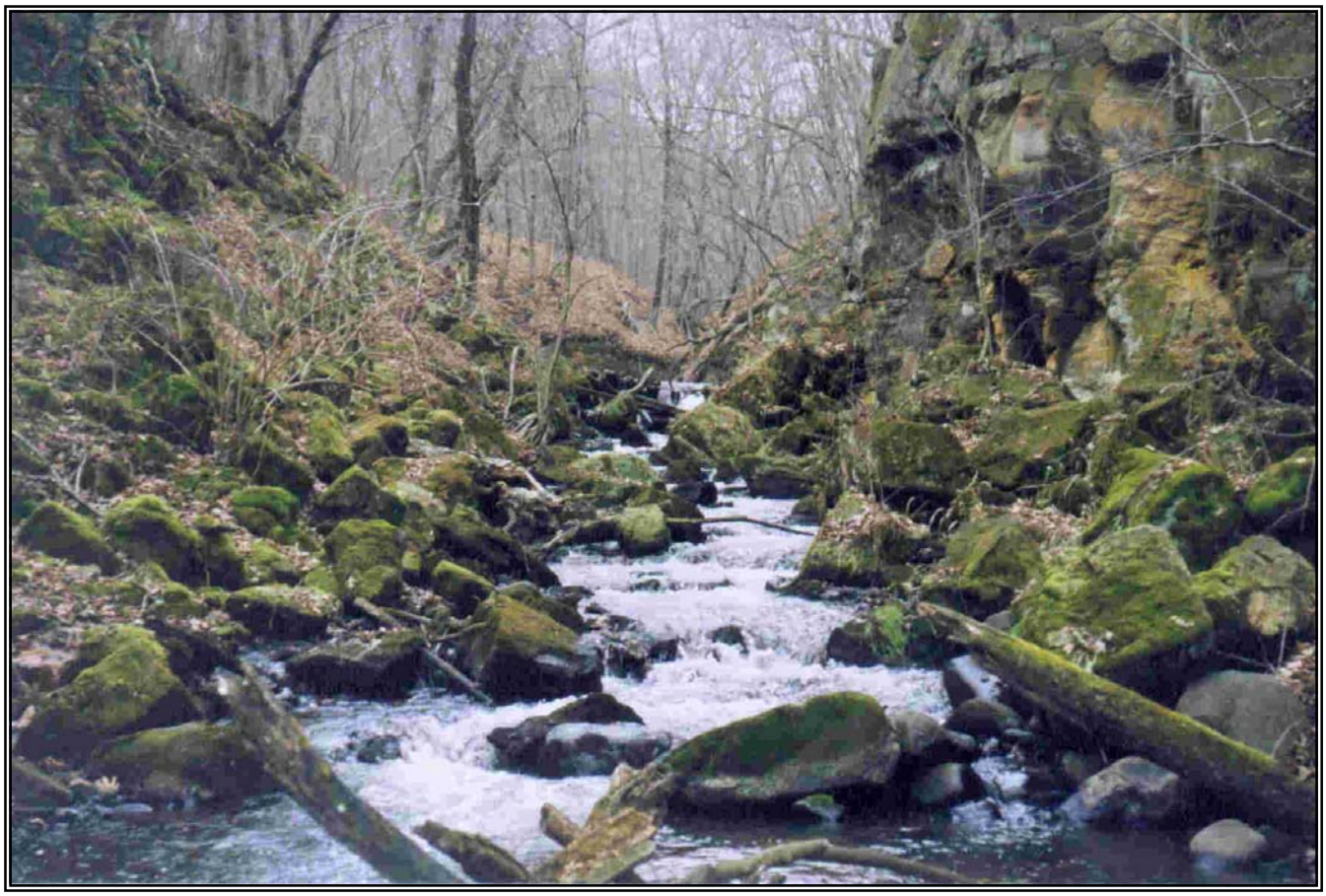

2005 WATER MONITORING REPORT

August 2006

Prepared for:

BROWN'S CREEK
WATERSHED DISTRICT

Prepared by:

Washington Conservation District

ACKNOWLEDGEMENTS

Many agencies and individuals were directly involved in many aspects of this project, such as: data collection, data analysis, as well as technical and administrative assistance.

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Minnesota Pollution Control Agency (MPCA)
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National Park Service
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Stillwater Area High School
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The WCD would also like to thank those volunteers and landowners who assist with the data collection and access.

EXECUTIVE SUMMARY

This report focuses on the summary and comparison of the Brown's Creek Watershed District (BCWD) lake and stream water quantity and quality data collected by the Washington Conservation District (WCD) from 2000-2005 and previous monitoring seasons. In 2005, BCWD added two lakes and one stream sites to their baseline monitoring program: Benz Lake, South School Section Lake and an additional Brown's Creek stream site at Highway 15. In addition to these sites, BCWD continued to monitor Goggin's Lake, Kismet Basin, and Long Lake and Brown's Creek stream sites on McKusick Road and Highway 96 (Figure 1). Four Brown's Creek stream sites were sampled for macroinvertebrates. Data was collected by the WCD at Hwy 15 and by volunteer stream monitoring groups at: (W4), just upstream from the mouth, (W3), about one mile from the mouth, and (W8) at the creek crossing with Neal Avenue. The purpose of the monitoring program was to assess and document the current water quality conditions of the lakes and streams and to continue a long-term monitoring program which will enable the BCWD to identify trends associated with land use changes in their watershed.

Lake Water Quality

In 2005, the five lakes monitored had fair to very poor water quality ratings and were classified as eutrophic and hypereutrophic.

Lake	2005 Trophic Status	2005 Grade
Benz	Hypereutrophic	F
Goggins	Hypereutrophic	C-
Kismet	Eutrophic	C+
Long	Hypereutrophic	C-
South School Section	Eutrophic	B-

Goggin's, Long, and Benz Lakes were considered worse than the ecoregion range for total phosphorus, total Kjeldahl nitrogen, chlorophyll-*a,* and Secchi disk transparency. Kismet Basin and South School Section Lake were within the ecoregion range for total phosphorus, total Kjeldahl nitrogen, chlorophyll-*a,* and Secchi disk transparency.

The past six years of water quality data has shown:

- Goggin's Lake has shown some minor improvement going from an annual average of D+ to a C- water quality rating.
- Kismet Basin's water quality average improved from 2000-2004 going from a D to a B+, but decreased slightly in 2005 to a C+.
- Long Lake's has shown some improvement going from an F to a C- water quality rating.

Water quality in a lake depends on a number of different variables such as: size of the contributing watershed, depth of the lake, and current amount of nutrients available and periodically released from the lake bottom, as well as external nutrient sources. Low water quality ratings of BCWD lakes are most likely due to the shallowness of the lakes and an abundant internal nutrient source. Shallow lakes do not completely stratify in the summer; therefore, they are capable of continually mixing. Mixing causes phosphorus to be distributed throughout the water column, causing more frequent heavy algal blooms.

Both WCD staff and volunteers monitored water levels on lakes and wetlands throughout the Brown's Creek Watershed District. Thirteen lakes and four wetlands were monitored for water surface elevation in 2005. Early season lake elevations were relatively low due to little snow, snowmelt, and rainfall in the spring. Elevations dropped throughout the summer until mid to late September when precipitation events began to increase in frequency. Lower amounts of evapotranspiration throughout late fall and a large storm in early October increased elevations near levels seen in the spring. Average water elevation in lakes, with the exception of Goggin's Lake (considered in the high impact flooding impact range), were in the low to moderate flooding impact ranges as compared to the Brown's Creek Watershed District's 2003 Hydrologic/Hydraulic Study.

Streams

The WCD has taken grab samples and flow-weighted samples during both baseflow and storm event conditions from March to November at two locations within Brown's Creek since 1998: McKusick Road (approximately 2.5 miles from the mouth) and at Highway 96/95 (0.3 miles from the mouth). A new stream monitoring site was added to Brown's Creek in 2005 at Hwy 15 (approximately 4.5 miles from the mouth). Two additional sites were added at different drainage locations to Long Lake in efforts to provide data for the Long Lake Management Plan (Data not contained in this report).

The stream monitoring sites on Brown's Creek are producing valuable baseline water quality information that will be a helpful tool in determining a healthy balance of resources as the watershed continues to experience growth and changes in land use. Discharge (base and storm), chemical, physical and biological parameters are compared on a year-to-year basis and with other streams in the region to determine the health of the stream.

Using a combination of composite and grab samples, total phosphorus and total suspended solid loads were calculated. The results were compared to a chart of export coefficients in a variety of land use scenarios and show the Brown's Creek watershed within regional averages for total phosphorus at both sites. In 2003-2005, the total phosphorus and total suspended solids loading estimates greatly decreased from the loading levels of 2001-2002 due to lack in overall runoff 2003-2005. Less runoff can be attributed to lack of snow, snowmelt, and precipitation events throughout the year. A portion of the overall reduction in total flow and loads at the McKusick Road and Outlet site may also be a reflection of the City of Stillwater's diversion structure installed in June 2003, which redirects up to the 1.5-year storm into Lake McKusick and down the ravine, preventing the warmer waters from the urban Long Lake tributary from reaching Brown's Creek.

Brown's Creek, upstream of Hwy 15, has been listed as impaired by the Minnesota Pollution Control Agency in 2002 for fish biodiversity and in 2004 for macroinvertebrate diversity. Due to this impairment, BCWD installed a monitoring site at Hwy 15 to determine the water quality impacts draining to this location.

To support the analytical water quality data, macroinvertebrates were collected at Hwy 15 by the WCD in order to determine water quality and habitat impacts to the biological communities in this reach. In 1998 - 2005, volunteers from the Stillwater High School have collected macroinvertebrate samples at sites: W3, W4, and W8 (2003-2005 only). Teachers were able to use the sampling for environmental education, as well as to assist BCWD to assess other water quality and habitat impacts in different reaches of the stream. Using Hilsenhoff's Biotic Index, an average evaluation of water quality for the period of record at each site was completed using collected data. Water quality was assessed at each site as: W3—very good water quality, W4—very good water quality, W8—very good water quality, and Hwy 15—good water quality. The Hwy 15 site has different habitat than the other three sites, which may account for the "good" rating versus the "very good" rating of the other sites within Brown's Creek.

Fisheries data was collected by the DNR and temperature data was collected by the WCD to see how the trout population may be affected by temperature impacts to Brown's Creek. In 2003-2005, few days had stream temperatures that would be considered very stressful to the trout population. At Hwy 15, the maximum daily temperature exceeded the high-impact temperature threshold a total of 17 days during the monitoring season. This reach of stream is not known to contain trout and temperatures are not currently suitable for trout survival compared to the downstream, high-groundwater input reaches of Brown's Creek. In 2003-2005, Brown's Creek experienced lower maximum daily water temperatures than in 2001 or 2002, which is likely due to the decreased surface runoff and larger proportion of groundwater keeping the stream cooler. The DNR has not yet published its most recent fish surveys to assess trout populations and natural reproduction, but 1,000 yearling trout were stocked in the stream during 2005.

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I. INTRODUCTION

This report focuses on the summary and comparison of the lake and stream water quality data collected by the Washington Conservation District (WCD) from 2000-2005 and previous monitoring seasons. In 2005, Brown's Creek Watershed District (BCWD) added two lakes and one stream sites to be monitored in their baseline monitoring program; Benz Lake, South School Section Lake and a stream site at Highway 15 (Brown's Creek). In addition to these sites, BCWD continued to monitor Goggin's Lake, Kismet Basin, and Long Lake and Brown's Creek stream sites on McKusick Road and Highway 96 (Figure 1). Multiple parameters were monitored at each site. Also included in this report are temperature data for Brown's Creek and macroinvertebrate data collected by volunteer stream monitoring groups for the past eight years. The purpose of this monitoring was to assess and document the current water quality conditions of the lakes and streams and to continue a long-term monitoring program which will enable the BCWD to identify trends associated with land use changes in their watershed.

The work plan for 2005 included the following activities: bi-weekly sampling (14 sampling sessions) of Benz Lake, Goggin's Lake, Kismet Basin, Long Lake, and South School Section Lake from April through October, and water elevation readings on sixteen water bodies. Three continuous monitoring stations were installed on Brown's Creek at Highway 15, McKusick Road, and at Highway 96 from March through November.

The WCD performed the sampling for the BCWD. Metropolitan Council Environmental Services Lab performed the analytical lab analyses.

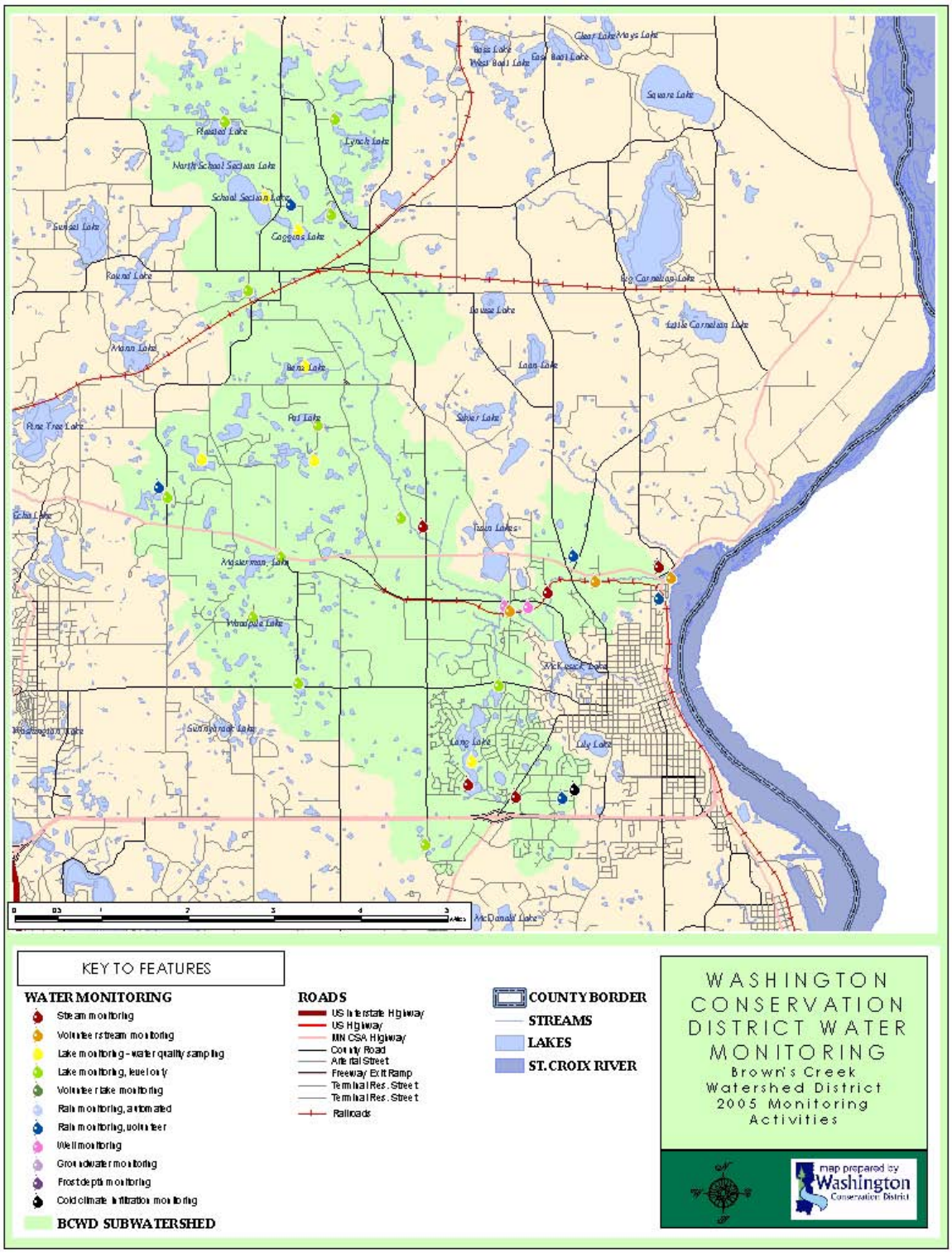


Figure 1: Sampling Location Map

II. LAKES

A. METHODS, RESULTS AND DISCUSSION

In 2005, water quality data was collected bimonthly over seven consecutive months (April–October) by the WCD on Benz Lake, Goggin's Lake, Long Lake, Kismet Basin, and South School Section Lake. Two-meter (6.56 feet) integrated surface water samples were collected with a column sampler. Metropolitan Council Environmental Services Lab analyzed these samples for total phosphorus, chlorophyll-*a*, total Kjeldahl nitrogen, and total chloride ions concentrations (on Kismet Basin only). A complete listing of the laboratory data is contained in Appendix A. Field measurements of Secchi disk transparency, dissolved oxygen and temperature profiles, and lake level were also recorded, as well as a user perception ranking (physical and recreational suitability). Measurements obtained over the sampling season are averaged for a comparison of individual lake dynamics from year to year, for differences between lakes within the watershed, and for comparison with the average North Central Hardwood Forest Ecoregion values. Average values for all parameters, as well as the typical ranges for lakes in this ecoregion, are presented in Table 1 and Appendix A. Table 4 shows the lake grade and trophic state of the lakes sampled. Figure 2 through Figure 5 show the historic annual averages for each parameter.

Table 1: Ecoregion Values and Average 2005 Parameters
2005 Brown's Creek Watershed Lakes

Lake/Units	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Secchi (feet)	Kjeldahl Nitrogen (mg/L)
Eco-Region Value	***0.025-0.050***	***5.00-22.00***	***4.9-10.5***	***0.60-1.20***
Goggins	0.082	39.56	4.0	1.59
Kismet	0.034	19.30	6.8	0.86
Long	0.069	48.93	3.0	1.47
S School Section	0.034	19.30	8.7	1.16
Benz	0.182	86.07	2.1	3.01

1. TRANSPARENCY (SECCHI DISK)

The measurement of depth of light penetration using a Secchi disk gives a simple measure of water transparency, or clarity. It is also a possible indication of turbidity in the water, as well as, an indication of the trophic state of the lake. A reduction in water transparency is usually the result of turbidity composed of suspended sediments, organic matter and/or phytoplankton (algae). The average water transparency in BCWD lakes, as measured by Secchi disk during the 2005 study period, was 3.0 feet in Long Lake, 4.0 feet in Goggin's, 6.8 feet in Kismet Basin, 2.1 feet in Benz Lake, and 8.7 feet in South School Section Lake (Figure 2). Typical ranges for this ecoregion are 4.9 - 10.5 feet. Goggin's, Long Lake, and Benz Lake had Secchi disk readings less (worse) than the ecoregion range, while Kismet Basin and South School Section Lake were within the ecoregion range.

