RILEY PURGATORY BLUFF CREEK
WATERSHED DISTRICT

Water Resources Report

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT
2017 ANNUAL REPORT

protect. manage. restore.

Executive Summary

The Riley Purgatory Bluff Creek Watershed District (RPBCWD) had a successful water quality sampling season in 2017, completing a full year of sample collection and data analysis. This effort was made possible through multiple partnerships with municipalities and organizations based within the watershed. Overall, water quality across both creeks and lakes generally improved in 2017. The results from the 2017 sampling effort are presented in this report.

Lake Monitoring

During the 2017 monitoring season, 13 lakes were monitored across the District. In addition to the lakes sampled, Lake Idlewild was monitored by the city of Eden Prairie and was included in this analysis, even though it was classified as a high value wetland in 2015. Regular water quality lake sampling was conducted on each lake approximately every two weeks throughout the growing season (June-September). In addition to regular lake sampling, the District monitored water levels of these 14 waterbodies, assessed carp populations within the Riley and Purgatory Chain of Lakes, and assessed zooplankton and phytoplankton populations in five lakes. The District also monitored public access points and analyzed water samples for the presence of zebra mussels in these 14 waterbodies. No zebra mussel (adults or juveniles) or invasive zooplankton were found in any District lake. Herbicide treatments were conducted on Lake Ann, Lotus Lake, Lake Susan, Mitchell Lake, Red Rock Lake, Staring Lake, and Lake Riley. Brittle Naiad was discovered in Lake Ann and Lotus Lake in 2017.

Surface water samples were collected, analyzed, and compared to standards set by the Minnesota Pollution Control Agency (MPCA) to assess overall lake health. Figure 1 displays lakes sampled in 2017 that met or exceeded the MPCA lake water quality standards for Chlorophyll-a (Chl-a), Total Phosphorus (TP), and Secchi Disk depth during the growing season (June-September). The MPCA has specific standards for both 'deep' lakes (Lake Ann, Lotus Lake, Lake Riley, and Round Lake) and 'shallow' lakes (Duck Lake, Hyland Lake, Lake Idlewild, Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, Staring Lake, Lake Susan, and Silver Lake) (MPCA 2016). Lake Ann, Lake Idlewild, Red Rock Lake, and Rice Marsh Lake met all three MPCA standards in 2017; Rice Marsh (TP) and Red Rock (Chl-a) did not previously meet all the standards in 2016. Lotus Lake, Mitchell Lake, and Lake Susan all exceeded both the Chl-a and TP standards in 2017. These lakes did not meet these two standards in 2016 as well. In 2016, four lakes did not meet any MPCA standards, Hyland Lake, Mitchell Lake, Silver Lake, and Staring Lake. In 2017, only Hyland did not meet all three standards. All lakes within the Riley Chain of Lakes met the MPCA's chloride chronic standard for class 2B water bodies in 2017.

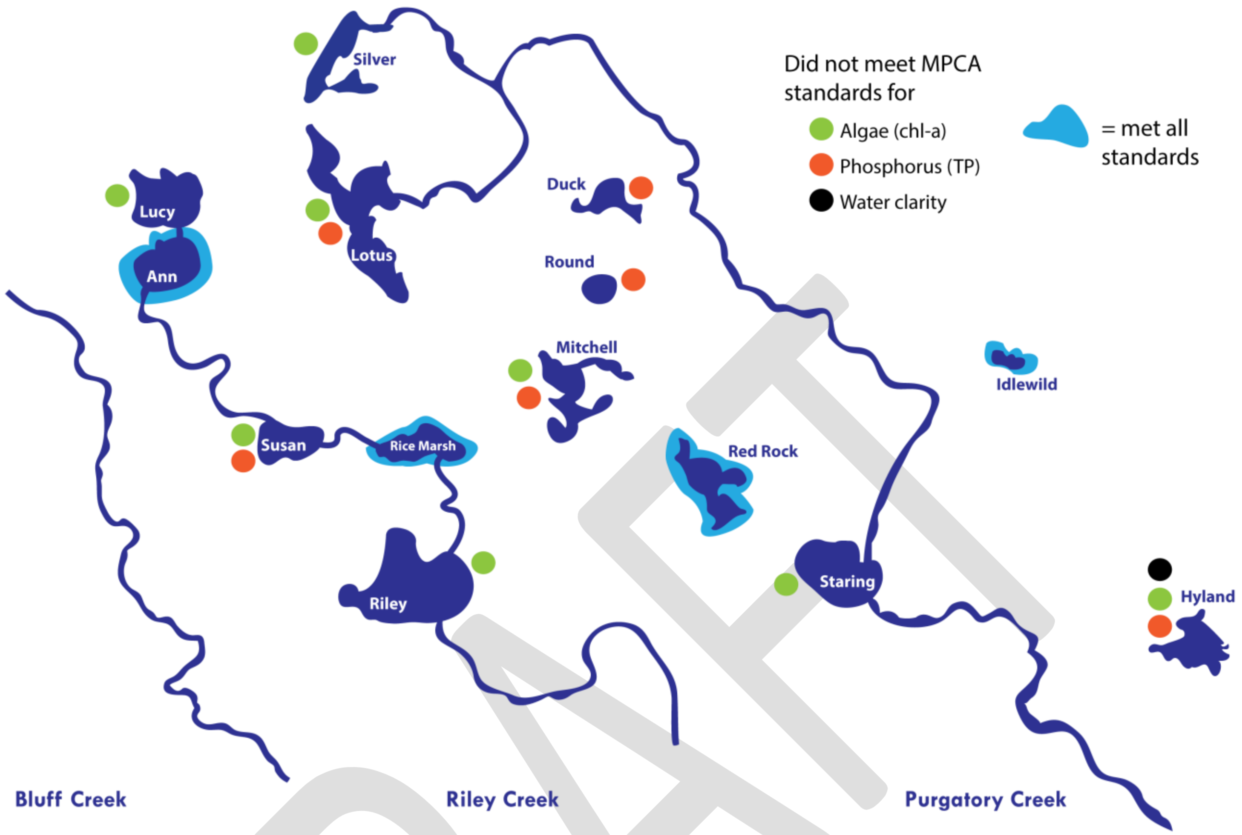

Figure 1   2017 Lake Water Quality

Summary of the lake water quality data collected in 2017 by the Riley Purgatory Bluff Creek Watershed District as compared to the Minnesota Pollution Control Agency Water Quality Standards. Chlorophyll-a (green), Total Phosphorus (orange), and Secchi Disk depth (black) were assessed during the growing season (June-September) for both 'deep' lakes or lakes >15 ft deep and < 80% littoral area (Lake Ann, Lotus Lake, Lake Riley, and Round Lake), and 'shallow' lakes or lakes <15 ft deep and >80% littoral area (Duck Lake, Hyland Lake, Lake Idlewild, Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, Staring Lake, Lake Susan, and Silver Lake). The corresponding dots next to each lake indicate which water quality standard was not met and the lakes surrounded by blue met all water quality standards.

Creek Monitoring

In 2017, the District collected water quality samples and performed data analysis on 21 different sampling sites along Riley Creek (six sites), Bluff Creek (five sites), and Purgatory Creek (ten sites). During the 2017 creek monitoring season (April-September) water chemistry and turbidity were regularly measured at the 18-regular water quality monitoring sites every two weeks. Water samples were collected to assess nutrient (TP and Chl-a) and total suspended sediment (TSS) concentrations. Creek flow was calculated from velocity measurements taken at consistent creek cross sections at each water quality monitoring location. Sections of upper Riley Creek and the Lotus Lake ravines were also walked and assessed using the Creek Restoration Action Strategy (CRAS) evaluation, which identifies stream reaches in the most need of restoration. Overall scores improved on Riley Creek and declined slightly on the Lotus Lake Ravines.

The summary for all three creeks is based on water quality parameters developed by the MPCA in 2014 for Eutrophication and TSS. The standards include some parameters the District has not yet incorporated into monitoring procedures. Therefore, this is the evaluation of the stream reaches that did not meet MPCA water quality standards using the current parameters measured by the District. The parameters measured during the summer growing season (April-September) and the associated MPCA water quality limits for streams located in the Central River Region include: Dissolved Oxygen (DO) daily minimum > 4mg/L, summer season average TP < 0.1mg/L, TSS < 10% exceedance of 30mg/L limit during the summer season, summer season average Chl-a <18ug/L, and summer season average pH < 9su and >6su (MPCA, 2016).

Overall water quality improved in from 2016 to 2017. A total of six stream water quality sites (R5, R3, R2, P5, P3, and P1) met all MPCA water quality standards in 2017 (Figure 2). Each stream varied in the number of water quality standards they did not meet; Bluff had ten, Riley had two, and Purgatory had seven. Bluff Creek remained the stream with the worst water quality, as previously seen in 2015 and 2016. Site B5 did not meet the most MPCA standards, DO, TSS and TP. Exceeding the TP water quality standard was the most violated water quality parameter in 2017 with 8 out of the 18-regular water quality monitoring sites not meeting the standard (summer average <0.1 mg/L). This, however, is down from 15 TP violations in 2015 and 11 in 2016. TSS violations were reduced to two in 2017, down from seven in 2016 and three in 2015. The dissolved oxygen minimum of 4mg/l was violated across four stream sites, Upper Purgatory Creek containing three of these sites.

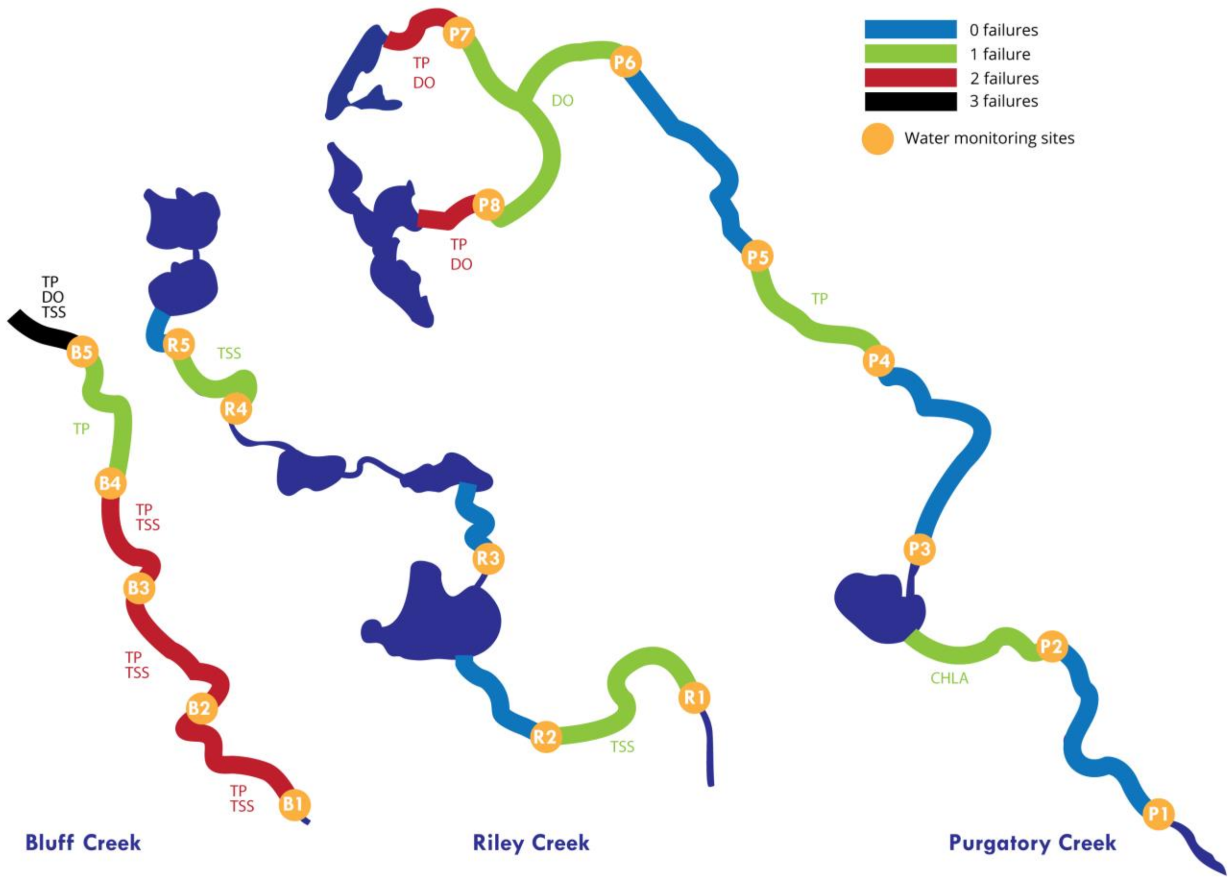

Figure 2 2017 Stream Water Quality

Summary of stream water quality data collected on Bluff Creek, Riley Creek, and Purgatory Creek in 2017 by the Riley Purgatory Bluff Creek Watershed District as compared to the Minnesota Pollution Control Agency (MPCA) Water Quality Standards. A total of 18 water monitoring locations (orange circles) were sampled and information gathered from the individual sites were applied upstream to the next monitoring location. The summer season (April-September) eutrophication and total suspended solids water quality standards used in this assessment included: Dissolved Oxygen (DO) daily minimum > 4mg/L, average Total Phosphorus (TP) < 0.1mg/L, Total Suspended Solids (TSS) < 10% exceedance of 30mg/L limit, average Chlorophyll-a (CHLA) <18ug/L, average pH < 9su and > 6su. The corresponding labels next to each stream section indicate which water quality standard was exceeded.

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Acronyms & Abbreviations

ac	Acre
BMP	Best Management Practice
cBOD	5-day Carbonaceous Biochemical Oxygen Demand
cf	Cubic feet
cfs	Cubic feet per second
Chl-a	Chlorophyll-a
Cl	Chloride
CRAS	Creek Restoration Action Strategy
CS	Chronic Standard
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency
EWM	Eurasian Watermilfoil
ft	Foot/Feet
FWSS	Freshwater Scientific Services
GPS	Global Positioning System
ha	Hectare
IBI	Index of Biological Integrity
in	Inch
kg	Kilogram
L	Liter
lb	Pound
m	Meter
MCWD	Minnehaha Creek Watershed District
METC	Metropolitan Council
mg	Milligram
mL	Milliliter
MNDNR	Minnesota Department of Natural Resources
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MS	Maximum Standard
MS4	Municipal Separate Storm Sewer System
NA	Not Available
NCHF	North Central Hardwood Forest
NH_3	Ammonia
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OHWL	Ordinary High-Water Level
ORP	Oxidation Reduction Potential
Ortho-P	Ortho-Phosphate
PAR	Photosynthetic Active Radiation
PCL	Purgatory Chain of Lakes
RCL	Riley Chain of Lakes
RPBCWD/District	Riley Purgatory Bluff Creek Watershed District
sec	Second
SRP	Soluble Reactive Phosphorus
TDP	Total Dissolved Phosphorus
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TPA	Total Phytoplankton Abundance
TP	Total Phosphorus

TSS	Total Suspended Solids
UMN	University of Minnesota-St. Paul Campus
WD	Watershed District
WIDNR	Wisconsin DNR
WMO	Watershed Management Organization
YOY	Young of Year

1 Introduction and Overview

The Riley Purgatory Bluff Creek Watershed District was established on July 31st, 1969, by the Minnesota Water Resources Board acting under the authority of the watershed law. The District is located in the southwestern portion of the Twin Cities Metropolitan Area. It consists of a largely developed urban landscape and encompasses portions of Bloomington, Chanhassen, Chaska, Deephaven, Eden Prairie, Minnetonka, and Shorewood (Figure 2.1-1). This total area for the watershed is close to 50 square miles located in both Hennepin and Carver Counties and includes three smaller subwatersheds: Riley Creek Watershed, Purgatory Creek Watershed, and Bluff Creek Watershed.

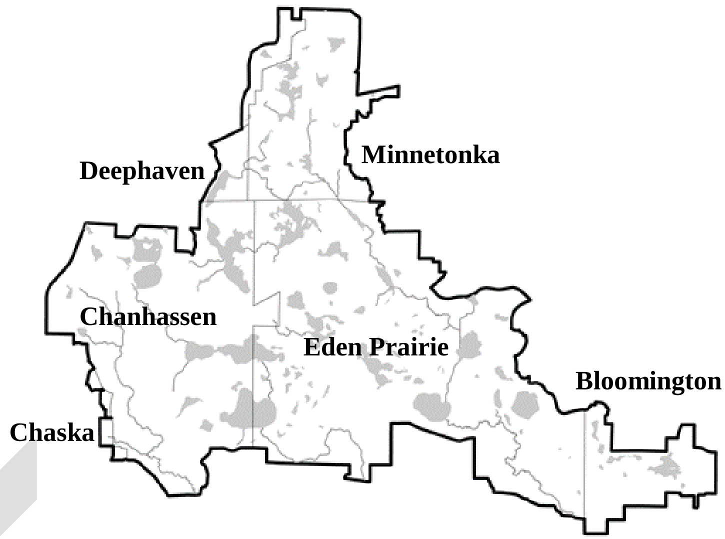

Figure 2.1-1 Riley Purgatory Bluff Creek Watershed District Boundary

Data collection and reporting are the foundation for the RPBCWD's work. Regular, detailed water quality monitoring provides the District with scientifically reliable information that is needed to decide if water improvement projects are needed and how effective they are in the watershed. Data collection remains a key component of the District's work as we strive to de-list, protect, and improve the water bodies within the watershed. The purpose of this report is to summarize the water quality and quantity results collected over the past year, which can be used to direct the District in managing our water resources.

Table 2.1-1 District Water Resource Sampling Partnerships

Water Resource	RPBCWD	Three Rivers Park District	EP	UMN	METC
Duck Lake	■				
Hyland Lake	■	■			
Lake Ann	■				
Lake Idlewild	■		■		
Lake Lucy	■				
Lake Riley	■			■	
Lake Susan	■			■	
Lotus Lake	■				
Mitchell Lake	■		■	■	
Red Rock Lake	■		■		
Rice Marsh Lake	■				
Round Lake	■		■		
Silver Lake	■				
Staring Lake	■			■	
Bluff Creek	■				■
Purgatory Creek	■				■
Riley Creek	■		■		■

Through partnerships with the cities of Chanhassen and Eden Prairie (EP), Three Rivers Park District, the University of Minnesota (UMN), and the Metropolitan Council (METC), water quality data was collected on 13 lakes, one high value wetland (Lake Idlewild), and 21 creek sites in the District. The 21 creek sites include five on Bluff Creek, six on Riley Creek, and ten on Purgatory Creek. Lake McCoy and Neil Lake, which are within the watershed boundaries, have not been part of the District's sampling regime. Each partner was responsible for monitoring certain parameters of their respective lakes/streams and reporting their findings, allowing for more time and attention to be given to each individual water resource (Table 2.1-1).

Water quality and water quantity was monitored at each stream site during the field season (April-September) approximately twice a month. The METC also has continuous monitoring stations near the outlet of each creek as part of its long-term monitoring program which identifies pollutant loads entering the Minnesota River. In addition to water quality monitoring, creek walks were also conducted to gather more information about the current stream conditions in the District. This information was included in the Creek Restoration Action Strategy (CRAS), which was developed by the District to identify and prioritize future stream restoration sites (Section 4.4). Bank pin data was also collected near each of the water quality monitoring sites to measure generalized sedimentation and erosion rates across all three streams.

Lakes were also monitored bi-weekly during the summer growing season (June-September) for water quality. Lake levels were continuously recorded from ice out to ice in. Lake water samples were also collected in early summer and analyzed for the presence of zebra mussel veligers. Additionally, during every sampling event, boat launch areas and zebra mussel monitoring plates were scanned for adult zebra mussels. Zooplankton and phytoplankton samples were also collected on five lakes to assess the overall health of the population as it applies to fishery health and water quality. Plant surveys and herbicide treatments were also conducted to assess overall health of the plant community and to search/treat for invasive plants. Common Carp have also been identified as being detrimental to lake health and are continually monitored by the District. Winter monitoring occurred on the Riley Chain of Lakes (Lucy, Ann, Susan, Rice Marsh, and Riley), as well as four separate stormwater ponds in 2017. Extending the monitoring activities into the winter months can provide key insights into ways to improve water quality during the summer months. Winter monitoring also allows us to evaluate the influence of chloride levels in our lakes. The data collection and reporting events were tracked throughout the year and can be seen in Table 2.1-2. Data was not collected in March, November, and December due to unsafe ice conditions. In addition to lakes and streams, multiple stormwater ponds and other specialty projects were monitored to evaluate their effectiveness or contributing pollutant loads to the watershed.

Table 2.1-2 RPBCWD Monthly Field Data Collection Locations

Water Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lake Ann	■	■		■	■	■	■	■	■	■		
Duck Lake				■	■	■	■	■	■	■		
Hyland Lake												
Lake Idlewild				■	■	■	■	■	■	■		
Lotus Lake				■	■	■	■	■	■	■		
Lake Lucy	■	■		■	■	■	■	■	■	■		
Mitchell Lake				■	■	■	■	■	■	■		
Red Rock Lake				■	■	■	■	■	■	■		
Rice Marsh Lake	■	■		■	■	■	■	■	■	■		
Round Lake												
Lake Riley	■	■		■	■	■	■	■	■	■		
Staring Lake				■	■	■	■	■	■	■		
Lake Susan	■	■		■	■	■	■	■	■	■		
Silver Lake				■	■	■	■	■	■	■		
Bluff Creek (5 sites)				■	■	■	■	■	■	■		
Purgatory Creek (8 sites)				■	■	■	■	■	■	■		
Riley Creek (5 sites)				■	■	■	■	■	■	■		

*Water Level Sensors were placed on all lakes.

2 Methods

Water quality and quantity monitoring entails the collection of multi-probe sonde data readings, water samples, zooplankton samples, phytoplankton samples, zebra mussel veliger samples, and physical readings, as well as recording the general site and climactic conditions at the time of sampling. Listed in the following sections are the methods and materials, for both lake and stream monitoring, used to gather the water quality and quantity data during the 2017 field-monitoring season. Table 2.1-1 identifies many of the different chemical, physical, and biological variables analyzed to assess overall water quality.

Table 2.1-1 Sampling Parameters

Parameter	Analysis/ Observation	Summer Lakes	Winter Lakes	Streams	Reason for Monitoring
Total Phosphorus	Wet	■	■	■	Nutrient, phosphorus (P) controls algae growth
Orthophosphate	Wet	■	■		Nutrient, form of P available to algae
Chlorophyll-a, pheophytin	Wet	Surface	Surface	■	Measure of algae concentration
Ammonia as N	Wet	■	■		Nutrient, form of nitrogen (N) available to algae
Nitrate + Nitrite as N	Wet	■	■		Nutrient, also oxygen substitute for bacteria
Total Alkalinity, adjusted	Wet	Surface	Surface		Measure of ability to resist drop in pH
Total Suspended Solids	Wet			■	Measure of the solids in water (block light)
Chloride	Wet		■		Measure of chloride ions, salts in water
Temperature	Sonde	■	■	■	Impacts biological and chemical activity in water
pH	Sonde	■	■	■	Impact chemical reactions (acidic or basic)
Conductivity	Sonde	■	■	■	Ability to carry an electrical current (TSS & Cl)
Dissolved Oxygen	Sonde	■	■	■	Oxygen for aquatic organisms to live
Oxidation Reduction Potential	Sonde	■	■	■	Tracks chemistry in low or no oxygen conditions
Phycocyanin	Sonde	■	■		Pigment, measures cyanobacteria concentration
Phytoplankton	Wet Analysis	■			Organisms fluctuate due to environmental variables
Photosynthetic Active Radiation	Sonde	■			Measure of light available for photosynthesis
Turbidity	Sonde			■	Measure of light penetration in shallow water
Secchi disk depth	Observation	■	■		Measure of light penetration in deeper water
Transparency Tube	Observation			■	Measure of light penetration into shallow water
Zooplankton	Wet Analysis	■			Organisms fluctuate due to environmental variables
Zebra Mussel Veligers	Wet/Observation	■			Larval form of zebra mussels/plate checks (AIS)

2.1 Water Quality Sampling

The monitoring program supports the District's 10-year water management plan to delist waters from the MPCA's 303d Impaired Waters list. The parameters monitored during the field season help determine the sources of water quality impairments and provide supporting data that is necessary to best design and install water quality improvement projects.

Multi-probe sondes (Hach Water Quality Sondes, Lakes DS-5/ Streams MS-5) were used for collecting water quality measurements across both streams and lakes. Sonde readings measured include: temperature, pH, dissolved oxygen, conductivity, photosynthetic active radiation (PAR), oxidation reduction potential (ORP), and phycocyanin. Secchi disk depth readings were recorded at the same time as sonde readings were collected at all lake sampling locations. When monitoring stream locations, transparency, turbidity, and flow measurements (Flow Tracker) were collected as well. General site conditions related to weather and other observations were recorded as well. A list of the variety of parameters monitored during each sampling event can be seen in Table 2.1-1.

Table 2.1-1 Basic Water Quality Monitoring Activities

Pre-Field Work Activities	Calibrate Water Quality Sensors (sonde) Obtain Water Sample Bottles and Labels from Analytical Lab Prepare Other Equipment and Perform Safety Checks Coordinate Events with Other Projects and Other Entities
Summer Lake – Physical and Chemical	Navigate to Monitoring Location Read Secchi Disk Depth and Record Climatic Data Record Water Quality Sonde Readings at Meter Intervals Collect Water Samples from Top, Thermocline, and Bottom
Summer Lake – Biological	Collect Zooplankton Tow (pulling a net) from Lake Bottom to Top Collect Phytoplankton Tow (2m composite sample) Collect Zebra Mussel Veliger Tow (pulling a net) from Lake Bottom to Top at Multiple Sites
Winter Lakes	Navigate to Monitoring Location Record Ice Thickness Read Secchi Disk Depth and Record Climatic Data Record Water Quality Sonde Readings at one Meter Intervals Collect Water Samples from top, middle, and bottom
Streams – Physical and Chemical	Navigate to Monitoring Location Measure Total Flow by Measuring Velocity at 0.3 to 1 Foot Increments across Stream Record Water Quality Sonde Measurements Upstream of Flow Measurement in Middle of Stream Read Transparency Tube and Perform Turbidity Test Collect Water Samples from Middle of Stream Collect Climatic Data and Take Photos
Post-Field Work Activities	Ship Water Samples to Analytical Lab Enter Data, Perform Quality Control Checks, and Format Data for Database Clean and Repair Equipment Reporting and Summarizing Data for Managers, Citizens, Cities, and Others

At each lake monitoring location, multiple water samples are collected using a Van Dorn, or depth integration sampler, for analytical laboratory analysis. For Duck, Idlewild, Rice Marsh, Silver, and Staring Lakes, water samples were collected at the surface and bottom due to the shallow depths (2-3m). For all other lakes within the District, water samples were collected at the surface, middle, and bottom of the lake. Lakes are monitored at the same location on each sampling trip, typically at the deepest part of the lake. All samples are collected from whole meter depths except for the bottom sample, which is collected 0.5 meters from the lake bottom to prevent disrupting the sediment. The surface sample is a composite sample of the top two meters of the water column. The middle sample is collected from the approximate midpoint of the temperature/dissolved oxygen change (>1-degree Celsius change) or thermocline. Pictures and climatic data are collected at each monitoring site. Water quality information collected in the winter is collected using the same procedures as in the summer. Zooplankton samples were collected using a 63 micrometer Wisconsin style zooplankton net and Phytoplankton samples were collected using a 2m integrated water sampler on Lake Susan, Lotus Lake, Staring, Lake Riley, and Red Rock Lake. Zooplankton are collected by lowering the net to a depth of 0.5 meters from the bottom at the deepest point in the lake and raised slowly. Zebra mussel veliger samples were collected on all lakes using the same zooplankton sampling procedures but collected at three sites and consolidated before being sent to a lab for analysis. A Zeiss Primo Star microscope with a Zeiss Axiocam 100 digital camera was used to monitor zooplankton populations, scan for invasive zooplankton, and to calculate Cladoceran-grazing rates on algae.

Water quality samples collected during stream monitoring events were collected from the approximate middle (width and depth) of the stream in ideal flow conditions or from along the bank when necessary. Both water quality samples and flow monitoring activities were performed in the same section of the creek during each sampling event. Stream velocity was calculated at 0.3 to 1-foot increments across the width of the stream using the FloTracker Velocity Meter at each sampling location. If no water or flow was recorded, only pictures and climatic data were collected. The activities associated with the monitoring program are described in Table 2.1-1.

2.2 Analytical Laboratory Methods

RMB Environmental Labs, located in Detroit Lakes, MN, is the third-party company that is responsible for conducting the analytical tests on the water samples that were collected by the District Staff. The methods used by the laboratory to analyze the water samples for the specified parameters are noted in Table 2.2-1. Zebra mussel veliger and phytoplankton samples were also sent to RMB Labs for analysis.

Additional samples were sent to the Metropolitan Council (METC), St. Paul, MN. These samples included quality control duplicate samples and special water quality monitoring project samples. METC allows staff to bring samples in on a Friday which is not possible with RMB because samples must be shipped.

Table 2.2-1 RMB Environmental Laboratories Parameters and Methods Used for Analyses

Parameter	Standard Method
Alkalinity	EPA 310.2
Ammonia	EPA 350.1 Rev 2.0
Nitrogen, Nitrate & Nitrite	EPA 353.2 Rev 2.0
Chlorophyll-a	SM 10200H
Total Phosphorus	EPA 365.3
Orthophosphate	EPA 365.3
Chloride	SM 10200H

2.3 Lake Water Levels

In-Situ Level Troll 500, 15-psig water level sensors have been placed on most lakes throughout the watershed district to monitor water quantity and assess yearly and historical water level fluctuations. These sensors are mounted inside a protective PVC pipe that are attached to a vertical post and placed in the water. A staff gauge, or measuring device, is also mounted to the vertical post, and surveyed by District staff to determine the elevation for each level sensor. Once the water elevation is established, the sensor records continuous water level monitoring data every 15 minutes from ice out until late fall.

Lake level data is used for developing and updating the District's models, which are used for stormwater and floodplain analysis. Monitoring the lake water levels can also help to determine the impact that climate change may have on lakes and land interactions in the watershed. Lake level data is also used to determine epilimnetic zooplankton grazing rates (located in section 4.74.6). Lake level data is submitted to the Minnesota Department of Natural Resources (MNDNR) at the end of each monitoring season and historical data specific to each lake can be found on MNDNR website using the Lakefinder database. See Exhibit A for 2017 level sensor results. Lake Levels for 2016 are also provided for a year-to-year comparison. In both the Lakefinder database and in Exhibit A, the Ordinary High-Water Level (OHWL) is displayed so water levels can be compared to what is considered the "normal" water level for each lake. The OHWL is used by governing bodies like the RPBCWD for regulating activities that occur above and below this zone. National Oceanic and Atmospheric Administration (NOAA) precipitation data collected from the area was also included in Exhibit A to evaluate how rain events influenced lake levels. Rain data recorded at the Flying Cloud Drive Airport, Eden Prairie, MN is included alongside lake level data from Lakes in Hennepin County (including lake Riley). A combination of rain data from Meteorological Station Chanhassen WSFO and Chanhassen 1.0 ESE is included alongside lake level data from Lakes in Carver County.

In 2017, lake level measurements were collected on 13 lakes in the District and one high value wetland, Lake Idlewild (Table 2.3-1). Lake Ann experienced the greatest change over the 2017 season, decreasing 0.957ft from ice-out to the last day of recording (Nov. 6). Staring Lake had the largest range of fluctuation through the 2017 season, having a low elevation of 813.8ft, and a high of 816.1ft (2.3ft difference). On average, lake levels increased by 0.079ft over the 2017 season. With the exceptions of Lake Ann, Lake Lucy and Lake Susan, all lake water levels increased in elevation over the 2017 season. The average fluctuation range across all lakes was 1.4ft.

Table 2.3-1 Lake Water Levels Summary

The 2017 (March-November) and historical recorded lake water levels (ft) for all monitored lakes within the Riley Purgatory Bluff Creek Watershed District. 2017 data includes the overall change in water level, the range of elevation fluctuation, and the highest and lowest recorded levels (elevation). Historical data includes the highest and lowest historical recorded levels and the date they were taken.

	2017 Lake Water Level Data				Historical Lake Water Levels			
Lake	Seasonal Fluctuation	Fluctuation Range	High level	Low level	Highest Level	Date	Lowest Level	Date
Ann	-0.957	1.418	957.22	955.80	957.93	2/18/1998	952.80	9/28/1970
Duck	0.041	0.729	914.90	914.17	916.12	6/20/2014	911.26	11/10/1988
Hyland	0.236	1.224	817.02	815.80	818.68	8/11/1987	811.66	12/2/1977
Idlewild	0.087	1.363	854.64	853.28	860.78	3/29/1976	853.10	1/7/1985
Lotus	0.391	0.971	896.21	895.24	897.08	7/2/1992	893.18	12/29/1976
Lucy	-0.703	1.283	957.15	955.87	957.67	6/20/2014	953.29	11/10/1988
Mitchell	0.162	1.213	871.96	870.75	874.21	6/25/2014	865.87	7/25/1977
Red Rock	0.201	1.76	841.80	840.04	842.69	7/13/2014	835.69	9/28/1970
Rice Marsh	0.31	1.487	876.73	875.25	877.25	5/28/2012	872.04	8/27/1976
Riley	0.083	0.969	865.60	864.63	866.74	7/6/1993	862.00	2/1/1990
Round	0.743	2.259	881.08	878.82	884.26	8/17/1987	875.29	7/25/1977
Silver	0.73	1.263	899.75	898.48	901.03	6/20/2012	894.78	6/6/1972
Staring	0.062	2.276	816.10	813.83	820.00	7/24/1987	812.84	2/12/1977
Susan	-0.28	1.722	882.53	880.81	883.77	6/21/2014	879.42	12/29/1976
Average	0.079	1.424						

3 Water Quality Standards

In 1974, the Federal Clean Water Act set forth the requirements for states to develop water quality standards for surface waters. In 2014, specific standards were developed for eutrophication and TSS for rivers and streams. In Minnesota, the agency in charge of regulating water quality is the Minnesota Pollution Control Agency (MPCA). Water quality monitoring and reporting is a priority for the District to determine the overall health of the water bodies within the watershed boundaries. The District’s main objectives are to prevent a decline in the overall water quality within lakes and streams and to prevent water bodies from being added to the 303d Impaired Water Bodies list (MPCA). The District is also charged with the responsibility to take appropriate actions to improve the water quality in water bodies that are currently listed for impairments.

There are seven ecoregions within Minnesota; the RPBCWD is within the Northern Central Hardwood Forest (NCHF) ecoregion. Rural areas in the NCHF are dominated by agricultural land and fertile soils characterize the ecoregion. For most water resources in the region, phosphorus is the limiting (least available) nutrient within lakes and streams, meaning that the available concentration of phosphorus often controls the extent of algal growth. The accumulation of excess nutrients (i.e. TP and Chl-a) in a waterbody is called eutrophication. This relationship has a direct impact on the clarity and recreational potential of our lakes and streams. Water bodies with high phosphorus concentrations and increased levels of algal production have reduced water clarity and limited recreational potential.

All lakes sampled in the district are considered Class 2B surface waters. The MPCA states that this class of surface waters should support the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. They should also be suitable for aquatic recreation of all kinds, including bathing. This class of surface water is not protected as a source of drinking water. For more detailed information regarding water quality standards in Minnesota, please see the MPCA’s Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment, 305(b) Report, and 303 (d) List of Impaired Waters. These resources provide information to better understand the water quality assessment process and the reasoning behind their implementation.

3.1 Lakes

The MPCA has specific standards for both ‘deep’ lakes or lakes >15ft deep and < 80% of the total lake surface area able to support aquatic plants (littoral area), and ‘shallow’ lakes or lakes <15ft deep and >80% littoral area. Except for chlorides, summer growing season (June-September) averages of the parameters listed in Table 3.1-1 for each lake are compared to the MPCA standards to determine the overall state of the lake. The standards are set in place to address issues of eutrophication or excess nutrients in local water bodies. Water samples are collected and sent to an analytical lab to assess concentrations of TP, Chl-a, and chlorides. If result values are greater than the standards listed in Table 3.1-1, the lake is considered impaired. Secchi disk readings are collected to measure the transparency, or visibility, in each lake. A higher individual reading corresponds to increased clarity within the lake as the Secchi Disk was visible at a deeper depth in the water column.

