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VLAWMO

Vadnais Lake Area
Water Management Organization

2016 WATER QUALITY REPORT

Pictured – Tyler Thompson VLAWMO GIS Watershed Technician

Prepared by

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VLAWMO would like to thank the volunteers for their vital role in the Citizens Lake Monitoring Program. The volunteers for 2016 were: Ron Auger & Jim Grisim (Birch Lake), Paul Peterson (Amelia), and Shannon Stewart (Tamarack Lake)

VLAWMO would also like to acknowledge and thank the following agencies for their assistance with assuring the quality of water within the watershed: St. Paul Regional Water Service, the Citizen's Lake Monitoring Program at the Minnesota Pollution Control Agency, the Lake Level Program at the Minnesota Department of Natural Resources, the Ramsey County Limnology Lab, Pace Analytical and Burns & McDonnell.

Definitions & Abbreviations

Ammonia (NH3) – an inorganic form of nitrogen that is contained in fertilizers, septic system effluent, and animal wastes. It is also a product of bacterial decomposition of organic matter. NH3 becomes a concern if high levels of the un-ionized form are present. In this form NH3 can be toxic to aquatic organisms. The presence of un-ionized ammonia is a function of the NH3 concentration, pH, and temperature. Conversion of NH3 to NO2 by nitrification requires large quantities of oxygen which can kill aquatic organisms due to the lowered dissolved oxygen concentrations in water.

Aquatic Invasive Species (AIS) – non-native species such as zebra mussels and Eurasian watermilfoil

Birch Lake Improvement District (BLID) – Homeowner/lakeshore owners on Birch Lake in White Bear Lake MN

Chlorophyll-a (Chl A) - Chl A is a green pigment in algae. Measuring Chl A concentration gives an indication of how abundant algae are in a waterbody.

Colony Forming Units (CFU) – unit used in measuring the level of E. coli in a water sample.

Conductivity (mS/cm) - Conductivity is a good measure of salinity in water. The measurement detects chloride ions from the salt. Salinity affects the potential dissolved oxygen levels in the water. The greater the salinity, the lower the saturation point. Measurement in millisiemens per cm. 1 mS/cm = 1000 uS/cm.

Dissolved Oxygen (DO) - The concentration of molecular oxygen (O2) dissolved in water. The DO level represents one of the most important measurements of water quality and is a critical indicator of a water body's ability to support healthy ecosystems. Levels above 5 mg/L are considered optimal, and most fish cannot survive for prolonged periods at levels below 3 mg/L. Microbial communities in water use oxygen to breakdown organic materials, such as animal waste products and decomposing algae and other vegetation. Low levels of dissolved oxygen can be a sign that too much organic material is in a water body.

Ecoli – Criteria for E. coli set forth in Minn.R. 7050.0222 creek must not exceed 126 organisms per 100 ml as a geometric mean of not less than 5 samples in any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml

EQuIS - a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others. The MPCA uses the information entered into the database to determine the quality of the state's water bodies. If water quality standards are not met, the water body will designated as impaired and will need to have a TMDL study conducted.

Eutrophic – a water body that is high in nutrients and low oxygen content. A eutrophic lake is usually shallow, green, with limited oxygen in the bottom layer of water.

Eutrophication – The aging process by which lakes are fertilized with nutrients. Natural eutrophication will gradually change the character of a lake. Human activities can accelerate the process.

Hypereutrophic – A very nutrient-rich lake with murky water, frequent algal blooms and fish kills, foul odor, and rough fish

Impaired Waters – The Clean Water Act requires states to publish, every two years, a list of streams and lakes that are not meeting their designated uses because of excess pollutants. The list, known as the 303(d) list, is based on violations of water quality standards.

Mesotrophic – the classification between eutrophic and oligotrophic lakes. These lakes have moderately clear water, late-summer algal blooms, moderate macrophyte populations, and occasional fish kills.

Molecular Sourcing – the use of specific DNA markers to determine presence of a specific host origin of E.coli in a water sample (example, Human or Avian)

Most Probable Number (MPN) - unit used in measuring the level of E. coli in a water sample, similar to (CFU)

Nitrate (NO3) – High NO3 levels are often caused by over application of fertilizers that leach into waterbodies. Nitrate loading from water bodies in Minnesota has national implications as it is the primary chemical contributing to the hypoxia (low oxygen) zone at the mouth of the Mississippi River in the Gulf of Mexico. The Environmental Protection Agency (EPA) has a standard for nitrates in drinking water of 10ppb, infants and children are especially at risk.

Nitrite (NO2) – The second stage of the nitrogen cycle. Nitrite is poisonous to fish. Levels over 75 ug/L can cause stress in fish and greater than 500 ug/L can be toxic

Nitrogen (N) – Nitrogen is second only to phosphorus as an important nutrient for plant and algae growth. The amount of nitrogen in a water body strongly correlates to land use. Nitrogen comes from fertilizers, animal waste, sewage treatment plants and septic systems through surface runoff or groundwater sources. Nitrogen does not occur naturally in soil minerals but is a major component of all organic matter.

Nitrogen Cycle - the process of nitrogen breakdown in water. The first stage is the production of NH3. The second stage is the oxidation of NH3 into NO2 which is very poisonous to fish. The final stage is conversion of NO3 which aquatic plants use. Once the plants have used their share of NO3, bacteria change it back into a gaseous form and release it back to the atmosphere. The Nitrogen Cycle is dependent on oxygen. If a water body has low DO, organic decay of nitrogen is slower and the water will have increased interim levels of toxic products (NH3 and NO2). The cycle also moves quicker in warmer water.

Oligotrophic – a water body that is generally clear, deep, and free of weeds or large algae blooms.

Particulate Phosphorus – a form of phosphorus that is attached to sediment particles and in plant and animal fragments suspended in the water and may not be immediately available to support algae growth. Some of this phosphorus is readily available but the amount can vary.

Phosphorus (P) - Phosphorus is the primary cause of excessive plant and algae growth in lake systems. Phosphorus originates from a variety of sources, many of which are human related. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland, yards, and streets.

Secchi Disk – a round, white, metal disk that is used to determine water clarity. It is lowered into the water until it is not visible. The depth is recorded, and then the disk is raised until it is visible. The mean value of the two readings gives the clarity.

Secchi Disk Transparency (SDT) - the term used in describing the results of a secchi reading expressed in feet or meters.

Soluble Reactive Phosphorus (SRP) – a form of phosphorus that dissolves in water and is readily available (bio-available) to algae and has an immediate effect on algae growth and DO depletion. Its concentration varies widely over short periods of time as plants take it up and release it.

St. Paul Regional Water Service (SPRWS) – Agency which assists VLAWMO with water quality testing and controls the Vadnais chain of lakes, which supplies drinking water to the city of St. Paul.

Surface Water Assessment Grant (SWAG) - Grant awarded by the PCA to help fund surface water monitoring

Total Kjehldahl Nitrogen (TKN) – The sum of NO2, NO3, and NH3 in a water body. High measurements of TKN typically results from sewage and manure discharges to water bodies.

Total Maximum Daily Load (TMDL) – Calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that amount to the pollutant's source.

Total Nitrate and Nitrite Nitrogen - Nitrate (NO3) plus nitrite (NO2) as nitrogen. In lakes, most nitrate/nitrogen is in NO3 form.

Total Phosphorus (TP) – A nutrient essential to the growth of organisms, and is commonly the limiting factor in the primary productivity of surface water bodies. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particle form. Agricultural drainage, wastewater, and certain industrial discharges are typical sources of phosphorus, and can contribute to the eutrophication of surface water bodies.

Total Suspended Solids (TSS) – Very small particles remaining dispersed in a liquid due to turbulent mixing that can create turbid or cloudy conditions. A measure of the material suspended in water in mg/l. Total suspended solids (TSS) cause: a) interference with light penetration, b) buildup of sediment and c) potential reduction in aquatic habitat. Solids also carry nutrients that cause algal blooms and other toxic pollutants that are harmful to fish. Clay, silt, and sand from soils, phytoplankton (suspended algae), bits of decaying vegetation, industrial wastes, and sewage are common suspended solids.

Trophic Status Indicator (TSI) – TSI is an indicator of water quality. Lakes can be divided into three categories based on trophic state – oligotrophic, mesotrophic and eutrophic. A natural aging process occurs in lakes which cause them to change from oligotrophic to eutrophic over time and eventually fill in. Humans can accelerate this process by allowing nutrients from agriculture, lawn fertilizers, streets, septic systems, and urban storm drains to enter lakes. Trophic status is determined through TP, Chl A, and SDT measurements.

Turbidity – a water quality parameter that refers to how clear the water is. It is an indicator of the concentration of suspended solids in the water. Excessive sedimentation in streams and rivers is considered

to be the major source of surface water pollution in the United States. Polluted waters are commonly turbid. Turbidity is expressed in NTU (Nephelometric Turbidity Units).

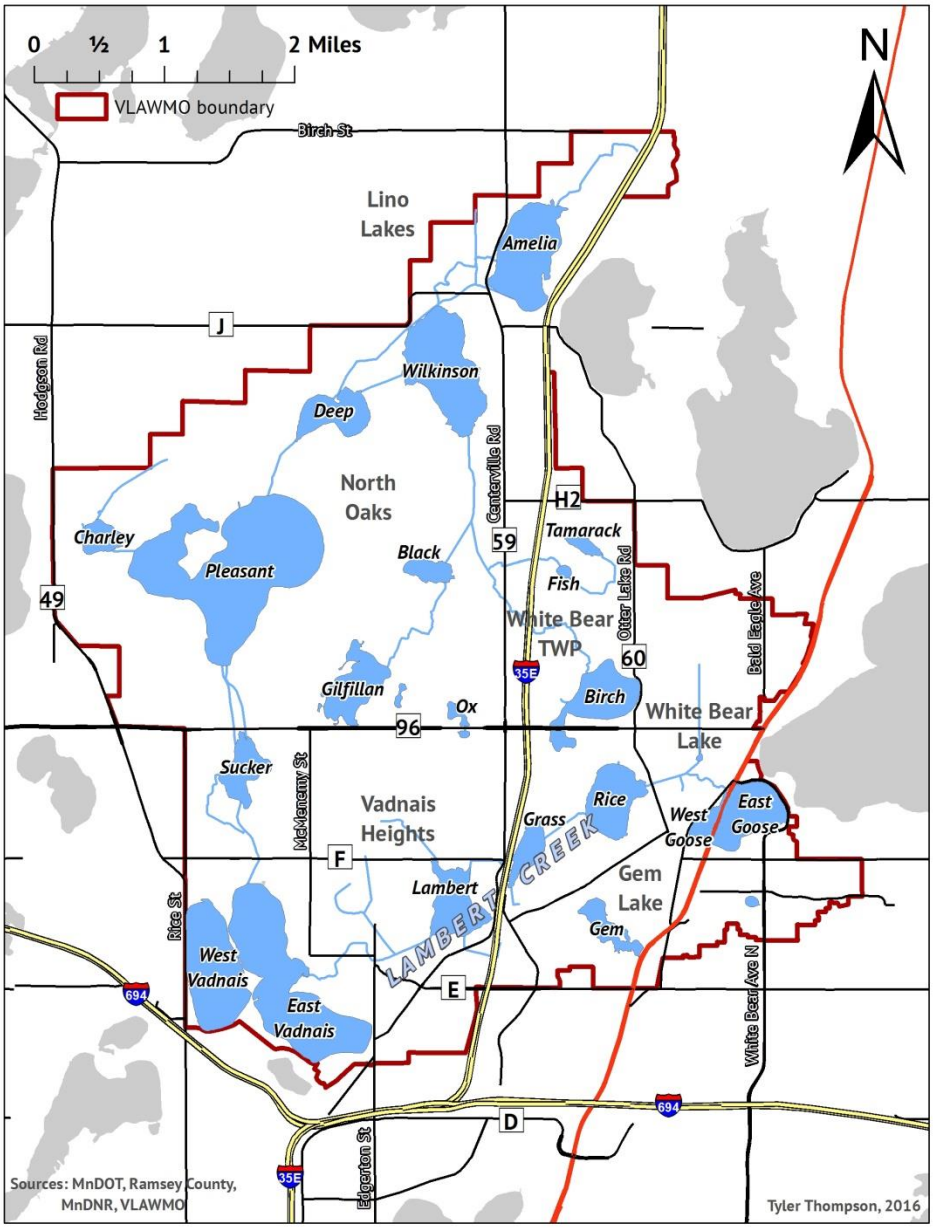
Volatile Suspended Solids (VSS) – a measure of the organic matter in suspended particles. When measured in conjunction with TSS, the proportions of organic versus mineral content of the particles can be determined.

Introduction

The Vadnais Lake Area Water Management Organization (VLAWMO) covers approximately 25 square miles in the northeast metropolitan area. The watershed encompasses the City of North Oaks and portions of the Cities of White Bear Lake, Gem Lake, Vadnais Heights, Lino Lakes, and White Bear Township. The watershed is 96% urbanized; agricultural land exists in the northern end of the boundaries. New land development is occurring near Wilkinson Lake. Data collected through this program tracks changes in water quality in conjunction with the change in land use around these water bodies.

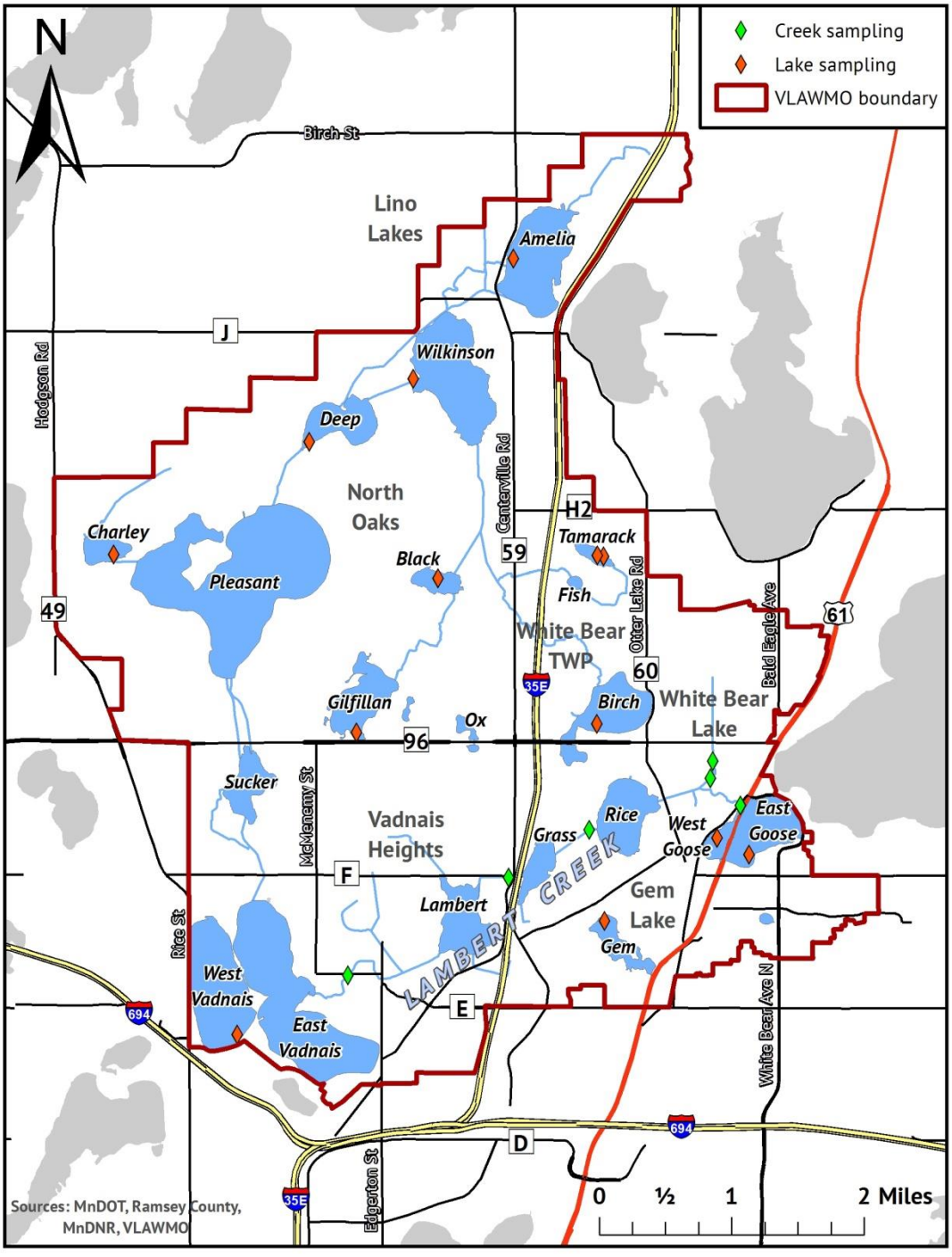
VLAWMO works in conjunction with the St. Paul Regional Water Service (SPRWS) on water quality monitoring. The SPRWS monitors the direct surface water flow into Vadnais Lake to assure high quality drinking water for over 400,000 consumers. The SPRWS monitors the main chain of lakes (Charley Lake, Pleasant Lake, Sucker Lake and Vadnais Lake) and while VLAWMO monitors Lambert Creek which flows directly into Vadnais Lake.

Figure 1: Map of VLAWMO



VLAWMO began the Citizens Lake Monitoring Program (CLMP) in 1997 to monitor several lakes and ponds within the watershed that were identified as having local significance. CLMP volunteers have helped collect samples from 12 water bodies: Amelia Lake, Birch Lake, Black Lake, Charlie Lake, Deep Lake, Gem Lake, Gilfillan Lake, Goose Lake East, Goose Lake West, Tamarack Lake, West Vadnais Lake and Wilkinson Lake. These lakes are all shallow with average depths no greater than 9 feet. Six areas along Lambert Creek are also sampled as part of the Organization's mission to protect and improve the water-related environment. The data received from the monitoring is used by VLAWMO and the Minnesota Pollution Control Agency (MPCA) to determine the health of the state's waters.

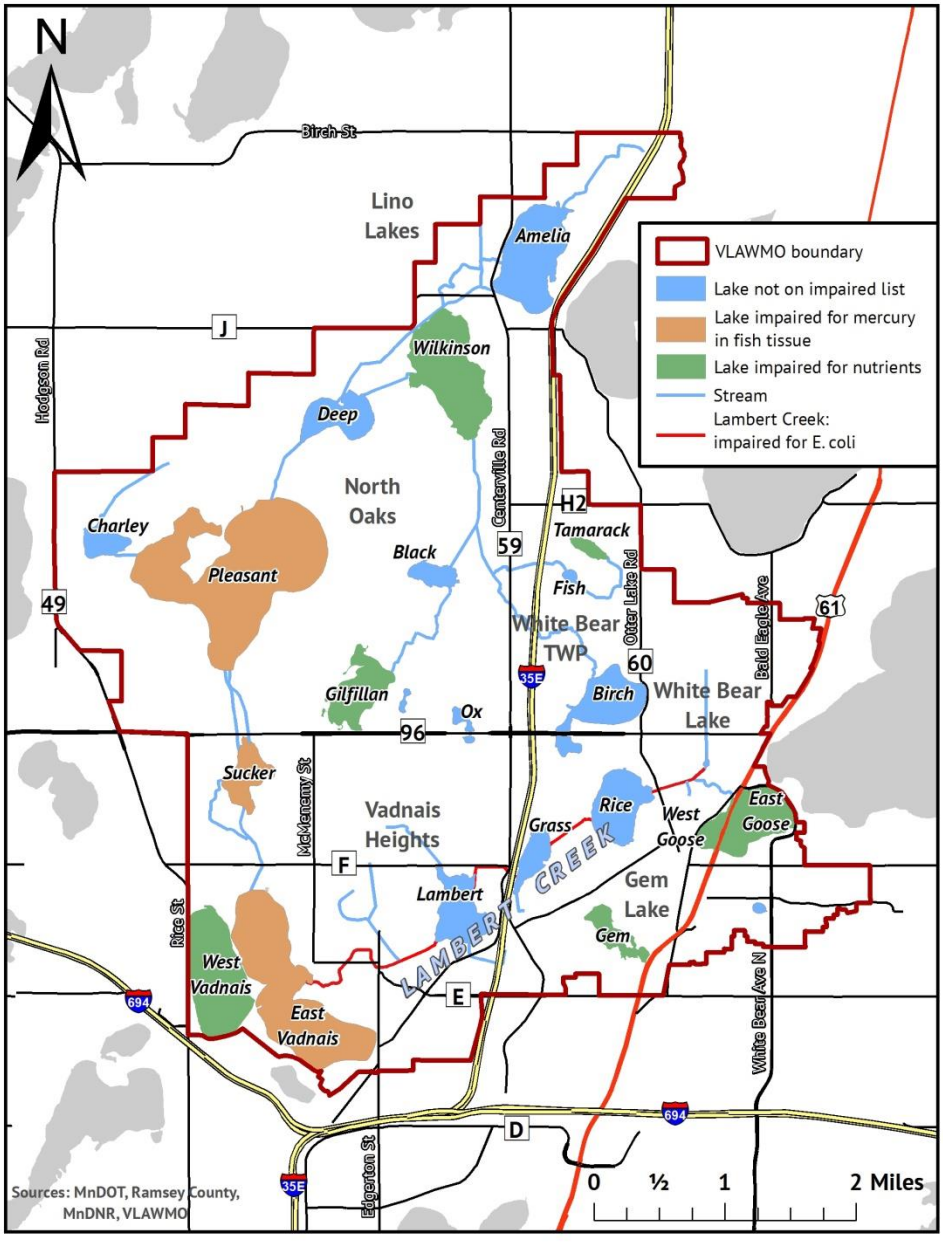
Figure 2: Sites Monitored by VLAWMO



Impaired Water Designations

The watershed has had several water bodies listed on the MPCA 303(d) list for Impaired Waters. The SPRWS Chain of Lakes (Pleasant, Sucker and Vadnais Lakes) have all been listed for nutrient pollution, specifically mercury. These lakes have been infested with zebra mussels, an aquatic invasive species, though this is not a condition of the Impaired Waters listing. This chain of lakes is fed by the Mississippi River through a pump in Fridley, MN. Lambert Creek (including Goose Lake and Whitaker Pond) has been added to the impaired list for bacteria, specifically fecal coliform or E. coli. Gem Lake, Gilfillan Lake, Goose Lake and Wilkinson Lake, impaired for nutrients, have also been added to the study due to the PCA's new "watershed wide' approach for TMDL's to make them more efficient. These water bodies are now scheduled for a TMDL study to determine the extent of pollution and if possible, where the pollutant is coming from. VLAWMO will initiate the study for Lambert Creek, Gilfillan, Wilkinson, Goose and Gem; while SPRWS will manage the study for Pleasant, Sucker, and Vadnais. Study began fall of 2010, still in review stage.

Figure 3: Waterbodies listed on the MPCA 303(d) Impaired Waters List



Typical Measurements for Lakes and Streams

VLAWMO's watershed falls within the North Central Hardwood Forest (CHF) ecoregion. This ecoregion is an area of transition between the forested areas to the north and east and the agricultural areas to the south and west. The terrain varies from rolling hills to smaller plains. Non-urbanized upland areas are forested by hardwoods and conifers. Plains include livestock pastures, hay fields and row crops such as potatoes, beans, peas and corn.

The ecoregion contains many lakes, and water clarity and nutrient levels are moderate. Land surrounding many of these lakes has been developed for housing and recreation, and the densely populated metropolitan area dominates the eastern portion of this region. Water quality problems that face many of the water bodies in the area are associated with contaminated runoff from paved surfaces and lawns.

Below are typical measurements one might find for lakes and streams in the CHF ecoregion:

Lakes							
Field pH	TSS (mg/L)	NO_X (µg/L)	TP (µg/L)	Turb (NTU)	SDT (m)	Chl-a (µg/L)	TKN (µg /L)
8.6 – 8.8	2 – 6	<100	23 – 50	1 – 2	1.5 – 3.2	5 – 22	600 - 1200
Streams							
Field pH	TSS (mg/L)	NO_X (µg/L)	TP (µg/L)	Turb (NTU)	Fecal Coliform (cfu/100 ml)	Temp (˚C)	BOD (in mg/L)
7.9 – 8.3	4.8 – 16	4 - 26	6 – 15	3 – 8.5	40 – 360	2 – 21	1.5 – 3.2

The MPCA has water quality standards based on a designated use for the water body. VLAWMO's water is classified as "2B". The SPRWS chain of lakes has a stricter designation of "2Bd" due to it being the drinking water source for St. Paul. The quality of Class 2B water must be suitable for aquatic recreation of all kinds as well as to support fish and aquatic plant life. In 2008, the MPCA approved new standards which will separate deep from shallow lakes. All of the lakes VLAWMO monitors are considered shallow and therefore those standards will apply. For those parameters which the MPCA does not have standards, the federal Environmental Protection Agency (EPA) has maximum contaminant level standards. VLAWMO's goal is to have its waterbodies within these standards.

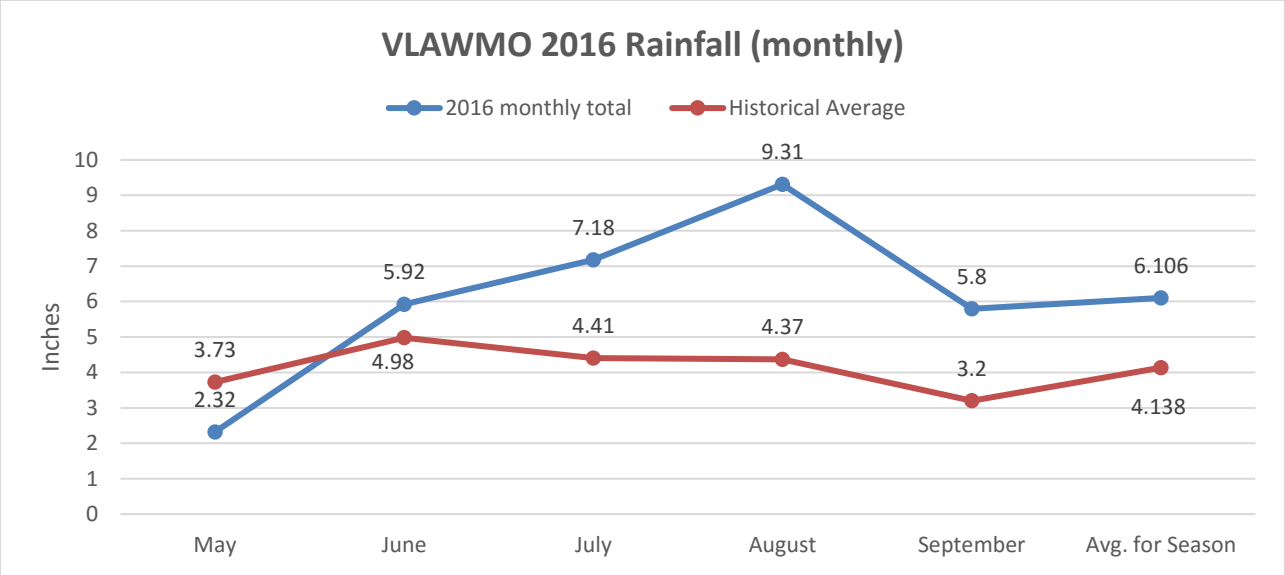
MPCA Standards Lakes					EPA Standards	
TP (µg/L)	Chl A (µg/L)	SDT (m)	Turb (NTU)	TSS (mg/L)	TKN (µg/L)	NO_2 (µg/L)
< 60	< 20	> 1	< 25	< 100	< 1000	< 100
MPCA Standards – Rivers and Streams					**EPA Standards**	
Fecal Coliform daily maximum (cfu/100 ml)	Chloride (Cl) chronic (mg/L)	Turb (NTU)	TSS (mg/L)	Un-ionized Ammonia (µg/L)	TKN (µg/L)	NO_2 (µg/L)
< 1260	< 230	< 25	< 100	<40	< 1000	< 100

Precipitation in 2016

Major factors influence water quality including the amount of precipitation, timing of precipitation events, and land use practices in the watershed. Long-term monitoring is necessary to characterize the impacts of various land use practices on surface water runoff within VLAWMO.

The 2016 monitoring season precipitation was very steady. Above average monthly rainfall amounts each month except May, even had rain in November and December. The sampling season averaged 1.97" above average monthly (May through September), compared to 1.07" above average in 2015. Precipitation moves contaminants resting on lawns, roofs, streets, and parking lots into nearby water bodies or into storm sewers that outlet into water bodies. Typically, the more precipitation that occurs, the more runoff there will be in the watershed. However, the timing and intensity of the precipitation, as well as soil types, land slopes, land uses, and other factors can influence the amount of runoff that reaches the water bodies. Lack of rain can also have an effect on the concentration of nutrients and chemicals in our water bodies. With a smaller volume of water in our water bodies, the more concentrated the nutrients and chemicals can become.

2016 Precipitation Data (in inches) Vadnais Heights City Hall Rain Gauge, Vadnais Heights, MN			
	2016 monthly total	Historical Average	Deviation
May	2.31	3.73	**-1.41**
June	5.92	4.98	**0.94**
July	7.18	4.41	**2.77**
August	9.31	4.37	**4.94**
September	5.8	3.2	**2.6**
Avg. for Season	**6.11**	**4.14**	**1.97**



- Rain gauge used for data is located at Vadnais Heights City Hall

Preliminary Analysis of Lake Data

VLAWMO staff worked with volunteers to collect samples from the lakes at two-week intervals from May through September. VLAWMO staff collected all creek samples. At the time of collection, volunteers measure water transparency with a Secchi disk (SDT), evaluate the physical and recreational conditions of the water, and if available, take a lake level reading. Samples are brought to Braun Intertec by VLAWMO staff within 24 hours for chemical analysis. Parameters measured at the lab include Phosphorus (TP &SRP), Chlorophyll-a (Chl A), total Kjeldahl Nitrogen, nitrate, ammonia and Total Suspended Solids (TSS). The data from these tests aid in the determination of the state of the water quality in a particular lake or stream and allow for monitoring of the long term health of the water body. Standards for water quality are set by the US Environmental Protection Agency (EPA) and enforced through the MPCA.

A measure of the lake health and lake age is Carlson's Trophic State Index (TSI), which measures the productivity level of a lake or degree of eutrophication. As a lake ages, it becomes more eutrophic, however human impact speeds up the process. High TSI values can relate to poorer water quality but not always. Trophic state is an absolute scale that describes the biological condition of a water body. Water quality, on the other hand, is a term used to describe the condition of a water body in relation to human needs or values

Water quality grades are given to each lake based on standards established by the Metropolitan Council. The standards give a range to each letter grade for the June – September averages of TP concentration, Chl A concentration, and SDT. The overall lake water quality grade is the average of the grades for each parameter. Other indicators of lake condition, such as aquatic plant growth or invasive species are not factored into the grades. As of 2016, the letter grades assigned to VLAWMO water bodies are as listed below:

VLAWMO Lake Grades

Lake	Grade 2015	Grade 2016	TSI Status
Amelia	B	B	Eutrophic
Birch	B+	B	Mesotrophic
Black	B+	A-	Mesotrophic
Charlie	C	C	Eutrophic
Deep	C-	C	Eutrophic
Gem	B	B	Mesotrophic
Gilffilan	C+	C+	Eutrophic
E. Goose	D-	D-	Eutrophic - Hypereutrophic
W. Goose	D	D-	Eutrophic - Hypereutrophic
Tamarack	D	D	Eutrophic - Hypereutrophic
Wilkinson	D	D+	Eutrophic

Below is the raw data and chart explaining the TSI Status 2015 & 2016

2015 Data	avg SD (m)	TSI (SD)	avg CHL (ug)	TSI (CHL)	avg TP (ug)	TSI(TP)
Amelia	1.1	59	21	60	28	52
Birch	1.7	52	1	31	21	48
Black	1.6	53	14	56	18	46
Charlie	1.1	59	14	56	57	62
Deep	1	60	23	61	89	69
Gem	2.2	49	23	61	38	57
Gilfillan	0.6	67	36	66	55	62
Goose East	0.6	67	115	77	231	83
Goose West	0.6	67	97	75	149	76
Tamarack	0.4	73	119	77	183	79
West Vadnais	0.3	77	108	77	88	69
Wilkinson	0.5	70	147	80	109	72

A list of possible changes that might be expected in a north temperate lake as the amount of algae changes along the trophic state gradient.

