds have lower pollutant removal efficiencies than wet bottom ponds, as sediment can be scoured off the bottom by incoming flows.

Wet detention ponds are effective at removing sediment-related pollutants. Pollutants removed by wet detention ponds include sediment, nutrients, heavy metals, oxygen demanding compounds (BOD), hydrocarbons, and bacteria. Pollutant removal in wet detention ponds is primarily due to the settling of particulate pollutants and sediment by gravity. An expanded list of typical pollutant removal efficiencies for wet detention ponds is outlined in Table 26.

Table 26
Pollutant Removal Efficiencies of Wet Detention Ponds

Pollutant	Percent Removal
Suspended Solids	85-96%
Oxygen Demanding Compounds	50-70%
Total Phosphorus	40-70%
Dissolved Phosphorus	40-72%
Nitrate Nitrogen	60-80%
Kjeldahl Nitrogen	20-40%
Copper	60-80%
Lead	80-95%
Zinc	40-80%

Source: Walker, 1987

The State of Wisconsin has developed a detention pond sizing methodology that is outlined in the *Wisconsin Stormwater Manual, Part Two: Technical Design Guidelines for BMP's* (WDNR, 2000). The methodology recommended in the Wisconsin Stormwater Manual is based on data from the National Urban Runoff Project (NURP) and sizes the pond based on land use characteristics of the drainage area and particle size distribution of the runoff. To achieve an 80% removal efficiency of 5 micron and larger particles, Wisconsin has developed a sizing method that sizes the permanent pool based on a percent of the drainage area and type of land use. Table 27 outlines the percent of each land use in a drainage area that is required as a permanent pool. To meet the 80% removal efficiency, the pond must have a minimum depth of 3 feet, and have live storage to retain the runoff from the first 1.5 inches of rainfall. The outlet structure is sized to maintain overflow velocities below the settling velocity of the smallest target particle size.

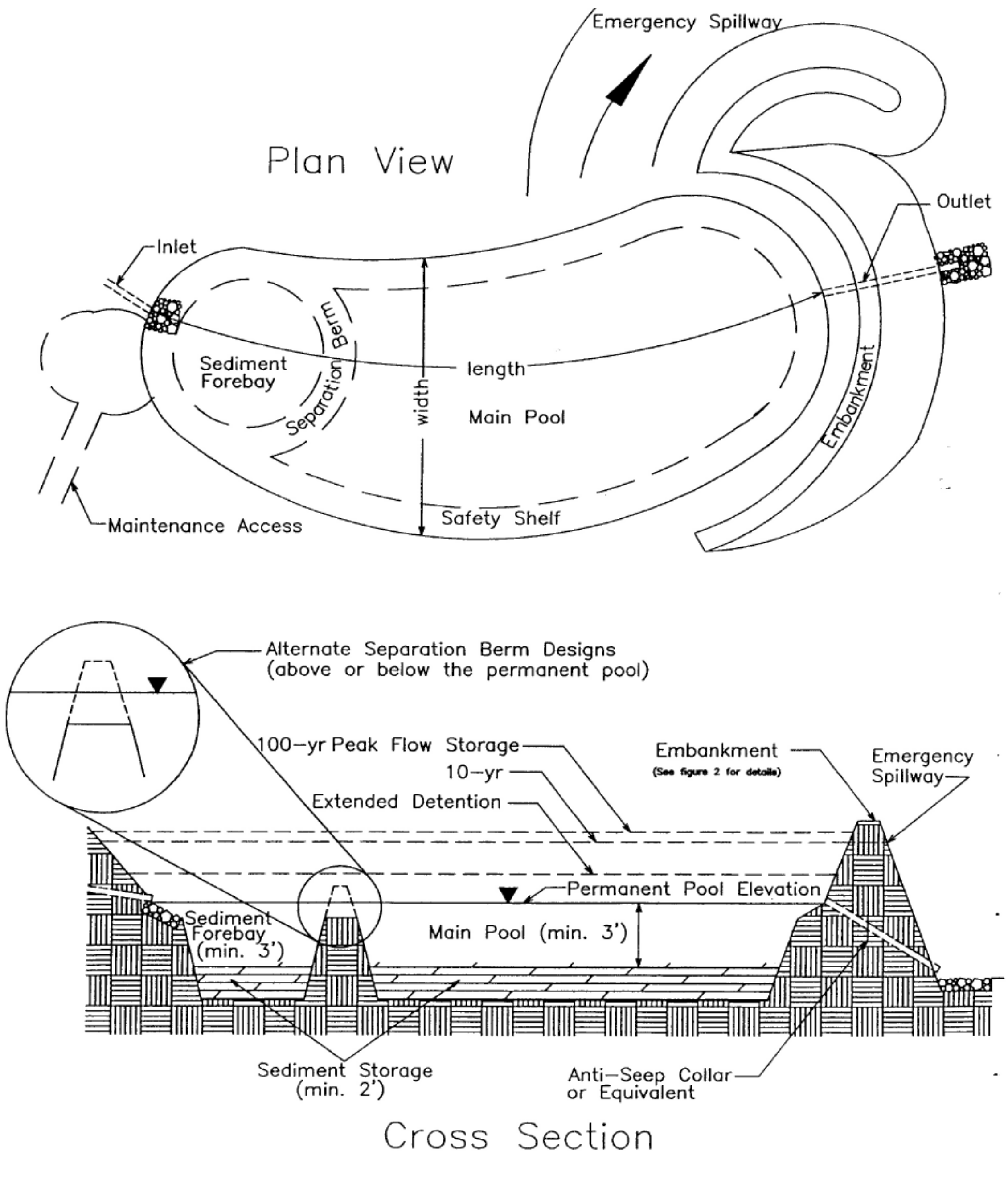

Figure 14
Wet Detention Pond Concept Drawing
(Source: Wisconsin Department of Natural Resources.)

Table 27
Percent of Drainage Area Required as
Wet Detention Permanent Pool

Land Use	Percent of Drainage Area
Freeways	2.8%
Industrial	2.0%
Commercial	1.7%
Institutional	1.7%
Residential	0.8%
Open Space	0.6%

Source: Pitt, 1991

The Miljola Channel tributary watershed is approximately 180 acres in size, mostly open space. A wet detention basin to treat the entire watershed would need to have a permanent pool of approximately 1.2 acres in size. With live storage, the total pond could be between 2 and 3 acres in size.

To reduce maintenance cost, wet detention ponds can be constructed with a forebay to trap coarse sediments in a location from which they can be easily removed. The cost of a wet detention pond varies greatly depending on the basin size and design, site constraints, and the cost of the land. Capital costs have been estimated to range from as low as $33,600 for a 0.25-acre basin to $410,400 for a five-acre basin (SEWRPC, 1991, updated to 2000 dollars). Based on these cost a wet detention basin to treat the entire watershed would range between $165,000 and $246,000. These costs do not include the cost of land purchase and/or acquisition of easements.

The pond will need dredged periodically to maintain its function. Routine maintenance tasks include lawn care, basin inspections, debris removal, erosion control, and nuisance plant control. Periodic maintenance tasks include inlet and outlet repairs and sediment removal. The estimated annual operation and maintenance cost for a wet detention basin is about three to five percent of the capital cost (SEWRPC, 1991) or $8,250 to $13,300 per year.

Retain Exiting Sediment Trap in Miljola Channel

Currently, there is a temporary sediment curtain in the dredged channel of Rock Lake that lies between Shorewood Hills Road and Cedar Lane. The temporary trap could be replaced with a permanent sediment curtain in the channel.

As outlined above, in Wisconsin a typical sediment trap is designed to have an 80% removal efficiency of 5 micron and larger particles. For the study watershed that would require a trap with a surface area of approximately 2 and 3 acres in size. Peat settles faster than 5 micron particles. Based on a study of settling velocities for peat conducted by Marttila and Kløve (2008) they measured a mean average settling velocity of 0.87 meters per hour (2.85 ft/hr). As outlined in the sediment basin section above, most basins are designed to treat up to a storm producing 1.5 inches of rain. Using (NRCS) TR-55, *Urban Hydrology for Small Watersheds* methodology it estimated that a 1.5 inch 24-hour storm will produce a peak flow of 22.63 cfs. Using the reported settling velocity, a sedimentation basin designed to only trap peat would need to be approximately 0.7 acres in size. The current area behind the sediment is approximately 30 by 35 feet, or 0.02 acres in size. A sediment trap in the Miljola Channel to trap only peat would need to approximately 870 feet long, or the entire length of the channel.

Alum Injection Upstream of Lake

The process of adding aluminum sulfate salt, otherwise known as alum, to stormwater is called alum injection. Alum causes fine particles to coalesce (or flocculate) into larger particles (USEPA, 2009). Alum injection can help meet downstream pollutant load reductions by reducing concentrations of fine particles and soluble phosphorus.

Alum treatment systems generally consist of three parts, a flow-weighted dosing system, storage tanks that provide alum to the doser, and a downstream pond that allows the alum, pollutants and sediments to settle out (Kurz, 1998). When injected into stormwater or stream flow, alum forms the harmless precipitates aluminum phosphate and aluminum hydroxide. These precipitates combine with heavy metals and phosphorus and sink into the sediment in a stable, inactive state (WEF, 1992). The collected mass of alum precipitates, pollutants and sediments is commonly referred to as floc. Dosage rates, which range from 5 to 10 mg of Al per liter, are determined on a flow-weighted basis (Harper, 1996). Figure 15 shows an alum injection system at NASA's Space View Park where alum is injected in a fore bay of a wet detention pond design to treat runoff.

Figure 15
Alum Injection System at NASA Space View Park Florida
(Source: NASA)

It's important to dispose of the floc that settles in downstream basins because it contains high concentrations of dissolved chemicals, as well as viable bacteria and viruses (Kurz, 1998). In addition to the settling pond, a separate floc collection pump-out facility should be installed to reduce the chance of re-suspension and transport of floc to receiving waterbodies. The facility's pumps dispose of the floc into a sanitary sewer system, a nearby upland area, or a sludge drying bed. Pumping into a sanitary sewer system requires a permit, however. The quantity of sludge produced at a site can be as much as 0.5 percent of the volume of water treated (Gibb et al., 1991).

Operation and maintenance for alum treatment is critical. Some typical items include:

- Routine inspection and repair of equipment, including the doser and pump-out facility.
- A trained operator should be on-site to adjust the dosage of alum and other chemicals, and possibly to regulate flows through the basin.
- Floc stored on-site in drying beds will need to be disposed of regularly.
- The settling basin must be dredged periodically to dispose of accumulated floc.

Limited performance data of alum injection is available in Table 28. One study (Harper and Herr, 1996) found high removal rates for total suspended solids (TSS), total phosphorus (TP) and fecal coliform bacteria. Another study (Carr, 1998) showed mixed results on total phosphorus and ortho-phosphorus.

Table 28
Literature Values of Alum Injection Removal Rates

Study	Percent Pollutant Removal (%)							
	TSS	TP	Dis.-P	TN	Fecal Coliform Bacteria	Heavy Metals	Zinc	NH3
Harper and Herr, 1996	95-99	85-95	90-95	60-70	99	50-90	-	-
Carr, 1998	-	37	42	52.2	-	-	41	24.5

This alternative if properly designed could reduce total phosphorus inputs from the watershed. Disadvantages of alum injection include:

- Capital cost to install alum injection system
- Need to construct a settling pond to collect the floc
- Need to dispose of floc
- Need for a professional operator for the system

Construction costs for alum treatment systems range from $135,000 to $400,000, depending on the watershed size. Operation and maintenance costs, including routine and chemical inspections, range from $6,500 to $25,000 per year (Harper and Herr, 1996). These costs do not include the cost of land purchase and/or acquisition of easements.

Sand Filters

Sand filters are a relatively new technique for treating stormwater, whereby runoff is diverted into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes, and returned back to the stream or channel. Monitoring has shown that a sand filter can remove 85% of the sediment, 40% of phosphorus, and 50 to 70% of the heavy metals, oil and grease can be removed from the runoff (Schueler, et. al 1991).