2. CHLOROPHYLL-*a*

Chlorophyll-*a* is a photosynthetic component found in algae and aquatic plants. It is also an indication of algal productivity. In 2005, average chlorophyll-*a* concentrations in BCWD lakes were 49 μg/L in Long Lake, 40 μg/L in Goggin's, 19 μg/L in Kismet Basin, 86 μg/L in Benz Lake, and 19 μg/L in South School Section Lake (Figure 3). The ecoregion value range for chlorophyll-*a* is 5-22 μg/L. Benz, Goggin's and Long Lakes exceeded (were poorer than) the ecoregion values for chlorophyll-*a*, while Kismet Basin, and South School Section Lake were within the ecoregion range.

3. PHOSPHORUS

Phosphorus is a major nutrient involved in eutrophication and is generally associated with the growth of aquatic plants and algal blooms. Common sources of phosphorus include runoff from agricultural fields, livestock areas, urban areas, lakeshore lawns, and improperly operating septic systems. In most lakes in this region, phosphorous is the least available nutrient; therefore, its abundance or scarcity controls the extent of algal growth. Algal growth in turn affects the clarity of the water and light penetration. Total phosphorous (TP) concentrations in BCWD lakes were 0.034 mg/L in Kismet Basin,

0.082 mg/l in Goggin's, 0.069 mg/L in Long Lake, 0.182 mg/L in Benz Lake, and 0.034 in South School Section Lake (Figure 4) in 2005. The typical range of the ecoregion values for total phosphorous is 0.025 – 0.050 mg/L. Long, Benz, and Goggin's Lakes exceeded (were poorer than) the ecoregion value in 2005. The total phosphorous average concentration for Kismet Basin and South School Section were within the ecoregion.

4. NITROGEN

Several forms of nitrogen are responsible for health problems and increase the rate of lake eutrophication. In 2005, average total Kjeldahl nitrogen (TKN) concentrations were 1.47 mg/L in Long Lake, 1.59 mg/l in Goggin's, 3.01 mg/L in Benz Lake, 1.16 in South School Section, and 0.86 mg/L in Kismet Basin (Figure 5). The ecoregion value range for total Kjeldahl nitrogen is 0.60-1.20 mg/L. Kismet Basin and South School Section were within the ecoregion value range, but Benz, Goggin's and Long Lakes exceeded (poorer than) the ecoregion values for total Kjeldahl nitrogen.

5. TEMPERATURE AND DISSOLVED OXYGEN

Temperature and dissolved oxygen readings were taken during each sampling event. In addition to surface water measurements, a temperature and dissolved oxygen profile was taken at each lake during each sampling event. These profiles were done at one-meter increments from the surface down to the lake bottom. The data collected from these profiles are contained in Appendix A. These data show the extent of summer stratification and are useful in identifying the thermocline (the layer of water in which the temperature rapidly declines) if one exists. As a lake stratifies, the water column becomes more stable and mixing is less likely to occur. If mixing occurs during the growing season, bottom nutrients become available and can result in increased algal production. South School Section, Long, and Goggin's Lakes exhibited thermal stratification during the summer months at approximately five, two and a half, and three meters respectively. This shows that South School Section, Goggin's, and Long Lakes

are less likely to completely mix during the summer months; whereas, Kismet Basin and Benz may mix throughout the summer allowing for some internal loading.

6. TROPHIC STATE AND LAKE GRADES

Many water quality scientists classify lakes according to their trophic state. Average summer values of total phosphorus, chlorophyll-*a*, and transparency (measured with the Secchi disk) are most often used to determine a lake's trophic state. The Carlson Trophic State Index is used to quantify the relationship between trophic status and water quality data. Lakes with low biological productivity or oligotrophic lakes, such as lakes common in the northeast part of Minnesota, have low phosphorus concentrations, low chlorophyll-*a* concentrations, and high Secchi disk transparencies. A good local example of an oligotrophic lake is nearby Square Lake, located in Section 23 of May Township. Mesotrophic lakes have slightly more biological production, and are characteristic of lakes found in the north central forest regions of Minnesota. On the other end of the spectrum, lakes with high biological productivity, characterized by high phosphorus concentrations, high chlorophyll-*a* concentrations, and low Secchi disk transparencies, are eutrophic or even hypereutrophic.

Based upon the 2005 data and utilizing the Carlson's Trophic State Index (Table 2) Goggin's Lake, Long Lake, and Benz Lake are classified as hypereutrophic, and Kismet Basin and South School Section are classified as eutrophic (Table 4). Lakes within the hypereutrophic range typically receive excess nutrient loading from sources within their watersheds. However, some percentage of these nutrients can also be attributed to internal loading within the lake, which is typical of shallow, sediment-rich lakes.

Table 2: Trophic State Index and Ranges

	Trophic State Index	TP (ug/L)	CLA (ug/L)	Secchi (m)
Oligotrophic	<40	<10	<4	>4.8
Mesotrophic	40-50	10-30	4-10	4.8-1.8
Eutrophic	50-70	30-60	10-30	1.8-0.8
Hypereutrophic	>70	>60	>30	<0.8

To allow for a better understanding of lake water quality data and to aid in the comparison of lakes, a Lake Grading System is also used in this report (Table 3). The lake water quality grading system was developed following the 1989 sampling season by Dick Osgood of the Metropolitan Council. The concept of the lake grading system is a ranking of water quality characteristics by comparing measured values to those of other metro area lakes. The grading curve represents percentile ranges for three water quality indicators - the May through September average values for total phosphorous, chlorophyll-*a* and Secchi disk. These percentiles use ranked data from 119 lakes sampled from 1980-1988 and are shown in Table 3.

Table 3: Lake Grade Ranges

Grade	Percentile	TP (ug/l)	CLA (ug/l)	SD (m)
A	<10	<23	<10	>3.00
B	10-29	23-31	10-19	2.20-3.00
C	30-69	32-67	20-47	1.20-2.19
D	70-90	68-152	48-77	0.70-1.19
F	>90	>152	>77	<0.70

The variables used in the grading system strongly relate to open-water nuisance aspects of a lake (i.e. algal blooms), which can indicate accelerated aging (cultural eutrophication). The Lake Grading System was used for lakes sampled in 2005; the grades are presented in Table 4. Comparing the Lake Trophic Status and the Lake Grading System shows a fair to good correlation between the two systems.

Table 4: Long Term Lake Grades, Trophic State Index, and Trophic Status

Lake	TP Grade & TSI	CLA Grade & TSI	Secchi Grade & TSI	Average Grade & TSI	Trophic Status
Goggins	D	C	C	**C-**	Hypereutrophic
	68	67	57	**64**	
Kismet	C	B	C	**C+**	Eutrophic
	55	60	49	**55**	
Long	C	C	C	**C-**	Hypereutrophic
	65	69	61	**65**	
S School Sec	C	B	B	**B-**	Eutrophic
	55	60	46	**53**	
Benz	F	F	F	**F**	Hypereutrophic
	79	74	66	**73**	