TSI	Chl (ug/L)	SD (m)	TP (ug/L)	Attributes	Water Supply	Fisheries & Recreation
<30	<0.95	>8	<6	**Oligotrophy:** Clear water, oxygen throughout the year in the hypolimnion	Water may be suitable for an unfiltered water supply.	Salmonid fisheries dominate
30-40	0.95-2.6	8-4	6-12	Hypolimnia of shallower lakes may become anoxic		Salmonid fisheries in deep lakes only
40-50	2.6-7.3	4-2	12-24	**Mesotrophy:** Water moderately clear; increasing probability of hypolimnetic anoxia during summer	Iron, manganese, taste, and odor problems worsen. Raw water turbidity requires filtration.	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate
50-60	7.3-20	2-1	24-48	**Eutrophy:** Anoxic hypolimnia, macrophyte problems possible		Warm-water fisheries only. Bass may dominate.
60-70	20-56	0.5-1	48-96	Blue-green algae dominate, algal scums and macrophyte problems	Episodes of severe taste and odor possible.	Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating.
70-80	56-155	0.25-0.5	96-192	**Hypereutrophy:** (light limited productivity). Dense algae and macrophytes		
>80	>155	<0.25	192-384	Algal scums, few macrophytes		Rough fish dominate; summer fish kills possible

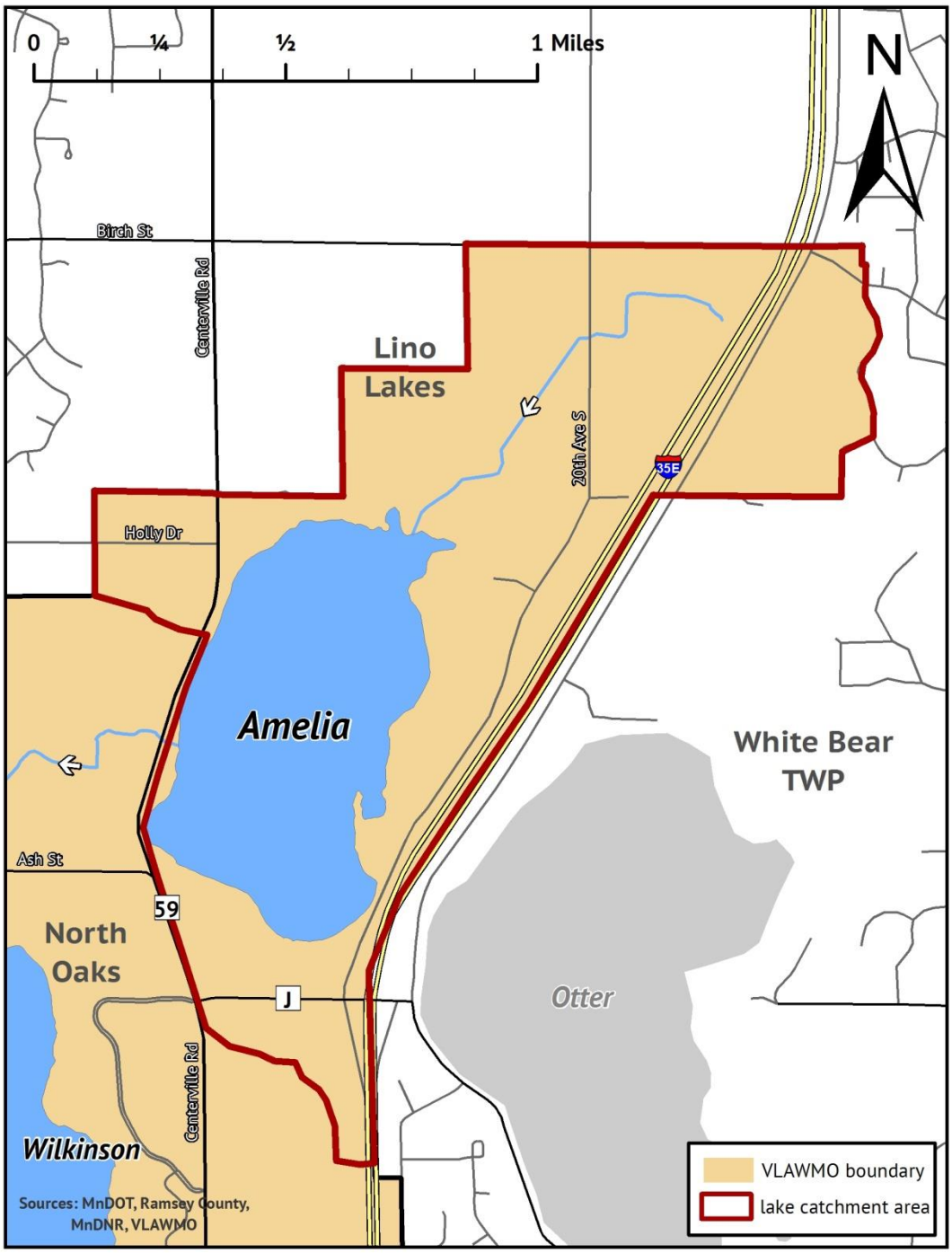
2016 Data	avg SD (m)	Tsi (SD)	avg CHL (ug)	Tsi (CHL)	avg TP (ug)	Tsi(TP)
amelia	1.1	59	12	55	51	61
birch	1.8	52	7	50	14	42
black	2	50	4	44	17	45
charlie	1.2	57	10	53	78	67
deep	1.1	59	8	51	76	67
gem	1.6	53	18	59	30	53
gilfillan	0.7	65	25	62	48	60
goose east	0.5	70	84	74	291	86
goose west	0.4	73	67	72	187	80
tamarack	0.4	73	87	74	187	80
west vadnais	0.3	77	71	72	110	72
wilkinson	1.1	59	24	62	169	78

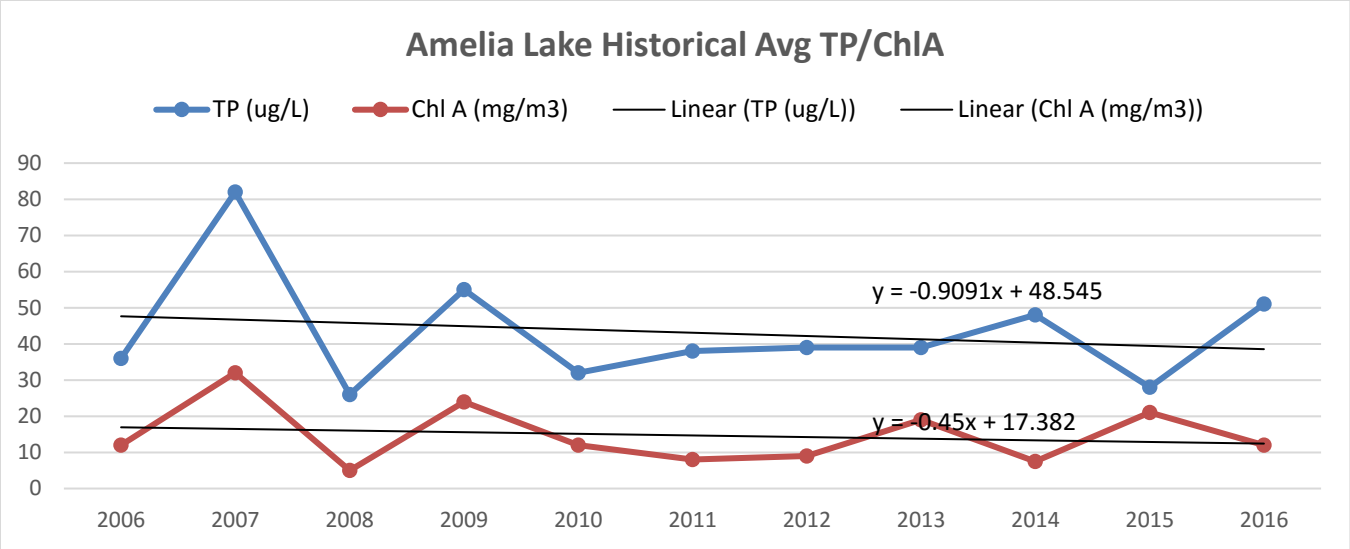
VLAWMO's water resource manager completes the required data entry each year into the MPCA EQuIS program which makes the determination of impairment and opens opportunities for grants to help remedy the impairments.

2016 Monitoring Results

Amelia Lake

Amelia is located in Anoka County and is approximately 217 acres. Maximum depth for the lake is 4 feet. The majority of agricultural land left in the watershed is near Amelia Lake. VLAWMO staff also collected all DO and YSI parameter readings on Amelia. VLAWMO has been monitoring Amelia since 1997. As you can see from the data below the trend for both TP and ChlA has been slightly downward over the last 10yrs. Overall Amelia is below the state standard of 60ug/L for TP and 20mg/m3 for ChlA over the last seven years. Runoff and rain events are a big factor in these parameters for Amelia due to the amount of agricultural land surrounding the lake. Due to the great water quality, runoff from the surrounding area does not seem to be affecting the lake.





Amelia Lake Data

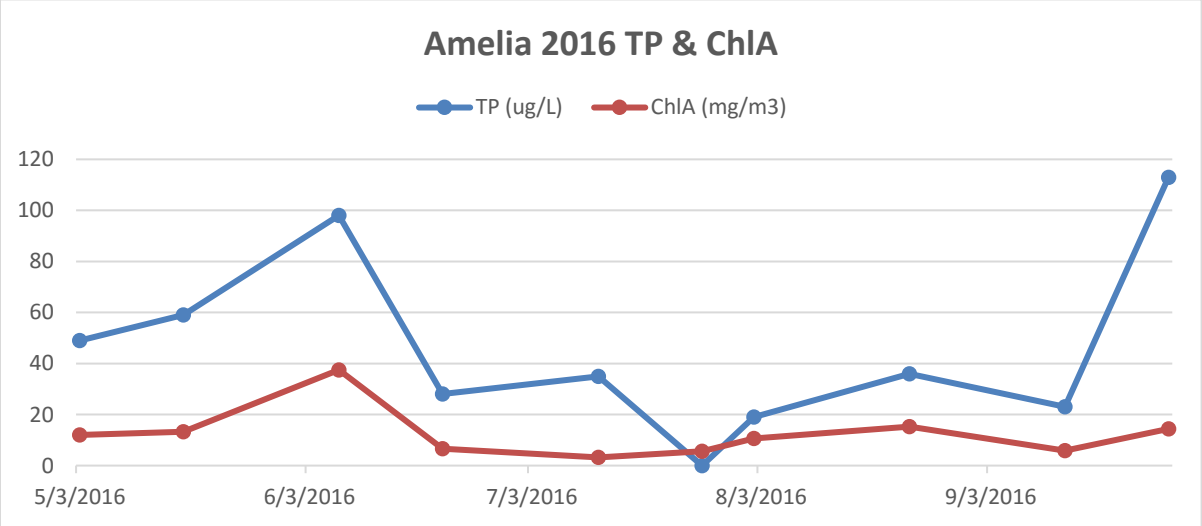
Amelia Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	13.03	0.463	8.2	8.18
1997	28	0	1.5	5/16/2016	t	13.28	0.462	7.95	8.11
1998	36	14	1.1	6/10/2016	b	23.73	0.412	7.67	9.16
1999	38	9	1.2	6/10/2016	t	23.84	0.414	7.69	9.11
2000	40	12	0.9	7/20/2016	b	26.4	0.374	6.97	9.3
2001	33	8	1.1	7/20/2016	t	26.43	0.374	7.22	9.38
2002	34	13	1.4	9/20/2016	b	19.91	0.385	6.18	8.47
2003	29	7	1.5	9/20/2016	t	19.87	0.386	5.84	8.57
2004	28	0	0						
2005	24	7	0						
2006	36	12	0						
2007	82	32	0.4						
2008	26	5	1.1						
2009	55	24	0.9						
2010	32	12	1.1						
2011	38	8	1.1						
2012	39	9	1.1						
2013	39	19	1.1						
2014	48	7.5	1.3						
2015	28	21	1.1						
2016	51	12	1.1						

- YSI parameters are good for Amelia Lake, no signs of concern. Red values indicate averages above state standard. Amelia has been below state standard for last 7 years

Amelia Lake 2015 Raw Data

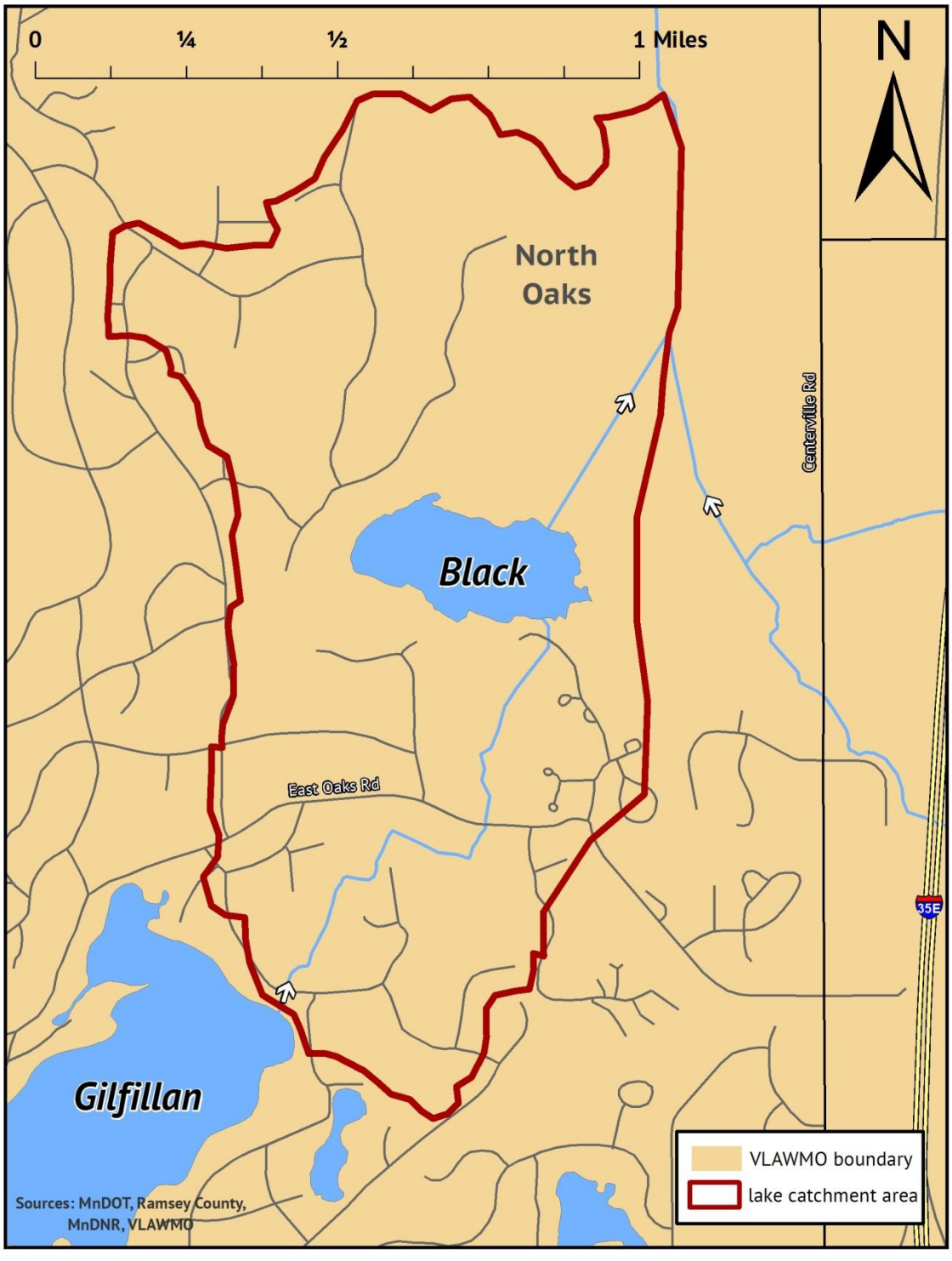
SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	Cl (mg/L)
amelia	3/28/2016							60
amelia	5/3/2016	3.5	49	12	2.9			
amelia	5/17/2016	3	59	13.3				
amelia	6/7/2016	3	98	37.5	3.9	0.24		
amelia	6/21/2016	4	28	6.6				
amelia	7/12/2016	3	35	3.2	1.8	0.11		
amelia	7/26/2016	4	ND	5.6				
amelia	8/2/2016	2.5	19	10.6	1.5	ND		
amelia	8/23/2016	3	36	15.3				
amelia	9/13/2016	3.75	23	5.9	1.1	ND		
amelia	9/27/2016	3.5	113	14.4				

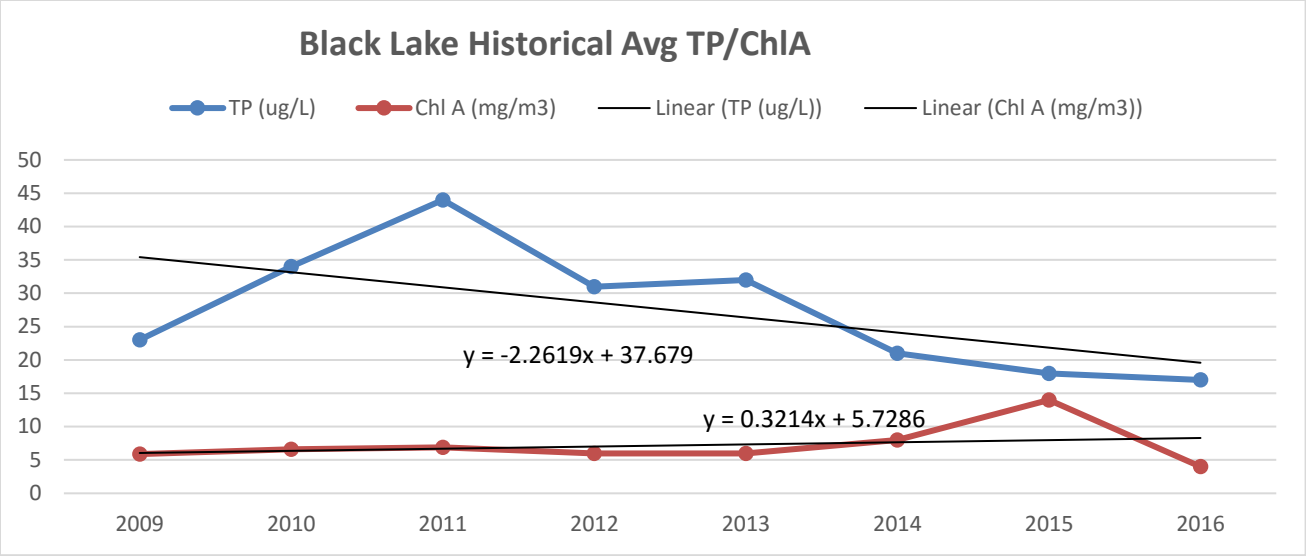
- Nitrogen and ammonia levels are well below state standards for Amelia Lake as well as chloride.



Black Lake

Black Lake is located in North Oaks. There is very little developed land or roads around the lake. The lake is about 10 acres and has a maximum depth of 12 feet. VLAWMO began to monitor Black Lake in 2009. Black Lake is also one of, if not the only lake left within VLAWMO that has a significant population of wild rice. Access to the lake is minimal and the lake is surrounded by private property, is very isolated and has a large wetland fringe. Black Lake is one of the healthiest lakes within VLAWMO with all lake nutrient parameters well below the state standards. An aquatic vegetation survey was completed in July 2014.





Black Lake Data

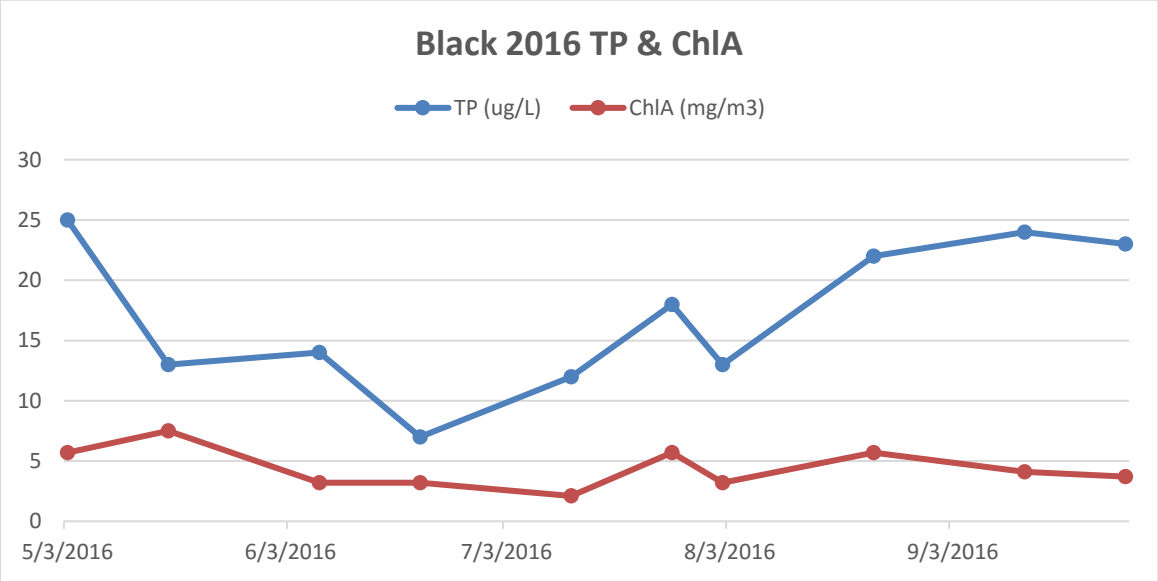
Black Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	12.82	0.289	8.06	7.8
2009	23	5.9	2	5/16/2016	t	13.66	0.287	8.46	7.7
2010	34	6.6	2.1	6/10/2016	b	19.19	0.308	2.04	8.02
2011	44	6.9	2.3	6/10/2016	t	25.04	0.261	7.19	8.82
2012	31	6	2.4	7/20/2016	b	22.61	0.273	0.33	7.37
2013	32	6	2	7/20/2016	t	26.79	0.236	6.48	8.39
2014	21	8	2	9/20/2016	b	19.22	0.308	0.6	7.69
2015	18	14	1.6	9/20/2016	t	20.19	0.3	3.27	7.86
2016	17	4	2						

- Black Lake YSI parameters are very good for this type of lake. Black Lake is around 12 ft deep and does show some signs of stratification

Black Lake 2016 Raw Data

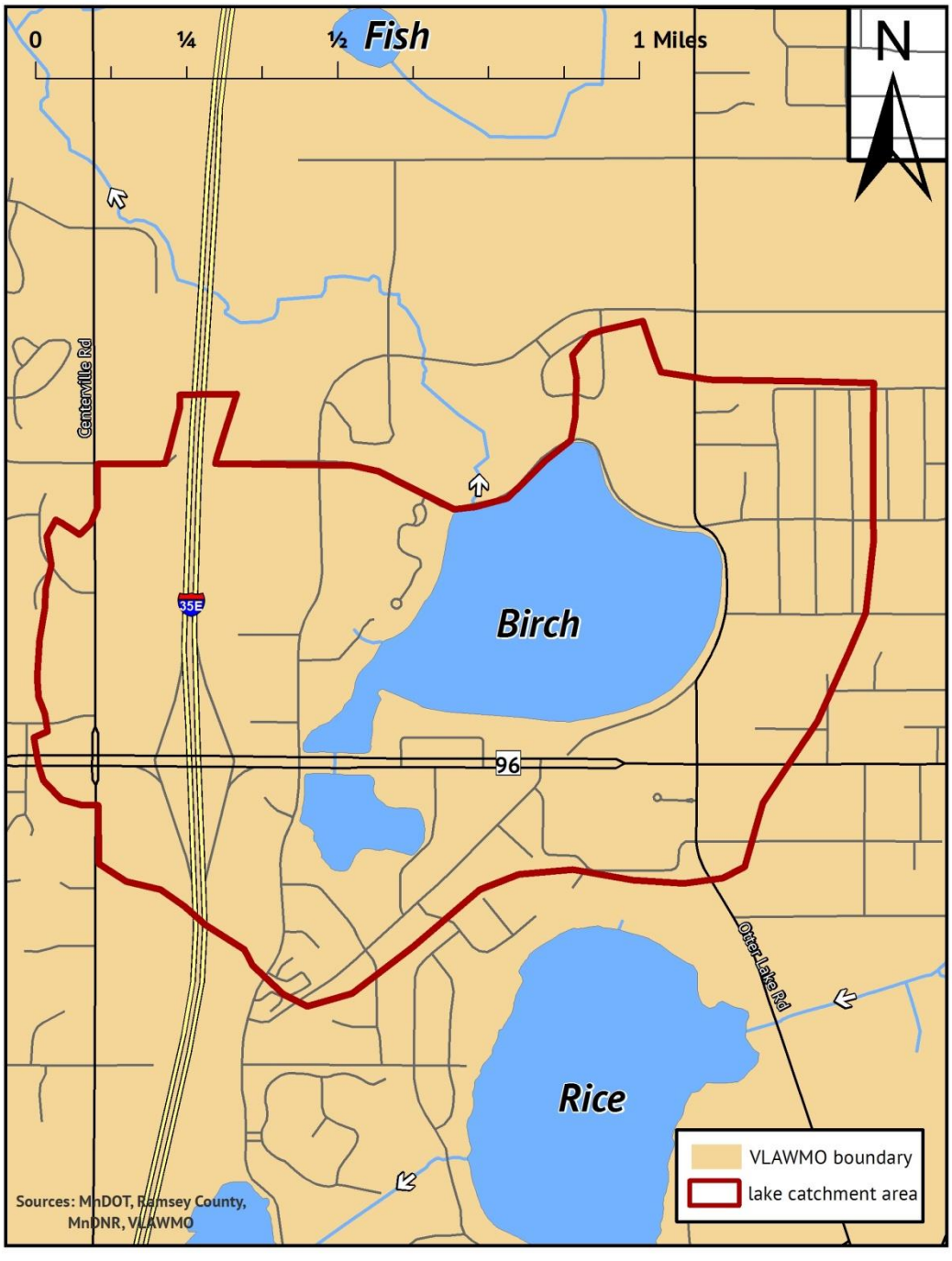
SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
Black	3/28/2016						10
Black	5/3/2016	6	25	5.7	0.94		
Black	5/17/2016	6	13	7.5			
Black	6/7/2016	7	14	3.2	0.95	ND	
Black	6/21/2016	7	7	3.2			
Black	7/12/2016	9	12	2.1	0.98	ND	
Black	7/26/2016	6	18	5.7			
Black	8/2/2016	6.5	13	3.2	0.82	ND	
Black	8/23/2016	7	22	5.7			
Black	9/13/2016	6	24	4.1	0.89	ND	
Black	9/27/2016	5	23	3.7			

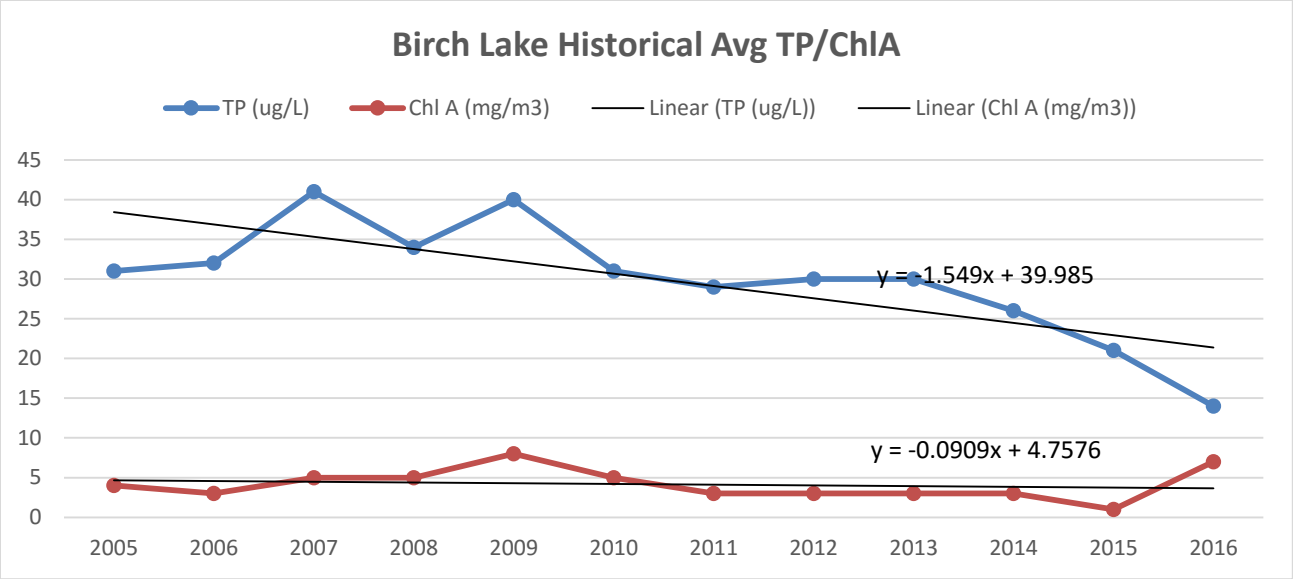
- Nitrogen and ammonia levels are well below state standards for Black Lake as well as chloride.



Birch Lake

Birch Lake is located within the City of White Bear Lake and is 127 acres with a maximum depth of 6 feet. Land is completely developed around Birch Lake and there are 4 main storm sewer inlets around the lake as well as other storm inlets. Birch Lake is a rare find in the metropolitan area because of its clarity and water quality. Results of ChlA and TP are very low for such an urbanized water body. TP and ChlA have had a slight down trend the last 16 years. This is good to see especially for a metro lake because it suggests that runoff from the surrounding watershed entering the lake is also low in nutrient levels and pre-treated. Birch Lake experienced a winter fish kill in 2014. Fish survey completed fall of 2014 did not show much change to the fish population from the 2011 survey except for a lack of largemouth bass in 2014. A lake vegetation survey was also completed in 2015.





Birch Lake Data

Birch Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	13.1	0.342	9.25	8.86
1997	22	14	2.4	5/16/2016	t	13.07	0.343	9.15	8.8
1998	41	4	2.4	6/10/2016	b	23.64	0.354	7.43	9.72
1999	31	8	2.4	6/10/2016	t	23.9	0.354	7.12	9.53
2000	27	14	2.4	7/20/2016	b	27.02	0.363	6.7	9.7
2001	42	8	2.4	7/20/2016	t	27.19	0.364	6.8	9.75
2002	31	10	2.4	9/20/2016	b	20.08	0.307	6.52	9.14
2003	35	13	2.4	9/20/2016	t	20.2	0.307	6.61	9.23
2004	31	0	2.4						
2005	31	4	2.4						
2006	32	3	2.4						
2007	41	5	2.4						
2008	34	5	1.2						
2009	40	8	1.1						
2010	31	5	1						
2011	29	3	2						
2012	30	3	2						
2013	30	3	2						
2014	26	3	1.7						
2015	21	1	1.7						
2016	14	7	1.8						

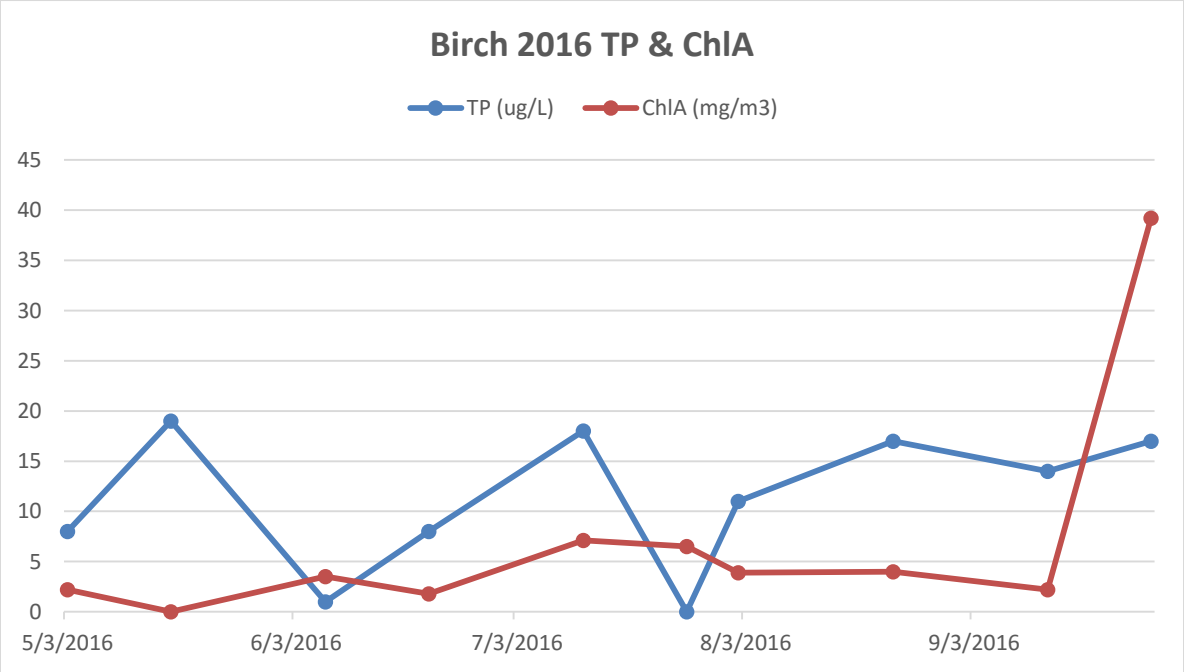
- Secchi reading for Birch is to lake bottom at sample site. Can see to bottom of lake throughout

- YSI parameters are very good for Birch Lake. Conductivity is on the high side but not unusual for a metro lake. This is most likely due to the amount of road runoff that enters Birch Lake. Winter conductivity levels are a bit higher

Birch Lake 2016 Raw Data

SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
Birch	1/21/2016						85
Birch	2/23/2016						85
Birch	3/28/2016						73
Birch	5/3/2016	5.5	8	2.2	0.63		77.9
Birch	5/17/2016	6	19	ND			80.3
Birch	6/7/2016	5.5	1	3.5	0.77	ND	85.6
Birch	6/21/2016	5.5	8	1.8			80.3
Birch	7/12/2016	4.5	18	7.1	0.93	ND	82.7
Birch	7/26/2016	5.5	ND	6.5			83.8
Birch	8/2/2016	5.5	11	3.9	0.72	ND	81.3
Birch	8/23/2016	5.5	17	4			73
Birch	9/13/2016	4	14	2.2	0.67	ND	71.6
Birch	9/27/2016	6.5	17	39.2			61.2

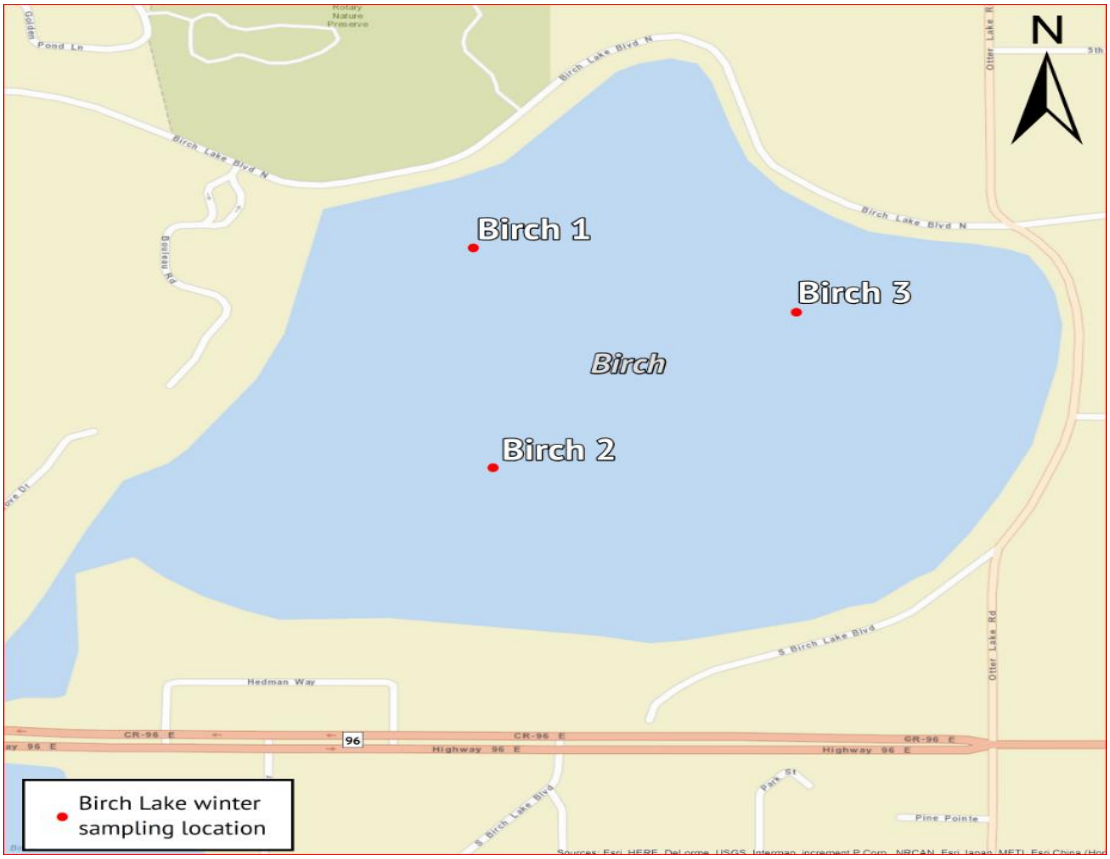
- Nitrogen and ammonia levels are well below state standards for Birch Lake



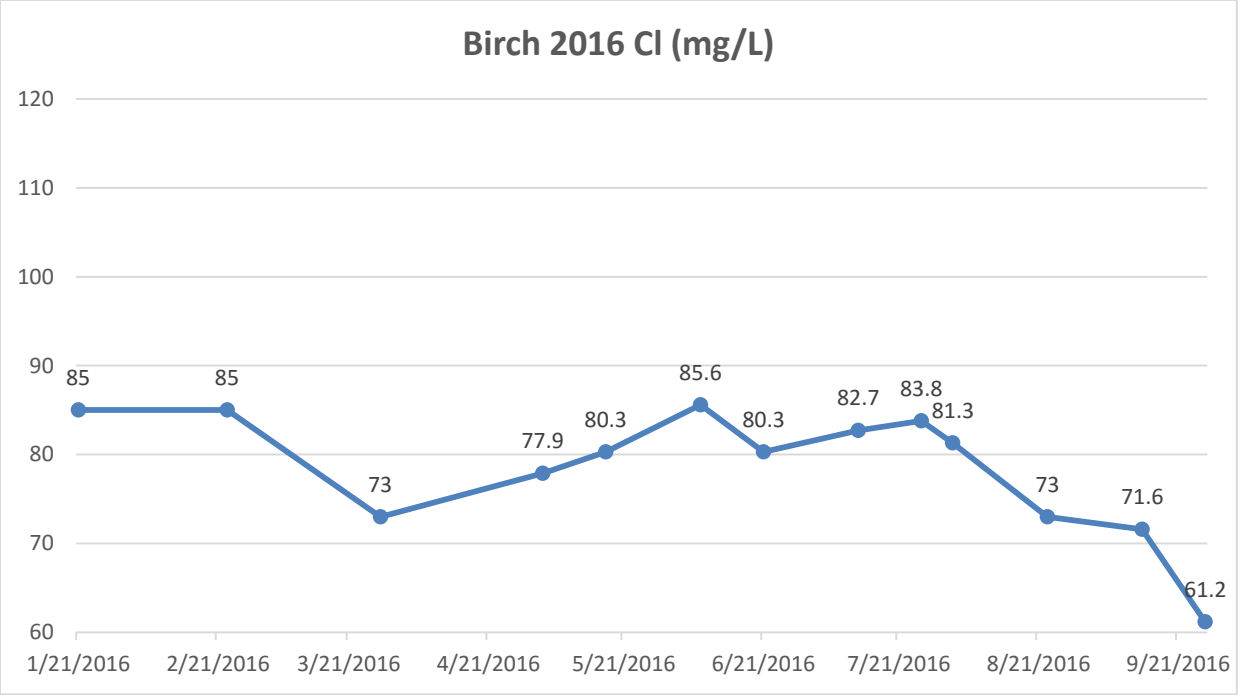
Birch Lake 2016 Winter YSI Readings

Lake	Date	Reading Depth (Bottom/Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
birch1	1/21/2016	t	2.46	0.37	10.18	5.93
birch1	1/21/2016	b	3.77	0.365	7.88	5.57
birch1	2/23/2016	t	3.76	0.387	7.44	5.93
birch1	2/23/2016	b	4.36	0.391	7.33	5.9
birch2	1/21/2016	t	2.72	0.371	10.1	5.77
birch2	1/21/2016	b	4.04	0.386	6.23	5.83
birch2	2/23/2016	t	4.15	0.396	8.53	6.39
birch2	2/23/2016	b	4.18	0.396	8.47	6.55
birch3	1/21/2016	t	3.28	0.365	10.15	5.87
birch3	1/21/2016	b	3.95	0.375	7.23	6.06
birch3	2/23/2016	t	4.06	0.398	8.51	6.65
birch3	2/23/2016	b	4.22	0.399	7.8	6.68

- VLAWMO started a year round chloride program on Birch in 2015. Bi-weekly samples were taken throughout the summer and winter monthly samples taken as well. Levels average around 80 mg/l. This is well below the 230mg/l state standard.