Sand filters can be designed in several configurations from surface basin filters, underground vaults, and double trench systems. Enhanced sand filters utilize layers of peat, compost, limestone, and/or topsoil, and may also have a grass cover crop. The adsorptive media of enhanced sand filters is expected to improve removal rates. Pollutant removal rates for sand peat filters have been measured at 90% for total phosphorus, 70% for total nitrogen, and 90% for BOD (Schueler, et. al 1991).

Construction cost for sand filters range from $3 to $10 per cubic foot of runoff treated (Schueler, et. al 1991). With an estimated annual flow of 6.8 million cubic feet of water, using Schueler's costs, a sand filter would cost on an annual basis between $20 and $68 million. With an estimated annual flow of 6.8 million cubic feet of water, using Schueler's costs, a sand filter would cost on an annual basis between $20 and $68 million. These costs do not include the cost of land purchase and/or acquisition of easements

Routine maintenance tasks include inspections annually and after large storms, debris removal, and upkeep of the pre-treatment practice, such as grass filter strips. Several designs are equipped with back flushing systems used to fluff the bed and maintain permeability of the sand. Periodic maintenance includes scraping off a clogged top layer of sand and replenishing the sand material.

Most sand filters, due to their cost, are used in urban development such as commercial or industrial areas. At Crystal Lake, Illinois a sand filter was installed at the outlet of a wetland treatment system to control agricultural runoff.

Ranking of Management Alternatives

Table 29 provides a ranking of the management alternatives based on their ability to control or trap sediment, phosphorus and bacteria, potential impacts to local surface or groundwater elevations, capital costs, required maintenance and potential for state and federal grants.

Appendix B provided a partial list of wetland and watershed restoration funding sources.

Table 29
Ranking of Management Alternatives

Management Practice	Ability to Control or Trap Sediment	Ability to Control or Trap Phosphorus	Ability to Control or Trap Bacteria	Potential Impacts to Local Water Levels	Costs	Required Mainten-ance	Potential for Federal or State Grants
Stream Bank Stabilization	Good	Low	None	Low	High	Low	Yes
Ditch Plugs	Good	Low	None	High	Low	Low	Yes
Wetland Restoration	Good	Good	Good	High	High	Moderate	Yes
Sedimentation Basin	Good	Moderate	Moderate	High	High	Moderate	Yes
Retain Exiting Sediment Trap in Miljola Channel	Poor	Poor	Poor	Low	Low	High	No
Alum Injection Upstream of Lake	Good	Excellent	Good	Low	High	High	Unknown
Sand Filters	Excellent	Excellent	Excellent	Low	High	High	Unknown

RECOMMENDATIONS FOR FUTURE ACTION

Development of management strategy to control stream bank and bed erosion and trap phosphorus and bacteria will require additional information than is available through the existing study. Additional information required would include:

- Better topographic survey data to determine practice location and potential impacts.
- Better understanding of landowner wiliness to allow practices to be installed on their land.
- Review of existing drainage easements which may impact practice selection and location. Also it will be important to identify where new easement agreements may be necessary to implement management practices.
- Availably of state or federal grants.
- Available financial resources of the Rock lake Improvement Association.

The management strategy many include a single management practice or a combination of practices. Management should be conducted in the following hierarchy:

1. The first priority should be given to source control practices that prevent soil from moving in the first place. Keeping soil in place is typically more cost effective that trapping or settling sediment once it is in suspension.
2. The second priority should be given to practices that trap or settle sediment once it is in suspension to keep it out of the Miljola Channel and Rock Lake.

Source controls for upland sediment erosion should be conservation tillage practices on agricultural fields, the use of grass waterways and other practices that keep soil on the field. The Jefferson County Land and Water Conservation Department and/or the Natural

Resources Conservation Service should work with local farmers to develop conservation and nutrient management plans for each farm where one does not exist.

Source controls for stream bank and bank erosion should include further evaluation of the use of stream bank stabilization, such as toe protection, and the use of ditch plugs.

Work should be done to rule out one of the possible sources of bacteria: septic systems. As outlined above, the majority of the septic systems in the watershed received permits from the Jefferson County Zoning and Planning Department when their systems were built. The permit holders are required to report to the Zoning Department when they complete the required pumping every 3 years. There are 2 septic systems in the watershed that pre-date the law that required a construction permit and maintenance. Jefferson County should ask the owners of these systems if an inspection can be done to insure that the systems are functioning correctly.

If the above source controls cannot be implemented to the degree necessary to protect the Miljola Channel, than sediment filtering and trapping practices such as sedimentation basins, and wetland filters should be explored.

Caution needs to be taken when identifying locations for management practices. If possible the practices should not be installed in natural wetland or in environment corridors as identified in Jefferson County Agricultural Preservation and Land Use Plan (1999) to protect native plants and wildlife. Figure 16 and 17 illustrate the locations of mapped wetlands and environmental corridors in the study watershed respectively.

To develop a management strategy for the control of sediment, phosphorus and bacteria from the Miljola Channel Tributary Watershed will require a phased planning and engineering approach that should include the following elements in Table 30.

Figure 16
WDNR Mapped Wetlands Miljola Channel Tributary Watershed
(Includes only wetland 2-acres and larger in size)

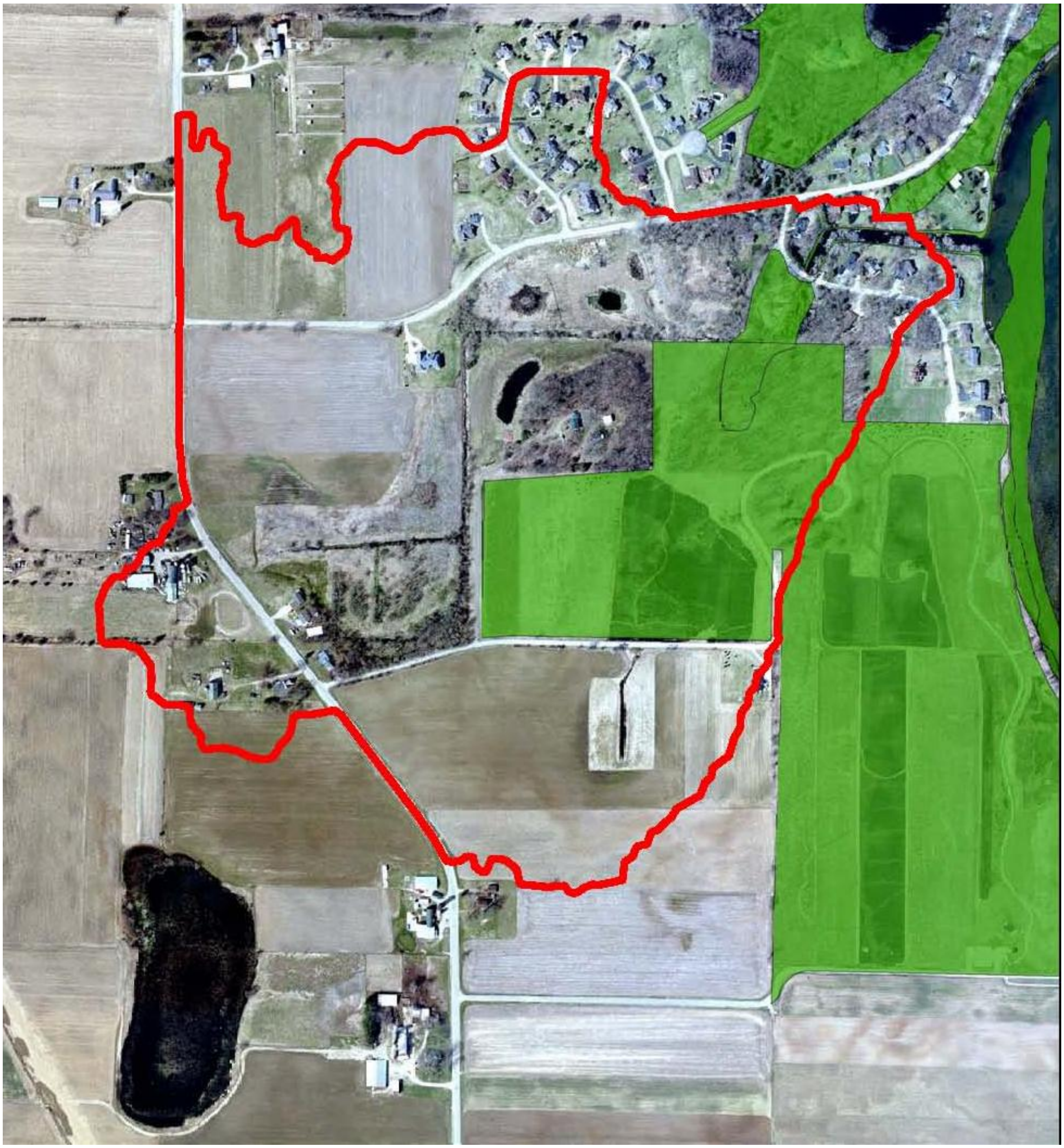

Figure 17
Primary Environmental Corridors Miljola Channel Tributary Watershed
(Source Jefferson County)

Table 30
Recommended Future Planning and Engineering Activities

	Planning and Engineering Activity	Estimated Cost	Eligible for Cost Share Under Lake Planning Grant Program
No. 1 Additional Pollutant Source Identification and Collection of Site Data	Additional bed load sampling to determine the annual quality of sediment that is entering the Miljola Channel and Rock Lake. This information will be needed to determine a maintenance program for the management practices that may be selected. Recommended eight samples.	$2,000	Yes
	Conduct additional bacterial sampling to determine the source of the cause of the fecal bacteria using RNA testing.	$2,000	Yes
	Prepare a detailed topographic survey of the drainage channel, which is necessary to prepare the design of the management practices.	$4,000	Yes
	Conduct wetland inventory to determine federal, state and local jurisdiction for potential permits.	$5,000	Yes
	Subtotal	**$13,000**	**$9,750 State $3,250 Assoc.**
No. 2 Development of Management Plan	Conduct tile survey along stream channel	$3,000	Yes
	Conduct a feasibility study to determine and design the preferred management alternative(s).	$6,000	Yes
	Identify potential federal and state funding sources that may assist with the installation of the preferred management alternative(s).	$960	Yes
	Conduct an open house with affected landowners to determine interest in participating in the implementation of the proposed management alternatives.	$500	Yes
	Subtotal	**$10,460**	**$7,845 State $2,615 Assoc.**
Not eligible for grant funding	Prepare necessary easement agreements with landowners.	$1,500	No
	Prepare federal, state and local permit applications for the preferred management alternative(s).	$3,500	No
	Prepare necessary grant applications.	$2,500	No
	Subtotal	**$7,500**	
	Total Cost	**$30,960**	