Chlorides (Cl) are a concern during the winter when road salt is heavily used. It is often sampled over the winter and during early spring melting periods when salts are being flushed through our waterbodies. The Cl standard is the same for both deep lakes and shallow lakes. The table includes both the Cl chronic standard (CS) and a maximum standard (MS). The CS is the highest water concentration of Cl to which aquatic life, humans, or wildlife can be exposed to indefinitely without causing chronic toxicity. The MS is the highest concentration of Cl in water to which aquatic organisms can be exposed for a brief time with zero to slight mortality.

Table 3.1-1 MPCA Water Quality Standards for Shallow and Deep Lakes

Parameter	Shallow Lakes Criteria	Deep Lakes Criteria
Total Phosphorus (mg/L)	≤ 0.060	≤ 0.040
Chlorophyll-a (ug/L)	≤ 20	≤ 14
Secchi Disk (m)	≥ 1	≥ 1.4
Chloride Chronic Standard (mg/L)	230	230
Chloride Maximum Standard (mg/L)	860	860

3.2 Streams

Table 3.2-1 displays the new water quality parameters developed by the MPCA in 2014 for eutrophication and TSS. The new standards include some parameters the District has not yet incorporated into their monitoring procedures that may eventually be added in the future. All streams sampled in the district are considered Class 2B surface waters. The MPCA states that this class of surface waters should support the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. They should also be suitable for aquatic recreation of all kinds, including bathing. This class of surface water is not protected as a source of drinking water. For more detailed information regarding water quality standards in Minnesota, please see the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment, 305(b) Report, and 303 (d) List of Impaired Waters. These resources provide information to better understand the water quality assessment process and the reasoning behind their implementation.

Eutrophication pollution is measured based upon the exceedance of the summer growing season average (May-September) of TP levels and Chl-a (seston), five-day biochemical oxygen demand (cBOD, amount of DO needed by organisms to breakdown organic material present in a given water sample at a certain temperature over a five-day period), diel DO flux (difference between the maximum DO concentration and the minimum daily DO concentration), or summer average pH levels. Streams that exceed phosphorus levels but do not exceed the Chl-a (seston), cBOD, diel DO flux, or pH levels meet the eutrophication standard. The District added Chl-a to its sampling regime in 2015 to account for the polluted condition when Chl-a (periphyton) concentration exceeds 150mg/m² more than once in ten years. The daily minimum DO concentration for all Class 2B Waters cannot dip below 4mg/L to achieve the MPCA standard, which was used in the analysis for the Annual Report.

TSS is a measure of the amount of particulate (soil particles, algae, etc.) in the water. Increased levels of TSS can be associated with many negative effects including: nutrient transport, reduced aesthetic value, reduced aquatic biota, and decreased water clarity. For the MPCA standard, TSS concentrations are assessed from April through September and cannot exceed 30mg/L more than 10 percent of the time during that period.

Table 3.2-1 MPCA Water Quality Standards for Streams

MPCA Standard	Parameter	Criteria
Eutrophication	Phosphorus	≤ 100ug/L
	Chlorophyll-a (seston)	≤ 18ug/L
	Diel Dissolved Oxygen	≤ 3.5mg/L
	Biochemical Oxygen Demand	≥ 2mg/L
	pH Max	≤ 9su
	pH Min	≥ 6.5su
Total Suspended Solids	TSS	≤ 30mg/L

4 Water Quality Projects/Monitoring

To improve water quality within the watershed, the District conducts studies to root out key sources of pollution or other negative variables that impact our lakes and streams. Once identified, the District will often monitor these locations and eventually act to improve the water resource if the data confirms the suspicion. Below is a summary of each special project/monitoring and an overall summary of the water quality data the District has collected in 2017.

4.1 2017 Lakes Water Quality Summary

The 2017 growing season Chl-a mean concentrations for all lakes sampled within the District are shown in Figure 4.1-1. Four lakes sampled in 2017 within the District are categorized as ‘deep’ by the MPCA (>15ft deep, < 80% littoral area): Lake Ann, Lotus Lake, Lake Riley, and Round Lake. The MPCA standard for Chl-a in deep lakes (< 14ug/L) was met by Lake Ann and Round Lake, but levels were just under three times the standard in Lotus Lake and just above the standard for Lake Riley. The remainder of the lakes sampled in 2017 are categorized as ‘shallow’ by the MPCA (<15ft deep, >80% littoral area): Duck Lake, Hyland Lake, Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, Staring Lake, Lake Susan, and Silver Lake. Water quality metrics on Lake Idlewild, classified as a high-value wetland, were compared to MPCA shallow lake standards. The water quality standard for shallow lakes (< 20ug/L) was met by Duck Lake, Lake Idlewild, Red Rock Lake, and Rice Marsh Lake in 2017. Lake Lucy, Mitchell Lake, Silver Lake, and Staring Lake did not meet the standard, while Hyland Lake and Lake Susan more than doubled the MPCA standard. However, both Mitchell Lake and Silver Lake decreased in levels, just exceeding the MPCA standard (20.5ug/L and 20.68ug/L respectively). Overall, six of the 14 lakes sampled in 2017 met the MPCA Chl-a standards for their lake classification (one more than in 2016): Lake Ann, Duck Lake, Lake Idlewild, Red Rock Lake, Rice Marsh Lake, and Round Lake.

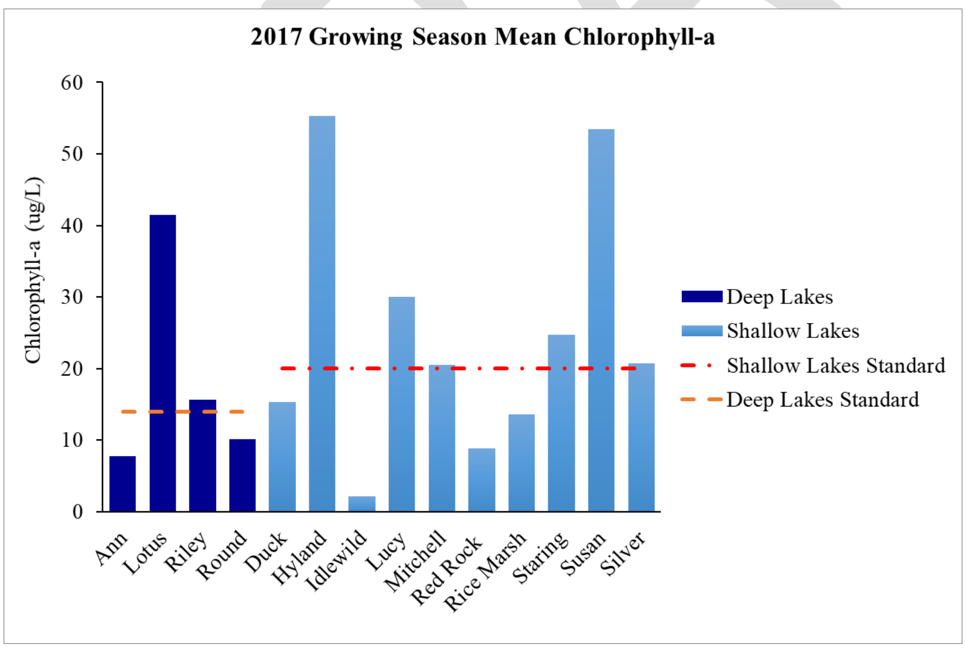

Figure 4.1-1 2017 Lake Growing Season Mean Chlorophyll-a

Lakes growing season (June-September) mean chlorophyll-a concentrations (ug/L) for shallow (lakes <15ft. deep, >80% littoral area-light blue bars) and deep lakes (lakes >15 ft. deep, <80% littoral area-dark blue bars) in the Riley Purgatory Bluff Creek Watershed District during 2017. The dashed lines represent the Minnesota Pollution Control Agency water quality standards for Chlorophyll-a for shallow (<20ug/L-orange dashed line) and deep lakes (<14ug/L-red dashed line).

The TP growing season averages for all lakes sampled within the District in 2017 are shown in Figure 4.1-2. The MPCA standard for TP in deep lakes (<0.040mg/L) was met by Lake Ann and Lake Riley. TP levels were above the standard in Lotus and Round Lake; Round Lake met the MPCA TP standard in 2016 (0.036mg/L) but increased to 0.049mg/L in 2017. Lake Riley was previously above the standard in 2015, but the aluminum sulfate treatment in early 2016 is attributable to it continuing to meet the standard, having met the standard in 2016 as well. For shallow lakes, the MPCA TP standard (<0.060mg/L) was met by Lake Idlewild, Lake Lucy, Red Rock Lake, Rice Marsh Lake, Staring Lake, and Silver Lake in 2017. In 2016, only three shallow lakes met the MPCA TP standard (Duck, Idlewild and Red Rock). Silver Lake, which had the highest total phosphorus concentrations in 2016 with 0.102mg/L, along with Staring lake and Rice Marsh Lake met the standard in 2017; these lakes did not meet the TP standard in 2016. Duck Lake, which met the standard in 2016 (0.049mg/L) did not meet the standard in 2017 (0.064mg/L). Lake Hyland, Mitchell Lake, and Lake Susan all decreased in TP, but no more than 0.007mg/L each. Overall, eight of the 14 lakes sampled met the MPCA total phosphorus standard for their lake classification in 2017: Lake Ann, Lake Idlewild, Lake Lucy, Red Rock Lake, Rice Marsh Lake, Lake Riley, Silver Lake, and Staring Lake. That is two additional lakes meeting the MPCA TP standards than in 2016.

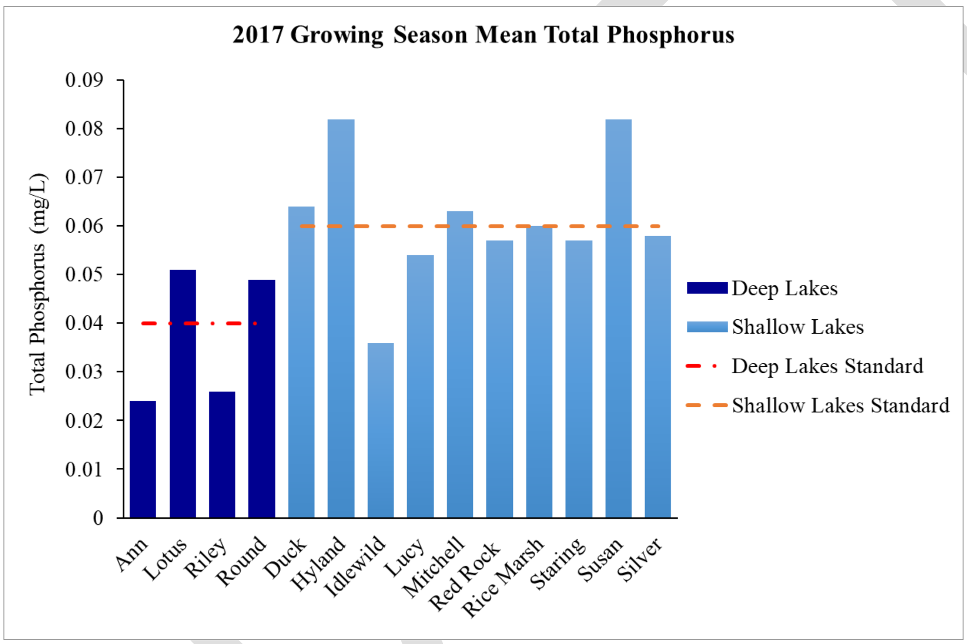

Figure 4.1-2 2017 Lakes Growing Season Mean Total Phosphorus

Lakes growing season (June-September) mean total phosphorus concentrations (mg/L) for shallow (lakes <15ft. deep, >80% littoral area-light blue bars) and deep lakes (lakes >15ft. deep, <80% littoral area-dark blue bars) in the Riley Purgatory Bluff Creek Watershed District during 2017. The dashed lines represent the Minnesota Pollution Control Agency water quality standards for Total Phosphorus for shallow (<0.060ug/L-orange dashed line) and deep lakes (<0.040ug/L-red dashed line).

The 2017 secchi disk growing season mean for all District lakes sampled is shown in Figure 4.1-3. The MPCA standard for secchi disk depth/water clarity for deep lakes (> 1.4m) was met by all deep lakes in the District (Ann, Lotus, Riley, and Round). Lake Riley had the largest change in clarity, measuring an average depth of 2.46m, a decrease of 0.43m from the average in 2016 (2.89m). This average secchi depth is still over a meter deeper than the MPCA standard. All other deep lakes had clarity readings similar-to numbers from 2016. For shallow lakes, nine of 10 lakes monitored achieved the MPCA secchi disk depth water quality standard (>1m). Hyland lake was the only lake to not meet the standard, although it was close, measuring an average of 0.93m. Mitchell Lake, Silver Lake and Staring Lake, which did not meet the standard in 2016, met it in 2017. Silver Lake previously had the poorest average secchi depth in 2016 at 0.73m, but it met the standard in 2017 (1.72m). Please note that only three secchi depths were measured on Idlewild during the season, July 25th, August 17th, and September 29th.

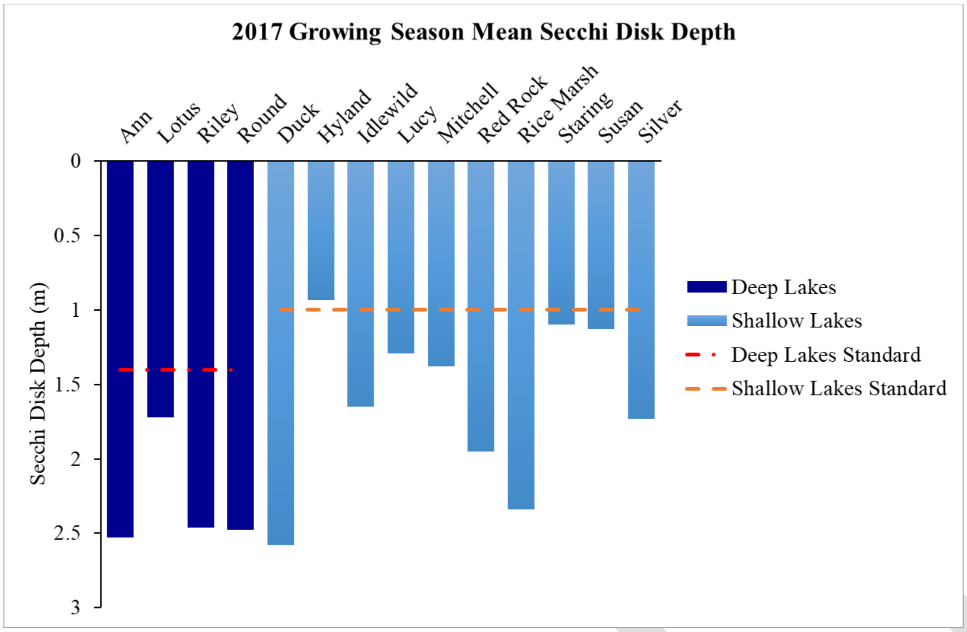

Figure 4.1-3 2017 Lakes Growing Season Mean Secchi Disk Depth

Lakes growing season (June-September) mean secchi disk depths (m) for shallow (lakes <15ft. deep, >80% littoral area-light blue bars) and deep lakes (lakes >15ft. deep, <80% littoral area-dark blue bars) in the Riley Purgatory Bluff Creek Watershed District during 2017. The dashed lines represent the Minnesota Pollution Control Agency water quality standards for secchi disk depths for shallow (>1m-orange dashed line) and deep lakes (>1.4m-red dashed line).

4.2 Alum Treatment on Lake Riley

In May of 2016, the District treated Lake Riley with the first dose of aluminum sulfate (Alum). Alum is a compound which works to reduce the growth of algae by trapping the nutrient phosphorus (the main food source of algae) in the lake sediments. The treatment was applied by injecting the alum into water several feet below the surface of the lake. Upon contact with water, alum becomes aluminum hydroxide (also called floc), a fluffy precipitate. As floc settles to the bottom of the lake it interacts with phosphorus, binding it, making it unusable by algae. This process also collects other particles suspended in the water column, helping to improve water clarity.

District staff have continued to monitor phosphorus levels on Lake Riley as a part of regular sampling, tracking the continued effectiveness of the treatment. Figure 4.2-1 illustrates total phosphorus (TP) levels two years prior to treatment, through the end of the 2017 growing season (17 months after the alum was applied). TP data was included from May 2014 to late September 2017 to highlight the abrupt changes in TP concentrations during that time. There was a large reduction in epilimnetic TP (upper layer of water in a thermally-stratified lake) after the treatment in May which led to Lake Riley achieving the MPCA standard over the summer growing season (June-September) in 2016. During the 2017 growing season, TP levels continued meeting the MPCA standard in the epilimnion; not only did the season average meet standards, but no single sampling event exceeded the standard. TP levels sampled in the hypolimnion (the bottom layer of water in a thermally-stratified lake) rose almost 0.6mg/L from May through September in 2015. In 2016, TP levels in the hypolimnion were drastically reduced after treatment and increased about 0.06mg/L through September. During the 2017 growing season, TP levels in the hypolimnion increased 0.16mg/L between May through September which was 0.1mg/L more than the previous year. Overall, this increase is still significantly less than what was observed in years before the alum treatment. In 2016, the decrease in TP led to reductions in summer averages of Chl-a (algae) concentrations, from 27.4ug/L in 2015 to 14.92ug/L. Additionally, secchi disk depth noticeably increased from 1.7m in 2015 to 2.89m in 2016. In 2017, a slight increase in TP affected these parameters. The average concentration of Chl-a was higher in 2017 (15.64 ug/L) than in 2016 (14.92ug/L). Water clarity fell slightly to an average of 2.46m in 2017 vs 2.89m in 2016. The 2017 nutrient results are still a significant improvement from those seen prior to the alum treatment.

The District will continue monitoring water clarity and nutrient levels in 2018, as it is a part of regular monitoring, but also to track the continued effectiveness of the alum treatment. Future monitoring will also indicate when a second dose of alum should be applied. More information about Lake Riley nutrient and water clarity data can be seen in the Fact Sheet located in Exhibit F.

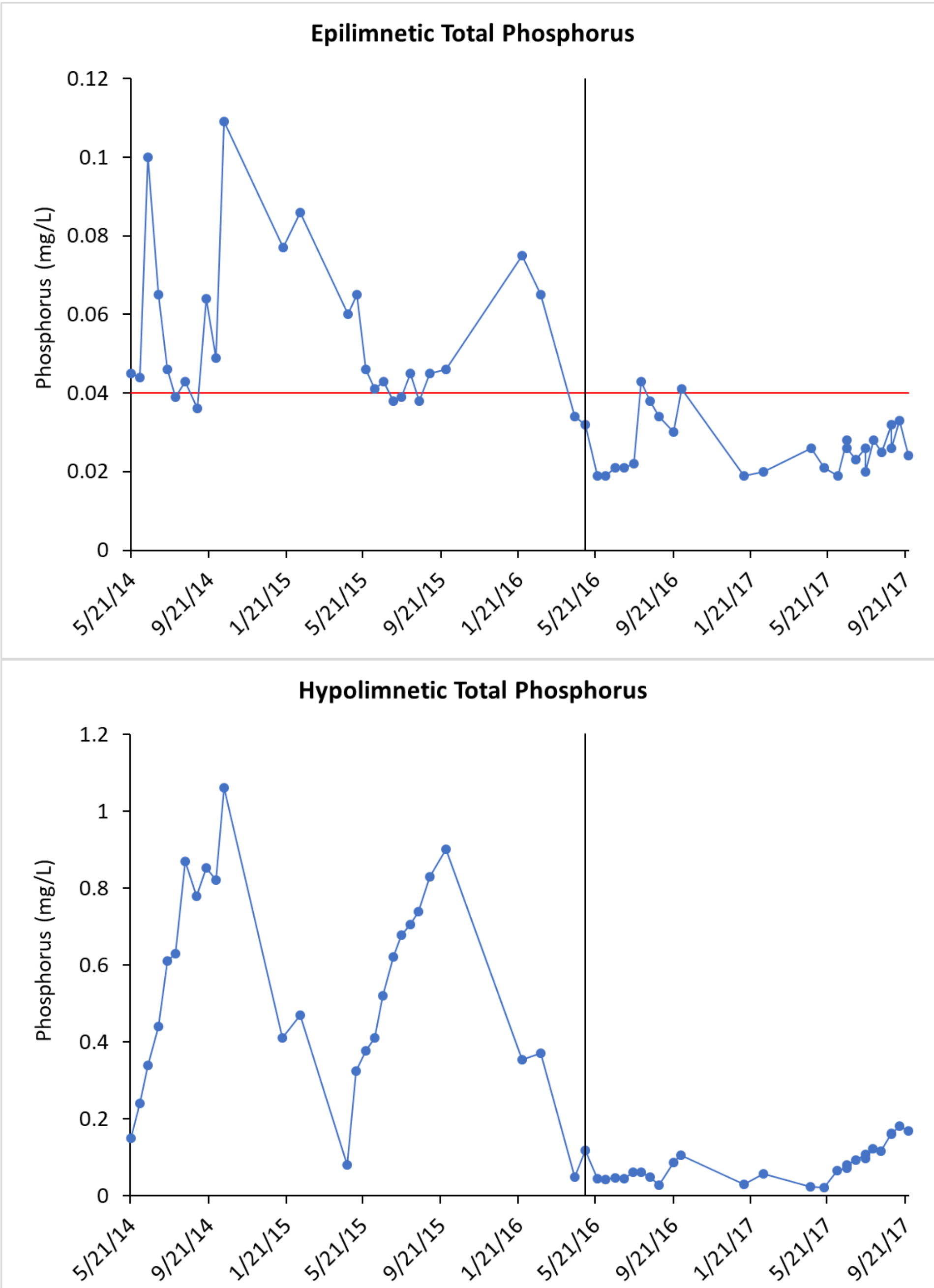

Figure 4.2-1 Lake Riley Total Phosphorus Levels pre- and post- Alum Treatment

Total phosphorus levels (TP) in Lake Riley between May 21, 2014 and September 26, 2017. The graphs reflect levels before and after the aluminum sulfate (Alum) treatment carried out in May of 2016 (indicated by vertical bar). The upper graph displays TP levels (mg/L) measured from 2m composite samples taken at the surface of the lake. The MPCA water quality standard for TP is represented in the upper graph by the horizontal red line (0.04mg/L). The lower graph displays the TP levels (mg/L) measured from samples taken 0.5-1m above the sediment in the deepest point of the lake.

4.3 Powers Blvd Riley Creek Crossing

In 2013, a Use and Attainability Analysis (UAA) identified Lake Susan Park Pond as a significant contributing source of nutrient pollution to Lake Susan. In 2015 and 2016, staff conducted sampling on Lake Susan Park Pond and at the Lake Susan Park Pond outlet to confirm the UAA findings. Results indicated the pond was contributing nutrient pollution, but at a lesser level then indicated by the UAA. In 2017, the District proposed actions to improve the water quality in Lake Susan through implementing the Lake Susan Park Pond Treatment and Stormwater Reuse Enhancement Project. As part of the project, staff placed an automated water-sampling unit on Riley Creek at the culvert passing under Powers Blvd, just upstream of Lake Susan and Lake Susan Park Pond. This was done to better capture and understand rain event nutrient loading from upstream sources, giving further direction to the proposed Lake Susan Park Pond Project. Analyzing the "first flush" of a storm event is important because these events are when water pollution entering storm drains in areas with high proportions of impervious surfaces is typically more concentrated compared to the remainder of the storm. Water samples were analyzed for total dissolved phosphorus (TDP), total phosphorus (TP), total suspended solids (TSS), and Chlorophyll-a (Chl-a). The automated water-sampling unit also estimated flow of the creek at that point.

In 2017, total phosphorus levels at the sampling site during storm events were high compared to the MPCA standard. As seen in Table 4.3-1, the average TP across 10 samples was 0.681mg/L, more than 6 times the MPCA eutrophication water quality standard for class 2B streams (≤ 0.1mg/L TP). The highest TP reading was 1.62mg/L (Figure 4.3-1). The TDP average across the sampling events was 0.034mg/L and the highest measurement was 0.066mg/L (Figure 4.3-1; Table 4.3-1). TSS concentrations at the sampling site were also high. The average amount of TSS across the 10 samples taken was 659.5mg/L (Table 4.3-1). To achieve the MPCA TSS stream water quality standard, a stream may not exceed 30mg/L TSS more than 10% of the time. One of ten samples taken in 2017 fell below 30mg/L TSS which was an initial grab sample at the start of the monitoring season (Figure 4.3-2). Eight Chl-a samples were taken from the site. Apart from one sample, which had 289ug/L Chl-a, all samples contained less than the MPCA eutrophication water quality standard of ≤ 18ug/L Chl-a (Table 4.3-1). It is important to remember that these samples are targeted samples, representative of the initial flush of water and pollutants that occurs during a rain event, and do not represent season-long pollutant levels in Riley Creek.

Table 4.3-1 2017 Powers Blvd Riley Creek Crossing Nutrient Summary

Powers Blvd Riley Creek Crossing Total Dissolved Phosphorus (mg/L), Total Phosphorus (mg/L), Chlorophyll-a (ug/L), and Total Suspended Solids (mg/L) concentrations (max, min, and average) from 2017 automated, flow-paced samples. The table also includes the Minnesota Pollution Control Agency water quality standards.

Parameter	# of samples	Minimum	Maximum	Average	MPCA Water Quality Standards
TP (mg/L)	10	0.104	1.620	0.681	≤ 0.1mg/L
TDP (mg/L)	10	0.003	0.066	0.034	-
Chl-a (ug/L)	8	1.78	289.00	41.04	≤ 18ug/L
TSS (mg/L)	10	4	2300	659.5	≤ 30mg/L

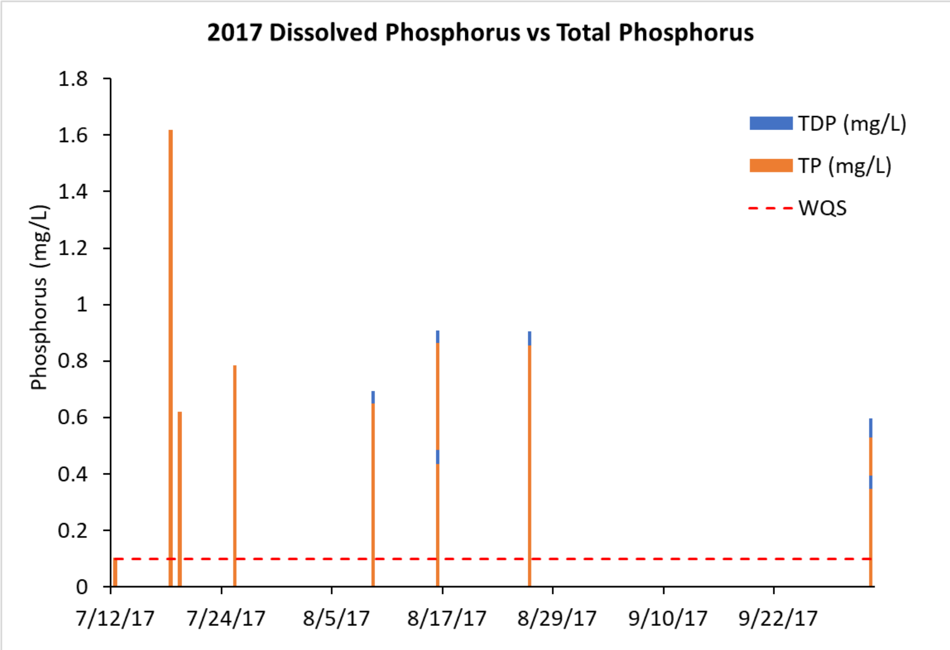

Figure 4.3-1 2017 Powers Blvd Riley Creek Crossing Total Dissolved Phosphorus and Total Phosphorus

The Total Dissolved Phosphorus (TDP) and Total Phosphorus (TP) concentrations (mg/L) from Riley Creek under Powers Blvd from 2017 automated, level triggered, flow-paced samples. Dashed line represents the Minnesota Pollution Control Agency standard for TP in class 2B creeks (≤ 0.1mg/L).

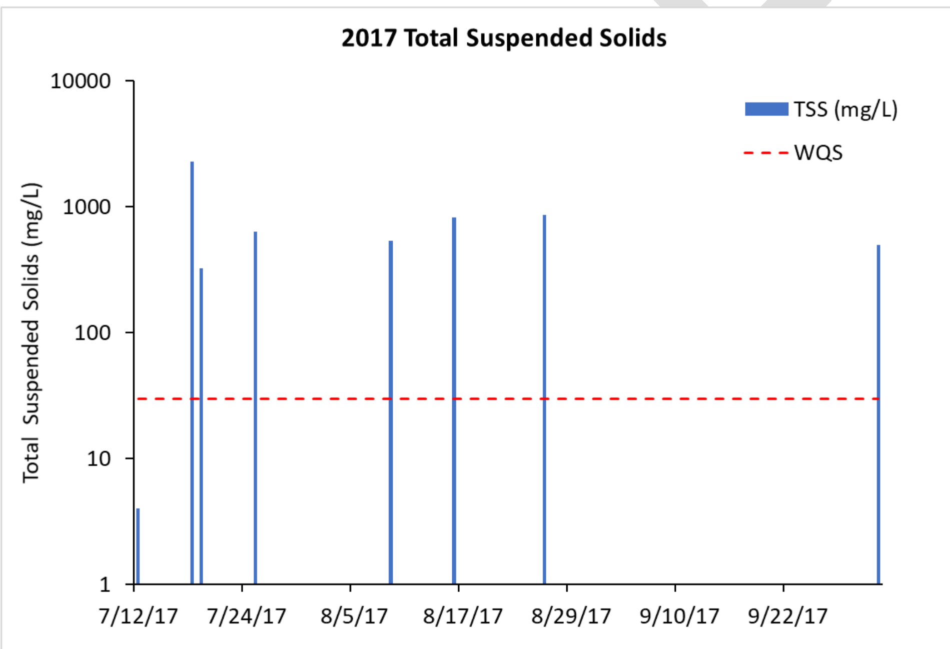

Figure 4.3-2 2017 Powers Blvd Riley Creek Crossing Total Suspended Solids

Total Suspended Solids (TSS) concentrations (mg/L) from Riley Creek under Powers Blvd from 2017 automated, level triggered, flow-paced samples. Dashed line represents the Minnesota Pollution Control Agency standard for TSS in class 2B creeks (≤ 30mg/L TSS no more than 10% of the time).

4.4 Creek Restoration Action Strategy

The RPBCWD developed the Creek Restoration Action Strategy (CRAS) to prioritize creek reaches, sub-reaches, or sites, in need of stabilization and/or restoration. The District has identified eight categories of importance for project prioritization including: infrastructure risk, erosion and channel stability, public education, ecological benefits, water quality, project cost, partnerships, and watershed benefits. These categories were scored using methods developed for each category based on a combination of published studies and reports, erosion inventories, field visits, and scoring sheets from specific methodologies. Final tallies of scores for each category, using a two-tiered ranking system, were used to prioritize sites for restoration/remediation. More information on the CRAS can be found on the District's website: www.rpbcwd.org. The CRAS was finalized/adopted in 2015 and was updated in April of 2017. A severe site list was developed which includes subreaches from all three creeks (Table 4.4-1).

Table 4.4-1 Severe Reaches Identified by the Creek Restoration Action Strategy

Stream	Tier II Rank	Tier I Rank	Reach	Subreach	Location
Purgatory	1	9	P7	P7E	Covington Road to Pond in Covington Park
Riley	2	2	R2	R2E	Middle 1/3 between Dell Road and Eden Prairie Road
Bluff	3	5	BT3	BT3A	Audubon Road to Pioneer Trail
Purgatory	4	4	P1	P1E	1,350 feet DS of Pioneer Trail to Burr Ridge Lane
Bluff	5	1	B1	B1D	475 feet US of Great Plains Blvd to Great Plains Blvd
Bluff	6	7	B3	B3A	750 feet DS of Railroad to 860 feet DS of Railroad
Bluff	7	10	B3	B3C	1,675 feet US of Audubon Road to Lyman Blvd
Bluff	8	6	R2	R2D	Upper 1/3 between Dell Road and Eden Prairie Road
Bluff	9	3	B5	B5C	Galpin Blvd to West 78th Street
Bluff	10	8	B5	B5B	985 feet US of Galpin Blvd to Galpin Blvd

Note: US = Upstream; DS = Downstream

As part of CRAS, stream reaches are walked on a rotational basis after the initial assessment was completed. This will allow staff to evaluate changes in the streams and update the CRAS accordingly. In 2017 staff walked Reach 3 of Riley Creek and the three Lotus Lake ravines on the west side of the lake. These sites were especially in need of a full assessment as previous scores were calculated based upon pictures and past studies. Staff conducted Modified Pfankuch Stream Stability Assessments, MPCA Stream Habitat Assessments (MSHA), took photos, and recorded notes of each subreach to assess overall stream conditions. In addition to creek walks, staff also checked bank pins which were installed in 2015 near all the regular water quality sites. The bank pins were installed in "representative" erosion sites to evaluate general erosion rates for each reach. Changes to the CRAS based upon 2017 creek walks can be seen in Exhibit E and in our Fact Sheets in Exhibit F.

Riley Creek-Rice Marsh Lake to Lake Riley-Reach 3-Subreach A/B/C/D/E

All subreaches assessed in 2017 changed CRAS categories (severe/poor/moderate/good) except for R3C. Previous CRAS scores were based on desktop assessments which explains the number of changes. R3A was split into two subreaches (R3A-Rice Marsh to 80ft downstream of Highway 212; and R3B-80ft downstream of Highway 212 to North of Bearpath golf course) forming a total of 5 subreaches within Reach R3. Reaches R3A, R3B, and R3D all scored lower using the Tier I assessment and were mostly influenced by reduced Pfankuch scores which had been overestimated based on past reviews. Subreach R3E was the only subreach to score higher which was cause by an increased Pfankuch score due to considerable erosion, mowing to stream edge (lack of riparian zone), lack of instream habitat, and a severely eroding stormwater culvert. Tier II scores remained similar to what was observed in 2016. A summary of the score changes can be seen in **Error! Reference source not found.**.

Purgatory Creek-Lotus Ravines-PT2A/B/C/D, PT3A, PT4A

Subreach PT2A is a wetland complex and should not have been scored in the previous assessment. PT2B Tier I score shifted from good to poor because of large amounts of sediment covering all instream habitat. Large erosion areas also existed along the entirety of the subreach including the severely eroded stormwater culvert seen in Figure 4.4-1. PT2C shifted from moderate to good overall because the city of Chanhassen completed a large restoration project that had been successful in stabilizing the subreach. Subreach PT2D and both the middle and southern ravine scores changed from good to moderate which was mostly based upon the more abundant erosion areas present that were missed upon reviewing old photos. A summary of the score changes can be seen in **Error! Reference source not found.**.

Figure 4.4-1 Degraded Stormwater Culvert PT2B

Table 4.4-2 2017 Creek Restoration Action Strategy Updates

Tier I and Tier II scores for the Creek Restoration Action Strategy for 2016 and the corresponding updates from 2017 for all subreaches within Reach 3 of Riley Creek and the three Purgatory Creek – Lotus Lake Ravines.