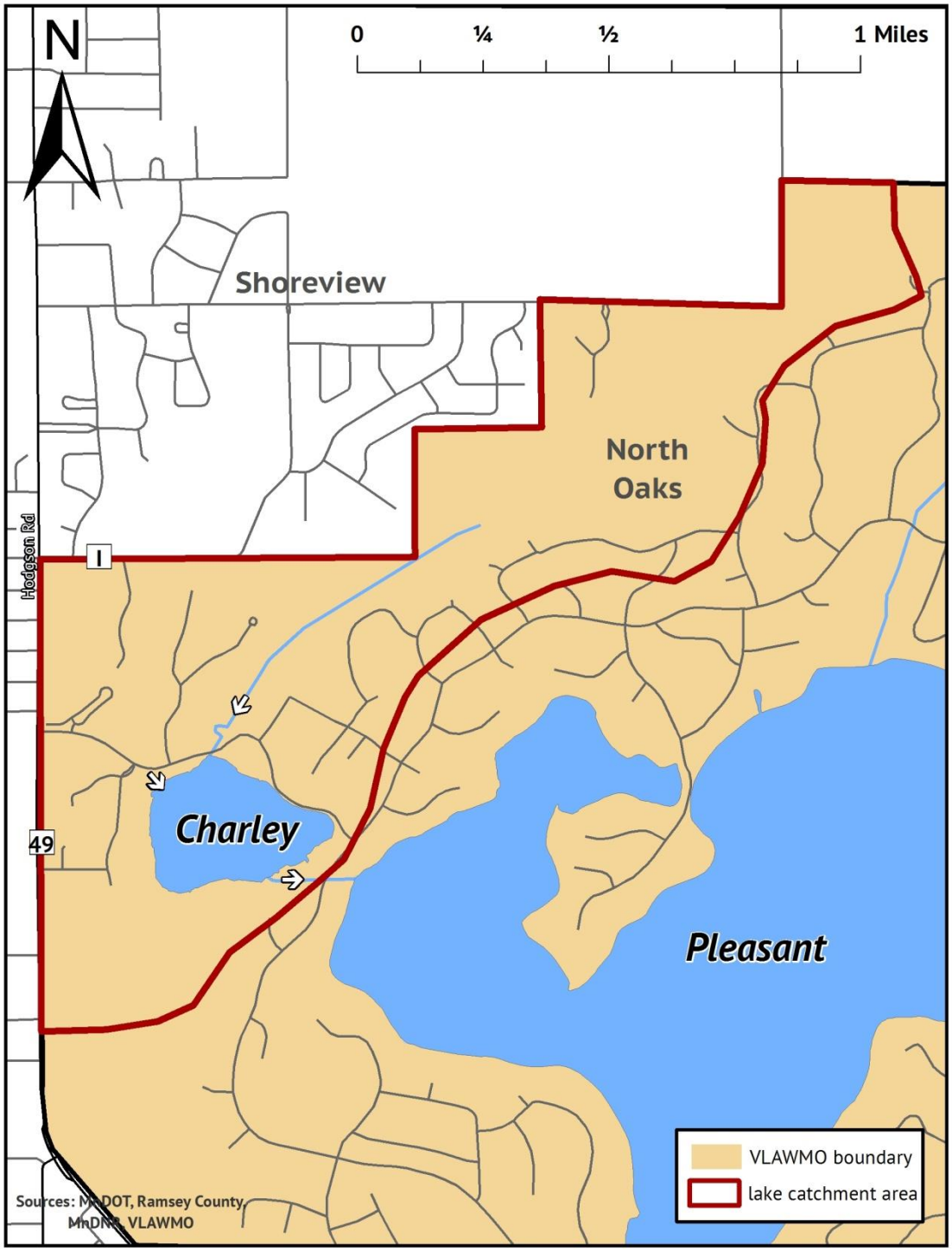


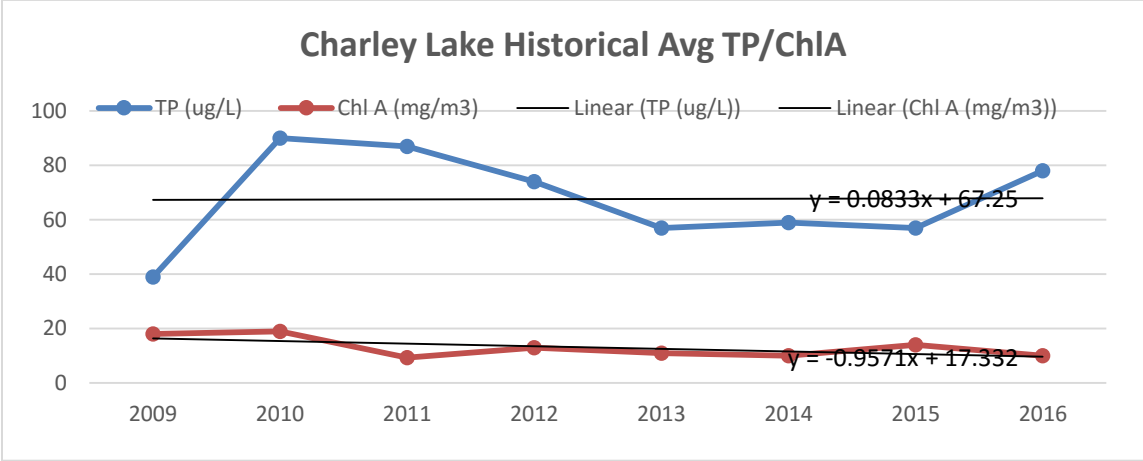
Birch Lake 2016 Chloride Readings



Charley Lake

Water is pumped from the Mississippi River to Charley Lake via a 60 inch 8 mile long pipe from a pumping station in Fridley. An average of 32 million gallons of water is pumped into Charley Lake each day. Charley Lake is the start of the chain of lakes controlled by the St. Paul Water Utility. This chain of lakes supplies drinking water for more than 400,000 customers. Most of the drinking water is coming from the Mississippi River, while some comes from wells to help cool the water and reduce treatment costs. VLAWMO began sampling Charley in 2009.





Charley Lake Data

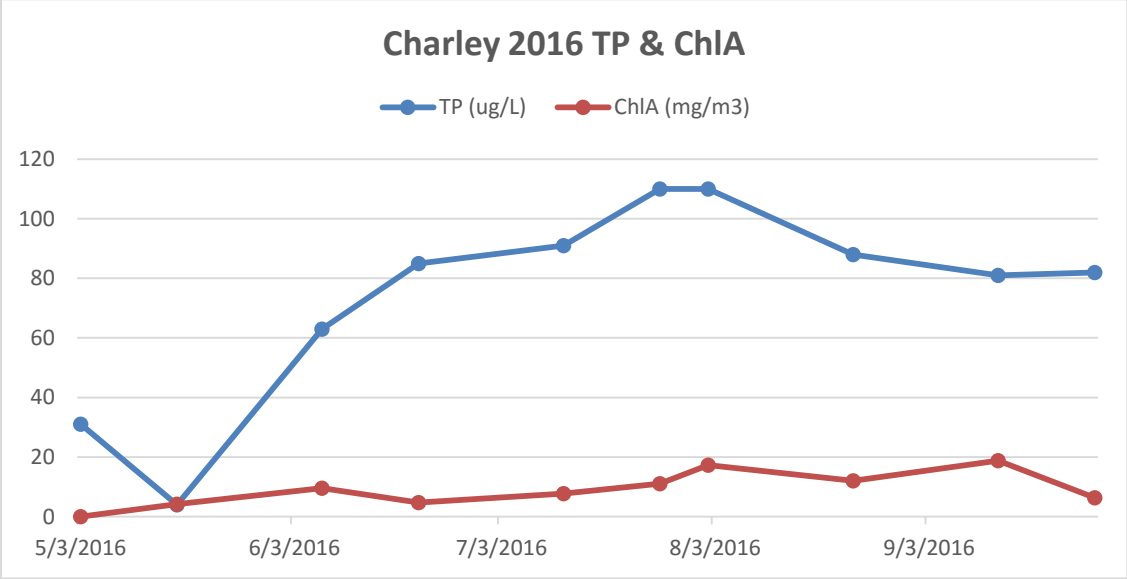
Charley Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	13.52	0.346	8.19	8.14
2009	39	18	1	5/16/2016	t	14.9	0.338	8.95	8.37
2010	90	18.9	1	6/10/2016	b	21.75	0.397	6.14	8.58
2011	87	9.3	1.1	6/10/2016	t	22.92	0.398	6.26	8.46
2012	74	13	1	7/20/2016	b	22.84	0.221	4.65	7.68
2013	57	11	1	7/20/2016	t	26.12	0.225	6.74	8.18
2014	59	10	1.1	9/20/2016	b	19.4	0.371	2.73	7.06
2015	57	14	1.1	9/20/2016	t	20.4	0.362	8.03	7.44
2016	78	10	1.2						

- Charley Lake YSI parameters are good. There is a constant flow of millions of gallons of Mississippi river water through Charley Lake year round and with that these parameters seem consistent with normal metro lakes. TP levels were higher than state standard of 40ug/l for deep lakes

Charley Lake 2016 Raw Data

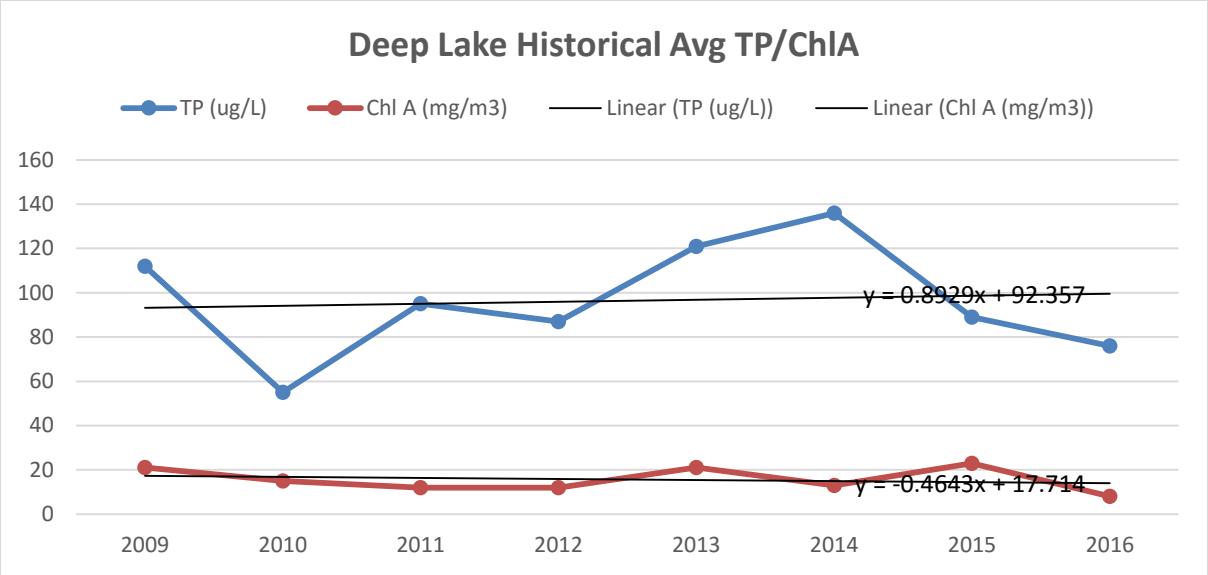
SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
Charley	3/28/2016						15
Charley	5/3/2016	4.5	31	ND	0.91	ND	
Charley	5/17/2016	4.5	4	4.2			
Charley	6/7/2016	4	63	9.6	0.7	ND	
Charley	6/21/2016	5	85	4.7			
Charley	7/12/2016	4	91	7.7	1	ND	
Charley	7/26/2016	4	110	11.1			
Charley	8/2/2016	3	110	17.3	0.94	ND	
Charley	8/23/2016	3	88	12			
Charley	9/13/2016	3	81	18.8	0.98	ND	
Charley	9/27/2016	4	82	6.3			

- Nitrogen and ammonia levels are below state standards for Charley Lake. NO3 levels are higher in Charley compared to the rest of VLAWMO lake and is most likely due to the Mississippi water that is pumped through the lake



Deep Lake

Deep lake is a little over 80 acres and sits between and is hydro logically connected to Wilkinson Lake to the north and Pleasant Lake to the south. A channel connects the three lakes. A Deep Lake Preservation Committee was formed in 2009 by the residents living around Deep Lake to help maintain and improve the quality of the lake. All VLAWMO lakes are tested for nitrogen's and ammonia and Deep lake year over year tends to have the highest concentrations, although they are still below the standards. TP and ChlA have been trending up since sampling began in 2009. By mid to late summer Deep Lake is very weedy and this has been a concern for residents along with the high nutrients coming from Wilkinson.



Deep Lake Data

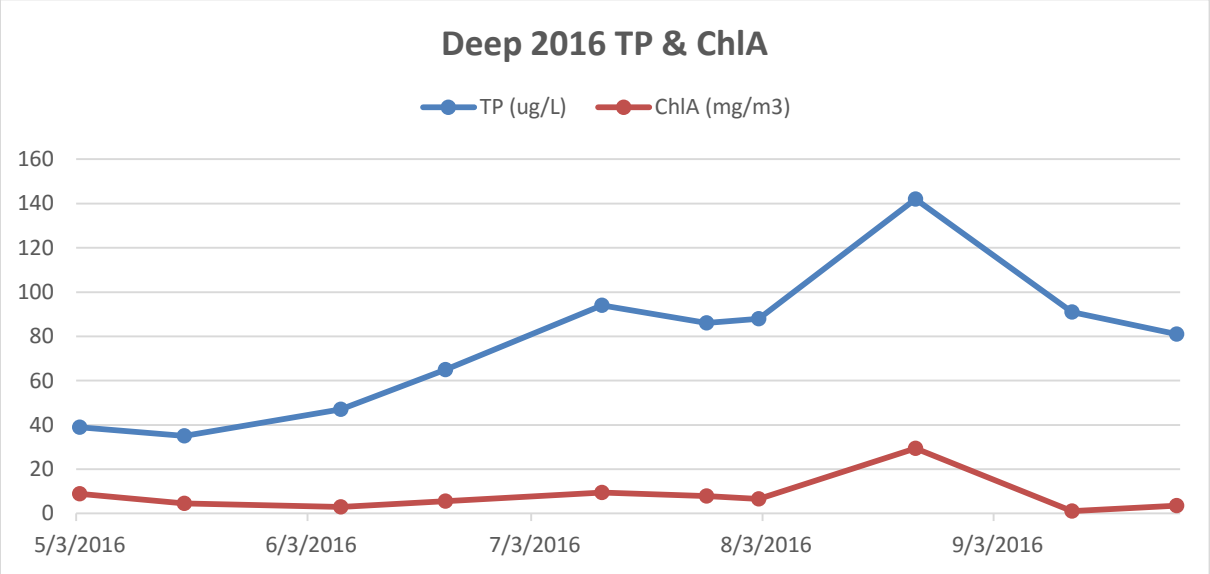
Deep Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/ Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	m	14.4	0.382	7.8	8.2
2009	112	21	1	6/10/2016	m	24.26	0.385	7.68	9.28
2010	55	15	0.9	7/20/2016	m	25.62	0.404	3.9	8.31
2011	95	12	1.2	9/20/2016	b	18.89	0.412	2.47	7
2012	87	12	1	9/20/2016	t	18.99	0.412	2.55	6.99
2013	121	21	1						
2014	136	13	1.1						
2015	89	23	1						
2016	76	8	1.1						

- Deep Lake YSI data is similar to that of Charlie Lake. Conductivity is on the high side. TP levels are very high with very low ChlA levels. This is unusual, TP and ChlA levels usually reflect each other, High TP = High ChlA, Low TP = Low ChlA. Charley is very weedy and this may be reducing the ChlA levels.

Deep Lake 2016 Raw Data

SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
Deep	3/28/2016						45
Deep	5/3/2016	4.5	39	8.8	1.1	ND	
Deep	5/17/2016	4	35	4.6			
Deep	6/7/2016	4	47	2.9	0.97	ND	
Deep	6/21/2016	4	65	5.6			
Deep	7/12/2016	3	94	9.5	1.2	ND	
Deep	7/26/2016	3	86	7.9			
Deep	8/2/2016	5	88	6.6	1.2	ND	
Deep	8/23/2016	2.5	142	29.4			
Deep	9/13/2016	3.5	91	1.1	1.7	0.39	
Deep	9/27/2016	4.5	81	3.5			

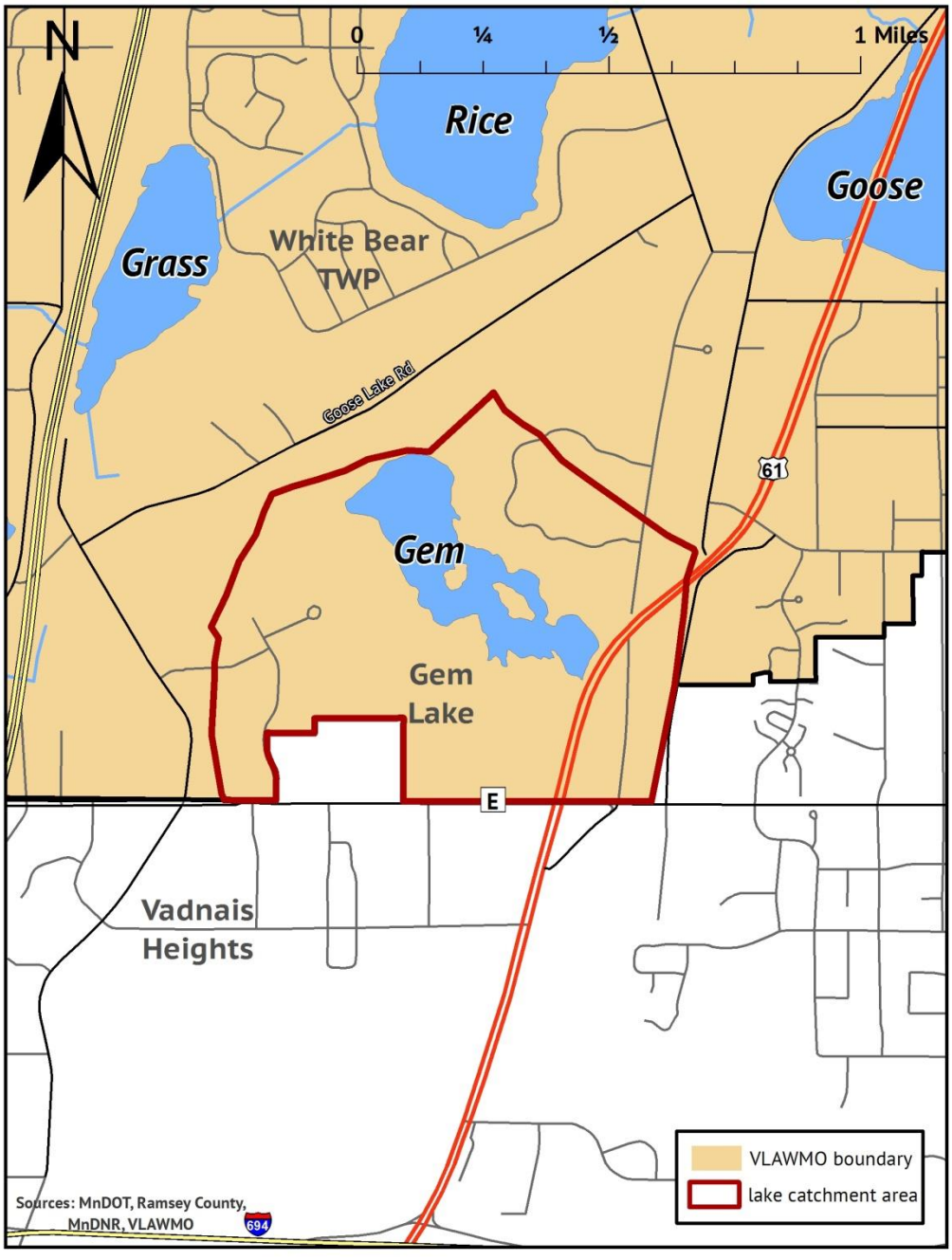
- Nitrogen and ammonia levels are below state standards for Deep Lake.

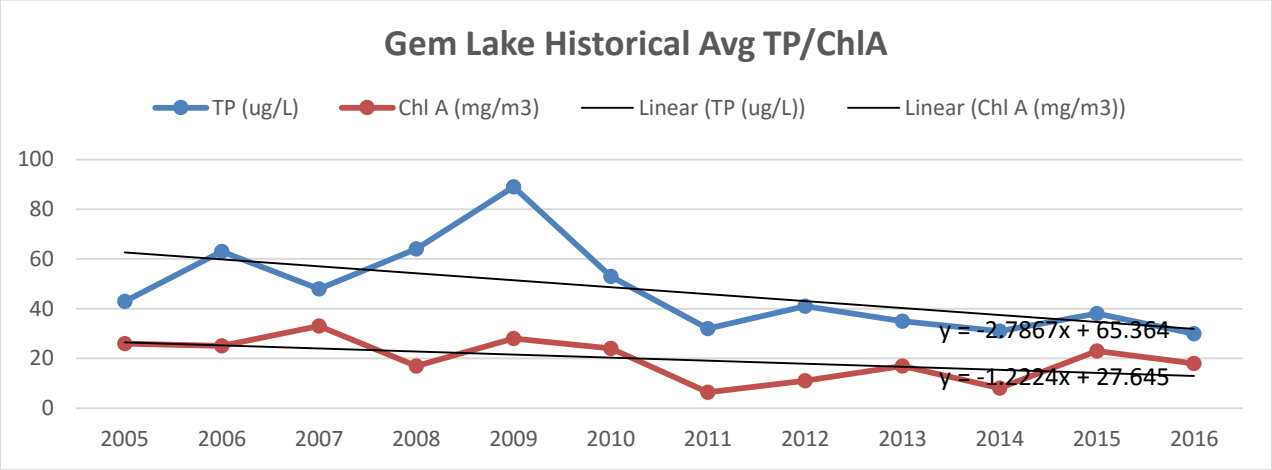


Gem Lake

Gem Lake is within the City of Gem Lake and has no public access. It is 25 acres in size and is 17 feet deep. There has been development along portions of the lake in recent years. In 2000, volunteers noticed a distinct algae bloom and noted that water clarity was getting poorer. Over the 16 years of monitoring data there is a slight up trend in TP levels with a slight down trend in ChlA levels.

Gem Lake has also been included on the Lambert Creek TMDL study for nutrient impairment. Recent years of monitoring data are suggesting that the trend may be heading down for nutrient levels in Gem Lake and the MN Pollution Control Agency will be assessing the data winter of 2017 for removal from the state impaired waters list. The City of Gem Lake, VLAWMO and stakeholders will be working together to implement the TMDL strategies from the approved 2014 report. MNDOT's Hwy 61 ditch work in 2011 has seemed to improve the water quality in Gem Lake.





Gem Lake Data

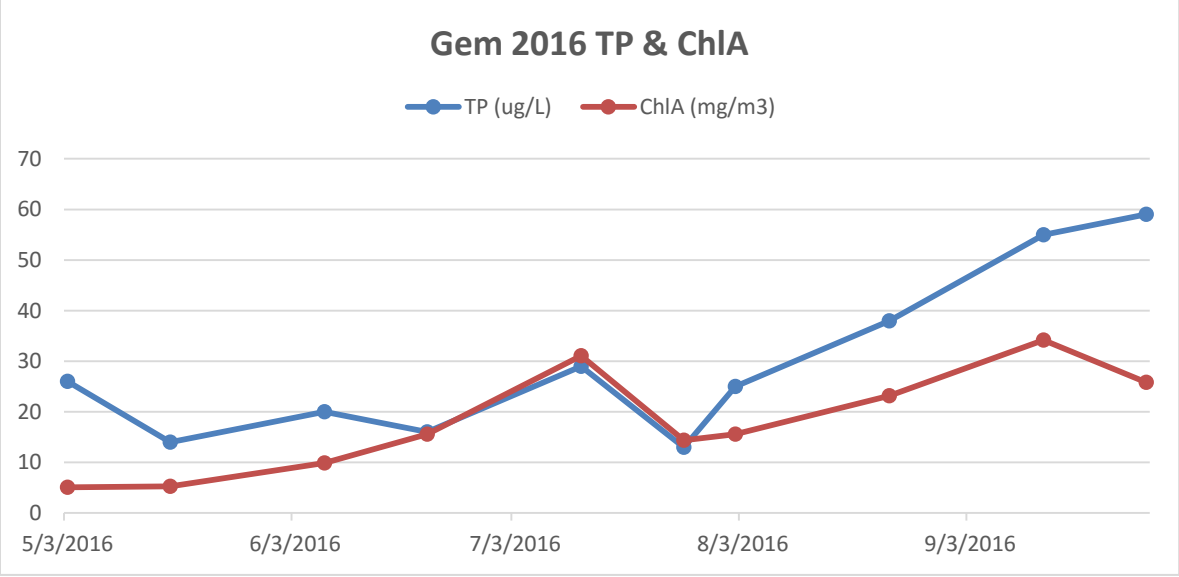
Gem Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/Middle /Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	13.3	0.185	6.83	8.07
1997	54	23	1.2	5/16/2016	m	14.08	0.185	7.11	8.06
1998	33	24		5/16/2016	t	14.31	0.185	7.3	8.15
1999	26	16	1.2	6/10/2016	b	16.16	0.192	1	7.81
2000	36	17	1.1	6/10/2016	m	21.09	0.191	6.93	8.07
2001	56	12	1.8	6/10/2016	t	23.22	0.19	6.79	8.74
2002	39	25	1.3	7/20/2016	b	24.72	0.185	4.66	7.61
2003	52	20	1.4	7/20/2016	t	26.35	0.185	5.92	8.23
2004	49	0	1.5	9/20/2016	b	20.29	0.176	3.28	8.19
2005	43	26	0	9/20/2016	m	20.49	0.176	5.69	8.19
2006	63	25	0	9/20/2016	t	20.58	0.176	5.78	8.15
2007	48	33	1.1						
2008	64	17	1.5						
2009	89	28	1.3						
2010	53	24	1.4						
2011	32	6.4	2.1						
2012	41	11	2						
2013	35	17	2						
2014	31	8	2.9						
2015	38	23	2.2						
2016	30	18	1.6						

- Gem Lake YSI data is similar to that of other metro lakes. Conductivity is pretty low which is good and usually Gem Lake shows signs of stratification. At 17ft, Gem is the deepest lake VLAWMO monitors. Gem usually has a late season algae bloom and that was the case in 2015. TP and ChlA levels are well below state standards for the 5th year in a row. Hwy 61 was redone in 2011 and MNDOT did work on the ditches along the Hwy. That work seems to have benefited the water quality in Gem

Gem Lake 2016 Raw Data

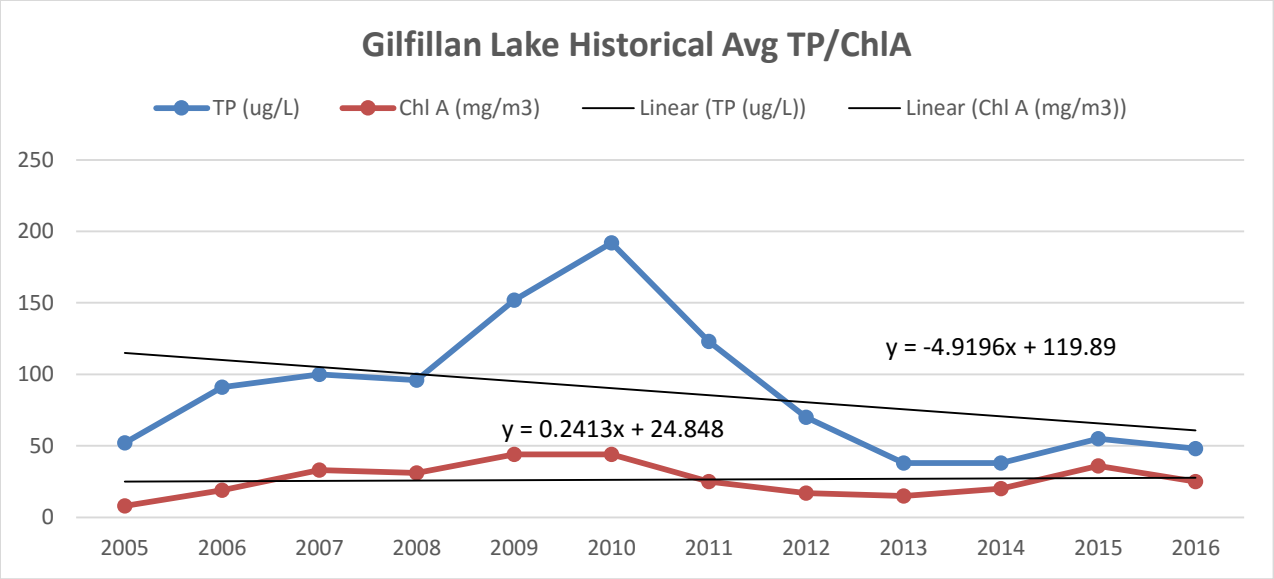
SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
Gem	3/28/2016						38
Gem	5/3/2016	8	26	5.1	0.71		
Gem	5/17/2016	9	14	5.3			
Gem	6/7/2016	5	20	9.9	1.1	ND	
Gem	6/21/2016	5.5	16	15.6			
Gem	7/12/2016	3	29	31.1	1.5	ND	
Gem	7/26/2016	4	13	14.4			
Gem	8/2/2016	5.5	25	15.6	0.88	ND	
Gem	8/23/2016	4	38	23.2			
Gem	9/13/2016	3	55	34.2	1	ND	
Gem	9/27/2016	4	59	25.8			

- Nitrogen and ammonia levels are below state standards for Gem Lake.



Gilfillan Lake

Gilfillan Lake is located within the City of North Oaks and is surrounded by homes. It is 110 acres with a maximum depth of 6 feet. The Minnesota Department of Natural Resources has used the lake for walleye stocking nursery in the past. According to available information, there has not been any fish stocking activity for a few years other than homeowners socking minnows. Gilfillan is one of four VLAWMO lakes that are part of the TMDL study due to nutrient impairment. The City of North Oaks and the SPRWS have been pumping water from Pleasant Lake to Gilfillan Lake to increase water levels. The pump, filter and piping were installed fall of 2011, pumping began spring of 2012. The increased water level (about 4.5ft) has significantly reduced nutrient levels in the lake, although they are still above state standards. The pumps have been turned on in the spring the last few years to make sure everything was working properly and were then shut off for the season due to high water. Water level stayed close to the max elevation of 910ft for the summer.