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APPENDIX A

Photographs from November 13, 2009 Stream Survey
By Hey and Associates

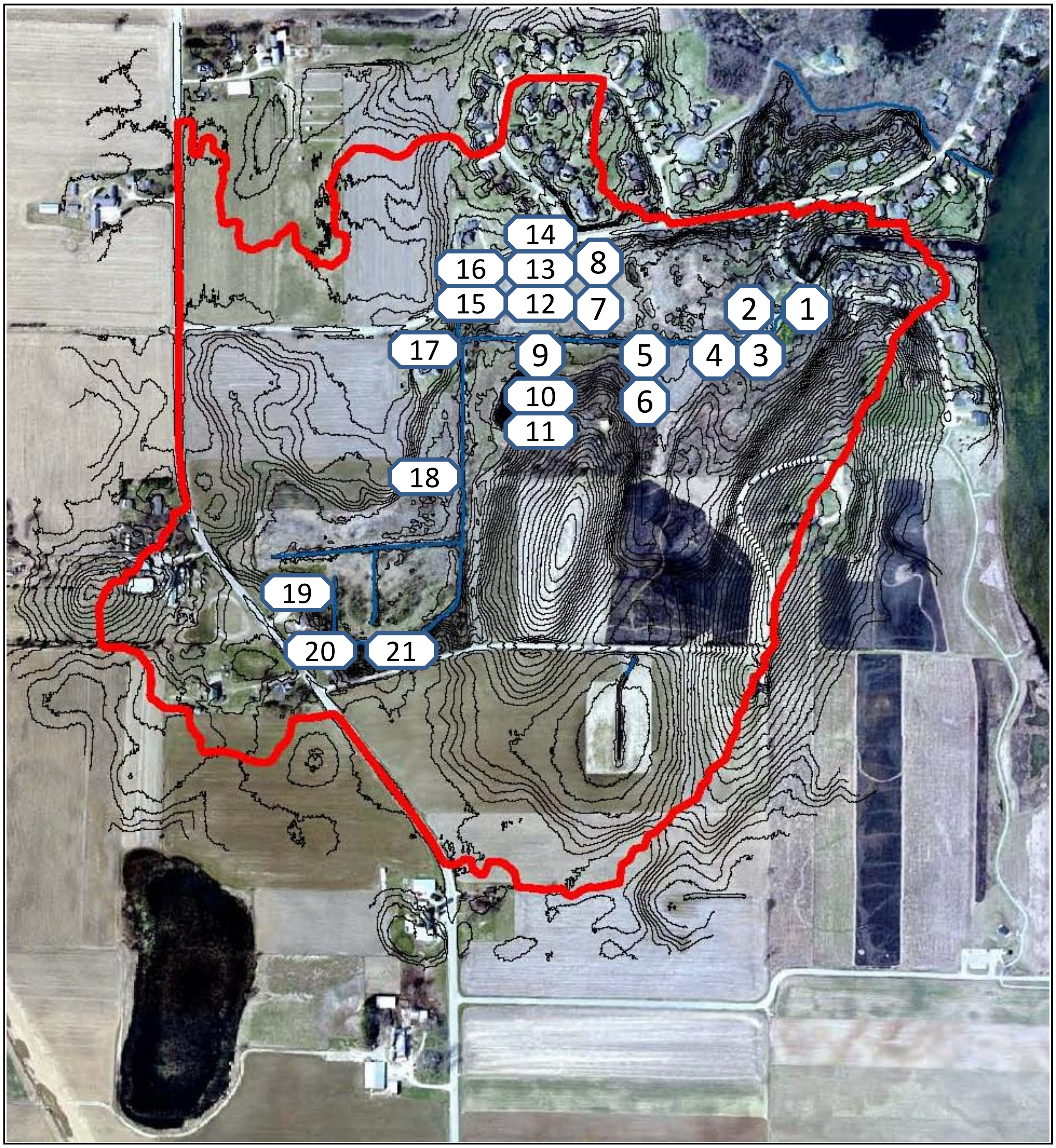

Exhibit 1
Location of Photographs


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APPENDIX B

A PARTIIAL LIST OF POTENTIAL WETLAND AND WATERSHED RESTORATION FUNDING SOURCES:

Wetlands Reserve Program (WRP)

The Wetlands Reserve Program (WRP) is a voluntary program offering landowners financial and technical assistance to restore, protect, and enhance wetlands and associated uplands through permanent easements, 30-year easements, and long-term restoration agreements. The program is designed to achieve maximum wetland functions and values while obtaining optimum wildlife habitat. Eligible land includes wetlands cleared or drained for farming, pasture, or timber production; certain adjacent lands that contribute significantly to wetland functions and values; previously restored wetlands that need long-term protection; upland areas needed to provide an adequate buffer or that contribute to creating a manageable boundary; drained wooded wetlands; existing or restorable riparian habitat corridors that connect protected wetlands; and certain lands substantially altered by flooding. The land must be restorable and be suitable for providing wildlife benefits

DEADLINE: June 30
MORE INFORMATION: www.nrcs.usda.gov/programs/wrp

USFWS National Coastal Wetlands Conservation Grant Program

The National Coastal Wetlands Conservation Grant Program was established by Title III of P.L. 101-646, Coastal Wetlands Planning, Protection and Restoration Act of 1990. Under the Program, the U.S. Fish and Wildlife Service provides matching grants to States for acquisition, restoration, management or enhancement of coastal wetlands. The Act also establishes a role for the Fish and Wildlife Service in interagency wetlands restoration and conservation planning in Louisiana. To date, about $183 million in grant monies have been awarded to 25 coastal States and one U.S. Territory and to acquire, protect or restore over 250,000 acres of coastal wetland ecosystems.

DEADLINE: 2009 cycle deadline TBA
MORE INFORMATION: www.fws.gov/coastal/CoastalGrants/

USFWS Partners for Fish and Wildlife Program

In Wisconsin, 85 percent of the land base is privately owned. Likewise, the fish and wildlife that residents and visitors watch, photograph and harvest spend some or all of their life cycles on private lands. Wisconsin’s fish and wildlife populations depend on private lands. The Partners for Fish and Wildlife (PFW) program works one-on-one with private landowners to improve respective fish and wildlife habitats. During initial site visits, program biologists work with private landowners to identify potential projects and assess the feasibility of restoring native plant communities on their properties. If private lands are eligible for the PFW program, a wildlife management agreement and plan will be developed to get projects underway. The involvement and commitment of landowners to improve their lands for fish and wildlife habitat makes them better stewards of Wisconsin’s natural resources. ***This***

program is a good source of funding for private landowners interested in doing wetland restoration work on their own property.

DEADLINE: apply anytime
MORE INFORMATION: www.fws.gov/midwest/WisconsinPartners/index.htm

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The Wetland Foundation: Student Travel Grants

The Wetland Foundation provides travel grants for students to attend wetland conferences and to get to field sites for research. The Wetland Foundation was initiated in 2008 by Drs. Karen L. McKee and Irving A. Mendelssohn. Following 30-year careers as wetland scientists, McKee and Mendelssohn began formulating a plan to leave a legacy that would support wetland education and research. Their goal was to establish a foundation and trust fund that would provide financial support and guidance to students of wetland science.

MORE INFORMATION: www.thewetlandfoundation.org/

Natural Resources Foundation Besadny Grant Program

The C.D. Besadny Conservation Grant Program promotes the responsible stewardship of Wisconsin's natural resources at the local level by providing matching grants for small-scale, natural resource projects and programs. The Besadny Conservation Grant Program is supported by the Besadny Conservation Endowment and the ATC Environmental Stewardship Fund. Grants awarded through this program range from $100 to $1,500. Grants must be matched 100% by recipient organizations either through cash or in-kind donations. Grant applications must be received in the Natural Resources Foundation office by January 15 of the year in which the grants are awarded. Funds are awarded in early March of each year.

DEADLINE: January 15, 2009
MORE INFORMATION: www.wisconservation.org/

USFWS & WDNR Landowner Incentive Program

The Landowner Incentive Program is a cost-share program that helps private landowners by providing financial and technical assistance to manage and restore habitat for at-risk species on their land. The program is funded by the U.S. Fish and Wildlife Service and administered by the DNR's Bureau of Endangered Resources. LIP provides up to 75% of the costs for eligible projects. At-risk species are rare plants and animals such as those listed as state or federally endangered or threatened, state special concern or species of greatest conservation need.LIP is currently accepting pre-proposals for both the **Prairie and Savanna** and the **Northern Lake Michigan Coastal Regions**. Pre-proposals must be postmarked by **April 20, 2007** to be eligible for project consideration. Eligible applicants will be invited to submit an application for 2007 funding. To learn more about the program or to download a pre-proposal form, visit our web site at dnr.wi.gov/org/land/er/WLIP/ or attend one of the upcoming LIP workshops.

DEADLINE: January 16, 2009
MORE INFORMATION: dnr.wi.gov/org/land/er/WLIP/

USFWS Private Stewardship Grants Program

The Private Stewardship Program provides grants and other assistance on a competitive basis to individuals and groups engaged in local, private, and voluntary conservation efforts that benefit federally listed, proposed, or candidate species, or other at-risk species. Diverse panels of representatives from State and Federal Government, conservation organizations, agriculture and development interests, and the science community assess applications and make recommendations to the Secretary of the Interior, who awards the grants. The Private Stewardship Program was initiated during Fiscal Year 2002, with grants first awarded during Fiscal Year 2003. For 2005, the Service awarded more than $5.7 million in Federal funding under the Private Stewardship Program. A ten percent (10%) match of cash or through in-kind contributions is required. The program is available to private landowners and their partners.

DEADLINE: February 14
MORE INFORMATION: www.fws.gov/endangered/grants/private_stewardship/

USFWS Great Lakes Coastal Program

The U.S. Fish and Wildlife Service's Great Lakes Coastal Program is accepting project proposals for the 2008 grant cycle. Beginning in 2008, the Coastal Program-Great Lakes will be accepting project applications throughout the year and entering into cooperative agreements on an ongoing basis, though it is highly recommended that project applications be received by February 22. The Coastal program focuses efforts of the U.S. Fish and Wildlife Service in bays, estuaries and watersheds around the Great Lakes basin. The Service provides funding through the program to conserve fish and wildlife and their habitats and to support healthy coastal ecosystems. Because coastal areas have the highest population densities in the country and are expected to face continuing population pressures, there is a strong need for action to protect and restore these habitats.

DEADLINE: February 22
MORE INFORMATION: www.fws.gov/midwest/greatlakes/glcoastal.htm

USFWS Great Lakes Fish and Wildlife Restoration Grants Program

The U.S. Fish and Wildlife Service is seeking pre-proposals for conservation projects to restore Great Lakes fish and wildlife resources through its Great Lakes Fish and Wildlife Restoration Grants Program. This program provides federal grants on a competitive basis to states, tribes and other interested entities to encourage cooperative conservation, restoration and management of fish and wildlife resources and their habitat in the Great Lakes basin. The projects are funded under authority of the Great Lakes Fish and Wildlife Restoration Act of 2006.

DEADLINE: January 23, 2009
MORE INFORMATION: www.fws.gov/midwest/Fisheries/glfwra-grants.html

SWS North Central Chapter Student Travel Grants

The Society of Wetland Scientist, North Central Chapter, announces the availabilty of the Student Travel Grant. The purpose of the student grants is to provide selected students financial support to attend professional meetings. Click here for more information regarding the Student Travel Grant or contact the Educational Outreach Chair, Mitchel R. Strain.

DEADLINE: Early March
MORE INFORMATION: http://www.sws.org/regional/northcentral

Coastal and Estuarine Land Conservation Program

The Wisconsin Coastal Management Program is soliciting coastal and estuarine land conservation acquisition projects. Wisconsin may submit up to three project proposals to the Office of Ocean and Coastal Resource Management (OCRM) in the National Oceanic and Atmospheric Administration (NOAA). The Coastal and Estuarine Land Conservation Program (CELCP) was established "for the purpose of protecting important coastal and estuarine areas that have significant conservation, recreation, ecological, historical, or aesthetic values, or that are threatened by conversion from their natural or recreational state to other uses." Requested funding may not exceed $3,000,000 per project. Proposals must follow the NOAA application requirements found in the Announcement of Federal Funding Opportunity (NOS-OCRM-2010-2001655). Do NOT submit applications via Grants.gov - applications must be submitted to the Wisconsin Coastal Management Program by March 9, 2009. For further information about the Wisconsin application process, applicants should

DEADLINE: March 9, 2009
MORE INFORMATION: Contact Travis Olson: 608-266-3687 or travis.olson@wisconsin.gov

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Five Star Restoration Challenge Grants

The Five Star Restoration Challenge Grant Program is a partnership between NACo, the National Fish and Wildlife Foundation, the Wildlife Habitat Council, and made possible with support from the U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration. This wetland restoration funding program provides challenge grants, technical support and opportunities for information exchange to enable community-based restoration projects. Funding levels are modest, from $5,000 to $20,000, with $10,000 as the average amount awarded per project. However, when combined with the contributions of partners, projects that make a meaningful contribution to communities become possible. At the completion of Five Star projects, each partnership will have experience and a demonstrated record of accomplishment, and will be well-positioned to take on other projects. Aggregating over time and space, these grassroots efforts will make a significant contribution to our environmental landscape and to the understanding of the importance of healthy wetlands and streams in our communities.