Reach	Subreach	Location	2016 Tier I Scores	2017 Tier I Scores	2016 Tier II Scores	2017 Tier II Scores
PT2	PT2A	Powers Blvd to 1,000 feet DS	12	n/a	28	n/a
PT2	PT2B	1,000 feet DS of Powers Blvd to Kerber Blvd	12	18	28	36
PT2	PT2C	Kerber Blvd to Carver Beach Road	16	12	36	28
PT2	PT2D	Carver Beach to Lotus Lake	12	16	24	26
PT3	PT3A	Kerber Pond to Lotus Lake	8	14	18	30
PT4	PT4A	Santa Fe Trail to Lotus Lake	8	14	18	24
R3	R3A	Rice Marsh Lake to 85 feet DS of 212	18	14	26	26
R3	R3B	85 feet DS of 212 to Northern Portion of Bearpath Country Club	18	14	26	22
R3	R3C	Northern Portion of Bearpath Country Club to 260 feet US of Bearpath Trail Bridge	16	14	22	20
R3	R3D	260 feet Us of Bearpath Trail Bridge to 250 feet DS of Bearpath Trail Bridge	16	12	22	18
R3	R3E	250 feet DS of Bearpath Trail Bridge to Lake Riley	16	18	24	28

Note: Orange = Poor, Yellow = Moderate, Blue = Good; US = Upstream, DS = Downstream

In addition to creek walks, staff have also checked bank pins yearly since they were installed in 2015 near all the regular water quality sites. The bank pins were installed at "representative" erosion sites to evaluate erosion rates for each reach. Staff measured the amount of exposed bank pin or sediment accumulation if buried in 2016 and 2017 (Table 4.4-3). From this, staff can quantify estimates of lateral bank recession rates. Engineering firm Wenck Associates, Inc. also installed bank pins at 11 sites on lower Riley Creek (south of Lake Riley) and Purgatory Creek (south of Riverview Road) in 2008 and 2010, to monitor bank loss and quantify lateral recession rates (Wenck, 2017). Monitoring of bank loss/change began in December of 2011. From their monitoring results, Wenck was able to track the potential effectiveness of upstream bank repairs on bank-loss-reduction at the Purgatory Creek sites. Results from monitoring the Riley Creek bank pins informed Wenck's recommendation to the City of Eden Prairie to prioritize several reaches for stabilization. District staff will continue to monitor the bank pins/bank loss at our 18 regular monitoring sites, as well as replace any pins which were not found in 2017.

Table 4.4-3 2016-2017 Bank Pin Data

Lateral creek bank loss per year as well as the estimated bank volume loss for a one-yard section of streambank at each of the 18 regular creek monitoring sites. Bank heights used to calculate the volume of bank loss were based off bank heights measured during installation in 2015. Negative values denote areas of bank where there was more sediment deposition, and empty cells denote sites where pins were not found. *Staff were unable to locate the bank pins at site R1 in 2016; losses in 2017 at R1 are estimated two-year losses (2015-2017).

	Average Lateral Loss (in/year)		Estimated bank loss per one-yard stretch of creek (ft3)	
Site	2016	2017	2016	2017
R5	2.85	1.08	4.16	3.22
R4	0.63	1.08	0.67	1.15
R3	4.24	4.05	4.87	4.65
R2	1.36	-0.04	0.48	-0.01
R1	--	4.50*	--	6.64*
P8	0.63	-1.64	0.10	-0.12
P7	3.57	3.37	2.97	1.76
P6	4.25	1.23	2.47	0.85
P5	1.18	3.82	0.89	2.86
P4	3.25	2.79	1.62	1.40
P3	3.02	1.07	2.42	0.86
P2	0.60	0.75	0.45	0.56
P1	1.52	7.11	1.52	7.11
B5	1.14	0.49	1.72	0.90
B4	4.42	10.16	7.75	25.84
B3	2.15	2.79	4.35	5.38
B2	7.93	2.07	3.14	0.82
B1	1.35	4.43	0.65	8.59

4.5 Chloride Monitoring

Chloride (Cl) levels in our water bodies are becoming of greater concern within the state of Minnesota. It takes only one teaspoon of road salt to permanently pollute five gallons of water, as chlorides do not break down over time. At high concentrations, Cl can also be harmful to fish, aquatic plants, and other aquatic organisms. The MPCA Cl Chronic Standard (CS, highest water concentration of Cl to which aquatic life, humans, or wildlife can be exposed to indefinitely without causing chronic toxicity) is 230mg/L for class 2B surface waters (all waters sampled within the district, excluding storm water holding ponds). The MPCA Cl Maximum Standard (MS, highest concentration of Cl in water to which aquatic organisms can be exposed for a brief time with zero to slight mortality) is 860mg/L for class 2B surface waters.

The District has been monitoring salt concentrations in our lakes and ponds since 2013 and will continue monitoring efforts to identify high salt concentration areas and to assess temporal changes in salt concentrations. In 2017, the District monitored the Riley Chain of Lakes (Lake Ann, Lake Lucy, Lake Susan, Rice Marsh Lake, and Lake Riley) and a chain of ponds that drains the City of Eden Prairie Center to Purgatory Creek. During sampling, staff collected a surface 2m composite and a bottom water sample to be analyzed for Cl. Every sample taken from the RCL since 2013 has fallen below the MPCA CS of 230mg/L (Figure 4.5-1). Cl levels have stayed consistent within the lakes year-to-year.

Figure 4.5-2 shows Cl levels within the four stormwater ponds, which includes all sampling events since 2013. In the spring of 2015, staff were no longer able to take accurate water samples on Pond A due to low water levels, so, sampling began on Pond B, directly upstream. Most samples taken from Eden Pond greatly exceed the class 2B CS, some exceeding the class 2B MS. Except for two sampling events, all samples taken from Pond K exceed the class 2B MS, although, there has been a noticeable drop in Cl levels each year since sampling began. It is important to note that these stormwater ponds are not classified as class 2B surface waters by the MPCA; the CS is given in the figure to demonstrate how much higher Cl levels accumulating within these ponds are before water moves into Purgatory creek. Staff will switch to monitoring the Purgatory Chain of Lakes in 2018 which will include: Lotus, Silver, Duck, Round, Mitchell, Red Rock, Staring, and Hyland Lake. The stormwater ponds draining Eden Prairie will also be monitored in 2018. Once-a-month Cl sampling may be added to the District's growing season lake and stream sampling SOP's to track levels throughout the summer months.

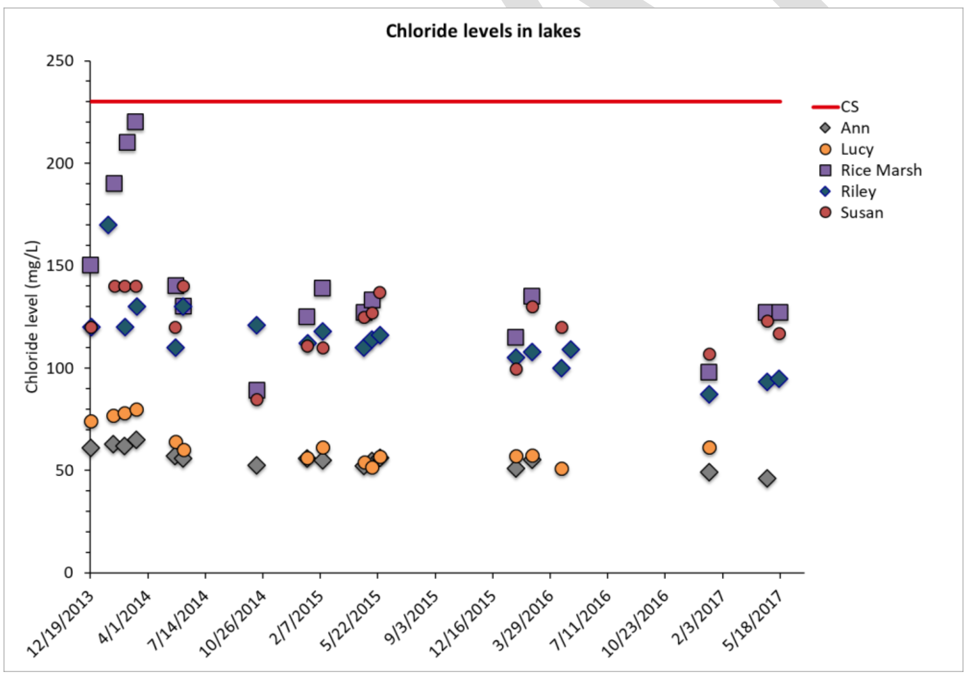

Figure 4.5-1 2013-2017 Chloride Levels within the Riley Chain of Lakes

All chloride sampling results (mg/L) on the Riley Chain of Lakes from 2013-2017. The MPCA chloride chronic standard for class 2B waters (230mg/L) is indicated by the red line.

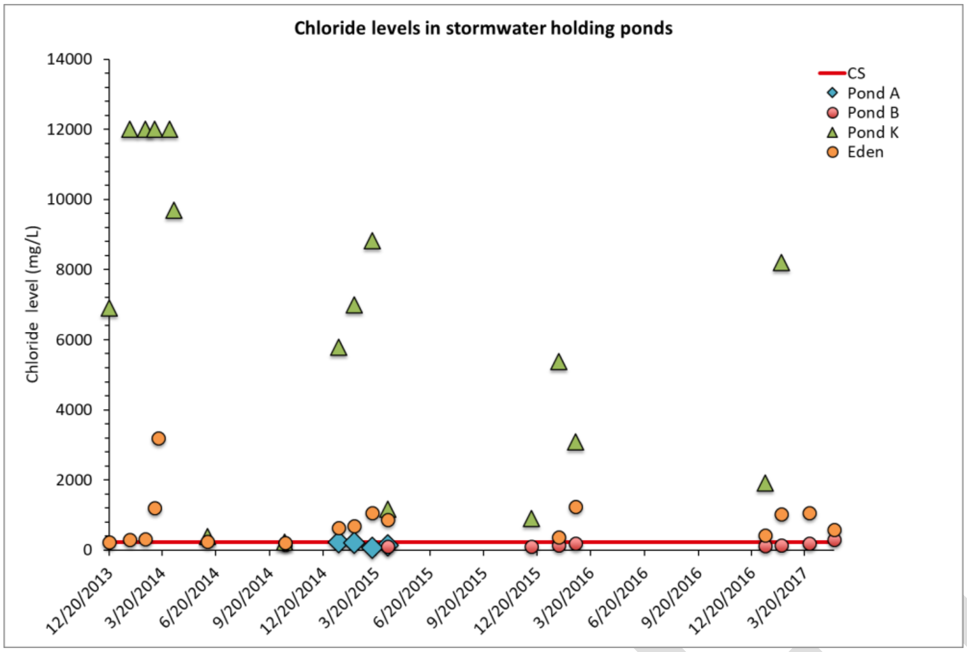

Figure 4.5-2 2013-2017 Chloride Levels within Stormwater Ponds

All chloride results (mg/L) on stormwater ponds draining the City of Eden Prairie Center to Purgatory Creek from 2013-2017. The MPCA chloride chronic standard (230mg/L) for class 2B waters indicated by the red line.

4.6 Nitrate Monitoring

The toxicity of nitrate to aquatic organisms has been a growing concern in MN over the last decade. Nitrate (NO_3), the most available form of nitrogen for use by plants, can accumulate in lakes and streams since aquatic plant growth is not limited by its abundance. While nitrate has not been found to directly contribute to eutrophication of surface waters (phosphorus is the main cause of eutrophication) and is not a MPCA water quality standard, studies have found that nitrate can cause toxicity in aquatic organisms. On November 12th, 2010, the MPCA released the Aquatic Life Water Quality Standards Technical Support Document for Nitrate: Technical Water Quality Standard Amendments to Minn. R. chs. 7050 and 7052 (still in the draft stage for external review) to address concerns of the toxicity of nitrate in freshwater systems and develop nitrate standards for class 2B and 2A systems. Sources of excess nitrate in freshwater systems are linked to human activities that release nitrogen into water. The draft chronic standard (CS) of 4.9mg/L nitrate-N.

During sampling, staff collects a surface 2m composite, a sample at the thermocline of the lake, and a bottom water sample to be analyzed for nitrate+nitrite and ammonia+ammonium. Three Rivers Park District conducts water sampling on Hyland Lake and shares data with the District. Their lab tests do not specifically test for nitrogen as nitrate+nitrite or ammonia, therefore, nitrogen data on Hyland has been omitted. The District monitors for nitrates in lakes as a part of its regular sampling regime. The District tests for nitrates in the form of nitrate+nitrite (the combined total of nitrate and nitrite, Table 4.6-1). This lab also tests for ammonia in the form of ammonia+ammonium (Figure 4.6-1). As seen in Table 2.1-1, all the lakes in the District met the draft nitrate CS. It is also important to note that the lab equipment used to test for nitrate has a lower limit of 0.03mg/L. Therefore, it is possible that some of the samples contained less than 0.03mg/L nitrate; because of this, actual average nitrate levels in District lakes may be lower than what measured (Table 4.6-1).

Table 4.6-1 2017 Lakes Summer Average Nitrate+Nitrite

2017 growing season (June-September) average nitrate+nitrite levels for District lakes. The MPCA proposed chronic standard (CS) is included in the table (orange). Lower limit of lab analysis of nitrate+nitrite is 0.03mg/L, some of these averages may be lower than indicated.

Lake	Average Nitrate+Nitrite (mg/L)
CS	**4.9**
Ann	0.030
Duck	0.030
Lotus	0.030
Lucy	0.030
Rice Marsh	0.030
Riley	0.031
Silver	0.030
Staring	0.030
Susan	0.037
Idlewild	<0.05
Mitchell	<0.05
Red Rock	<0.05
Round	<0.05

Ammonia (NH_3), a more toxic nitrogen-based compound, is also of concern when discussing toxicity to aquatic organisms. It is commonly found in human and animal waste discharges, as well as agricultural fertilizers in the form of ammonium nitrate. When ammonia builds up in an aquatic system, it can accumulate in the tissues of aquatic organisms and eventually lead to death. The MPCA does have standards for assessing toxicity of ammonia; the CS of ammonia in class 2B is 0.04mg/L. Lab water sample testing measures for ammonia in the form of ammonia+ammonium. In lakes and streams, ammonium (NH_4) is usually much more predominant than ammonia under normalized pH ranges. Ammonium is less toxic than ammonia, and not until pH exceeds 9 will ammonia and ammonium be present in about equal quantities in a natural water system (as pH continues to rise beyond 9, ammonia becomes more predominant than ammonium). Figure 4.6-1 shows ammonia+ammonium average levels in each lake during the growing season. These numbers are not of concern at this point seeing that pH levels were normal throughout the 2017 growing season and because lab testing measures the combination of ammonia and ammonium. This suggesting that most of nitrogen found in these tests was from the less toxic compound ammonium.

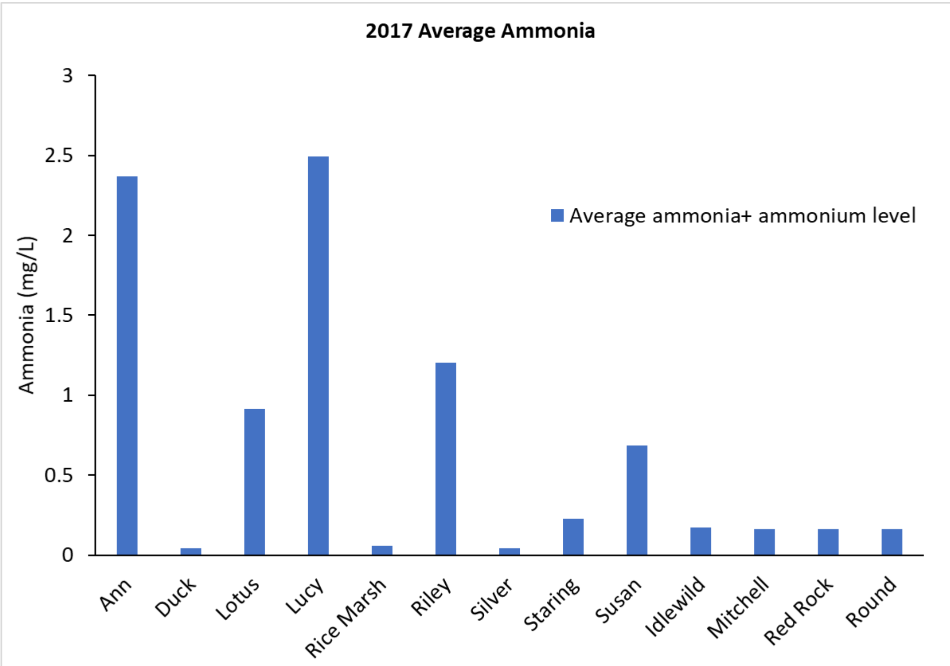

Figure 4.6-1 2017 Lakes Summer Average Ammonia+ Ammonium

The figure includes the average levels of ammonia+ammonium from samples taken on each lake during regular sampling within the growing season (June-September).

4.7 Zooplankton and Phytoplankton

In 2017, five lakes were sampled for both zooplankton and phytoplankton: Lake Riley, Rice Marsh Lake, Lake Susan, Lotus Lake, and Staring Lake. Zooplankton play an important role in a lake's ecosystem, specifically in fisheries and bio control of algae. Healthy zooplankton populations are characterized by having balanced densities (number per m^2) of three main groups of zooplankton: Rotifers, Cladocerans, and Copepods. The Sedgwick-Rafter Chamber (SRC) was used for zooplankton counting and species identification. A two mL sub-sample was prepared in which all zooplankton were counted and identified to the genus and/or species level. The sample was scanned at 10x magnification to count and identify zooplankton using a Zeiss Primo Star microscope. Cladocera images were taken using a Zeiss Axiocam 100 digital camera and lengths were calculated in Zen lite 2012. The District analyzed zooplankton populations for the following reasons:

1. Epilimnetic Grazing Rates (Burns 1969): The epilimnion is the uppermost portion of the lake during stratification where zooplankton feed. Zooplankton can be a form of bio control for algae that may otherwise grow to an out-of-control state and therefore influence water clarity.
2. Population Monitoring (APHA, 1992): Zooplankton are a valuable food source for planktivorous fish and other organisms. The presence or absence of healthy zooplankton populations can determine the quality of fish in a lake. Major changes in a lake (removal of common carp, winter kill, large scale water quality improvement projects, etc.) can change zooplankton populations drastically. By insuring that the lower parts of the food chain are healthy, we can protect the higher ordered organisms.
3. Aquatic Invasive Species Monitoring: Early detection of water fleas is important to ensure these organisms are not spread throughout the District. These invasive species outcompete native zooplankton for food and grow large spines which make them difficult for fish to eat.

The Sedgwick-Rafter Chamber (SRC) was used for phytoplankton counting and species identification. A one mL aliquot of the sample was prepared using a Sedgewick Rafter cell. Phytoplankton was identified to genus level. The sample was scanned at 20x magnification to count and identify phytoplankton species using a Carl Zeiss Axio Observer Z1 inverted microscope equipped with phase contrast optics and digital camera. Higher magnification was used as necessary for identification and micrographs. The District analyzed phytoplankton populations for the following reasons:

1. Population Monitoring: Phytoplankton are the base of the food chain in freshwater systems and fluctuate throughout the year. By insuring that the lower parts of the food chain are healthy, we can protect the higher ordered organisms such as macroinvertebrates and fish.
2. Toxin Producers and Algae Blooms: Some phytoplankton produce toxins that can harm animals and humans, or cause water to have a fowl taste or odor (*Microcystis, Aphanizomenon, Dolichospermum, Planktothrix, and Cylindrospermopsis).* Monitoring these organisms can help us take the proper precautions necessary and identify possible sources of pollution.

Lake Riley

In 2017, all three groups of zooplankton were captured in Lake Riley (Exhibit C), however only 4.3% of the population was comprised of Cladocerans. As expected, rotifers were the most abundant zooplankton sampled across all sampling dates (Figure 4.7-1). Similar to 2016, the number of rotifers identified in 2017 was highest during the first spring sampling event at 2.8 million, before declining to around 800 thousand for the remainder of the year. Copepod numbers followed a similar seasonal trend as seen with the rotifers. Cladoceran numbers remained low across all sampling dates; the highest number was recorded in April (193 thousand) and the lowest in August (17 thousand). Total Cladoceran counts in 2017 were very similar to numbers seen in 2016 (around 450 thousand) which is slightly lower than Cladoceran numbers seen in 2015. The slight reduction may be due to the increase in water clarity because of the alum treatment, causing increased predation although zooplankton populations can fluctuate for many reasons. The most predominant Cladoceran found in Riley was *Daphnia galeata mendotae* which was found across all sample dates.

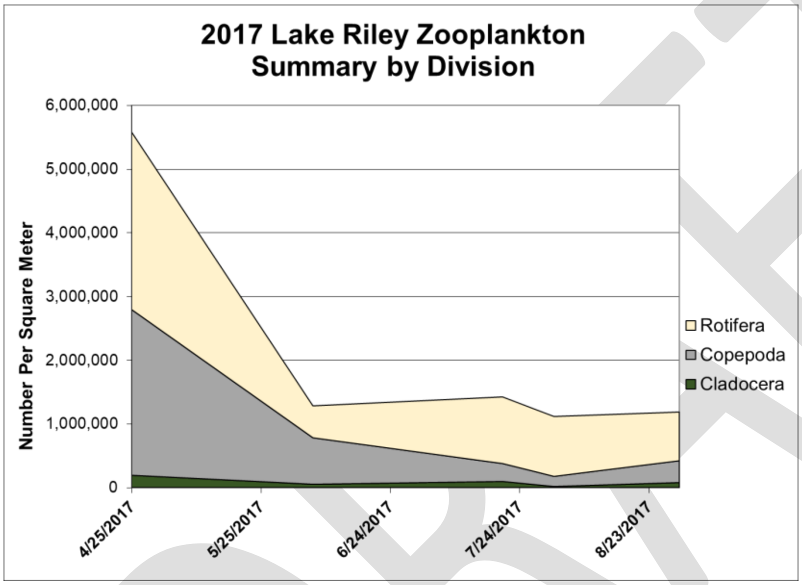

Figure 4.7-1 2017 Lake Riley Zooplankton Counts (#/m²)

Cladocera consume algae and have the potential to improve water quality if they are abundant in numbers. The estimated epilimnetic grazing rates of Cladocera observed were very similar-to and followed a similar seasonal trend to what was seen in 2016 but were down from rates observed in 2015. Early spring grazing rates were relatively stable peaking at 22% in June before bottoming out at 2% in August (Figure 4.7-2). The highest June grazing rates were linked to the presence of *Daphnia galeata mendotae* and optimal water temperatures for grazing, which were around 20 degrees Celsius.

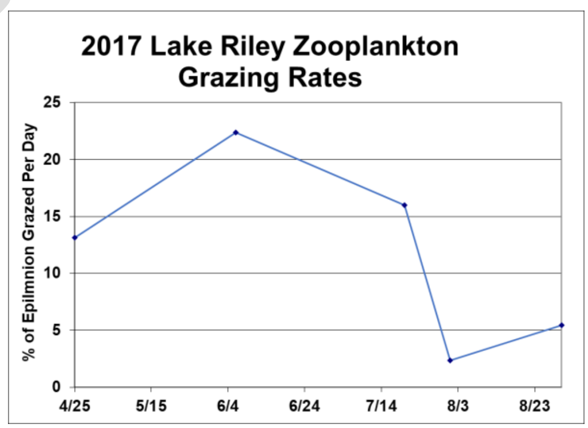

Figure 4.7-2 2017 Lake Riley Epilimnetic Grazing Rates

During the summer of 2017, staff collected three phytoplankton samples on Lake Riley (Exhibit D). The seasonal abundance of phytoplankton is presented in Figure 4.7-3. In mid-July, *Aphanizomenon sp*. made up 25% of the total phytoplankton abundance (TPA). During the early August sample event, Cyanobacterial species all together were 65% of the TPA. The cyanobacterial species *Aphanizomenon sp.* was a dominant species in the sample (55% of TPA).

Aphanizomenon sp. also comprised 42% of total phytoplankton abundance in late August. *Aphanizomenon sp.* is known as a possible toxin producer that may potentially produce cylindrospermopsin, anatoxins, and saxitoxins. These toxic compounds can pose serious threats to human and environmental health via contamination of drinking water, recreational exposure to waterborne toxins and possible accumulation of toxins in the food-web. *Rhodomonas sp.* or green algae (Class Cryptophyceae) was also dominant across all sampling events.

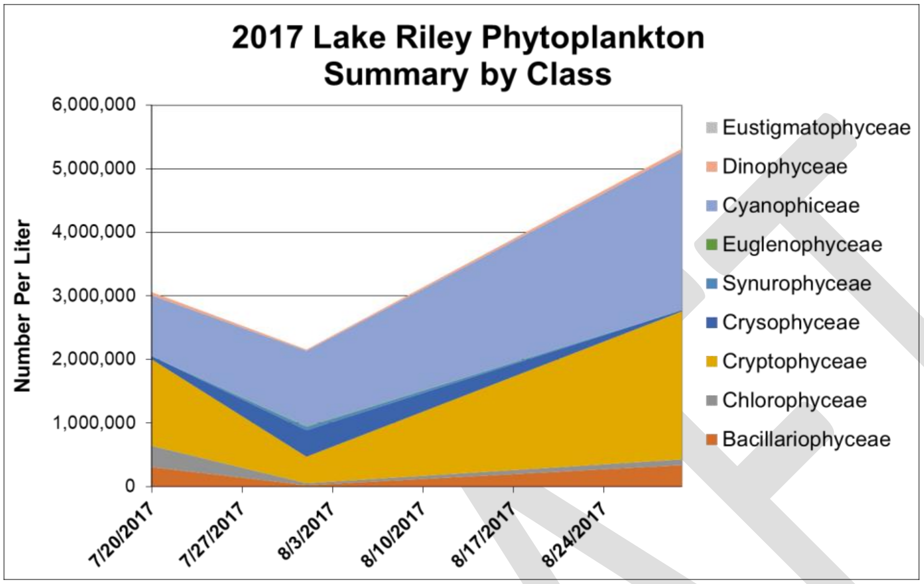

Figure 4.7-3 2017 Lake Riley Phytoplankton Abundance (#/L) by Class.

Lotus Lake

In 2017, all three groups of zooplankton were present in Lotus Lake (Exhibit C). Rotifers were the most abundant zooplankton sampled across all sampling dates (Figure 4.7-4). April rotifer numbers were very high (14.8 million) before oscillating between two and four million for the remainder of the year. Copepod numbers remained relatively level throughout the year averaging near one million across the sample dates. Cladoceran numbers were flat for most of the year (around 180 thousand) before increasing to nearly 700 thousand on the last sampling date in August. This increase was attributed to an increase in the larger Cladocera *Daphnia retrocurva* which was the most abundant Cladocera sampled in 2017. *Daphnia retrocurva* is known for its large curved helmet it develops in late spring-to-summer to reduce predation by planktivorous fish and invertebrates.

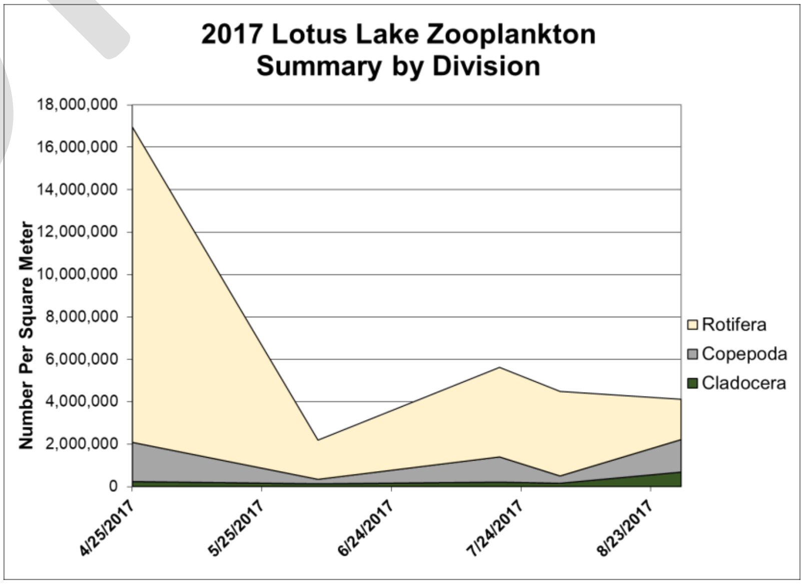

Figure 4.7-4 2017 Lotus Lake Zooplankton Counts (#/m²)

Large Cladocera consume algae and, if enough are present in a lake, they have the potential to improve water quality. The estimated epilimnetic grazing rates observed in 2017 ranged from 9% to 39% (Figure 4.7-5). As expected, grazing rates followed a similar trend to what was seen in the population fluctuations; the largest grazing rate occurred on August 30th when the spike in *Daphnia retrocurva* numbers occurred.

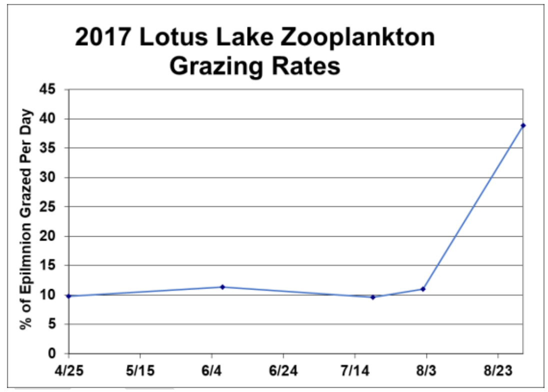

Figure 4.7-5 2017 Lotus Lake Epilimnetic Grazing Rates

During the summer of 2017, staff collected five phytoplankton samples on Lake Riley (Exhibit D). Abundance of phytoplankton across all sampling dates is presented in Figure 4.7-6. In early June the phytoplankton community was dominated by the green algae *Rhodamonas sp.* (43% from TPA) and green *Oocystis sp.* (31 % TPA). The cyanobacterial species *Dolichospermum* (previously *Anabaena sp.*), *Woronichinia sp*., and *Aphanizomenon sp*. were also observed in the sample. Both *Aphanizomenon* and *Dolichospermum* are known as potential toxin producers. *Dolichospermum* are a potential microcystin, anatoxin-a, saxitoxins and cylindrospermopsin producer. *Aphanizomenon* are a potential cylindrospermopsin, anatoxins, and Saxitoxins producer. Woronichinia are potential producers of microcystins. Only *Aphanizomenon sp.* increased in the late June sample while the others remained stable. *Chrysochromulina* and *Oocistis* sp. (Class Chlorophyceae) dominated the TPA in the June sample, making up 61% of the TPA. In July the cyanobacterial species *Aphanizomenoon sp*. bloomed and was dominant in the sample (57% TPA). The bloom should appear like grass clippings (leaf like aggregates) on the water, due to the aggregation of thousands of individuals. During the early August sample, Cyanobacterial species all together made up 73% of the TPA. The cyanobacterial species *Aphanizomenon sp.* was a dominant species in the sample (56% of TPA) which was reduced to 35% TPA during the late August sample.

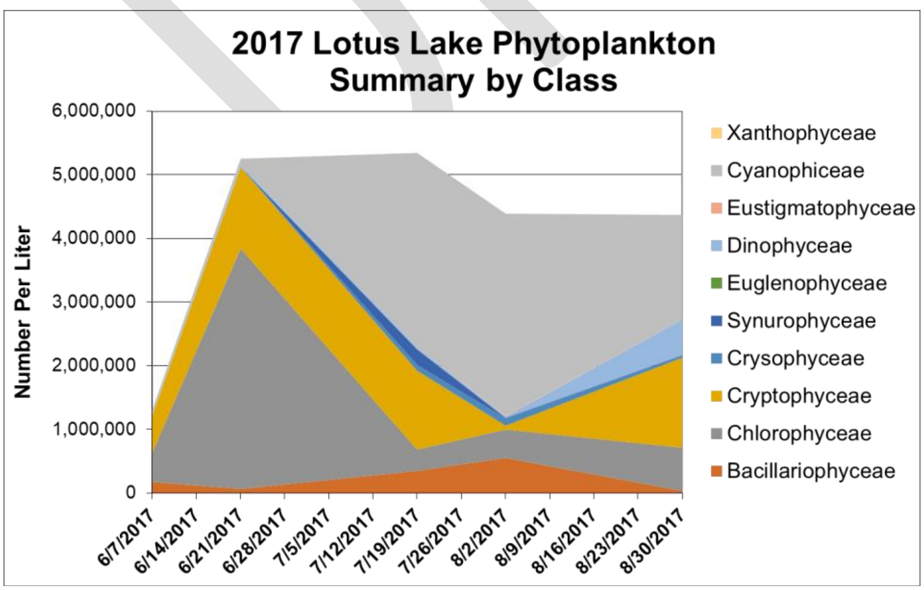

Figure 4.7-6 2017 Lotus Lake Phytoplankton Abundance (#/L) by Class.

Lake Susan

Rotifers were the most abundant zooplankton captured in 2017 in Lake Susan (Exhibit C). The rotifer population was variable over the sampling events with the highest concentration occurring in April (4.8 million organisms). Copepod numbers were also highest during the spring sampling event (1.5 million) but remained stable across the remainder of the year, averaging around 400 thousand (Figure 4.7-7). Overall, Cladocera numbers were low, under 91 thousand individuals per sampling event, except for the spring sample which had 409 thousand organisms. The lowest Cladocera population was recorded in early August when only 28 thousand individuals were captured. The most abundant Cladocera captured in Lake Susan was *Daphnia galeata mendotae*.

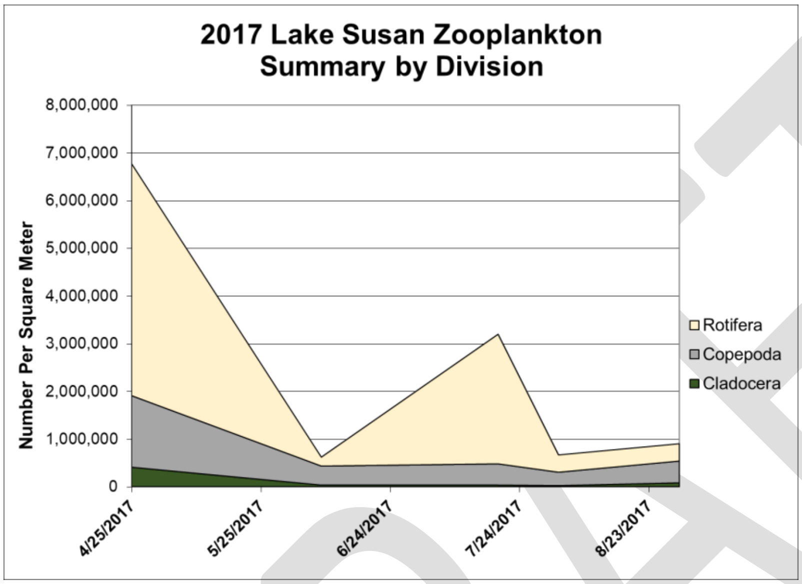

Figure 4.7-7 2017 Lake Susan Zooplankton Counts

The estimated epilimnetic grazing rates upon algae observed in 2017 were very low, ranging from 0.3% to 4.2% (Figure 4.7-8). This is mainly due to the very limited number of Cladocera present. The highest grazing rate was observed in April (4.2%) when *Daphnia galeata mendotae* were more numerous in the zooplankton community. During the last sampling event, *Leptodora kindtii* were captured, which has been uncommon. Leptodora, the largest planktonic Cladoceran, occurs in a wide range of conditions, including clear, oligotrophic lakes, as well as eutrophic lakes.

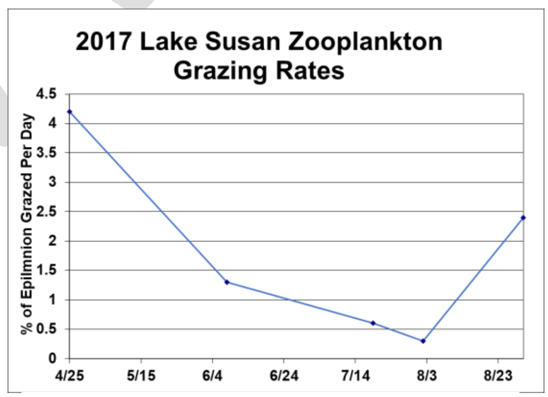

Figure 4.7-8 2017 Lake Susan Epilimnetic Grazing Rates

During the summer of 2017, staff collected four phytoplankton samples on Lake Susan (Exhibit D). Abundance of phytoplankton by Class are presented in Figure 4.7-9. Across all sampling dates, cyanobacterial species were the dominant phytoplankton available. The cyanobacterial species *Cylindrospermopsis*, *raciborskii*, and *Aphanizomenoon sp.* began blooming in early July and an extremely large bloom of *Cylindrospermopsis raciborskii* occurred in early August (96% TPA). *Cylindrospermopsis sp.* remained at high concentrations (42% TPA) in late August. However, *Chlamidomonas sp.* was among the common species in the sample (nearly 19% of TPA). Higher abundance of *Chlamidomonas* may indicate increased organic pollution. Chlamydomonas together with *Criptomonas*, and *Tetraselmis* produce cucumberlike, fishy, or "skunklike" odorous compounds.