Gilfillan Lake Data

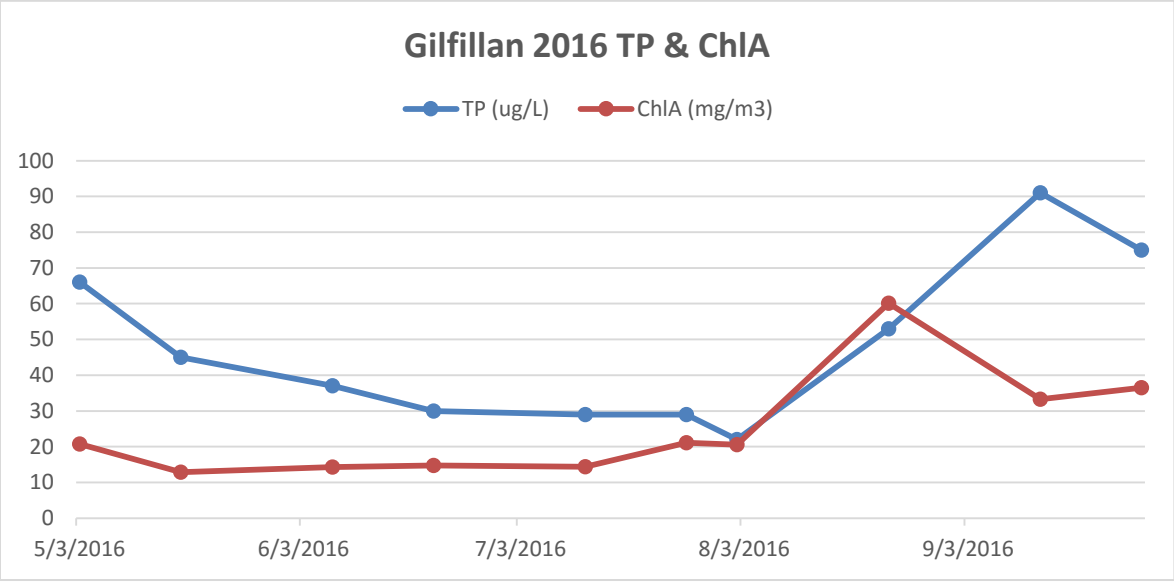
Gilfillan Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/ Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	13.69	0.28	7.4	7.88
1997	96	32	0.5	5/16/2016	t	14.33	0.279	7.62	7.79
1998	47	44	0.5	6/10/2016	b	20.37	0.282	8.11	8.74
1999	72	23	0	6/10/2016	t	24.07	0.28	7.91	9.02
2000	35	47	0	7/20/2016	b	24.9	0.269	7.85	8.41
2001	84	20	0	7/20/2016	t	26.7	0.27	7.8	8.59
2002	81	43	0.4	9/20/2016	b	19.96	0.267	7.6	8.01
2003	44	25	1.4	9/20/2016	t	20.51	0.267	7.66	8.14
2004	58	0	0						
2005	52	8	0						
2006	91	19	0						
2007	100	33	0.7						
2008	96	31	0.5						
2009	152	44	0.4						
2010	192	44	0.4						
2011	123	25	0.4						
2012	70	17	0.8						
2013	38	15	1						
2014	38	20	0.8						
2015	55	36	0.6						
2016	48	25	0.7						

- Gilfillan Lake YSI data is similar to that of other metro lakes. Conductivity is pretty low and is consistent with other lakes that don't receive much or any road runoff. Inlet data is from 2012, shows below state standard Tp levels being pumped into main lake. Since augmentation began again in 2012, lake nutrients have dropped substantially. This could very well be due to the 4+ft of Pleasant Lake water added to Gilfillan in 2012. Since 2012 very little augmentation has taken place to the lake due to natural precipitation keeping the lake at the residents desired elevation of around 910ft. Nutrient levels look be slightly rising from the lows at the start of augmentation.

Gilfillan Lake 2016 Raw Data

SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
Gilfillan	3/28/2016						30
Gilfillan	5/3/2016	3	66	20.7	1.8		
Gilfillan	5/17/2016	2.5	45	12.9			
Gilfillan	6/7/2016	1.5	37	14.3	1.8	ND	
Gilfillan	6/21/2016	3	30	14.7			
Gilfillan	7/12/2016	3	29	14.4	1.4	ND	
Gilfillan	7/26/2016	2.5	29	21.1			
Gilfillan	8/2/2016	3.5	22	20.6	1.3	ND	
Gilfillan	8/23/2016	2.5	53	60.1			
Gilfillan	9/13/2016	3	91	33.3	1.5	ND	
Gilfillan	9/27/2016	2	75.000	36.5			

- Nitrogen and ammonia levels are below state standards for Gilfillan Lake.



Goose Lake

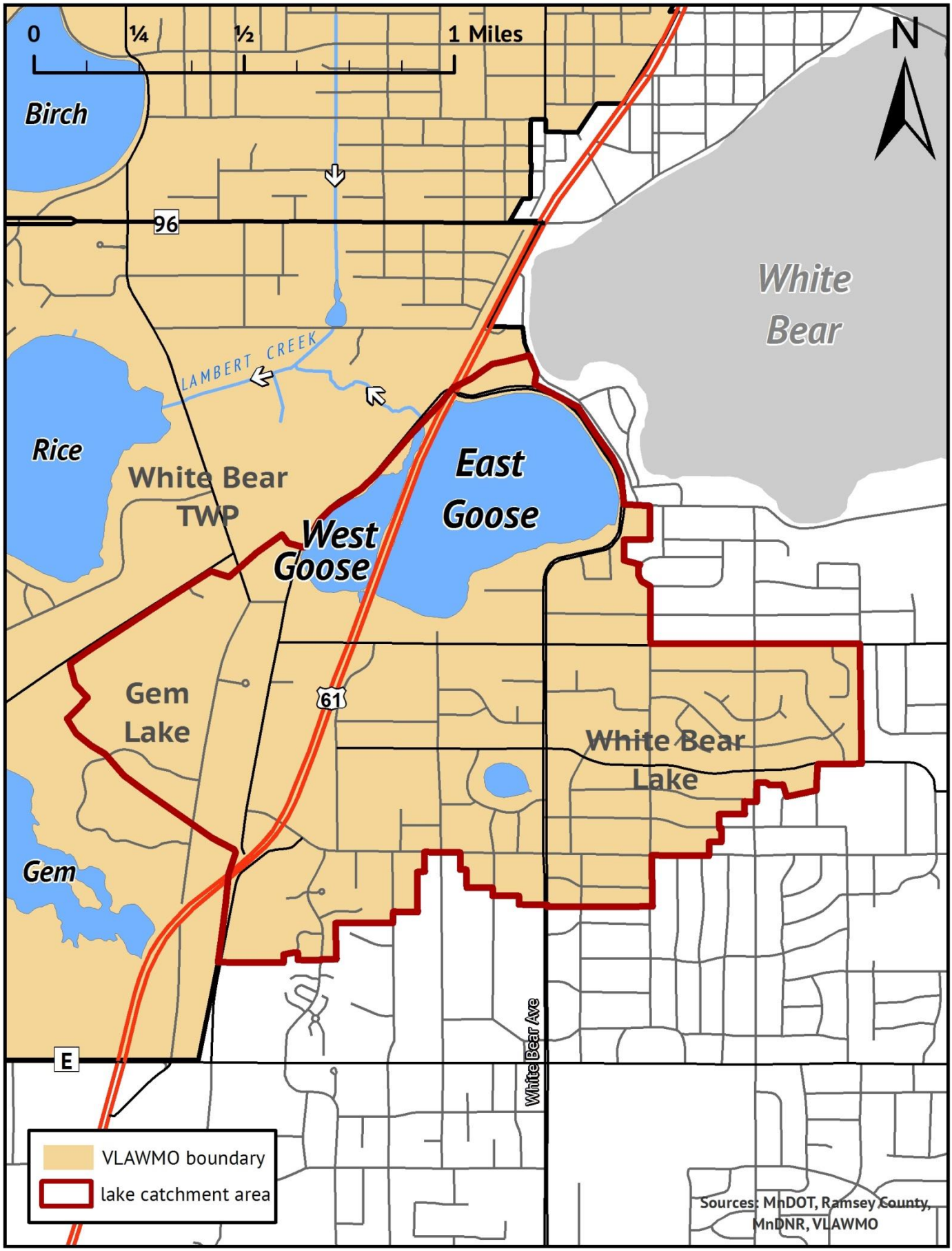
Goose Lake is located in White Bear Lake and is 145 acres with a maximum depth of 7 feet. The land use is largely residential and industrial around the lake and Highway 61 cuts through the lake. The old White Bear Lake sewage treatment plant discharged to Goose Lake for almost 50 years. A sediment study conducted in 1989 found that there was PCB contamination as well as high levels of cadmium, lead, and zinc. Another sediment study should be conducted to look for any changes in the last 20 years.

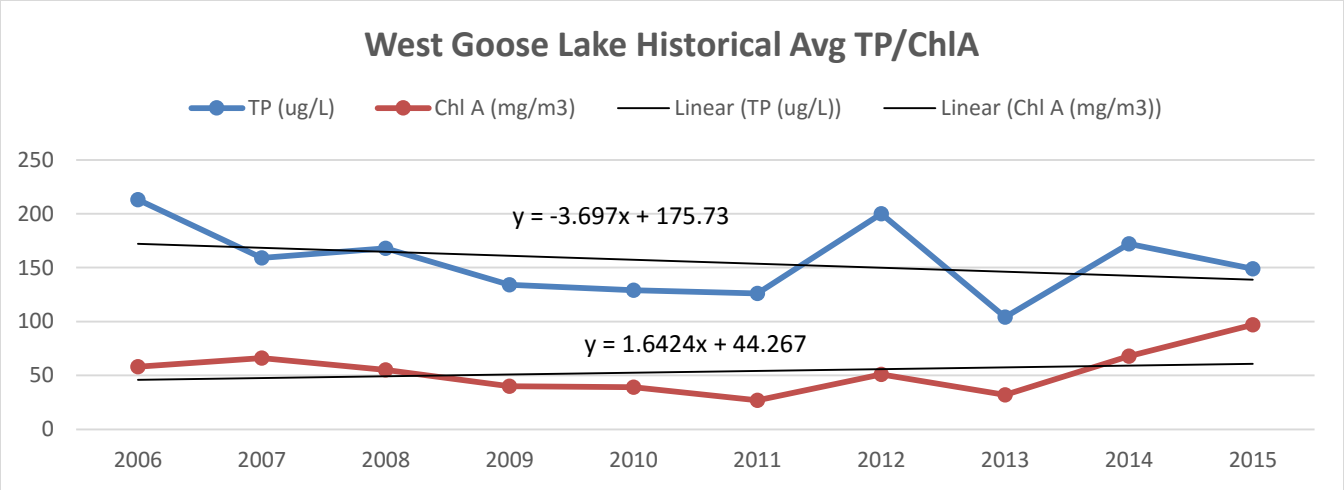
Though the lake is connected via culverts under the highway, VLAWMO began to assess the lake on each side of the road to track any differences between the two water bodies. In years past, only the east side of the lake was monitored. In 2006, VLAWMO began to collect samples from the west side. Both East and West Goose Lake are included in the Lambert Creek TMDL for nutrient impairment.

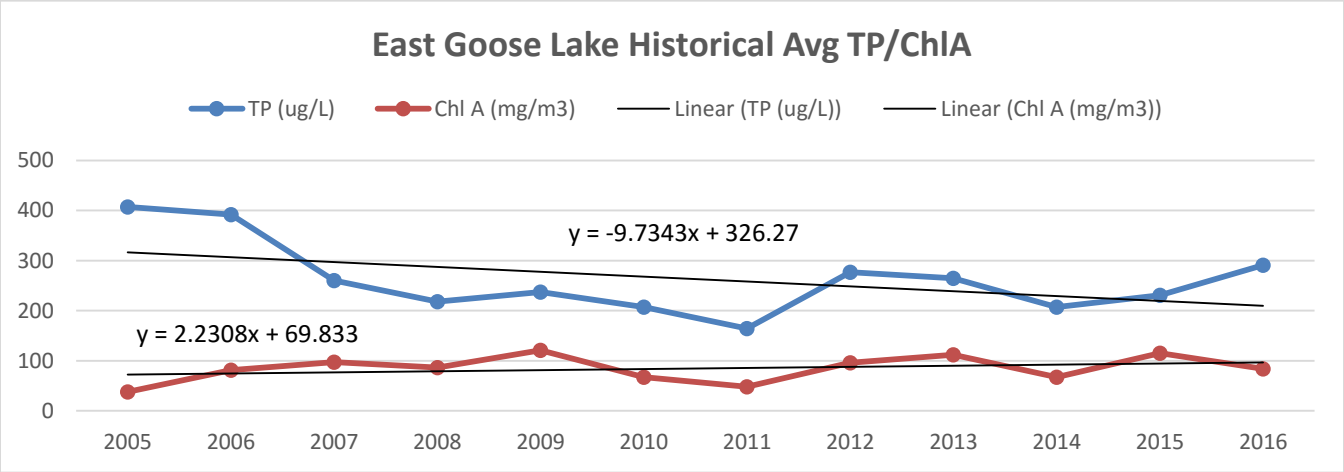
Groundwater used to cool equipment at the Kohler Mix Company is continuously discharging into the south end of West Goose Lake year round at a rate of 500 gallons/minute. This seems to be "flushing" the west side of the lake and could be a major reason the west side of the lake has consistently had better water quality compared to the east side over the years. The north end of West Goose discharges through a weir into Lambert Creek which flows into East Vadnais Lake, the drinking water reservoir for the SPRWS.

Approximately 16,000lbs of bullhead were removed out of both basins in 2013. The main source of nutrient issues in Goose Lake is from internal loading. Rough fish (bullhead, carp, sucker) suspend nutrients in the water column while foraging for food. We hope to see a decrease in nutrient levels over the next few years due to the rough fish removal. Spring of 2015 nets were be placed in the lake again to make sure the fish harvest was successful. BioBase surveys were done on both basins in 2014 to monitor the aquatic vegetation.

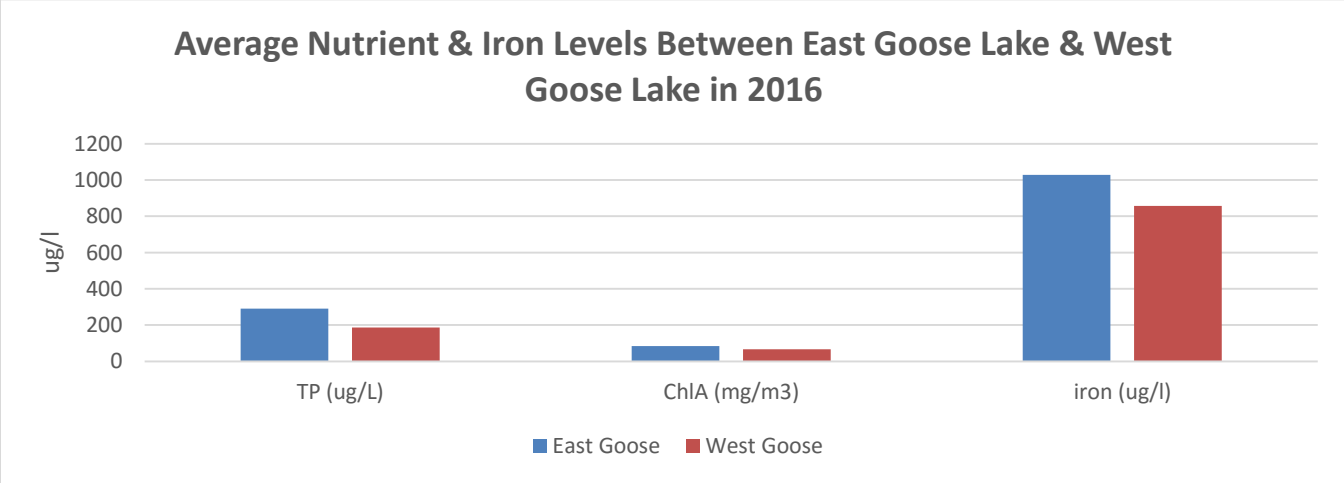
In 2017 another fish survey will be completed to determine how well the rough fish removal worked. VLAWMO also hired specialized consultants to work on Goose Lake to help determine what is causing the extremely high nutrient levels and to figure out what steps are needed to remedy the issue.


0
¼
½
1 Miles
N
Birch
96
White Bear
LAMBERT CREEK
Rice
White Bear TWP
East Goose
West Goose
Gem Lake
61
White Bear Lake
Gem
E
White Bear Ave
VLAWMO boundary
lake catchment area
Sources: MnDOT, Ramsey County, MnDNR, VLAWMO





- Both the East and West side are showing long term downward trends for both TP & ChlA. This is a good sign but both these water bodies are still well above state standards.



- Comparison of water quality between the two basins above shows that Goose Lake West has better average TP and Chla levels compared to Goose Lake East, however both basins are still above PCA

standards. TMDL will focus on strategies to move these two basins closer to state standards. Rough fish removal by VLAWMO along with new road construction projects around the lake by the City of White Bear Lake will hopefully help with both the external and internal nutrient loading to the lake reducing overall nutrient levels in the lake.

Goose Lake Data

East Goose

East Goose Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/ Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	13.11	0.323	9.01	9.01
1997	21	134	0.4	5/16/2016	t	13.21	0.323	8.93	8.93
1998	17	93	0.2	6/10/2016	b	19.81	0.332	2.14	8.68
1999	475	56	0.3	6/10/2016	t	24.01	0.374	12.2	10.19
2000	49	154	0.3	7/20/2016	b	24.26	0.306	1.28	N/A
2001	603	28	0.3	7/20/2016	t	25.88	0.315	7.07	N/A
2002	613	170	0.2	9/20/2016	b	19.39	0.259	6.6	9.18
2003	342	66	0.3	9/20/2016	t	19.76	0.26	6.95	9.31
2004	526	0	0						
2005	407	38	0						
2006	392	81	0						
2007	260	97	0						
2008	218	86	0.3						
2009	237	121	0.3						
2010	207	67	0.3						
2011	164	48	0.3						
2012	277	96	0.2						
2013	265	112	0.5						
2014	207	67	0.4						
2015	231	115	0.6						
2016	291	84	0.5						

- East Goose Lake YSI data is similar to that of other metro lakes.

West Goose

West Goose Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	13.43	0.302	7.4	8.12
2006	213	58		5/16/2016	t	13.61	0.302	7.82	8.52
2007	159	66		6/10/2016	b	23.33	0.312	7.91	9.08
2008	168	55	0.3	6/10/2016	t	23.43	0.312	7.81	9.12
2009	134	40	0.5	7/20/2016	b	26.12	0.301	5.7	8.75
2010	129	39	0.5	7/20/2016	t	26.17	0.301	5.85	8.96
2011	126	27	0.8	9/20/2016	b	19.93	0.281	7.12	9.02
2012	200	51	0.7	9/20/2016	t	20	0.281	7.24	9.17
2013	104	32	1						
2014	172	68	0.5						
2015	149	97	0.5						
2016	187	67	0.4						

- West Goose Lake YSI data is similar to that of East Goose Lake. .

Goose Lake 2016 Raw Data

East Goose

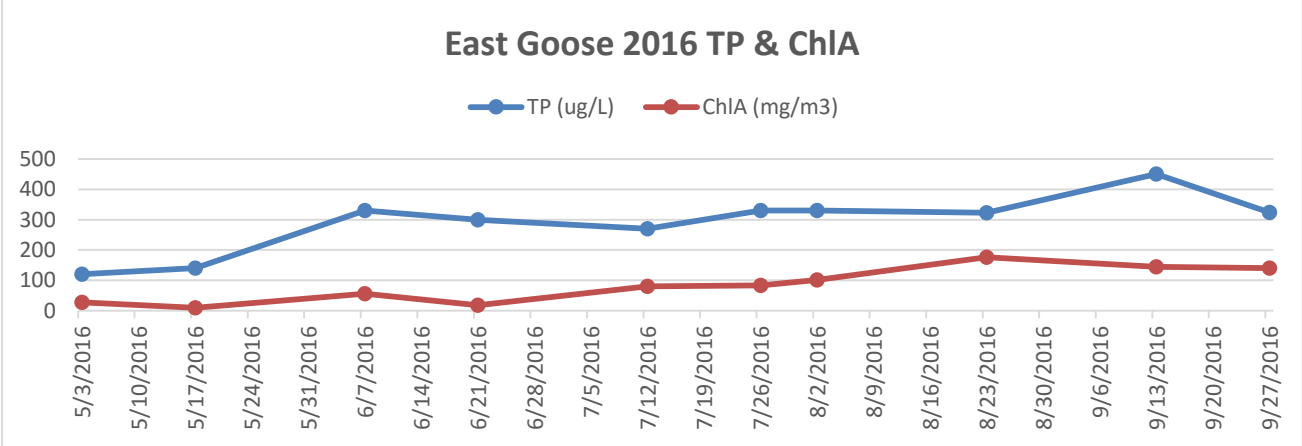
SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)	Iron (ug/L)
East Goose	3/28/2016						61	
East Goose	5/3/2016	2	120	27.7	2.1			527
East Goose	5/17/2016	1.25	140	9.6				681
East Goose	6/7/2016	0.5	330	56	3.9	ND		923
East Goose	6/21/2016	0.5	300	18.6				1020
East Goose	7/12/2016	0.5	270	80.1	3.2	ND		846
East Goose	7/26/2016	0.5	330	83.3				1590
East Goose	8/2/2016	0.5	330	102	2.7	ND		1160
East Goose	8/23/2016	0.5	323	176				1290
East Goose	9/13/2016	0.5	450	145	3.5	ND		1200
East Goose	9/27/2016	0.5	324	140				1050

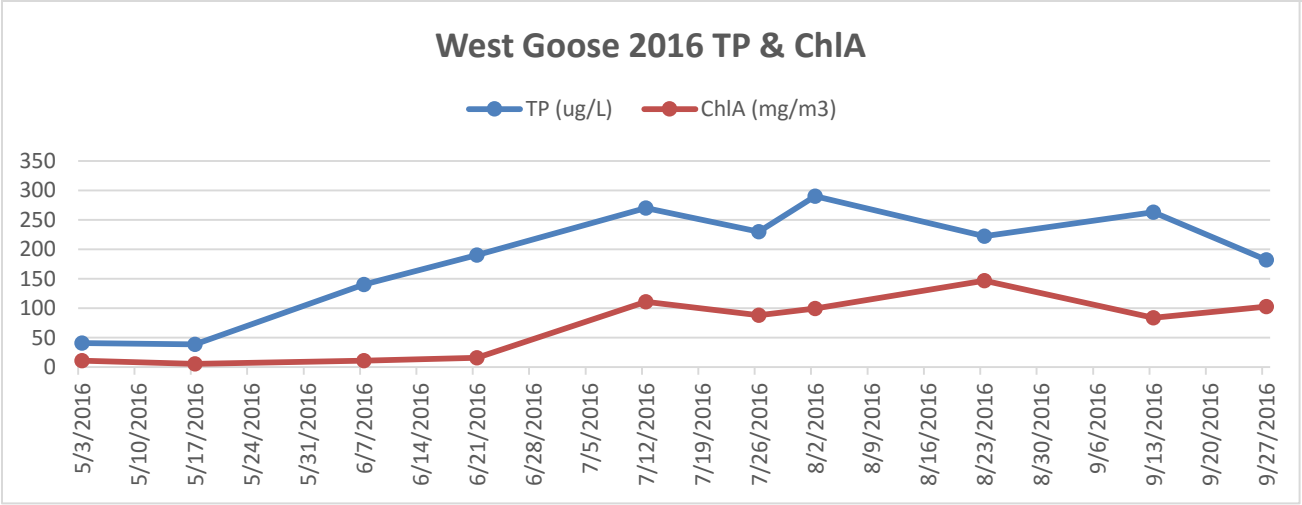
- Iron levels are well above standards for East Goose Lake 300 ug/l

West Goose

SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)	Iron (ug/L)
West Goose	3/28/2016						29	
West Goose	5/3/2016	3.5	41	10.9	0.86			651
West Goose	5/17/2016	2.5	39	5.5				330
West Goose	6/7/2016	1	140	11.2	2.4	ND		885
West Goose	6/21/2016	0.5	190	15.9				845
West Goose	7/12/2016	0.5	270	111	4.1	ND		1080
West Goose	7/26/2016	0.5	230	88				930
West Goose	8/2/2016	0.5	290	99.5	1.1	ND		888
West Goose	8/23/2016	0.5	222	147				1330
West Goose	9/13/2016	0.5	263	83.8	1.1	ND		684
West Goose	9/27/2016	0.5	182	103				942

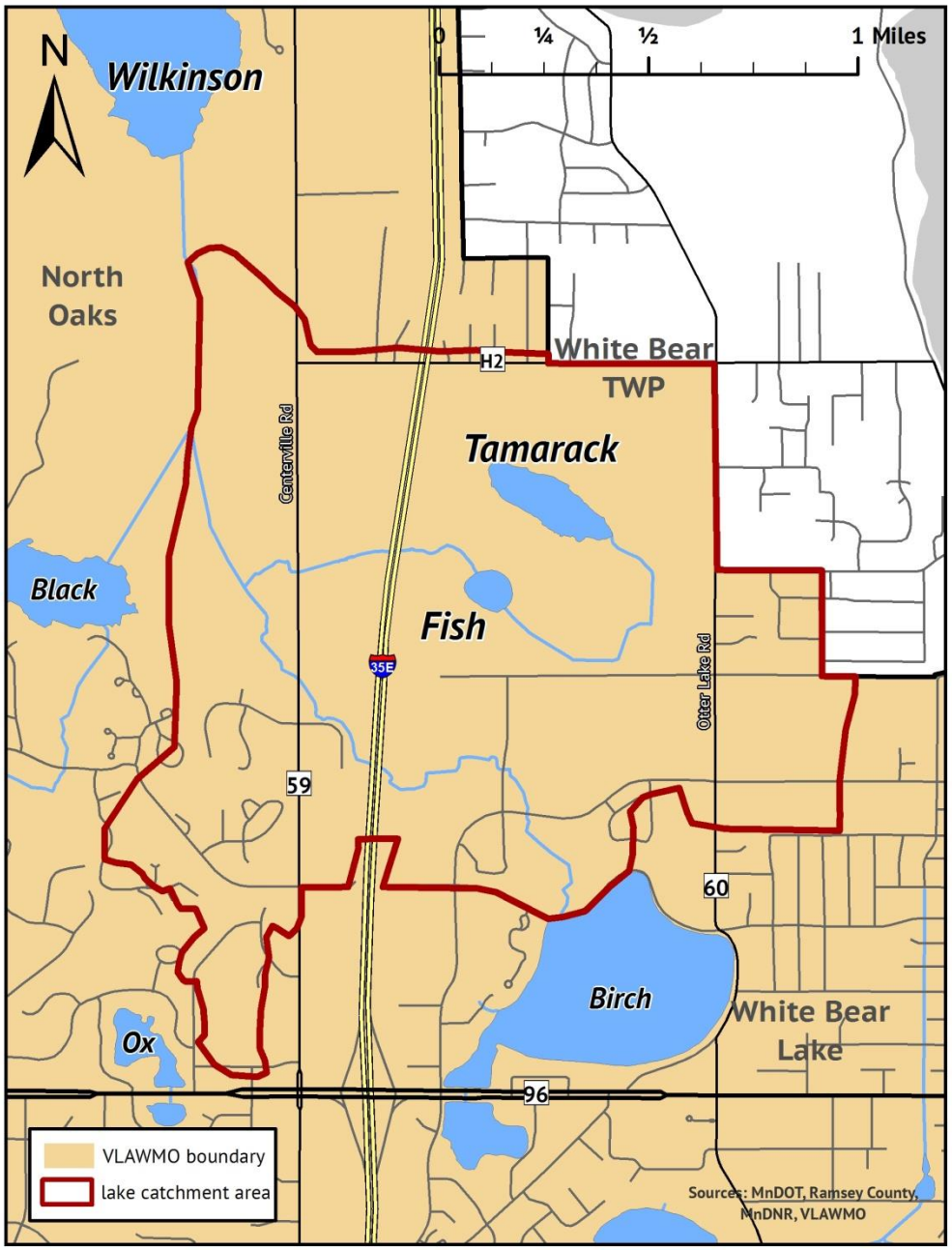
- Iron levels are well above standards for West Goose Lake. West side levels are slightly lower than the East side levels, overall they are pretty similar considering the big differenceses in nutrient levels between the two basins even though they are connected.

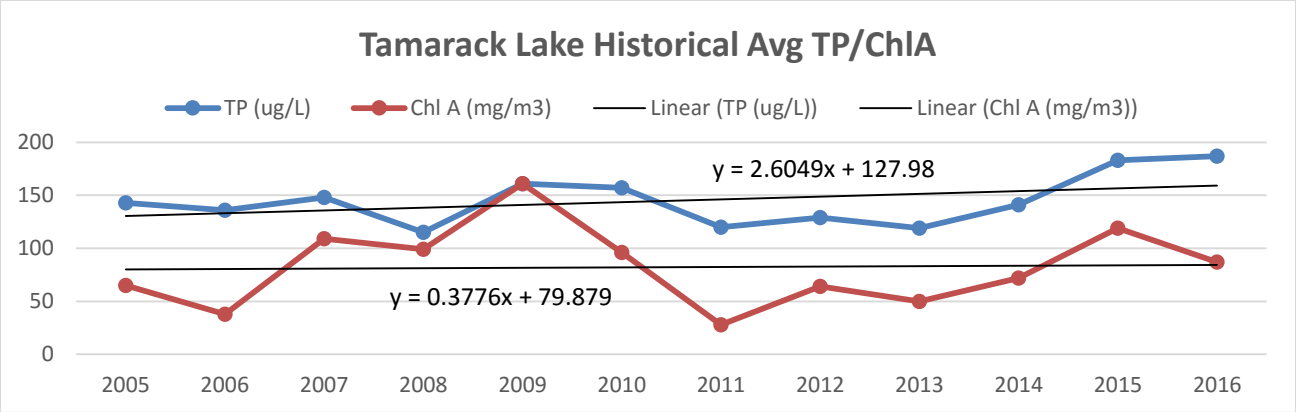




Tamarack Lake

Tamarack Lake is part of the Tamarack Nature Center. It is 86 acres with a maximum depth of 10 feet. As there is no boat access, samples are taken from the observation dock on the southeast side of the lake. Ramsey County restored a large ditched wetland downstream of Tamarack and upstream of Fish Lake, as part of a wetland-banking project in 1997. Tamarack Lake is one of 4 lakes listed as impaired for nutrients on the 2010 Lambert Creek TMDL study. Internal loading is the major reason for the impairment. This is a very isolated lake with a large natural buffer, runoff from Hwy 35E will make its way to Tamarack on the west side after going through a large wetland. Historically Tamarack was surrounded by farmland. TP & ChlA levels are extremely high and show little sign of lowering. In the summer of 2013 VLAWMO installed a floating island on the lake. The island was planted with native vegetation. The root systems that develop below the island create a large surface area for highly beneficial microbes allowing for increased nutrient uptake and reduction in overall nutrient levels in the lake.





Tamarack Lake Data

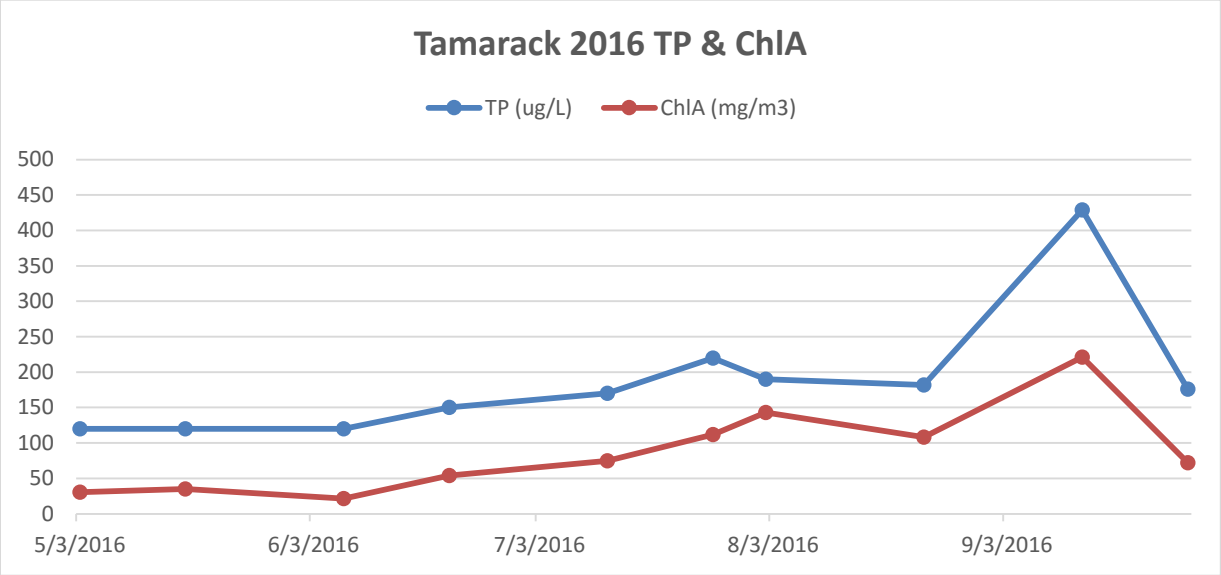
Tamarack Lake Historical Avg TP/ChlA/SDT					Dock			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)		6/7/2016	7/12/2016	8/2/2016	8/13/2016
1997	17	180	0.2	Sample ID	V70	V111	V153	V194
1998	54	32	0.5	Temp.	20.22/20.04	25.66/25.44	25.7/26.56	20.53/20.59
1999	90	26	0.4	Cond.	.405/.406	.387/.390	.376/.369	.370/.369
2000	60	27	0.4	DO	6.97/6.74	6.71/6.20	4.21/8.72	6.56/6.60
2001	132	37	0.4	pH	8.42/8.33	8.51/8.33	8.42/8.87	8.08/8.25
2002	164	120	0.4	Secchi Depth	1.5 ft	1	1	1
2003	168	95	0.3	Weather conditions	Sunny & warm	Sunny & warm	Sunny & humid	Sunny & cool
2004	96	0	0.8		Island			
2005	143	65	0		6/7/2016	7/12/2016	8/2/2016	8/13/2016
2006	136	38	0	Sample ID	V71	V112	V154	V195
2007	148	109	0.5	Temp.	20.09/19.28	25.04/24.43	22.38/27.67	20.47/20.59
2008	115	99	0.3	Cond.	.404/.408	.387/.402	.475/.362	.369/.369
2009	161	161	0.2	DO	7.20/6.70	6.61/3.64	.41/8.40	5.57/5.61
2010	157	96	0.2	pH	8.40/8.23	8.09/7.32	7.40/8.46	8.29/8.27
2011	120	28	0.6	Secchi Depth	1.5	1	1	1
2012	129	64	0.4	Weather conditions	Sunny & warm	Sunny & warm	Sunny & humid	Sunny & cool
2013	119	50	0.5					
2014	141	72	0.5					
2015	183	119	0.4					
2016	187	87	0.4					

- Tamarack Lake YSI data is similar to that of similar metro lakes, nutrient levels are very high especially for an isolated lake with significant buffers. Internal loading is most likely the cause of these high levels.