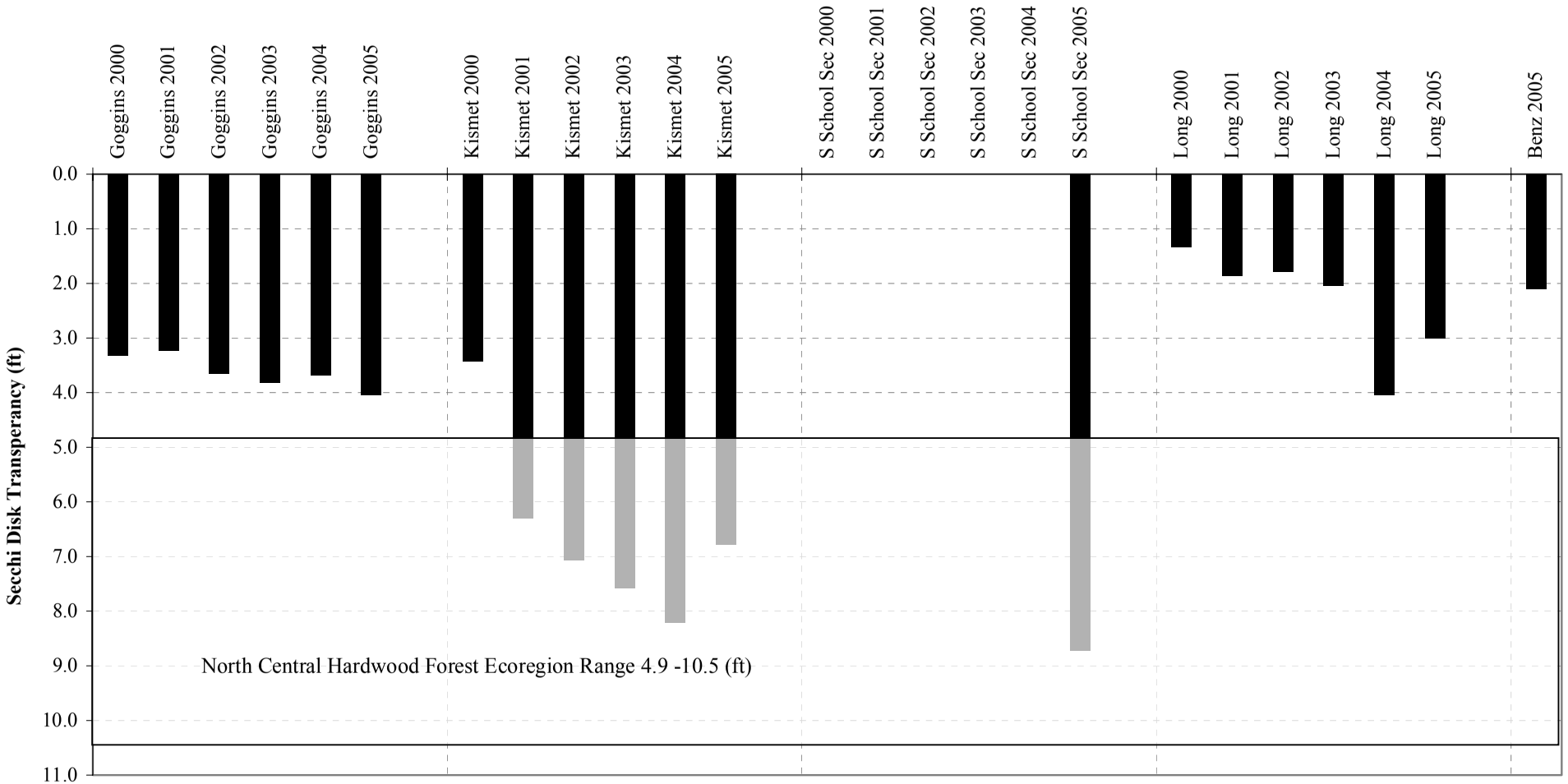


Figure 2: 2005 and Historic Secchi Records

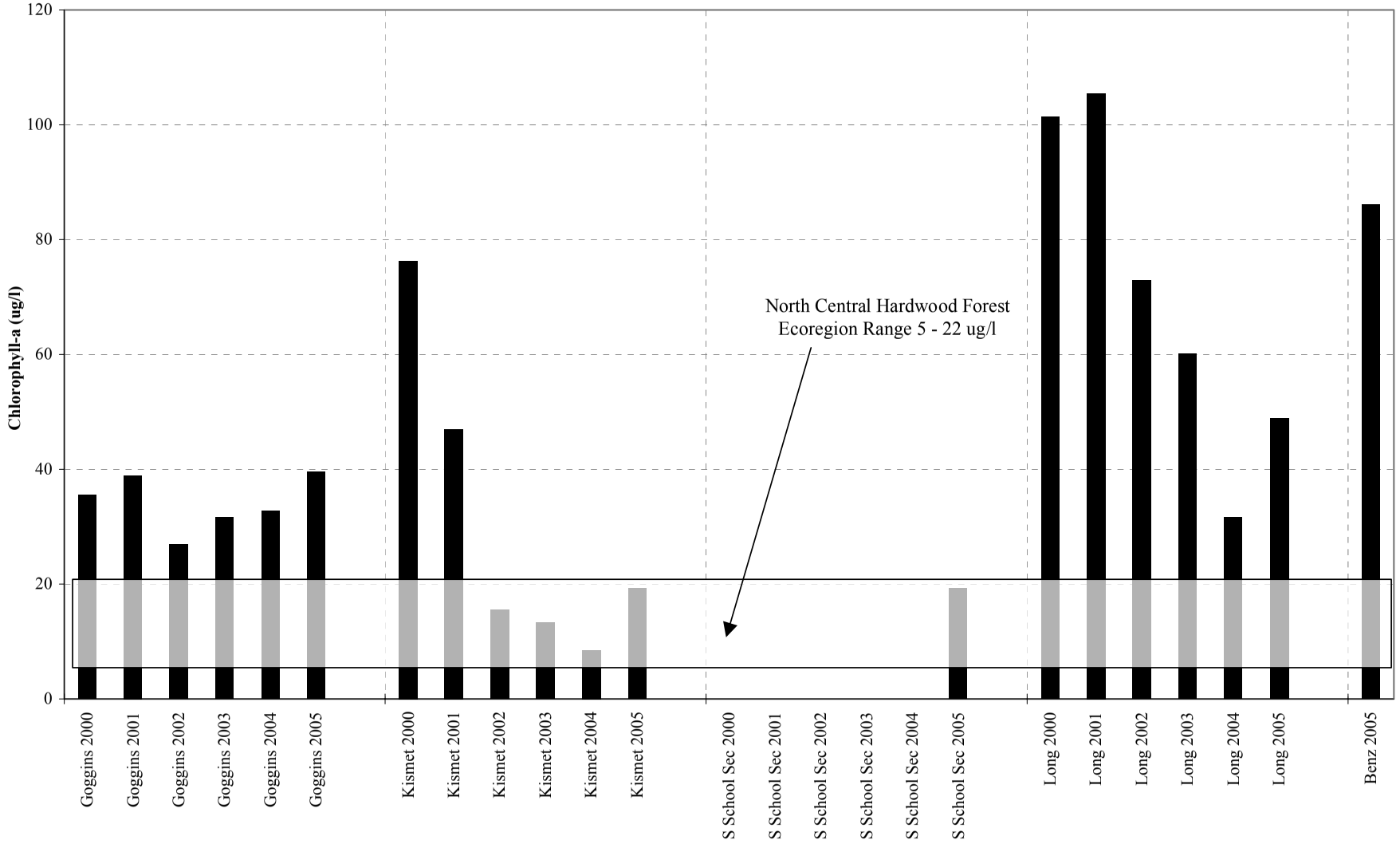


Figure 3: 2005 and Historic Chlorophyll-*a* Data

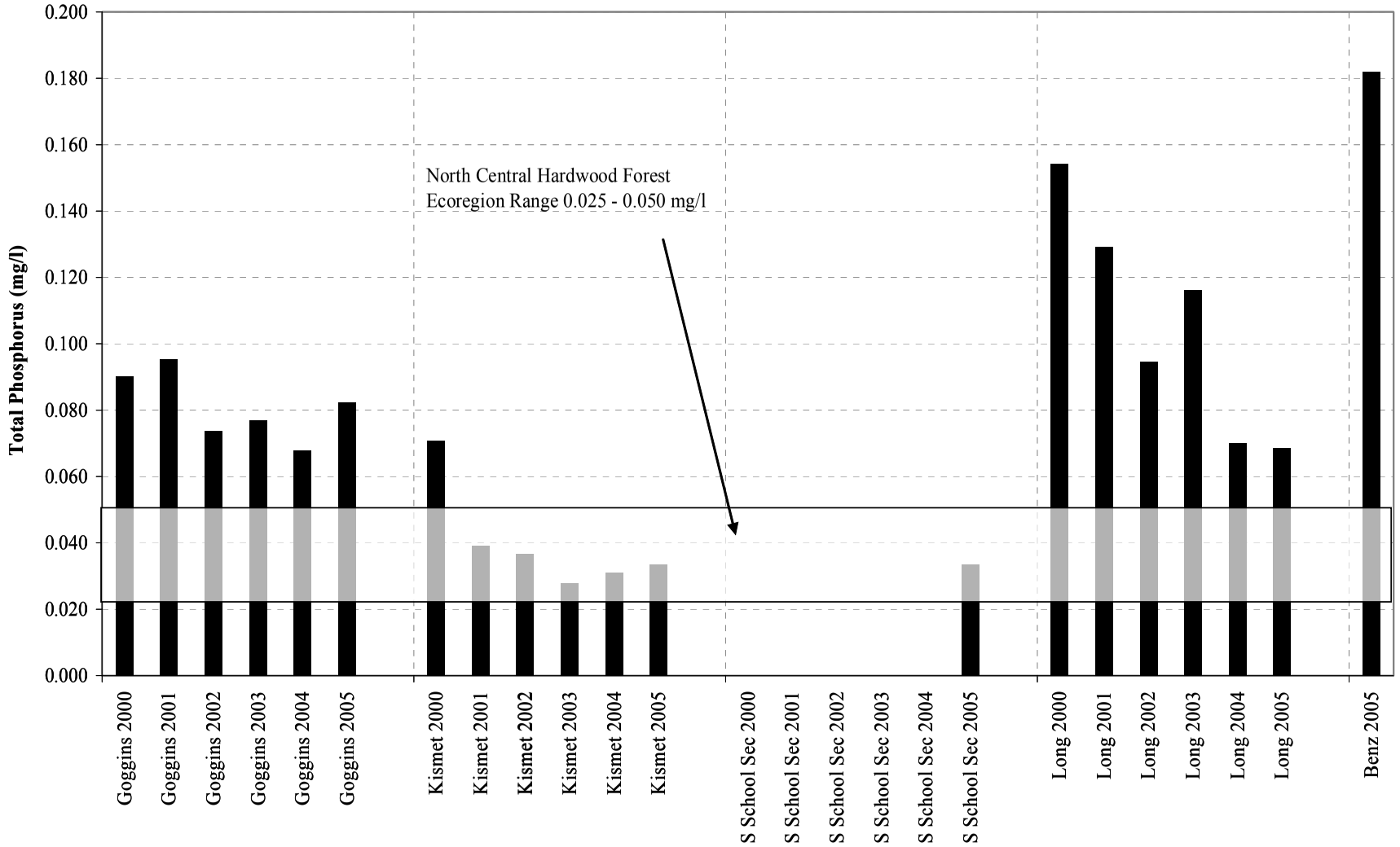


Figure 4: 2005 and Historic Total Phosphorus Data

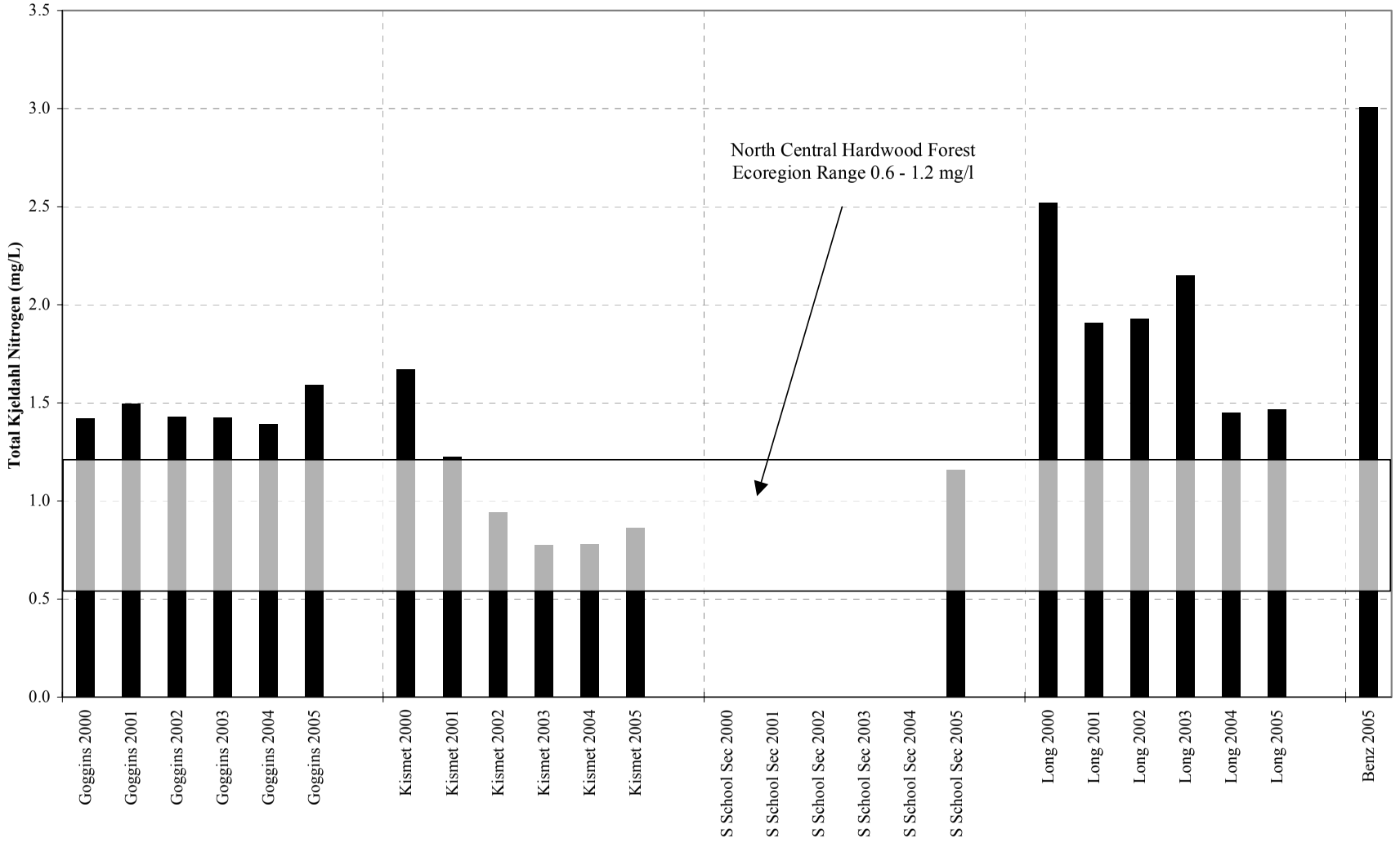


Figure 5: 2005 and Historic Total Kjeldahl Nitrogen Data

7. LAKE ELEVATIONS

Lake elevation gages are located on sixteen lakes and wetlands throughout BCWD and are monitored by both WCD staff and volunteers. Complete lake elevation data for 2005 can be found in Figure 7.

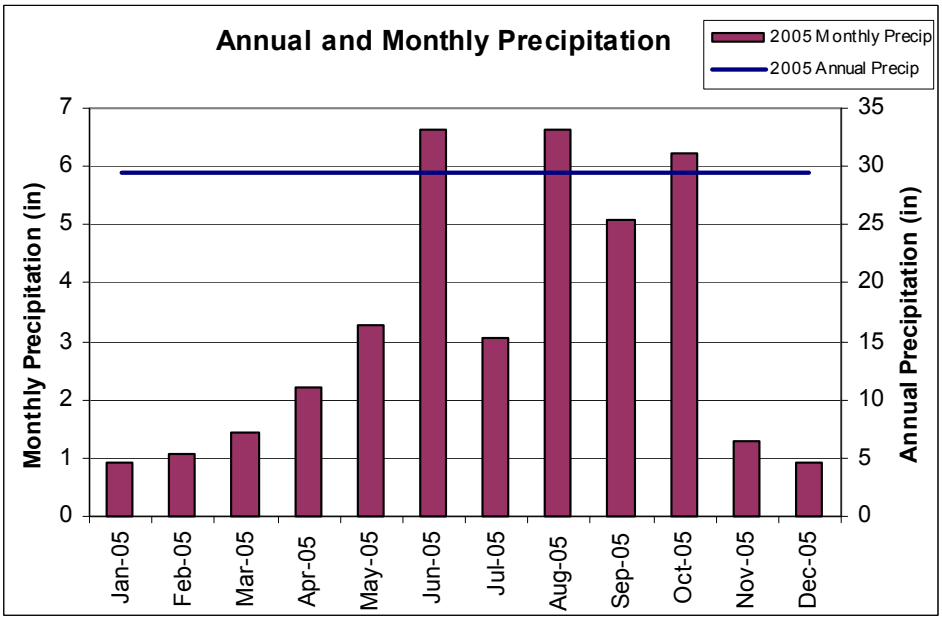
Brown's Creek Watershed District Hydrologic/Hydraulic Study November 1998 (H&H) developed an issues matrix to quantify and summarize flooding impacts. Impacts due to water elevations were determined relative to land that is normally not inundated such as septic systems, wells, residential structures, outbuildings, roads, and driveways. Low impact levels would be water levels above the MN DNR's Ordinary High Water Level that are sustained for long periods of time. Moderate impact levels affect septic systems, drinking water wells, uninhabited structures, or the lowest floor of inhabited structures. In high impact water elevations, water levels are at the lowest opening of inhabited structure or the lowest floor for sustained periods of time. Brown's Creek Watershed District completed the 2003 Hydrologic/Hydraulic Study. The issues matrix to quantify and summarize flooding impacts has remained unchanged in the 2003 H&H Study.

Despite the dry summers of 2003, 2004, and 2005, the elevations of some of the lakes in Brown's Creek Watershed District were within these developed flooding impact ranges (Table 5). Plaisted Lake and South School Section Lake were within the low impact range for the entire year of 2005. Goggin's Lake was within the high impact range for most of the year, dropping into the low impact range from mid-July to mid-October. Kismet Basin remained in the moderate impact range for all of 2005. Woodpile Lake was at levels categorized as low impact during 2005. Long Lake and Jackson WMA remained below the high impact range for all of 2005.

Table 5: 2005 Water Elevation Flooding Impacts

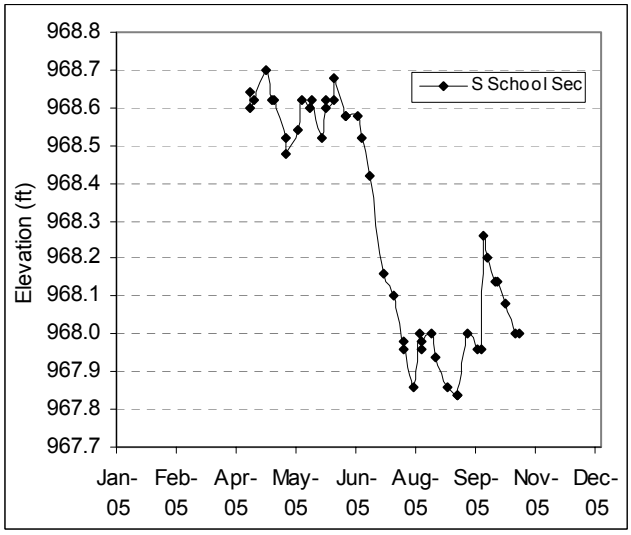
LAKE/WATERBODY	Average Elevation for 2005	Highest Elevation for 2005	Low Impact*	Moderate Impact*	High Impact*
Plaisted	968.39	968.86	*966.0-970.5*	*970.5-971.7*	*>971.7*
School Section	968.29	968.70	*965.3-971.0*	*971-977.2*	*>977.2*
Lynch	1006.25	1006.59	NA	NA	NA
Goggins	968.31	968.70	*966.5-968.2*	----	*>968.2*
July Avenue	972.17	972.94	NA	NA	NA
Benz	954.15	954.44	NA	NA	NA
Bass	954.19	954.52	NA	NA	NA
Pat	941.81	942.06	NA	NA	NA
Kismet	941.92	942.27	*<940.6*	*940.6-946.6*	*>946.6*
BC at Gateway Trail	908.19	908.42	NA	NA	NA
Unnamed 82-0128	981.22	981.66	NA	NA	NA
Masterman	953.99	954.23	NA	NA	NA
Woodpile	966.26	966.57	*<968.5*	NA	NA
Kimbro and Hwy 12	927.68	928.02	NA	NA	NA
Jackson WMA	889.55	890.17	NA	NA	>893.4
Long	889.91	891.52	NA	NA	*>893.4*

** Brown's Creek Watershed District Hydrologic/Hydraulic Study, February 2004, Section VI Table 21*



Data from Stillwater National Weather Service Station

Figure 6: Annual and Monthly Precipitation


S School Sec
Elevation (ft)
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968.7
968.6
968.5
968.4
968.3
968.2
968.1
968.0
967.9
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967.7
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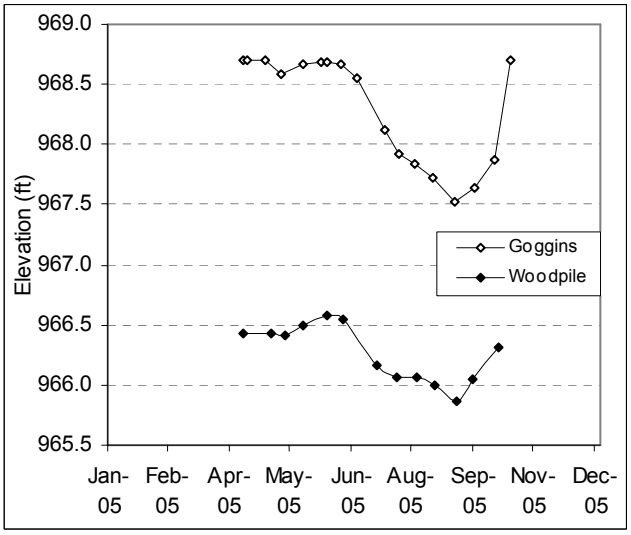
May-05
Jun-05
Aug-05
Sep-05
Nov-05
Dec-05


Goggins
Woodpile
Elevation (ft)
969.0
968.5
968.0
967.5
967.0
966.5
966.0
965.5
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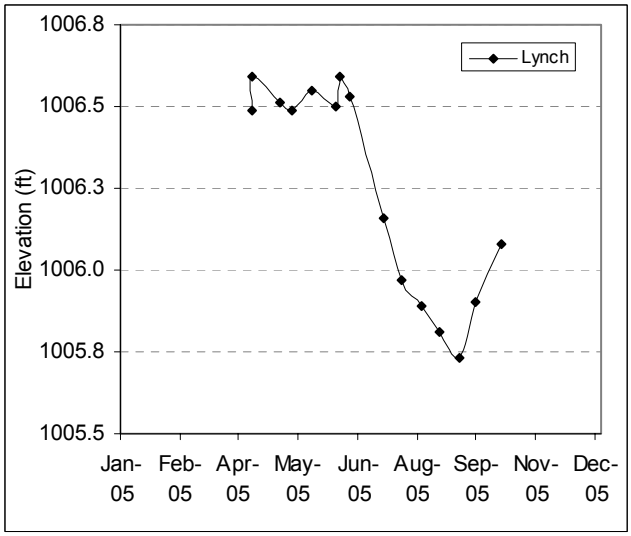
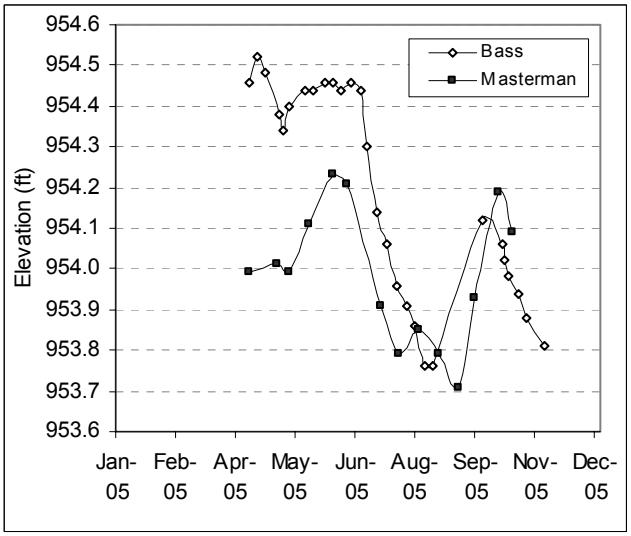
May-05
Jun-05
Aug-05
Sep-05
Nov-05
Dec-05


Lynch
Elevation (ft)
1006.8
1006.5
1006.3
1006.0
1005.8
1005.5
Jan-05
Feb-05
Apr-05
May-05
Jun-05
Aug-05
Sep-05
Nov-05
Dec-05


Bass
Masterman
Elevation (ft)
954.6
954.5
954.4
954.3
954.2
954.1
954.0
953.9
953.8
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Jan-05
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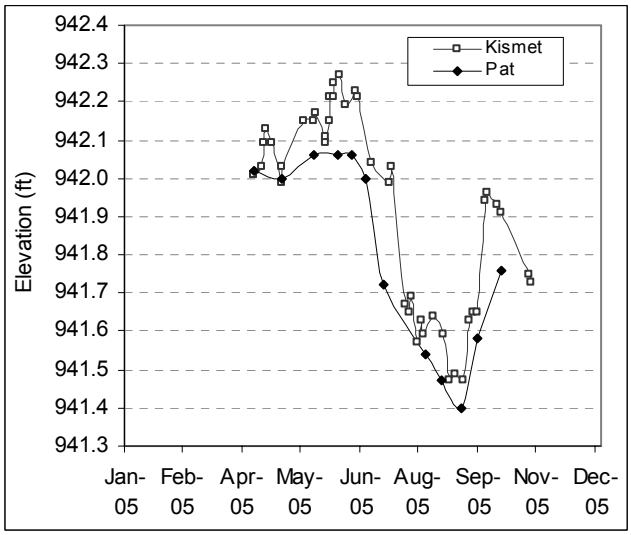
May-05
Jun-05
Aug-05
Sep-05
Nov-05
Dec-05


Kismet
Pat
Elevation (ft)
942.4
942.3
942.2
942.1
942.0
941.9
941.8
941.7
941.6
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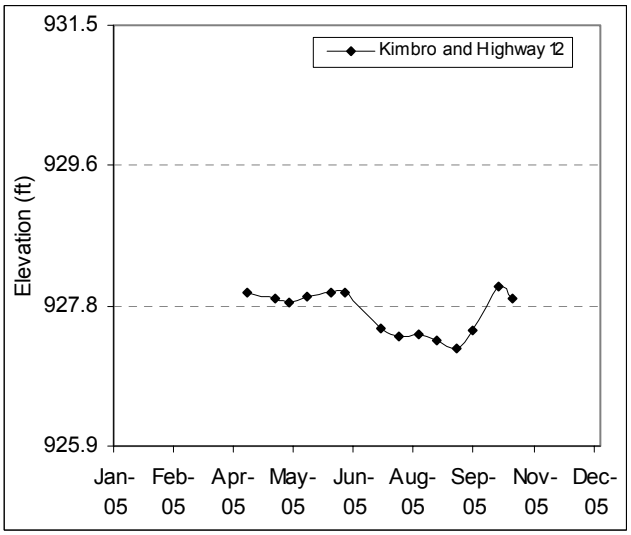
May-05
Jun-05
Aug-05
Sep-05
Nov-05
Dec-05


Kimbro and Highway 12
Elevation (ft)
931.5
929.6
927.8
925.9
Jan-05
Feb-05
Apr-05
May-05
Jun-05
Aug-05
Sep-05
Nov-05
Dec-05

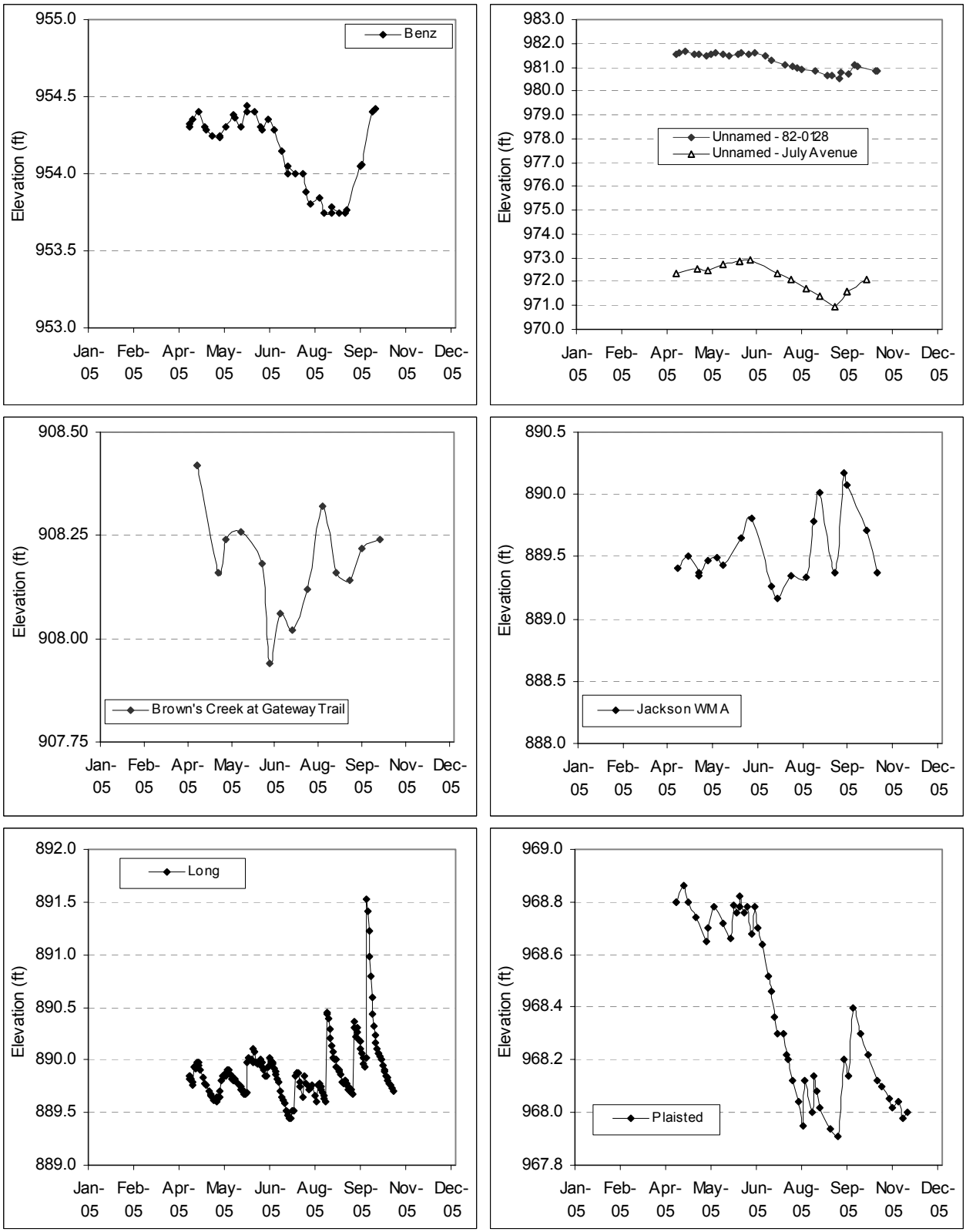


Figure 7: 2005 Lake Levels

B. CONCLUSIONS AND RECOMMENDATIONS

Lake monitoring in Brown's Creek Watershed District continues to provide valuable baseline water quality information. To determine the health of the lakes in BCWD, physical and chemical parameters are compared on a year-to-year basis and with other lakes in the region.