Aphanizomenon may produce cylindrospermopsin, anatoxins, and saxitoxins. *Cylindrospermopsis* is a well-studied species due to the production of toxins like cylindrospermopsin and anatoxin; it was also shown to produce paralytic shellfish poisoning (PSP) toxins. These toxic compounds can pose serious threats to human and environmental health via contamination of drinking water, recreational exposure to waterborne toxins and possible accumulation of toxins in the food-web.

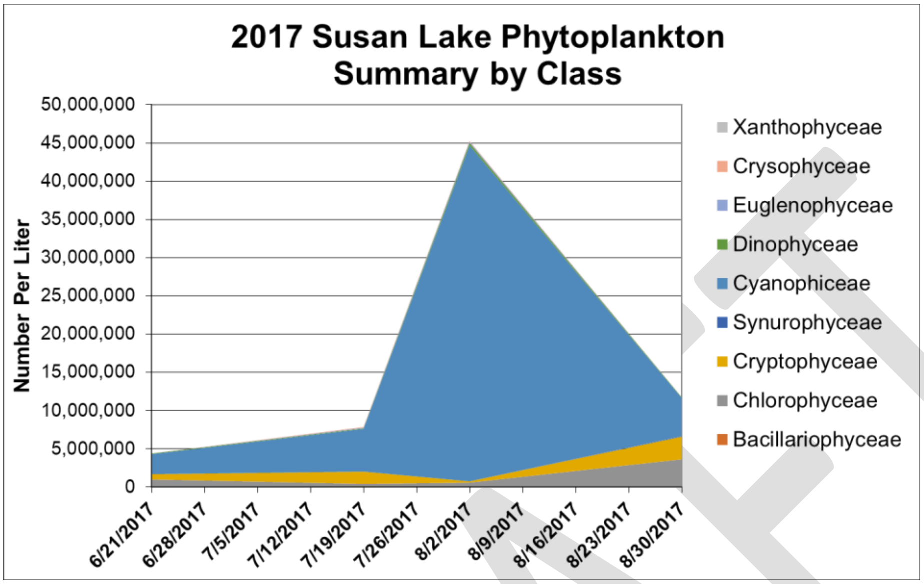

Figure 4.7-9 2017 Lake Susan Phytoplankton Abundance (#/L) by Class.

Rice Marsh Lake

In 2017, all three groups of zooplankton were captured in Rice Marsh Lake (Exhibit C), in which 27% of the population was comprised of Cladocerans. As expected, rotifers were the most abundant zooplankton sampled across all sampling dates, except during the late August sample when many *Bosmina longirostris* were captured (Figure 4.7-10). All zooplankton groups were at their highest abundance during the first sampling event in August. All other dates yielded far lower densities. Cladoceran numbers remained relatively low during the first two sampling dates, averaging 223 thousand; larger populations were captured during the last two sampling periods, averaging 1.6 million. Across all sampling dates the Cladoceran community was dominated by small-bodied zooplankton, consisting of mainly *Bosmina longirostris* and *Ceriodaphnia sp*.

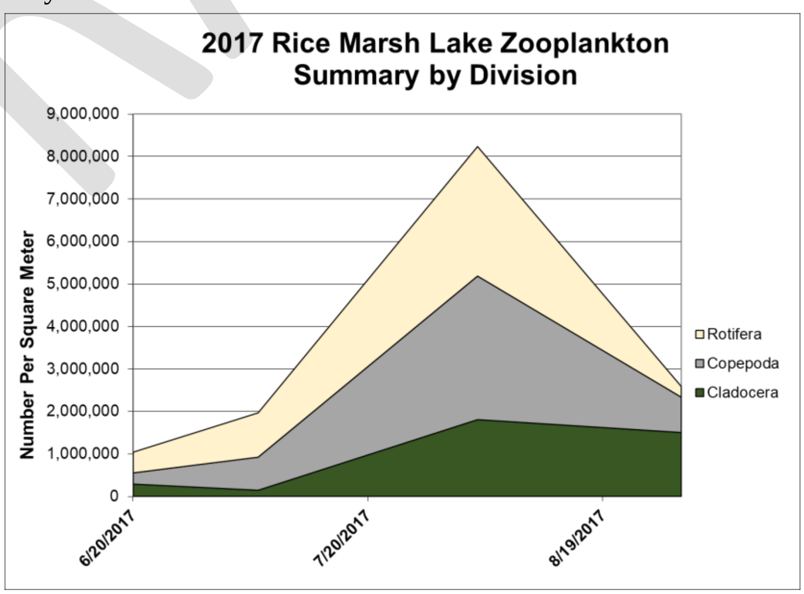

Figure 4.7-10 2017 Rice Marsh Lake Zooplankton Counts (#/m²)

The estimated epilimnetic grazing rates of Cladocera observed in 2017 ranged from 3.9% to 32% on Rice Marsh Lake (Figure 4.7-11). April and June grazing rates were relatively low before peaking at 32% in early August. The highest August grazing rate was linked with the high number of *Bosmina longirostris* and *Ceriodaphnia sp*. present. The most common Cladocera present was *Bosmina longirostris* which are commonly found in bog lakes such as Rice Marsh Lake.

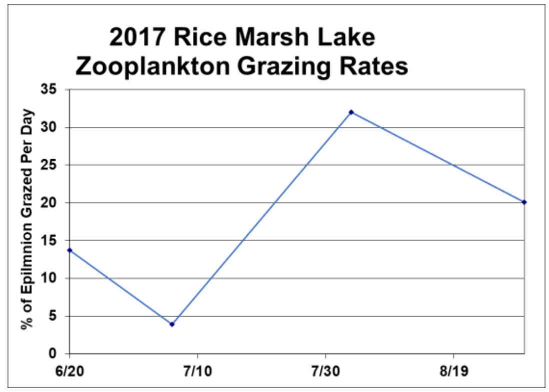

Figure 4.7-11 2017 Rice Marsh Lake Epilimnetic Grazing Rates

During the summer of 2017, staff collected four phytoplankton samples on Rice Marsh Lake (Exhibit D). Abundance of phytoplankton by Class for Rice Marsh Lake is presented in Figure 4.7-12. Across all sampling events the phytoplankton community was dominated by the green algae *Rhodamonas sp.* (Class Cryptophyaceae). The only exception occurred in early June when the community was dominated by the *Aulacoseira sp.* (57% TPA) or diatoms (Class Bacillariophyceae). Cyanobacteria species remained consistent across the summer averaging 233 thousand individuals per sampling event.

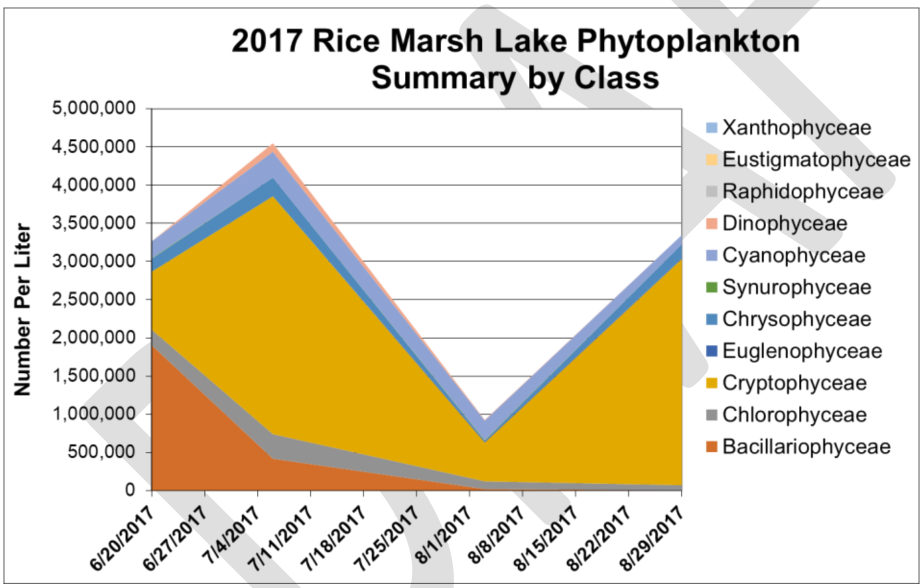

Figure 4.7-12 2017 Rice Marsh Lake Phytoplankton Abundance (#/L) by Class.

Staring

In 2017, all three groups of zooplankton were present in Staring Lake (Exhibit C). Rotifers were the most abundant zooplankton sampled in the 2017 (Figure 4.7-13). April rotifer numbers were high (over 3.1 million) before a decline to 1.6 million in June, and an average of 243 thousand for the remainder of the year. Copepod numbers were relatively flat across the first three sampling dates, averaging around one million before declining for the last two sampling periods. Cladoceran numbers remained relatively stable across all sampling dates except for the June sample which more than doubled the populations seen for the remainder of the year at 1.4 million individuals. The most abundant Cladocera were *Bosmina longirostris* which are common in lakes and ponds across the United States.

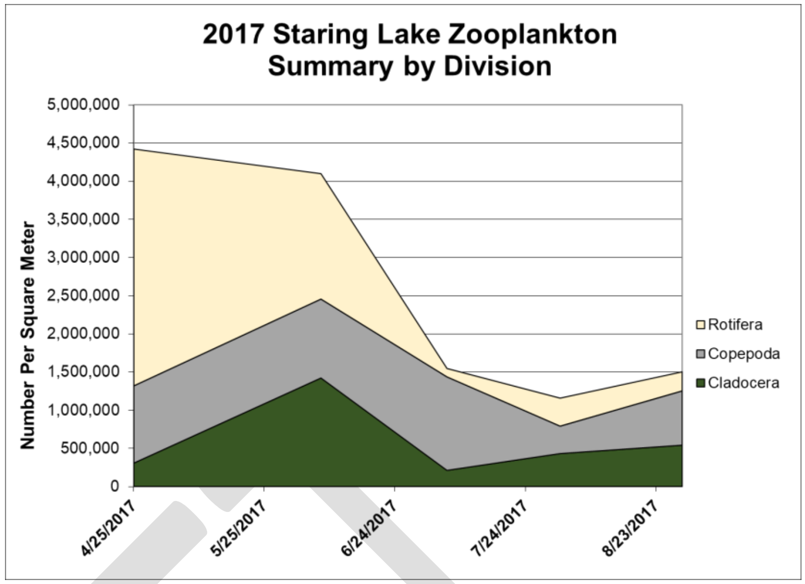

Figure 4.7-13 2017 Staring Lake Zooplankton Counts (#/m²)

Large Cladocera consume algae and may have the potential to improve water quality when present in large densities. The estimated epilimnetic grazing rates observed in 2017 ranged from 4.5% to 92% (Figure 4.7-14). The max grazing rate corresponded with the population spike in Cladocera seen in June. The grazing rates were variable across the remaining sampling dates.

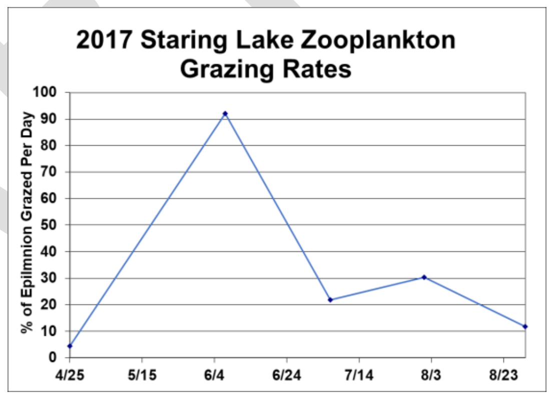

Figure 4.7-14 2017 Staring Lake Grazing Rates

During the summer of 2017, staff collected four phytoplankton samples on Staring Lake (Exhibit D). Abundance of phytoplankton by Class are presented in Figure 4.7-15. Cyanobacteria concentrations were very high across all sampling dates. *Aphanozomenon sp.*, *Microcystis wesenbergii*, and *Cylindrospermopsis* sp. were the most common. All these species can produce harmful toxins. Class Cryptophyceae and Chlorophyceae were also common across all sampling dates.

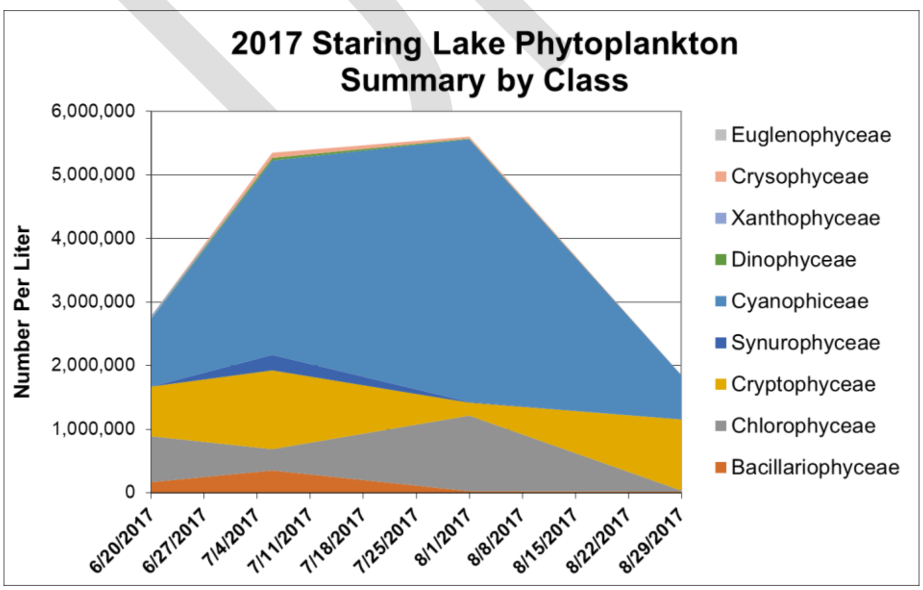

Figure 4.7-15 2017 Staring Lake Phytoplankton Abundance (#/L) by Class.

4.8 Lotus Lake and Hyland Lake Fish Kill

On May 12th, 2017, while conducting a regular check of District lake level sensors, RPBCWD staff observed several dead bluegills and crappies on Hyland lake around the boat launch. Additionally, on June 5th, 2017, staff noticed some dead bluegills and crappies near the boat ramp of the Lotus Lake public boat access while conducting regular water quality monitoring (Figure 4.8-1). The fish found had been dead for at least a few days and a majority were whole. Most of the fish were of catchable size with very few small fish visible, however smaller fish are scavenged more easily and could have been removed. Surface water temperatures on Lotus had warmed 3.09 degrees Celsius from the previous month's sampling date (5/16/2017) on Lotus.

Figure 4.8-1 Deceased Crappie Observed on Lotus Lake 6/5/2017

These fish kills were likely due to rapidly rising water temperatures combined with increased stress. Fish kills can occur on different area lakes when water temperatures warm in May and June following spawning activity. In the past, pathology investigations have identified a bacterial infection *Flexibacter columnaris* as a reason for previous fish kills. The University of Minnesota had previously collected fish samples from Lotus Lake in 2016 to determine if the bacterial infection is a secondary cause or a primary cause, but the results were inconclusive due to desiccation. Staff reported the 2017 fish kills to the University of Minnesota Fish Kill Reporting Map. See information below about *F. colmnaris* provided by the MNDNR:

A common fish disease caused by the bacterium *Flexibacter columnaris* can occur in local lakes. This pathogen can cause large kills of fish, particularly crappies, sunfish, and bullheads. Often only one fish species is affected (if more than one species is affected, the fish are generally the same size); frequently smaller, less hardy fish make up most of mortalities observed. Die-offs happen for a short period (typically 1-7 days) in spring and early summer. Effects of the bacterium are non-existent at other times of the year. Temperature conditions determine the timing and severity of infections and die-off. Fish disease caused by other bacteria species can happen under similar water conditions.

The *columnaris* bacterium exists naturally in lakes and can cause disease during conditions stressful to fish. The primary fish stresses triggering *columnaris* infection are rapid springtime increases in water temperature, coupled with spawning activity and low energy reserves from the previous winter. Fish infected with or killed by *Flexibacter columnaris* show signs of eroded fin edges, skin lesions, eroded gill tissue, and a grey-white to yellow skin slime. External symptoms might not be obvious. Fish succumbing to the disease or secondary infections often results in a noticeable fish kill. *Columnaris* disease-caused kills occur in many Minneapolis-St. Paul area lakes and can occasionally affect several thousand fish. On some lakes, kills occur every year. Almost always, fish losses are small relative to numbers of the lake's total population. In observing and investigating many fish kills, MNDNR Fisheries have seen little, if any, noticeable changes in angler success attributable to *columnaris*-related die-offs. No practical antibiotic treatment exists for treating lake areas affected by this naturally occurring, common bacterium. Live fish infected with *Flexibacter columnaris* are edible. Fish caught having *columnaris* should be skinned and prepared as desired, make sure the fish is cooked to a temperature of at least 140 degrees F for at least five minutes.

4.9 Lake Susan Spent-Lime Treatment System

Lake Susan is an 88-acre lake next to Lake Susan Park. It is an important resource in the city of Chanhassen and the Riley Purgatory Bluff Creek Watershed District. The lake is a popular recreational water body used for boating and fishing. Lake Susan is connected to four other lakes by Riley Creek. It receives stormwater runoff from 66 acres of land around it, and from two upstream lakes. The stormwater entering the lake carries debris and pollutants, including the nutrient phosphorus. Phosphorus is a nutrient that comes from sources such as erosion, fertilizers, and decaying leaves and grass clippings. Excess phosphorus can cause cloudy water and algal blooms in lakes. Removing phosphorus from stormwater is a proven way to improve the water quality of lakes and streams.

Figure 4.9-1 Spent Lime Treatment System

A spent-lime filtration system was constructed at a culvert of a tributary stream draining a wetland on the south-west corner of Lake Susan (Figure 4.9-1). Based on a system performance at the one other site in the Twin Cities area, the system was anticipated to remove approximately 45 pounds of phosphorus annually from water entering the lake. This would result in improved water quality and recreational opportunities. Spent-lime is calcium carbonate that comes from drinking-water treatment plants as a byproduct of treating water. Instead of disposing of it, spent-lime can be used to treat stormwater runoff. When nutrient-rich water flows through the spent-lime system, the phosphorus binds to the calcium. The water flows out of the spent-lime system, leaving the phosphorus behind.

In 2016, staff collected water samples at the spent-lime treatment system to assess the treatment effectiveness of the unit. Overall, results varied considerably across all sampling dates. With this type of treatment system as seen in other locations, we would expect to see reductions in phosphorus and suspended solids, however, for the first year of monitoring this largely did not occur. In 2016 it was determined that the major source of the variable results was that the unit may have been short circuiting through the cleanout access points and various other areas when water conditions were high. As with most new treatment systems, often things need to be tested and altered slightly to achieve the greatest removal efficiencies. Barr Engineering hired a contractor to modify the system to minimize the potential for short circuiting and top-off the spent lime. Following the modifications, the system was put online for the summer of 2017.

In 2017, RPBCWD staff sampled the unit weekly during the summer and into the fall. The results were again highly variable, similar-to what was seen in 2016. Of the 17 total phosphorus sampling dates, 10 had reductions (Figure 4.9-1). The largest reduction occurred in early August; TP was reduced by 0.127 mg/l which is equal to a 14% reduction. In a lab setting, the spent-lime within the system was removing 20-30%, a rate of removal that could occur in the field under optimal conditions. Across seven sampling events, the results indicated an increase in TP at the outlet, which cannot occur as the phosphorus should be binding with the available calcium. The phosphorus should be locked in the system and phosphorus levels should be reduced.

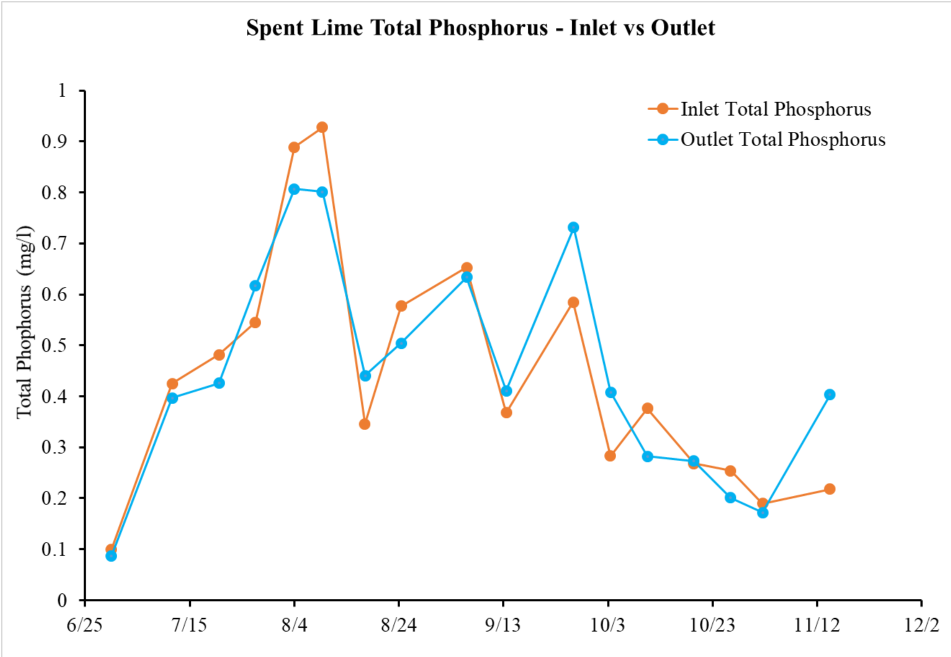

Figure 4.9-2 2017 Spent Lime Total Phosphorus (mg/L) - Inlet vs Outlet

District staff and Barr Engineering met to discuss options moving forward to improve the phosphorus removal performance of the system. One plausible explanation discussed for the variable results was that stream water was entering the sampling location, hence compromising our monitoring location at the outlet. If this was the case, sample results would not reflect the filtering capacity of the system. The spent-lime system has a backflow preventer valve system between it and the stream to deter this from occurring, however, the flap might not be sealing property, or debris may be causing stream water to contaminate the sample area. To address this issue, staff will take future samples at a different location. In 2017, sampling ports were installed at various locations within the spent-lime. Monitoring these locations will allow us to see removals throughout the spent lime layers and will let us know removal efficiencies. If it is determined that limited removal is occurring, the spent lime will further be tested in the lab to assess dry/wet periods and its effect on phosphorus removals. We will continue to monitor the pH of the system to ensure water contact time with the spent lime is optimized for maximum removal efficiency.

4.10 Rice Marsh Lake Stormwater Inputs

The District wanted to better capture and understand rain event nutrient loading into Rice Marsh Lake from the residential and business area northwest of the lake. This area was identified as a potential site for a water quality improvement project. However, more information on nutrient loading was needed to assess whether a project was needed. In August of 2016, District staff deployed an automated water-sampling unit at a storm drain pipe access point on Dakota Lane. They redeployed this unit again at this point in 2017. This pipe drains to a stormwater pond which then drains into Rice Marsh Lake. Analyzing the "first flush" of a storm event is important because these events are when water pollution entering storm drains in areas with high proportions of impervious surfaces is typically more concentrated compared to the remainder of the storm. Water samples were analyzed for TDP, TP, TSS, and Chl-a. The automated water-sampling unit also tracked flow of water in the storm drain pipe at that point. In conjunction with the unit samples taken during/after a rain event, staff collected post-rain samples from the pond.

In 2017, the amount of TP moving through the culvert after a rain event was high, as seen in figure 4.10-1. Five of 14 samples taken had TP levels exceeding the ceiling of the MPCA standard for stormwater ponds (0.1mg/L-0.25mg/L), the highest being 0.43mg/L. The rest of the samples all exceed the floor of the standard (Figure 4.10-1). TP levels in the pond were lower, none exceeding the ceiling of the MPCA TP water quality standard (Figure 4.10-2); all but two samples did however exceed the floor of the standard. Relative to TP measurements, TDP readings were low, the highest in-drain reading measuring 0.07mg/L, and the highest pond reading measuring 0.063mg/L (Figure 4.10-1, Figure 4.10-2). TSS was also quite high in samples taken from the stormwater drain pipe. Seven of the 14 samples had TSS levels higher than 30mg/L (MPCA standard for TSS in District creeks is <10% of the time exceedance of 30mg/L TSS, Figure 4.10-3). There is no water quality standard for water in a stormwater pond, but all samples collect from the pond had TSS levels below 30mg/L (Figure 4.10-4). These results indicate the stormwater pond is reducing the amount of nutrients entering Rice Marsh Lake from these inputs. However, removing more nutrients from the water before it enters the pond via a treatment system or BMP could potentially lead to a greater increase in water quality of the lake.

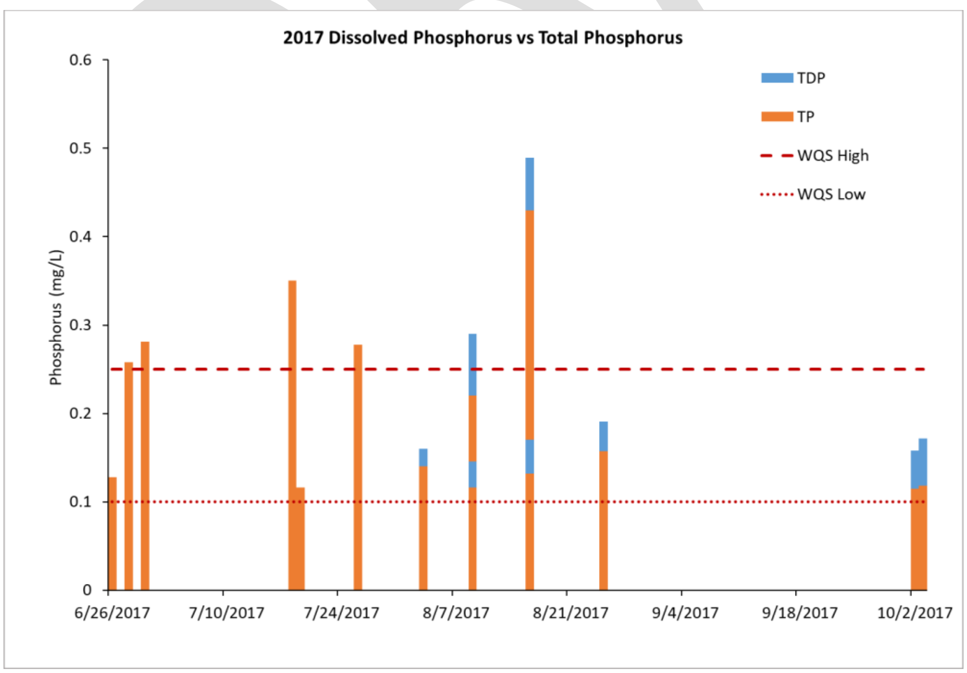

Figure 4.10-1 2017 Stormwater Dissolved Phosphorus and Total Phosphorus Inputs to Rice Marsh Lake

Total Dissolved Phosphorus (TDP) and Total Phosphorus (TP) concentrations (mg/L) from the stormwater draining into the pond at the northwest end of Rice Marsh Lake. Dashed lines represent the Minnesota Pollution Control Agency TP Standards for stormwater ponds (0.1mg/L-0.25mg/L).

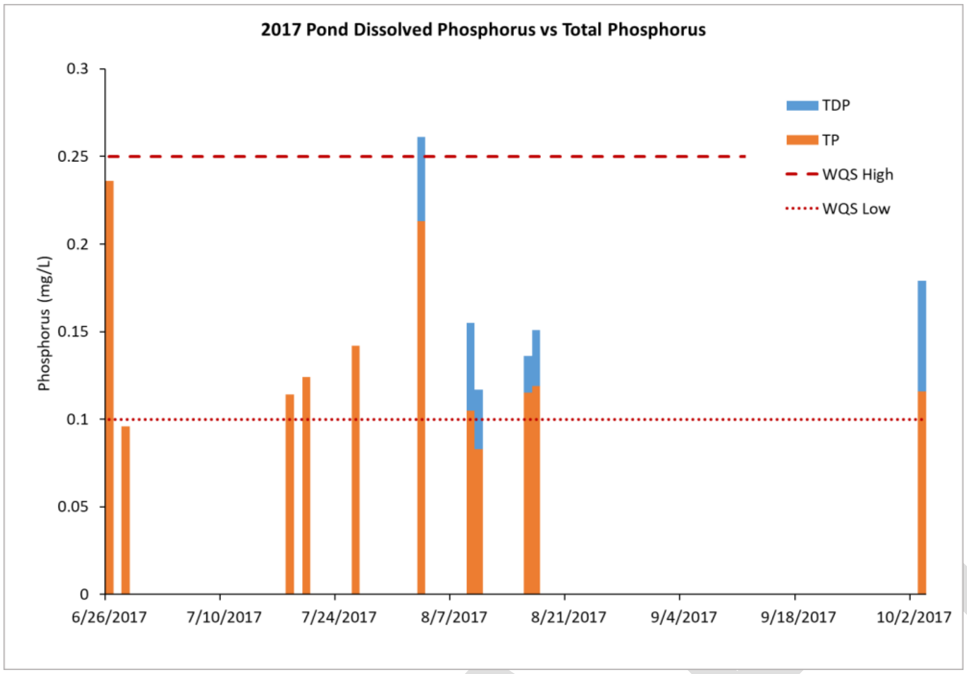

Figure 4.10-2017 Stormwater Pond Dissolved Phosphorus and Total Phosphorus Inputs to Rice Marsh Lake

Total Dissolved Phosphorus (TDP) and Total Phosphorus (TP) concentrations (mg/L) from the stormwater pond draining into the northwest corner of Rice Marsh Lake. Dashed lines represent the Minnesota Pollution Control Agency TP standards for stormwater ponds (0.1mg/L-0.25mg/L).

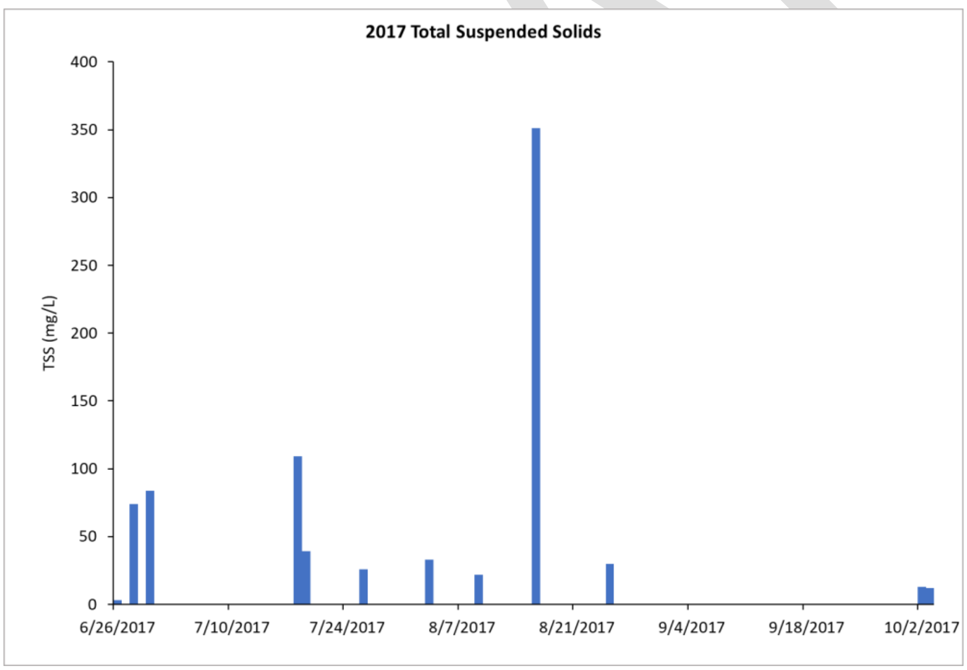

Figure 4.10-3 2017 Stormwater Total Suspended Solids Input to Rice Marsh Lake

Total Suspended Solids (TSS) concentrations (mg/L) from the stormwater draining into the pond at the northwest corner of Rice Marsh Lake.

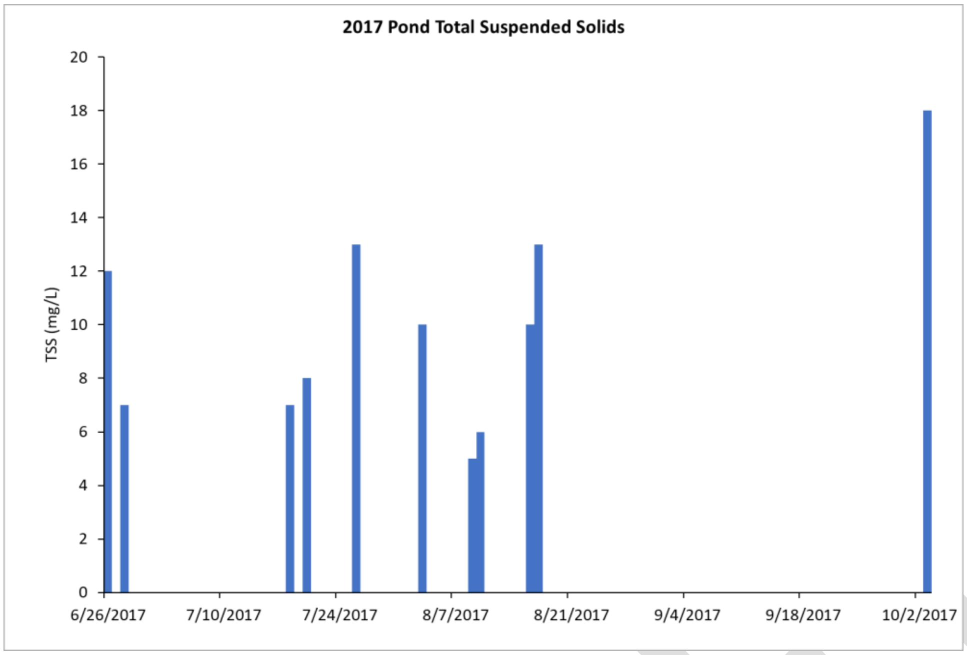

Figure 4.10-4 2017 Stormwater Pond Total Suspended Solids Inputs to Rice Marsh Lake

Total Suspended Solids (TSS) concentrations (mg/L) from the stormwater pond draining into the northwest end of Rice Marsh Lake.

5 Aquatic Invasive Species

5.1 AIS Management

Due to the increase in spread of Aquatic Invasive Species (AIS) throughout the state of Minnesota, staff completed an AIS early detection and management plan in 2015. As part of the plan, an AIS inventory for all waterbodies within the District was completed and a foundation was set up to monitor invasive species that are currently established within District waters (Table 5.1-1). Early detection is critical to reduce the negative impacts of AIS and to potentially eliminate an invasive species before it becomes fully established within a waterbody. Effective AIS management of established AIS populations will also reduce negative impacts and control their further spread. The RPBCWD AIS plan is adapted from the Wisconsin Department of Natural Resources (WIDNR), Minnehaha Creek Watershed District (MCWD), and the Minnesota Department of Natural Resources (MNDNR) Aquatic Invasive Species Early Detection Monitoring Strategy. The goal is to not only assess AIS that currently exist in RPBCWD waterbodies, but to be an early detection tool for new infestations of AIS. Figure 5.1-1 identifies what AIS monitoring/management occurred in 2017 excluding common carp management.