DEADLINE: early March
MORE INFORMATION: www.epa.gov/owow/wetlands/restore/5star/

Great Lakes Aquatic Habitat Network and Fund

The goal of GLAHNF's grants program is to provide financial support to advocacy activities that strengthen the role of individuals and community groups working locally to protect and restore shorelines, inland lakes, rivers, wetlands, and other aquatic habitats in the Great Lakes Basin. Advocacy work, as defined here, involves local community members actively promoting aquatic habitat protection by influencing community and/or individual behavior or opinion, corporate conduct, and/or public policy.There are four funding programs in the Great Lakes Aquatic Habitat Network and Fund: the Project Grants Program, the Technical Assistance Grants Program, the Special Opportunities Grants Program and the Theme Grants Program. You can apply for a Project Grant only or a Project Grant and a Technical Assistant Grant. The Project Grants Program provides grant awards ranging from $500 to $3,500 USD to be used for specific project expenses for river, lake, and wetland protection.

DEADLINES: March 31 and September 30 (each year)
MORE INFORMATION: www.glhabitat.org/grants.html

Upper Mississippi River Watershed Fund

The Upper Mississippi River Watershed Fund (UMRWF) is a partnership between the USDA Forest Service and the National Fish and Wildlife Foundation. This partnership will provide grants that benefit the stewardship of the forests and the restoration of watersheds in the Upper Mississippi River drainage. Eligible projects:

- Restore or enhance important forest habitats, other important bird habitats, and water quality of the watershed.
- Strengthen the link between local communities and organizations and the natural resources of the watershed.
- Establish new working relationships with non-traditional partners or enhance existing collaborative projects.
- Generate innovative approaches, tools and products that can be replicated in other states/regions.
- Improve wildlife habitat through hazardous fuels reduction in communities at risk from wildfire.

DEADLINE: April 15 (pre-proposal)
MORE INFORMATION: www.nfwf.org/uppermiss

WDNR Lake Protection Grants

Counties, towns, cities, villages, tribes, qualified lake associations, public inland lake districts, qualified nonprofit conservation organizations, town sanitary districts, and other local governmental units as defined in s. 66.0301 (1))(a) Wis. Stats. established for lake management, are eligible to apply for funding to protect and improve the water quality of lakes and their ecosystems. Grant awards may fund up to 75 percent of project costs (maximum grant amount $200,000). Because of the size, complexity, and technical nature of many projects, a pre-application meeting with the DNR is highly recommended, especially if the project requires plan or permit approvals. This will ensure the application will be complete and can be evaluated and considered for funding. Eligible projects include **restoration of wetlands** and shorelands that will protect a lake's water quality or its natural ecosystem (these grants are limited to $100,000). Special wetland incentive grants of up to $10,000 are eligible for 100 percent state funding if the project is identified in the sponsor's comprehensive land use plan.

DEADLINE: May 1
MORE INFORMATION: www.dnr.state.wi.us/org/caer/cfa/grants/Lakes/lakeprotection.html

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U.S. Army Corps Estuary Habitat Restoration Program

On behalf of the Estuary Habitat Restoration Council, the U.S. Army Corps of Engineers is soliciting project proposals for estuary habitat restoration projects. Proposed projects must meet the definition of an Estuary Habitat Restoration Activity in section 103 of the Estuary Restoration Act, as amended. In addition Section 104 of the Estuary Restoration Act, as amended, contains considerable information about required elements and other factors to be considered in the evaluation of proposals. The Non-Federal interests are responsible for at least 35 percent of the total project cost including the costs of monitoring for a five year post-construction period. This may be provided in cash, credit for required real estate interests, services or other appropriate in-kind contributions. The Federal share of the incremental cost of including innovative technology or approaches is 85 percent. Monitoring is required for a minimum five year period post-construction.

DEADLINE: May 12
MORE INFORMATION: www.usace.army.mil/CECW/ERA/Pages/pps.aspx

North American Wetlands Conservation Act Grants

The North American Wetlands Conservation Act (Act) of 1989 provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico. The Act was passed, in part, to support activities under the North American Waterfowl Management Plan, an international agreement that provides a strategy for the long-term protection of wetlands and associated uplands habitats needed by waterfowl and other migratory birds in North America. In December 2002, Congress reauthorized appropriations for the Act through Fiscal Year (FY) 2007, reflecting its and the public’s support of the Act’s goals. Congress increased the appropriation authorization to $55 million in 2003, with $5 million increases to occur annually until FY 2007, when the appropriation cap will be $75 million.

DEADLINE: March 1, and August 1
MORE INFORMATION: birdhabitat.fws.gov/NAWCA/grants.htm

Fund for Wild Nature

The Fund for Wild Nature provides money for campaigns to save and restore native species and wild ecosystems, including actions to defend wilderness and biological diversity. FWN funds advocacy, litigation, public policy work, development of citizen science, and similar endeavors. Activities that are not eligible include basic scientific research, private land acquisition, individual action or study, or conferences. FWN will only fund media projects that have a clear strategic value and a concrete plan for dissemination of the final product.

DEADLINE: February 1, May 1 and November 1
MORE INFORMATION: http://www.fundwildnature.org

Citizen-Based Monitoring Partnership Program

The purpose of the Citizen-based Monitoring Partnership Program is to provide funding and support to initiate or expand citizen-based monitoring programs involved in the monitoring of aquatic and terrestrial plants, animals and their habitats. $100,000 is available for the 2007 funding period.

DEADLINE: May
MORE INFORMATION: Contact Angela Engelman or visit cbm.wiatri.net/Partnership/

WDNR Aquatic Invasive Species (AIS) Control Grants

Aquatic Invasive Species (AIS) Control Grants are designed to assist in a state/local partnership to control aquatic invasive species. The Department of Natural Resources (DNR) was directed to establish procedures to award cost-sharing grants to public and private entities for up to 50% of the costs of projects to control invasive species. These funds are available to units of local government and others for grants to control aquatic invasive species. The grant projects are broken down into three major categories:
1) Education, Prevention and Planning
2) Early Detection and Rapid Response
3) Controlling Established Infestations
Grants are available to conduct projects on all waters of the state, including lakes, rivers, streams, wetlands and the Great Lakes.

DEADLINE: August 1
MORE INFORMATION: http://www.uwsp.edu/cnr/uwexlakes/grants/AIS_glance.pdf

ERA/NOAA Estuary Habitat Restoration Program

The Estuary Habitat Restoration Program currently seeks projects that achieve cost-effective restoration of ecosystems while promoting increased partnerships among agencies and between public and private sectors. Projects will be evaluated for their support of the Estuary Habitat Restoration Strategy, which aims to ensure a comprehensive approach to restoration activities and to foster the coordination of federal and non-federal efforts. Projects funded under this program will contribute to the Estuary Habitat Restoration Strategy goal of restoring 1,000,000 acres of estuary habitat. Eligible habitat restoration activities include re-establishment of chemical, physical, hydrologic, and biological features and components associated with an estuary.

DEADLINE: August 14
MORE INFORMATION: http://era.noaa.gov/htmls/era/era_projfund.html

Native Plant Conservation Initiative- National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation is offering the 2005 Native Plant Conservation Initiative, which provides federal dollars to nonprofit organizations and government agencies to promote the conservation of native plants. There is a strong preference for "on-the-ground" projects that involve local communities and citizen volunteers in the restoration of native plant communities. Projects that include a pollinator conservation component are also encouraged. Grants range from $5,000 to $40,000 with an average grant size of $15,000. It is expected that all grant funds will be matched by non-federal contributions from project partners.

DEADLINE: Pre-proposals are due February 17 and August 25
MORE INFORMATION: http://www.nfwf.org/programs/npci.cfm

NOAA Community-based Restoration Program Direct Grants

Through NOAA's Community-based Restoration Program, funds are provided to implement individual, grass-roots restoration projects to restore fish habitat. The program invites the public to submit proposals for available funding to implement grass-roots habitat restoration projects that will benefit living marine resources, including anadromous fish, under the NOAA Community-based Restoration Program. The Federal Funding Opportunity (link below) describes the conditions under which applications (project proposals) will be accepted under the CRP and describes criteria under which applications will be evaluated for funding consideration. Projects funded through the CRP will be expected to have strong on-the-ground habitat restoration components that provide educational and social benefits for people and the communities in addition to long-term ecological habitat improvements for NOAA trust resources. Proposals selected for funding through this solicitation will be implemented through a project grant or cooperative agreement mechanism.

DEADLINE: September 28
MORE INFORMATION:
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners_funding/callforprojects.html

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NFWF Pulling Together Initiative: Partnerships to Manage Invasive Weeds

The Pulling Together Initiative, a program of the National Fish and Wildlife Foundation (NFWF), supports nonprofit organizations and government agencies interested in managing invasive and noxious plant species through the formation of local Weed Management Area (WMA) partnerships. These partnerships engage federal resource agencies, state and local governments, private landowners, and other interested parties in developing long-term weed management projects within the scope of an integrated pest management strategy. To be competitive, a project must prevent, manage, or eradicate invasive and noxious plants through a coordinated program of public/private partnerships. In addition, funded projects should increase public awareness of the adverse impacts of invasive and noxious plants.

DEADLINE: New deadline TBA
MORE INFORMATION: National Fish & Wildlife Foundation website

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Knowles Nelson Stewardship Program for Friends Groups

The Wisconsin Legislature has allocated $46 million annually through 2010 to provide outdoor recreational opportunities, protect sensitive lands, and conserve and restore wildlife habitat. Each year, $250,000 will be set aside in a special grant program for Friends groups and nonprofit conservation organizations (NCOs) to improve facilities, build new recreation projects and restore habitat on state properties. The program recognizes the important role these groups play in meeting the development and restoration needs of state properties.

DEADLINE: November 15
MORE INFORMATION: dnr.wi.gov/org/caer/cfa/lr/stewardship/friends.html

Appendix c

Jefferson County Land and Water Final Report

FINAL REPORT:

WATER QUALITY MONITORING AND EVALUATION OF POLLUTANT SOURCES WITHIN THE SOUTHWEST SUBWATERSHED OF ROCK LAKE

2010
Jefferson County
Land and Water Conservation Department

The work done by the Jefferson County Land and Water Conservation Department on this project was a contribution to a Wisconsin Department of Natural Resources Lake Planning Grant received by the Rock Lake Improvement Association.

FINAL REPORT:
WATER QUALITY MONITORING AND EVALUATION OF POLLUTANT SOURCES WITHIN THE SOUTHWEST SUBWATERSHED OF ROCK LAKE

Project Area

The Southwest Subwatershed drains 176.6 acres in the southwest corner of Rock Lake (Map 1). This landscape is a mix of agriculture, parkland, wetlands, forest, and residential development (Table 1). The low gradient glaciated landscape of the subwatershed was ditched for agricultural drainage probably in the 1930s or 1940s. This drainage ditch (referred to as ditch or stream in this report) enters Rock Lake via a channel adjacent to Cedar Lane and Shorewood Hills Road (identified as the "Miljala channel" in this report).

Table 1. Land Uses in the Southwest Subwatershed of Rock Lake

Land Use	Acreage	Percentage
Agriculture	59.2	33.5%
Grassland/Pasture (includes prairies)	36.34	20.6%
Forest	29.61	16.8%
Medium Density Urban (1/4 acre lots)	14.91	8.4%
Rural Residential (>1 acre lots)	13.59	7.7%
Wetland	10.81	6.1%
Roads	10.26	5.8%
Open water	1.89	1.1%

A portion of the subwatershed boundaries were field verified. As a result, there were some changes made to the watershed boundaries in the area of the Shorewood Meadows development. Please refer to Map 1 for the watershed boundaries.

Description of Problem

In 1995, the subwatershed of Rock Lake was modeled by R.A. Smith and Associates, Inc. using WINHUSLE and reported as delivering 41 tons/year of sediment and 262 lbs/year of phosphorus into Rock Lake (R.A. Smith and Associates 1995). As a comparison, the model estimated 339 tons of sediment and 2,066 lbs of phosphorus flow into Rock Lake annually from rural lands in the watershed. The R.A. Smith and Associates report ranked 28 subwatersheds of Rock Lake in terms of sediment load per acre per year. There are 12 subwatersheds that have higher sediment load per acre than the Miljala subwatershed.