In 2005, the five lakes monitored had fair to very poor water quality ratings and were classified as eutrophic (Kismet and South School Section) and hypereutrophic (Benz, Goggin's, and Long). The overall 2005 lake grades were, for South School Section a B-, Kismet Basin a C+, Goggin's Lake a C-, Long Lake a C-, and Benz Lake an F. Kismet Basin deteriorated from the previous years' ratings and grades, but Goggin's Lake and Long Lake stayed fairly consistent with previous years' ratings and grades. Being the first year for monitoring on Benz Lake and for South School Section, trends cannot be established prior to this year. Benz, Goggin's, and Long Lakes were considered worse than the ecoregion range for total phosphorus, total Kjeldahl nitrogen, chlorophyll-*a* and Secchi disk transparency. Kismet Basin and South School Section were within the ecoregion range for total phosphorus, total Kjeldahl nitrogen, chlorophyll-*a* and Secchi disk transparency.

Water quality in a lake depends on a number of different variables such as: size of the contributing watershed, depth of the lake, and current amount of nutrients available and periodically released from the lake bottom, as well as external nutrient sources. Low water quality ratings of BCWD lakes are most likely due to the shallowness of the lakes. Shallow lakes do not completely stratify in the summer; therefore, they are capable of continually mixing. Mixing causes phosphorus to be distributed throughout the water column, causing more frequent heavy algal blooms. This is unlike deeper, stratified lakes where the phosphorus is below the thermocline is not available for primary production. Shallow lakes throughout the county showed water quality degradation in 2005. Explanations for this countywide degradation are: for a majority of the winter, there was little snow on the ice allowing more sun penetration and early proliferation of algae and phytoplankton, and a large majority of the summer was warm allowing for warmer water

temperatures and more sediment phosphorus release. Warmer water has less capacity to hold dissolved oxygen and when lakes or wetlands become anoxic (lacking in oxygen), the possibility of phosphorous release becomes greater. Another factor that may be contributing to the degradation in many of the shallow lakes is that many of our runoff events were intense and short in duration. More pollutants can be introduced in shorter periods of time than in slow, less intense storm events. Controls on land use practices in the watershed may halt the decline in water quality although it may not be enough to provide short-term noticeable improvements. The Minnesota Pollution Control Agency monitors statistically significant trends in water quality throughout the state and can be accessed at **http://www.pca.state.mn.us**.

The twelve lakes and four wetlands monitored for water elevation showed peaks in spring and early summer of 2005 and then steadily declined until the very end of the monitoring season when heavier precipitation events caused an increase in elevation on many of the lakes. The decrease in elevation throughout the summer was in large part due to the lack of precipitation during this period. Average water elevation in lakes with the exception of Goggin's Lake were in the low to moderate flooding impact ranges, as compared to the Brown's Creek Watershed District's 2003 Hydrologic/Hydraulic Study. It is recommended that water level monitoring continue in the BCWD lakes and wetlands.

The following lake-by-lake discussion of the water monitoring data will include 2005 data as well as data from previous monitoring years, which in some cases is several years. This data is found in Appendix A. The Trophic State Index (TSI), which was developed by Carlson in 1977, is similar to the Metropolitan Council lake grading system in that it is a method to classify and rank lakes based on water quality. A lower TSI value corresponds to lower concentrations of total phosphorus and chlorophyll-*a* and greater Secchi transparencies. The TSI also provides for a method of analysis to determine how a lake is functioning. The TSI values for Secchi depth, chlorophyll-*a*, and total phosphorus are calculated such that equal values for each should occur if a lake is functioning "normally". Deviations from equality in TSI values may indicate some more detailed information about the water quality of a lake (Table 8 and Figure 8). The

following excerpts from Carlson and Simpson (1986) describe how TSI is calculated and what information the TSI values will provide.

Table 6: Trophic State Index Equations

$$TSI(SD) = 60 - 14.41 \ln(SD)$$

$$TSI(CHL) = 9.81 \ln(CHL) + 30.6$$

$$TSI(TP) = 14.42 \ln(TP) + 4.15$$

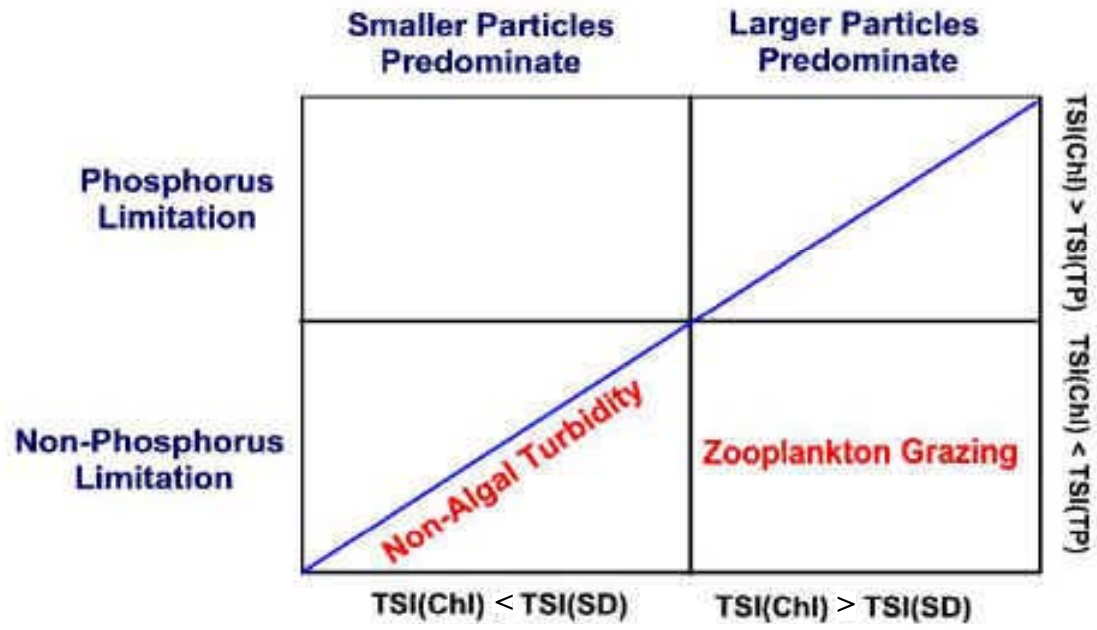
Table 7: Trophic State Gradient

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	CLA (µg/L)	SD (m)	TP (µg/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

Table 8: Relationship between TSI Variables

Relationship Between TSI Variables	Conditions
TSI(CLA) = TSI(TP) = TSI(SD)	Algae dominate light attenuation; TN/TP ~ 33:1
TSI(CLA) > TSI(SD)	Large particulates, such as *Aphanizomenon* flakes, dominate
TSI(TP) = TSI(SD) > TSI(CHL)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(CHL) > TSI(TP)	Phosphorus limits algal biomass (TN/TP >33:1)
TSI(TP) >TSI(CHL) = TSI(SD)	Algae dominate light attenuation but some factor such as nitrogen limitation, zooplankton grazing or toxics limit algal biomass.



A representation of possible explanations of deviations of the Trophic State Index equations.

Figure 8: Deviations of the Trophic State Index Values for Different Parameters

Goggin's Lake

Secchi disk transparency, total phosphorus, and chlorophyll-*a* averages have remained relatively consistent in Goggin's Lake (C- to D+) in the seven years it has been monitored for water quality. In 2005, average TP, CL-a concentrations, and average Secchi transparency increased slightly when compared to 2004. This increase in CLA may be due to a component of internal loading and existing nutrients allowing for more algal production. In 2005, the water level was at its highest in April and steadily declined until October when it increased sharply. As in previous years, Goggin's Lake's TSI values indicate that the transparency is better than the amount of TP and CLA would indicate. Therefore, this may show that the lake's algal population is composed primarily of large particulates, such as filamentous algae. These large particles would still affect the chlorophyll-a concentration but would allow more light to penetrate, which would account for the deeper than expected transparency. Another possible explanation is that zooplankton may be grazing and limiting the algal biomass. It is recommended that water quality samples and lake level readings continue to be taken to monitor this situation.

Kismet Basin

After peaking in mid-June, Kismet Basin's elevation declined until late September. Lake elevations returned to early season highs after an early October storm. The basin remained below the ordinary high water mark for the entire monitoring season. The water quality of Kismet Basin worsened in 2005, dropping the lake grade down to a C+, compared to a B- in 2004. Kismet Basin is one of two lakes monitored that is within the ecoregion ranges for Secchi disk transparency, total phosphorus, chlorophyll-*a,* or total Kjeldahl nitrogen. Total chloride ion was collected again in 2005, and the same average concentrations were shown in both 2004 and 2005, which is below the MPCA warning levels. The TSI values in 2005 became slightly poorer for all parameters, however those TSI values are still below the eight year average. The TSI values indicate that chlorophyll-*a* is being limited mainly by phosphorus and low Secchi disk readings are due to algal turbidity. Some slight divergence in TP and CLA TSI values may be attributed to nutrient inputs from groundwater sources. The lake elevation of Kismet

Basin has decreased overall as the water quality has improved. This may show that as surface water inputs are limited, higher quality groundwater has a larger impact on the overall water quality of the lake. Continued water quality and lake level monitoring are recommended.

Long Lake

In 2005 the lake's elevation trend increased throughout the year, peaking on October 5th to go above the OHW mark for the first time since May of 2003. The water quality in Long Lake has remained consistently poor in the years the lake has been monitored. The Minnesota Pollution Control Agency determined the presence of a statistically significant negative trend in 2002 for Secchi disk transparency over the period of record. In 2005, only TP concentrations remained constant from 2004. Average Secchi disk transparency dropped a foot from 2004 to 2005 and CLA concentrations increased from 2004. In 2003, the Minnesota Pollution Control Agency determined that the improvements in water quality reflected positively for Long Lake indicating that the statistically significant negative trend found in 2002 was not occurring in 2003 based on the latest data and that it showed no recent trend in transparency. The TSI values indicate that chlorophyll-*a* is being limited by phosphorus and low Secchi disk readings are due to algal turbidity. It should be noted that although all parameters decreased from a year ago, TSI values were still below the eight-year average. The MPCA has listed Long Lake for impairment due to excess nutrients. Continued water quality monitoring, lake level monitoring, and a TMDL study to address the nutrient impairment are recommended.

Benz Lake

The 2005 monitoring season was the first year for water quality monitoring on Benz Lake. Lake elevations continued to be monitored for the eighth consecutive year by Washington Conservation District. The overall elevation average was up from 2004, but still maintained a level that is below the OHW mark. Lake levels were steady until the beginning of July, after that point elevation declined until early October. October storms forced a sharp rise in the lake level and remained around that elevation through the rest of the year. Concentration averages on Benz Lake were the worst amongst lakes monitored

in Brown's Creek Watershed. It is tough to tell any kind of trends on this lake due to no prior water quality records. Benz received an F in its first year of monitoring. As with average concentrations, TSI values reflected poor water quality. Land use practices around Benz Lake might be a cause for such low water quality. Also, the depth of the lake allows nutrients in sediments to mix throughout the water.

South School Section Lake

This was the first year since 1998 that South School was tested for water quality. Lake elevations were recorded again as in 2004. Average levels dropped from 2004, but still remained above the OHW mark. This continued a declining trend started in 2000. Elevations were steady until June, after which the lake level dropped roughly a foot until an October storm raised the lake elevation a half-foot. South School Section showed a steady drop in elevation after the peak in October. Average concentrations of TP and CL-a were equal to that of Kismet, but had a better average Secchi transparency. South School Section received the best lake grade within the watershed district, and it was also the deepest. A high grade could be the result of having an established thermocline during the summer disallowing mixing of nutrient rich deep waters to fuel algal blooms. It is hard to tell trends from year to year, due to the lack of information from 1998 to 2004, but it would seem that the average Secchi readings were better than those of 1998. Also TP and CL-a concentrations were below the 1998 averages. Large algal particles dominate the water column.

III. BROWN'S CREEK

A. METHODS, RESULTS, AND DISCUSSION

Brown's Creek is a spring fed tributary of the St. Croix River. It is 9.7 miles long, flowing from its source through a variety of glacial drift landscapes. The middle reach of the stream flows through various wetlands and marshes with substrates of mucky peat, changing to course sand-gravel in areas with higher gradients. The lower reaches of the stream cut deeply into steeply sloping hills of sandstone and dolomite adjacent to the St. Croix River. Cold groundwater springs provide a major hydrologic input of this portion of the stream, and is the only portion that supports trout. Brown trout currently reproduce naturally in the stream.

About 2,200 feet of Brown's Creek underwent realignment in the fall of 1999. Before the realignment the stream ran through a ditched channel in a wetland adjacent to McKusick Lake. The new channel no longer runs through the wetland and was constructed to mimic a natural gravel streambed with a series of pools and riffles. This restored channel is significantly shorter than the old channel therefore peak flows are expected to increase downstream. The time of travel through this section of stream will decrease significantly, so water temperature should decrease as well. The macroinvertebrate population may also change along with changes in hydrology, substrate, dissolved oxygen and temperature in this portion of the stream.

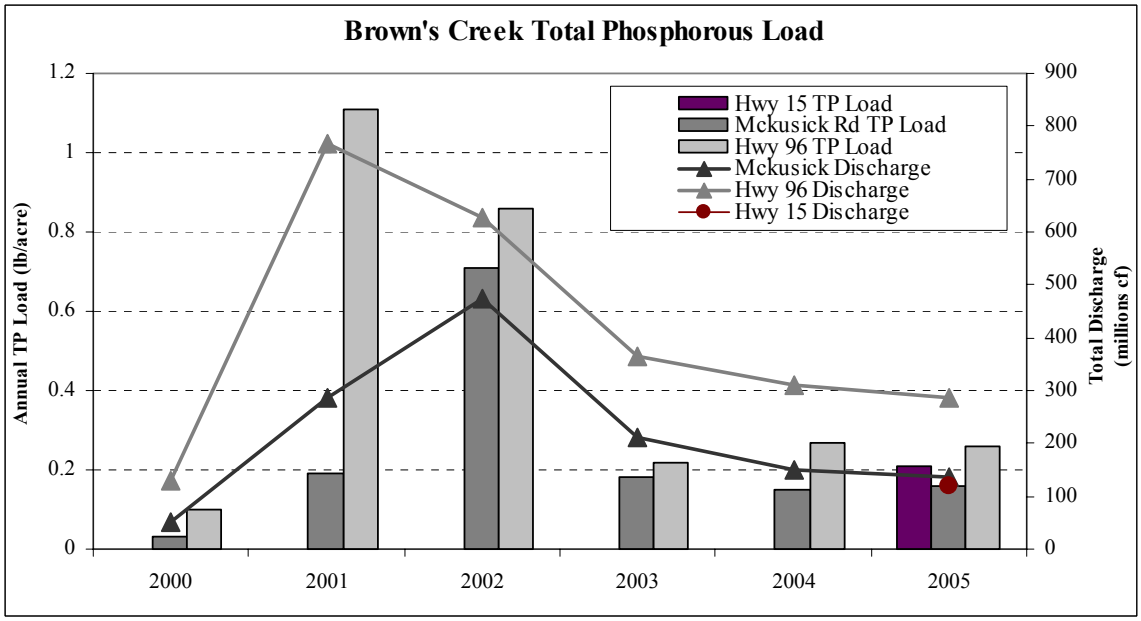
The City of Stillwater completed the Trout Stream Mitigation Project in June 2003 and has been functioning to divert stormwater from the 1800-acre Annexation Area away from Brown's Creek, through McKusick Lake to the St. Croix River. This diversion structure will keep the warmer urban strormwater from the southern tributary out of the temperature and nutrient sensitive Brown's Creek Ravine.