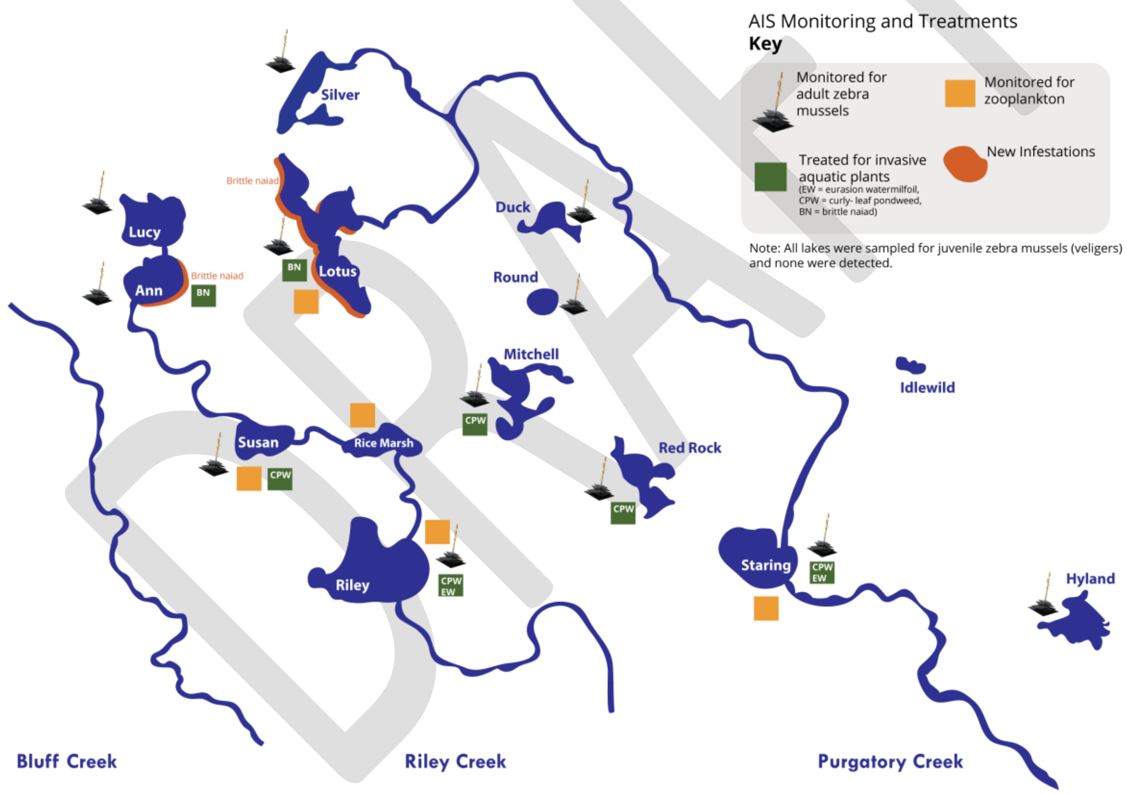

Figure 5.1-1 2017 Aquatic Invasive Species Sampling

Aquatic Invasive Species work conducted in 2017 within the Riley-Purgatory-Bluff Creek Watershed District. Zebra mussel plate symbol indicates some combination of the installation of plates at public boat accesses and bi-weekly public boat launch scans. Lakes that received zooplankton and phytoplankton sampling are identified by orange squares and lakes that received herbicide treatments are identified by green squares (CPW=curly-leaf pondweed; BN=Brittle Naiad; EW=Eurasian watermilfoil). The orange outlines around Lake Ann and Lotus Lake indicate that Brittle Naiad was discovered there in 2017. All lakes received juvenile mussel sampling; none were found. This map excludes carp management.

Table 5.1-1 Aquatic Invasive Species Infested Lakes

Lake Names	Infested Waters	Brittle Naiad	Eurasian Watermilfoil	Curlyleaf Pondweed	Purple Loosestrife	Common Carp
Ann	x	**X**	x	x	x	x
Lotus	x	**X**	x	x		x
Lucy	x		x	x	x	x
Red Rock	x		x	x	x	
Rice Marsh	x			x	x	x
Riley	x		x	x	x	x
Silver	x			x	x	
Staring	x	x	x	x		x
Susan	x		x	x	x	x
Duck	x			x	x	
Mitchell	x		x	x	x	
Round	x	x	x	x		
Hyland	x			x		

X – Indicates new infestation.

5.2 Aquatic Plant Management

Aquatic plant surveys are important because they allow the District to map out invasive plant species for treatment, locate rare plants for possible protection, create plant community/density maps which evaluate temporal changes in vegetation community, identify the presence of new AIS within water bodies, and they can assess the effectiveness of herbicide treatments. Aquatic plant surveys have been conducted on a rotational basis within RPBCWD to ensure all lakes have received adequate assessments. As projects arise, or issues occur, additional plant surveys are conducted to aid in the decision-making process. Herbicide treatments have been shown to reduce and control aquatic invasive plants to a manageable level, which may in turn allow for native plants to increase in abundance. The District will continue to monitor the aquatic plant communities within our lakes and use herbicide treatments to manage aquatic invasive plants to sustain healthy aquatic communities into the future. In early May of 2017, herbicide treatments were carried out on Mitchell Lake, Red Rock Lake, Lake Riley, Staring Lake, and Lake Susan for curly leaf pondweed. Herbicide treatments were also carried out on Riley and Staring for Eurasian watermilfoil in mid-summer and early fall, as well as on Ann and Lotus for Brittle Naiad.

Eurasian watermilfoil (EWM) is a species native to Europe and Asia that has been introduced to the United States. The concern with this species is that it can form dense mats that outcompete native species and interfere with recreational activities such as boating, swimming, and fishing. Since the infestation of EWM in Staring Lake in 2015, the District has been working with James Johnson from the Freshwater Scientific Services (FWSS) and has developed a mechanical and chemical rapid response strategy to potentially eliminate the plant from the lake. The strategy of hand-pulling followed by a fall herbicide treatment has been successfully used to control new infestations of EWM on Weaver Lake (Hennepin Co.) and Lake Charlotte (Wright Co.). After surveying for EWM surveying during October of 2015, a combination of mechanical removal and herbicide treatments took place on Staring (treatment of 9.1ac).

A granular 3,5,6-trichloro-2-pyridinyloxyacetic acid herbicide was applied up to the maximum rate of 67.5 pounds per acre foot to eliminate plants too deep to pull.

The herbicide treatment in 2015 was successful as no EWM was discovered in the treatment areas in 2016. That said, during the first two scans or the 2016 summer, 30 plants were discovered across the lake (Figure 5.2-1 – Panel A). RPBCWD staff hand pulled these plants (Figure 5.2-1 – Panel A). The same herbicide was then applied to Staring Lake, treating 6.5ac (one site at the northwest end, and another at the east end of the Lake). This treatment targeted deep plants that were not pulled (Figure 5.2-1 – Panel A). Johnson and RPBCWD staff each performed one last scan in the fall and identified an additional 20 plants (Figure 5.2-1 – Panel B), after which RPBCWD staff mechanically removed all plants except two deep plants that were topped and marked for removal/treatment in 2017.

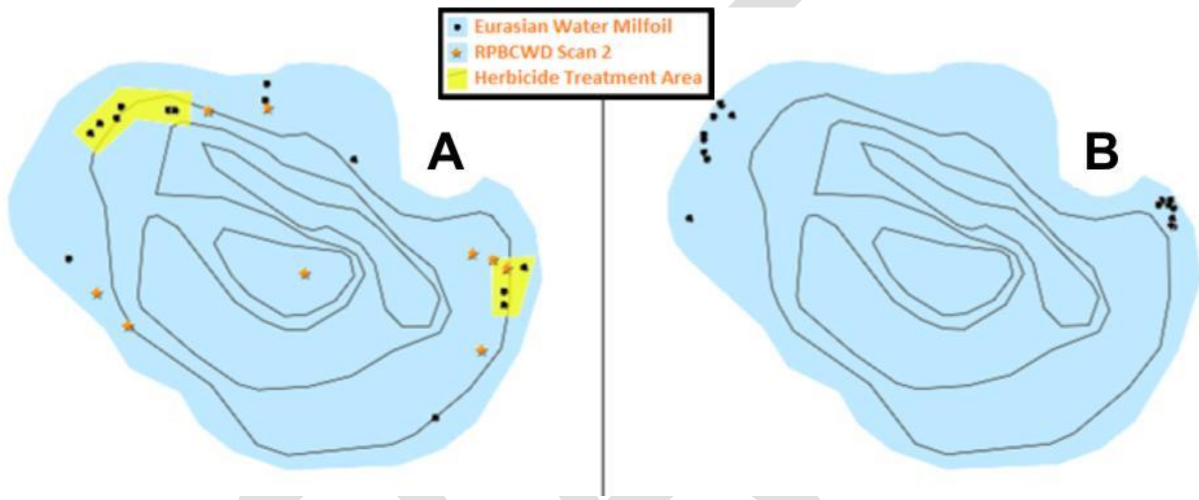

Figure 5.2-1 2016 Staring Lake Eurasian Watermilfoil Scans and Treatment

Eurasian watermilfoil scans/mechanical removals and mid-July herbicide treatment (yellow polygons-A) on Staring Lake in 2016. The initial scan conducted by James Johnson Freshwater Scientific Services on July 1st, 2016, are represented by the black dots. Scan and mechanical removal by RPBCWD staff on July 18th, 2016 is represented by the stars. Scan and mechanical removal on map B was conducted by FWSS on September 19th, 2016 and RPBCWD on October 1st, 2016.

RPBCWD staff conducted two scans during the 2017 season. During the first scan, which took place on July 28th, 2017, staff located several EWM plants, as well as a large cluster of plants at the west end of the lake; two floating plant fragments were also found along the south-southwest edge. Staff removed most of these plants and marked the large cluster in the eastern end of the lake for herbicide treatment (Figure 5.2-2). In the late summer of 2017, PLM Lakes and Land Management Corp applied herbicide to a two-acre area encompassing the large cluster of EWM plants. A second scan took place on September 7th, 2017, in which District staff located and mechanically removed 151 individual EWM plants from the northwest corner of the lake (Figure 5.2-2). The abundance of plants found on Staring in 2017 indicates that EWM is now well established within the lake. Staff will continue to monitor and remove plants in 2018 and further assess future actions at the end of the year.

Figure 5.2-2 2017 Staring Lake Eurasian Watermilfoil Infestation Areas

Eurasian watermilfoil scans carried out by RPBCWD staff on Staring Lake in 2017. The red markers indicate plants/clusters of plants marked by staff (the large group of markers at the east side of the lake were marked to be treated with herbicide; 2 ac). The blue markers indicate plants/clusters of plants marked and removed mechanically by staff.

On September 26, 2017, during a routine boat launch AIS inspection, staff observed brittle naiad (*Najas minor*) located on both sides of the public boat access on the south side of Lotus Lake. Brittle Naiad is a species native to Europe, western Asia, and northern Africa that has been introduced to the United States. The concern with Brittle Naiad is that it can form dense mats that can outcompete native plants. These dense communities can disrupt fish and waterfowl habitat, choking out plants which animals depend on for survival and potentially decreasing dissolved oxygen levels upon its decomposition. With that said, brittle naiad is a very new AIS and not much is known about its effects especially in Minnesota. Brittle naiad is a fairly resilient plant; it can survive in some polluted and eutrophic waters and can reproduce by fragmentation. Staff reported the occurrence of brittle naiad to Aquatic Invasive Species Specialist Keegan Lund of the MN DNR. Staff extended the inspection to a full scan of the lake, mapping the position of every observed brittle naiad occurrence with a handheld GPS. An effective treatment area was determined from the GPS points (Figure 5.2-3). That fall, PLM Lakes and Land Management Corp applied herbicide to treat for brittle naiad in the lake within the affected areas (area totaling 2.42ac, Figure 5.2-3). Brittle naiad was also found at one location on Lake Ann the previous month during a regular vegetation survey conducted by FWSS (August 2nd, Figure 5.2-4). Only a small cluster of plants were discovered across the lake; these plants were treated immediately with hopes to eliminate the plant before it could become established. A 0.25ac treatment plot was designated and treated with herbicide (Figure 5.2-4).

Figure 5.2-3 2017 Lotus Lake Brittle Naiad Treatment Areas

The red polygons indicate the areas treated with herbicide during the fall of 2017 for brittle naiad. The total area treated was 2.42ac.

Figure 5.2-4 2017 Lake Ann Brittle Naiad Treatment Area

The red polygon indicates the 0.25ac brittle naiad herbicide treatment area during late summer of 2017.

5.3 Common Carp Management

The RPBCWD, in cooperation with the University of Minnesota (UMN), has been a key leader in the development of successful carp management strategy for lakes within the state of Minnesota. Following the completion of the Riley Chain of Lakes (RCL) Carp Management Plan drafted by the UMN in 2014 (Bajer, 2014), and the Purgatory Creek Carp Management Plan drafted in 2015 (Sorensen, 2015), the District took over monitoring duties from the University in 2015. Adult carp are monitored by conducting, three, 20-minute electrofishing transects per lake, three times between late July and October. If the total biomass estimate of carp is above 100kg/h, the District would need to consider hiring commercial fisherman to conduct winter seining. Young of the year (YOY) carp are monitored by conducting five, 24-hour small mesh fyke net sets between August and September. If YOY carp were captured during this event, it meant successful recruitment occurred and monitoring efforts should be increased with the additional option of conducting winter seining.

Figure 5.3-1 Purgatory Chain of Lakes Northern Pike – 41.4 inches

District staff completed fyke net surveys on all lakes within the RCL, as well as lakes within the Purgatory Chain of Lakes (PCL), including Lotus Lake, Staring Lake, the Upper Purgatory Creek Recreational Area (UPCRA), and the Lower Purgatory Recreation Area (LPCRA). As is true with many lakes during late summer located within the twin cities metro area, the RCL and PCL inshore fish community was dominated by bluegill sunfish and bullhead species. In 2017, Lake Riley had the highest number of bluegills captured averaging 342.8 fish per net, while an average of only 53.2 bluegills/net were captured on Staring Lake. In 2016 bluegill numbers/net in Staring Lake were the highest at 2,142 fish. The discrepancy between years may be explained by the natural fluctuation in bluegill populations but may also be related to the water levels when the fyke nets were set. In 2016 the water level was higher and allowed the nets to fish more effectively than in 2017. Many other Centrarchid species, including pumpkinseed sunfish and black crappie, were also very common across all lakes. Larger predator fish including northern pike and largemouth bass were frequently captured via fyke netting. A full summary table of the fish captured for each lake can be found in Exhibit B. In 2017 no YOY carp were captured in any of the lakes during fyke net surveys. Three YOY carp were captured during fyke netting on the Lower Purgatory Recreation Areas, suggesting minimal recruitment has occurred since 2015. The lack of young individuals captured indicates that 2017 was a very poor recruitment year for common carp overall. Bluegill catch rates within the LPCRA and UPCRA were similar to what was observed in the lakes sampled in 2017. In addition, the bluegill size structure combined with the limited winter monitoring conducted on the system, indicates that the past winters have not resulted in a winterkill.

PCL lakes (Staring and Lotus) and the Purgatory Recreation Area were surveyed via electrofishing in 2017. Due to the higher number of adults captured on Lotus Lake in 2016 (107.43 kg/ha), it was again sampled during the 2017 field season. In the 2017 assessment of Lotus Lake, the estimated total carp biomass was under the carp threshold (100 kg/ha) with an estimate of 68.75 kg/ha (Table 5.3-1). This can be attributed to the variability of the number of carp captured electrofishing from year to year. With no YOY carp captured combined with the lower adult carp biomass estimate deem the resident carp population in Lotus Lake of limited concern. In 2016 Staring Lake had common carp biomass estimates above the set threshold developed by the UMN (141 kg/h). Most of these fish were from the 2013/2015-year class with very few large adults captured. In 2017 the carp biomass estimate was below the UMN threshold at 61.7 kg/ha (Table 5.3-1). The Lower Purgatory Recreational Area was electrofished one time for 1.33 hours, which yielded a biomass estimate of 33.7 kg/ha. This was similar to 2016 which had an estimate of 35 kg/ha. These fish consisted entirely of individuals from the 2013/2015-year class, as seen in Staring Lake. Additionally, only two YOY carp were captured via electrofishing. The UPCRA again vastly exceeded the recommended biomass threshold in 2017 (245.2 kg/ha) and had an estimate similar to what was seen in 2016 (287 kg/ha). Normally, the upper rec area is disconnected from the lower rec area by a berm that splits the two. However, there was a breach in the berm in 2016 allowing for the system to be connected for most of 2017. Since the upper rec area is essentially the top of the system (fish cannot get to Silver Lake and Lotus) and has a deep-water refuge, fish moved to this location. Due to the shallowness of the system, winter seining would have limited effectiveness at capturing carp. Staff will investigate the possibility of conducting an open water seine this spring to reduce carp numbers in the upper rec area. Due to the low number of carp captured in Staring Lake, winter seining may yield limited success. Overall, 16 carp were tagged with implant-style VHF transmitters, twelve fish in Staring and four in the Purgatory Recreation Area. This will allow staff to locate when and where in the lake the carp are schooling.

Table 5.3-1 2017 Common Carp Biomass Estimates for the Riley and Purgatory Chains of Lakes

	Lake	Fish per Hour	Density per Hectare	Average Weight (kg)	Carp Biomass (kg/h)
Riley Chain	*Ann	0	0	0	0
	Lucy	3	17.17	4.53	77.83
	Rice Marsh Lake	1.33	9.32	6.08	56.62
	Susan	1.67	10.89	2.20	23.93
	Riley	0.33	4.61	3.19	14.72
	Lake Susan Park Pond	57.47	273.71	1.46	403.82
Purgatory Chain	Lotus	3.67	20.31	3.39	68.75
	Staring	9.76	48.99	1.26	61.66
	Lower Purgatory	8.27	41.99	0.80	33.70
	Upper Purgatory	26.62	128.40	1.91	245.17

*No adults (>300 mm) captured

Floating Trap Net

In the spring of 2017, staff placed a large floating trap net below the barrier in Purgatory Creek during peak spawning runs to capture carp as an experimental gear (Figure 5.3-2). Placing the net below the barrier did reduce fowling of the net by debris, however when the barrier had to be removed, the pulse of water did top the net or scour below it in some cases. This net was checked daily; fish were sorted, releasing natives and removing carp. The barrier was opened on March 3rd to allow northern pike to move up into the recreational area to spawn and return to Staring Lake. The barrier was closed on April 4th as temperatures exceeded 10 degrees Celsius on multiple days prior. The floating trap net was deployed April 11th to capture fish for education and outreach events and gauge carp movement. The City of Eden Prairie opened, cleaned, and closed the fish barrier multiple times this spring and late summer due to high water levels in the Purgatory Recreational Area, and eventually started cleaning it every Friday. Fish species captured included northern pike, black

Figure 5.3-2 Large Floating Trap Net Deployed in Purgatory Creek

crappie, freshwater drum, bigmouth buffalo, bluegills, largemouth bass, and black bullheads. The first carp was captured on April 21st and the total amount of carp removed was 139. We had hoped a larger number of fish would have been captured by the trap net, but as an experimental gear we were unsure of how many would be captured. At one point, an estimated 300-500 carp were trapped between the fish barrier and the net, however the net became overcome by a large rain event and the fish escaped by the time we could arrange the use of a backpack electrofisher. Staff will apply to again utilize the net next year and target these concentrations of fish with an electrofishing backpack.

Lake Susan Park Pond Fish Assessment

As a continuation of last year's sampling, Riley Purgatory Bluff Creek Watershed District Staff added Lake Susan Park Pond to its regular monitoring schedule to assess the overall fish community and the abundance of common carp within the pond. Lake Susan Park Pond is a small (approximately 5.09ac) stormwater pond located on the northwest side of the lake. The pond's outlet is located at its southeast side and drains to Riley Creek which eventually enter Lake Susan approximately 623ft downstream. It was thought that Lake Susan Park Pond might be acting as a carp nursery, contributing to the carp population within Lake Susan.

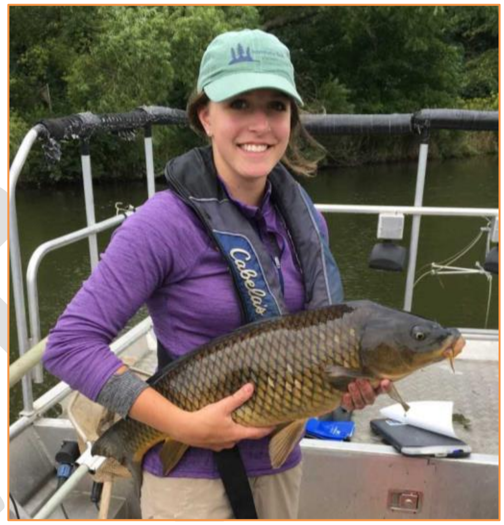

Figure 5.3-3 Lake Susan Park Pond Common Carp

Table 5.3-2 Lake Susan Park Pond Fyke Net Results

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Hour
black bullhead		1		1					2	0.4
black crappie	46	19							65	13
bluegill	218	43							261	52.2
common carp						1			1	0.2
golden shiner	1	4							5	1
green sunfish	10	1							11	2.2
hybrid sunfish		1							1	0.2
northern pike						1	1		2	0.4
pumpkinseed	3								3	0.6
yellow bullhead		2	3	1					6	1.2
yellow perch	10								10	2

Adult carp had been visually observed within the pond and attempting to access the pond from Lake Susan at the pond outlet during high flow events. A total of four electrofishing surveys were conducted on the pond in which the entire pond was sampled.

Five fyke nets were set and pulled on the pond. In total, eleven species of fish were captured, all of which are species found within Lake Susan (Table 5.3-2). Fyke netting yielded no YOY carp which suggests that limited recruitment is occurring. The most abundant fish sampled was the bluegill sunfish (261 fish) which limit carp recruitment via egg predation (Table 5.3-2). Movement of fish in and out of the pond does occur in the southeast outlet to Riley Creek, however it is limited due to the culvert size, undercutting occurring below the culvert, and because of the high velocities during flow regimes high enough for fish to pass the culvert.

In 2016 one, 30-minute transect was conducted which yielded six large common carp. Calculating a carp biomass estimate for the pond using methods developed by the UMN yielded a biomass estimate of 90.5 kg/ha (Table 5.3-1). In 2017, four surveys were conducted which yielded a combined total of 243 adult carp captured and a biomass estimate of 403.82 kg/ha. Of this total, 153 carp were captured during the 10/5/2017 date when water levels were higher, and fish could easily be trapped against the shoreline brush. The UMN assessment method was developed for lakes within the watershed and not ponds, so biomass estimates should be used with caution. This said, LSPP has some characteristics similar-to shallow lake standards, including a depth of 13 feet. The biomass threshold for a lake is 100 kg/h, meaning the fish densities for the pond are alarmingly above this level and could considerably impact the water quality of the pond. Additionally, Lake Susan Park Pond is a small pond which could see a greater impact from a smaller density of carp than would be observed in lakes.

The results from electrofishing suggest that in 2017, Lake Susan Park Pond is not a significant source of recruitment for the carp population in Lake Susan (no YOY captured). The large number of adults caught is a concern for the potential of the pond becoming a nursery. However, the number of bluegills captured, coupled with the small size of the pond and the low likelihood of a winterkill due to groundwater connectivity, reduces this concern. The large number of adult carp found suggest that fish from the RCL are concentrating in the pond due to the instinct to swim upstream. After entering the pond during high flow events, the fish become trapped in the pond in numbers that may eventually degrade water quality. Fish within the pond seemed to be more easily captured than in area lakes. There was a reduction of the number of fish captured with each subsequent survey, suggesting that fish within the pond may be fished down utilizing electrofishing only. Additionally, with the proposed project which includes LSPP culvert replacement (extending its length) and surrounding stabilization, carp movement into the pond may be further hindered. The District will continue to monitor the pond to ensure LSPP does not become an issue for the RCL of lakes.

5.4 Zebra Mussel Monitoring

The District continued to monitor for adult and veliger zebra mussels in 2017. The District conducted veliger sampling from June to July on 13 lakes and a high-value wetland to detect the presence of zebra mussels. Each lake was sampled once, apart from Lake Riley and Lotus Lake, each of which were sampled twice due to the amount of summer traffic on these lakes. RMB processed the samples and found no zebra mussel veligers across all lakes.

Adult zebra mussel presence was assessed using monitoring plates that were hung from all public access docks and private docks of residents participating in the Adopt-a-Dock program. Monitoring plates were checked monthly and no mussels were found across all lakes during the 2017 open water season. Additionally, public accesses were scanned for approximately ten minutes during each regular water quality sampling period (bi-weekly). Staff visually searched rocks, docks, sticks, and vegetation for adult zebra mussels. No adult zebra mussels were found utilizing this technique in 2017. Brittle naiad was discovered during one of these regular boat launch checks, highlighting the importance of such scans and their continuation.

6 Lake and Creek Fact Sheets

The Riley Purgatory Bluff Creek Watershed District has included in this report informational fact sheets for the lakes and creeks that were monitored during the 2017 sampling season (See Exhibit F). The lake fact sheets include: Lake Ann, Duck Lake, Hyland Lake, Lake Idlewild (high value wetland), Lotus Lake, Lake Lucy, Mitchell Lake, Red Rock Lake, Rice Marsh Lake, Lake Riley, Round Lake, Silver Lake, Staring Lake, and Lake Susan. The creek fact sheets include: Bluff Creek, Purgatory Creek, and Riley Creek.

Each lake fact sheet includes a summary of the historical water quality data collected as related to the MPCA water quality parameters: Secchi Disk depth, Total Phosphorus, and Chlorophyll-a. Each creek fact sheet includes a summary of the most current Creek Restoration Acton Strategy assessment, which includes the analysis of infrastructure risk, water quality, stream stability/erosion, and habitat. Lake or creek characteristics, stewardship opportunities, and information about what the District is doing in and around local water bodies is also described in each fact sheet.

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8 Exhibits

Exhibit A	2016 & 2017 Lake Level Sensor Graphs
Exhibit B	2017 Fyke Net Summary Data
Exhibit C	2017 Zooplankton Summary Data
Exhibit D	2017 Phytoplankton Summary Data
Exhibit E	2017 Creek Assessments
Exhibit F	2017 Lake and Creek Fact Sheets

Exhibit A

2016 & 2017 Lake Level Sensor Graphs

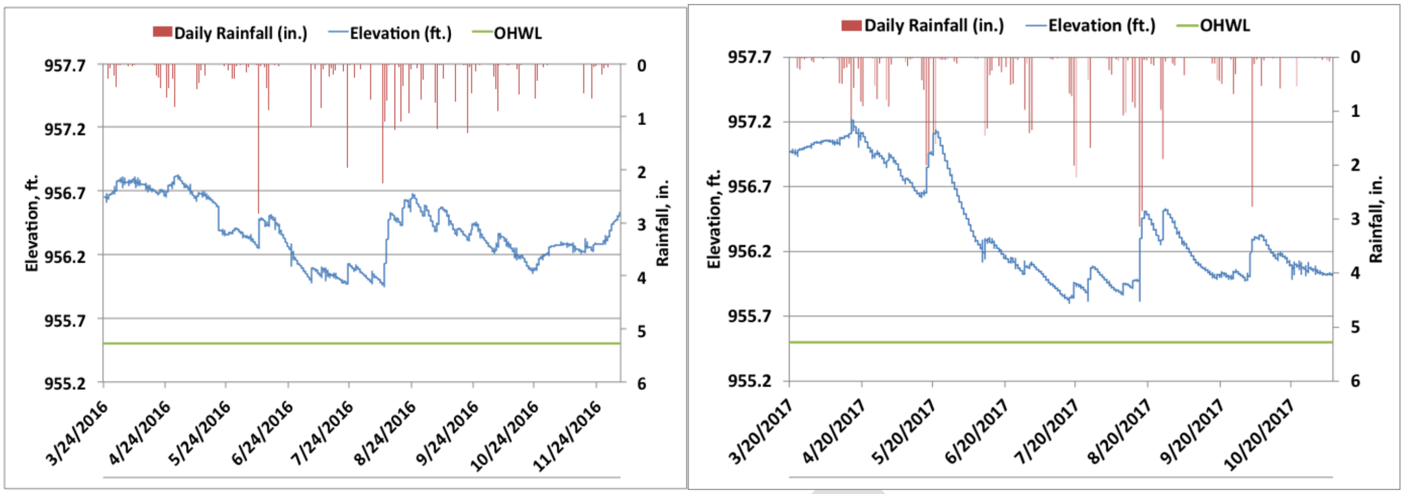


Figure A-1. **Lake Ann** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

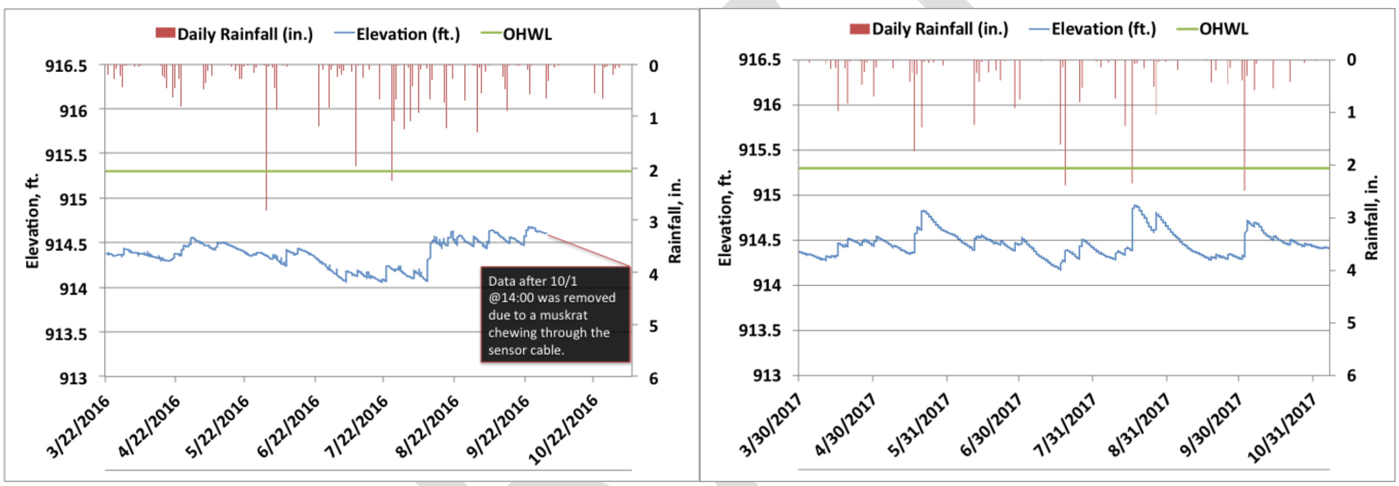


Figure A-2**. Duck Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

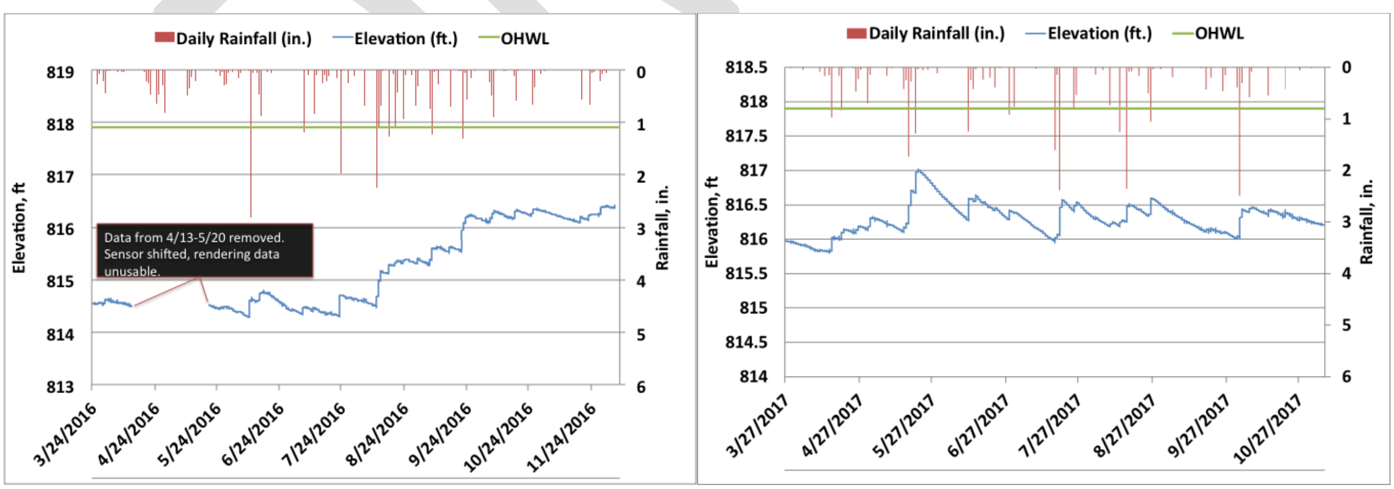


Figure A-3. **Hyland Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

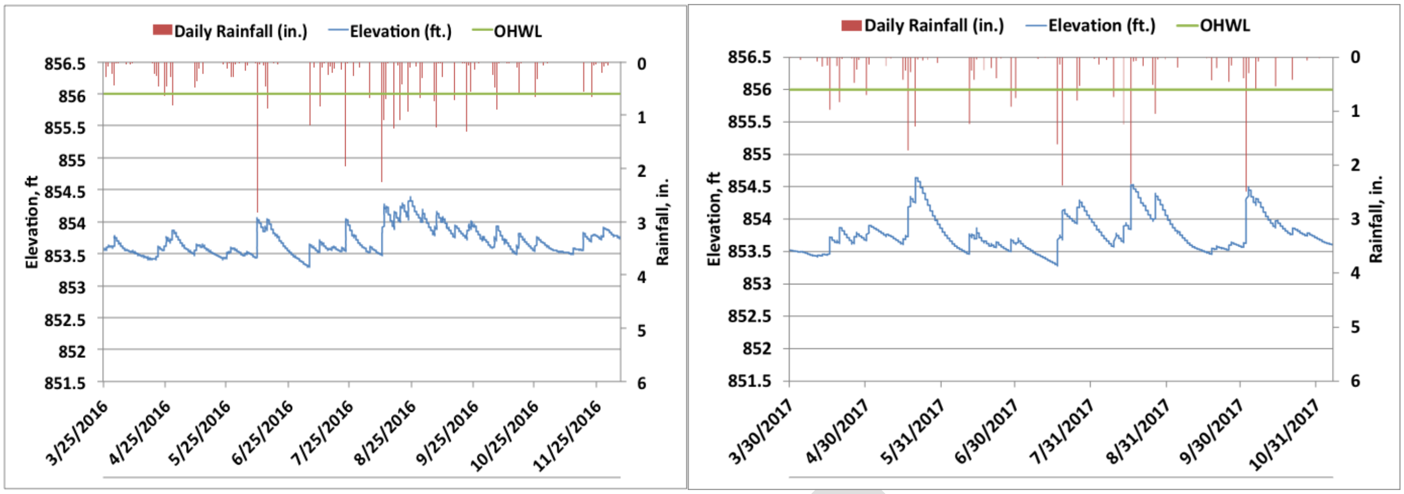


Figure A-4. **Lake Idlewild** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