In recent years, the amount of sediment entering the channel from the drainage ditch was thought to be more than what was modeled – based on observations and the necessity to dredge sediment from the Miljala channel. The extreme flooding events of the fall of 2007 and the spring of 2008 delivered a large amount of sediment to the channel, with the deepest deposits settling in the first 70 feet of the channel. The deepest sediment deposition was measured by landowners as 70 feet long by 50 feet wide by 6 feet deep. As a result, additional dredging of the channel occurred in 2009.

Testing by the Department of Natural Resources in June and July of 2008 found fluctuating levels of fecal coliform and e-coli counts. The e-coli ranged from 29 to 2,400 colonies per 100 ml. The fecal coliform ranged from 70 to 6,900 colonies per 100 ml.

Project Goals

Original Project Goals

Due to concerns over the amount of sediment, phosphorus, and bacteria in the stream/ditch, the Rock Lake Improvement Association applied for and received a Department of Natural Resources lake planning grant to perform sampling and analysis of the stream. Underwater Habitat Investigations, LLC (UHI) was hired to work on the project cooperatively with the Jefferson County Land and Water Conservation Department (LWCD) and the Rock Lake Improvement Association (RLIA).

The goal of the project was to monitor the stream and channel during both low flow and rainfall events to identify pollutant sources and loads. This includes assessing sources of fecal coliform and e-coli bacteria, phosphorus, and sediment. The health of the tributary was also assessed by performing fish and aquatic invertebrate sampling.

The project write-up for the original project goals, as well as comments on the Hey and Associates, Inc. report (see next section) is contained in this report written by the Land and Water Conservation Department.

Amended Project Goals

After approximately 3 months of sampling and assessment in 2009, it was determined that the source of the sediment and nutrients is the bottom and sides of the drainage ditch. Underground Habitat Investigations suggested that the remaining money in the grant should not be spent on additional base flow sampling or his time to perform the sampling. Instead, UHI recommended that the project move to the next level and include a preliminary engineering assessment to identify possible practices that would control the sediment and phosphorus delivery, and potentially the bacteria delivery also. With that advice, the RLIA requested and received a grant amendment to hire an engineering firm to do the following:

- Estimate watershed runoff volumes and peak flows for several storm events.
- Estimate stream hydraulic conditions (storm flow velocities) and sediment transport rates.
- Describe 2-3 management practices to improve sediment trapping. This description would include approximate sizes of the potential systems, ranges of possible costs, and discussion of feasibility. The feasibility discussion would include: potential upstream surface and ground water drainage impacts, long-term maintenance considerations, the most relevant storms to control for water quality and navigation objectives, and cost.
- Describe the conceptual engineering analysis, including concept drawings.
- Recommend next steps for developing preliminary and final engineering designs, including additional data needs and detailed engineering analyses needed.

The project write-up for the amended project goals are contained in a report prepared by Neal O'Reilly of Hey and Associates, Inc.: Evaluation of Management Alternatives for the Control of Sediment and Nutrient Inputs to the Miljala Channel and Rock Lake, January 15, 2010.

History of Channel Dredging

The Miljala channel was initially dredged for development most likely in 1957, based on aerial photos and newspaper ads for new "lake lots" available for development. The next known dredging of the channel took place in August 1998 with a hydraulic dredge on a barge. Approximately 6,000 cubic yards of sediment were removed from the channel. It is notable that half of what was removed was located in between the Cedar Lane road culvert and the bend of the channel (in the 1st 170 feet of the channel). The remaining 3,000 cubic yards was dredged from the bend of the Miljala channel to Rock Lake (approximately 700 feet). Therefore, the vast majority of sediment discharged in the Miljala channel from the stream is settling out within 170 feet of the road culvert. The dredged material removed in 1998 was placed upstream on farmland adjacent to the drainage ditch.

In March 2005, dredging of a portion of the Miljala channel was done with a back hoe from Cedar Lane. Approximately 500 cubic yards of sediment were removed from the culvert to the extent of the back hoe's reach. The dredged material was spread on conservation club land located outside of the subwatershed. In September 2007, landowners measured the depth of the sediment in the channel just downstream from the road culvert and found 2-3 feet of sediment. Therefore, 2-3 feet of sediment was deposited in 2.5 year. In the summer of 2009, the landowners reported that the area downstream from the road culvert had 6 feet of sediment. Therefore, 3-4 feet of sediment was deposited into the channel in 2 years. This increase of sediment deposition is more likely than not caused by the large and unprecedented precipitation events in the fall of 2007 and spring of 2008.

In August 2009, dredging was done again with a back hoe from Cedar Lane and from the land on both sides of the Miljala channel. Approximately 700 cubic yards of sediment were removed in the channel within 70 feet of the culvert. Sediment that was beyond 70 feet of the culvert was not dredged. It is the opinion of the author that the significant precipitation events of 2007 and 2008 delivered a large amount of sediment to the Miljala channel – more than what would have been delivered during normal precipitation years. The material taken out of the channel was spread on a farm field located outside of the subwatershed. A turbidity curtain was placed 30 feet from the culvert to prevent additional sediment from entering the rest of the channel. This curtain is anchored on the shoreline on both sides of the Miljala channel and extends to the bottom of the channel. A small portion of the top of the curtain is weighed down to allow water flow over the top of the curtain. The DNR permit for the turbidity curtain expires on August 17, 2012 and can be extended only once for an additional two years to August 17, 2014.

All of the dredging in the Miljala channel and material "disposal" was implemented under permits from the Department of Natural Resources (DNR). Any future dredging in the channel will require permits from the DNR.

Water Sampling

Methods

Underwater Habitat Investigations led the sampling effort with support from the Land and Water Conservation Department and several board members of the RLIA: Larry Clark, Milt Strauss, Ron Niedfeldt, and Tom Pezzi. Lee Gatzke also helped on one of the storm sampling events.

Several stream sampling points were chosen for the project (Map 2). Some of these points were pipes that never had any water flow out of them: I is a road culvert, and D is a large metal pipe coming out of the stream bank. Samples were taken from May 2009 through October 2009. Only one storm event was sampled. Other storm events were not sampled because there was not enough precipitation, or the timing did not fit into the schedules of the volunteers and consultants.

Parameters measured/sampled and the meter/method used are listed below:

Flow (cfs) – water flow was measured with a Swoffer Model 2100 meter. Water flow was also recorded by Hey & Associates on November 13, 2009 – a different type of meter may have been used.

Water Level (ft) – water level was read from a stream gauge graduated to hundredths and marked at every foot and every tenth. The gauge was attached to a steel beam which was driven into the stream bottom upstream from the culvert (site B)

Transparency (cm) – a 120 cm secchi transparency tube was used to measure the transparency or clarity of the water.

pH – the ExStik pH Meter was used to measure pH. The instrument was calibrated according to the manufacturer's directions. The YSI Model 63 was also used to measure pH.

Conductivity (uS/cm) – The ExStik II Conductivity Meter was used to measure conductivity. The instrument was calibrated according to the manufacturer's directions. The YSI Model 63 was also used to measure conductivity.

Dissolved Oxygen (mg/l) – The Hach Portable LDO meter (HQ10) was used to measures dissolved oxygen and temperature. The YSI Model 52 was also used to measure DO.

Temperature (°C) – Temperature was measured with the ExStik II Conductivity meter (°C) and the Hach Portable LDO meter (°F, then later converted to °C).

Total Phosphorus (mg/l), Ammonia as Nitrogen (mg/l), Nitrate plus Nitrite (mg/l) – Water sample collected in a 250 ml bottle, preserved with sulfuric acid, tested with pH paper to ensure pH <2, put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking the sample.

Total Suspended Solids (mg/l), Total Dissolved Solids (mg/l) – Water sample collected in quart bottle, put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking the sample.

Fecal Coliform, E. coli (colonies/100ml) – water sample collected in 125 ml bottle (sealed by lab), put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking the sample.

Chloride (mg/l), Sulfate (mg/l) - water sample collected in quart bottle, put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking sample.

Total Phosphorus in Sediment (mg/kg) – sediment sample collected in 250 ml bottle, put on ice, and delivered to the State Laboratory of Hygiene within 24 hours of taking sample.

Results

The majority of sampling parameters and associated results are contained in the Hey and Associates, Inc. report. Parameters not covered in the Hey and Associates report are covered below. (The Hey report, page 9, states that Total Dissolved Solids was not measured. However, there was one sample taken on July 28, 2009.)

There was one small storm event sampled on October 22-23, 2009. Hey and Associates presented these results in tables in their report. These tables include 2 columns at the end of the table that both are labeled for October 23. It is important to note that the 1st column contains results from the morning sampling, and the 2nd column has results from the afternoon sampling.

Water Level and Flow

The water level at Site B was recorded on every sampling date (Table 2). It ranged from 0.26 feet to 0.54 feet – a difference of only 0.28 feet, or 3.4 inches.

Table 2. Water Level (ft) Measurements at Site B (all readings taken in 2009)

5/19	**6/2**	**6/8**	**6/16**	**6/28**	**7/10**	**7/22**	**7/28**	**8/11**	**8/19**	**8/27**	**10/1**	**10/6**	**10/22**	**10/23 am**	**10/23 pm**
0.52	0.47	0.54	0.44	0.44	0.36	0.44	0.35	0.39	0.34	0.26	0.35	0.37	0.38	0.56	0.55

It should be noted that the 2.14 inch rain event in October did not produce a large rise in water level at Site B, upstream of the Cedar Lane road culvert. Given the size of the watershed, it would have been expected that a 2.14 inch rain event would have caused there to be more water at the discharge of the stream. This means that much of the rainwater infiltrated into the ground.

The water flow in cubic feet per second was also recorded (Table 3).

Table 3. Water Flow (cfs) Measurements at Site B (all readings taken in 2009)

5/5	**5/19**	**6/2**	**6/8**	**6/28**	**7/28**	**11/13**
0.21	0.34	0.42	0.5	0.25	0.14	0.46

Ammonia Nitrogen

In the Hey and Associates report (page 8), Table 7 containing the ammonia results did not include a comment from the State Laboratory of Hygiene:

- On June 26, 2009, the AE and AS lab test had the quality control compromised. Therefore, these results may not be definitive.

Chloride

Chloride can be an indication of pollution because it is not common in Wisconsin soils or rocks, except in areas with limestone deposits. Jefferson County is located in an area of the state that contains higher concentrations (>10 mg/l) of chloride than in other areas. Sources of chloride are animal waste, potash fertilizer, septic systems, water softening salt, and road salt. Roads in the watershed (Hwy S and Cedar Lane) receive road salt in the winter. Chloride can inhibit plant growth, impair reproduction, and negatively impact the diversity of the in-stream organisms.

On July 28, 2009, the chloride concentration of the water upstream of the Cedar Lane road culvert (site B) was 70.1 mg/l. This amount is well below the U.S. Environmental Protection Agency recommendation for aquatic life which is a 4-day average chloride concentration of 230 mg/l occurring once every 3 years; and the USEPA secondary maximum contaminant level fo 250 mg/l for chloride in drinking water (Mullaney 2009).