1. FLOW AND WATER QUALITY

From 1998 to 2005, WCD took grab and flow-weighted samples during both baseflow and storm event conditions at the Outlet, McKusick Road, and the Hwy 15 site (2005

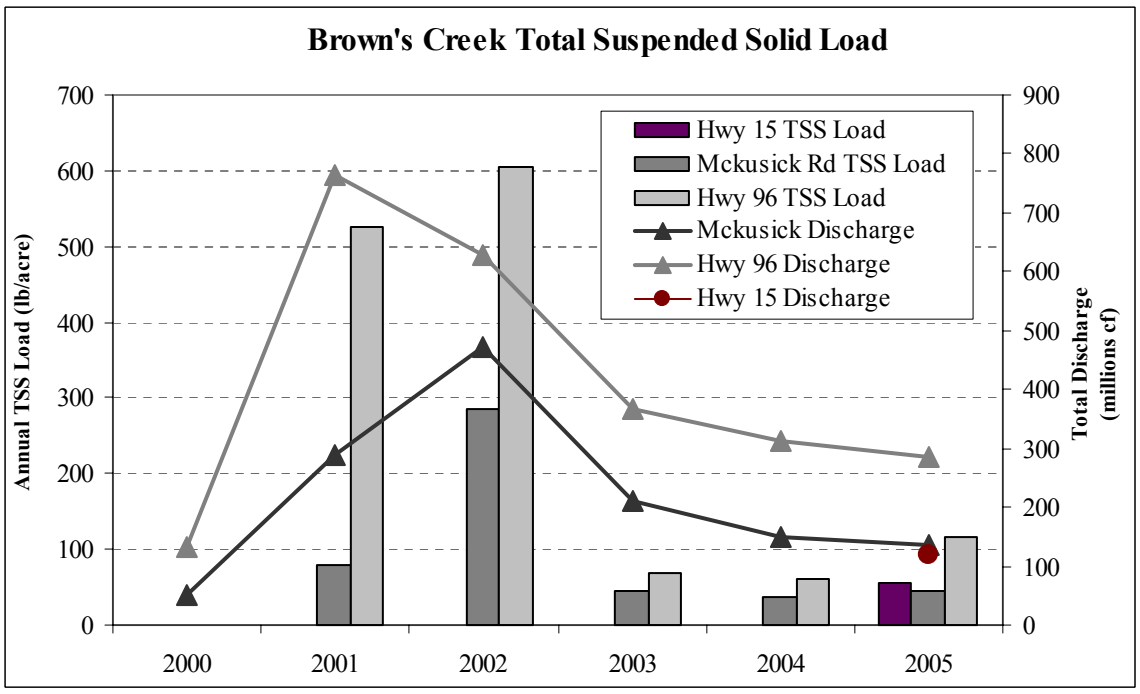
only). Three automated samplers continuously monitored stream flow and collected storm and baseflow composite samples from March through November. Brown's Creek was monitored at Highway 15, approximately 4.5 miles from the mouth, McKusick Road, approximately 1.7 miles from the mouth and at Highway 96, 0.2 miles from the mouth of the Creek (Figure 1). Data collected by the WCD on Brown's Creek included the total discharge, temperature, precipitation, conductivity, dissolved oxygen, and analytical analysis. Analytical analysis for the McKusick Road and Hwy 96 sites included testing for the following parameters: total phosphorus, dissolved phosphorus, total suspended solids, volatile suspended solids, total Kjeldahl nitrogen, nitrate, nitrite, chemical oxygen demand, turbidity, ammonia nitrogen, hardness, alkalinity, copper, nickel, lead, zinc, cadmium, chromium, total organic carbon, total biochemical oxygen demand, chloride, sulfate, and fecal coliform. Analytical analysis for the Hwy 15 site included testing for the following parameters: total phosphorus, dissolved phosphorus, total suspended solids, volatile suspended solids, total Kjeldahl nitrogen, copper, nickel, lead, zinc, cadmium, chromium, chloride, and fecal coliform. All data from 2005 can be found on pages 29-45. All historical data (2000-2004) is available in Appendix B.

Using a combination of composite and grab samples, total phosphorus and total suspended solid loads were calculated. The results were compared to a chart of export coefficients in a variety of land use scenarios and show the Brown's Creek Watershed within regional averages for total phosphorus at all three sites. In 2003, 2004, and 2005, the total phosphorus and total suspended solids loading estimates greatly decreased from the loading levels of 2001-2002 (Figure 9and Figure 10). The lack in overall runoff during the 2003, 2004, and 2005 seasons is the major contributor to the lesser amounts of total loads that were seen. The minimal snowfall in the winters of 2002-03 and 2003-04 and the dry summers of 2003, 2004, and 2005 primarily caused the runoff reduction experienced in 2003, 2004, and 2005. This reduction in total flow may also be a reflection of the diversion structure rerouting the nutrient and sediment-laden storm waters from the urban south tributary away from Brown's Creek.



***TP Load (lb/acre) = Total Load of Total Phosphorus (lb)/Drainage Area (acres)**

Figure 9: Brown's Creek Annual Total Phosphorous Loads



***TSS Load (lb/acre) = Total Load of Total Suspended Solids (lb)/Drainage Area (acres)**

Figure 10: Brown's Creek Annual Total Suspended Solids Loads

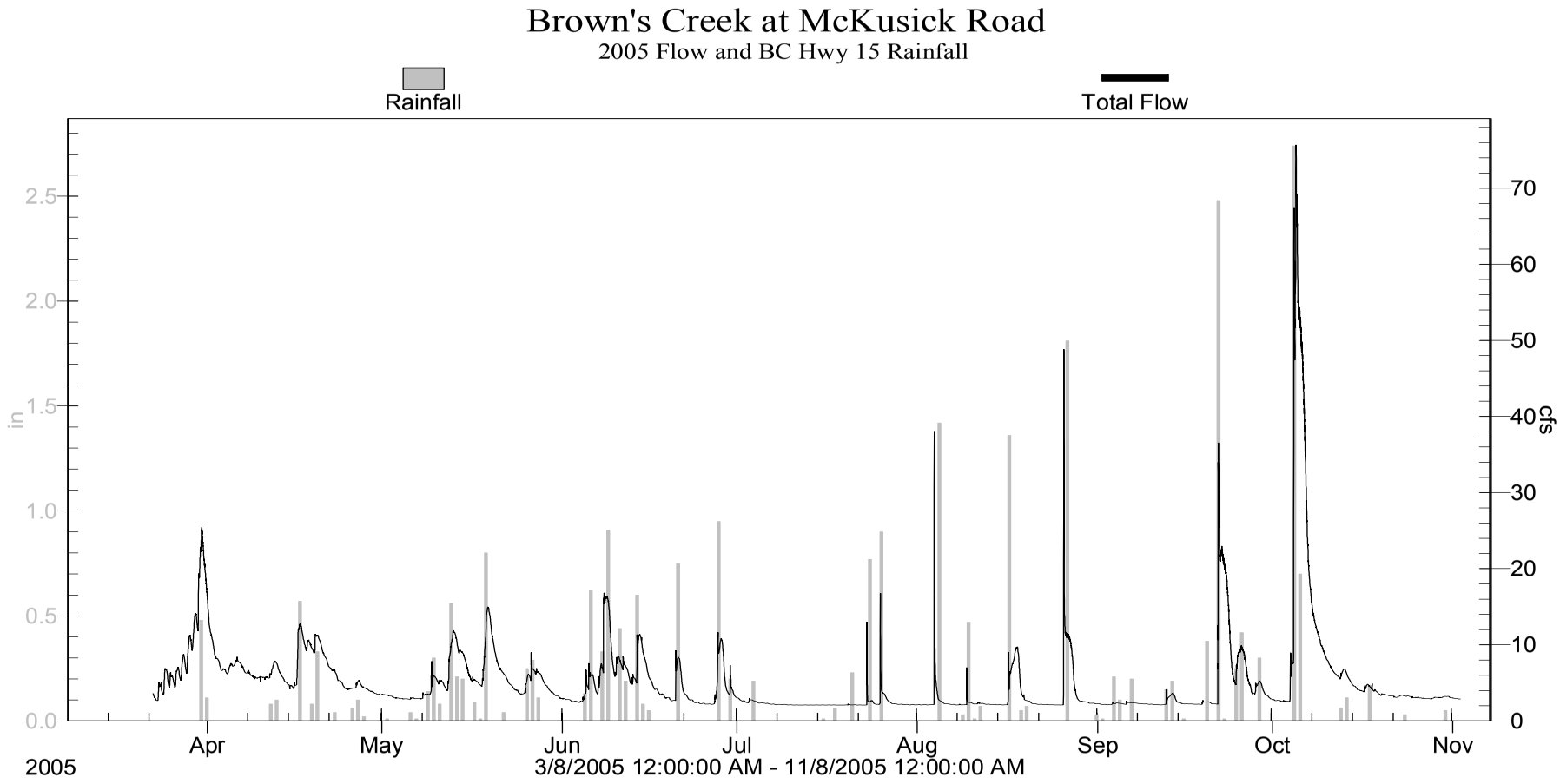


Figure 11: 2005 Brown's Creek at McKusick Road Discharge and Brown's Creek at Hwy 15 Daily Rainfall

Table 9: Brown's Creek at McKusick Road 2005 Total Suspended Solids (TSS) and Phosphorus Loading (TP)

	Sample Collection Time						Loading Interval				
Sample Type	Start Date	Start Time	End Date	End Time	TP (mg/L)	TSS (mg/L)	Start	End	Interval Volume (cf)	Interval TP (lb)	Interval TSS (lb)
BASE					*0.102*	*8*	*1/1/2005 0:00*	*2/2/2005 12:00*	*7,020,000*	*44.87*	*3,593*
Snowmelt Grab	2/3/05	10:30	2/3/05	10:30	0.058	7	2/2/2005 12:00	2/4/2005 12:00	1,036,800	3.75	453
BASE					*0.102*	*8*	*2/4/2005 12:00*	*3/22/2005 17:15*	*11,979,900*	*76.58*	*6,132*
BASE					*0.102*	*8*	*3/22/2005 17:15*	*3/30/2005 10:15*	*4,546,020*	*29.06*	*2,327*
Storm Composite	3/30/05	10:36	3/30/05	23:55	0.484	195	3/30/2005 10:15	4/1/2005 15:15	3,542,915	107.05	43,128
BASE					*0.102*	*8*	*4/1/2005 15:15*	*4/11/2005 18:15*	*6,048,728*	*38.67*	*3,096*
STORM					*0.441*	*164*	*4/11/2005 18:15*	*4/13/2005 21:15*	*1,265,580*	*34.85*	*12,978*
BASE					*0.102*	*8*	*4/13/2005 21:15*	*4/16/2005 10:15*	*1,074,260*	*6.87*	*550*
STORM					*0.441*	*164*	*4/16/2005 10:15*	*4/21/2005 5:15*	*4,272,200*	*117.64*	*43,811*
Base Grab	4/26/05	12:15	4/26/05	12:15	0.062	3	4/21/2005 5:15	5/9/2005 12:15	6,481,002	25.08	1,214
STORM					*0.441*	*164*	*5/9/2005 12:15*	*5/11/2005 16:15*	*1,008,374*	*27.77*	*10,341*
BASE					*0.102*	*8*	*5/11/2005 16:15*	*5/12/2005 8:15*	*251,559*	*1.61*	*129*
Storm Composite	5/12/05	15:56	5/15/05	13:05	0.129	33	5/12/2005 8:15	5/15/2005 8:15	2,431,202	19.58	5,008
BASE					*0.102*	*8*	*5/15/2005 8:15*	*5/18/2005 8:15*	*1,466,358*	*9.37*	*751*
Storm Composite	5/18/05	21:07	5/20/05	5:00	0.196	62	5/18/2005 8:15	5/21/2005 8:15	2,676,979	32.75	10,361
BASE					*0.102*	*8*	*5/21/2005 8:15*	*5/25/2005 15:15*	*1,777,667*	*11.36*	*910*
STORM					*0.441*	*164*	*5/25/2005 15:15*	*5/29/2005 11:15*	*1,930,525*	*53.16*	*19,797*
BASE					*0.102*	*8*	*5/29/2005 11:15*	*6/4/2005 15:15*	*1,630,285*	*10.42*	*835*
STORM					*0.441*	*164*	*6/4/2005 15:15*	*6/6/2005 12:15*	*784,372*	*21.60*	*8,044*
BASE					*0.102*	*8*	*6/6/2005 12:15*	*6/7/2005 5:15*	*256,444*	*1.64*	*131*
STORM					*0.441*	*164*	*6/7/2005 5:15*	*6/8/2005 3:15*	*480,838*	*13.24*	*4,931*
Storm Composite	6/8/05	4:37	6/9/05	10:13	0.331	128	6/8/2005 3:15	6/9/2005 12:15	1,738,671	35.93	13,893
BASE					*0.102*	*8*	*6/9/2005 12:15*	*6/10/2005 10:15*	*552,824*	*3.53*	*283*
STORM					*0.441*	*164*	*6/10/2005 10:15*	*6/11/2005 13:15*	*756,602*	*20.83*	*7,759*
STORM					*0.441*	*164*	*6/11/2005 13:15*	*6/12/2005 12:15*	*588,734*	*16.21*	*6,037*
BASE					*0.102*	*8*	*6/12/2005 12:15*	*6/13/2005 21:15*	*636,876*	*4.07*	*326*
Storm Grab	6/14/05	14:45	6/14/05	14:45	0.296	63	6/13/2005 21:15	6/15/2005 21:15	1,583,564	29.26	6,228
BASE					*0.102*	*8*	*6/15/2005 21:15*	*6/20/2005 13:15*	*1,495,832*	*9.56*	*766*
STORM					*0.441*	*164*	*6/20/2005 13:15*	*6/22/2005 0:15*	*827,157*	*22.78*	*8,482*
BASE					*0.102*	*8*	*6/22/2005 0:15*	*6/27/2005 8:15*	*1,167,847*	*7.47*	*598*
Storm Composite	6/27/05	20:39	6/28/05	17:51	0.422	130	6/27/2005 8:15	6/29/2005 6:15	1,240,836	32.69	10,070
BASE					*0.102*	*8*	*6/29/2005 6:15*	*6/29/2005 22:15*	*217,931*	*1.39*	*112*
STORM					*0.441*	*164*	*6/29/2005 22:15*	*6/30/2005 15:15*	*256,570*	*7.06*	*2,631*
Base Grab	7/15/05	11:30	7/15/05	11:30	0.147	11	6/30/2005 15:15	7/23/2005 10:15	4,424,952	40.61	3,039
STORM					*0.441*	*164*	*7/23/2005 10:15*	*7/24/2005 11:15*	*271,294*	*7.47*	*2,782*
BASE					*0.102*	*8*	*7/24/2005 11:15*	*7/25/2005 18:15*	*249,801*	*1.60*	*128*
STORM					*0.441*	*164*	*7/25/2005 18:15*	*7/27/2005 5:15*	*511,630*	*14.09*	*5,247*
BASE					*0.102*	*8*	*7/27/2005 5:15*	*8/4/2005 0:15*	*1,469,289*	*9.39*	*752*
Storm Composite	8/4/05	1:10	8/4/05	4:36	0.740	400	8/4/2005 0:15	8/4/2005 23:15	514,437	23.76	12,846
BASE					*0.102*	*8*	*8/4/2005 23:15*	*8/9/2005 14:15*	*891,934*	*5.70*	*457*
STORM					*0.441*	*164*	*8/9/2005 14:15*	*8/9/2005 19:15*	*56,510*	*1.56*	*580*
BASE					*0.102*	*8*	*8/9/2005 19:15*	*8/16/2005 19:15*	*1,342,790*	*8.58*	*687*
Storm Composite	8/16/05	19:52	8/18/05	20:00	0.269	80	8/16/2005 19:15	8/19/2005 13:15	1,581,545	26.56	7,898
Base Composite	8/25/05	9:45	8/25/05	9:45	0.117	12	8/19/2005 13:15	8/26/2005 6:15	1,302,856	9.52	976
Storm Composite	8/26/05	6:58	8/26/05	9:24	0.892	335	8/26/2005 6:15	8/28/2005 10:15	1,957,443	109.00	40,936
BASE					*0.102*	*8*	*8/28/2005 10:15*	*9/12/2005 23:15*	*3,098,352*	*19.81*	*1,586*
STORM					*0.441*	*164*	*9/12/2005 23:15*	*9/14/2005 17:15*	*485,080*	*13.36*	*4,974*
Base Composite	9/19/05	10:03	9/21/05	11:11	0.109	12	9/14/2005 17:15	9/21/2005 19:15	1,409,018	9.59	1,056
Storm Composite	9/21/05	19:55	9/22/05	9:20	0.654	229	9/21/2005 19:15	9/23/2005 18:15	3,466,370	141.52	49,554
BASE					*0.102*	*8*	*9/23/2005 18:15*	*9/24/2005 22:15*	*751,439*	*4.80*	*385*
STORM					*0.441*	*164*	*9/24/2005 22:15*	*9/26/2005 20:15*	*1,398,019*	*38.50*	*14,337*
BASE					*0.102*	*8*	*9/26/2005 20:15*	*9/28/2005 7:15*	*548,905*	*3.51*	*281*
STORM					*0.441*	*164*	*9/28/2005 7:15*	*9/29/2005 16:15*	*565,990*	*15.58*	*5,804*
BASE					*0.102*	*8*	*9/29/2005 16:15*	*10/4/2005 6:15*	*1,132,923*	*7.24*	*580*
Storm Composite	10/4/05	20:37	10/5/05	6:08	0.439	152	10/4/2005 6:15	10/8/2005 23:15	12,813,500	351.15	121,584
BASE					*0.102*	*8*	*10/8/2005 23:15*	*10/12/2005 23:15*	*2,722,815*	*17.41*	*1,394*
STORM					*0.441*	*164*	*10/12/2005 23:15*	*10/14/2005 6:15*	*713,519*	*19.65*	*7,317*
BASE					*0.102*	*8*	*10/14/2005 6:15*	*10/17/2005 0:15*	*1,064,326*	*6.80*	*545*
STORM					*0.441*	*164*	*10/17/2005 0:15*	*10/18/2005 8:15*	*517,061*	*14.24*	*5,302*
Base Grab	10/19/05	10:15	10/19/05	10:15	0.077	3	10/18/2005 8:15	11/2/2005 15:15	4,235,747	20.36	793
BASE					*0.102*	*8*	*11/2/2005 15:15*	*1/1/2006 0:00*	*12,827,250*	*82.00*	*6,566*
Storm Average					0.441	164					
Base Average					0.102	8					
Snowmelt Average					0.058	7					
All Average					0.319	109					
Total									**135,350,245**	1,901	534,090
Brown's Creek Major Subwatershed Total Acres									11,877		
Total TP/TSS(lb/ac/yr)										0.16	44.97
Total TP/TSS (kg/ha/yr)										0.18	50.40

*Italics indicate estimated concentrations based on average base and storm flow concentrations

Table 10: Brown's Creek at McKusick Road 2005 Primary Chemistry Result Averages

Parameter	Storm Flow Average	Base Flow Average	Average (all samples)
TSS (mg/L)	164	8	109
VSS (mg/L)	58	4	39
TKN (mg/L)	2.57	0.48	1.83
TP (mg/L)	0.44	0.10	0.32
Fecal Coliform (#/100 mL)	--	--	210

Of the parameters sampled at McKusick Road (Table 13), copper and lead exceeded the MPCA Rule 7050 Water Quality Chronic Standard. There were four samples in which copper exceeded the MPCA Rule 7050 Water Quality Maximum Standard (Table 11).