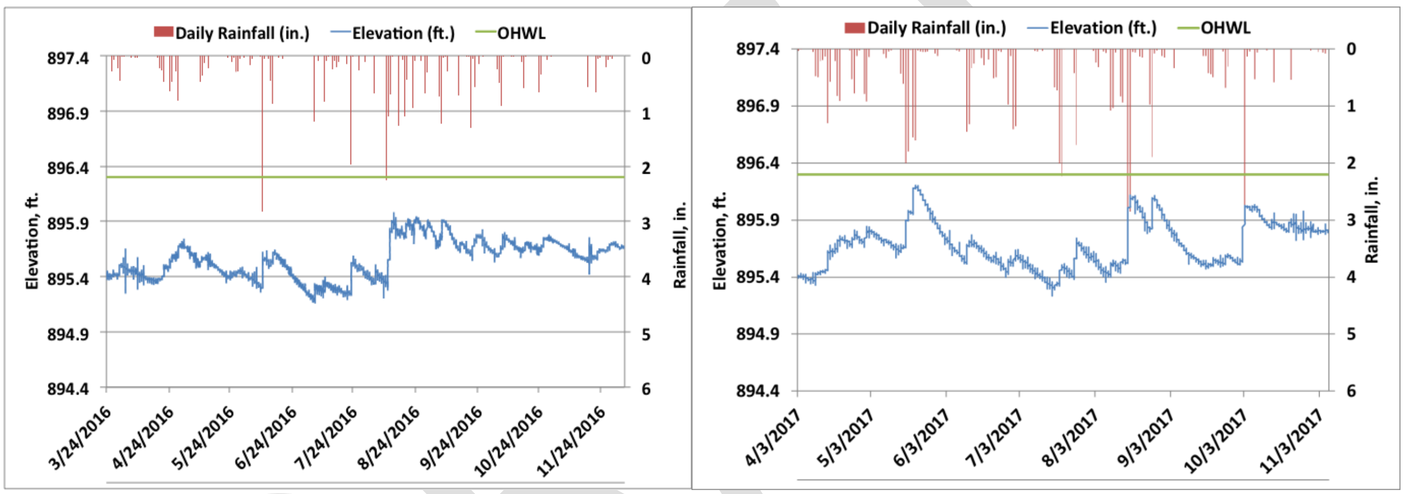


Figure A-5. **Lotus Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

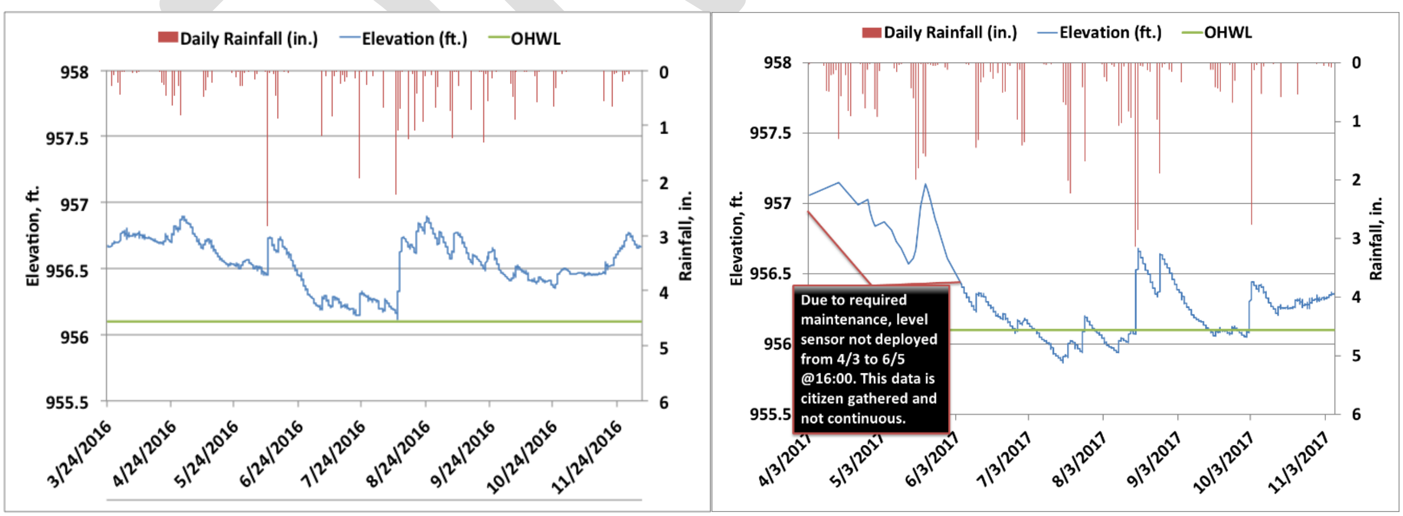


Figure A-6. **Lake Lucy** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

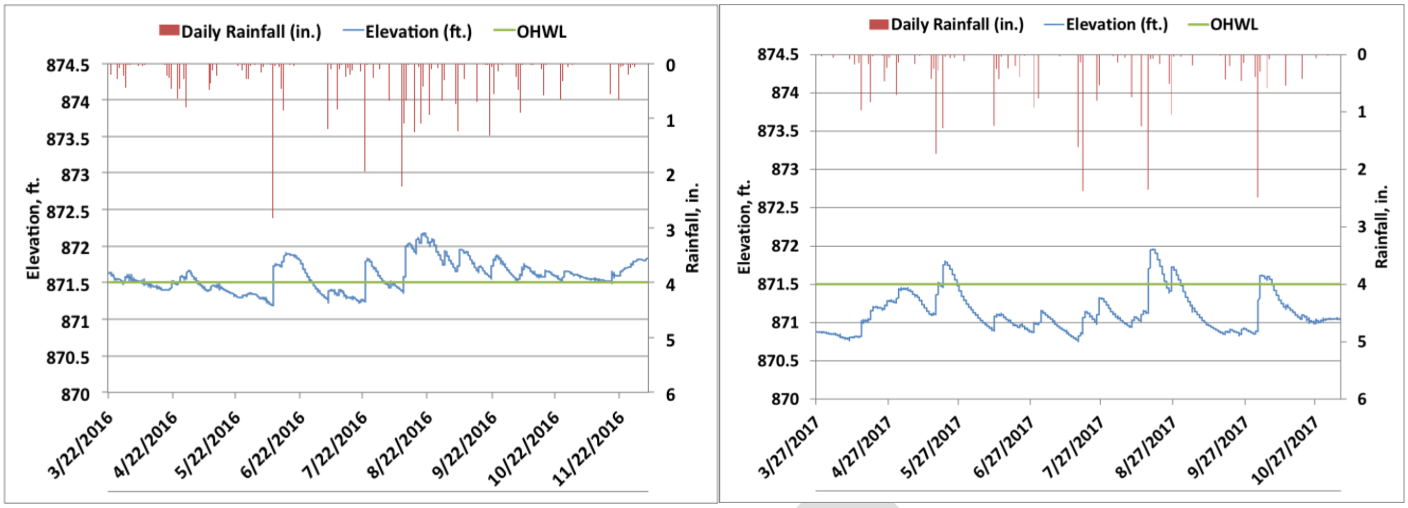


Figure A-7. **Mitchell Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

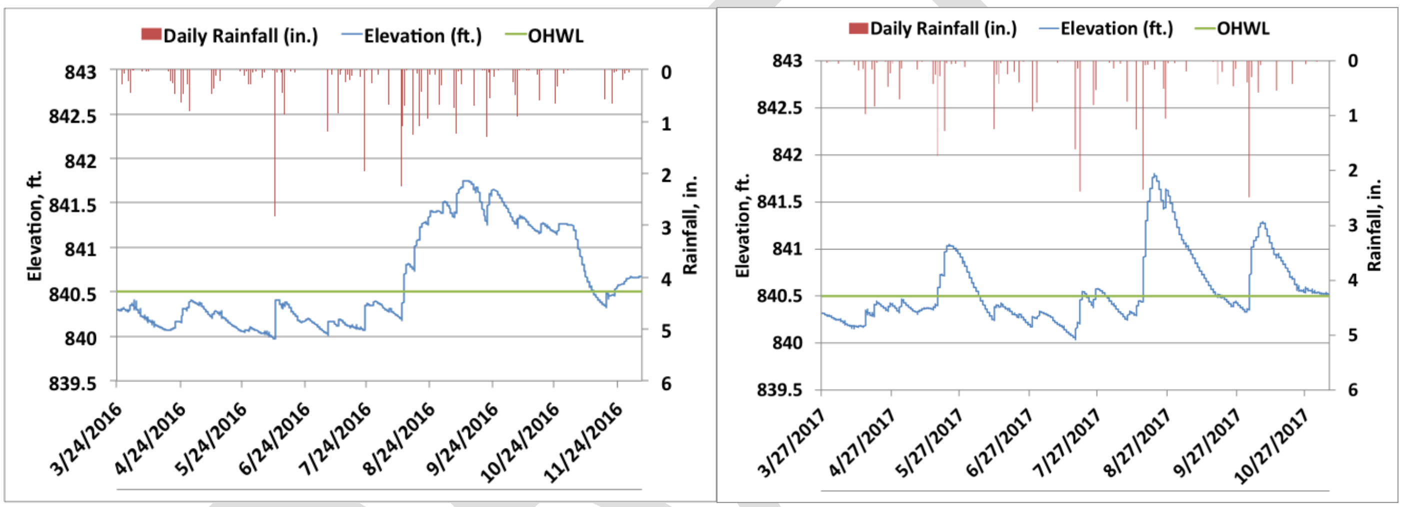


Figure A-8. **Red Rock Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

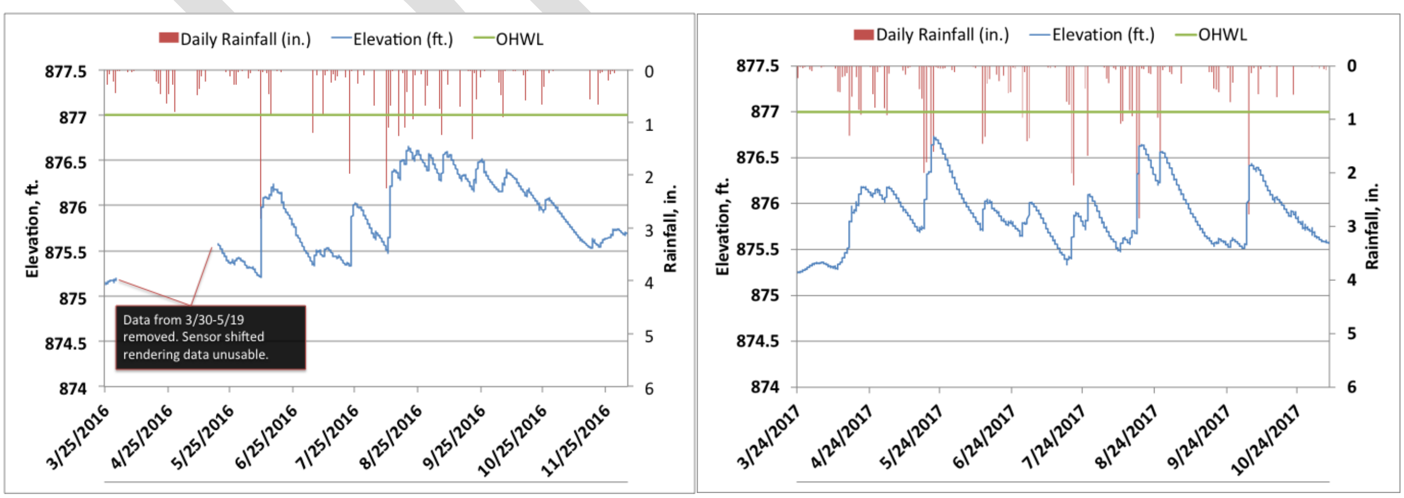


Figure A-9. **Rice Marsh Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

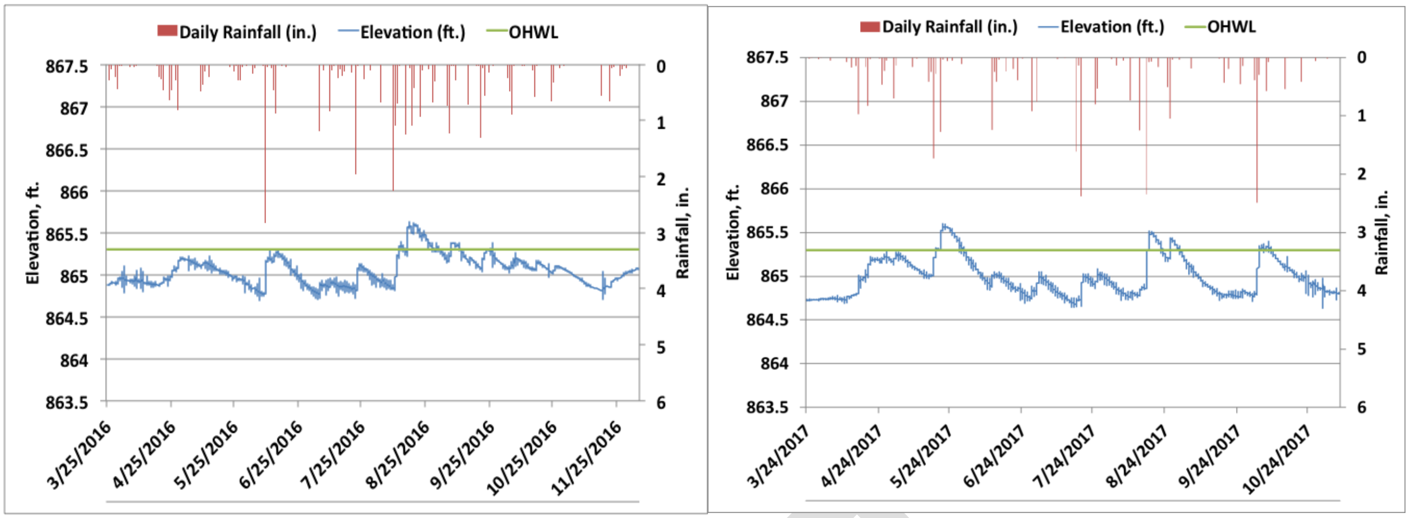


Figure A-10. **Lake Riley** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

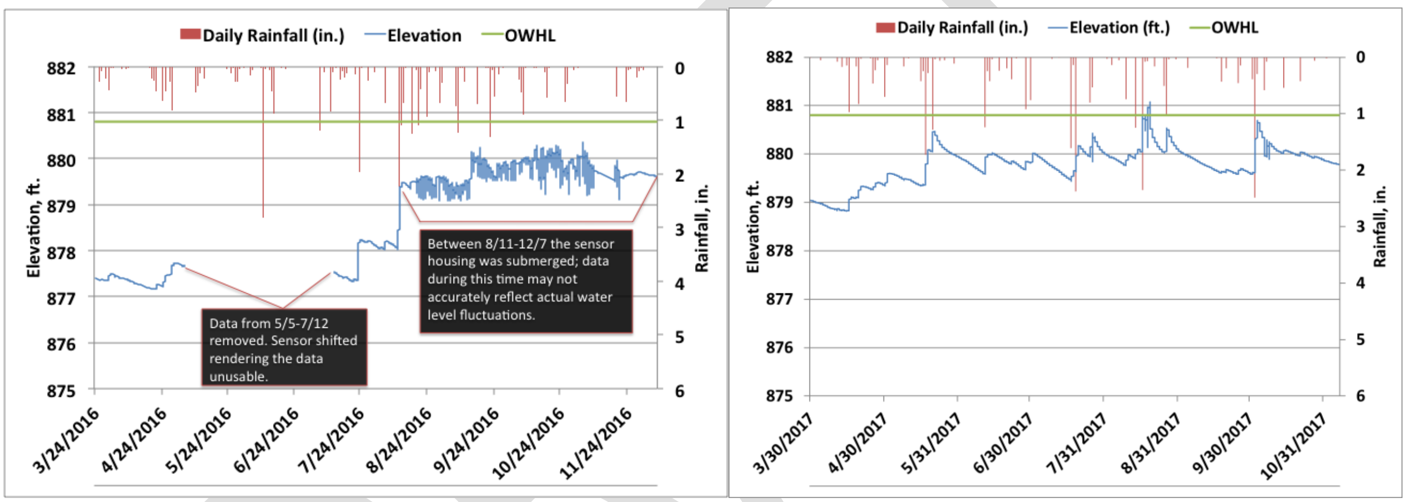


Figure A-11. **Round Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

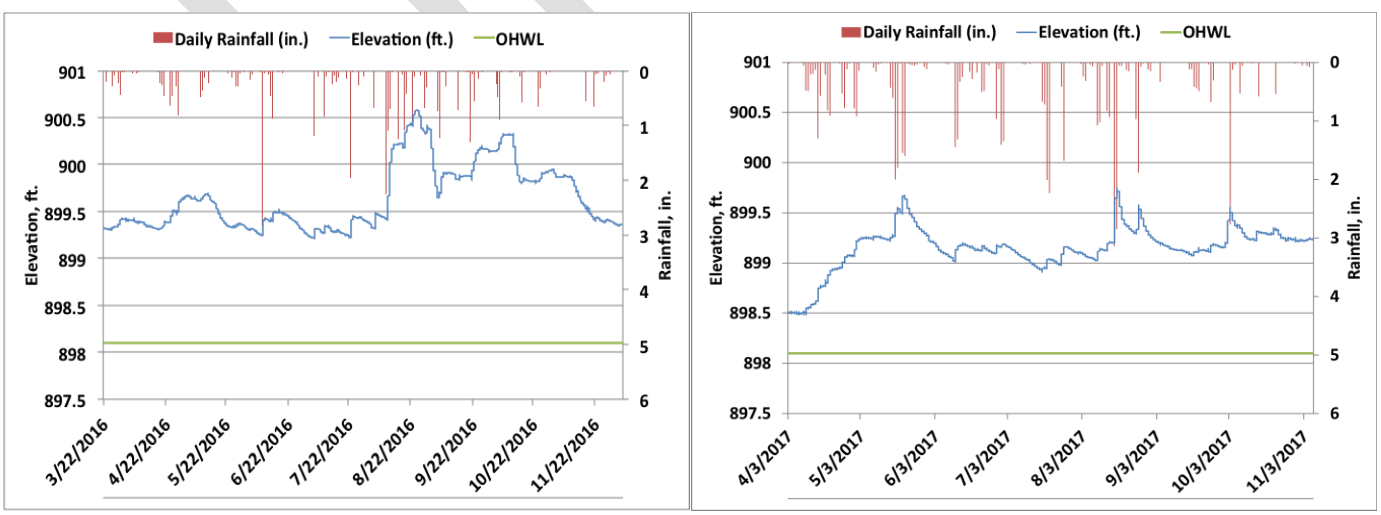


Figure A-12. **Silver Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

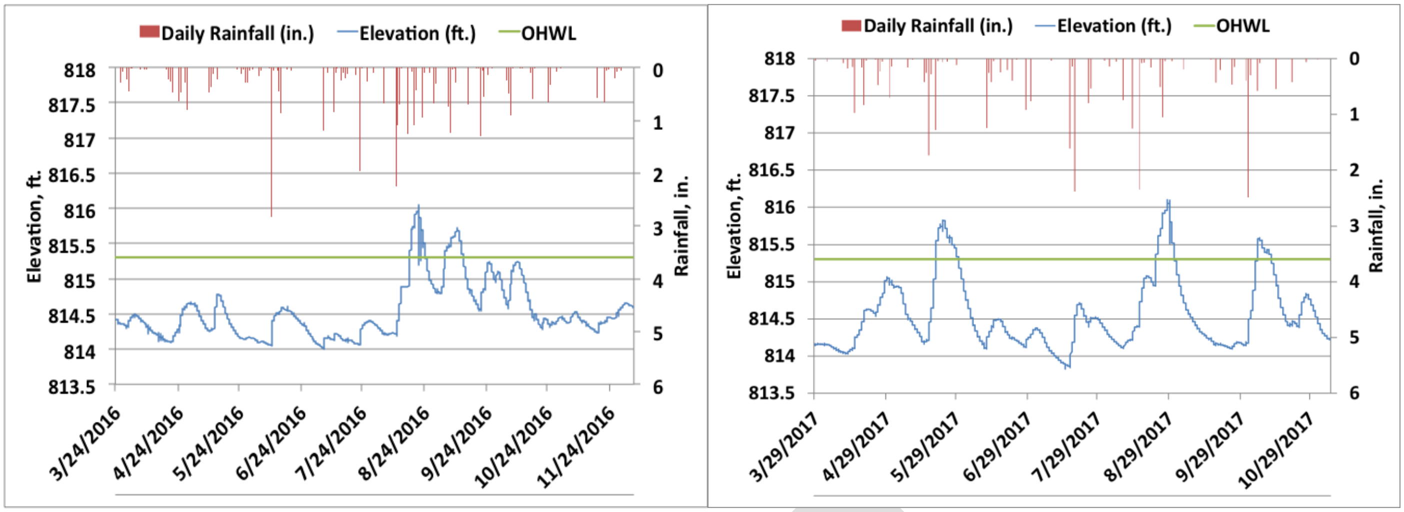


Figure A-13. **Staring Lake** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

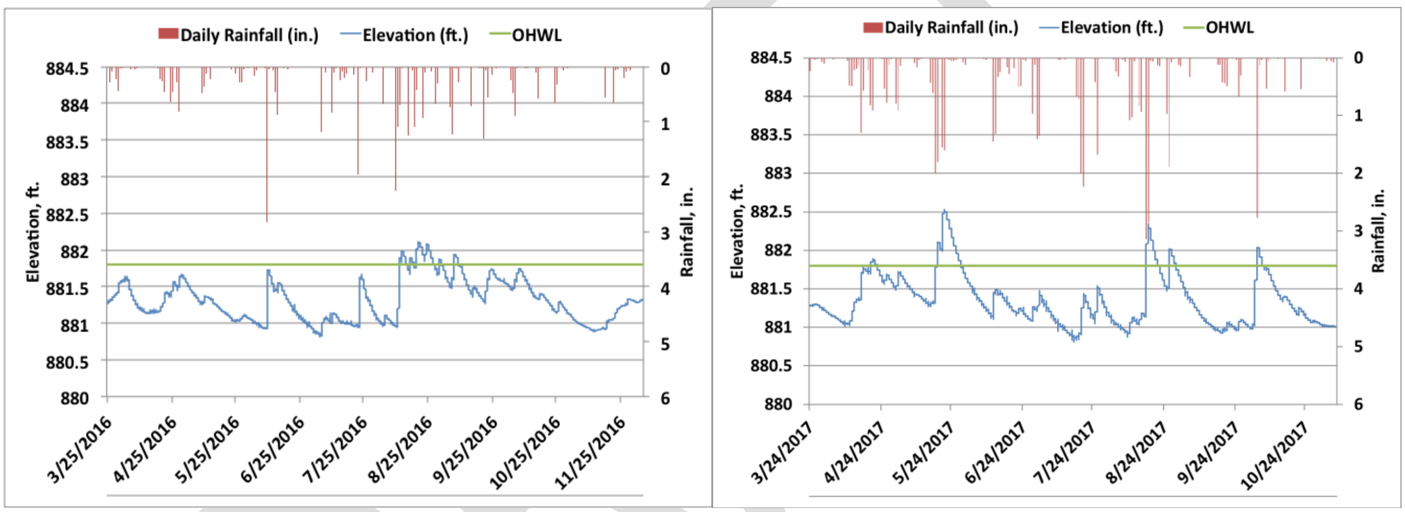


Figure A-14**. Lake Susan** level elevation data (ft.) for 2016 and 2017 along with the lake's ordinary high-water level (OHWL). Daily rainfall (in.) is displayed along the top of the graph (NOAA).

Exhibit B

2017 Fyke Net Summary Data

Table B1: 2017 **Lake Ann** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead										
black crappie		7							7	1.4
bluegill	1170	410							1580	316
common carp										
golden shiner	1	1							2	0.4
green sunfish	6	6							12	2.4
hybrid sunfish		3							3	0.6
largemouth bass	4				1				5	1
northern pike				1	1				2	0.4
pumpkinseed	111	5							116	23.2
walleye										
white sucker										
yellow bullhead	3	8	28	7					43	8.6
yellow perch	6	1							7	1.4

Table B2: 2017 **Lake Lotus** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead										
black crappie	3	26	1						30	6
bluegill	180	188							368	73.6
common carp							2		2	0.4
golden shiner		2							2	0.4
green sunfish										
hybrid sunfish										
largemouth bass			1	1					2	0.4
northern pike								2	2	0.4
pumpkinseed		1							1	0.2
walleye				1	9	4			14	2.8
white sucker										
yellow bullhead			3	8					11	2.2
yellow perch										

Table B3: 2017 **Lake Lucy** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead				1					1	0.2
black crappie	1	19	6						26	5.2
bluegill	452	137							589	117.8
common carp										
golden shiner										
green sunfish	25								25	5
hybrid sunfish	3	1							4	0.8
largemouth bass	1	1							2	0.4
northern pike					1	1			2	0.4
pumpkinseed	65	19							84	16.8
walleye										
white sucker										
yellow bullhead		11	36	3					50	10
yellow perch	1								1	0.2

Table B4: 2017 **Lower Purgatory Creek Recreational Area** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead	39	168	11	4					222	44.4
black crappie	19	12							31	6.2
bluegill	773	30							803	160.6
common carp	2		1	8	12	1			24	4.8
golden shiner	7	1							8	1.6
green sunfish	77	1							78	15.6
hybrid sunfish	4								4	0.8
largemouth bass	3	1							4	0.8
northern pike										
pumpkinseed	84								84	16.8
walleye										
white sucker										
yellow bullhead		6	2						8	1.6
yellow perch	8	26							34	6.8

Table B5: 2017 **Upper Purgatory Creek Recreational Area** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead	67	153	2						222	44.4
black crappie	48	13	2						63	12.6
bluegill	564	16							580	116
common carp				11	3				14	2.8
golden shiner										
green sunfish	24	1							25	5
hybrid sunfish	12								12	2.4
largemouth bass										
northern pike										
pumpkinseed	84								84	16.8
walleye										
white sucker			2						2	0.4
yellow bullhead	1	13	9						23	4.6
yellow perch	11	4							15	3

Table B6: 2017 **Rice Marsh Lake** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead		2	2	1					5	1
black crappie	1	71	2						74	14.8
bluegill	360	140							500	100
common carp					1				1	0.2
golden shiner										
green sunfish										
hybrid sunfish	1	1							2	0.4
largemouth bass	5	1			1				7	1.4
northern pike		1			1	2		1	5	1
pumpkinseed	15	12							27	5.4
walleye										
white sucker										
yellow bullhead	1	14	77	14					106	21.2
yellow perch		1							1	0.2

Table B7: 2017 **Lake Riley** fyke net data

Species	Number of fish caught in each category (inches)								
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead				2					2	0.4
black crappie	1	17	3						21	4.2
bluegill	1359	355							1714	342.8
common carp										
golden shiner										
green sunfish										
hybrid sunfish										
largemouth bass	1	1			1	1			4	0.8
northern pike						1	2		3	0.6
pumpkinseed	16	8							24	4.8
walleye		1			2		2		5	1
white sucker										
yellow bullhead	1	11	41	22					75	15
yellow perch										

Table B8: 2017 **Staring Lake** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead										
black crappie		13	5						18	3.6
bluegill	226	40							266	53.2
common carp				2	3				5	1
golden shiner										
green sunfish	26								26	5.2
hybrid sunfish										
largemouth bass										
northern pike								1	1	0.2
pumpkinseed	10								10	2
white crappie										
walleye										
white sucker					1				1	0.2
yellow bullhead		4							4	0.8
yellow perch	1								1	0.2

Table B9: 2017 **Lake Susan** fyke net data

Species	Number of fish caught in each category (inches)									
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	Total	Fish/Net
black bullhead	1								1	0.2
black crappie		122	6						128	25.6
bluegill	504	339							843	168.6
common carp					1	1			2	0.4
golden shiner										
green sunfish	13	2							15	3
hybrid sunfish		1							1	0.2
largemouth bass					3				3	0.6
northern pike								1	1	0.2
pumpkinseed	26	4							30	6
walleye						1			1	0.2
white sucker					1	1			2	0.4
yellow bullhead	1	14	91	23					129	25.8
yellow perch	1	2							3	0.6

Exhibit C

2017 Zooplankton Summary Data

Table C1: 2017 **Lake Riley** Zooplankton Counts (#/m²)

LAKE RILEY

DIVISION	TAXON	4/25/2017 #/m2	6/6/2017 #/m2	7/20/2017 #/m2	8/1/2017 #/m2	8/30/2017 #/m2
CLADOCERA	*Bosmina longirostris*	7,604	7,206	0	0	13,528
	Ceriodaphnia sp.	0	0	0	0	0
	Chydorus sphaericus	0	0	0	0	0
	Daphnia ambigua/parvula	0	0	0	0	0
	Daphnia galeata mendotae	152,081	50,443	38,683	8,400	40,585
	Daphnia pulex	26,614	0	38,683	0	0
	Daphnia retrocurva	0	0	23,210	0	27,056
	Diaphanosoma leuchtenbergianum	3,802	0	0	8,400	0
	Immature Cladocera	3,802	0	0	0	0
	Kindtti	0	0	0	0	0
	CLADOCERA TOTAL	**193,904**	**57,649**	**100,577**	**16,800**	**81,169**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	414,422	187,361	85,104	50,399	13,528
	Diaptomus sp.	136,873	64,856	15,473	8,400	101,461
	Nauplii	2,053,099	475,608	177,944	100,798	229,979
	Copepodid	0	0	0	0	0
	COPEPODA TOTAL	**2,604,394**	**727,824**	**278,521**	**159,597**	**344,968**
ROTIFERA	*Asplanchna priodonta*	15,208	144,124	317,205	0	0
	Brachionus sp.	0	0	7,737	0	0
	Filinia longiseta	19,010	0	0	0	0
	Lecane sp.	0	0	0	0	0
	Monostyla sp.	0	0	0	0	169,102
	Keratella cochlearis	1,809,769	187,361	317,205	713,987	412,609
	Keratella quadrata	828,844	7,206	7,737	0	6,764
	Kellicottia sp.	72,239	79,268	0	0	0
	Polyarthra vulgaris	22,812	79,268	123,787	16,800	6,764
	Trichocerca cylindrica	0	0	0	0	0
	Trichocera similis	0	0	0	0	0
	Trichocerca multicrinis	0	0	15,473	0	0
	Conochilus sp.	11,406	0	255,311	125,998	0
	Noltholca	3,802	0	0	0	0
	UID Rotifer	0	0	0	83,998	169,102
	ROTIFERA TOTAL	**2,783,089**	**497,227**	**1,044,454**	**940,783**	**764,342**
	TOTALS	**5,581,387**	**1,282,700**	**1,423,553**	**1,117,179**	**1,190,479**

Table C2: 2017 **Staring Lake** Zooplankton Counts (#/m²)

STARING

DIVISION	TAXON	4/25/2017 #/m2	6/7/2017 #/m2	7/6/2017 #/m2	8/1/2017 #/m2	8/29/2017 #/m2
CLADOCERA	*Bosmina longirostris*	93,371	1,188,534	30,107	64,546	87,535
	Ceriodaphnia sp.	0	49,869	80,285	177,502	175,070
	Chydorus sphaericus	199,474	41,557	40,142	112,956	80,241
	Daphnia ambigua/parvula	0	0	0	0	0
	Daphnia galeata mendotae	12,732	124,671	30,107	32,273	87,535
	Daphnia pulex	0	16,623	0	0	0
	Daphnia retrocurva	0	0	0	0	29,178
	Diaphanosoma leuchtenbergianum	0	0	30,107	48,410	87,535
	Immature Cladocera	0	0	0	0	0
	Kindtti	0	0	0	0	0
	CLADOCERA TOTAL	**305,577**	**1,421,254**	**210,748**	**435,687**	**547,095**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	560,225	124,671	200,712	32,273	167,776
	Diaptomus sp.	21,221	16,623	140,498	48,410	87,535
	Nauplii	432,901	897,634	873,097	274,321	437,676
	Copepodid	0	0	10,036	0	14,589
	COPEPODA TOTAL	**1,014,348**	**1,038,928**	**1,224,344**	**355,004**	**707,576**
ROTIFERA	*Asplanchna priodonta*	59,418	556,865	10,036	16,137	29,178
	Brachionus sp.	4,244	0	0	16,137	0
	Filinia longiseta	190,986	66,491	0	0	0
	Lecane sp.	4,244	0	0	0	0
	Monostyla sp.	0	91,426	70,249	96,819	43,768
	Keratella cochlearis	2,737,465	0	30,107	209,775	51,062
	Keratella quadrata	25,465	0	0	0	0
	Kellicottia sp.	59,418	216,097	0	0	0
	Polyarthra vulgaris	21,221	656,603	0	32,273	116,714
	Trichocerca cylindrica	0	0	0	0	0
	Trichocera similis	0	0	0	0	0
	Trichocerca multicrinis	0	0	0	0	7,295
	Conochilus sp.	0	49,869	0	0	0
	UID Rotifer	0	0	0	0	0
	ROTIFERA TOTAL	**3,102,460**	**1,637,351**	**110,392**	**371,140**	**248,016**

TOTALS	**4,422,385**	**4,097,532**	**1,545,483**	**1,161,831**	**1,502,688**

Table C3: 2017 **Lotus Lake** Zooplankton Counts (#/m²)

LOTUS LAKE

DIVISION	TAXON	4/25/2017 #/m2	6/7/2017 #/m2	7/19/2017 #/m2	8/2/2017 #/m2	8/30/2017 #/m2
CLADOCERA	*Bosmina longirostris*	135,282	15,915	71,797	42,441	99,472
	Ceriodaphnia sp.	0	0	0	0	0
	Chydorus sphaericus	39,789	7,958	53,847	14,147	0
	Daphnia ambigua/parvula	0	0	0	0	0
	Daphnia galeata mendotae	55,704	103,451	17,949	7,074	33,157
	Daphnia pulex	0	0	0	0	0
	Daphnia retrocurva	0	7,958	26,924	35,368	477,465
	Diaphanosoma leuchtenbergianum	0	0	35,898	70,736	72,946
	Immature Cladocera	0	0	0	0	0
	Kindtti	0	0	0	0	0
	CLADOCERA TOTAL	**230,775**	**135,282**	**206,415**	**169,765**	**683,040**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	572,958	0	116,669	134,398	145,892
	Diaptomus sp.	71,620	39,789	242,313	42,441	106,103
	Nauplii	1,221,514	183,028	834,635	148,545	1,279,871
	Copepodid	0	0	0	7,074	0
	COPEPODA TOTAL	**1,866,092**	**222,817**	**1,193,618**	**332,457**	**1,531,866**
ROTIFERA	*Asplanchna priodonta*	19,894	23,873	0	0	0
	Brachionus sp.	0	0	0	0	0
	Filinia longiseta	31,831	15,915	0	84,883	0
	Lecane sp.	0	0	0	0	0
	Monostyla sp.	0	0	0	0	0
	Keratella cochlearis	13,591,832	55,704	2,611,600	2,886,010	762,617
	Keratella quadrata	7,958	23,873	17,949	0	0
	Kellicottia sp.	1,169,789	0	376,932	219,280	1,094,190
	Polyarthra vulgaris	0	0	62,822	28,294	6,631
	Trichocerca cylindrica	0	0	0	0	0
	Trichocera similis	0	0	0	0	0
	Trichocerca multicrinis	0	0	8,975	49,515	0
	Conochilus sp.	23,873	1,734,789	26,924	35,368	0
	UID Rotifer	0	0	1,130,796	671,988	53,052
	ROTIFERA TOTAL	**14,845,177**	**1,854,155**	**4,235,997**	**3,975,337**	**1,916,491**
	TOTALS	**16,942,044**	**2,212,254**	**5,636,030**	**4,477,559**	**4,131,397**

Table C4: 2017 **Lake Susan** Zooplankton Counts (#/m²)

LAKE SUSAN

DIVISION	TAXON	4/25/2017 #/m2	6/8/2017 #/m2	7/19/2017 #/m2	8/2/2017 #/m2	8/30/2017 #/m2
CLADOCERA	*Bosmina longirostris*	49,736	3,758	0	0	11,318
	Ceriodaphnia sp.	0	0	0	0	0
	Chydorus sphaericus	27,631	0	0	0	0
	Daphnia ambigua/parvula	0	0	0	0	0
	Daphnia galeata mendotae	331,573	33,820	11,052	0	22,635
	Daphnia pulex	0	0	0	0	0
	Daphnia retrocurva	0	0	0	0	28,294
	Diaphanosoma leuchtenbergianum	0	0	33,157	28,471	22,635
	Immature Cladocera	0	0	0	0	0
	Kindtti	0	0	0	0	5,659
	CLADOCERA TOTAL	**408,940**	**37,578**	**44,210**	**28,471**	**90,541**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	629,988	90,188	71,841	21,353	107,518
	Diaptomus sp.	27,631	41,336	71,841	21,353	11,318
	Nauplii	828,932	263,048	298,416	234,886	333,872
	Copepodid	16,579	0	0	0	0
	COPEPODA TOTAL	**1,503,130**	**394,572**	**442,097**	**277,593**	**452,707**
ROTIFERA	*Asplanchna priodonta*	93,946	11,273	0	0	0
	Brachionus sp.	0	0	0	0	0
	Filinia longiseta	0	0	176,839	64,060	0
	Lecane sp.	0	0	0	0	0
	Monostyla sp.	0	0	0	0	0
	Keratella cochlearis	4,459,654	105,219	486,307	213,533	260,307
	Keratella quadrata	138,155	0	5,526	0	0
	Kellicottia sp.	132,629	33,820	0	0	11,318
	Polyarthra vulgaris	38,683	41,336	16,579	0	11,318
	Trichocerca cylindrica	0	0	0	0	0
	Trichocera similis	0	0	0	0	0
	Trichocerca multicrinis	0	0	0	14,236	5,659
	Conochilus sp.	0	0	22,105	21,353	0
	UID Rotifer	0	0	2,006,015	49,824	79,224
	ROTIFERA TOTAL	**4,863,068**	**191,649**	**2,713,371**	**363,006**	**367,825**
	TOTALS	**6,775,138**	**623,799**	**3,199,678**	**669,070**	**911,074**