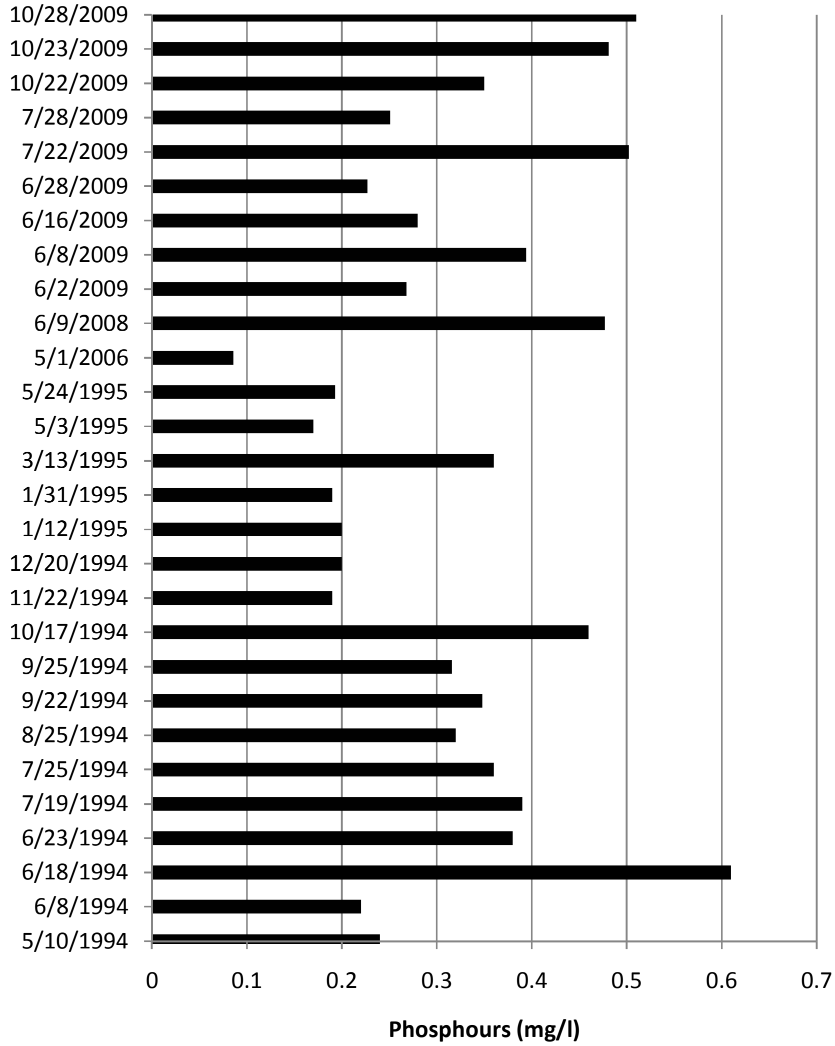
Phosphorus

It should be noted that Rock Lake has been shown to be phosphorus limited because the nitrogen to phosphorus ratio is approximately 55:1 (Marshall 1997). Lakes are phosphorus limited as long as the nitrogetn to phosphorus ratio exceeds 15:1.

The Hey and Associates report notes that three phosphorus samples (taken from site G and H) were above the statewide maximum levels of phosphorus in Wisconsin streams. On both occasions when water samples were taken from site G and H, the water was stagnant.

Phosphorus sampling in the stream upstream of the Cedar Lane culvert was performed in the past, mainly as part of the research for the Rock Lake Priority Lake project. Chart 1 shows the variation of total phosphorus measurements over time that ranges from 0.086 mg/l to 0.61 mg/l (within the range of statewide min/max values) and has an average value of 0.32 mg/l (greater than the statewide mean).

Chart 1. Total Phosphorus Data Available from Ditch Upstream of Cedar Lane Road Culvert



Sediment Phosphorus

On May 19, 2009, a sediment sample was taken upstream of the Cedar Lane road culvert (site B). The phosphorus concentration in the sediment was measured to be 1,410 mg/kg. This value is used below to estimate the annual phosphorus delivery from sediment delivered as bed load (see Table 10).

Sulfate

Sulfate is not an indication of pollution. Sulfate concentrations in water are associated with minerals found in the land and acid rain. Jefferson County is located in an area of the state that contains concentrations of sulfate >40 mg/l.

On July 28, 2009, the sulfate concentration of the water upstream of the Cedar Lane road culvert (site B) was 54.7 mg/l. However, the State Laboratory of Hygiene noted that the result is not definitive because a cooler in their facility lost power and the standard temperature was not maintained.

Total Dissolved Solids

On July 28, 2009, the total dissolved solids of the water upstream of the Cedar Lane road culvert (site B) was 566 mg/l.

Transparency

Transparency is a measure of water clarity. Materials suspended and dissolved in the water will impact the clarity of the water. The results from the sampling in the ditch are presented in Table 4.

Table 4. Transparency (cm) Measurements (all dates were in 2009)

Site	**5/5**	**5/19**	**6/2**	**6/8**	**6/16**	**6/28**	**7/22**	**7/28**	**8/11**	**10/22**	**10/23 am**	**10/23 pm**
B	110	120	77.6	66.4	87.6	115	ND*	77	42.8	67.8	45	35.4
AE		120	107		49.5	73	55.5			113.8	>120	
AS			>120		>120	>120	>120				>120	
G			>120		63							
H			>120		91.6							

*An accurate reading was not obtained.

Table 5. Median and Average Transparency (cm) for Wisconsin (Robertson 2006) and the Ditch

Month	**WI Median Transparency**	**Ditch Median Transparency***	**WI Average Transparency**	**Ditch Average Transparency***
May	105.0	120	89.8	116.7
June	88.5	107	79.6	96.7
July	90.0	77	82.9	84.2
August	>120	42.8	92.9	42.8
October	>120	90.8	107.9	83.7

*Transparencies that were >120 were assumed to be 120 for the median and mean calculations.

Table 5 shows the Wisconsin median and average transparency of streams and the data from the ditch (please note that in some months, the data from the ditch is limited). In May and June, the ditch transparency was greater than the average and median transparency of streams throughout WI. In July, the ditch transparency was close to WI stream norms. In August, the ditch transparency was much lower than the WI stream norms (based on one sample). For October, the median and average transparencies in the ditch were less than the WI stream norms. However, it should be noted that the October data was during a storm event, and transparencies decrease because more sediment is carried during storm events. The State minimum transparency for streams is 23.5 cm.

Storm Sampling

On October 22 and 23, 2009, a small storm event was sampled. The storm event produced 2.14 inches of rain (as measured from a volunteer's rain gauge). Total rain amounts were measured as follows:

10-22-09, 1:30 pm = 0.71 inches of total rain
10-23-09, 7:00 am = 1.82 inches of total rain
10-23-09, 4:00 pm = 2.14 inches of total rain

Measurements taken during the storm event at Site B are contained in Table 6 and 7.

Table 6. Water quality measurements at Site B during a storm event

Site B	**Water Level (ft)**	**Temp (C)**	**Clarity (cm)**	**Conduc -tivity (uS/cm)**	**D.O. (mg/l)**	**Total P (mg/l)**	**Ammonia (mg/l)**	**Nitrate + Nitrite (mg/l)**	**TSS (mg/l)**
10/22 10:50am	0.38	8.8	67.8	1052	8.2	0.35	0.032	2.83	34
10/23 9:50 am	0.56	9.2	45	1069	7.8	0.481	0.09	5.09	80
10/23 2:00 pm	0.55	10.3	35.4	1054	7.3	0.51	0.095	6.06	114

Table 7. Bacteria measurements at Site B during a storm event

Site B	**E-coli (colonies/100 ml)**	**Fecal Coliform (colonies/100 ml)**
10/22 10:50am	230	310
10/23 9:50 am	550	450
10/23 2 pm	350	320

The following can be said about the results:

- Conductivity levels suggest that the stream flow consists of mostly groundwater. Therefore, much of the rainfall during this event was mainly infiltrated through the ground and not delivered as runoff.
- The water level did not increase very much during the storm given the size of the watershed. Therefore, much of the rainfall is infiltrating into the ground instead of being delivered to the stream via surface runoff.
- Sediment delivery increases with increased flow. Because the flow is mostly groundwater, it is probably the case that the sediment in the stream originates in the channel of the stream.
- Bacteria levels increased with flow and then decreased again when the flow decreased.

Results Summary

A number of conclusions can be made from the results of the water quality sampling.

- Both temperature and conductivity results indicate that the water during the sampling days consisted primarily of ground water. This is not surprising since there was not much rain during the sampling period (May through October 2009).

- Ammonia results suggest that agricultural fertilizer runoff was not a major pollutant during the sampling period (May through October 2009).

- Total phosphorus concentrations in the stream are high compared to the statewide means.

- Nitrate plus nitrite concentrations are high compared to state statewide means. However, they are much less than the State maximum for streams (20.55 mg/l) and also less than the State and Federal public drinking water maximum of 10 mg/l.

Bacteria Sampling

One of the goals of the grant project was to discover the source of e-coli and fecal coliform bacteria. The sampling that was planned and implemented did not result in identifying the source. This is because the bacteria levels were very variable at all of the sampling points and therefore did not indicate a possible pollutant location. Possible bacteria sources could be one or more of the following: leakage from septic systems into the groundwater, leakage from a manure storage into the groundwater, contaminated sediment from previous runoff events from agricultural fields spread with animal waste, contributions of bacteria associated with organic wetland soils, and wildlife in the area.

The one manure storage structure in the watershed was properly closed in early December 2009. The storage had a concrete floor and clay side-walls. A Natural Resources Conservation Service engineer designed and inspected the closure which consisted of removing any remaining manure, breaking up the concrete floor, removing all contaminated soils, and filling the hole with clean fill. Therefore, if this storage was a source, then it will no longer be a source in the future.

During sampling events, there were several sightings and evidence of wildlife in the area. These include deer, waterfowl, and groundhogs.

A Jefferson County Health Department official cautioned about comparing bacteria levels from the stream to the levels set for beach advisories and closures. The reason for this caution is that the stream is only a couple inches deep, where as the beach samples are taken in a foot of water. Therefore, the sampling situations are different and the results should not be compared.

LWCD staff had a discussion with Sharon Kluender from the State Lab of Hygiene about bacteria and tests that could reveal a source of bacteria. She suggested a series of tests that could possibly help with source testing (human vs animal) that include: antibiotics, bacteriodes spp., bifidobacteria, hormones, pharmaceuticals/personal care products, rhodococcus coprophilus, sterols, and male specific RNA coliphage. She recommended that these tests should be done together (instead of picking a subset). Again, she was quick to point out that the testing could be implemented, and there could still be uncertainty in the results.

LWCD staff sent questions to Dr. Sandra McLellen about the bacteria data and future sampling on January 21, 2009. A response from her was not received prior to finalizing this report.

Habitat Sampling

On August 21, 2009, UHI and the LWCD surveyed the stream for fish and aquatic insects. Because of the shallow stream depth and very narrow channel, dip nets were used instead of electroshocking gear or seines. Six sites along the length of the stream were sampled (see Map 3).

No fish were found at any of the sites. In terms of the insects, amphipods were the dominant organism. Water striders were also present.

The amphipod's (also called scud – *Gammarus psuedolimneus*) body shape and side-swimming behavior enables it to not be washed downstream in currents. It eats decaying plants and animals. Amphipods are semi-tolerant of pollutants and their presence often indicate the presence of ground water.

Water striders live on the water surface and therefore breathe from the atmosphere instead of the water as do most fish, crustaceans and other aquatic insects. They can walk on water and they eat plants and insects. Water striders are not water quality indicators because they are air breathers and will not be effected by pollutants that lower dissolved oxygen in the water.

Stream Channel and Sediment Survey

On August 21, 2009, UHI and LWCD surveyed the stream bottom at six locations along the length of the stream (Map 3). Characteristics found at each sampling point are recorded in Table 8. Sediment depths along the channel profile were also measured at site 5 and 6 (Charts 2, 3). During the survey (and on other sampling days) the dark peat (or muck) sediment was observed flowing above the bottom of the stream (bed load). The dark peat/muck sediment is characteristic of wetland soils, such as Houghton muck which is the wetland soil surrounding the stream/ditch.

Given the sediment profiles (Charts 2, 3), an estimate of sediment that is located in the stream channel and has the potential to be delivered downstream during storm events can be determined. Based on field observations, an estimate was made as to the length of stream that contains sediment in the bottom of the channel. The estimated amount of sediment in the stream channel is 9,200 cubic yards.

Table 8. Stream Channel Characteristics

Site	Substrate	Channel Width (ft)	Average water Depth (ft)	Comments
1	Sand	3’	0.25	
2	Gravel, rubble	4’	0.25	
3	Mostly muck	4’	0.33	Bank erosion
4	~1” muck over sand	2.5’	0.25	Bank erosion
5	Muck	11’		Dredge spoils on west bank, eroding and poorly vegetated
6	Muck	15’	0.33	Heavily shaded with eroding banks

Field observations indicate that the section of the ditch that contains the most sediment in its channel is located upstream of Site 4, where the stream makes a 90 degree turn to run north-south (Map 3).

It is important to note that the observations on August 21, 2009 are different than the observations made by Hey and Associates on November 13, 2009 in terms of stream channel substrate. The differences are in Reach 1 and 2. In August, the channel substrate was characterized by sand and an area with gravel and rubble. In November, the channel substrate was characterized by peat (muck). This highlights the dynamic nature of this stream and again the sediment flow occurring in the stream.