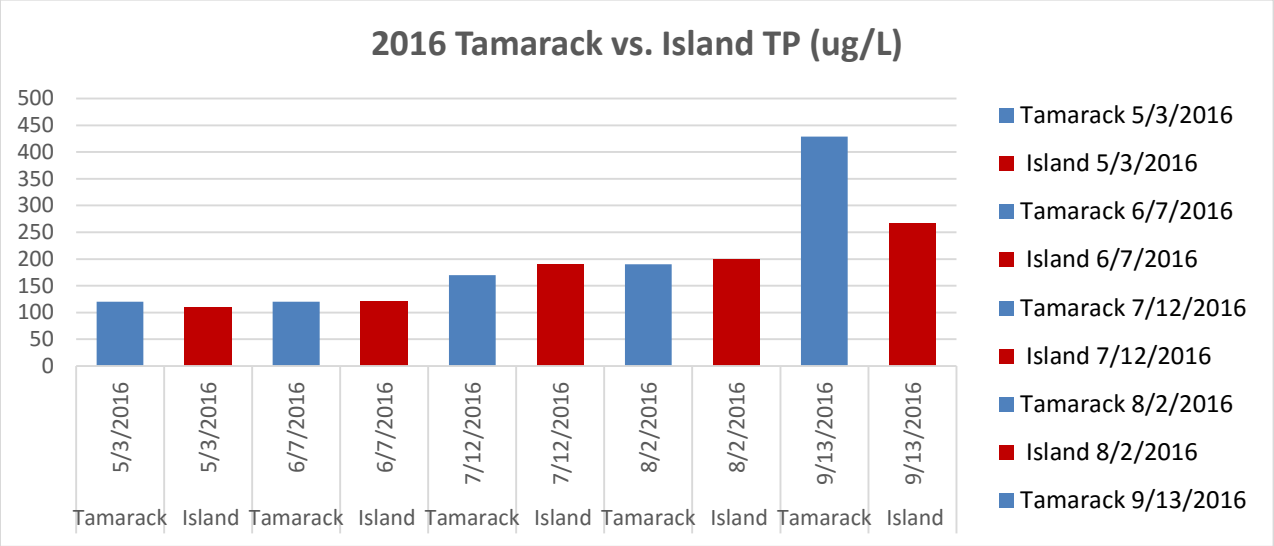
Tamarack Lake 2016 Raw Data

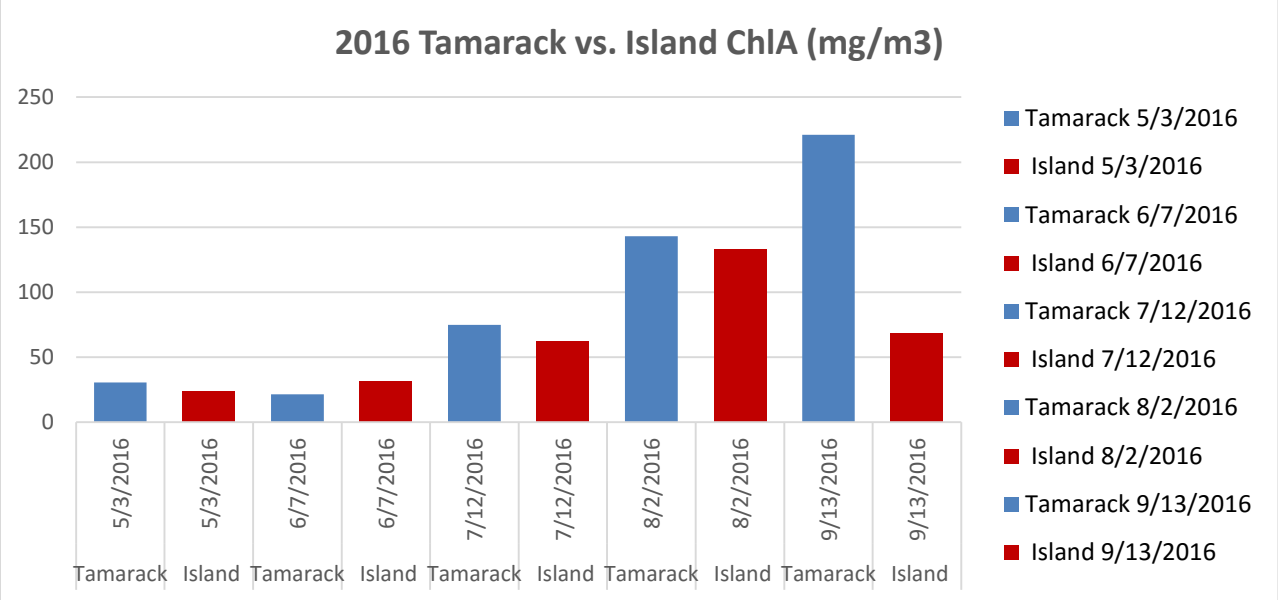
SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
Tamarack	3/28/2016						30
Tamarack	5/3/2016	1.5	120	30.5	1.9		
Tamarack	5/17/2016	1.5	120	34.9			
Tamarack	6/7/2016	1.5	120	21.4	2.3	ND	
Tamarack	6/21/2016	1.5	150	54.1			
Tamarack	7/12/2016	1	170	75	2.7	ND	
Tamarack	7/26/2016	1	220	112			
Tamarack	8/2/2016	1	190	143	3.5	ND	
Tamarack	8/23/2016	1	182	108			
Tamarack	9/13/2016	1	429	221	2.4	ND	
Tamarack	9/27/2016	0.5	176	72			

- Nitrogen and ammonia levels are below state standards for Tamarack Lake and similar to the rest of the VLAWMO lakes



Floating Island Data





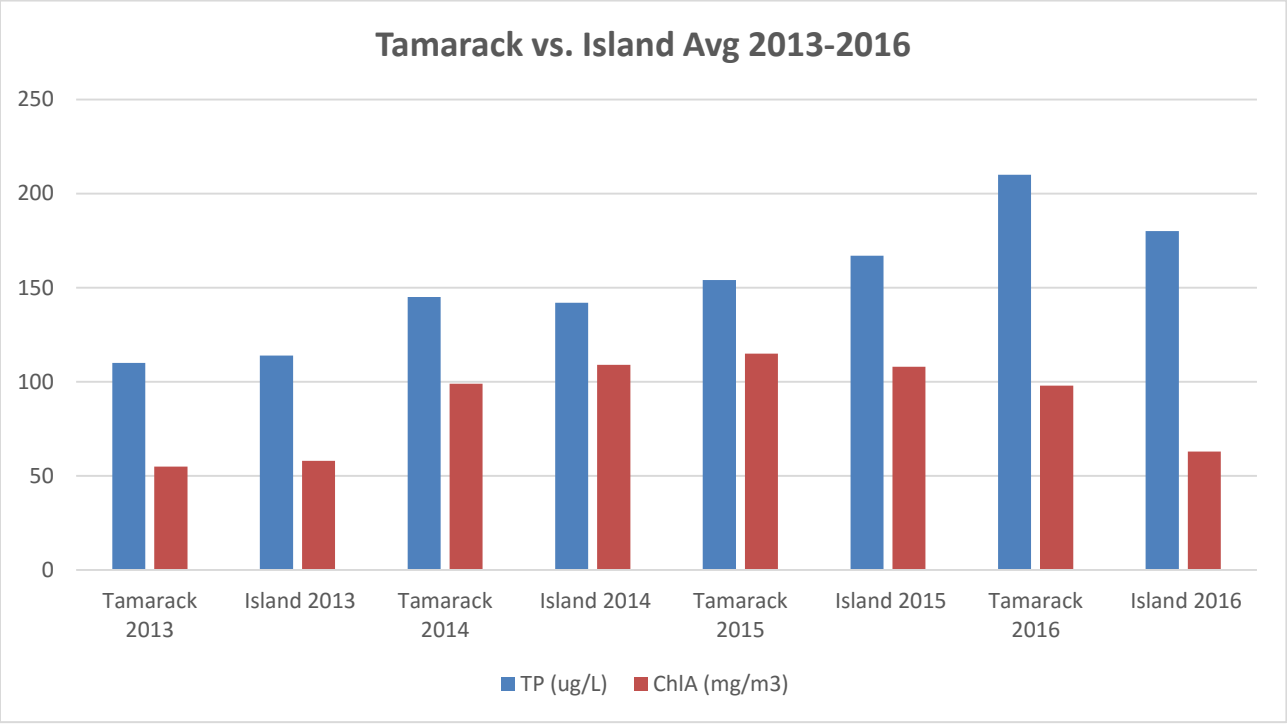
- A floating island was installed July 2013 to reduce nutrient levels in Tamarack. Island is located in the middle of the lake. Samples are taken at both the island and the dock each sample run to monitor changes between both sits. Below is the potential effect the island could have on nutrient levels

Reductions based on 2012 avg TP of 129 ug/L			
reductions	result (ug/L)	reductions	result (ug/L)
10%	116.1	25%	96.75
15%	109.65	50%	64.5

Tamarack VS Floating Island 2016 Raw Data

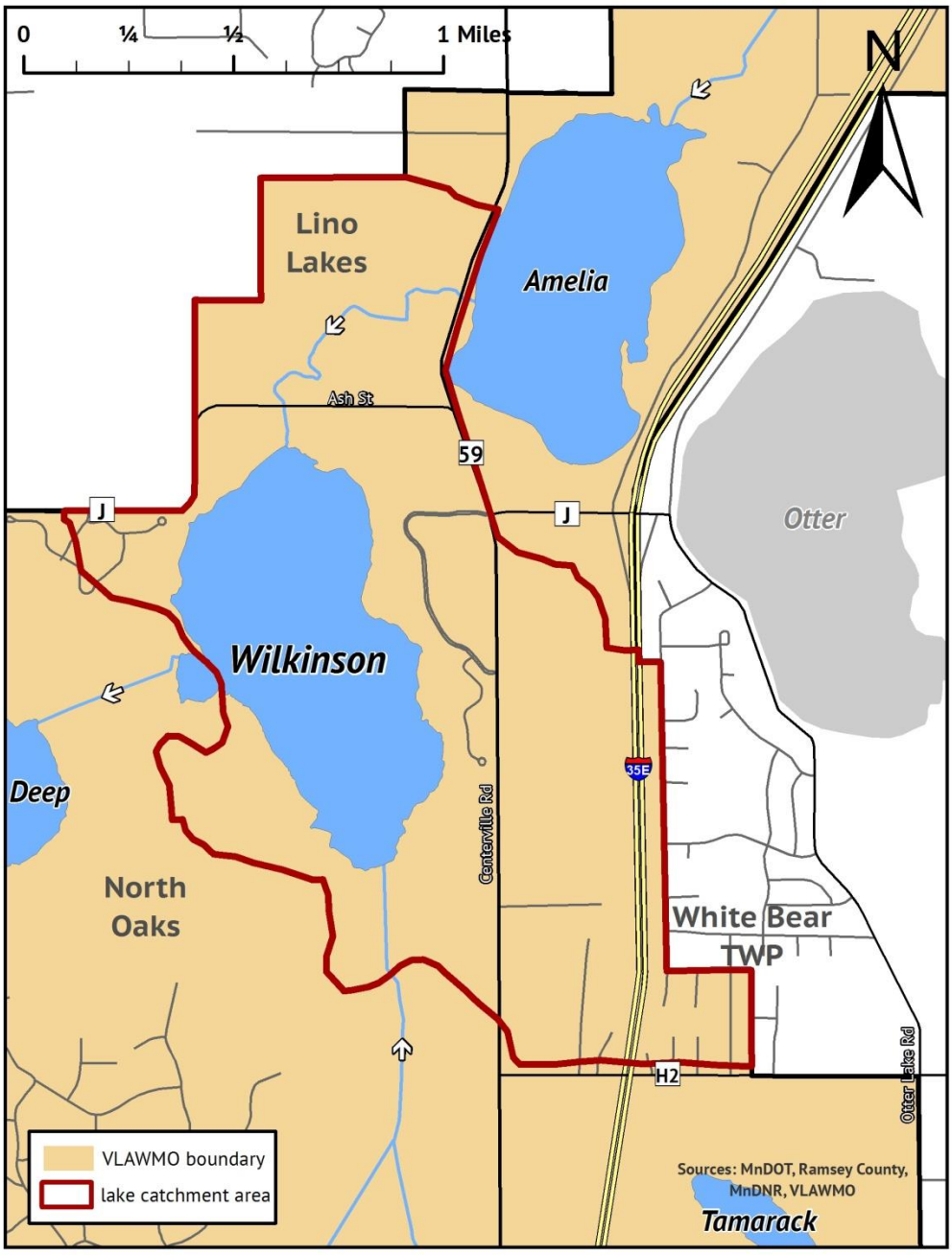
SITE	DATE	Secchi (ft)	TP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)
Tamarack	5/3/2016	1.5	0.12	30.5	1.9	
Tamarack	6/7/2016	1.5	0.12	21.4	2.3	ND
Tamarack	7/12/2016	1	0.17	75	2.7	ND
Tamarack	8/2/2016	1	0.19	143	3.5	ND
Tamarack	9/13/2016	1	0.4291	221	2.4	ND
	average	***1.20***	***0.21***	***98.18***	***2.56***	***#DIV/0!***
Island	5/3/2016	1.75	0.11	24	2.3	
Island	6/7/2016	1.5	0.12	31.8	2.2	ND
Island	7/12/2016	2	0.19	62.6	3	ND
Island	8/2/2016	1	0.2	133	3.2	ND
Island	9/13/2016	1	0.267	68.5	2.3	ND
	average	***1.45***	***0.18***	***63.98***	***2.60***	***#DIV/0!***
	Difference	***-0.25***	***0.03***	***34.20***	***-0.04***	***#DIV/0!***

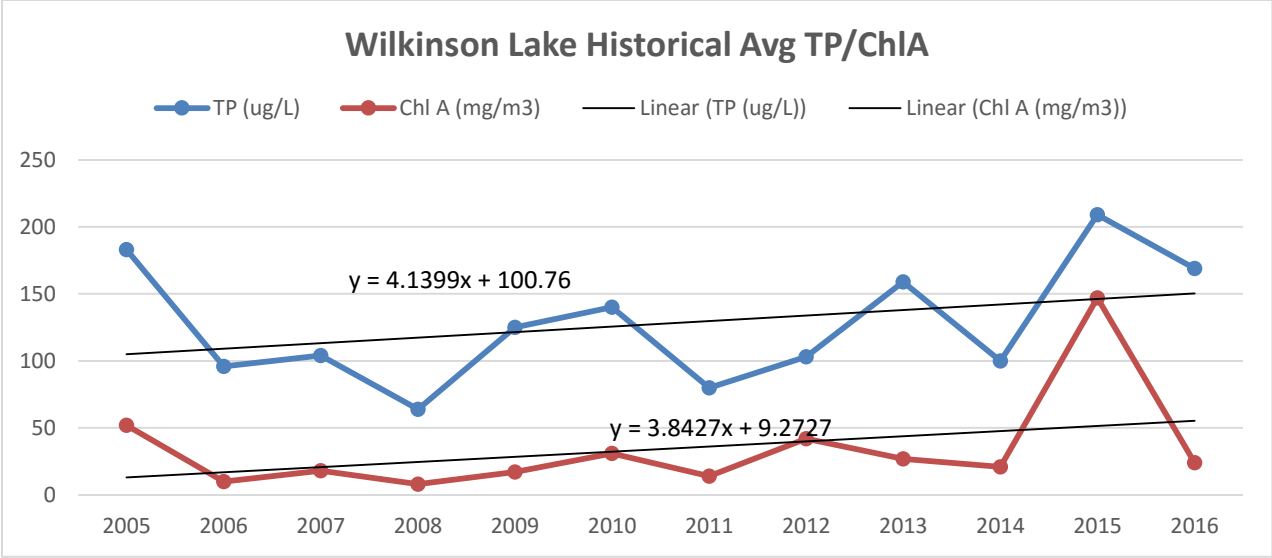
- This was the fourth year of sampling the Island and there has yet to be any significant sign of water quality improvement in Tamarack Lake from the Island. ChlA was much lower at the Island this year, but will have to see if this trend continues to be able to conclude the Island is helping.



Wilkinson Lake

Wilkinson Lake was part of the James J. Hill experimental farm and is now part of the Minnesota Land Trust, which preserves the land in a natural condition. The City of North Oaks required 150-foot buffer between the lake edge and any structures. The property on the northwest side of the lake is currently being developed. The North Oaks Company has spent considerable time and effort over the years to restore the lake including the installation of a fish barrier to attempt to keep the rough fish from destroying the natural vegetation and waterfowl habitat and to improve water quality. The lake has also had two drawdowns to kill the carp. Wilkinson is the fourth lake within VLAWMO to be on the 2010 impaired waters list for nutrients and is part of the on-going Lambert Creek TMDL study. Farmland runoff and internal loading seem to be the main factors to the poor water quality. Water quality has not changed much over the last 16 years of monitoring, but a noticeable spike in average TP levels has occurred the last three years. TP levels are still within the 16 year monitoring range.





Wilkinson Lake Data

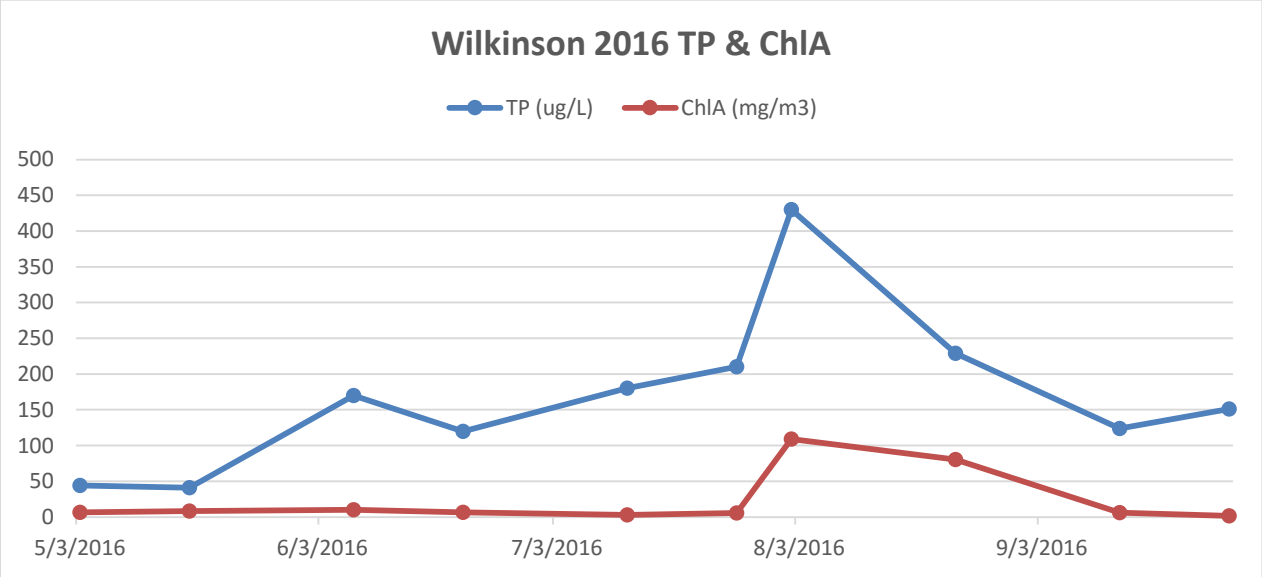
Wilkinson Lake Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	12.91	0.467	9.06	8.16
1998	48	26	1.1	5/16/2016	t	13.69	0.469	8.71	8.15
1999	62	8	0	6/10/2016	b	22.97	0.381	3.22	8.75
2000	38	34	0	6/10/2016	t	24.25	0.377	7.52	9.16
2001	299	99	0.2	7/20/2016	b	24.73	0.413	2.27	8.31
2002	107	40	0	7/20/2016	t	25.2	0.419	3.3	8.24
2003	130	18	0	9/20/2016	b	18.7	0.422	1.05	7.79
2004	72	0	0	9/20/2016	t	19.07	0.422	0.85	8.2
2005	183	52	0						
2006	96	10	0						
2007	104	18	0.9						
2008	64	8	0.3						
2009	125	17	1						
2010	140	31	0.8						
2011	80	14	1						
2012	103	42	0.9						
2013	159	27	0.9						
2014	100	21	0.9						
2015	209	147	0.5						
2016	169	24	1.1						

- Wilkinson Lake YSI data is similar to that of similar metro lakes, DO's are slightly lower on average than the rest of VLAWMO lakes, Conductivity is on the high side for VLAWMO lakes.

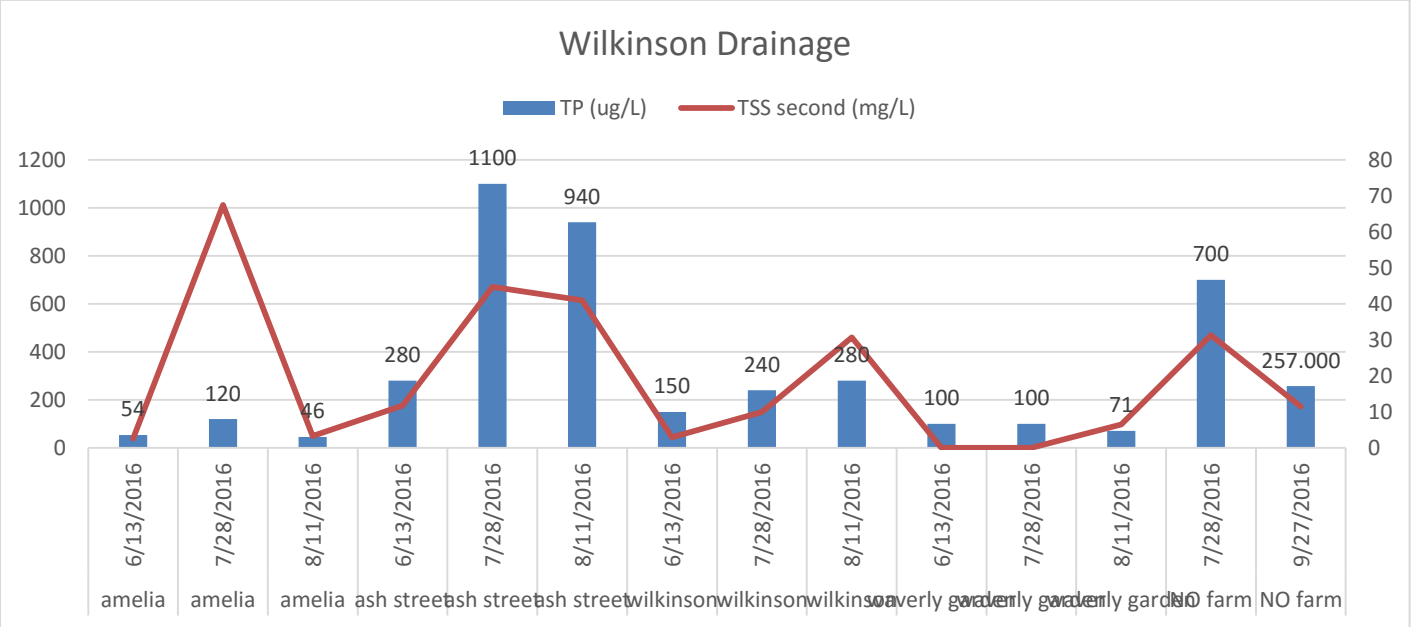
Wilkinson Lake 2016 Raw Data

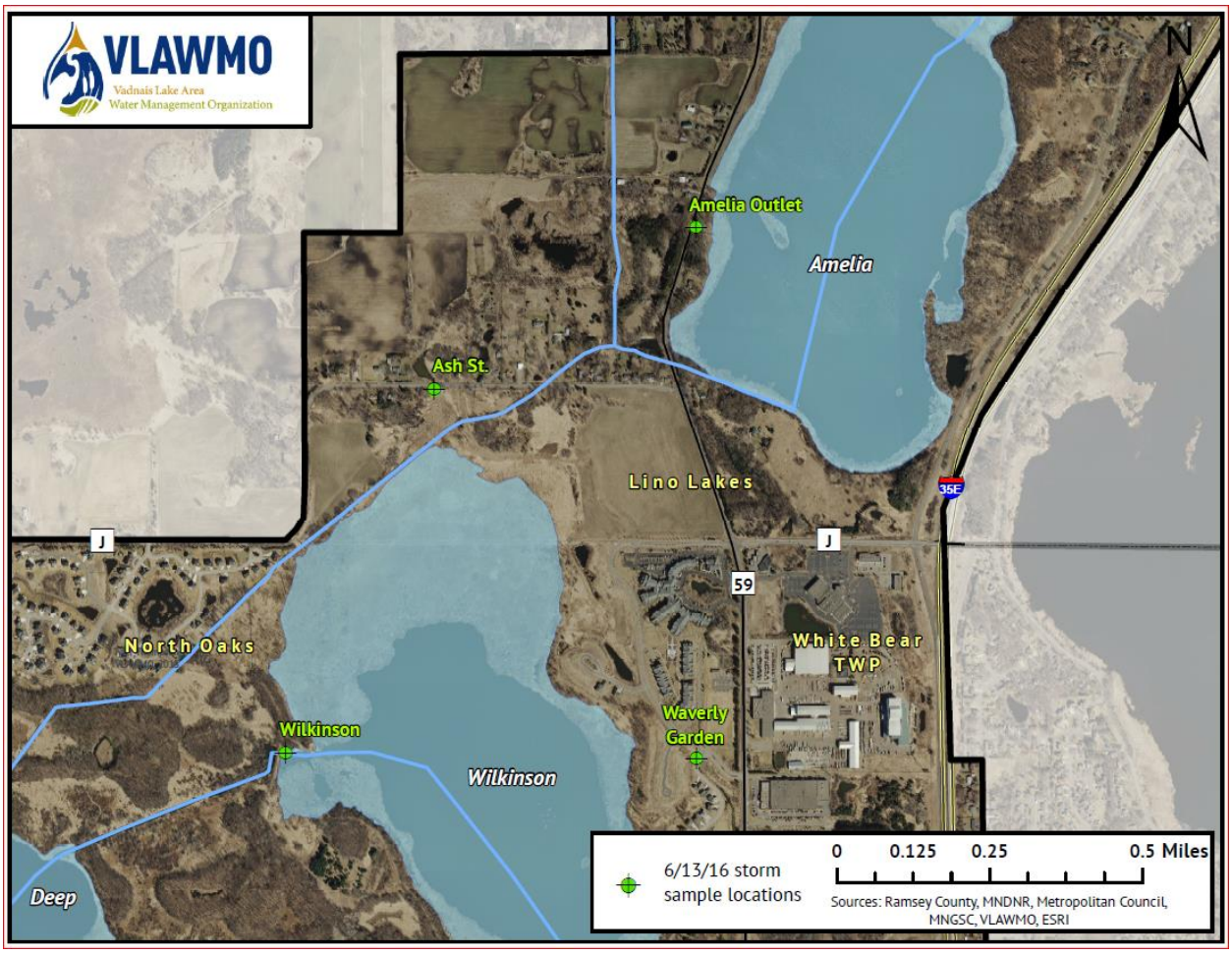
SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
Wilkinson	3/28/2016						55
Wilkinson	5/3/2016	3.5	44	6.6	1.1		
Wilkinson	5/17/2016	4.5	41	8.1			
Wilkinson	6/7/2016	4.5	170	10.3	1.7	0.25	
Wilkinson	6/21/2016	3	120	6.4			
Wilkinson	7/12/2016	4.5	180	3	1.6	0.15	
Wilkinson	7/26/2016	3	210	5.6			
Wilkinson	8/2/2016	1	430	109	2.3	ND	
Wilkinson	8/23/2016	1.5	229	80.5			
Wilkinson	9/13/2016	4	124	6	1.8	0.51	
Wilkinson	9/27/2016	4	151	1.6			

- Nitrogen and ammonia levels are below state standards for Wilkinson Lake and similar to the rest of the VLAWMO lakes. TP levels have increased dramatically over the last two years but are still within the 16 year monitoring range



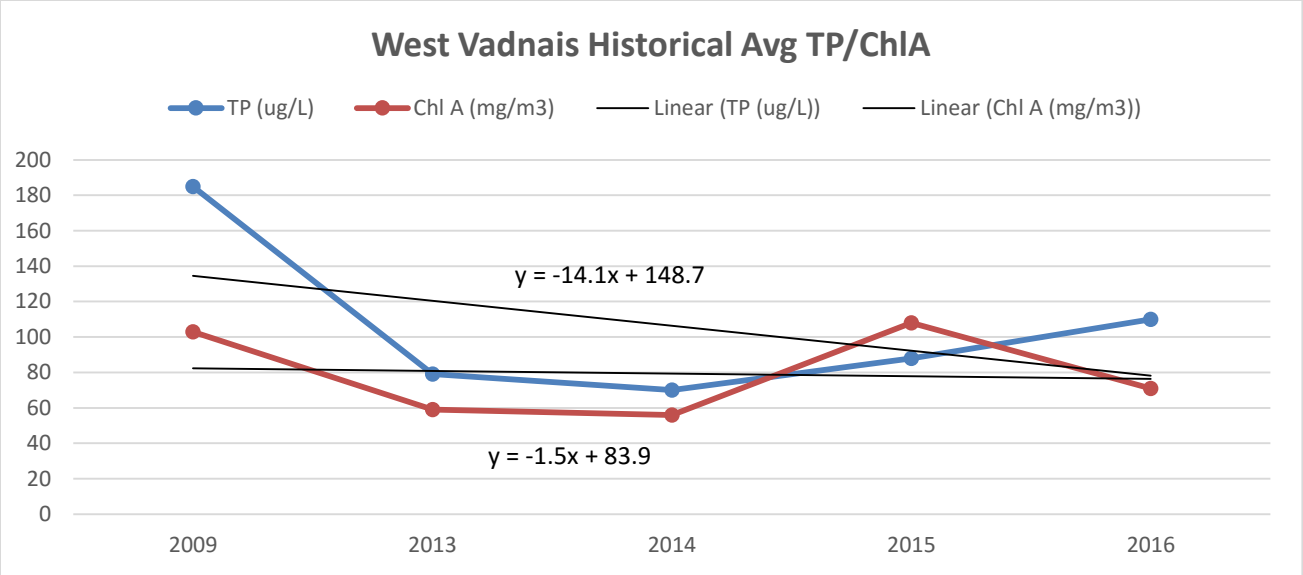
Wilkinson Drainage Data





West Vadnais Lake

West Vadnais Lake is located in the southwest corner of the watershed. Its neighbor, East Vadnais Lake, receives in lake treatment by the Saint Paul Water Authority (SPRWS) as a measure to protect the drinking water supply. Even though these lakes are right next to each other they are not connected and have drastically different water quality. The SPRWS monitors East Vadnais Lake. VLAWMO monitored West Vadnais for part of 2009 and began full monitoring in 2013. West Vadnais is on the 2014 impaired waters list for nutrients.



West Vadnais Lake Data

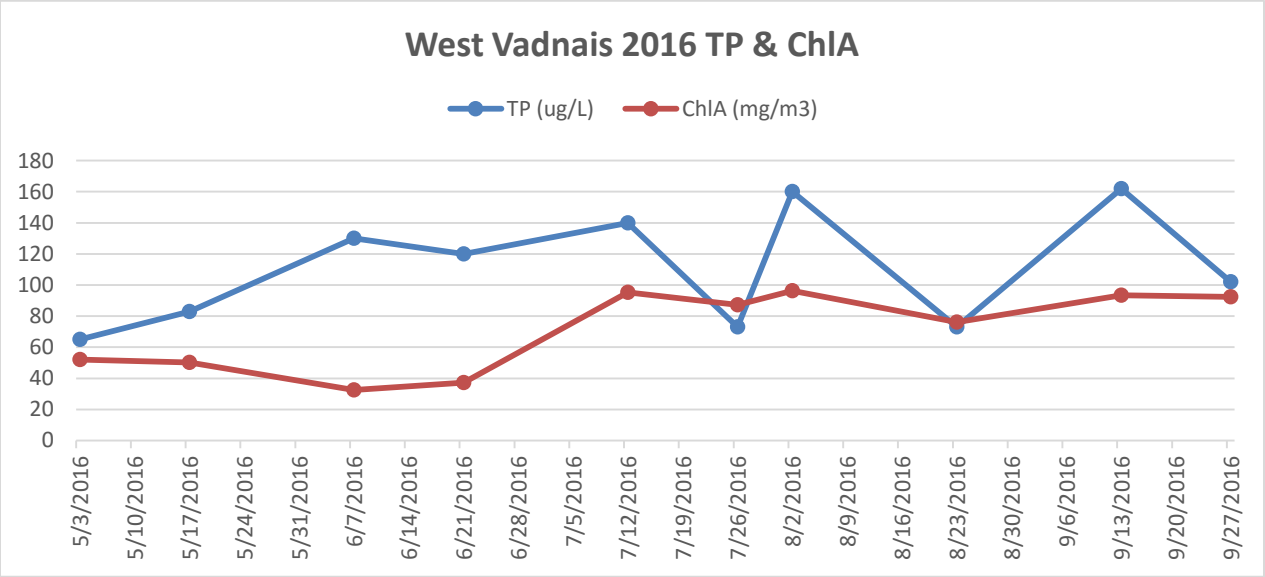
West Vadnais Historical Avg TP/Chl A/SDT				Date	Reading Depth (Bottom/Top)	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)	5/16/2016	b	13.08	0.47	9.25	7.58
2009	185	103	0.4	5/16/2016	t	13.12	0.468	9.48	7.77
2013	79	59	0.4	6/10/2016	b	21.72	0.506	3.4	8.06
2014	70	56	0.5	6/10/2016	t	23.07	0.499	7.06	8.54
2015	88	108	0.3	7/20/2016	b	24.61	0.489	0.59	8.49
2016	110	71	0.3	7/20/2016	t	25.78	0.454	7.45	8.82
				9/20/2016	b	19.55	0.42	4.72	8.3
				9/20/2016	t	19.72	0.419	5.27	8.36

- Wilkinson Lake YSI data is similar to that of similar other metro lakes, conductivity is on the high side for VLAWMO lakes.