Table C5: 2017 **Rice Marsh Lake** Zooplankton Counts (#/m²)

RICE MARSH

DIVISION	TAXON	6/20/2017 #/m2	7/6/2017 #/m2	8/3/2017 #/m2	8/29/2017 #/m2
CLADOCERA	*Bosmina longirostris*	0	8,223	1,213,822	1,358,918
	Ceriodaphnia sp.	278,521	49,338	505,759	24,934
	Chydorus sphaericus	0	82,230	44,254	62,336
	Daphnia ambigua/parvula	9,947	0	18,966	0
	Daphnia galeata mendotae	9,947	0	0	0
	Daphnia pulex	0	0	0	0
	Daphnia retrocurva	0	0	0	0
	Diaphanosoma leuchtenbergianum	0	8,223	25,288	12,467
	Immature Cladocera	0	0	0	43,635
	Kindtti	0	0	0	0
	CLADOCERA TOTAL	**298,416**	**148,014**	**1,808,089**	**1,502,290**
COPEPODA	*Cyclops sp. / Mesocyclops sp.*	0	32,892	208,626	130,905
	Diaptomus sp.	0	32,892	82,186	37,401
	Nauplii	258,627	707,178	2,977,656	660,758
	Copepodid	0	0	113,796	0
	COPEPODA TOTAL	**258,627**	**772,963**	**3,382,264**	**829,065**
ROTIFERA	*Asplanchna priodonta*	9,947	0	132,762	0
	Brachionus sp.	0	0	139,084	0
	Filinia longiseta	0	0	44,254	0
	Lecane sp.	0	0	6,322	0
	Monostyla sp.	0	24,669	37,932	6,234
	Keratella cochlearis	79,577	493,380	1,068,416	49,869
	Keratella quadrata	0	8,223	0	0
	Kellicottia sp.	0	0	0	0
	Polyarthra vulgaris	9,947	57,561	1,055,772	205,708
	Trichocerca cylindrica	0	0	0	0
	Trichocera similis	0	0	0	0
	Trichocerca multicrinis	0	0	0	0
	Conochilus sp.	387,940	468,711	410,929	0
	Euchlaris sp.	0	0	145,406	0
	UID Rotifer	0	0	0	0
	ROTIFERA TOTAL	**487,412**	**1,052,545**	**3,040,876**	**261,810**
	TOTALS	**1,044,454**	**1,973,521**	**8,231,228**	**2,593,165**

Exhibit D

2017 Phytoplankton Summary Data

Table D1: 2017 **Lotus Lake** Phytoplankton #/L

	6/7/2017	6/21/2017	7/19/2017	8/2/2017	8/30/2017
Class	**#/L**	**#/L**	**#/L**	**#/L**	**#/L**
Bacillariophyceae	175405	59422	347485	548722	34000
Chlorophyceae	462297	3786155	339493	447401	681250
Cryptophyceae	570811	1277941	1238947	64948	1412500
Crysophyceae	0	0	86842	111340	31250
Synurophyceae	0	0	243158	4639	12500
Euglenophyceae	0	0	0	1206	
Dinophyceae	16351	32353	34737	27835	550000
Eustigmatophyceae	0	0	0	4639	
Cyanophiceae	74225	97706	3057652	3178670	1650000
Xanthophyceae	0	0	0	0	500
Total	**1299089**	**5253577**	**5348314**	**4389400**	**4372000**

Table D2: 2017 **Staring Lake** Phytoplankton #/L

	6/20/2017	7/6/2017	8/1/2017	8/29/2017
Class	**#/L**	**#/L**	**#/L**	**#/L**
Bacillariophyceae	163819	347485	22982	13412
Chlorophyceae	724000	339493	1187064	22706
Cryptophyceae	781818	1238947	209876	1117647
Synurophyceae	3636	243158	10494	0
Cyanophiceae	1062091	3057652	4132050	697527
Dinophyceae	11454	34737	8605	2000
Xanthophyceae	43636	0	210	0
Crysophyceae	0	86842	31481	0
Euglenophyceae	0	0	105	2942
Total	**2790454**	**5348314**	**5602867**	**1856234**

Table D3: 2017 **Lake Riley** Phytoplankton #/L

	7/20/2017	8/1/2017	8/30/2017
Class	**#/L**	**#/L**	**#/L**
Bacillariophyceae	310636	21670	340188
Chlorophyceae	329454	36991	91958
Cryptophyceae	1368182	413242	2326316
Crysophyceae	45455	413242	13684
Synurophyceae	364	55435	274
Euglenophyceae	455	5040	0
Cyanophiceae	952726	1195680	2487654
Dinophyceae	54545	15321	54737
Eustigmatophyceae	0	5040	0
Total	**3061817**	**2161661**	**5314811**

Table D4: 2017 **Rice Marsh** Lake Phytoplankton #/L

	6/20/2017	7/6/2017	8/3/2017	8/29/2017
Class	**#/L**	**#/L**	**#/L**	**#/L**
Bacillariophyceae	1905429	414928	21637	6914
Chlorophyceae	206180	323878	101274	66914
Cryptophyceae	749063	3111341	505739	2962766
Euglenophyceae	184		17796	1595
Chrysophyceae	168906	247794	12804	191489
Synurophyceae	14688		6530	1276
Cyanophyceae	213062	340332	255047	117871
Dinophyceae	1469	105526	2304	638
Raphidophyceae	275	0	0	319
Eustigmatophyceae	0	0	1024	106
Xanthophyceae	0	0	128	0
Total	**3259256**	**4543799**	**924283**	**3349888**

Table D5: 2017 **Lake Susan** Phytoplankton #/L

	6/21/2017	7/19/2017	8/2/2017	8/30/2017
Class	**#/L**	**#/L**	**#/L**	**#/L**
Bacillariophyceae	79840	28979	60909	53105
Chlorophyceae	933932	410172	499396	3596048
Cryptophyceae	698703	1538298	159091	2944909
Synurophyceae	998	0	0	108624
Cyanophiceae	2600199	5655830	43937475	4978984
Dinophyceae	40519	13277	378788	39829
Euglenophyceae	0	108894	129394	0
Crysophyceae	0	63830	53030	0
Xanthophyceae	1397	0	0	0
Total	**4355588**	**7819280**	**45218083**	**11721499**

Exhibit E

2017 Creek Assessments

Riley Creek Assessment

Rice Marsh Lake to Lake Riley

Conducted by: RPBCWD staff [Josh Maxwell, Zach Dickhausen] and University of MN volunteers

Summary

Site/Scope

On the 28th of November 2016, and continuing on the 17th of November 2017, Riley Purgatory Bluff Creek Watershed District (RPBCWD) staff conducted a stream corridor assessment of Reach R3 of Riley Creek. On the 28th of November 2016, staff started at Rice Marsh Lake and walked to 85ft downstream of highway 212 (approximately 0.2 stream miles). The walk continued in 2017 on the 17th of November, starting 85ft downstream of highway 212 before ending at Lake Riley (approximately 0.93 stream miles). Staff walked both sides of the creek to assess overall stream conditions and to discover and prioritize possible restoration locations. Staff conducted a Modified Pfankuch Channel Stability Assessment and a Minnesota Pollution Control Agency (MPCA) Stream Habitat Assessment (MSHA) on each subreach to better characterize the stream. A GPS, and a GPS-enabled camera were used to mark points and take photos.

- All pictures were taken <u>Facing Downstream</u> unless noted otherwise.
- <u>Right</u> and <u>Left</u> bank are defined by looking <u>Downstream</u>.
- Erosion was defined as <u>Slight</u>, <u>Moderate</u>, or <u>Severe</u>.
- <u>Stream Bank Erosion</u> was measured from the streambed to the top of the eroding bank.
- Vegetation was defined as <u>Sparse</u>, <u>Patchy</u>, or <u>Dense</u>.
- All measurements were recorded in <u>Feet</u>.
- All major erosion sites were labeled on the GPS by the erosion site number and reach.

Weather Conditions

11/28/2016	11/17/2017
Wind: NA	Wind: 2mph
Temp: NA	Temp: 5.4°C
Cloud Cover: NA	Cloud Cover: 100%

Stream Features

This reach starts in wetlands at the edge of Rice Marsh Lake and then passes through deciduous forest, residential areas, and a golf course before ending at Lake Riley. Riparian widths along both banks averaged about 90ft. The substrate in this reach consisted mainly of sandy mixtures (sand/silt and sand/gravel) with areas of moderate to heavy deposition of silt/silty mixtures. Slope gradients in this reach ranged from less than 10% or flat, to 45%. The first stretch of the reach (R3A) was not very sinuous, but the stream became very sinuous once reaching the wetland area around the golf course (R3B). The channel development (riffle/run/pool), for the most part, was poor-to-fair, except for subreach R3C, in which development was good.

Areas of Concern

There was little-to-moderate erosion along both banks throughout the reach. Subreach R3D exhibited some heavy erosion along both banks, which caused Pfankuch scores to shift to poor/moderately unstable. R3D also had a degraded stormwater culvert along the right bank exhibiting considerable erosion. The R3D riparian zone was less than 16ft, and non-existent in some areas (there were several areas where grass was mowed down to the edge of the stream). MSHA scores were fair for R3A and R3D due to increased siltation, but subreaches R3B and R3C received good scores. No major infrastructure risks or severe mass wasting sites were observed in this reach.

Subreach R3A - Rice Marsh Lake to 85ft Downstream of Highway 212

MSHA: 42.5 (Fair); Pfankuch: 71 (Moderately Stable)

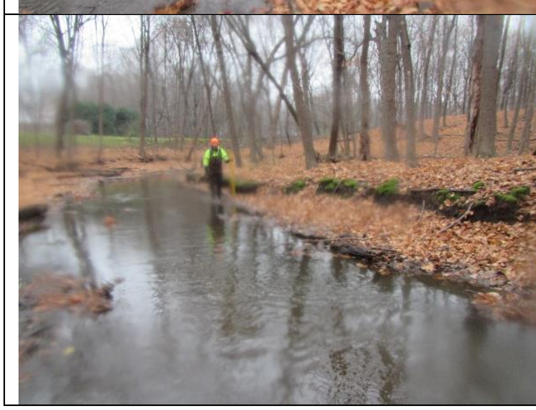
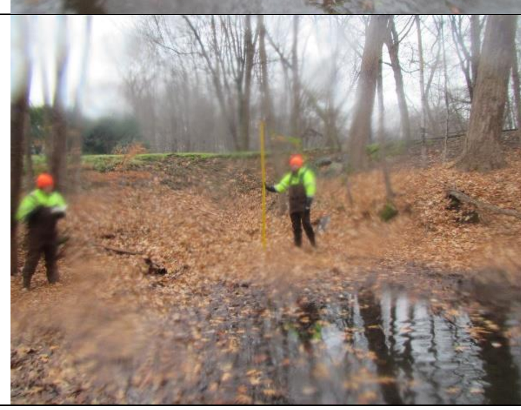
Staff began the creek walk at the south side of Rice Marsh Lake at the outlet of the lake to Riley Creek. The landscape surrounding outlet was full of emergent vegetation, lots of cattails, wetland sedges and grasses, as well as some woody vegetation (small, sparsely growing shrubs). Staff observed submersed vegetation in the creek as well (broadleaf pondweed, curly leaf pondweed, duckweed), along with filamentous algae. The surrounding landscape was very flat, virtually no grade existed within the first few hundred feet. Staff encountered some woody debris throughout the wetland stretch of the subreach which increased in magnitude as staff moved downstream. The channel was rather wide and shallow for a majority of the subreach. Most of the subreach was a glide with little-to-no channel development (riffle/run/pool). The sediment was very soft, silt/clay mixture. Approximately 70ft upstream of the recreational trail bridge, some relatively minor cutting/erosion occurred along the left bank. Just upstream of the bridge, staff observed a woody debris dam backing up the stream and boulders had been placed under the bridge to prevent erosion. Downstream, staff found some broadleaf pondweed in the stream. At this point, the channel narrowed a bit. The sediment remained very soft, predominantly a silt substrate. Underneath the 212 overpasses, a large amount of riprap was concentrated along both banks to prevent erosion. In addition, multiple artificial rock riffles had been created to add structure within the stream flow. The substrate in areas without the cobble was very mucky/silty and staff easily sunk into it. Staff ended this subreach 85ft downstream of the overpass.

Subreach R3B - 85ft Downstream of the Highway 212 Overpass to the North end Bearpath Golf Course

MSHA: 54.75 (Good); Pfankuch: 87 (Moderately Unstable)

This creek walk was a continuation of the creek walk started on the 11th of November 2016. Staff began this creek walk 85ft downstream of the Highway 212 overpass. The landscape within this subreach included forest and residential land-use types. Large oaks and a few smaller trees made up most of the forest canopy. Groundcover was very sparse; leaf litter covered much of the forest floor at the time of the assessment. The slope of the surrounding landscape was moderate, reaching grades up to 50%, but staying mostly around 30%. Houses were set back about 50ft to 100ft from both banks of the stream. Staff observed moss growing along a large proportion of both stream banks within the subreach (IMG_2155), which helped to protect the upper and lower banks from eroding. There was also a fair amount of woody debris within the stream. This subreach was sinuous, but the channel development was poor (riffle/run/pool).

Towards the beginning of the subreach, staff observed some erosion measuring up to 5ft high by 30ft along the right bank (IMG_2157). There were boulders in and along the channel throughout the start of the subreach (IMG_2157). The substrate was primarily composed of gravel and sand, with some silt occurring in the few pooling areas, and some cobble present within the riffles. Just downstream there was another stretch of erosion along the right bank, measuring 4ft high by 20ft (IMG_2158). Staff continued to see woody debris in-stream, including a small woody debris dam (IMG_2159). At this point there was some more erosion along the left bank measuring 3.5ft high (IMG_2159, IMG_2160). Continuing downstream, staff observed a stretch of cutting measuring 0.25ft high which was continuous along the right bank (IMG_2161). However, due to the presence of moss, the right bank was stable, despite the continuous cut bank. The stream then came up to a culvert under a driveway along the outside bend of the left bank as it shifted south (IMG_2162). The culvert was nearly full of sediment and the immediate sediment as seen in IMG_2163 was extremely soft muck/silt. The stream channel then shifted south and there was yet another stretch of erosion along the left bank, 3ft high by 30ft (IMG_2163). A considerable amount of sandy/silt deposition can also be seen in IMG_2163 on the opposing right bank. The stream at this point was 0.94ft deep by 11ft wide. At the start of the Bearpath golf course, staff encountered another woody debris dam (IMG_2165) which was causing some erosion measuring 3ft high by 10ft along the left bank. The golf course was adjacent to the left bank at this point; the grass was mowed to the stream edge (IMG_2165). Staff observed one final patch of erosion on the right bank before entering the next subreach (IMG_2166). The stream at this point measured 1.24ft deep by 6.4ft wide.

	**IMG_2155** General stream picture.		**IMG_2156** General stream picture.
	**IMG_2157** Erosion, 5ft by 30ft, RB.		**IMG_2158** Erosion, 4ft by 20ft, RB.
	**IMG_2159** Woody debris dam; bank erosion, LB.		**IMG_2160** Erosion, 3.5ft high, LB.
	**IMG_2161** General erosion, 0.25ft high, RB; moss on banks.		**IMG_2162** Culvert entrance under driveway on LB.

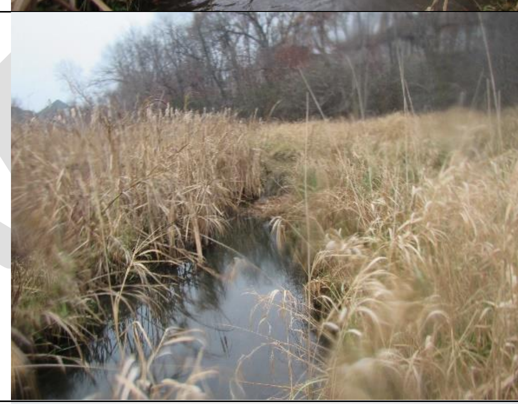
	**IMG_2163** General stream picture; erosion measuring 3ft high by 30ft, LB.		**IMG_2164** General stream picture.
	**IMG_2165** Woody debris dam causing erosion, 3ft by 10ft, LB.		**IMG_2166** Erosion near end of subreach, RB.

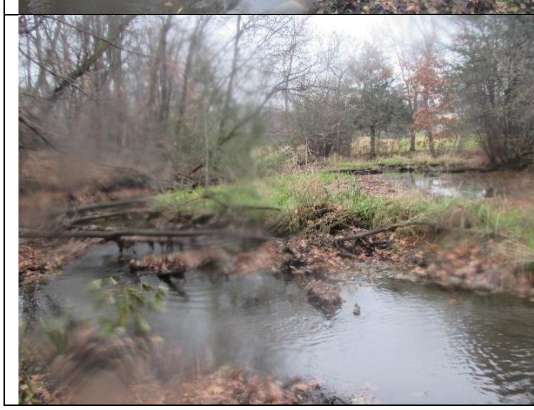
Subreach R3C - North End of Bearpath Golf Course to 260ft Upstream of Bearpath Trail MSHA: 50 (Fair); Pfankuch: 73 (Moderately Stable)

This subreach started at the north end of Bearpath Golf Course and had surrounding land slopes with grades less than 5% throughout its entirety. Wetland vegetation, mainly tall sedges and cattails surrounded the immediate banks. The golf course was setback 3ft to 7ft back from the left bank for the first 150ft before the meandering south into a thicker wetland area surrounding a large pond. The golf course was set back 30ft to 45ft along the last 260ft of the subreach. There was limited channel development (riffle/run/pool) in this subreach; it was mostly one continuous glide upstream and downstream of the pond. The channel was typical of a wetland stream as it was deep and narrow throughout the subreach. The channel was also very sinuous and there was little erosion throughout. The vegetation surrounding the channel was made up of primarily wetland and emergent plants, cattails, and wetland sedges and grasses (IMG_2167, IMG_2169, IMG_2170). The substrate within the channel consisted mainly of silt and sand throughout the reach. Staff did encounter mucky sediment in some areas.

About 260ft into the subreach, staff came upon a hairpin turn in the creek which bent right. There was a large deposition zone long the right bank here. Bank-full was measured at this point, approximately 22ft wide by 1.8ft deep. Continuing, the wetland area adjacent to the channel became thicker with tall grasses and the beginning of cattail stands (IMG_2168, IMG_2169). In this area, ponding within the riparian zone was frequent due to the low landscape slopes/floodplain. Bank-full was again measured; it narrowed, measuring approximately 11ft wide by 2.7ft deep. Staff observed some vegetation growing in-stream at this point that appeared to be sago pondweed (IMG_2171). The stream then entered the large ponded wetland area which covered about 2.13 acres (IMG_2172).

Staff walked along the pond to access the stream at the pond's outlet (IMG_2173). About 250ft downstream of the pond was a wooden walking/golf cart bridge crossing the stream (IMG_2174). The channel was deeper and much wider after the ponded wetland area (the surrounding riparian zone was ponded in several areas) but narrowed after the walking bridge. Immediately downstream of the bridge, staff observed a large grass/sedge island in the channel measuring 75ft long by 20ft wide (IMG_2175). Continuing downstream, the surrounding land-type began to shift to from grassy wetland back to mixed grass/forest (IMG_2176). Staff observed a large cement structure (IMG_2176) set back about 15ft from the left bank; its purpose was not identified. At this point, the golf course was set back about 15ft to 45ft from the right bank, and houses were set back about 90ft to 120ft from the left bank. The channel was still very connected to the floodplain at this point with small, isolated ponds being common along the channel. With an increase in canopy cover came an increase in woody debris within the stream with multiple piles of woody debris present (IMG_2178, IMG_2179). Near the second woody debris pile, a smaller riffle was present which was one of the few present in this subreach. The riffle then emptied into a deeper pool which measured 2.3ft in depth. Just downstream of the riffle and pool, erosion was observed on the left bank, measuring 2ft high and stretching for about 100ft (IMG_2181). Staff then found a dumpsite containing organic yard waste on the left bank behind a residence (IMG_2182). The stream then transitioned back to a grassy wetland landscape for about 210ft before the wooden walking/gulf cart bridge at the end of the subreach (IMG_2183). The stream was very connected to the floodplain at the bridge with ambiguous stream/channel edges. The in-stream sediment was very mucky just upstream of the bridge.

	**IMG_2167** General stream picture; golf course in background.		**IMG_2168** General stream picture; narrow, deep channel; cattails starting.
	**IMG_2169** Wetland grasses and sedges, LB.		**IMG_2170** Stream dispersed into wetland.
	**IMG_2171** In-stream vegetation.		**IMG_2172** Stream entering a large, ponded wetland.

	**IMG_2173** Stream DS of pond.		**IMG_2174** Wooden walking/golf cart bridge across stream.
	**IMG_2175** Grass/sedge island, 75ft by 20ft; US.		**IMG_2176** Large cement structure; LB.
	**IMG_2177** General stream picture.		**IMG_2178** Woody debris.
	**IMG_2179** General stream picture; woody debris.		**IMG_2181** Erosion on LB, 2ft high by 100ft.

IMG_2182

Yard waste dump site, LB.

IMG_2183

Walking/cart bridge across stream; mucky sediment; end of subreach.

Subreach R3D - 260ft Upstream of Bearpath Trail to 250ft Downstream of Bearpath Trail MSHA: 66.7 (Good); Pfankuch: 65 (Very Stable)

This subreach started at the walking bridge/cart path just north of Bearpath Trail (IMG_2184). The surrounding landscape contained a higher slope gradient than subreach R3C. At the beginning of the subreach, slope grades were estimated at 20% to 30%; these grades lessened to below 10% in the last quarter of the subreach. The surrounding landscape was mostly deciduous forest with moderate shrub cover. Ground cover was patchy; some areas were bare, while others had a considerable amount of cover. The substrate within the stream was made up predominantly of sand and gravel, with boulders and some cobble in the riffles. This subreach had good channel development (riffle/run/pool), improving from the previous subreach. The subreach also had excellent sinuosity. Houses were set back 30ft to 60ft from both banks.

Staff encountered a fair amount of woody debris immediately following the start of the subreach (IMG_2184). Like the previous subreach, vegetation was observed growing in-stream. Upon construction of the Bearpath Trail bridge, a large amount of riprap was placed for bank stabilization (IMG_2185). Addit6ionl boulders were placed for bank protection and used to create an artificial riffle downstream of the bridge as well (IMG_2186, IMG_2187). About 45ft downstream of the bridge, staff observed some exposed erosion blankets on the right bank behind the boulders (IMG_2187). Continuing downstream, a plugged stormwater culvert was found on the right bank which was causing some minor erosion (IMG_2188). Following the District's regular creek sampling site (R3), the surrounding slopes began to flatten out. Staff observed some erosion and undercutting along the left and right banks that measured 1ft high and continued for 50ft as the stream shifted south (IMG_2189). Staff ended this subreach at the walking bridge/cart path seen in IMG_2190. The stream widened for a short stretch here before narrowing again.

IMG_2184

General stream picture; woody debris.

IMG_2185

Bearpath Trail.

	**IMG_2186** Boulder riffle; boulders placed for bank stabilization.		**IMG_2187** Boulder riffle; exposed erosion blanket, RB.
	**IMG_2188** Stormwater culvert causing minor erosion, RB.		**IMG_2189** Erosion along left bank, 1ft by 50ft.
	**IMG_2190** Walking bridge/cart path over stream; end of subreach.		

Subreach R3E - 250ft Downstream of Bearpath Trail to Lake Riley

MSHA: 40.1 (Fair); Pfankuch: 87 (Moderately Unstable)

This subreach started at the cart path just downstream of Bearpath Trail. This subreach was short, and it was surrounded primarily by the golf course and wetland grasses and sedges before it crossed Riley Lake Road. The riparian width was very narrow, about 15ft or less throughout. This subreach exhibited a great deal of erosion along both banks which was affecting stability. The predominant substrate types were sand and silt; the riffles contained some gravel. Although sinuosity was very good, channel development (riffle/run/pool) was graded as fair because of limited riffles present. There were spots where the golf course lawn was mowed to the bank edge which reduced bank stability (IMG_2195, IMG_2198). The slopes of the immediate upper banks were high (entrenched) but flattened out just a few yards beyond the upper bank tops.

Staff observed more instream vegetation growing at the start of this stretch. Immediately downstream of the bridge, staff encountered a heavily clogged stormwater culvert on the right bank (IMG_2191) which was suspended 3ft from the stream bed and was undercut 3.5ft (IMG_2191). Downstream of the culvert, there was considerable silt deposition in the stream and along the right bank as seen in IMG_2192. As the stream turned east, there was a stretch of erosion along the outside bend of the right bank measuring 3ft high by 100ft long (IMG_2193). This erosion reached past the next wooden bridge/cart path (IMG_2194). Downstream of the bridge was another stretch of erosion along the left bank measuring 2ft high by 20ft (IMG_2195). At this point, the riparian zone was non-existent; the top of the bank was sparsely covered by patchy, mowed grass (IMG_2195). The next length of erosion staff observed was on the left bank, measuring 4.5ft high by 40ft as the stream shifted south, heading towards Riley Lake Road (IMG_2196). The right bank was eroding as well, the erosion measuring 2.5ft by 30ft (IMG_2197). There were more silt deposits observed here along the left bank (IMG_2198). Just past the deposition, the outside bend of the left bank was bare and looked unstable (IMG_2198). The stream shifted south, and staff observed the culvert underneath Riley Lake Road (IMG_2199). Staff crossed Riley Lake Road and ended the walk at Lake Riley (IMG_2200, IMG_2201).

	**IMG_2191** Stormwater culvert suspended 3ft and undercut 3.5ft, RB, US.		**IMG_2192** Silt deposition DS of culvert.
	**IMG_2193** Erosion 3ft high by 100ft, RB.		**IMG_2194** Walking bridge/cart path; erosion, RB.
	**IMG_2195** Erosion 2ft high by 20ft, LB; grass mowed to channel.		**IMG_2196** Erosion 4.5ft by 40ft, LB.

	**IMG_2197** Erosion 2.5ft by 30ft, RB.		**IMG_2198** Silt deposition and bare banks, LB.
	**IMG_2199** Culvert under Riley Lake Road.		**IMG_2200** DS side of culvert under Riley Lake Road.
	**IMG_2201** Lake Riley, end of reach.		

Purgatory Creek Assessment

Powers Blvd to Lotus Lake

Conducted by: RPBCWD staff [Josh Maxwell] and University of MN volunteers

Summary

Site/Scope

On the 1st and 3rd of November 2017 at 14:56 and 12:35 (respectively), Riley Purgatory Bluff Creek Watershed District (RPBCWD) staff conducted a stream corridor assessment of Reach PT2 of Purgatory Creek. On the 1st of November, staff started at Lotus lake and walked upstream to just south of Carver Beach Road and Big Woods Blvd. On the 3rd of November, staff started at the recreation trail next to the pond just south of Butte Court and walked downstream to just south of Carver Beach Road and Big Woods Blvd. Subreach PT2A consisted of the pond which begins at Powers Blvd and ends at the recreation trail just south of Butte Court. Staff walked both sides of the creek to assess overall stream conditions and to discover and prioritize possible restoration locations (approximately 0.77 stream miles). Staff conducted a Modified Pfankuch Channel Stability Assessment and a Minnesota Pollution Control Agency (MPCA) Stream Habitat Assessment (MSHA) on each subreach to better characterize the stream. A GPS, and a GPS-enabled camera were used to mark points and take photos.

- All pictures were taken <u>Facing Downstream</u> unless noted otherwise.
- <u>Right</u> and <u>Left</u> bank are defined by looking <u>Downstream</u>.
- Erosion was defined as <u>Slight</u>, <u>Moderate</u>, or <u>Severe</u>.
- <u>Stream Bank Erosion</u> was measured from the streambed to the top of the eroding bank.
- Vegetation was defined as <u>Sparse</u>, <u>Patchy</u>, or <u>Dense</u>.
- All measurements were recorded in <u>Feet</u>.
- All major erosion sites were labeled on the GPS by the erosion site number and reach.

Weather Conditions

11/1/2017	11/3/2017
Wind: 5mph	Wind: 0mph
Temp: 3.5°C	Temp: 5.1° C
Cloud Cover: 100%	Cloud Cover: 100%

Stream Features

Tributary PT2 passes through deciduous forest and residential areas, beginning at the pond on the east side of Powers Blvd and ending at Lotus Lake. The substrate in this reach consisted mainly of sand mixtures. Several sections of the subreaches had gravel mixed with sand, while others had a mixture of silt and sand. There were multiple stretches within PT2D that contained large boulder riffles and had streambanks lined with different size rock. Subreach PT2C had a piped channel with interstitial surface water flow. Slope gradients within this reach were predominantly between 30% and 40%. The majority of subreach PT2C contained gradients predominantly between 0% and 5%. This reach was not very sinuous. Except for PT2D, which had good channel development (riffle/run/pool) throughout most of the subreach, this tributary had poor development.

Areas of Concern

There were two areas exhibiting mass wasting within this reach. One was in subreach PT2D, measuring about 15ft tall by 20ft wide. The other was located in PT2B where a stormwater culvert on the left bank was severely eroded and created a large scour hole. The lower quarter of PT2D was very incised 3-5ft. Landscaping rock was utilized in this section to stabilize the banks (often failing) and "beautify" the stream. Above the rock, banks were mowed to the edge and/or planted with hostas etc. PT2A was not scored because it was a pond. PT2B was very silted and was incised 3-4 feet. PT2C was a restored by the city of Chanhassen and looked good.

Subreach PT2D - Lotus Lake to Walking Trail South of Carver Beach Road and Big Woods Blvd MSHA: 53.3 (Good); Pfankuch: 86 (Moderately Unstable)

Staff began the creek walk at Lotus Lake and walked upstream (all photos taken upstream unless noted otherwise). While accessing the creek from Shadowmere Drive, staff observed a large stormwater pond just south of the creek, which collected runoff from the cul-de-sac. The pond had a large overflow structure that drained to the creek (IMG_2075). Staff noticed trash and debris around this pond as well as erosion around the inlet pipe entering the pond. The channel was surrounded by deciduous forest, but the riparian width was initially narrow, 0-15ft from residential properties along both banks. This changed about half way through the subreach, when the riparian width along the left bank increased to 30-150ft. Initially, the slope gradients of both banks were flat, but quickly increased to include slope gradients greater than 10%. Just upstream of Lotus, a walking bridge spanned the stream, joining the two adjacent properties (IMG_2076). Leaf litter was the predominant substrate throughout the subreach at the time of the creek walk. Boulders were placed along both stream banks, from the lake to upstream of the bridge, to reduce erosion. The adjacent properties had mowed lawns down to the stream edge (IMG_2077, IMG_2078). After the boulders, there was a check dam with landscape fabric covering it in the stream (IMG_2078). Upstream of the check down was a large sand/gravel deposition island just beneath the stormwater pond outlet culvert (IMG_2079). The outlet culvert itself was undercut, exposing an erosion blanket, and was clogged with detritus (IMG_2080).

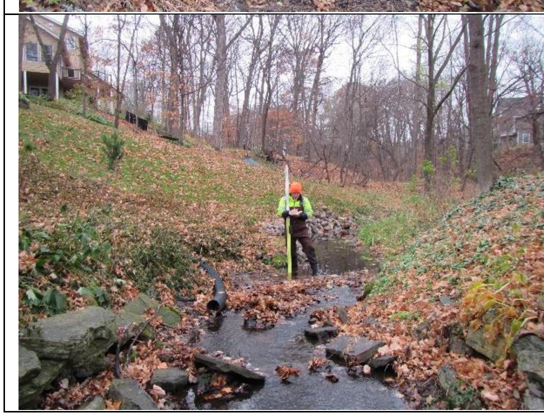
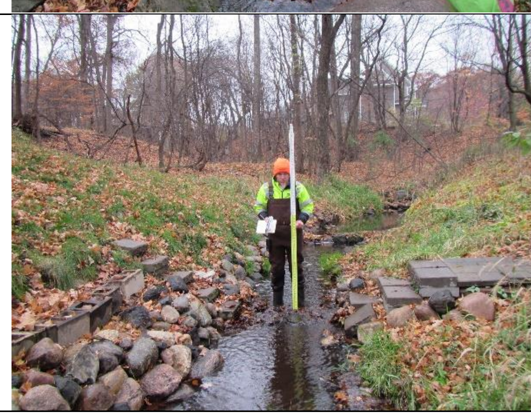
	**IMG_2075** Stormwater pond off Shadowmere Drive.		**IMG_2076** Bridge just US of Lotus.
	**IMG_2077** Bridge US of Lotus; lawns mowed to creek edge.		**IMG_2078** Placed boulders lining creek banks; check dam, US.

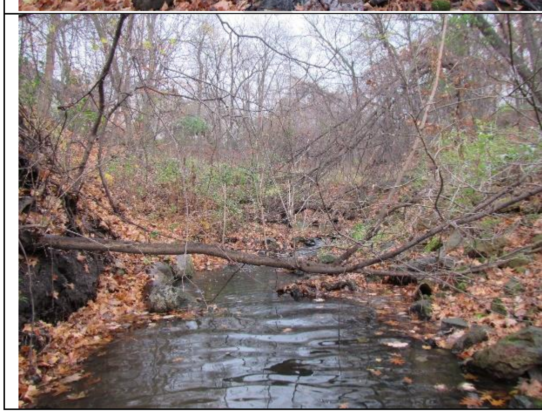
	**IMG_2079** Deposition island of sand and gravel; SW culvert on RB, US.		**IMG_2080** SW culvert from pond; undercut and clogged with debris; RB, US.

Continuing upstream, staff observed continuous erosion on the left bank, measuring up to 3ft high (IMG_2081). The in-stream sediment to this point consisted of gravel/sand in the riffles, sand/gravel in the runs, and sand/silt in the pools. Staff then encountered another bridge, made of large logs and boards (IMG_2082). Underneath the bridge there was significant undercutting occurring around the footings. After the bridge, the right bank was eroded, measuring about 6ft high, and was covered with an erosion blanket (IMG_2083). The channel around this section measured about 0.2ft deep and 4ft wide. Further upstream, staff observed erosion on the left bank measuring up to 4ft high stretching for 20ft (IMG_2085). At this point, there was some chain link fencing in the stream that may have been used to help stabilize the bank (IMG_2084). Upstream of the fencing, a resident had placed flat rock along both banks which was sloughing into the creek in some locations (IMG_2086). Hostas lined the upper banks above the rock and with bare soil beneath them. A third wooden walking bridge spanned the channel at this point (IMG_2086). At the next property line, there were three plastic drain pipes entering the stream from adjacent homes on the right bank (IMG_2087).