Chart 2. Sediment Depths at Site 5 (see Map 3)

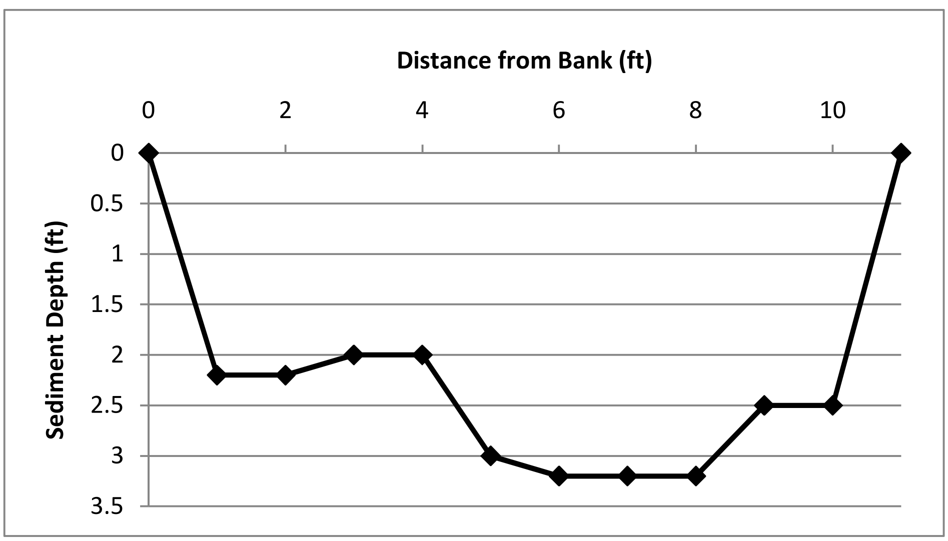
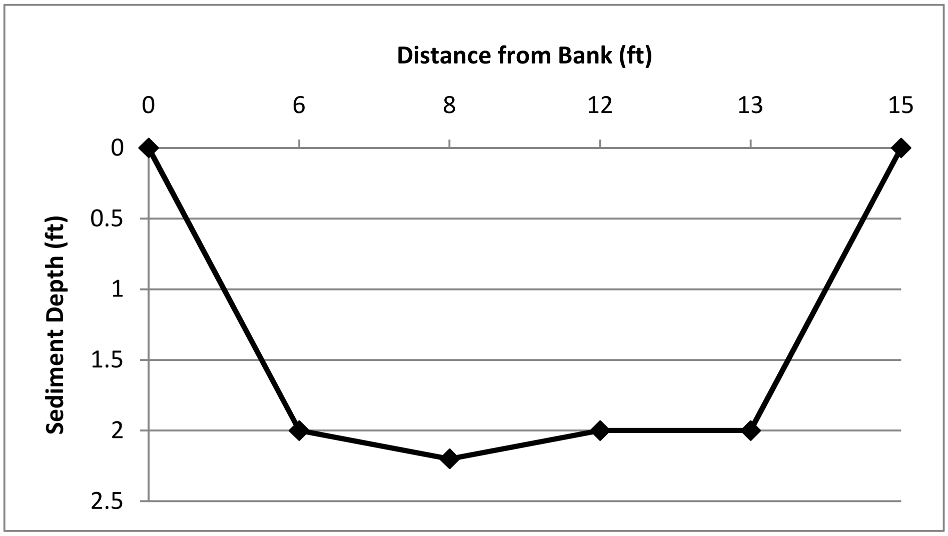


Chart 3. Sediment Depths at Site 6 (see Map 3)



Sediment and Phosphorus Loading

The Wisconsin Lake Modeling Suite (WiLMS) is a model that can estimate phosphorus loading rates from the stream. The results from the WiLMS model with current land uses are in Table 9. It is the case that the WiLMS model is conservative when it comes to estimating phosphorus loading from wetland areas. Because of the presence of a wetland soil (Houghton muck) along the ditch, it is possible that the area surrounding the ditch contain wetlands.

Table 9. Estimated Annual Phosphorus Loading from the Stream

	Low	**Most Likely**	**High**
Phosphorus Loading (lb/yr)	37.5	79.3	146.7

Table 10 reports the various estimates of sediment and phosphorus loading from the stream. What is important to note is that sediment and phosphorus delivery is occurring from the stream to the dredged channel, and the amount of loading to the channel has been identified as a problem impacting the channel and probably the lake area near the channel outlet.

Table 10. Estimates of Sediment and Phosphorus Loading

	WINHUSLE 1995	**WiLMS 2009**	**Bed Load 2009**
Estimated Sediment (tons/yr)	41		11.8
Estimated Phosphorus (lbs/yr)	262	37.5 - 146.7	33.3*

*The phosphorus loading was calculated given the sediment load delivery and the analysis of the amount of phosphorus contained in the sediment (1,410 mg/kg).

Potential Management Alternatives

The Hey and Associates, Inc. report includes an overview of several management alternatives. Below are a few comments and additional information about the practices.

Stream Bank Stabilization

A review of historic aerial photographs (1957, 1963, 1996, 2000, and 2004) indicates that the stream is not widening or meandering. Therefore, bendway weirs and stream barbs can be ruled out as possible management practices.

Rock riffles are another practice that can be ruled out because the stream does not have a steep grade and because of the nature of the soils in the stream. The wetland soils (peat/muck) in the stream are fine would probably just cover the rocks placed in the stream.

Though bank erosion is a concern for this system, it is the opinion of the LWCD that the bank erosion is not severe enough to warrant stone toe protection (also called “riprap”).

Willow posts, vegetation, and stone toe protection could all address erosion happening on the bank of the stream/ditch. It is important to note that these practices will not address the sediment that is present on the bottom of the ditch channel.

Ditch Plugs

The Wisconsin Wetland Association’s Wetland Restoration Handbook for Wisconsin Landowners states that the recommendation is to “plug at least 150 feet of ditch” (Thompson 2004). Hey and Associates, Inc. has interpreted this to mean a ditch plug every 150 feet of ditch for the entire 4,000 feet of ditch, amounting to 25-30 ditch plugs. The LWCD contacted a Natural Resources Conservation Service (NRCS) engineer who stated that ditch plugs are installed to fill in 150 feet of the ditch in order to ensure that the plugs are not eroded by the water flow and the water flow does not move around the side of the ditch plug. After given the information on the stream in question, the NRCS engineer stated that the system would most likely need 3-4 ditch plugs, each filling in 150 feet of ditch.

Field observations indicate that the majority of the stored sediment in the ditch is located upstream of Site 4 (Map 4). So, perhaps ditch plugs are not necessary downstream of Site 4 (amounting to roughly 1,500 feet of stream).

The NRCS engineer also noted that steps should be taken to make sure adjacent landowners are not impacted by the backed-up surface water and groundwater which can rise in elevation once the ditch plugs are installed.

Wetland Restoration

It should be noted that the information in Table 13 of the Hey and Associates, Inc. report (Typical Pollutant Removal Rates of Wetlands) should contain some caveats. The publication that is the source of the Table 13 information (Winer 2000) states that the figures are based on very limited data. In some instances, the percent removal of certain pollutants was based on fewer than 5 data points. The Winer publication also explains that the data in the table is based on ideal conditions and within the first 3 years of the practice installation. Long term pollutant removal rates are also not known. Therefore, the pollutant removal values in Table 13 of the Hey and Associates report should not be taken as definitive pollutant removal rates for constructed wetlands.

The Hey and Associates report indicates that the size of the Miljala channel watershed would require a constructed wetland to be 5.6 to 9.4 acres in size. To help in visualizing the size of such a wetland, please refer to Map 4.

<u>Sedimentation Basin</u>

The Hey and Associates report points out that forebays to capture coarse sediments are often added to wet detention ponds to reduce maintenance costs. Field observations do not indicate the presence of coarse sediments. Therefore, a forebay may not be applicable to the stream in question.

The Hey and Associates report comments that a detention pond for the size of the stream's watershed would be 2-3 acres in size. To help in visualizing the size of 2 and 3 acres, please refer to Map 4.

Conclusions and Recommendations

Underwater Habitat Investigations, Land and Water Conservation Department, Hey and Associates, Inc., and the Rock Lake Improvement Association are all in agreement that a solution should be identified and implemented to control the sediment, nutrients, and bacteria being delivered from the ditch to the Miljala channel.

<u>Source of Sediment and Phosphorus</u>

Underwater Habitat Investigations, Land and Water Conservation Department, and Hey and Associates all agree that the "source" of sediment is the sediment that is contained in the bottom and sides of the stream/ditch. Based on channel profiles of the sediment, the estimated amount of sediment sitting in and along the stream is 9,200 cubic yards. Based on a bed load sample, the estimated annual load of sediment is 23,652 pounds/year. Storm events will increase the sediment and nutrient delivery of the stream which is evidenced in the one storm event sampled and the sediment deposited in the Miljala channel during the record-setting precipitation events between Fall 2007 and Spring 2008.

Prior to starting this grant project, it was known that the sediment delivery to the channel was a problem because of the continued necessity to dredge the channel. This project has revealed the source of the sediment which will continue to be delivered to the channel as bed load and during storm events. Given the estimates of the sediment loading in the stream, it may not be necessary to perform additional sampling to estimate the amount of sediment loading.

Source of Bacteria

Bacteria levels in the stream have been variable. The source of the bacteria still remains a mystery. The LWCD recommends that the following questions be answered before choosing to initiate additional sampling:

- Given the mix of possible sources in the watershed, how definitive will RNA testing be? Would a series of bacteria testing (RNA, antibiotics, bacteriodes spp., bifidobacteria, hormones, pharmaceuticals/personal care products, rhodococcus coprophilus, and sterols) be more definitive?
- What is the sampling protocol, and the costs, for the recommended test(s)? For instance, how many samples and how many sampling points?
- Can the source of bacteria actually be contained in the sediments found in the stream channel?
- Can processes in adjacent wetlands and associated groundwater flow be a source of the bacteria?
- Will practices to control sediment in the stream work to control bacteria?

The LWCD sent these questions to Dr. Sandra McLellan, with the Great Lake WATER Institute in Milwaukee, and will forward the answers to the RLIA and DNR when they are received.

Work could be done to rule out one of the possible source of bacteria: septic systems. The majority of the septic systems in the watershed received permits from the Jefferson County Zoning and Planning Department when their systems were built. These permit holders also report to the Zoning Department when they complete the required pumping every 3 years. There are 2 septic systems in the watershed that pre-date the law that required a construction permit and maintenance. A request could be made to the Zoning Department to ask the owners of these systems if an inspection can be done to insure that the systems are functioning correctly. These inspections would not cost anything to the RLIA and could be performed prior to spending more money on bacteria sampling and analysis.

Possible Alternative

Currently, there is a temporary sediment curtain in the dredged channel of Rock Lake that lies between Shorewood Hills Road and Cedar Lane. Is there a possibility to install a permanent sediment curtain in the channel? Based on the fact that some landowners beside the ditch may not allow access to their land, it might be wise to investigate the feasibility of this practice. A meeting/conversation with the Water Regulations and Zoning Specialist with the Department of Natural Resources would reveal if a long-term sediment curtain could be used in the channel. If the DNR responds that this is an option, then it could be added to the list of possible solutions.

Costs

Based on construction costs alone, the most affordable practices include ditch plugs, streambank stabilization, and sedimentation basins. Estimated maintenance costs are only available for wetland restorations and sedimentation basins. Based on the high costs, the LWCD recommends that no further study be done on the feasibility of alum treatments or sand filters for this watershed.

It is the policy of Jefferson County to solicit written quotations for projects that will cost $5,000 - $25,000 and to obtain competitive bids for projects that will cost greater than $25,000. This policy ensures that the services purchased by the county are the most cost-effective and that tax-payer money is well spent. Perhaps the RLIA should consider adopting a similar policy.

Information Important to Permitting

Dan Hunt (Water Regulations and Zoning Specialist, Department of Natural Resources) was consulted about the designation of the stream. He determined that the stream does not have stream history and is not "navigable" under the Chapter 30 permit process.