Table 11: McKusick Road Chemical Parameters Which Exceeded MPCA 7050 Water Quality Standards

Sample Type	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)
Chronic Standard	**0.0064**	**0.088**	**0.0013**	**0.0590**	**0.00066**	**0.117**	**230**
# of Exceedences/# of Samples	9/17	0/17	8/17	0/17	0/17	0/17	0/17
Maximum Standard	**0.0092**	**0.789**	**0.0340**	**0.0650**	**0.01500**	**0.984**	**860**
# of Exceedences/# of Samples	4/17	0/17	0/17	0/17	0/17	0/17	0/17

Table 12: Brown's Creek at McKusick Road 2005 Primary Chemistry Results

Sample Type	Start Date	Start Time	End Date	End Time	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	Fecal Coliform (#/100 mL)
Snowmelt Grab	2/3/05	10:30	2/3/05	10:30	7	~4	0.38	0.058	~0.033	
Storm Composite	3/30/05	10:36	3/30/05	23:55	195	~53	3.30	0.484	0.132	
Base Grab	4/26/05	12:15	4/26/05	12:15	~3	~2	0.56	0.062	~0.033	
Fecal Grab	5/5/05	9:00	5/5/05	9:00						28
Storm Composite	5/12/05	15:56	5/15/05	13:05	33	~10	0.94	0.129	~0.042	
Storm Composite	5/18/05	21:07	5/20/05	5:00	62	~22	1.30	0.196	~0.046	
Storm Composite	6/8/05	4:37	6/9/05	10:13	128	~46	2.30	0.331	0.079	
Storm Grab	6/14/05	14:45	6/14/05	14:45	63	30	2.00	0.296	0.078	
Storm Composite	6/27/05	20:39	6/28/05	17:51	130	72	2.80	0.422	0.070	
Fecal Grab	7/13/05	10:45	7/13/05	10:45						590
Base Grab	7/15/05	11:30	7/15/05	11:30	11	5	0.54	0.147	0.082	
Storm Composite	8/4/05	1:10	8/4/05	4:36	400	~112	4.00	0.740	0.112	
Storm Composite	8/16/05	19:52	8/18/05	20:00	80	~38	1.90	0.269	0.071	
Base Composite	8/25/05	10:09	8/26/05	5:14	12	~6	0.46	0.117	0.069	
Fecal Grab	8/25/05	9:45	8/25/05	9:45						180
Storm Composite	8/26/05	6:58	8/26/05	9:24	335	106	3.30	0.892	0.165	
Base Composite	9/19/05	10:03	9/21/05	11:11	12	7	0.49	0.109	~0.038	
Storm Composite	9/21/05	19:55	9/22/05	9:20	229	91	3.90	0.654	0.114	
Storm Composite	10/4/05	20:37	10/5/05	6:08	152	~62	2.50	0.439	0.093	
Fecal Grab	10/19/05	10:15	10/19/05	10:15						40
Base Grab	10/19/05	10:15	10/19/05	10:15	3	~2	0.36	0.077	0.070	

Table 13: Brown's Creek at McKusick Road 2005 Secondary Chemistry Results

Sample Type	Start Date	Start Time	End Date	End Time	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)
Snowmelt Grab	2/3/05	10:30	2/3/05	10:30	0.0007	0.0016	<0.00007	0.0037	0.00008	0.0008	17
Storm Composite	3/30/05	10:36	3/30/05	23:55	0.0780	0.0037	0.00290	0.0159	0.00030	0.0046	39
Base Grab	4/26/05	12:15	4/26/05	12:15	0.0005	0.0013	<0.00007	0.0029	<0.00004	0.0008	17
Fecal Grab	5/5/05	9:00	5/5/05	9:00							
Storm Composite	5/12/05	15:56	5/15/05	13:05	0.0153	0.0019	0.00060	0.0077	0.00010	0.0011	17
Storm Composite	5/18/05	21:07	5/20/05	5:00	0.0064	0.0025	0.00080	0.0100	0.00010	0.0021	15
Storm Composite	6/8/05	4:37	6/9/05	10:13	0.0080	0.0032	0.00220	0.0117	0.00020	0.0033	12
Storm Grab	6/14/05	14:45	6/14/05	14:45	0.0015	0.0022	0.00120	0.0060	<0.00004	0.0022	13
Storm Composite	6/27/05	20:39	6/28/05	17:51	0.0113	0.0038	0.00230	0.0111	0.00010	0.0039	12
Fecal Grab	7/13/05	10:45	7/13/05	10:45							
Base Grab	7/15/05	11:30	7/15/05	11:30	0.0007	0.0019	0.00030	0.0026	<0.00004	0.0010	15
Storm Composite	8/4/05	1:10	8/4/05	4:36	0.0091	0.0061	0.00610	0.0250	0.00030	0.0077	10
Storm Composite	8/16/05	19:52	8/18/05	20:00	0.0068	0.0025	0.00160	0.0086	0.00010	0.0022	13
Fecal Grab	8/25/05	10:09	8/26/05	5:14	0.0028	0.0017	0.00030	0.0040	0.00008	0.0005	16
Base Composite	8/25/05	9:45	8/25/05	9:45							
Storm Composite	8/26/05	6:58	8/26/05	9:24	0.0117	0.0042	0.00520	0.0200	0.00040	0.0056	9
Base Composite	9/19/05	10:03	9/21/05	11:11	0.0022	0.0022	0.00030	0.0046	0.00030	0.0014	16
Storm Composite	9/21/05	19:55	9/22/05	9:20	0.0100	0.0042	0.00470	0.0171	0.00010	0.0064	13
Storm Composite	10/4/05	20:37	10/5/05	6:08	0.0066	0.0035	0.00260	0.0124	0.00020	0.0046	11
Fecal Grab	10/19/05	10:15	10/19/05	10:15							
Base Grab	10/19/05	10:15	10/19/05	10:15	0.0005	0.0160	0.00020	0.0035	<0.00004	0.0005	18

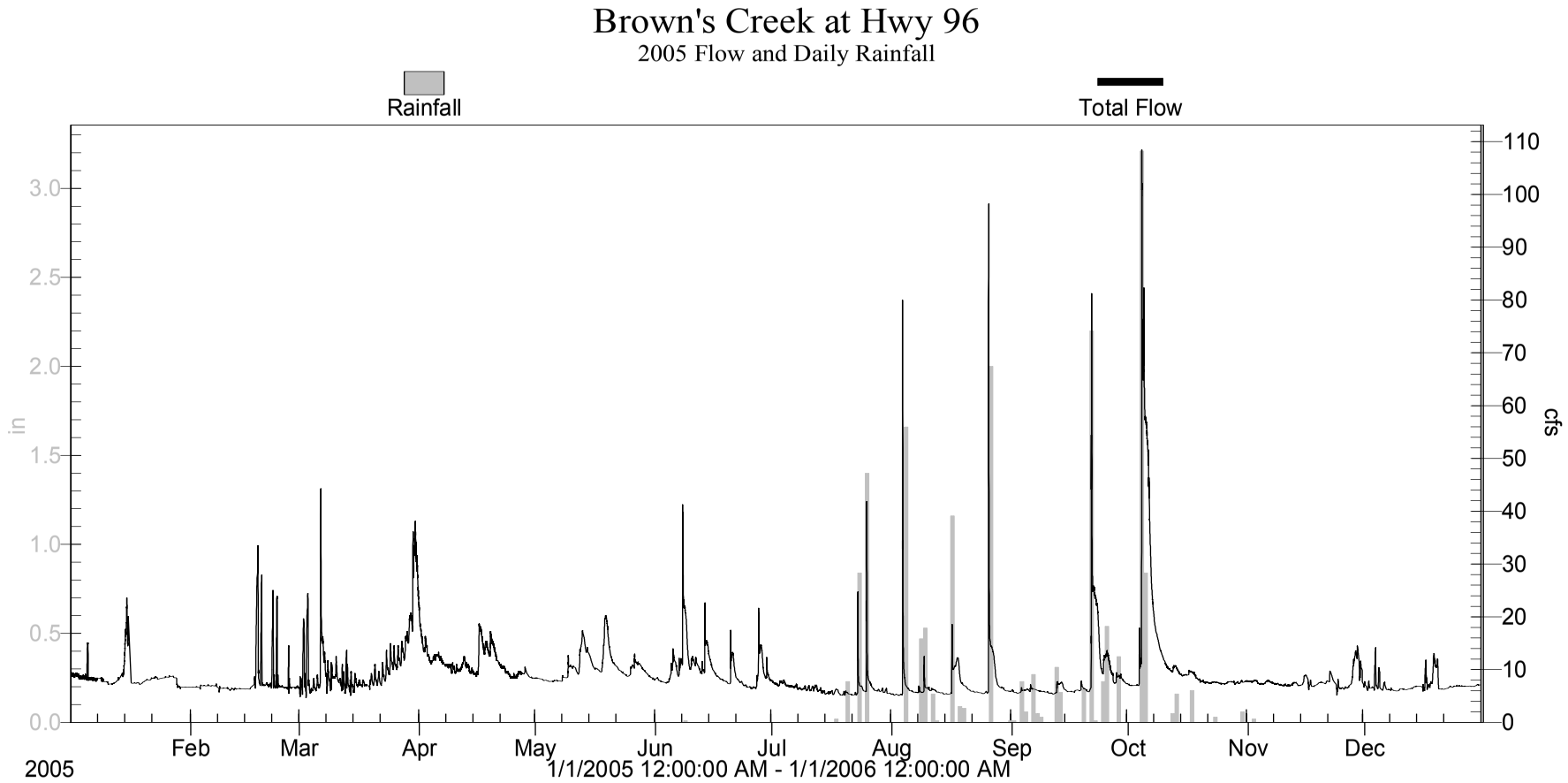


Figure 12: Brown's Creek at Mouth (Highway 96) 2005 Continuous Flow and Daily Rainfall

Table 14: Brown's Creek at Mouth (Highway 96) 2005 Total Suspended Solids TSS) and Phosphorus Loading (TP)

	Sample Collection Time						Loading Interval				
Sample Type	Start Date	Start Time	End Date	End Time	TP (mg/L)	TSS (mg/L)	Start	End	Interval Volume (cf)	Interval TP (lb)	Interval TSS (lb)
Base					*0.107*	*7*	*1/1/2005 0:00*	*1/5/2005 5:00*	*3,178,730*	*21.15*	*1,389*
Snowmelt					*0.062*	*10*	*1/5/2005 5:00*	*1/5/2005 13:00*	*371,901*	*1.44*	*232*
Base					*0.107*	*7*	*1/5/2005 13:00*	*1/14/2005 11:00*	*6,162,663*	*41.01*	*2,693*
Snowmelt					*0.062*	*10*	*1/14/2005 11:00*	*1/15/2005 23:45*	*2,006,661*	*7.77*	*1,253*
No Data							**1/15/2005 23:45**	**1/16/2005 16:00**		**0.00**	**0**
Base					*0.107*	*7*	*1/16/2005 16:00*	*1/24/2005 18:00*	*5,524,508*	*36.76*	*2,414*
Base Grab	*1/28/05*	*9:30*	*1/28/05*	*9:30*	*0.052*	*8*	*1/24/2005 18:00*	*1/28/2005 11:00*	*2,747,267*	*8.92*	*1,372*
Base					*0.107*	*7*	*1/28/2005 11:00*	*2/2/2005 12:00*	*2,928,474*	*19.49*	*1,280*
Snowmelt Grab	*2/3/05*	*9:00*	*2/3/05*	*9:00*	*0.062*	*10*	*2/2/2005 12:00*	*2/4/2005 12:00*	*1,173,502*	*4.54*	*733*
Base					*0.107*	*7*	*2/4/2005 12:00*	*2/16/2005 12:45*	*6,810,994*	*45.32*	*2,976*
No Data							**2/16/2005 12:45**	**2/17/2005 11:00**		**0.00**	**0**
Snowmelt					*0.062*	*10*	*2/17/2005 11:00*	*2/18/2005 16:00*	*1,747,468*	*6.76*	*1,091*
Base					*0.107*	*7*	*2/18/2005 16:00*	*2/19/2005 1:00*	*243,976*	*1.62*	*107*
Snowmelt					*0.062*	*10*	*2/19/2005 1:00*	*2/19/2005 11:00*	*638,562*	*2.47*	*399*
Base					*0.107*	*7*	*2/19/2005 11:00*	*2/22/2005 0:00*	*1,559,329*	*10.38*	*681*
Snowmelt					*0.062*	*10*	*2/22/2005 0:00*	*2/22/2005 20:00*	*934,068*	*3.62*	*583*
Base					*0.107*	*7*	*2/22/2005 20:00*	*2/23/2005 2:00*	*141,602*	*0.94*	*62*
Snowmelt					*0.062*	*10*	*2/23/2005 2:00*	*2/23/2005 19:00*	*771,580*	*2.99*	*482*
Base Grab	2/25/05	9:15	2/25/05	9:15	0.055	6	2/23/2005 19:00	2/26/2005 5:00	1,395,276	4.79	523
Snowmelt					*0.062*	*10*	*2/26/2005 5:00*	*2/26/2005 17:00*	*363,839*	*1.41*	*227*
Base					*0.107*	*7*	*2/26/2005 17:00*	*3/1/2005 5:00*	*1,436,807*	*9.56*	*628*
Snowmelt					*0.062*	*10*	*3/1/2005 5:00*	*3/3/2005 19:00*	*2,522,696*	*9.76*	*1,575*
Base					*0.107*	*7*	*3/3/2005 19:00*	*3/6/2005 11:00*	*1,538,222*	*10.24*	*672*
Snowmelt					*0.062*	*10*	*3/6/2005 11:00*	*3/9/2005 22:00*	*3,525,868*	*13.65*	*2,201*
Base Grab	3/25/05	9:00	3/25/05	9:00	0.164	10	3/9/2005 22:00	3/30/2005 10:00	17,247,030	176.57	10,767
Storm Grab	3/31/05	13:30	3/31/05	13:30	0.298	129	3/30/2005 10:00	4/2/2005 7:00	6,106,364	113.60	49,174
Base					*0.107*	*7*	*4/2/2005 7:00*	*4/16/2005 7:00*	*13,427,840*	*89.36*	*5,868*
Storm Grab	4/18/05	13:30	4/18/05	13:30	0.117	36	4/16/2005 7:00	4/21/2005 10:00	6,394,777	46.71	14,371
Base Grab	4/26/05	12:00	4/26/05	12:00	0.064	10	4/21/2005 10:00	5/1/2005 10:00	8,050,882	32.17	5,026
Base Grab	5/5/05	8:45	5/5/05	8:45	0.058	5	5/1/2005 10:00	5/9/2005 10:00	5,567,699	20.16	1,738
Storm					*0.389*	*260*	*5/9/2005 10:00*	*5/9/2005 21:00*	*399,518*	*9.69*	*6,489*
Base					*0.107*	*7*	*5/9/2005 21:00*	*5/12/2005 9:00*	*2,196,951*	*14.62*	*960*
Storm Composite	5/13/05	9:10	5/13/05	16:33	0.049	180	5/12/2005 9:00	5/15/2005 12:00	3,768,618	11.53	42,347
Base					*0.107*	*7*	*5/15/2005 12:00*	*5/18/2005 8:00*	*2,516,624*	*16.75*	*1,100*
Storm Composite	5/19/05	0:16	5/19/05	23:22	0.347	188	5/18/2005 8:00	5/20/2005 22:00	3,455,644	74.86	40,556
Base					*0.107*	*7*	*5/20/2005 22:00*	*5/25/2005 18:00*	*4,114,972*	*27.38*	*1,798*
Storm					*0.389*	*260*	*5/25/2005 18:00*	*5/28/2005 2:00*	*2,217,094*	*53.79*	*36,008*
Base					*0.107*	*7*	*5/28/2005 2:00*	*6/4/2005 14:00*	*5,605,672*	*37.30*	*2,450*
Storm					*0.389*	*260*	*6/4/2005 14:00*	*6/16/2005 10:00*	*12,591,360*	*305.50*	*204,499*
Base					*0.107*	*7*	*6/16/2005 10:00*	*6/20/2005 13:00*	*2,913,516*	*19.39*	*1,273*
Storm					*0.389*	*260*	*6/20/2005 13:00*	*6/21/2005 23:00*	*1,408,170*	*34.17*	*22,870*
Base					*0.107*	*7*	*6/21/2005 23:00*	*6/27/2005 8:00*	*3,326,384*	*22.14*	*1,454*
Storm					*0.389*	*260*	*6/27/2005 8:00*	*6/30/2005 2:00*	*2,659,726*	*64.53*	*43,197*
Base Grab	7/13/05	11:30	7/13/05	11:30	0.108	6	6/30/2005 2:00	7/23/2005 11:00	12,881,830	86.85	4,825
Storm					*0.389*	*260*	*7/23/2005 11:00*	*7/24/2005 0:00*	*467,707*	*11.35*	*7,596*
Base					*0.107*	*7*	*7/24/2005 0:00*	*7/25/2005 18:00*	*959,431*	*6.38*	*419*
Storm Composite	7/25/05	19:00	7/25/05	21:04	0.257	944	7/25/2005 18:00	7/27/2005 2:00	1,134,082	18.19	66,832
Base					*0.107*	*7*	*7/27/2005 2:00*	*8/4/2005 1:00*	*3,934,838*	*26.18*	*1,719*
Storm Composite	8/4/05	1:42	8/4/05	4:56	1.210	916	8/4/2005 1:00	8/5/2005 6:00	1,362,219	102.90	77,895
Base					*0.107*	*7*	*8/5/2005 6:00*	*8/9/2005 14:00*	*2,208,411*	*14.70*	*965*
Storm					*0.389*	*260*	*8/9/2005 14:00*	*8/10/2005 0:00*	*279,110*	*6.77*	*4,533*
Base					*0.107*	*7*	*8/10/2005 0:00*	*8/16/2005 19:00*	*3,424,200*	*22.79*	*1,496*
Storm					*0.389*	*260*	*8/16/2005 19:00*	*8/19/2005 2:00*	*2,133,030*	*51.75*	*34,643*
Base Grab	8/25/05	9:30	8/25/05	9:30	0.076	5	8/19/2005 2:00	8/26/2005 6:00	3,779,465	17.93	1,180
Storm Composite	8/26/05	7:51	8/26/05	13:50	0.970	588	8/26/2005 6:00	8/28/2005 7:00	3,003,167	181.85	110,236
Base					*0.107*	*7*	*8/28/2005 7:00*	*9/12/2005 23:00*	*8,170,775*	*54.37*	*3,570*
Storm					*0.389*	*260*	*9/12/2005 23:00*	*9/14/2005 18:00*	*1,130,221*	*27.42*	*18,356*
Base					*0.107*	*7*	*9/14/2005 18:00*	*9/19/2005 5:00*	*2,306,101*	*15.35*	*1,008*
Storm					*0.389*	*260*	*9/19/2005 5:00*	*9/19/2005 16:00*	*278,309*	*6.75*	*4,520*
Base Composite	9/19/05	16:08	9/20/05	8:54	0.090	12	9/19/2005 16:00	9/21/2005 19:00	1,132,138	6.36	848
Storm					*0.389*	*260*	*9/21/2005 19:00*	*9/23/2005 11:00*	*3,891,700*	*94.42*	*63,206*
Base					*0.107*	*7*	*9/23/2005 11:00*	*9/24/2005 23:00*	*1,743,895*	*11.60*	*762*
Storm					*0.389*	*260*	*9/24/2005 23:00*	*9/26/2005 17:00*	*1,851,870*	*44.93*	*30,077*
Base					*0.107*	*7*	*9/26/2005 17:00*	*9/28/2005 6:00*	*1,149,425*	*7.65*	*502*
Storm					*0.389*	*260*	*9/28/2005 6:00*	*9/28/2005 18:00*	*370,236*	*8.98*	*6,013*
Base					*0.107*	*7*	*9/28/2005 18:00*	*10/4/2005 7:00*	*3,600,247*	*23.96*	*1,573*
Storm Composite	10/4/05	21:25	10/5/05	10:26	0.551	440	10/4/2005 7:00	10/9/2005 17:00	16,396,630	563.99	450,374
Base Grab	10/19/05	10:00	10/19/05	10:00	0.077	5	10/9/2005 17:00	11/15/2005 18:00	26,064,280	125.29	8,135
Storm					*0.457*	*276*	*11/15/2005 18:00*	*11/17/05 18:00*	*1,375,678*	*39.21*	*23,720*
Base					*0.107*	*7*	*11/17/2005 18:00*	*11/28/05 3:00*	*6,481,928*	*43.13*	*2,832*
Storm					*0.457*	*276*	*11/28/2005 3:00*	*12/1/05 2:00*	*2,811,443*	*80.14*	*48,475*
Base					*0.107*	*7*	*12/1/2005 2:00*	*12/4/05 1:00*	*1,734,153*	*11.54*	*758*
Snowmelt					*0.062*	*10*	*12/4/2005 1:00*	*12/4/05 12:00*	*419,162*	*1.62*	*262*
Base					*0.107*	*7*	*12/4/2005 12:00*	*12/5/05 1:00*	*312,612*	*2.08*	*137*
Snowmelt					*0.062*	*10*	*12/5/2005 1:00*	*12/5/05 12:00*	*360,271*	*1.39*	*225*
Base					*0.107*	*7*	*12/5/2005 12:00*	*12/17/05 1:00*	*6,404,546*	*42.62*	*2,799*
Snowmelt					*0.062*	*10*	*12/17/2005 1:00*	*12/20/05 18:00*	*2,872,937*	*11.12*	*1,793*
Base Grab	12/21/05	10:45	12/21/05	10:45	0.322	3	12/20/2005 18:00	1/1/06 0:00	6,570,516	132.08	1,231
Storm Average					0.389	260					
Base Average					0.107	7					
Snowmelt Average					0.062	10					
All Average					0.259	184					
Total									**284,689,396**	3,338	1,499,031
Brown's Creek Major Subwatershed Total Acres									12,864		
Total TP/TSS (lb/ac/yr)										0.26	116.53
Total TP/TSS (kg/ha/yr)										0.29	130.61