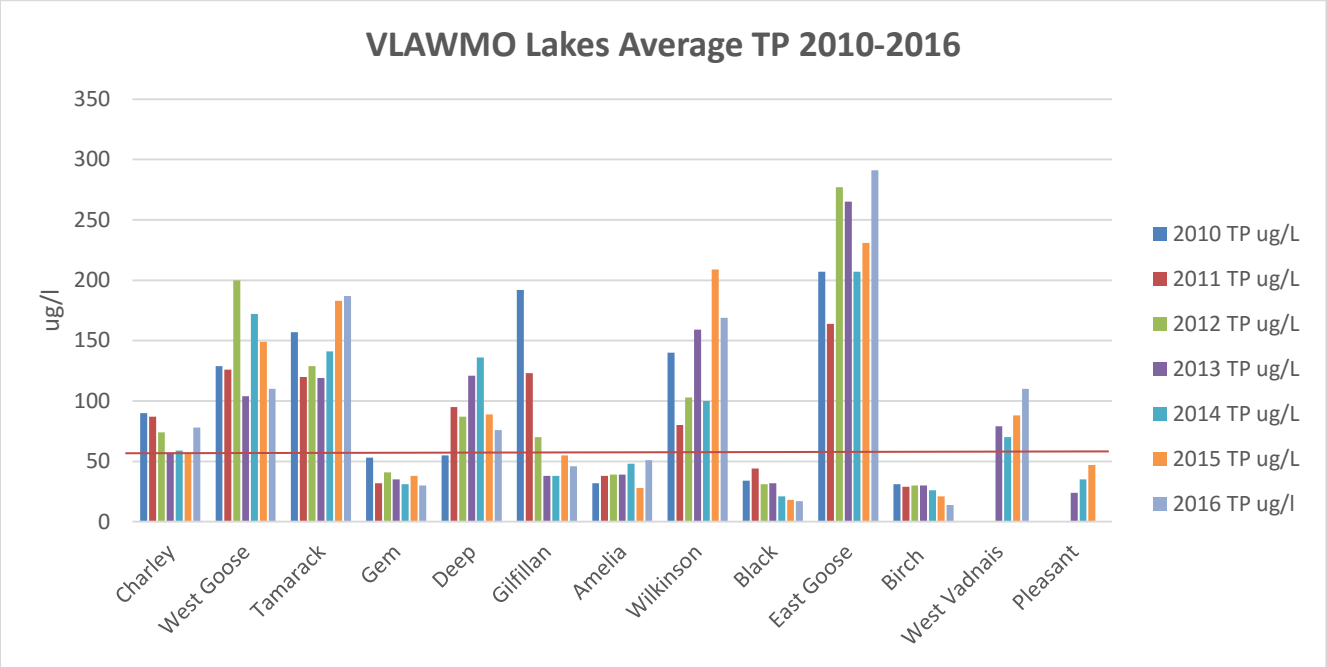
West Vadnais Lake 2016 Raw Data

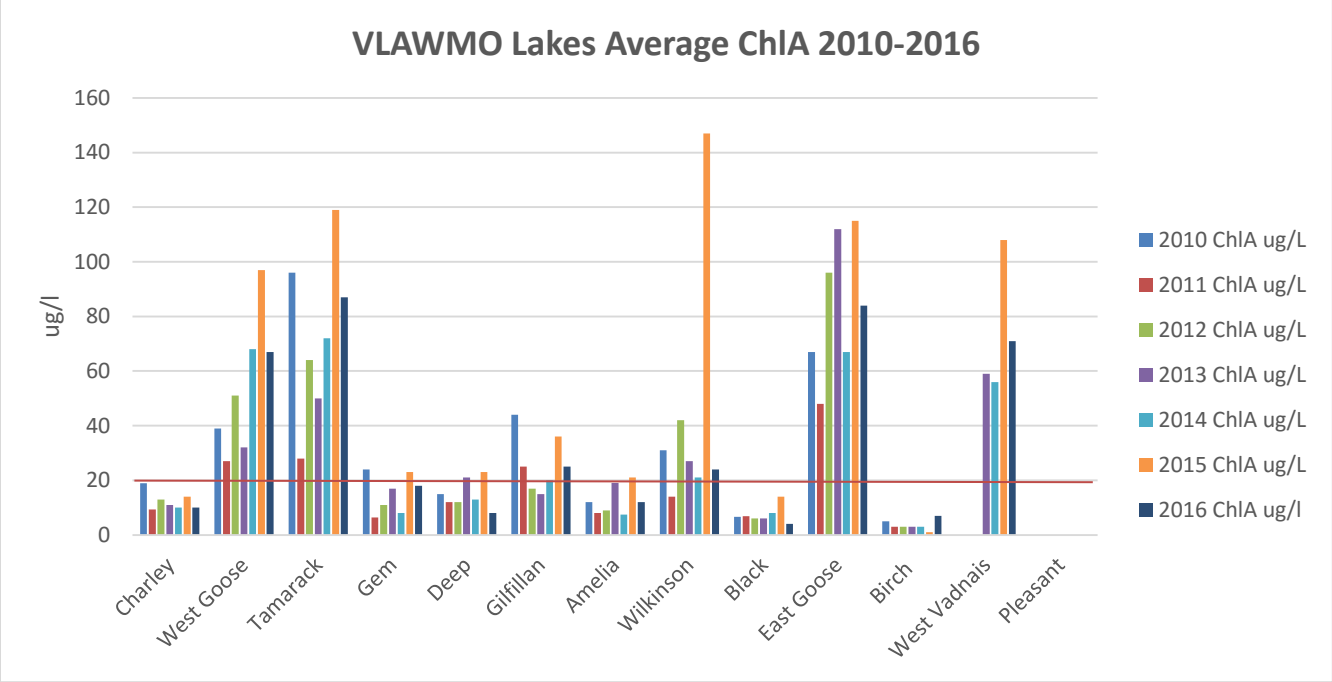
SITE	DATE	Secchi (ft)	TP (ug/L)	ChlA (mg/m3)	TKN (mg/L)	NH3 (mg/L)	Cl (mg/L)
West Vadnais	3/28/2016						80
West Vadnais	5/3/2016	1.5	65	52	3.2		
West Vadnais	5/17/2016	1	83	50.1			
West Vadnais	6/7/2016	1.00	130	32.5	4.1	1.3	
West Vadnais	6/21/2016	1	120	37.2			
West Vadnais	7/12/2016	0.5	140	95.2	3.2	0.57	
West Vadnais	7/26/2016	1	73	87.2			
West Vadnais	8/2/2016	1	160	96.3	1.4	ND	
West Vadnais	8/23/2016	1	73	76.1			
West Vadnais	9/13/2016	0.75	162	93.4	1.9	ND	
West Vadnais	9/27/2016	1	102	92.3			

- Nitrogen and ammonia levels are below state standards for West Vadnais Lake and similar to the rest of the VLAWMO lakes.



Lake TP and ChlA Summary





VLAWMO 2016 Lake Chloride Levels

Chloride Standards:

Chronic Exposure Standard;

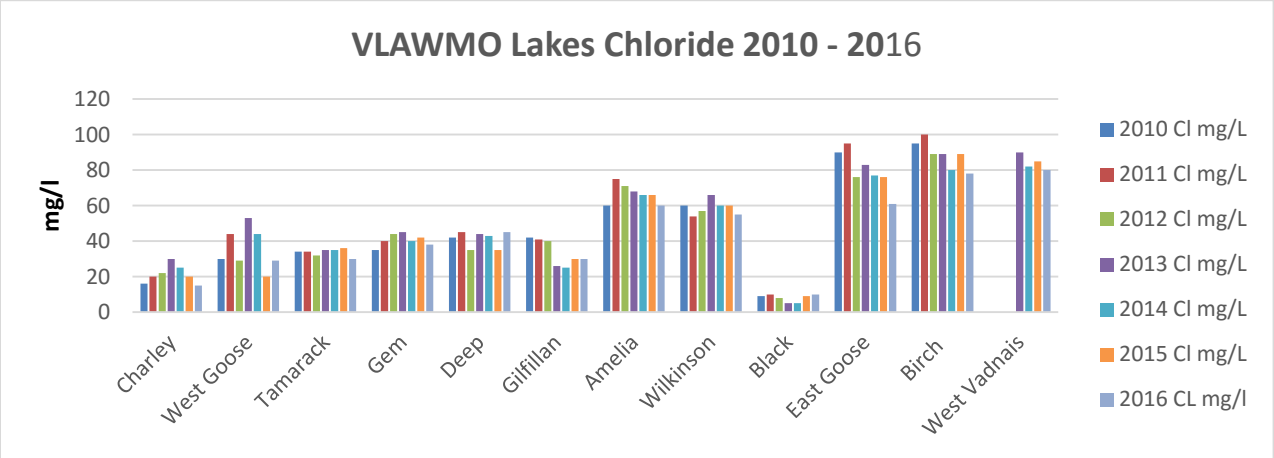
- 4 day average >230 mg/l

Acute Exposure Standard;

- One hour >860 mg/l

Impairment Threshold;

- Two or more exceedances in a three year period having at least five data points



- VLAWMO staff takes Lake Chloride readings in the spring right after ice-off. The samples are taken from the middle of the lake. 2016 was the seventh year of VLAWMO's chloride program. The lakes with the highest chloride levels are typically the lakes that receive the most street/storm water runoff. Most of our cities have gone to an all salt mix for winter ice control and future monitoring will be interesting to see how that will affect the chloride levels in VLAWMO lakes..

	2010 Cl mg/L	2011 Cl mg/L	2012 Cl mg/L	2013 Cl mg/L	2014 Cl mg/L	2015 Cl mg/L	2016 CL mg/l
Charley	16	20	22	30	25	20	15
West Goose	30	44	29	53	44	20	29
Tamarack	34	34	32	35	35	36	30
Gem	35	40	44	45	40	42	38
Deep	42	45	35	44	43	35	45
Gilfillan	42	41	40	26	25	30	30
Amelia	60	75	71	68	66	66	60
Wilkinson	60	54	57	66	60	60	55
Black	9	10	8	5	5	9	10
East Goose	90	95	76	83	77	76	61
Birch	95	100	89	89	80	89	78
West Vadnais				90	82	85	80

Lake Level Data

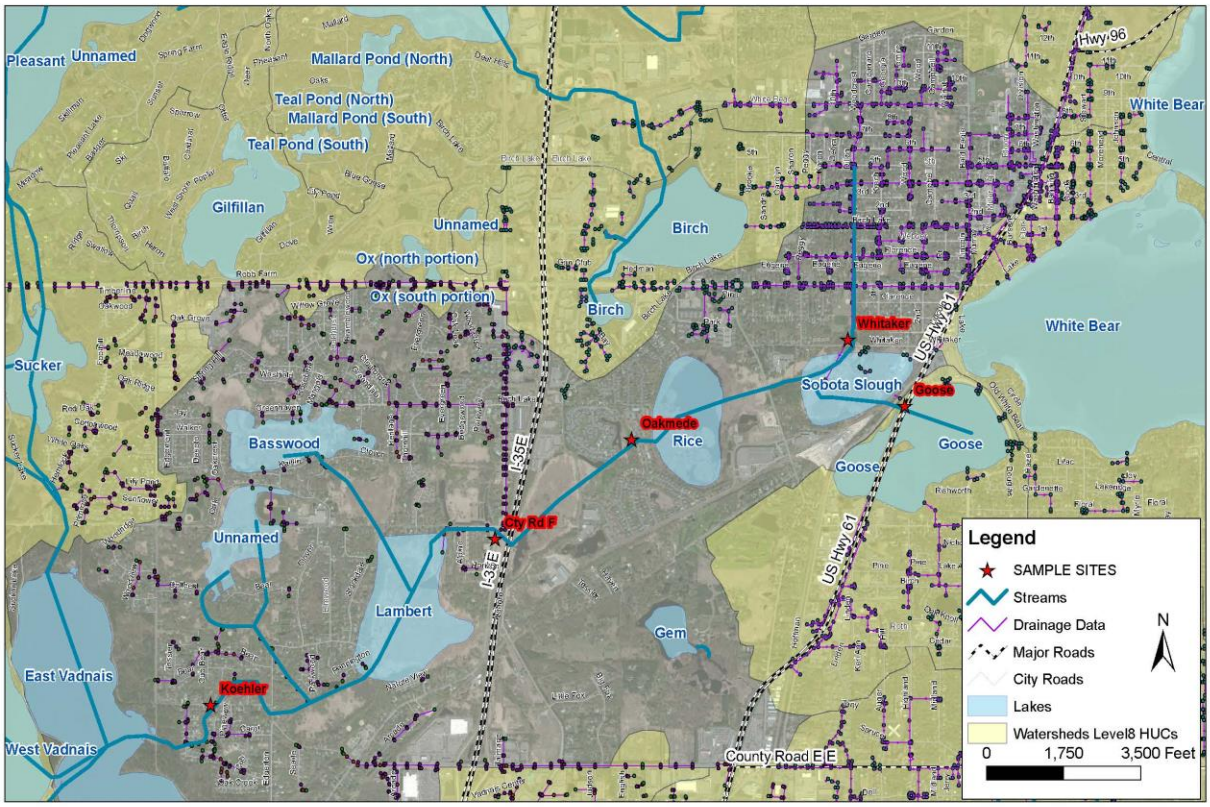
	Lake Elevations 2016					
	Gilfillan	**Birch**	**Gem**	**Goose**	**Wilkinson**	**Pleasaant**
gauge reading start	1.66	2.5	9.63	0.8		1.01
lake level start 4/29/2016	911.13	920.19	947.44	924.5		892.51
0.00 out	909.47	917.69	937.81	923.7		891.5
5/3/2016	911.08	917.65	947.39	924.4	1.84	
5/17/2016	911.03	920.05	947.32	924.35	1.75	
6/7/2016	910.87	919.85	947.12	924.28	1.62	
6/13/2016		920.14			1.83	
6/21/2016	911.11	921.19	947.62	924.59	1.85	
7/12/2016	910.95	919.95	947.47	924.38	1.65	
7/26/2016	910.89	919.85	947.41	924.36	1.62	
8/2/2016	910.87	919.89	947.53	924.38	1.66	892.51
8/23/2016	911.35	920.04	na	924.6	2	
9/13/2016	911.3	920.21	947.91	924.38	1.85	893.05
9/27/2016	911.68	920.59	948.41	924.66	2.21	893.15
yearly increase/decrease	**0.55**	**0.4**	**0.97**	**0.16**	**0.37**	

2016 Lambert Creek Monitoring Results

Lambert Creek Monitoring Details

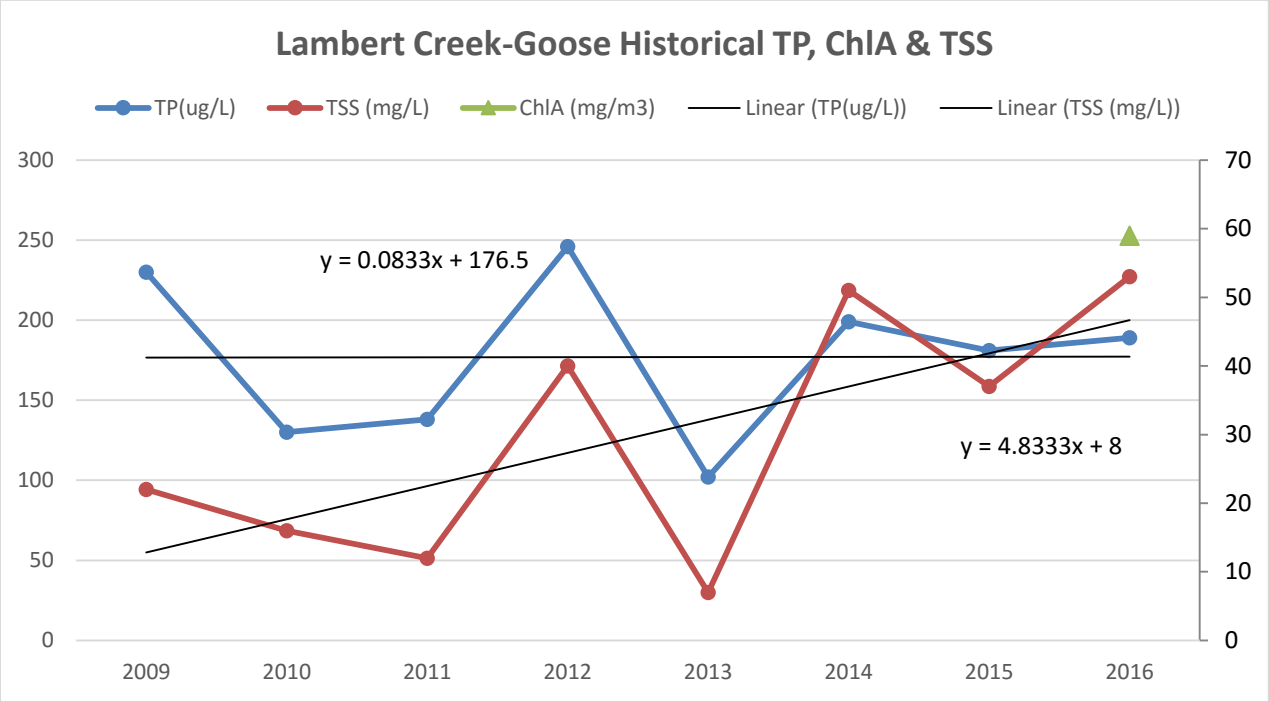
Samples are collected by VLAWMO staff at six sites along Lambert Creek on a bi-weekly basis May through September. The six sites noted in charts and graphs are: Goose Lake, WBL storm sewer, Whitaker Pond, Oakmede, County Rd F, and Kohler Rd. The samples are analyzed by Pace Analytical for TP, SRP, TKN, NH3, N03, TSS. VLAWMO staff collects pH, conductivity, DO and temperature readings at all locations except the WBL storm sewer. Creek flow is also collected at the flumes along with a flow meter in the WBL storm sewer. This information will also help with the TMDL process and allows us to set baselines to compare with future monitoring data.

VLAWMO has collected samples at five of the six sites to test for E. coli. Samples were analyzed at the SPRWS lab. Lambert Creek is on the impaired waters list for its high levels of E. coli. Water contaminated with bacteria from human or animal fecal material can cause illness in humans if ingested. The maximum daily level allowed is 1260 cfu/100ml. The maximum 30 day mean level is 126 cfu/100ml. Standards are designed to protect swimmers who might ingest small quantities of water from getting sick. VLAWMO began the E.coli source monitoring study in 2014 concentrating on the County Rd F and Oakmede sites during dry weather conditions, at least 72hrs after a rain event. We continued this study in 2015 concentrating on the Goose and Whitaker drainages. In 2016 we did wet weather conditions at County Rd F and Oakmede sites.



- Red marks the creek sampling locations. From left to right Koehler, Cty Rd F, Oakmede, Whitaker and WBLSS, and Goose.

Lambert Creek-Goose Lake Data

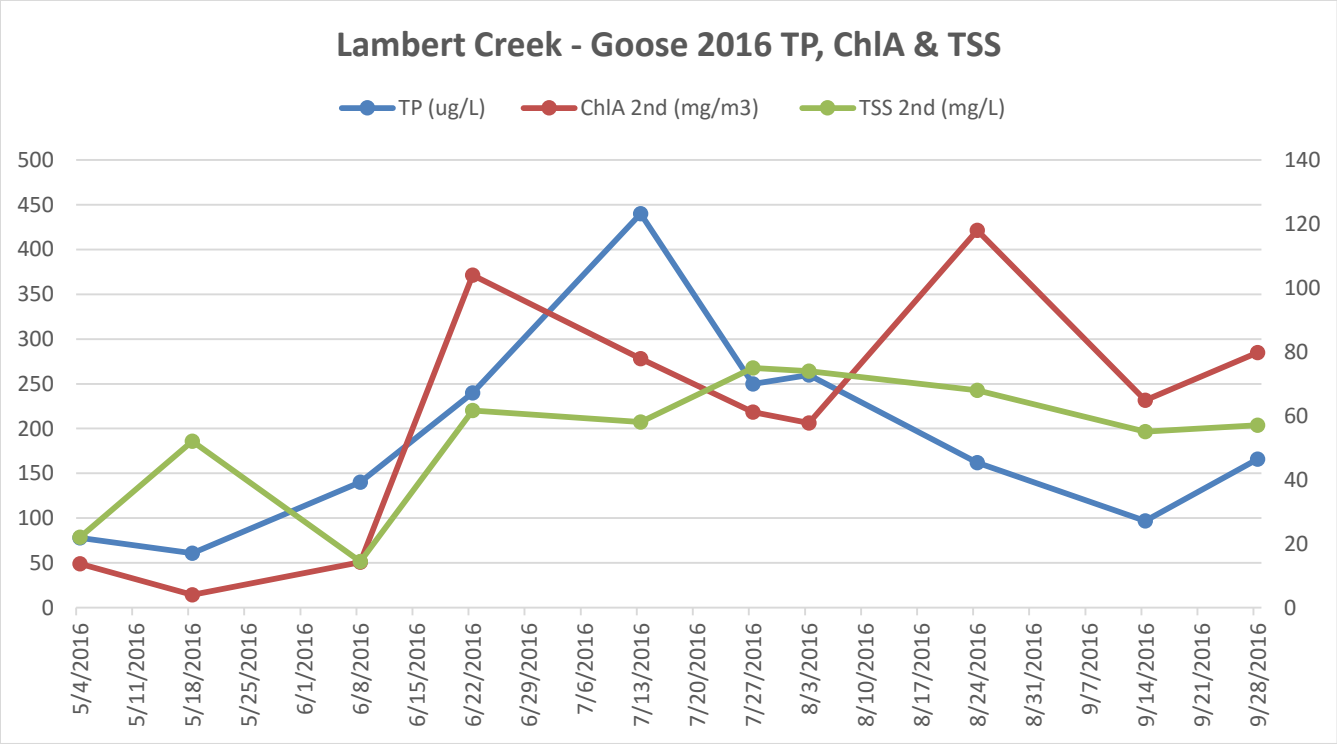


- LC-Goose Lake was close to the state standards for TP and the lowest average over the last 5 years. State standard is 150 ug/l. State standard for TSS is 14mg/l. LC-Goose TSS has been pretty constant over the last 5 years. 2016 was the first year of collecting ChlA on the creek.

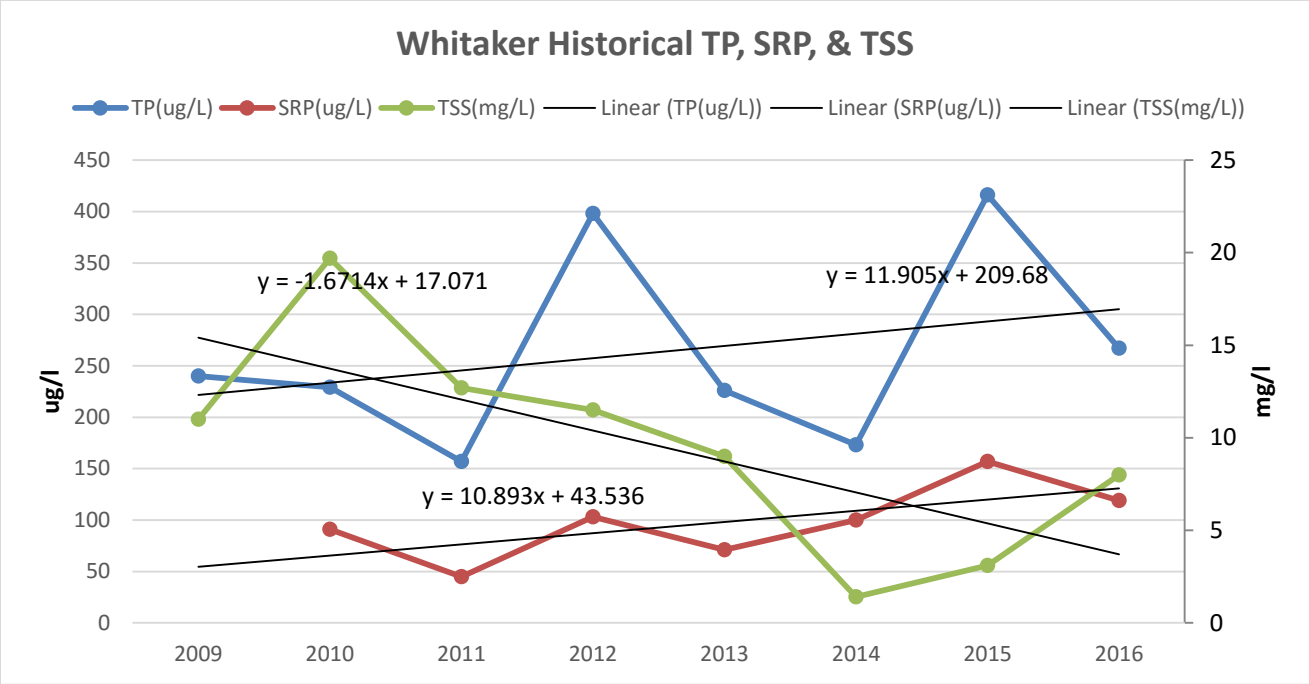
Lambert Creek-Goose				Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP(ug/L)	TSS (mg/L)	ChlA (mg/m3)	5/2/2016	16.59	0.319	9.33	8.42
2009	230	22		6/9/2016	22.57	0.286	7.81	8.86
2010	130	16		7/19/2016	25.44	0.3	5.22	8.8
2011	138	12		9/19/2016	19.66	0.248	4.97	8.47
2012	246	40						
2013	102	7						
2014	199	51						
2015	181	37						
2016	189	53	59					

Goose – LC 2016 Raw Data

SITE	DATE	TP (ug/L)	ChlA 2nd (mg/m3)	TSS 2nd (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO3 mg/L	Cl (mg/L)
LC-Goose	3/14/2016							30
LC-Goose	3/25/2016							30
LC-Goose	5/4/2016	78	13.7	22	1.3	ND	ND	
LC-Goose	5/18/2016	61	4	52				
LC-Goose	6/8/2016	140	14.2	14.4	1.9	ND	ND	
LC-Goose	6/22/2016	240	104	61.6				
LC-Goose	7/13/2016	440	77.9	58	4	0.11	ND	
LC-Goose	7/27/2016	250	61.1	75				
LC-Goose	8/3/2016	260	57.7	74	1.4	ND	ND	
LC-Goose	8/24/2016	162	118	68				
LC-Goose	9/14/2016	97	64.9	55	5.9	0.12	ND	
LC-Goose	9/28/2016	166	79.8	57				



Lambert Creek-Whitaker Pond Data

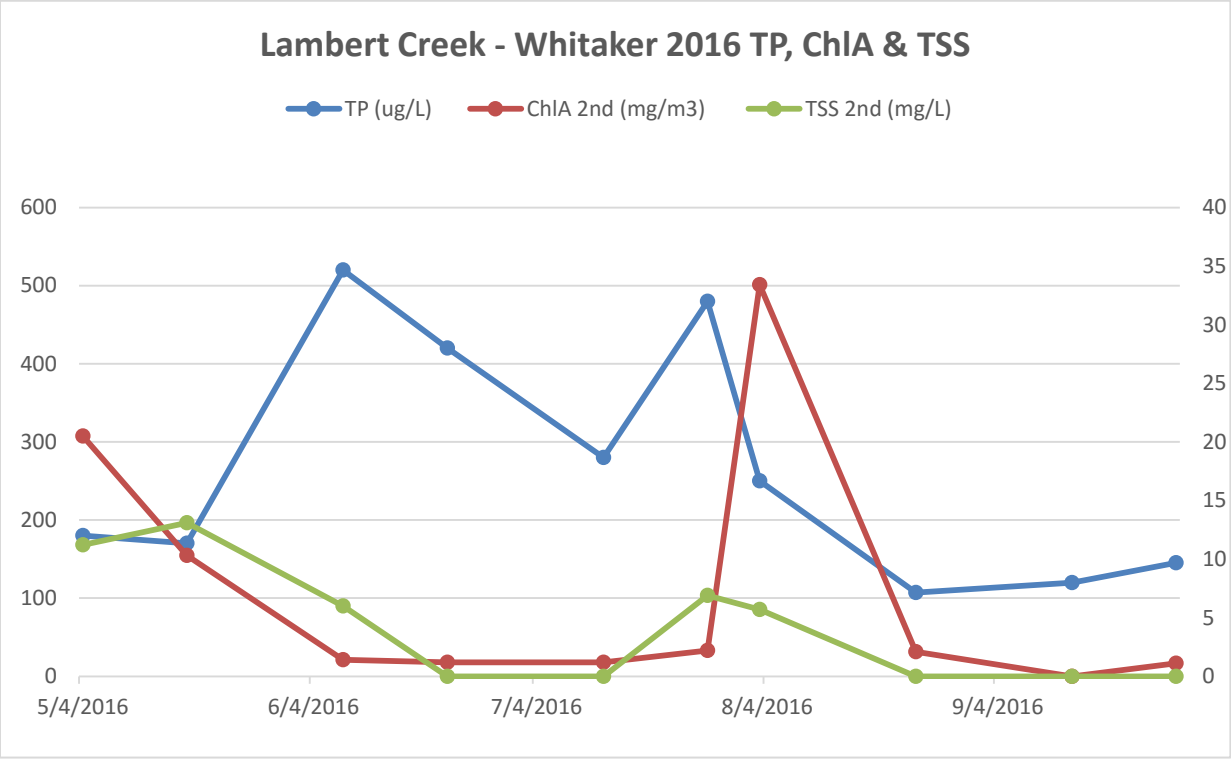


- Whitaker Pond on average for the last 8 years is above state standards for TP. State standard is 130 ug/l. State standard for TSS is 14mg/l. Since the forebay was installed in 2011 TSS has dropped, indicating the forebay is functioning as designed.

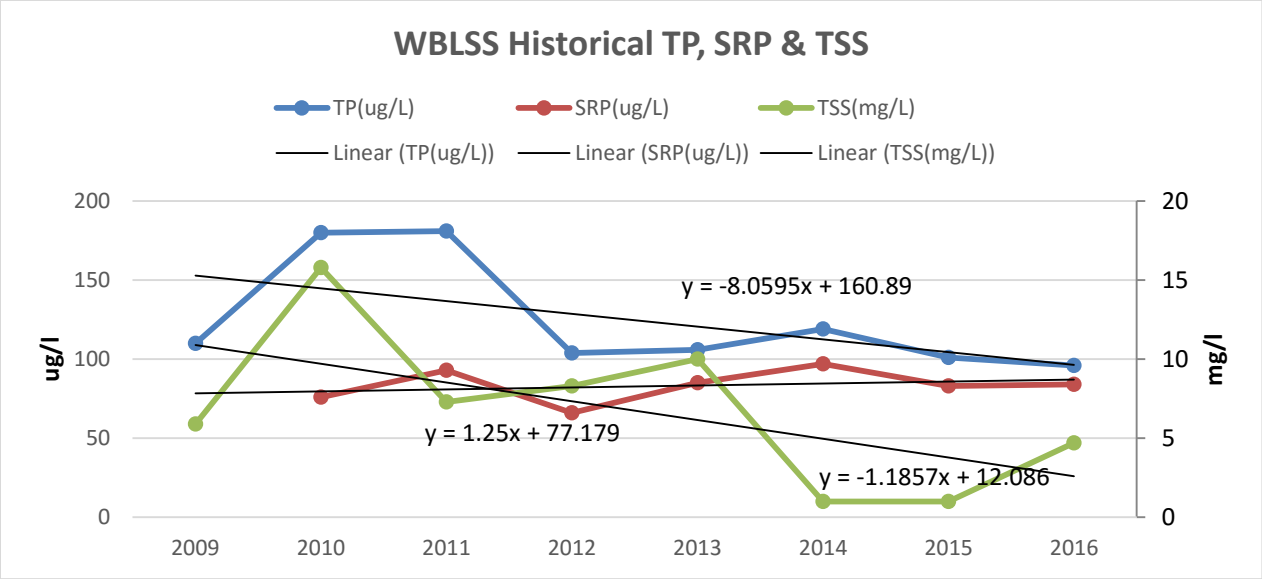
Whitaker					Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP(ug/L)	SRP(ug/L)	TSS(mg/L)	ChlA (mg/m3)	5/2/2016	16.66	0.472	5.19	7.94
2009	240		11		6/9/2016	19.8	0.393	2.29	7.51
2010	229	91	19.7		7/19/2016	22.12	0.422	0.45	7.87
2011	157	45	12.7		9/19/2016	19.27	0.459	1.36	7.48
2012	398	103	11.5						
2013	226	71	9						
2014	173	100	1.4						
2015	416	157	3.1						
2016	267	119	8	8					

Whitaker 2016 Raw Data

SITE	DATE	TP (ug/L)	ChlA 2nd (mg/m3)	TSS 2nd (mg/L)	SRP (ug/L)	TKN (mg/L)	NH3 (mg/L)	NO3 mg/L	Cl (mg/L)
Whitaker	3/14/2016								215
Whitaker	3/25/2016								120
Whitaker	5/4/2016	180	20.5	11.2	0.041	1	0.18	0.67	
Whitaker	5/18/2016	170	10.3	13.1	0.081				
Whitaker	6/8/2016	520	1.4	6	0.26	1.7	0.79	ND	
Whitaker	6/22/2016	420	1.2	ND	0.15				
Whitaker	7/13/2016	280	1.2	ND	0.17	1.4	0.74	0.12	
Whitaker	7/27/2016	480	2.2	6.9	0.23				
Whitaker	8/3/2016	250	33.4	5.7	0.05	1.6	0.81	0.11	
Whitaker	8/24/2016	107	2.1	ND	0.086				
Whitaker	9/14/2016	120	ND	ND	0.036	1.2	0.62	0.76	
Whitaker	9/28/2016	145	1.1	ND	0.087				



Lambert Creek-White Bear Lake Storm Sewer (WBLSS) Data



- Since 2012 WBLSS is below state standards for TP. State standard is130 ug/l. State standard for TSS is 14mg/l. SRP is also tested at this site. Both TP and TSS are showing a downtrend, SRP levels have been fairly consistent since monitoring began in 2010 showing a slight uptrend.

White Bear Lake Storm Sewer				
Year	**TP(ug/L)**	**SRP(ug/L)**	**TSS(mg/L)**	**ChlA (mg/m3)**
2009	110		5.9	
2010	180	76	15.8	
2011	181	93	7.3	
2012	104	66	8.3	
2013	106	85	10	
2014	119	97	1	
2015	101	83	1	
2016	96	84	4.7	5

Whitaker Pond Weir Data

In 2010 VLAWMO worked with Ramsey County, White Bear Lake, White Bear Township and the SPRWS to improve the Whitaker Pond site. The WBLSS drains about 640 acres into Whitaker Pond, which eventually flows into East Vadnais Lake, the drinking water reservoir for the SPRWS. A forebay was installed before the pond to help settle out TSS. The weir was rebuilt and sand/iron filing bags were installed to help reduce TP and SRP levels. Monitoring over the last three years since the project was complete has not shown the reductions VLAWMO was hoping for.

- Did not show improvements for TP reduction
- Has shown little improvement for TSS reduction
- Did not show an improvement in SRP reduction

The following graphs will show the TP, TSS and SRP levels entering Whitaker Pond through the WBLSS and leaving Whitaker Pond on the downstream side of the weir. Monitoring data still suggests the pond is not improving water quality, average levels of TP, SRP and TSS are higher downstream of the weir than they are entering the pond at the WBLSS. Only TSS is below state standards, both TP and SRP are close to or above state standards when leaving Whitaker Pond.