Dan Hunt pointed out that there are designated wetlands adjacent to the stream which are regulated under state, federal and county regulations. Designated wetlands are wetlands that were identified by aerial photographs. The vast majority of the soil on either side of the stream is a hydric soil named Houghton Muck. When development or land disturbing activities are proposed near designated wetlands or in hydric soils, it is recommended that a wetland delineation be performed to ensure that the exact locations of wetlands are known.

Recommendations for Next Steps

The RLIA, Hey and Associates, LWCD, and UHI all agree that the sediment, nutrient, and bacteria pollution should be addressed by controlling the source of pollution. The LWCD recommends the following actions and process to achieve this goal.

Landowner and Public Input

During the course of the last few months, some landowners who live along the ditch have voiced their concerns about not being included in the process. In the public-centered and resource-centered work done every day by the Land and Water Conservation Department, the LWCD knows that including effected and interested citizens in the decision-making process is not only vital when making resource decisions, but it also results in a stronger product. Therefore, it is the recommendation of the LWCD that a meeting be held with the landowners to bring them up to date on the current data and possible solutions, and to include them in the decision-making process. This meeting could also accomplish the following:

- Landowners may have important information to add about their land, such as the location of tile drains.
- Landowners could potentially provide input as to the practice(s) that would be acceptable to them and the practice(s) that would not be acceptable to them. This in turn could reduce the costs of the next grant project because if a practice is not acceptable to the landowners, then that practice would not be considered by the next grant project. It is important to note that the practice should not be considered if there are valid reasons given for not wanting the practice on their land.

- If certain landowners decided that they don't want their land to be used for practice placement, then that land would not be included in the wetland delineation or the tile drain survey if they were down stream of the potential practice location. Therefore, there would be additional cost-savings for the next grant project.
- Landowners would be included in the process to identify solutions and therefore would be more willing to have the selected practice installed on their property.

Process for Achieving a Solution to Problems

⇒ Meeting with Affected Landowners, RLIA, LWCD, and Hey and Associates
  - to review information produced in the Hey and Associates report and in this report
  - to help possibly refine the practices that will be considered in the next grant
  - to determine which areas of the ditch will be available for practice installation

⇒ Possible Inspection of Septic Systems by the Jefferson County of Zoning and Planning

⇒ Obtain Additional Information and Make Decision on Bacteria Sampling

⇒ Write a Request for Proposal to Engineering Firms to complete the following:
  - Draft Lake Planning grant application
  - Determine 2-3 conceptual practice options (including conceptual drawings showing practices in potential locations in watershed) based on current data, watershed/ditch characteristics, and potential to receive permits through conversations with the DNR
  - Meeting with stakeholders (RLIA, LWCD, affected landowners, interested citizens) to present conceptual options and to help determine chosen practice(s)
  - Choose practice(s) with project leaders
  - Perform necessary surveys (tile drains, wetland delineation) at the potential sites where practice(s) could be installed
  - Produce engineering designs for chosen practice(s) (It might be possible that an engineer from NRCS or the State Department of Agriculture could provide this service free of charge.)
  - Produce a report that includes the engineering designs, review of public input & acceptance by affected landowners, and fiscal estimates for implementing the chosen practice
  - Present final design to all stakeholders
  - After approval of design and reports, obtain any necessary easements and permits
  - Draft Lake Protection grant application for implementation

⇒ Choose an Engineering Firm to Complete Project and Write Necessary Lake Planning Grant Application(s)

⇒ Review and Submit Lake Planning Grant Applications (August 1, 2010)

⇒ Hire Engineering Firm to Complete Project

⇒ Submit Project Results to DNR for Review, Obtain Easements, and Obtain Permits

⇒ Write a Request for Proposal for Construction and Inspection of the Project (If a State Department of Agriculture or NRCS engineer designs the project, they could inspect the installation free of charge)

⇒ Choose a Contractor to Construct Project

⇒ Review and Submit Lake Protection Grant Application (May 1, 2011) for Implementation

⇒ Implement Management Practice in 2011

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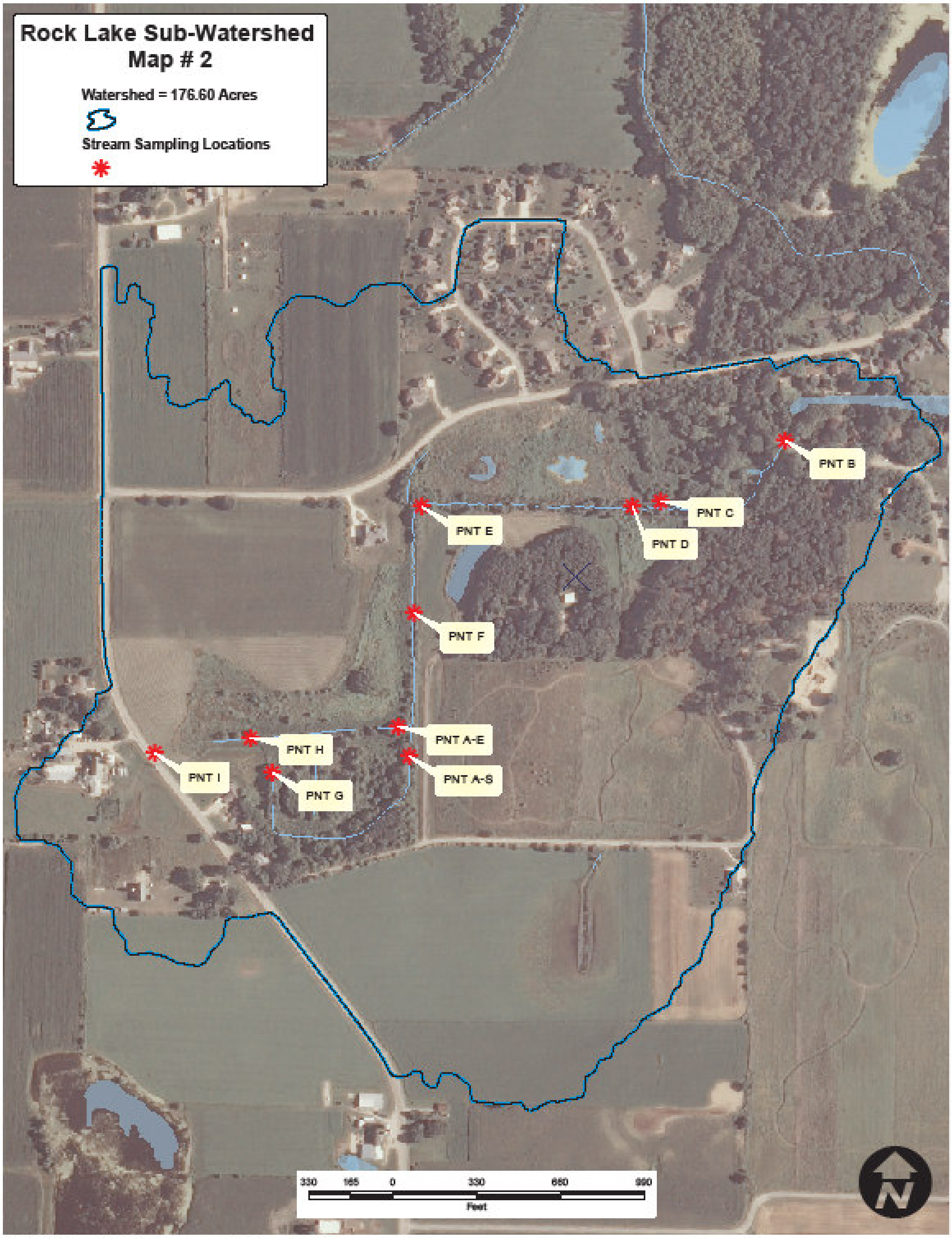
Note

This report was written with comments on the draft from Underwater Habitat Investigations, the Department of Natural Resources, and a member of the Rock Lake Improvement Association Board.

Aerial Photos Taken Summer 2008

Compiled by the Jefferson County Land & Water Conservation Department



Aerial Photos Taken Summer 2008

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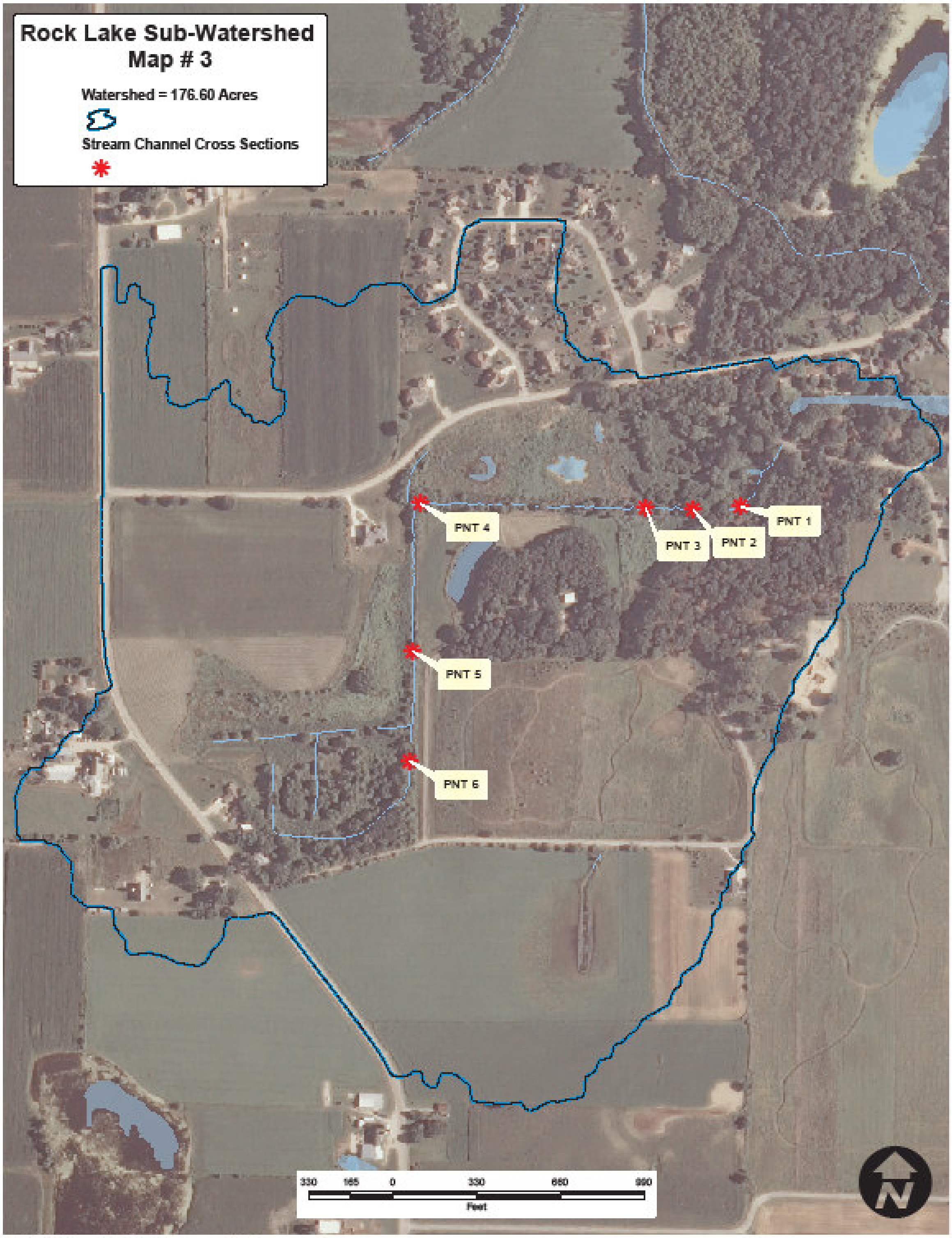

Aerial Photos Taken Summer 2008

Compiled by the Jefferson County Land & Water Conservation Department


Rock Lake Sub-Watershed
Map # 4
Watershed = 176.60 Acres
= 9 acres
= 5 acres
= 3 acres
= 2 acres
= 1 acres
330
165
0
330
660
990
Feet
Aerial Photos Taken Summer 2008
Compiled by the Jefferson County Land & Water Conservation Department