*Italics indicate estimated concentrations based on average base and storm flow concentrations

*Bold indicates data lost due to equipment failure

Table 15: Brown's Creek at Hwy 96 (WOMP) 2004 Primary Chemistry Result Averages

Parameter	Storm Flow Average	Base Flow Average	Average (all samples)
TSS (mg/L)	260	7	184
VSS (mg/L)	51	5	47
TKN (mg/L)	2.49	0.40	1.28
TP (mg/L)	0.42	0.10	0.26
Fecal Coliform (#/100 mL)	--	--	59
COD (mg/L)	97	17	54
Alkalinity (mg/L)	103	175	144
Hardness (mg/L)	113	198	159

Of the parameters sampled at Hwy 96 (Table 16), copper and zinc exceeded both the MPCA Rule 7050 Water Quality Chronic and Maximum Standard on five samples. Copper, Lead, and Ammonia Nitrogen all exceeded the MPCA Rule 7050 Chronic Standard. All other sampled parameters were below the Chronic Standard.

Table 16: Hwy 96 Chemical Parameters Which Exceeded MPCA 7050 Water Quality Standards

Sample Type	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Ammonia Nitrogen (mg/L)
Chronic Standard	**0.0064**	**0.088**	**0.0013**	**0.0590**	**0.00066**	**0.117**	**230**	**0.04**
# of Exceedences/# of Samples	6/19	0/19	6/19	1/19	0/19	0/19	0/19	11/19
Maximum Standard	**0.0092**	**0.789**	**0.0340**	**0.0650**	**0.01500**	**0.984**	**860**	**No Standard**
# of Exceedences/# of Samples	6/19	0/19	0/19	1/19	0/19	0/19	0/19	NA

Table 17: Brown's Creek at Mouth (Highway 96) 2004 Primary Water Quality Results

Sample Type	Start Date	Start Time	End Date	End Time	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	Fecal Coliform (#/100 mL)	COD (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)
Base Grab	1/28/05	9:30	1/28/05	9:30	8	3	0.27	0.052	0.025		~9	188	210
Snowmelt Grab	2/3/05	9:00	2/3/05	9:00	10	3	0.29	0.062	0.027		~7	172	210
Base Grab	2/25/05	9:15	2/25/05	9:15	6	~2	0.15	0.055	0.031		~7	189	208
Base Grab	3/25/05	9:00	3/25/05	9:00	10	4	1.10	0.164	0.088		29	124	146
Storm Grab	3/31/05	13:30	3/31/05	13:30	129	~21	2.20	0.298	0.106		61	79	90
Storm Grab	4/18/05	13:30	4/18/05	13:30	36	~7	0.91	0.117	0.051		33	129	148
Base Grab	4/26/05	12:00	4/26/05	12:00	10	3	0.54	0.064	0.039		20	154	
Base Grab	5/5/05	8:45	5/5/05	8:45	5	~2	0.32	0.058	0.022	21	15	172	190
Storm Composite	5/13/05	9:10	5/13/05	16:33	180	42	1.50	~0.049			50	137	138
Storm Composite	5/19/05	0:16	5/19/05	23:22	188	~50	1.90	0.347	0.078		74	112	124
Base Grab	7/13/05	11:30	7/13/05	11:30	6	3	0.29	0.108	0.053	140	16	188	206
Storm Composite	7/25/05	19:00	7/25/05	21:04	944	260	0.86	0.257	0.135		191	107	114
Storm Composite	8/4/05	1:42	8/4/05	4:56	916	260	5.40	1.210	0.144		184	92	100
Base Grab	8/25/05	9:30	8/25/05	9:30	5	~2	0.27	0.076	0.053	53	~9	195	206
Storm Composite	8/26/05	7:51	8/26/05	13:50	588	135	4.80	0.970	0.128		184	93	100
Base Composite	9/19/05	16:08	9/20/05	8:54	12	5	0.53	0.090	0.056		16	188	206
Storm Composite	10/4/05	21:25	10/5/05	10:26	440	~84	2.30	0.551	0.094		100	71	90
Base Grab	10/19/05	10:00	10/19/05	10:00	5	~2	0.39	0.077	0.051	20	~13	170	
Base Grab	12/21/05	10:45	12/21/05	10:45	~3	<1	0.21	0.322	0.026		<5	182	210

Table 18: Brown's Creek at Mouth (Highway 96) 2004 Secondary Water Quality Results

Sample Type	Start Date	Start Time	End Date	End Time	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Turbidity (NTU)	Toc (mg/L)
Base Grab	1/28/05	9:30	1/28/05	9:30	0.0007	0.0015	0.00020	0.0024	<0.00004	0.0008	19	<0.03	1.38	~0.04	5.0	1.0
Snowmelt Grab	2/3/05	9:00	2/3/05	9:00	0.0007	0.0016	0.00020	0.0026	<0.00004	0.0008	23	0.03	1.36	~0.05	4.4	1.2
Base Grab	2/25/05	9:15	2/25/05	9:15	0.0006	0.0013	0.00010	0.0027	<0.00004	0.0006	19	<0.03	1.42	~0.05	3.7	1.6
Base Grab	3/25/05	9:00	3/25/05	9:00	0.0012	0.0013	0.00020	0.0054	<0.00004	0.0009	19	<0.03	0.87	0.19	4.3	7.2
Storm Grab	3/31/05	13:30	3/31/05	13:30	0.0026	0.0022	0.00120	0.0086	<0.00004	0.0026	17	<0.03	0.43	0.42	8.6	14.6
Storm Grab	4/18/05	13:30	4/18/05	13:30	0.0011	0.0018	0.00020	0.0039	<0.00004	0.0009	19	<0.03	0.58	~0.04	4.3	7.4
Base Grab	4/26/05	12:00	4/26/05	12:00	0.0005	0.0014	<0.00007	0.0022	<0.00004	0.0009	19	<0.03	0.74	0.1	2.4	4.7
Base Grab	5/5/05	8:45	5/5/05	8:45	0.0006	0.0014	<0.00007	0.0024	<0.00004	0.0006	20	<0.03	0.76	<0.02	2.5	3.6
Storm Composite	5/13/05	9:10	5/13/05	16:33	0.0730	0.0043	0.00180	0.1320	0.00050	0.0034	50	<0.03	0.55	<0.02	16.0	8.1
Storm Composite	5/19/05	0:16	5/19/05	23:22	0.0134	0.0036	0.00180	0.0134	0.00020	0.0037	18	<0.03	0.27	~0.04	15.0	8.9
Base Grab	7/13/05	11:30	7/13/05	11:30	0.0015	0.0019	0.00020	0.0028	<0.00004	0.0010	20	<0.03	1.02	<0.02	3.1	2.4
Storm Composite	7/25/05	19:00	7/25/05	21:04	0.0157	0.0083	0.00740	0.0290	0.00060	0.0130	12	0.03	0.59	0.14	60.0	6.4
Storm Composite	8/4/05	1:42	8/4/05	4:56	0.0211	0.0106	0.01140	0.0380	0.00030	0.0157	9	0.04	0.61	<0.02	47.0	5.0
Base Grab	8/25/05	9:30	8/25/05	9:30	0.0005	0.0016	0.00010	0.0026	<0.00004	0.0004	20	<0.03	0.94	1.17	2.6	2.1
Storm Composite	8/26/05	7:51	8/26/05	13:50	0.0220	0.0103	0.01020	0.0360	0.00030	0.0146	10	<0.03	0.45	~0.03	60.0	6.0
Base Composite	9/19/05	16:08	9/20/05	8:54	0.0028	0.0017	0.00020	0.0047	0.00020	0.0012	19	<0.03	0.97	<0.02	2.9	2.9
Storm Composite	10/4/05	21:25	10/5/05	10:26	0.0152	0.0079	0.00590	0.0230	0.00010	0.0100	11	<0.03	0.27	<0.02	39.0	9.5
Base Grab	10/19/05	10:00	10/19/05	10:00	0.0005	0.0016	0.00010	0.0039	<0.00004	0.0007	19	0.06	0.76	<0.02	3.0	5.0
Base Grab	12/21/05	10:45	12/21/05	10:45	0.0006	0.0015	0.00010	0.0038	<0.00004	0.0009	19	<0.03	1.36	~0.05	4.9	1.6

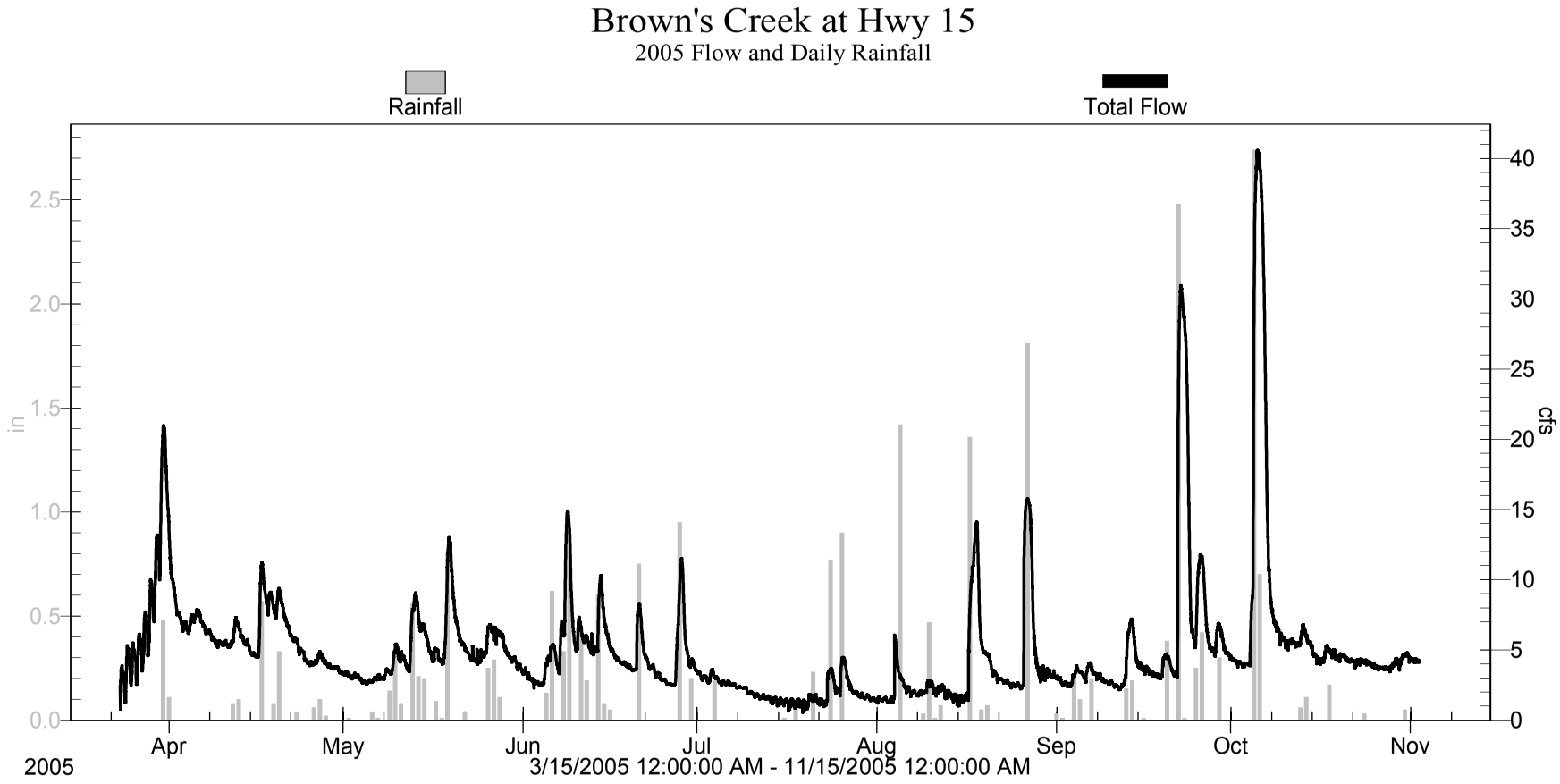


Figure 13: Brown's Creek at Hwy 15 Continuous Flow and Daily Rainfall

Table 19: Brown's Creek at Hwy 15 2005 Total Suspended Solids (TSS) and Phosphorus (TP) Loading