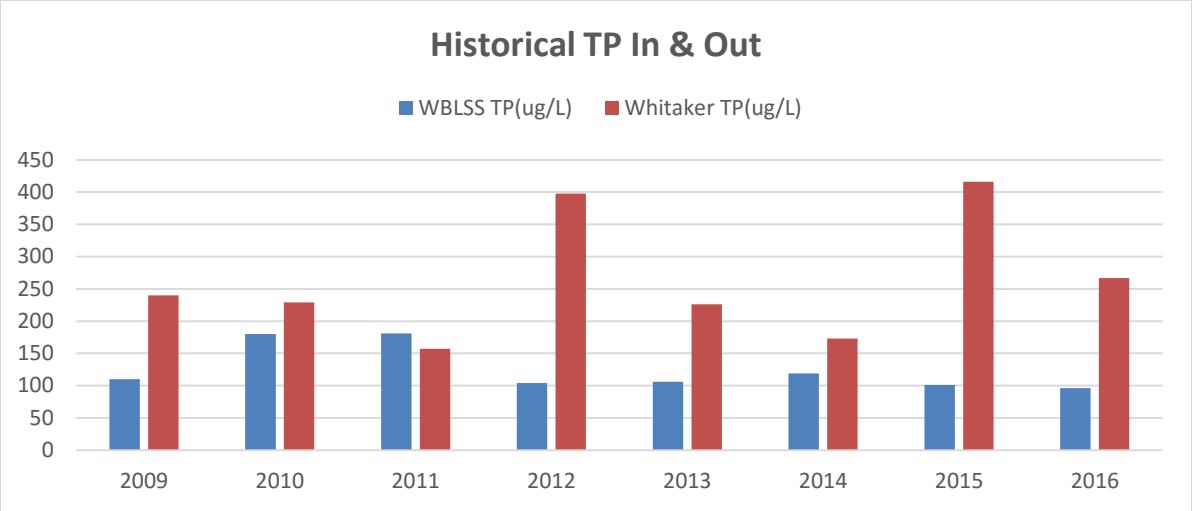
WBLSS 2016 Raw Data

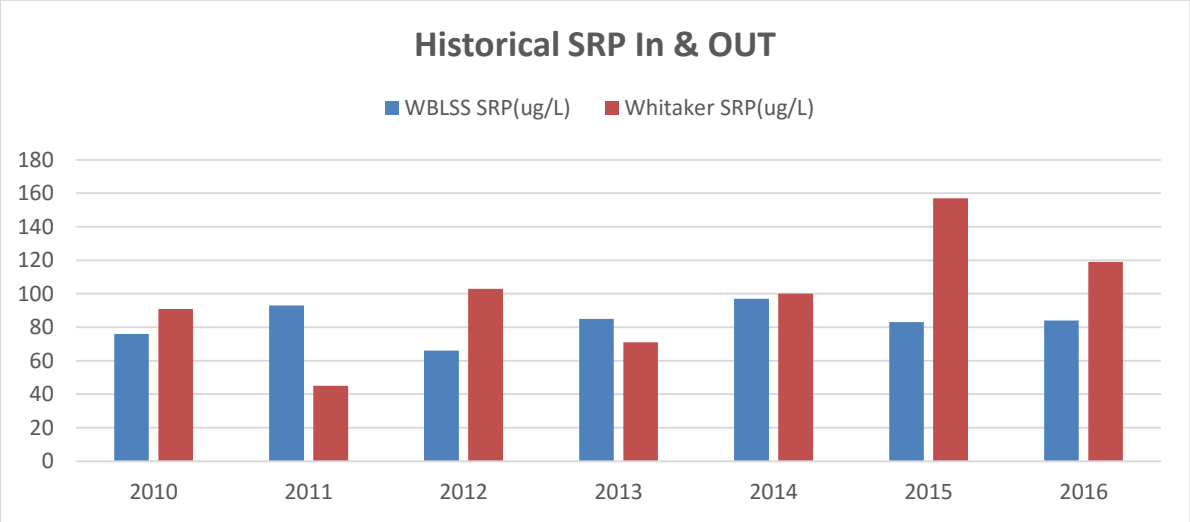
SITE	DATE	TP (ug/L)	ChlA 2nd (mg/m3)	TSS 2nd (mg/L)	SRP (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO3 mg/L	Cl (mg/L)
WBLSS	3/14/2016								110
WBLSS	3/25/2016								116
WBLSS	5/4/2016	97	ND	ND	0.079	ND	ND	5	
WBLSS	5/18/2016	79	ND	2.2	0.081				
WBLSS	6/8/2016	110	ND	8.3	0.13	ND	ND	4.8	
WBLSS	6/22/2016	98	ND	ND	0.077				
WBLSS	7/13/2016	87	1.2	ND	0.082	ND	ND	5.3	
WBLSS	7/27/2016	110	ND	ND	0.085				
WBLSS	8/3/2016	98	8.8	3.8	0.087	ND	ND	5.2	
WBLSS	8/24/2016	79	ND	ND	0.064				
WBLSS	9/14/2016	104	ND	ND	0.081	ND	ND	5.3	
WBLSS	9/28/2016	102	ND	ND	0.076				

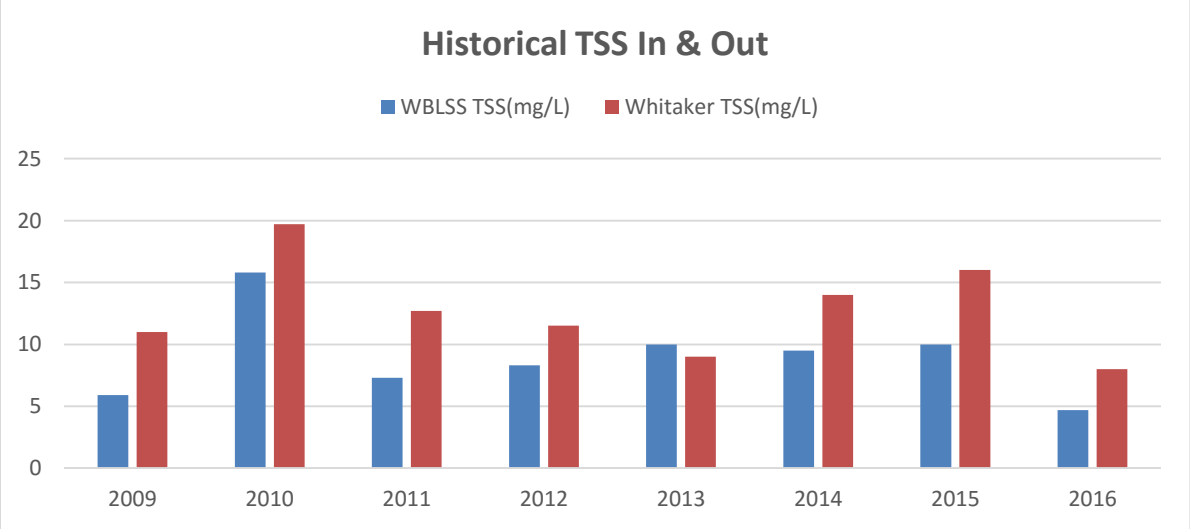
- VLAWMO takes TP, SRP and TSS samples twice a month. Nitrogen samples are taken once a month

	WBLSS TP(ug/L)	Whitaker TP(ug/L)		WBLSS SRP(ug/L)	Whitaker SRP(ug/L)		WBLSS TSS(mg/L)	Whitaker TSS(mg/L)
2009	110	240	**2009**			**2009**	5.9	11
2010	180	229	**2010**	76	91	**2010**	15.8	19.7
2011	181	157	**2011**	93	45	**2011**	7.3	12.7
2012	104	398	**2012**	66	103	**2012**	8.3	11.5
2013	106	226	**2013**	85	71	**2013**	10	9
2014	119	173	**2014**	97	100	**2014**	9.5	14
2015	101	416	**2015**	83	157	**2015**	10	16
2016	96	267	**2016**	84	119	**2016**	4.7	8

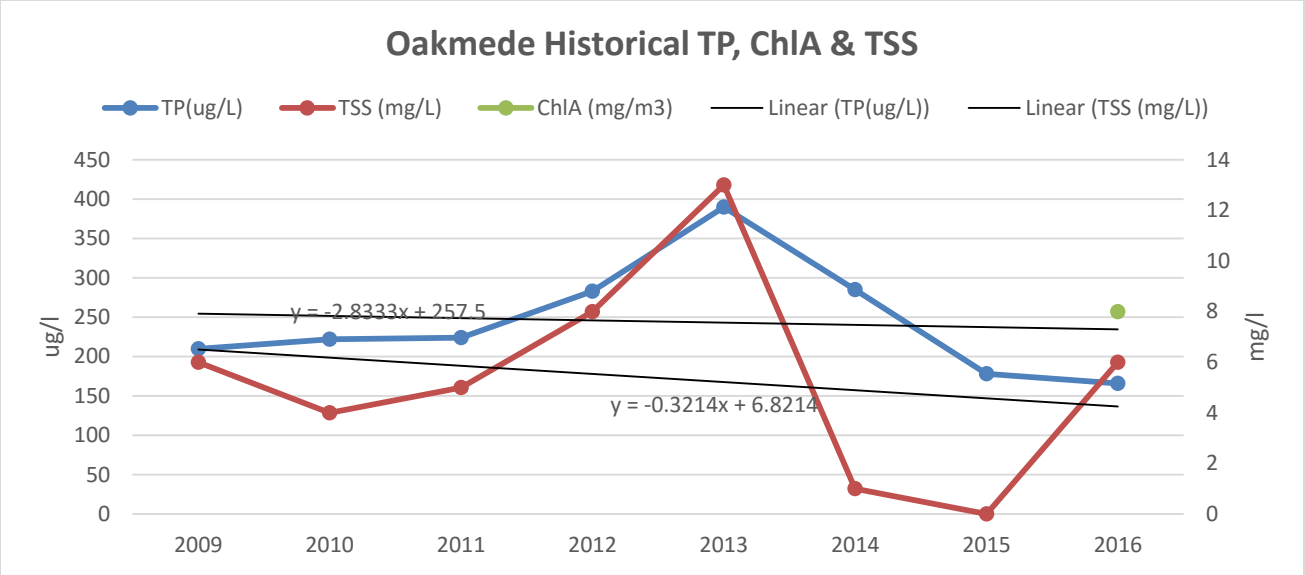
- The above tables are the average year to year comparisons of nutrient levels entering Whitaker Pond from the WBLSS and leaving Whitaker Pond. Below shows graphs of the same data.


Historical TP In & Out
WBLSS TP(ug/L)
Whitaker TP(ug/L)
450
400
350
300
250
200
150
100
50
0
2009
2010
2011
2012
2013
2014
2015
2016


Historical SRP In & OUT
WBLSS SRP(ug/L)
Whitaker SRP(ug/L)
180
160
140
120
100
80
60
40
20
0
2010
2011
2012
2013
2014
2015
2016


Historical TSS In & Out
WBLSS TSS(mg/L)
Whitaker TSS(mg/L)
25
20
15
10
5
0
2009
2010
2011
2012
2013
2014
2015
2016

Lambert Creek - Oakmede Data

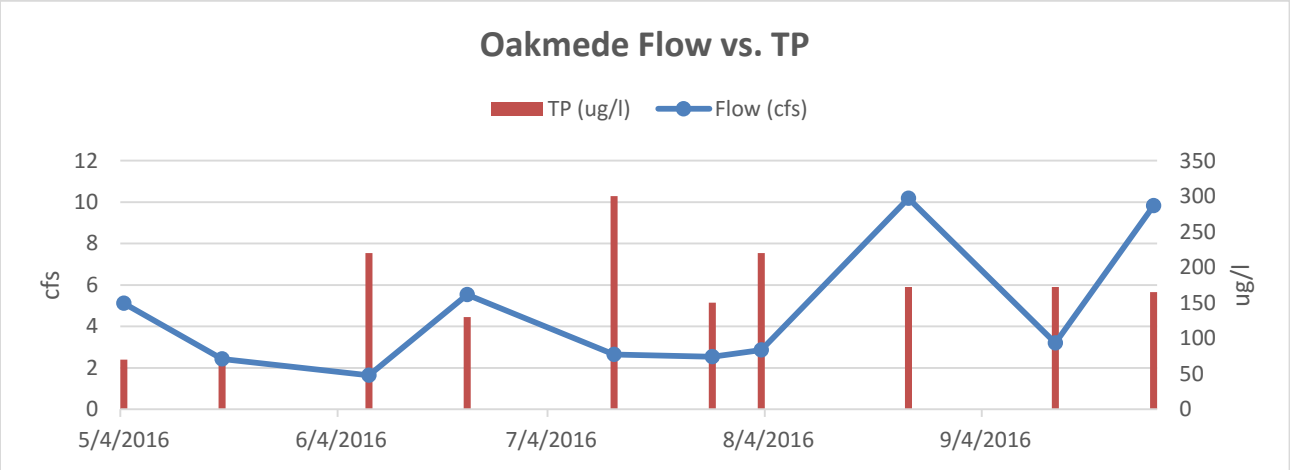


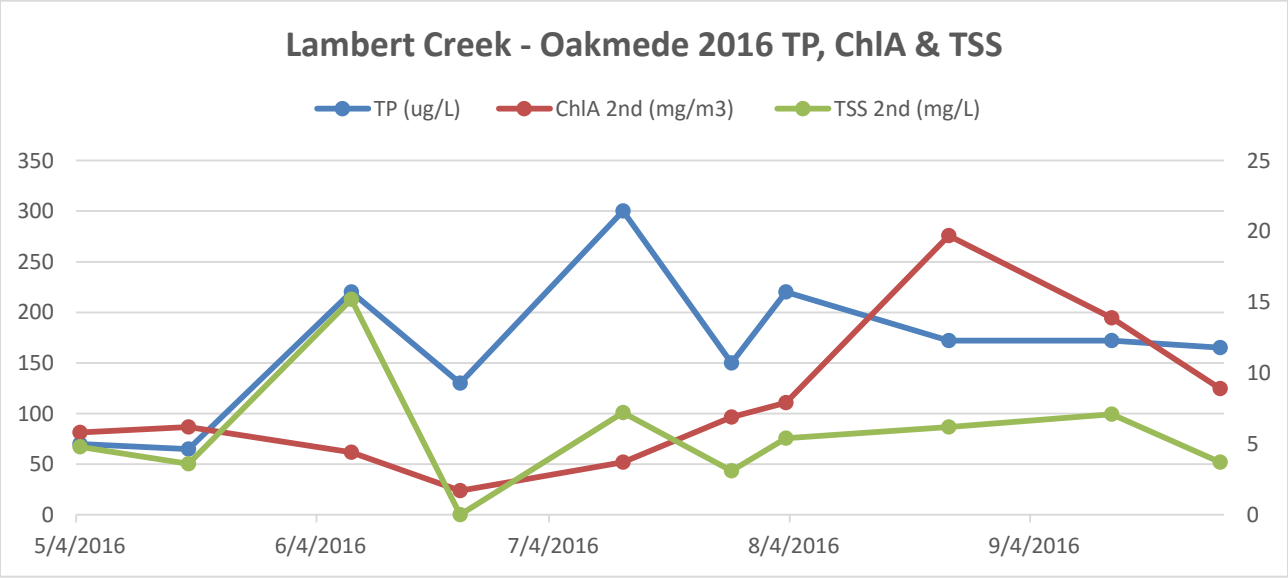
- LC-Oakmede has been well above state standards for TP over the last 8 years of monitoring, but has shown a down trend since 2013. State standard 130 ug/l State standard for TSS is 14mg/l, LC-Oakmede is below state standard for the last 7 years.

Oakmede				Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP(ug/L)	TSS (mg/L)	ChlA (mg/m3)	5/2/2016	13.41	0.481	5.49	7.36
2009	210	6		6/9/2016	21.44	0.467	4.56	8
2010	222	4		7/19/2016	25.35	0.403	3.49	7.8
2011	224	5		9/19/2016	20.13	0.34	3.44	4.98
2012	283	8						
2013	390	13						
2014	285	1						
2015	178	0						
2016	166	6	8					

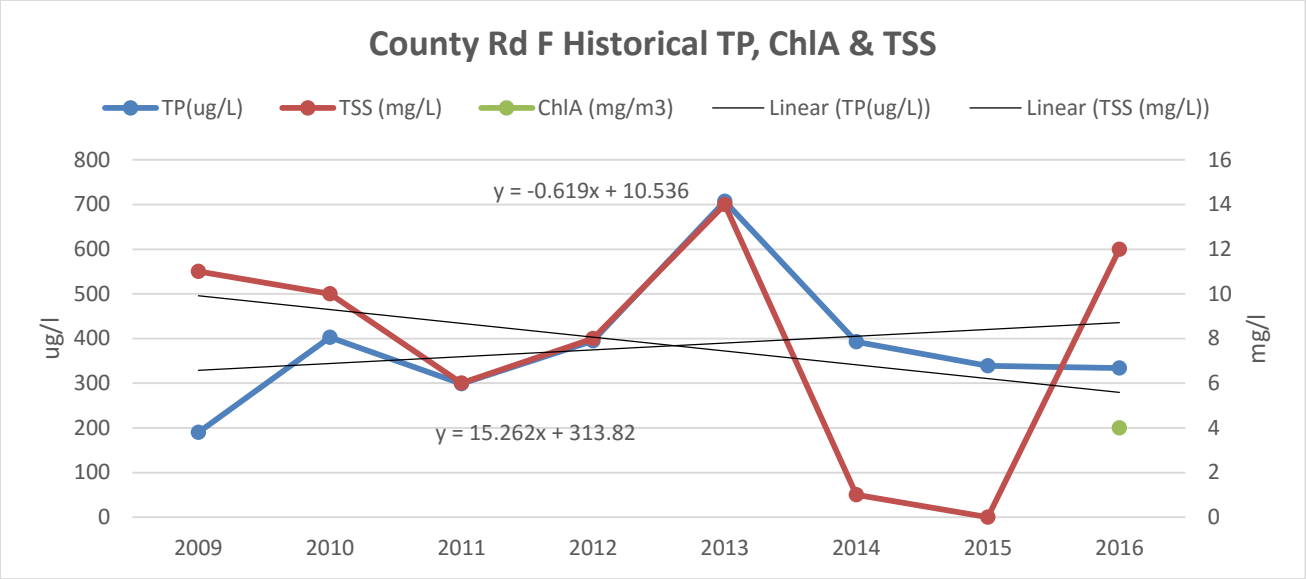
Oakmede 2016 Raw Data

SITE	DATE	TP (ug/L)	ChlA 2nd (mg/m3)	TSS 2nd (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO3 mg/L	Cl (mg/L)
Oakmede	3/14/2016							92
Oakmede	3/25/2016							88
Oakmede	5/4/2016	70	5.8	4.8	0.64	ND	ND	
Oakmede	5/18/2016	65	6.2	3.6				
Oakmede	6/8/2016	220	4.4	15.2	1.1	ND	ND	
Oakmede	6/22/2016	130	1.7	ND				
Oakmede	7/13/2016	300	3.7	7.2	1.6	0.18	ND	
Oakmede	7/27/2016	150	6.9	3.1				
Oakmede	8/3/2016	220	7.9	5.4	0.76	ND	0.021	
Oakmede	8/24/2016	172	19.7	6.2				
Oakmede	9/14/2016	172	13.9	7.1	1.3	ND	0.029	
Oakmede	9/28/2016	165	8.9	3.7				





Lambert Creek - County Rd. F Data

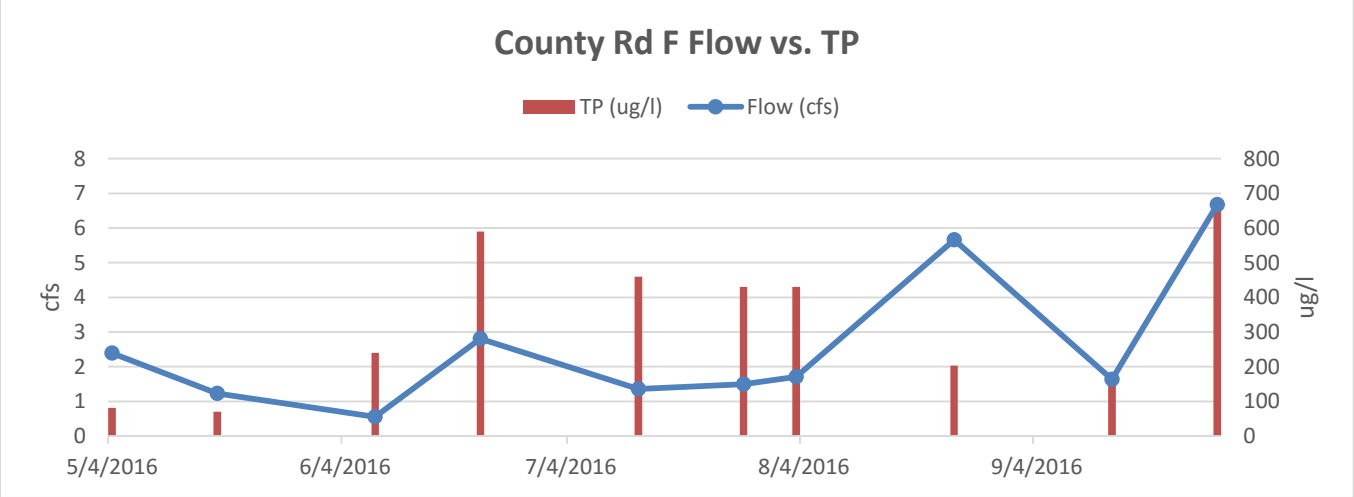


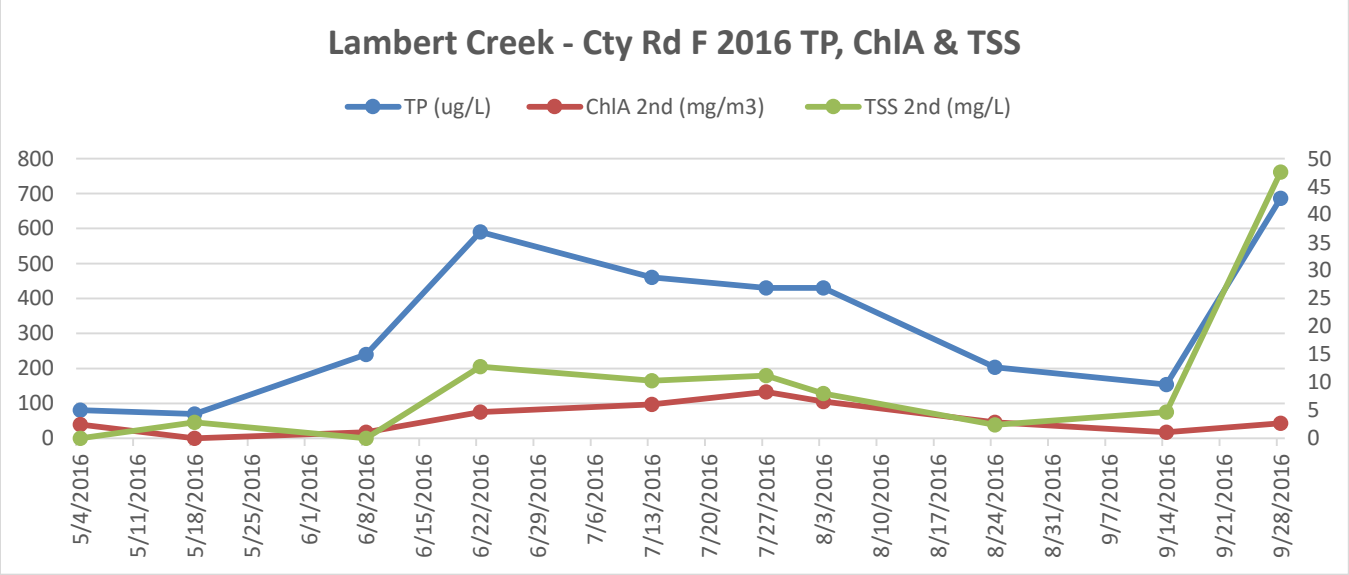
- LC-Cty Rd. F has been well above state standards for TP over the last 8 years of monitoring. This is the highest level of TP out of all six sampling sites on the creek. State standard is 130 ug/l.. State standard for TSS is 14mg/l. MNDOT did work on 35E and the ditch running into the creek during 2016. Ponds and structures were added to the ditch to address flow. Time will tell if this will have an effect on the water quality at this site.

Country Road F				Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP(ug/L)	TSS (mg/L)	ChlA (mg/m3)	5/2/2016	14.29	0.5	6.98	7.42
2009	190	11		6/9/2016	19.4	0.47	5.04	7.95
2010	403	10		7/19/2016	22.98	0.502	3.64	7.95
2011	299	6		9/19/2016	17.93	0.375	3.94	4.95
2012	395	8						
2013	707	14						
2014	393	1						
2015	339	0						
2016	334	12	4					

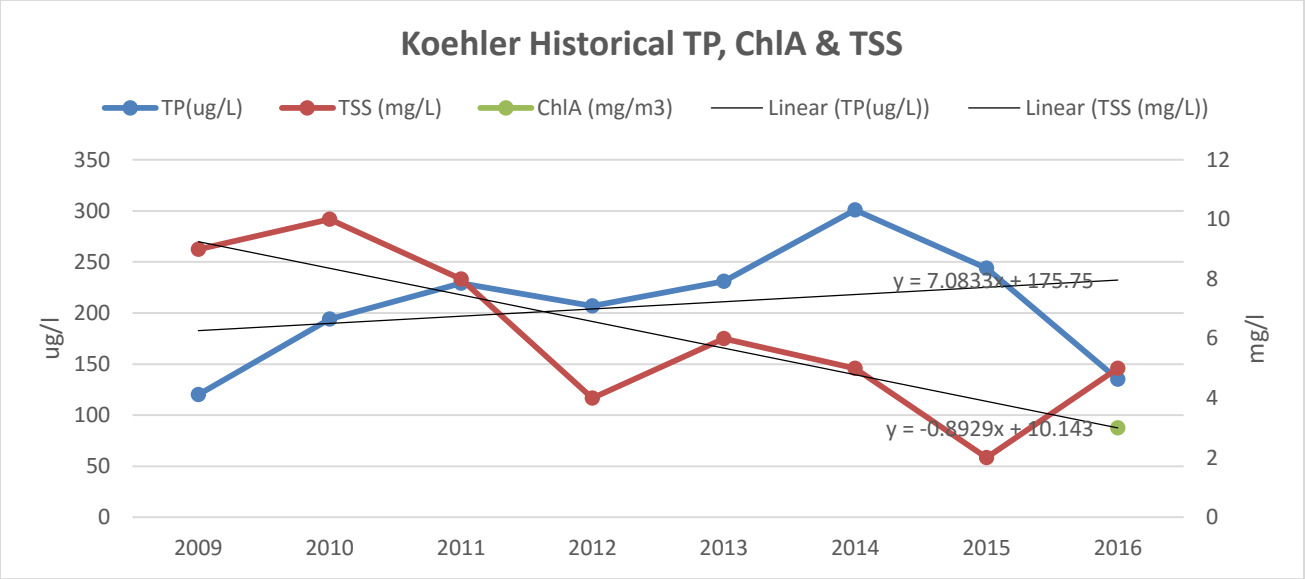
Cty Rd F 2016 Raw Data

SITE	DATE	TP (ug/L)	ChlA 2nd (mg/m3)	TSS 2nd (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO3 mg/L	Cl (mg/L)
Cty Rd F	3/14/2016							80
Cty Rd F	3/25/2016							90
Cty Rd F	5/4/2016	81	2.5	ND	0.64	ND	ND	
Cty Rd F	5/18/2016	70	ND	2.9				
Cty Rd F	6/8/2016	240	1.1	ND	0.81	0.13	0.11	
Cty Rd F	6/22/2016	590	4.7	12.8				
Cty Rd F	7/13/2016	460	6.1	10.3	1.4	0.13	ND	
Cty Rd F	7/27/2016	430	8.3	11.2				
Cty Rd F	8/3/2016	430	6.6	8	0.94	ND	0.055	
Cty Rd F	8/24/2016	203	2.9	2.4				
Cty Rd F	9/14/2016	154	1.1	4.7	0.84	ND	0.036	
Cty Rd F	9/28/2016	686	2.7	47.6				





Lambert Creek - Koehler Rd. Data

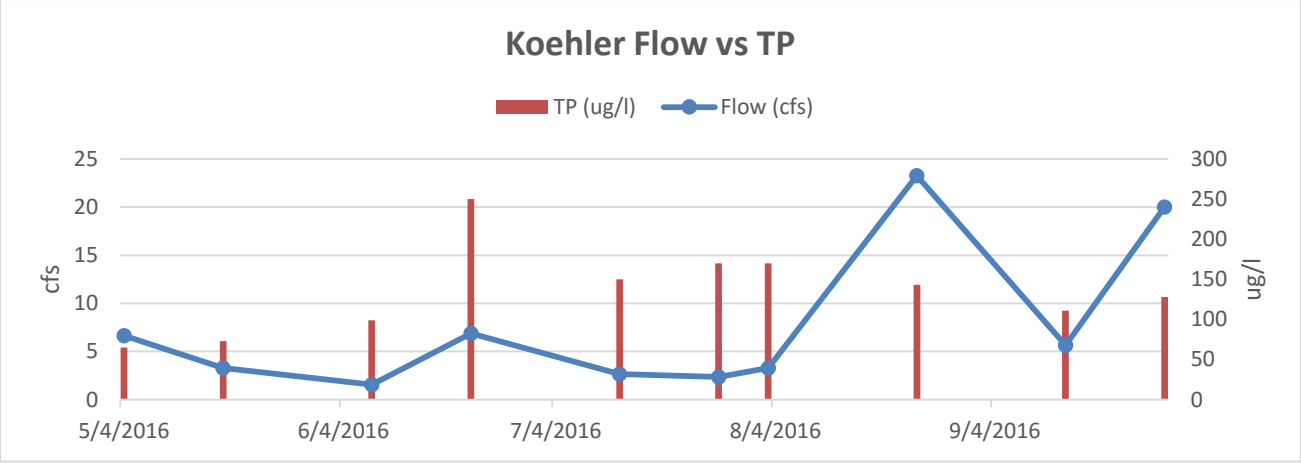


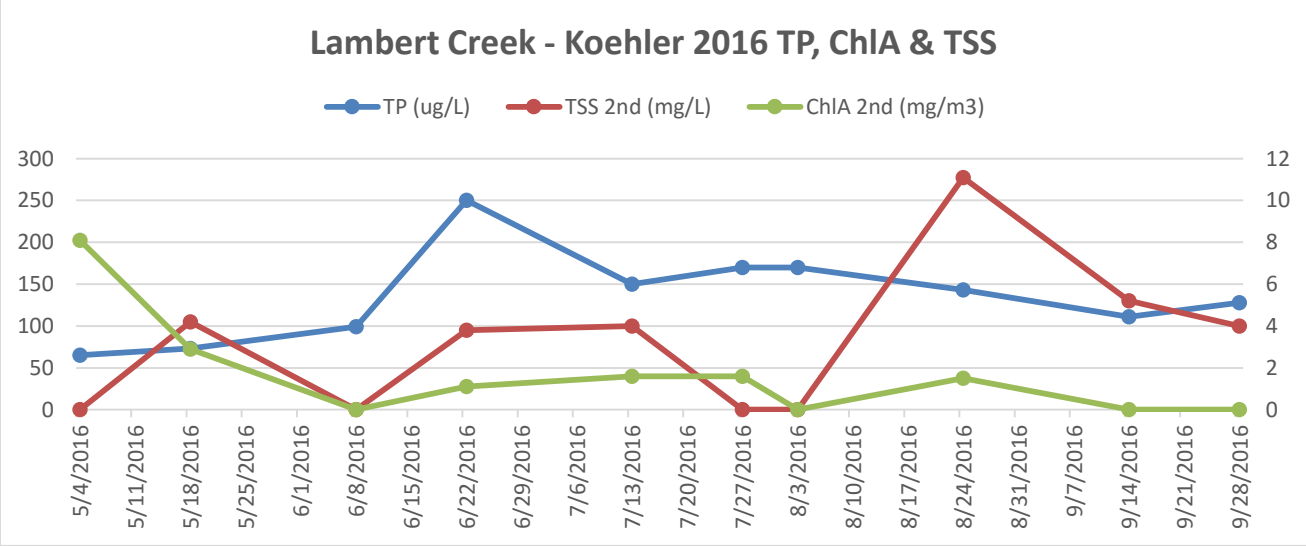
- Koehler has been well above state standards for TP over the last 8 years of monitoring. This is the highest level of TP out of all six sampling sites on the creek. State standard is 130 ug/l.. State standard for TSS is 14mg/l. Stream bank restoration was done in 2011 and have noticed improvement in TSS levels over the years since restoration.

Koehler				Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
Year	TP(ug/L)	TSS (mg/L)	ChlA (mg/m3)	5/2/2016	11.72	0.567	9.94	6.82
2009	120	9		6/9/2016	18.16	0.628	4.31	7.63
2010	194	10		7/19/2016	21.45	0.633	3.81	8.19
2011	229	8		9/19/2016	17.53	0.515	3.7	4.65
2012	207	4						
2013	231	6						
2014	301	5						
2015	244	2						
2016	135	5	3					

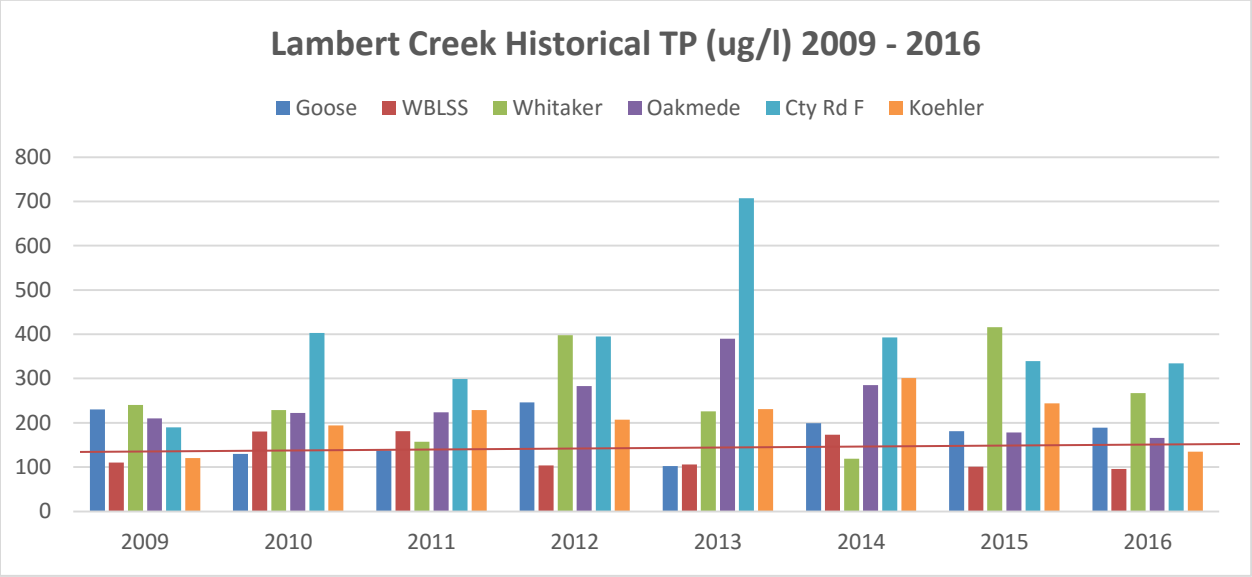
Koehler 2016 Raw Data

SITE	DATE	TP (ug/L)	TSS 2nd (mg/L)	ChlA 2nd (mg/m3)	TKN (mg/L)	NH3 (mg/L)	NO3 mg/L	Cl (mg/L)
Koehler	3/14/2016							102
Koehler	3/25/2016							100
Koehler	5/4/2016	65	ND	8.1	1	0.12	0.18	
Koehler	5/18/2016	73	4.2	2.9				
Koehler	6/8/2016	99	ND	ND	1.1	0.28	0.52	
Koehler	6/22/2016	250	3.8	1.1				
Koehler	7/13/2016	150	4	1.6	1.1	0.12	0.33	
Koehler	7/27/2016	170	ND	1.6				
Koehler	8/3/2016	170	ND	ND	1.1	ND	0.23	
Koehler	8/24/2016	143	11.1	1.5				
Koehler	9/14/2016	111	5.2	ND	1.1	0.21	0.15	
Koehler	9/28/2016	128	4	ND				





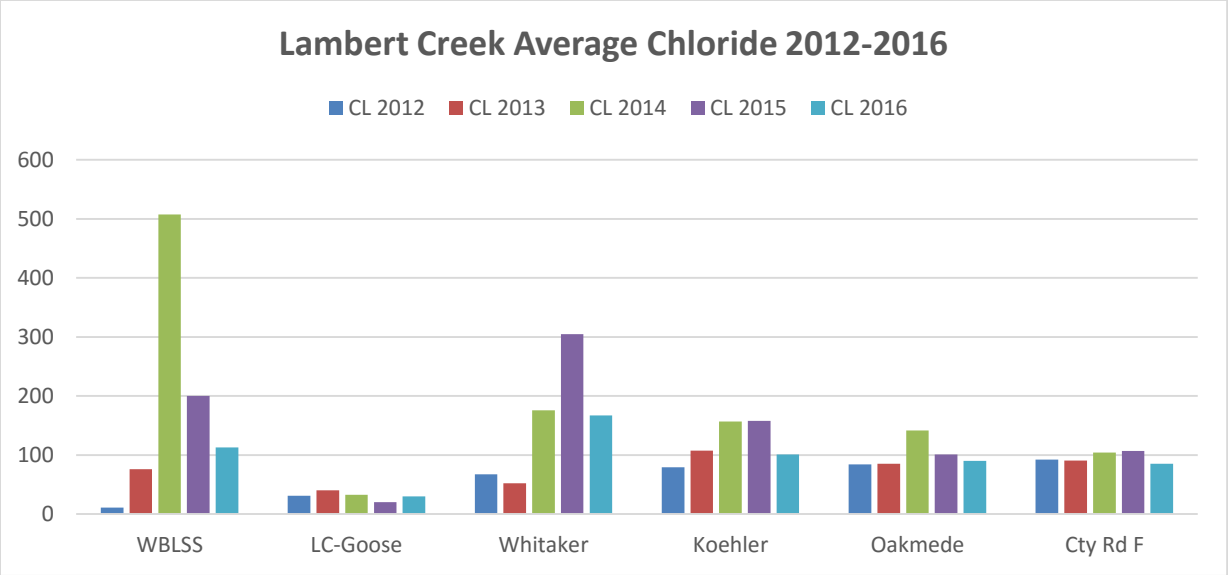
Lambert Creek Average Total Phosphorus



- Current state standard for stream Tp is 130 ug/l. All stream location have averaged over the state standard at least half of the time over the last 8 years with many of the locations over the state standard all eight years. Red line indicates standard.