At this point, the bank slope gradient became more variable; some slopes reached gradients steeper than 40%. Moving upstream, there was a man-made stream crossing with stairs made from pavers (IMG_2088). The pavers were in-stream and restricting flow. Just upstream of the crossing was a small boulder check dam (IMG_2088). Upstream of the check dam was a large rock riffle (IMG_2089). The riparian width increased about 50ft on both sides. The stream turned south, and staff observed another check dam (IMG_2090). There was a stormwater culvert and a small, black, plastic drainage pipe entering the channel on the left bank (IMG_2090). North of the stormwater culvert was a large pond that was separated from the creek by a narrow berm. Erosion measuring up to 3ft high extended 30ft upstream from the culvert (IMG_2090). Continuing upstream, the left bank gradient increased, reaching slopes of 60% to 70%, while the right bank flattened (less than 5%, IMG_2091). There was also erosion along the left bank, measuring 1.5ft high (IMG_2091). The riparian zone then increased in size along both banks. Staff started to observe horse tail reed in large densities lining both banks (IMG_2091). Staff soon encountered the first mass wasting site observed in this tributary on the left bank, measuring 15ft tall by 20ft (GPS point: PT2DE1, IMG_2092). The estimated bank-full measurement at this point was 2ft deep by 9ft wide.

Continuing upstream, there was a former channel setback from the left bank. Just upstream, erosion was occurring on the right bank measuring 5ft high by 20ft (IMG_2093, IMG2094). Woody debris increased moving upstream (IMG_2095). There was also a manhole access point on the left bank (IMG_2096). Across the stream from the manhole cover was some erosion around a fallen tree's roots, measuring 5ft high by 20ft (IMG_2097). The estimated bank-full at this point was 2.2ft deep by 10ft wide. Continuing upstream, a remnant channel was observed along the right bank next to a large boulder riffle within the channel (IMG2_098). Further upstream, there was a stretch of erosion measuring 3ft to 5ft high along the RB, opposite a hard-armored left bank (IMG_2100). Staff noticed another black, plastic drainage pipe on the right bank (IMG_2101). At this point, the stream shifted north, and the outside bend of the right bank was lined with large boulders. The boulders on the downstream end of the placement had fallen into the stream and large amount of erosion was occurring on the right bank above them (IMG_2102).

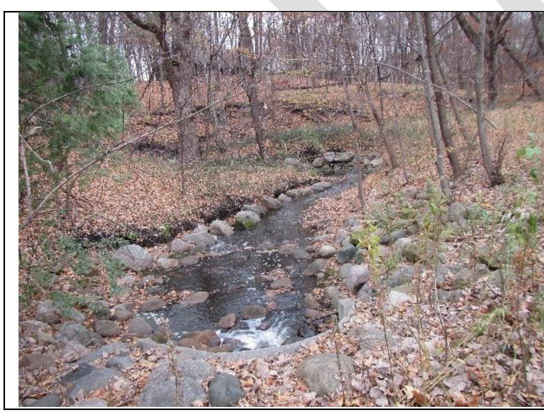
	**IMG_2081** Continuous, 3ft erosion, LB, US.		**IMG_2082** Log bridge over creek, US.
	**IMG_2083** Erosion covered by erosion blanket; RB, US.		**IMG_2084** Wire fencing in stream; US.
	**IMG_2085** Erosion on LB.		**IMG_2086** Rock lining stream; hostas on banks; 3rd bridge across stream; US.
	**IMG_2087** Plastic drain pipes; RB, US.		**IMG_2088** Man-made stream crossing; boulder check dam; US.

	**IMG_2089** Large rock riffle; US.		**IMG_2090** Large rock riffle; black pipe and SW culvert entering channel on LB; US.
	**IMG_2091** Native vegetation; increased slope gradient on LB; US.		**IMG_2092** Mass wasting site PT2DE1; LB, US.
	**IMG_2093** Former channel, LB; US.		**IMG_2094** Erosion 5ft by 20ft, RB; US.
	**IMG_2095** Woody Debris; US.		**IMG_2096** Manhole access, LB; US.

	**IMG_2097** Erosion 5ft by 20ft, RB; US.		**IMG_2098** Large boulder riffle; remnant channel, RB; US.
	**IMG_2100** Erosion 3ft to 5ft high, RB; hard-armored RB; US.		**IMG_2102** Erosion, RB; large boulders in—stream; US.

PT2D Continued (11/3/2017)

The continuation of the walk of this subreach started at the culvert under the walking path just south of South of Carver Beach Road and Big Woods Blvd (IMG_2146). From here, staff walked downstream towards where they had previously left-off. The stream, out of the culvert, was very sinuous and there were many large boulders placed along the banks for erosion protection (IMG_2146, IMG_2148). Pools in this section measured up to 1.5ft deep. Staff noticed horse tail reeds and other native emergent vegetation growing in the riparian zone. As the channel shifted south, staff observed a failed boulder placement on the left bank with erosion occurring (IMG_2149). After a straight stretch (IMG_2150) staff observed two rock/debris riffles (IMG_2151), followed by some erosion on the outside bend of the right bank, measuring 4ft high by 20ft (IMG_2152). This was just before the hard-armoring began along the right bank, where staff stopped the previous creek walk.

	**IMG_2146** Culvert under walking path.		**IMG_2148** Riprap along banks, LB.

	**IMG_2149** Failed riprap/ boulder placement, LB.		**IMG_2150** General stream picture.
	**IMG_2151** Two rock/debris riffles.		**IMG_2152** Erosion 4ft high by 20ft, RB.

Subreach PT2B - Recreation Trail Next to Pond South of Butte Court to Kerber Blvd MSHA: 41.8 (Fair); Pfankuch: 95 (Moderately Unstable)

Staff started this walk at the walking trail on the east side of the pond (IMG_2105) just south of Butte Court. This subreach had low and interstitial flows. Within the first third of the subreach, the riparian zone ranged from 15ft to 30ft on both sides. The surrounding vegetation was made up of deciduous (oaks, maple, birch) forest bordered by residential properties on the south side, and mowed, open parkland on the northwest side. Most of the slope gradients throughout the subreach were between 30% and 50%. The creek bed at the start of the subreach was piped underground. Above ground, there were four backyards with gardens, dump sites, and compost bins. (IMG_2106, IMG_2107, IMG_2109, IMG_2110). Approximately 45ft downstream, the channel was daylighted. After the creek was daylighted, the riparian zone on the left bank widened to 75ft. Staff did not locate the culvert; it was buried under a large pile of woody debris, some natural, some dumped (IMG_2111). The ground cover was sparse-to-absent beneath the blanketing leaf litter.

Where the stream started flowing, the left bank was incised 3ft to 6ft high, stretching for about 100 yards (IMG_2112). The sediment in this subreach was predominantly a silt and sand mixture, some areas containing gravel (IMG_2113) Gravel and sand were the predominant substrate in the riffles. Staff also observed boulders sparsely located in and along the channel throughout the subreach. There was a lot of woody debris and detritus throughout the subreach (IMG_2114). Continuing downstream, the stream was incised 4ft to 5ft high for 100ft on the left bank (IMG_2114) and for 50ft on the right bank. Most of the soil around the creek and on the banks was bare, with limited vegetative cover. Staff then walked a stretch of creek that was rather straight, with a very low, wide channel (IMG_2115). The creek shifted south. There was a large woody debris pile just upstream of a small, wooden walking bridge crossing the channel (IMG_2116). Just after the bridge, staff observed another woody debris jam which was creating a mini waterfall (IMG_2117); there was also erosion along the right bank measuring 0.8ft high (IMG_2117).

	**IMG_2105** Pond at start of subreach PT2B; US.		**IMG_2106** Start of creek; garden area of residents.
	**IMG_2107** Compost bins next above ground drainage, LB.		**IMG_2109** Dump pile/yard waste.
	**IMG_2110** Large dump site/wood pile blocking stream.		**IMG_2111** Creek bed, no water.
	**IMG_2112** Start of stream flow; erosion on RB, 3ft to 6ft high for 100yd.		**IMG_2113** In-stream sediment: silt/sand/gravel.

	**IMG_2114** Erosion 4ft to 5ft high for 100ft, LB.		**IMG_2115** General stream picture; low-interstitial flow/level.
	**IMG_2116** Large woody debris pile US of small wooden bridge over stream.		**IMG_2117** Large woody debris dam; small waterfall with 0.8ft of erosion, RB; US.

Continuing downstream, there was an old stormwater culvert on the right bank (IMG_2118). Staff observed a large pile of riprap in the channel (IMG_2119) where a metal stormwater pipe entered the stream from the left bank. The culvert had eroded all the surrounding sediment and had fallen into the stream causing a very large scour hole. An eroding ravine had formed above the culvert measuring up to 6ft high (GPS point: PT2BE1, IMG_2121, IMG_2122). This site was the creek's main source of water at the time of the creek walk; the pool depth here measured 2.9ft (IMG_2121). The site in IMG_2121 was another erosion site on the outside bend of the left bank, measuring 6ft high by 12ft (IMG_2123). The stream at this point was 0.5ft deep by 3ft wide. Just upstream of the end of the subreach was a small, partially eroded ravine on the left bank (IMG_2125). When staff reached the end of the subreach, at Kerber Blvd, the culvert under the road was almost completely blocked by debris (IMG_2126, IMG_2127). There was an access structure located above the culvert (IMG_2128).

	**IMG_2118** Old stormwater culvert, RB.		**IMG_2120** Large pile of riprap in stream.

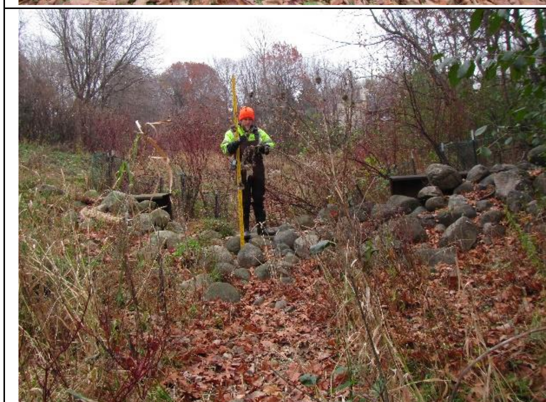
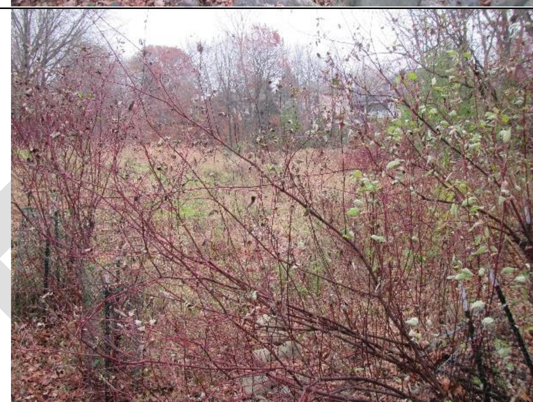
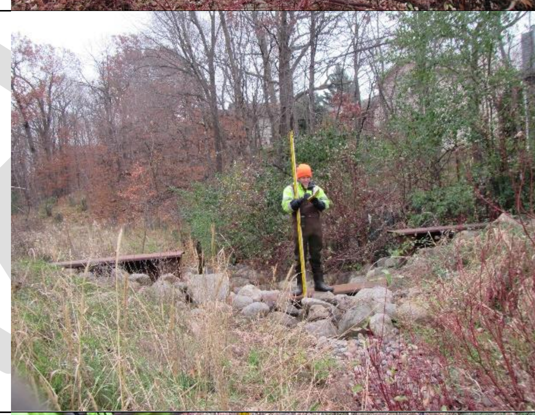
	**IMG_2121** Mass wasting site PT2BE1; stormwater culvert on LB.		**IMG_2122** Mass wasting site PT2BE1 (continued).
	**IMG_2123** Erosion on LB, 6ft by 12ft.		**IMG_2124** General stream picture.
	**IMG_2125** Partially eroding ravine, LB.		**IMG_2126** End of subreach; access to culvert.
	**IMG_2127** Culvert under Kerber Blvd nearly completely blocked by debris.		**IMG_2128** Access structure above culvert at end of subreach.

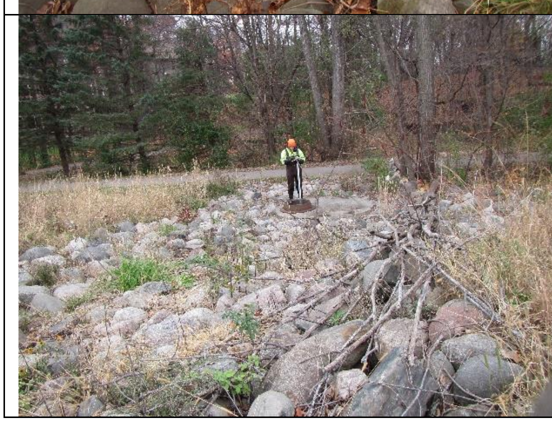
Subreach PT2C - Kerber Blvd to Walking Trail South of Carver Beach Road and Big Woods Blvd MSHA: 33.5 (Fair); Pfankuch: 53 (Very Stable)

Staff started this subreach on the east side of Kerber Blvd. The above-ground creek bed started in the back yard of a residential home (IMG_2129). For the majority of the subreach the stream was piped underground, running underneath residential yards and restored prairie (IMG_2132, IMG_2135). The riparian width was between 15ft and 90ft within the first third of the subreach but expanded to over 150ft. The surrounding landscape contained mostly wet-prairie, surrounded by deciduous forest and residential areas. Immediate slopes, for the most part, had gradients less than 10% throughout most of the subreach. Staff encountered four weir structures within the channel of this subreach.

After starting the walk, about 80ft downstream, staff observed an access/overflow structure (IMG_2130). Just downstream, staff encountered the first large, metal weir structure (IMG_2131). There were large boulders spread along the width of the structure to prevent erosion. Some short shrubs were observed surrounding the creek bed just downstream, but most of the vegetation continuing downstream was made up of grasses and sedges (IMG_2132). The second weir structure was about 170ft downstream of the first one (IMG_2133). There was small cobble placed in the overland streambed along the entire length of the subreach (IMG_2135, IMG_2136). Staff encountered a third weir structure about another 170ft downstream of the last, similar in size with the same boulder configuration (IMG_2136). Staff still had not observed any water in the creek by this point in the walk. Just downstream of the third weir, a stormwater culvert crossed the overland streambed and exited the channel on the left bank (IMG_2138). The fourth weir structure was several hundred feet downstream of the last weir (IMG_2139). Before reaching the pond near the end of the subreach, staff observed another overflow structure containing standing water. The structure was about 50ft upstream of the diked pond (IMG_2141). Just north of this pond receiving the tributary flows was another, larger pond. The culvert at the inlet of the pond was clogged with organic material/detritus (IMG_2143). Staff observed another overflow structure at the downstream end of the pond (IMG_2144) which both ponds would drain into if levels where high enough. The last 50ft to 70ft of the subreach was full of many large, placed boulders (IMG_2145). Staff observed a manhole access here (IMG_2145). The walk ended at the recreation trail extending from Carver Beach Road and Big Woods Blvd.

	**IMG_2129** Start of subreach; residential yard.		**IMG_2130** Access/ overflow structure.

	**IMG_2131** Large metal weir structure; surrounded by boulders.		**IMG_2132** General stream picture.
	**IMG_2133** Second weir structure.		**IMG_2134** General stream picture.
	**IMG_3135** General stream picture.		**IMG_2136** Third weir structure.
	**IMG_2137** General stream picture.		**IMG_2138** Stormwater culvert leaving channel, LB.

	**IMG_2139** Fourth weir structure.		**IMG_2140** General stream picture.
	**IMG_2141** Overflow structure; piped creek inside structure.		**IMG_2142** Stream daylighting into diked pond.
	**IMG_2143** Inlet culvert entering pond clogged with debris.		**IMG_2144** Overflow structure at west end of pond.
	**IMG_2145** End of subreach; manhole access.		

Purgatory Creek Assessment

Kerber Pond to Lotus Lake

Conducted by: RPBCWD staff [Josh Maxwell, Zach Dickhausen]

Summary

Site/Scope

On the 11th of April at 11:45, 2017, Riley Purgatory Bluff Creek Watershed District (RPBCWD) staff conducted a stream corridor assessment of PT3A, the middle Lotus ravine of Purgatory Creek that drains into Lotus Lake. Staff started at Lotus lake and walked upstream, crossing Frontier Trail, to Kerber Pond. Staff walked both sides of the creek to assess overall stream conditions and to discover and prioritize possible restoration locations (walked approximately 0.22 stream miles). Staff conducted a Modified Pfankuch Channel Stability Assessment and a Minnesota Pollution Control Agency (MPCA) Stream Habitat Assessment (MSHA) on each subreach to better characterize the stream. A GPS, and a GPS-enabled camera were used to mark points and take photos.

- All pictures were taken Facing Upstream unless noted otherwise.
- Right and Left bank are defined by looking Downstream.
- Erosion was defined as Slight, Moderate, or Severe.
- Stream Bank Erosion was measured from the streambed to the top of the eroding bank.
- Vegetation was defined as Sparse, Patchy, or Dense.
- All measurements were recorded in Feet.
- All major erosion sites were labeled on the GPS by the erosion site number and reach.

Weather Conditions

4/11/2017
Wind: 0.5mph
Temp: 12.4°C
Cloud Cover: NA

Stream Features

This reach of the stream drains from Kerber Pond, passing through deciduous forest and residential areas, before ending at Lotus Lake. The substrate within the reach was made up of sand, silt, and gravel. Boulders were sparsely present in-stream in some areas, and there was a significant buildup of detritus at the time of the creek walk. The subreach had moderate-to-heavy woody debris in sections of the reach. Slope gradients were between 30% and 50% for much of the reach but flattened out upon reaching Kerber Pond. Sinuosity was fair-to-poor throughout the reach, as was channel development (riffle/run/pool). Staff did encounter several riffles between long runs. Water level was low, slow flowing and fairly dispersed throughout the entirety of the reach.

Areas of Concern

There was little bank erosion and the channel was stable (moderate/high). Near Frontier Trail on the left bank was a compost pile spilling into the stream. Smaller yard waste dump sites were found along the reach. There was potential for erosion on the banks of the middle section of the reach, most of the soil there was bare and fallen trees were scattered along the steep slopes of this area.

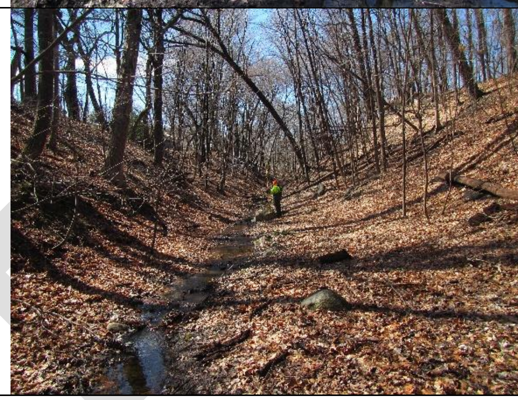
PT3A: Middle Lotus Ravine - Lotus Lake to Kerber Pond

MSHA: 40.8 (Fair); Pfankuch: 75 (Moderately Stable)

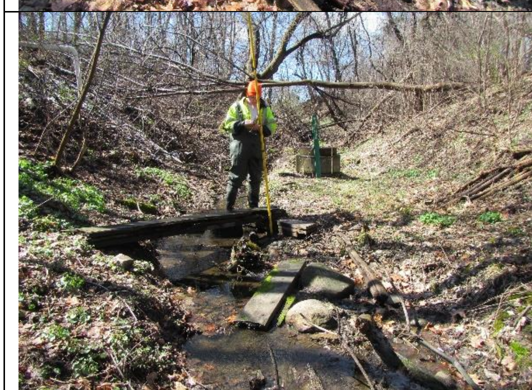
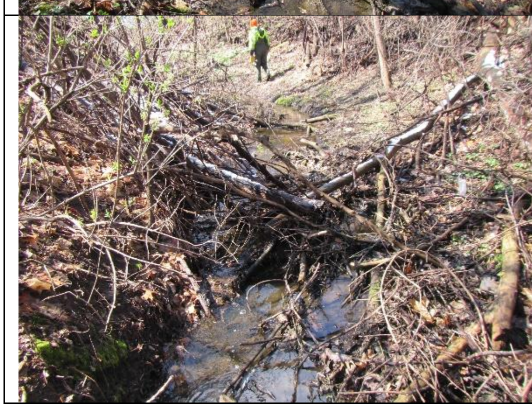
Staff began this walk at the culvert and storm drain just east of Frontier Trail, at the west upper bank of Lotus Lake (IMG_0406, IMG_0407). Staff continued across Frontier Trail to the culvert on the upstream side (IMG_0408, IMG_0409); here they observed two wooden weir structures holding back about 0.3ft of water

(IMG_0408). The substrate early in the reach consisted of mainly sand and gravel, with some scattered boulders. The riparian width was about 15ft to 30ft on the left bank, and 45ft on the right bank near Frontier Trail. The overhead canopy was rather thick, made up of small-to-medium sized deciduous trees. Just upstream of the wooden weirs was a natural check dam (IMG_0410). Continuing upstream, staff encountered a raised manhole near the right bank that was well within the channel (IMG_0411); the manhole was marked as a sewer main access point. The stream water levels were low and there was quite a bit of detritus and woody debris in and around it (IMG_0411). Just opposite the manhole was a residential compost pile surrounded by chain-link fencing (IMG_0412). As seen in IMG_0412, some of the compost was falling directly into the stream. Staff observe increased woody debris in-stream as they continued upstream (IMG_0413). The upper bank slopes were high, reaching gradients of 40% to 50%. The soil of the upper slopes was bare and exposed; downed trees were also scattered along the slopes. A second raised manhole access was observed upstream (IMG_0414). The stream continued to be very shallow and dispersed. The upper banks reduced in height moving upstream (IMG_0415).

	**IMG_0406** Culvert draining into Lotus Lake; US.		**IMG_0407** Storm drain leading to Lotus.
	**IMG_0408** Wooden Weirs (x2).		**IMG_0409** Culvert under Frontier Trail.
	**IMG_0410** Riffle and check dam.		**IMG_0411** Raised manhole within channel.

	**IMG_0412** Compost pile falling into stream, LB.		**IMG_0413** General stream picture; woody debris.
	**IMG_0414** Second raised manhole, LB.		**IMG_0415** General stream picture.

The channel continued to lack sinuosity and channel development (riffle/run/pool) as staff moved upstream. The stream was very straight but contained both riffles and runs. One of the riffles encountered by staff had cinder blocks and scrap wood discarded in it (IMG_0417). About 45ft upstream of this riffle was a third manhole (IMG_0418). Continuing upstream, staff observed a storage shed on the upper slopes of the right bank (IMG_0419); the shed could potentially fall into the channel if the steep bank gave way. Towards the end of the reach, herbaceous ground cover was growing on the banks. Staff encountered a small, wooden bridge across the stream and a fourth manhole access just upstream (IMG_0420). There was a heavy amount of woody debris at this point in the walk (IMG_0420, IMG_0422). On the right bank a 4in PVC pipe was entering the channel from the residence above, possibly a sub pump pipe (IMG_0421). After passing the last manhole and heavy woody debris, staff approached the end of the reach and the culvert running below a walking path from Kerber Pond (IMG_0423); the area around the culvert had eroded away. At the outlet of the pond, staff observed an overflow structure (IMG_0424). At the west end of the pond was a wetland drainage area which drained into the pond (IMG_0427). Just south of the pond outlet and the pond was a second, small stormwater pond (IMG_0428, IMG_0429).

	**IMG_0416** General stream picture.		**IMG_0417** Riffle with cinder blocks and discarded wood.
	**IMG_0418** Third raised manhole, RB.		**IMG_0419** Shed on slope, RB.
	**IMG_0420** Small, board bridge and a fourth manhole on LB.		**IMG_0421** 4in PVC pipe entering stream from home above, RB.
	**IMG_0422** Heavy woody debris.		**IMG_0423** Culvert below walking path, connecting to Kerber pond; rock riffle.

	**IMG_0424** Kerber pond and overflow structure.		**IMG_0425** Kerber pond.
	**IMG_0427** Wetland drainage area above pond.		**IMG_0428** Walking path and small stormwater pond adjacent to Kerber pond (south side of Kerber Pond).
	**IMG_0429** Small stormwater pond adjacent to Kerber pond (south side of Kerber Pond).		

Purgatory Creek Assessment

Santa Fe Trail to Lotus Lake

Conducted by: RPBCWD staff [Josh Maxwell, Zach Dickhausen]

Summary

Site/Scope

On the 11th of April at 9:45, 2017, Riley Purgatory Bluff Creek Watershed District (RPBCWD) staff conducted a stream corridor assessment of PT4A, the southern Lotus ravine of Purgatory Creek that drains into Lotus Lake. Staff started at Lotus lake and walked upstream, crossing Frontier Trail, to Santa Fe Trail, and then walked along a tributary which ran from the crossing point at Frontier trail southeast to Eire Ave. Staff walked both sides of the creek to assess overall stream conditions and to discover and prioritize possible restoration locations (walked approximately 0.8 stream miles). Staff conducted a Modified Pfankuch Channel Stability Assessment and a Minnesota Pollution Control Agency (MPCA) Stream Habitat Assessment (MSHA) on each subreach to better characterize the stream. A GPS, and a GPS-enabled camera were used to mark points and take photos.

- All pictures were taken Facing Upstream unless noted otherwise.
- Right and Left bank are defined by looking Downstream.
- Erosion was defined as Slight, Moderate, or Severe.
- Stream Bank Erosion was measured from the streambed to the top of the eroding bank.
- Vegetation was defined as Sparse, Patchy, or Dense.
- All measurements were recorded in Feet.
- All major erosion sites were labeled on the GPS by the erosion site number and reach.

Weather Conditions

4/11/2017
Wind: 1mph
Temp: 10.6°C
Cloud Cover: NA

Stream Features

This reach of the stream passed through deciduous forest and residential areas, ending at the Lotus Lake. The substrate within this reach was made up of gravel and detritus with areas of silt. Once above the two ponds west of Frontier Trail, the creek bed was dry and detritus/leaflitter made up most of the creek bed. Placed boulders and cobble were predominant between Lotus Lake and Frontier Trail. At Frontier Trail, there was a tributary flowing into the subreach from the south. This tributary was about 0.27 stream miles long, starting just to the west of Erie Ave. Close to Lotus Lake, slope gradients were lower (rarely reaching 20%), but increased as the walk continued west, reaching up-to about 50% above Frontier Trail. In areas where flow occurred, channel development (riffle/run/pool) was fair-to-poor. The stream was not very sinuous.

Areas of Concern

Overall, the channel within this subreach was fairly stable with relatively little bank erosion. Clogging of culverts by detritus and garbage could be an issue by backing up water. Above the ponds, surrounding bank slopes were steep (up to 60%) and many downed trees were scattered across them. A single mass wasting scarp was observed in this area as well. Bare, exposed soils were common in this stretch. Staff did find multiple yard-waste dump sites. The tributary stream had considerable deposition in slack water areas and above each check dam. The old culvert and the plastic drain tile at the top of the subreach could be replaced to reduce erosion.

PT4A: Southern Lotus Ravine - Lotus Lake to Santa Fe Trail

MSHA: 45.95 (Fair); Pfankuch: 65 (Moderately Stable)

Staff started this walk at Lotus Lake and walked upstream to Santa Fe Trail. Starting at the outlet, there was a small, metal bridge spanning the stream (IMG_0356). The adjacent residential properties grass was mowed about 3ft to 5ft away from the stream banks for first 110ft of the stream (IMG_0356, IMG_0357). There were boulders in-stream and placed along the banks for stabilization (IMG_0357, IMG_0358). Staff observed quite a bit of detritus and leafy debris as seen in IMG_0358. The underlying substrate consisted primarily of placed/artificial cobble. Continuing upstream, the stream was surrounded by moderately-dense deciduous forest containing a mixture of medium sized trees (IMG_0359). At this point, houses were set back about 150ft to 180ft from the right bank, and 75ft to 110ft from the left bank. There was a dirt road/trail connecting Frontier Trail to the lake edge about 15ft from the left bank (IMG_0359). Before reaching Frontier Trail, staff encountered some woody debris, including a large, downed tree across the stream (IMG_0360). This was the point where the stream formed a "Y" and the tributary entered the subreach along the right bank. There was also some woody debris/downed trees and more boulders just below the downstream side culvert under Frontier Trail (IMG_0361).

	**IMG_0356** Lotus inlet; bridge across stream; DS		**IMG_0357** General stream picture; large boulders and placed rock.
	**IMG_0358** Rock riffle.		**IMG_0359** General stream picture.

IMG_0360

Tributary converges on stream; large downed tree; boulders in-stream (GPS-115).

IMG_3061

DS culvert under Frontier Trail.

Staff then crossed Frontier Trail to continue the walk. On the upstream side of the road, there was a series of three stormwater ponds which drained into the stream. The culvert on the upstream side of the Frontier Trail was extremely clogged with leaf litter (IMG_0362). After clearing the debris, staff observed a 1ft-drop in water level on the first pond upstream of Frontier Trail. The substrate above Frontier Trail was silty. Directly upstream of the pond was a second pond which drained, via a culvert, into the first pond (IMG_0364, IMG_0365, IMG_0368). Again, the culvert above the first pond was heavily clogged with detritus and garbage (IMG_3065). There were many boulders placed above the culvert draining into the second pond which was the emergency overflow structure (IMG_0366). The second pond sat about 15ft to 20ft higher than the first pond. The culvert at the eastern side of the second pond can be seen in IMG_0368. Water entered the second pond via another culvert (IMG_0367).

Staff walked uphill to the structure above the second pond (IMG_0369). AT the time of the creek walk, staff did not observe any water in-stream above the stormwater ponds. The channel bed was covered with leaf litter and the upper banks were heavily forested, but there was a significant amount of bare soil (IMG_0369). Staff also observed a truck topper and tire dumped in the channel near the outflow structure (IMG_0369). The grade of the upper banks also increased, reaching slopes of 50% to 60% (IMG_0369, IMG_0370). These higher slopes were littered with fallen trees along both banks above the dry channel (IMG_0370). Further upstream, staff encountered a large scarp/mass wasting site along the left bank (IMG_0372); it was not entirely clear how extensive the scarp was due to the amount of leaf litter covering the banks. Continuing upstream, staff observed a dump-site on the right bank, consisting of branch trimmings, logs, and boulders (IMG_0373). Staff soon ran into a second large earth berm, covered in woody debris from several large, fallen trees (IMG_0374). There was some water ponding on the downstream side of the berm which was slowly draining downstream (IMG_0374). Upstream of the berm was a large ravine entering the channel from the right bank (IMG_0375); there was some erosion, as well as some dumped branches and yard waste at the top of it (IMG_0375, IMG_0376). Continuing upstream, staff found the first drain pipe/tile which drained to the culvert downstream into the ponds (IMG_0377); it was marked with a GPS point (point "116"). Approximately, 600ft upstream of the drain pipe was Santa Fe Trail. Before reaching Santa Fe Trail, staff found another storm drain pipe (the end of the reach, IMG_0378, IMG_0379, IMG_0380).

IMG_0362

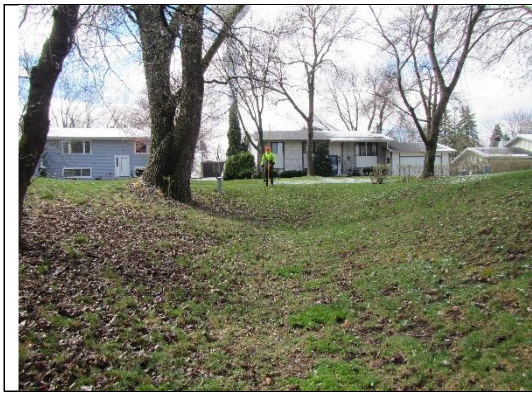
US culvert under Frontier Trail, clogged with debris.

IMG_3063

Pooling water/small pond draining into creek.

	**IMG_3064** Culvert draining into first pond.		**IMG_3065** Culvert above first pond, clogged with debris and garbage.
	**IMG_0366** Placed boulders on berm above culvert.		**IMG_0367** Culvert draining into second pond.
	**IMG_0368** Second pond draining into creek, DS.		**IMG_0369** Stream bed above second pond; no flow/water; garbage in channel; grated overflow drain.
	**IMG_0370** Fallen trees above dry channel, RB.		**IMG_0371** Fallen trees above dry channel, RB.

	**IMG_0372** Scarp/mass wasting along left bank.		**IMG_0373** Large boulders and dump pile, RB.
	**IMG_0374** Large earth berm and fallen tree across channel.		**IMG_0375** Large ravine entering channel from right bank; dumpsite at top of ravine.
	**IMG_0376** Dump pile at top of large ravine, right bank.		**IMG_0377** Storm drain pipe leading to culvert above ponds downstream.
	**IMG_0378** Second storm drain pipe.		**IMG_0379** Second storm drain pipe.

	**IMG_0380** End of reach at Santa Fe Trail.		

Staff then went back to where the tributary entered the reach below Frontier Trail and walked upstream. There was a second culvert under Frontier Trail draining stormwater runoff from the road and area across the road. The tributary can be seen entering the subreach on the left bank in IMG_0381. The stream was small; it measured about 0.15ft deep and 3.3ft wide. The substrate was made up of silt, sand, and gravel. There was some minor erosion measuring 0.8ft high along both banks, about 60ft upstream from the culvert (IMG_0385). Before reaching a culvert under a residential driveway (about 150ft upstream of the second culvert under Frontier Trail), the stream flowed over a mowed lawn and had visible silt deposition occuring (IMG_0386, IMG_0387). Upstream of the culvert under the driveway had a lot of leaf litter and sediment deposits in and around it (IMG_0388). The stream continued through forested area, but the riparian zone was very narrow, ranging from about 3ft to 30ft on either side. The stream was restricted along the right bank due to a driveway (IMG_0391). The stream was flowing very slowly here, and water level was low (IMG_0389). About 390ft upstream of the previous culvert, staff encountered a raised manhole cover on the left bank (IMG_0390). About 60ft upstream of that was another raised manhole cover on the right bank (IMG_0392). Here, the riparian width increased to about 150ft on either side. A third manhole cover was observed just upstream of the second (IMG_0393). At this point, staff started to observe remnant stream restoration measures, including a series of boulder check dams (IMG_0393, IMG_0394, IMG_0397, IMG_0398). Woody debris in the channel increased, building up near the check dams. Sediments directly upstream of the check dams were comprised of heavy silt. The channel became narrow and the immediate banks were higher. The upper bank slope gradients increased, but some areas were still relatively flat. Just upstream of the first check dam, the banks were lined with black, plastic erosion netting for sediment control (IMG_0396). About 660ft from the driveway culvert, staff encountered a culvert draining from a pond and its overflow structure (IMG_0398, IMG_0399). Above the pond was another check dam which was backfilled with silt (IMG_0401). There was another check dam upstream, with erosion occurring along both sides of it, and tree roots stretching across the channel (IMG_0403). At the start of the tributary (end of the walk) was an old cement drain pipe (IMG_0404); staff also observed broken, plastic drain tile coming out of the right bank, next to the culvert. Both failing structures were causing 1.5ft high erosion on the left bank (IMG_0404). The walk ended at a storm drain structure in a residential yard above the pipe (IMG_0405).

	**IMG_0381** Second culvert under Frontier Trail, draining into tributary.		**IMG_0383** General stream picture of south tributary draining into reach.

	**IMG_0385** Erosion along both banks measuring 0.8ft high.		**IMG_0386** Stream running through residential lawn.
	**IMG_0387** DS culvert under residential driveway.		**IMG_0388** US culvert under residential driveway; lots of leaf litter and sediment deposition, DS.
	**IMG_0389** General stream picture; low water level; sediment deposition.		**IMG_0390** First raised manhole cover, LB.
	**IMG_0391** Ditched along a driveway.		**IMG_0392** Second raised manhole cover, RB.

	**IMG_0393** Third manhole cover, RB.		**IMG_0394** Woody debris built up at boulder check dam.
	**IMG_0396** Stream lined with plastic netting for sediment control.		**IMG_0397** Second rock check dam.
	**IMG_0398** Heavy woody debris and downed trees; culvert below pond.		**IMG_0399** Overflow structure for pond draining into tributary.
	**IMG_0401** Check dam above pond.		**IMG_0402** Second check dam above pond; roots spanning channel width.

	**IMG_0404** Old cement stormwater culvert and broken plastic drain tile causing significant erosion.		**IMG_0405** Storm drain pipe in residential yard; start of tributary.

Exhibit F

2017 Lake and Creek Fact Sheets