Lambert Creek Average Yearly Tp (ug/L) 2009-2016								
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Goose	230	130	138	246	102	199	181	189
WBLSS	110	180	181	104	106	173	101	96
Whitaker	240	229	157	398	226	119	416	267
Oakmede	210	222	224	283	390	285	178	166
Cty Rd F	190	403	299	395	707	393	339	334
Koehler	120	194	229	207	231	301	244	135

Lambert Creek Chloride Data



- Lambert Creek Cl levels are below state standards. VLAWMO has been monitoring Cl levels since 2010

Chloride Standards:

Chronic Exposure Standard;

- 4 day average >230 mg/l

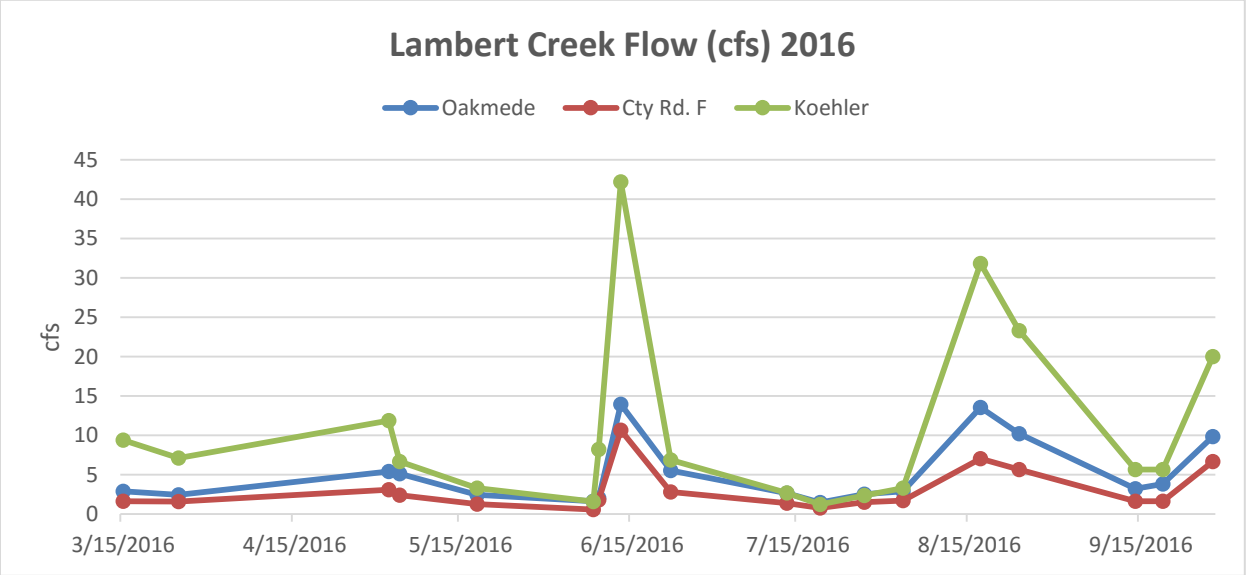
Acute Exposure Standard;

- One hour >860 mg/l

Impairment Threshold;

- Two or more exceedances in a three year period having at least five data points

Lambert Creek Flow



Lambert Creek YSI Data

Reading Location	Date	Temp C	Conductivity	DO (mg/l)	pH
Cty Rd F	5/2/2016	14.29	0.5	6.98	7.42
Cty Rd F	6/9/2016	19.4	0.47	5.04	7.95
Cty Rd F	7/19/2016	22.98	0.502	3.64	7.95
Cty Rd F	9/19/2016	17.93	0.375	3.94	4.95
Koehler	5/2/2016	11.72	0.567	9.94	6.82
Koehler	6/9/2016	18.16	0.628	4.31	7.63
Koehler	7/19/2016	21.45	0.633	3.81	8.19
Koehler	9/19/2016	17.53	0.515	3.7	4.65
LC- Goose	5/2/2016	16.59	0.319	9.33	8.42
LC- Goose	6/9/2016	22.57	0.286	7.81	8.86
LC- Goose	7/19/2016	25.44	0.3	5.22	8.8
LC- Goose	9/19/2016	19.66	0.248	4.97	8.47
Oakmede	5/2/2016	13.41	0.481	5.49	7.36
Oakmede	6/9/2016	21.44	0.467	4.56	8
Oakmede	7/19/2016	25.35	0.403	3.49	7.8
Oakmede	9/19/2016	20.13	0.34	3.44	4.98
Whitaker	5/2/2016	16.66	0.472	5.19	7.94
Whitaker	6/9/2016	19.8	0.393	2.29	7.51
Whitaker	7/19/2016	22.12	0.422	0.45	7.87
Whitaker	9/19/2016	19.27	0.459	1.36	7.48

- The YSI data for all creek sites above are within state standards. One thing to note is the high conductivity levels at the Koehler Rd. site.

2016 E.coli Source Monitoring

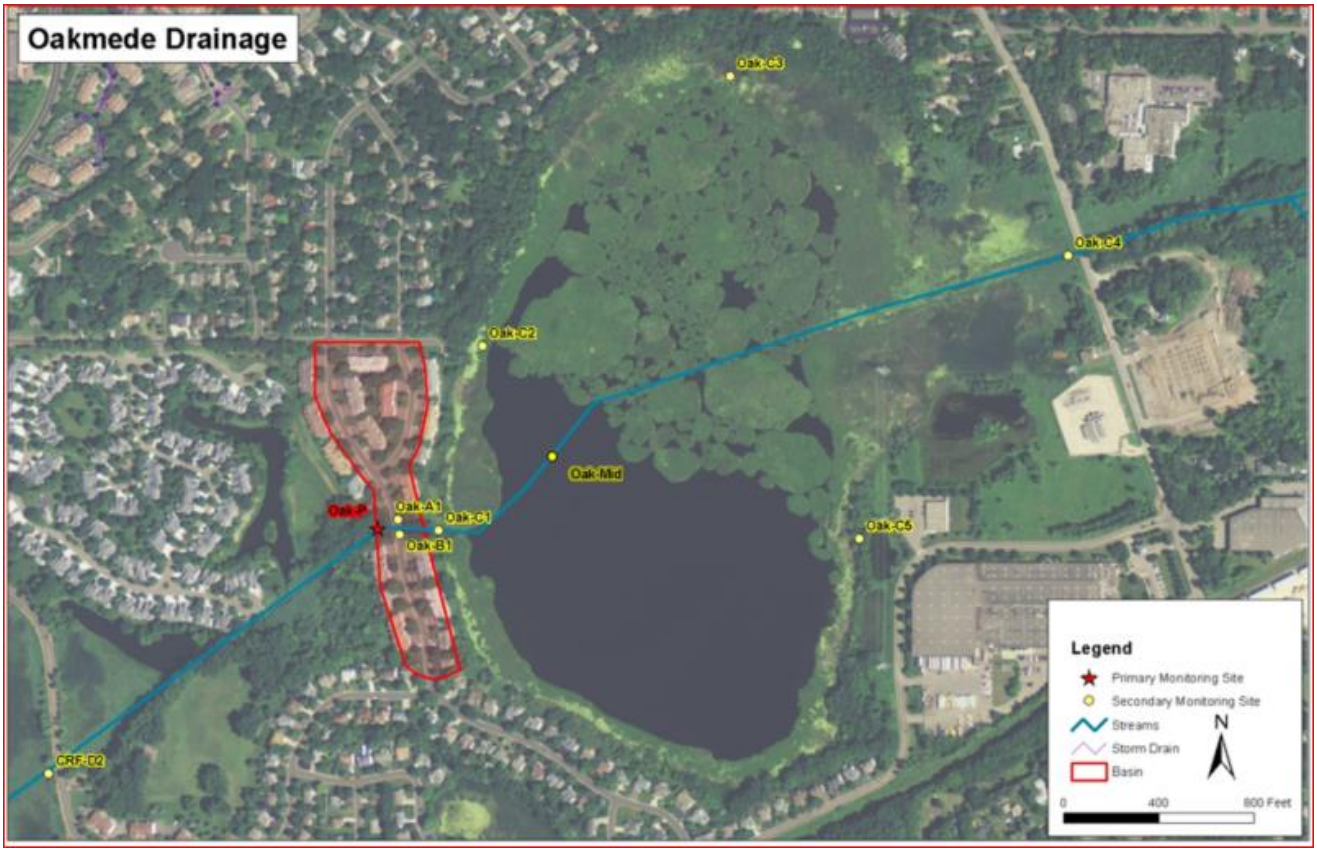
The Bacteria Sourcing study uses and integrated approach to identifying and reducing bacteria loads to meet regulatory requirements, in this case the TMDL MS4 wasteload allocations. The three main sources for the bacteria loading to the creek have been identified as wildlife, human and urban stormwater. The sourcing study has broken the creek into five sub-drainages and each sub-drainage will be monitored first during dry conditions and then during wet conditions.

VLAWMO completed the Oakmede and Cty. Rd F sub-drainages this summer for wet weather conditions. Ecoli concentrations were monitored at a primary site and also possible source sites at both locations which were identified during a creek recon spring of 2014. These sites were also tested for the human, canine and avian genetic markers.

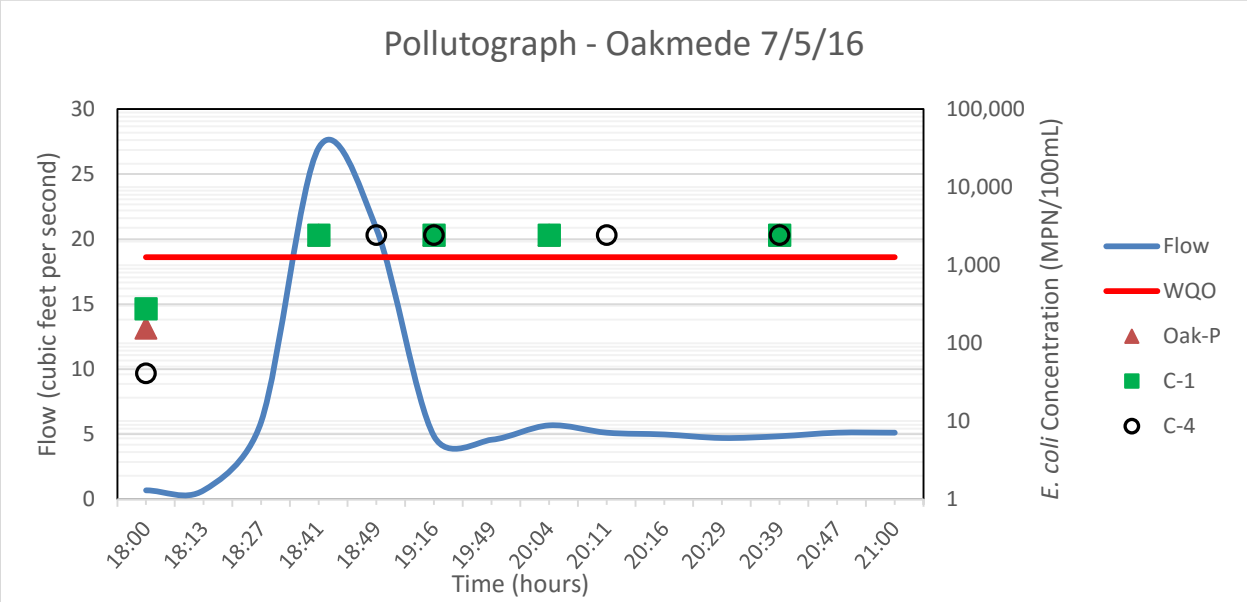
Results at both sites showed above state chronic standard levels of ecoli (less than 126cfu/100ml) which indicates the impairment is wet weather/stormwater runoff related at these sites. Cty Rd f was negative for the human marker and Oakmede had a few positive hits for human marker but they we very close to non-detect and it is common in wet weather conditions to get traces of human ecoli. Both sites were positive for the bird marker suggesting waterfowl have an influence on the bacteria levels in the creek.

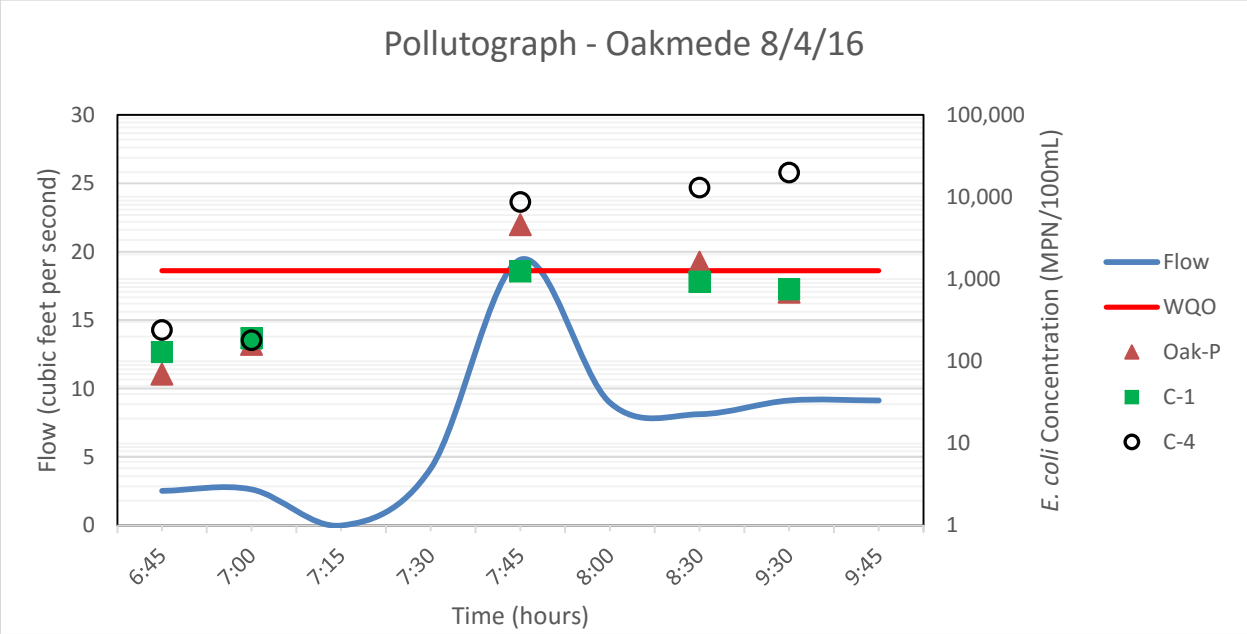
VLAWMO will finish the wet weather monitoring with the Goose and Whitaker sites in 2017.

Oakmede



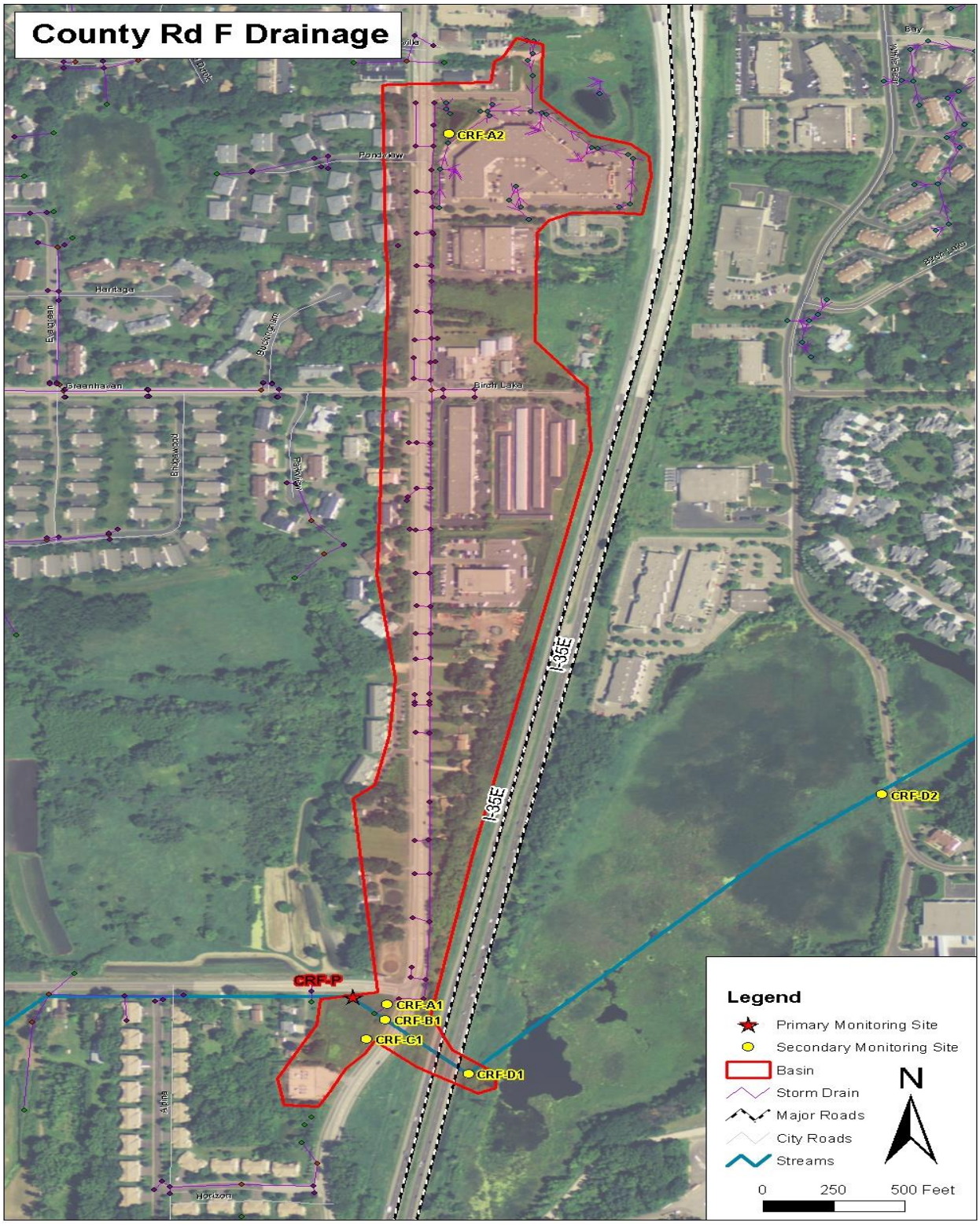
Pollutograph Oakmede



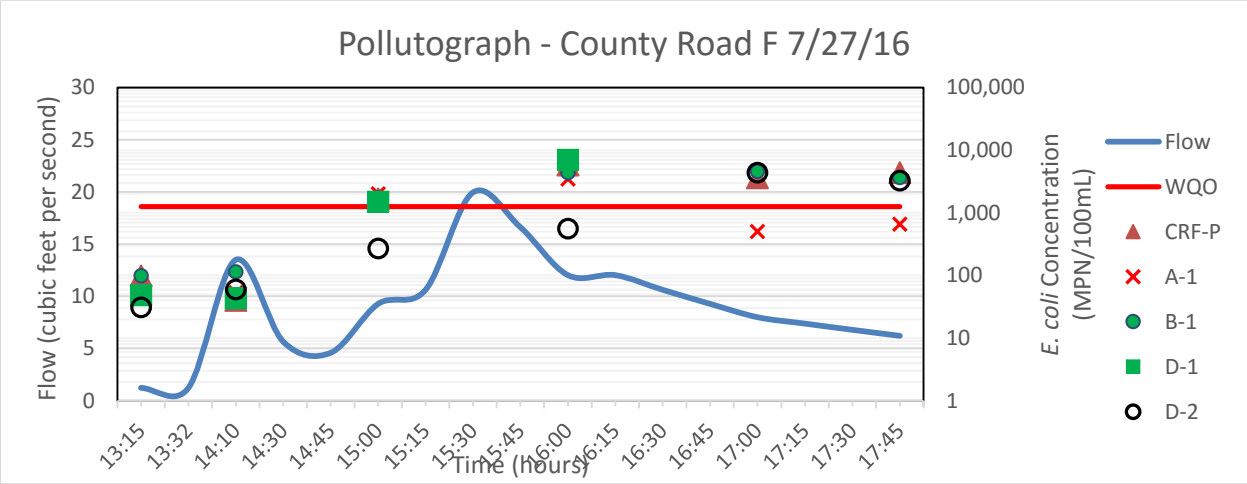


- This data was from a 1.6” and 1.05” storm over a 3hr period. Low ecoli levels before runoff/storm begins, levels shoot up as flows increase from storm and ecoli levels stay high as flow decreases

Cty Rd F


County Rd F Drainage
CRF-A2
CRF-P
CRF-A1
CRF-B1
CRF-C1
CRF-D1
CRF-D2
I-35E
I-35E
Legend
Primary Monitoring Site
Secondary Monitoring Site
Basin
Storm Drain
Major Roads
City Roads
Streams
N
0
250
500 Feet

Pollutograph Cty Rd F



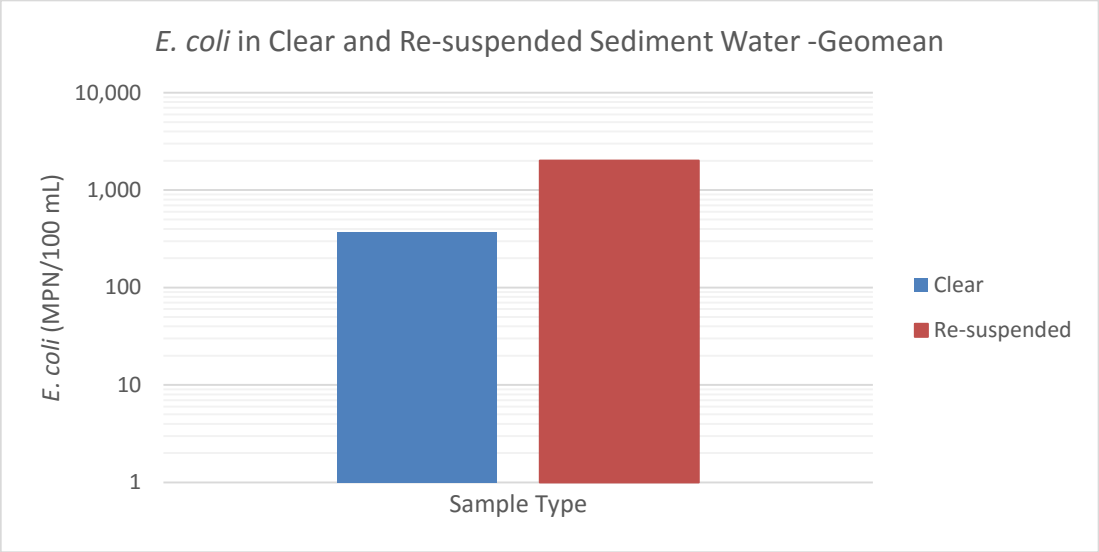
- Similar results as Oakmede, low levels of ecoli until flows begin to increase. High levels of ecoli after flows begin to drop

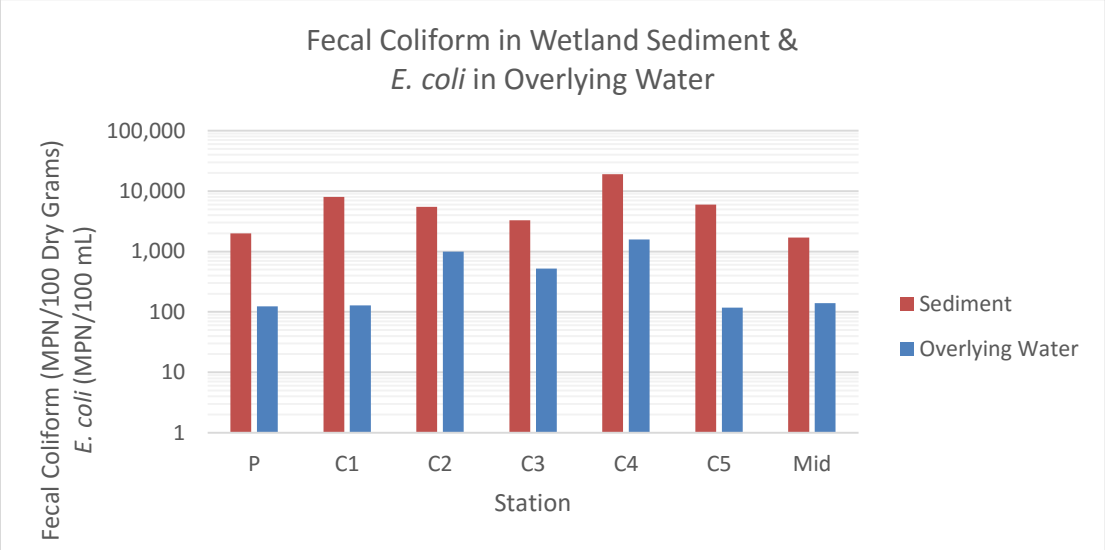
Sample ID	Date Sampled	Human - HF183		Avian - GFD		Canine-DogBact	
		Sample Result	(positive/negative)	Sample Result	(positive/negative)	Sample Result	(positive/negative)
Oakmede Pollutogaph							
MOaKWP-1	7/5/2016	BDL, Equivocal	negative	DNQ	positive	DNQ	positive
MOaKWC4-1	7/5/2016	ND	negative	Detected, ROQ	positive	ND	negative
MOaKWP-2	7/5/2016	DNQ	positive	Detected, ROQ	positive	ND	negative
MOaKWC4-2	7/5/2016	Detected, ROQ	positive	Detected, ROQ	positive	BDL, Equivocal	negative
MOaKWP-3	7/5/2016	BDL, Equivocal	negative	Detected, ROQ	positive	ND	negative
MOaKWC4-3	7/5/2016	Detected, ROQ	positive	Detected, ROQ	positive	DNQ	positive
MOaKWC4-3 Blank	7/5/2016	ND	negative	ND	negative	ND	negative
County Road F Pollutogaph							
MCRFWP-1	7/27/2016	ND	negative	Detected, ROQ	positive	ND	negative
MCRFWD2-1	7/27/2016	ND	negative	Detected, ROQ	positive	ND	negative
MCRFWP-2	7/27/2016	ND	negative	Detected, ROQ	positive	BDL, Equivocal	negative
MCRFWD2-2	7/27/2016	ND	negative	Detected, ROQ	positive	Detected, ROQ	positive
MCRFWP-3	7/27/2016	BDL, Equivocal	negative	Detected, ROQ	positive	ND	negative
MCRFWD2-3	7/27/2016	ND	negative	Detected, ROQ	positive	DNQ	positive
2546MCRFWP-3 Blank	7/27/2016	ND	negative	ND	negative	ND	negative

- Abbreviations: Avg = Average; BDL = Below Detection Limit; cpr = copies per reaction; Cq = quantification (threshold) cycle; DNQ = Detectable But Not Quantifiable; FB = Field Blank; LLOQ = Lower Limit of Quantification; LOD = Limit of Detection; n=number; N/A = Not Applicable; ND = Not Detected; NDsub = substitution value for nondetects; PCR = Polymerase chain reaction; rxs = reactions; StdDev = Standard Deviation; sub = substitution; TSC = Target Sequence Copies; ROQ = Range of Quantification.

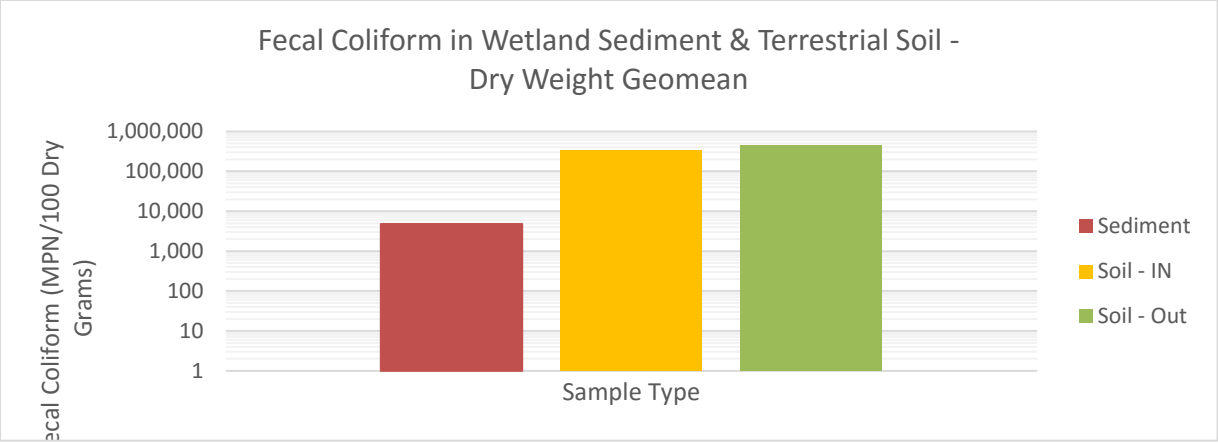
- Molecular results indicate all sites positive for avian ecoli, few hits for canine and a few low detect hits for human which is common during storm events

Special Study – Sediments & Re-suspension Results





- These graphs show that re-suspended/cloudy water column is higher in ecoli than a clear water column, suggesting the increase levels of ecoli during rain/runoff events



- This graph shows that the terrestrial soils both in and out have much higer ecoli concentrations than the wetland sediments indicating that the increase in ecoli levels during rain events has a lot to due with the ecoli washing off of terrestrial soils into waterbodies

Special Study Molecular Results								
Human Marker			Canine			Avian		
Sample ID	Date Sampled	Binary Result (positive/ negative)	Sample ID	Date Sampled	Binary Result (positive/ negative)	Sample ID	Date Sampled	Binary Result (positive/ negative)
SOaK-C2-A1	09/14/16	negative	SOaK-C2-A1	09/14/16	negative	SOaK-C2-A1	09/14/16	positive
SOaK-C2-B1	09/14/16	negative	SOaK-C2-B1	09/14/16	equivocal	SOaK-C2-B1	09/14/16	positive
SOaK-C5-A1	09/14/16	negative	SOaK-C5-A1	09/14/16	negative	SOaK-C5-A1	09/14/16	equivocal
SOaK-C5-B1	09/14/16	negative	SOaK-C5-B1	09/14/16	negative	SOaK-C5-B1	09/14/16	positive
SOaK-C3-A1	09/14/16	negative	SOaK-C3-A1	09/14/16	negative	SOaK-C3-A1	09/14/16	positive
SOaK-C3-B1	09/14/16	negative	SOaK-C3-B1	09/14/16	negative	SOaK-C3-B1	09/14/16	positive
MOaKW-P-1	09/15/16	equivocal	MOaKW-P-1	09/15/16	equivocal	MOaKW-P-1	09/15/16	positive
MOaKW-C1-1	09/15/16	negative	MOaKW-C1-1	09/15/16	negative	MOaKW-C1-1	09/15/16	positive
MOaKW-C1-1 Blank	09/15/16	negative	MOaKW-C1-1 Blank	09/15/16	negative	MOaKW-C1-1 Blank	09/15/16	negative
MOaKW-C4-1	09/15/16	negative	MOaKW-C4-1	09/15/16	equivocal	MOaKW-C4-1	09/15/16	positive
MOaKW-C2-1	09/15/16	negative	MOaKW-C2-1	09/15/16	negative	MOaKW-C2-1	09/15/16	positive
MOaKW-C3-1	09/15/16	negative	MOaKW-C3-1	09/15/16	equivocal	MOaKW-C3-1	09/15/16	positive
MOaKW-C5-1	09/15/16	negative	MOaKW-C5-1	09/15/16	negative	MOaKW-C5-1	09/15/16	positive
Soil samples designated as A were inside the alluvial fan of the outfall								
Soil samples designated as B were outside the alluvial fan of the outfall								
Water samples were collected from the water column containing suspended sediment								

VLAWMO Zebra Mussel Monitoring

VLAWMO placed zebra mussel traps in 4 lakes (Goose Lake, Birch Lake, Gilfillan Lake, Wilkinson Lake), as well as 1 location on Lambert Creek (just below the Koehler flume).

This was VLAWMO's fifth year of Zebra Mussel monitoring and nothing was found in the above lakes and stream location. VLAWMO does have Zebra Mussels in the North Oaks chain of lakes (Charley, Deep, Pleasant, Vadnais, and Sucker) White Bear Lake, just outside our watershed, was confirmed to have zebra mussels fall of 2014.

2016 Monitoring Highlights

- Gem Lake's chemistry has improved over the last 4 years which may coincide with the work that was done on Highway 61 and the reconstructed grass swales flowing into the lake. The MNPCA is currently looking into delisting Gem Lake from the impaired list.
- Gilfillan is another lake that has been on the Impaired List. Since the augmentation system went in to raise the water level, the water quality has improved (most likely due to dilution). We have been told that no augmentation has occurred the last four years so it has been maintaining its level on its own. Nutrient levels look to be slightly rising over the las four years.
- East Goose and West Goose still have very high nutrient levels. Bullhead removal did not make the water quality impact we hoped, but it did reduce nutrient levels a little. More in depth studies will be starting in 2017.
- Wilkinson's phosphorus is over state standards but this year the Chlorophyll A is below or at standard. Wilkinson acts more like a wetland and therefore what goes on in the watershed has a greater effect on the chemistry, MNPCA is looking into changing the lake classification to wetland..
- Tamarack's numbers are still high. The floating wetland has not shown any effect as of yet. This is the third full year of monitoring. Samples were taken right next to the island and compared it to samples taken off the dock. There is no difference between the two spots. So far the water chemistry is similar to what was seen in the past. Monitoring will continue. The floating island currently provides good habitat and educational opportunities and will hopefully help improve water quality over the next few years.
- VLAWMO installed its first automated storm sampler this summer and worked great and provided good results.
- The two cell system at Whitaker continues to export phosphorus. However the pond and forebay has shown a positive effect on suspended solids.
- Chloride levels overall were similar to last year. We have been sampling for 7 years and there have been no significant changes within the lakes. Black Lake has the lowest levels. Birch Lake and East Goose are the highest which makes sense due to the proximity to major roads. All of the lakes are below the current State standards. The creek samples are difficult to catch because it has to be done when water is flowing. Year round chloride sampling on Birch Lake was done for the second year and levels have stayed steady
- Wet weather e. coli study showed that the flow from storm events in the creek has a correlation to the amount of E. coli in the samples. Stormwater runoff seems to be the source of high E. coli levels in the Oakmede and Cty Rd F subwatersheds, mainly from the runoff carrying high levels of e.coli off of terrestrial soils.

- Small study was done on wetland/stream complex connecting Amelia Lake to Wilkinson Lake and it indicated that nutrient loading to Wilkinson Lake is coming from that complex.