	Sample Collection Time						Loading Interval				
Sample Type	Start Date	Start Time	End Date	End Time	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval TP (lb)	Interval TSS (lb)
BASE					*12*	*0.100*	*1/1/2005 0:00*	*2/2/2005 12:00*	*2,246,400*	*13.99*	*1,613*
Snowmelt Grab	2/3/05	10:00	2/3/05	10:00	7	0.070	2/2/2005 12:00	2/4/2005 12:00	691,200	3.02	302
BASE					*12*	*0.100*	*2/4/2005 12:00*	*3/23/2005 13:45*	*4,067,100*	*25.33*	*2,920*
BASE					*12*	*0.100*	*3/23/2005 13:45*	*3/30/2005 7:45*	*3,448,570*	*21.47*	*2,476*
Storm Composite	3/28/05	16:58	3/31/05	7:51	82	0.317	3/30/2005 7:45	4/2/2005 3:45	3,489,546	69.05	17,863
BASE					*12*	*0.100*	*4/2/2005 3:45*	*4/12/2005 0:45*	*5,470,455*	*34.06*	*3,927*
STORM					*120*	*0.350*	*4/12/2005 0:45*	*4/13/2005 7:45*	*744,168*	*16.26*	*5,570*
BASE					*12*	*0.100*	*4/13/2005 7:45*	*4/16/2005 8:45*	*1,353,771*	*8.43*	*972*
STORM					*120*	*0.350*	*4/16/2005 8:45*	*4/20/2005 23:45*	*3,412,380*	*74.58*	*25,539*
Base Grab	4/26/05	10:30	4/26/05	10:30	3	0.077	4/20/2005 23:45	4/26/2005 11:45	2,414,925	11.61	452
STORM					*120*	*0.350*	*4/26/2005 11:45*	*4/27/2005 22:45*	*559,546*	*12.23*	*4,188*
BASE					*12*	*0.100*	*4/27/2005 22:45*	*5/8/2005 1:45*	*2,810,627*	*17.50*	*2,018*
STORM					*120*	*0.350*	*5/8/2005 1:45*	*5/12/2005 8:45*	*1,510,845*	*33.02*	*11,307*
Storm Composite	5/13/05	12:10	5/13/05	20:11	113	0.151	5/12/2005 8:45	5/14/2005 9:45	1,276,524	12.03	9,005
STORM					*120*	*0.350*	*5/14/2005 9:45*	*5/15/2005 21:45*	*788,463*	*17.23*	*5,901*
BASE					*12*	*0.100*	*5/15/2005 21:45*	*5/18/2005 5:45*	*917,002*	*5.71*	*658*
Storm Composite	5/18/05	19:35	5/20/05	3:51	59	0.239	5/18/2005 5:45	5/21/2005 0:45	2,054,359	30.65	7,566
BASE					*12*	*0.100*	*5/21/2005 0:45*	*5/25/2005 13:45*	*1,872,775*	*11.66*	*1,344*
STORM					*120*	*0.350*	*5/25/2005 13:45*	*5/28/2005 15:45*	*1,642,111*	*35.89*	*12,290*
BASE					*12*	*0.100*	*5/28/2005 15:45*	*6/4/2005 13:45*	*2,132,688*	*13.28*	*1,531*
STORM					*120*	*0.350*	*6/4/2005 13:45*	*6/8/2005 1:45*	*1,437,913*	*31.43*	*10,762*
Storm Composite	6/8/05	5:49	6/9/05	7:26	86	0.327	6/8/2005 1:45	6/9/2005 8:45	1,345,525	27.47	7,224
BASE					*12*	*0.100*	*6/9/2005 8:45*	*6/10/2005 6:45*	*477,340*	*2.97*	*343*
STORM					*120*	*0.350*	*6/10/2005 6:45*	*6/11/05 1:45*	*447,832*	*9.79*	*3,352*
BASE					*12*	*0.100*	*6/11/2005 1:45*	*6/13/05 20:45*	*1,396,256*	*8.69*	*1,002*
STORM					*120*	*0.350*	*6/13/2005 20:45*	*6/15/05 6:45*	*1,013,252*	*22.15*	*7,583*
BASE					*12*	*0.100*	*6/15/2005 6:45*	*6/20/05 11:45*	*1,973,166*	*12.29*	*1,417*
STORM					*120*	*0.350*	*6/20/2005 11:45*	*6/21/05 18:45*	*762,777*	*16.67*	*5,709*
BASE					*12*	*0.100*	*6/21/2005 18:45*	*6/27/05 5:45*	*1,536,020*	*9.56*	*1,103*
Storm Composite	6/28/05	3:22	6/28/05	11:17	171	0.488	6/27/2005 5:45	6/28/05 22:45	1,185,671	36.12	12,657
Base Composite	7/13/05	9:21	7/15/05	6:33	20	0.119	6/28/2005 22:45	7/23/05 8:45	4,576,579	34.00	5,714
STORM					*120*	*0.350*	*7/23/2005 8:45*	*7/24/05 17:45*	*385,149*	*8.42*	*2,883*
BASE					*12*	*0.100*	*7/24/2005 17:45*	*7/25/05 16:45*	*181,092*	*1.13*	*130*
STORM					*120*	*0.350*	*7/25/2005 16:45*	*7/26/05 23:45*	*435,203*	*9.51*	*3,257*
BASE					*12*	*0.100*	*7/26/2005 23:45*	*8/3/05 22:45*	*1,160,605*	*7.23*	*833*
STORM					*120*	*0.350*	*8/3/2005 22:45*	*8/5/05 2:45*	*410,186*	*8.97*	*3,070*
BASE					*12*	*0.100*	*8/5/2005 2:45*	*8/9/05 13:45*	*827,827*	*5.15*	*594*
STORM					*120*	*0.350*	*8/9/2005 13:45*	*8/10/05 16:45*	*261,705*	*5.72*	*1,959*
BASE					*12*	*0.100*	*8/10/2005 16:45*	*8/16/05 16:45*	*1,003,828*	*6.25*	*721*
Storm Composite	8/17/05	5:43	8/17/05	9:49	168	0.461	8/16/2005 16:45	8/18/05 21:45	1,905,960	54.85	19,989
BASE					*12*	*0.100*	*8/18/2005 21:45*	*8/26/05 5:45*	*2,061,262*	*12.84*	*1,480*
Storm Composite	8/26/05	19:16	8/27/05	3:35	120	0.289	8/26/2005 5:45	8/28/05 20:45	2,345,628	42.32	17,571
BASE					*12*	*0.100*	*8/28/2005 20:45*	*9/3/05 15:45*	*1,508,913*	*9.40*	*1,083*
STORM					*120*	*0.350*	*9/3/2005 15:45*	*9/7/05 5:45*	*1,069,788*	*23.38*	*8,007*
BASE					*12*	*0.100*	*9/7/2005 5:45*	*9/12/05 13:45*	*1,260,735*	*7.85*	*905*
STORM					*120*	*0.350*	*9/12/2005 13:45*	*9/15/05 0:45*	*1,128,447*	*24.66*	*8,446*
Base Composite	9/19/05	9:21	9/21/05	7:17	18	0.111	9/15/2005 0:45	9/21/05 18:45	2,133,136	14.78	2,397
Storm Composite	9/21/05	20:25	9/22/05	13:02	192	0.559	9/21/2005 18:45	9/24/05 4:45	4,773,912	166.59	57,219
BASE					*12*	*0.100*	*9/24/2005 4:45*	*9/24/05 19:45*	*323,103*	*2.01*	*232*
STORM					*120*	*0.350*	*9/24/2005 19:45*	*9/27/05 6:45*	*1,880,990*	*41.11*	*14,078*
BASE					*12*	*0.100*	*9/27/2005 6:45*	*9/28/05 7:45*	*448,744*	*2.79*	*322*
STORM					*120*	*0.350*	*9/28/2005 7:45*	*9/30/05 2:45*	*925,372*	*20.23*	*6,926*
BASE					*12*	*0.100*	*9/30/2005 2:45*	*10/4/05 5:45*	*1,508,744*	*9.39*	*1,083*
Storm Composite	10/4/05	19:32	10/5/05	14:24	88	0.320	10/4/2005 5:45	10/8/05 9:45	8,318,170	166.17	45,696
BASE					*12*	*0.100*	*10/8/2005 9:45*	*10/12/2005 20:45*	*2,244,966*	*13.98*	*1,612*
STORM					*120*	*0.350*	*10/12/2005 20:45*	*10/14/2005 8:45*	*789,738*	*17.26*	*5,911*
BASE					*12*	*0.100*	*10/14/2005 8:45*	*10/17/2005 0:45*	*1,074,930*	*6.69*	*772*
STORM					*120*	*0.350*	*10/17/2005 0:45*	*10/18/2005 9:45*	*588,681*	*12.87*	*4,406*
Base Grab	10/19/05	10:30	10/19/05	10:30	5	0.092	10/18/2005 9:45	11/2/2005 13:45	5482697	31.49	1,711
BASE					*12*	*0.100*	*11/2/2005 13:45*	*1/1/2006 0:00*	*15411600*	*95.97*	*11,064*
Storm Average					120	0.350					
Base Average					12	0.100					
Snowmelt Average					7	0.070					
All Average					81	0.259					
Total									**120,906,897**	1,507	398,661
Brown's Creek Major Subwatershed Total Acres									7,193		
Total TP/TSS(lb/ac/yr)										0.21	55.42
Total TP/TSS (kg/ha/yr)										0.23	62.12

*Italics indicate estimated concentrations based on average base and storm flow concentrations

Table 20: Brown's Creek at Hwy 15 2005 Primary Chemical Result Averages

Parameter	Storm Flow Average	Base Flow Average	Average (all samples)
TSS (mg/L)	120	12	81
VSS (mg/L)	70	6	47
TKN (mg/L)	2.72	0.70	2.00
TP (mg/L)	0.35	0.10	0.26
Fecal Coliform (#/100 mL)	--	--	209

Of the parameters sampled at Hwy 15 (Table 23), lead and cadmium exceeded the MPCA Rule 7050 Water Quality Chronic Standard. There were no samples in which the MPCA Rule 7050 Water Quality Maximum Standard was exceeded (Table 21).

Table 21: Brown's Creek at Hwy 15 Chemical Parameters Which Exceeded MPCA 7050 Water Quality Standards

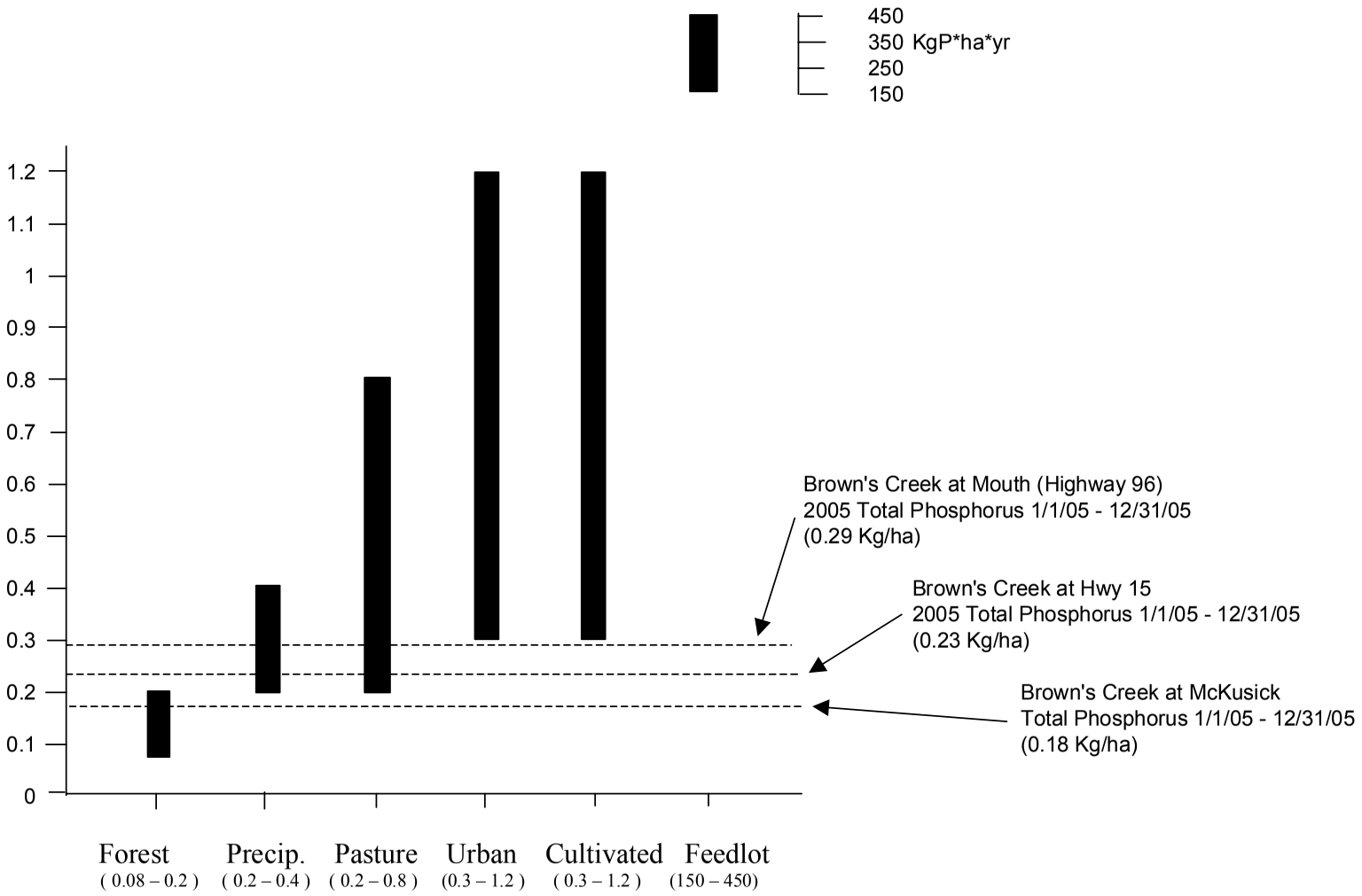
Sample Type	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)
Chronic Standard	**0.0064**	**0.088**	**0.0013**	**0.0590**	**0.00066**	**0.117**	**230**
# of Exceedences/# of Samples	0/14	0/14	7/14	0/14	1/14	0/14	0/14
Maximum Standard	**0.0092**	**0.789**	**0.0340**	**0.0650**	**0.01500**	**0.984**	**860**
# of Exceedences/# of Samples	0/14	0/14	0/14	0/14	0/14	0/14	0/14

Table 22: Brown's Creek at Hwy 15 2005 Primary Water Quality Results

Sample Type	Start Date	Start Time	End Date	End Time	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	Fecal Coliform (#/100 mL)
Snowmelt Grab	2/3/05	10:00	2/3/05	10:00	7	4	0.75	0.070	~0.010	
Storm Composite	3/28/05	16:58	3/31/05	7:51	82	46	2.70	0.317	0.094	
Base Grab	4/26/05	10:30	4/26/05	10:30	~3	~2	0.56	0.077	~0.024	
Fecal Grab	5/5/05	8:00	5/5/05	8:00						460
Storm Composite	5/13/05	12:10	5/13/05	20:11	113	~19	1.60	0.151	~0.026	
Storm Composite	5/18/05	19:35	5/20/05	3:51	59	34	1.50	0.239	~0.022	
Storm Composite	6/8/05	5:49	6/9/05	7:26	86	~56	2.50	0.327	0.063	
Storm Composite	6/28/05	3:22	6/28/05	11:17	171	120	3.40	0.488	0.057	
Base Composite	7/13/05	9:21	7/15/05	6:33	20	11	0.96	0.119	0.067	
Fecal Grab	7/13/05	8:45	7/13/05	8:45						170
Storm Composite	8/17/05	5:43	8/17/05	9:49	168	~100	3.70	0.461	0.064	
Fecal Grab	8/25/05	8:00	8/25/05	8:00						140
Storm Composite	8/26/05	19:16	8/27/05	3:35	120	~73	2.20	0.289	0.076	
Base Composite	9/19/05	9:21	9/21/05	7:17	18	9	0.83	0.111	~0.029	
Storm Composite	9/21/05	20:25	9/22/05	13:02	192	118	4.70	0.559	0.109	
Storm Composite	10/4/05	19:32	10/5/05	14:24	~88	~60	2.20	0.320	0.069	
Base Grab	10/19/05	10:30	10/19/05	10:30	~5	~3	0.43	0.092		
Fecal Grab	10/19/05	10:30	10/19/05	10:30						67

Table 23: Brown's Creek at Hwy 15 2005 Secondary Water Quality Results

Sample Type	Start Date	Start Time	End Date	End Time	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)
Snowmelt Grab	2/3/05	10:00	2/3/05	10:00	<0.0005	0.0015	0.0002	0.0024	<0.00004	0.0003	12
Storm Composite	3/28/05	16:58	3/31/05	7:51	0.0035	0.0017	0.0016	0.0097	<0.00004	0.0027	12
Base Grab	4/26/05	10:30	4/26/05	10:30	0.0005	0.0012	<0.0001	0.0021	<0.00004	0.0007	15
Fecal Grab	5/5/05	8:00	5/5/05	8:00							
Storm Composite	5/13/05	12:10	5/13/05	20:11	0.0017	0.0017	0.0007	0.0105	0.00080	0.0017	14
Storm Composite	5/18/05	19:35	5/20/05	3:51	0.0019	0.0018	0.0007	0.0080	0.00006	0.0016	12
Storm Composite	6/8/05	5:49	6/9/05	7:26	0.0023	0.0022	0.0016	0.0091	0.00010	0.0025	9
Storm Composite	6/28/05	3:22	6/28/05	11:17	0.0026	0.0028	0.0026	0.0121	0.00020	0.0044	8
Base Composite	7/13/05	9:21	7/15/05	6:33	0.0015	0.0018	0.0004	0.0049	0.00030	0.0010	11
Fecal Grab	7/13/05	8:45	7/13/05	8:45							
Storm Composite	8/17/05	5:43	8/17/05	9:49	0.0027	0.0026	0.0029	0.0117	0.00020	0.0039	10
Fecal Grab	8/25/05	8:00	8/25/05	8:00							
Storm Composite	8/26/05	19:16	8/27/05	3:35	0.0016	0.0018	0.0013	0.0075	0.00006	0.0018	10
Base Composite	9/19/05	9:21	9/21/05	7:17	0.0010	0.0016	0.0004	0.0050	0.00010	0.0013	13
Storm Composite	9/21/05	20:25	9/22/05	13:02	0.0039	0.0030	0.0034	0.0146	0.00030	0.0054	8
Storm Composite	10/4/05	19:32	10/5/05	14:24	0.0016	0.0020	0.0015	0.0080	0.00010	0.0026	9
Base Grab	10/19/05	10:30	10/19/05	10:30	0.0005	0.0012	0.0001	0.0033	0.00020	0.0005	13
Fecal Grab	10/19/05	10:30	10/19/05	10:30							



1 Kg = 2.2 lbs
1 ha (hectare) = 2.47 acres

Figure 14: Total Phosphorus Export Coefficients: Brown's Creek and estimated range by landuse (literature estimates)

2. FISHERIES DATA

Brown's Creek is a designated trout stream managed by The Minnesota Department of Natural Resources, Division of Fisheries. It's one of the few trout streams in the Twin Cities Metropolitan area that support a fishable trout population. Compared to other fish species, trout need colder and cleaner water to survive. They also need a variety of stream habitats, including deep pools with overhead cover. The DNR has actively managed Brown's Creek since 1955 (Table 24).

Table 24: Fish Stocking in Brown's Creek

Species/Strain	Year	Number	Size
Brook Trout	56-59	370	yearling
Brook Trout	51	495	fingerling
Brown Trout	55-59	3167	yearling
Brown Trout	60-69	7668	yearling
Brown Trout	70	1086	adolecent
Brown Trout	70-79	8121	yearling
Brown Trout	80-89	7940	yearling
Brown Trout	84	1100	fingerling
Brown Trout	90-96	6400	yearling
Brown Trout	96-00	6400	yearling
Brown Trout	2004	800	yearling
Brown Trout	2005	1000	yearling

In the past 48 years, DNR Fisheries has conducted 19 known population assessments of the brown trout population in portions of the stream. Population assessments help the DNR track the health of the stream and manage the recreational fishery. Fishing pressure in Brown's Creek is fairly strong at the season opener and tapers off as the season progresses. DNR Fisheries acquired an angler easement ten feet on either side of the stream up to the first house below the stone bridge. Brown's Creek was first stocked with brown trout in 1955 and then annually from 1958 to present. Current

management plans call for about 800 to 1,000 fingerling brown trout to be stocked each spring. Stocked fish typically average about 5 to 6 inches in length, although some can be as large as 12 inches. Brown trout stocked in Brown's Creek fare quite well, growing at fairly rapid rates. Fall electrofishing surveys by the DNR typically find many fish in the 10- to 12-inch range and several as large as 18 to 20 inches. Survey data also show that in many years' adult trout successfully spawn and the young fish survive and grow to be part of the fishable population. This is known as natural reproduction. In some years, however, eggs and young fish do not survive, or survival is poor.

Recent years have been some of the best recorded for the brown trout population in Brown's Creek. The DNR has not yet published its most recent fish surveys to assess trout populations and natural reproduction, but 1,000 yearling trout were stocked in the stream during 2005. Figure 15 gives an indication of changes in the trout population since 1966. This graph represents the number of trout captured during fall surveys and includes all sizes of trout; the actual number of trout in the stream is higher, since not all fish are captured during surveys. The areas sampled varied from year to year, but would typically coincide with the sections of stream where trout were found. In some years, the area was not very far upstream from the intersection of Highways 95 and 96. Some years were sampled twice, only fall samples are shown. Part of the variation in surveys was due to the fact that the DNR historically did not find trout upstream of the Highway 5 bridge and therefore did not survey beyond the bridge. However, they now find trout over a mile upstream of the bridge. Sampling has been extended to include this upstream habitat. This upstream expansion is directly linked to habitat improvement projects that are described later in this summary. The upstream expansion and overall increase in trout numbers is viewed by the DNR as a positive sign for Brown's Creek.

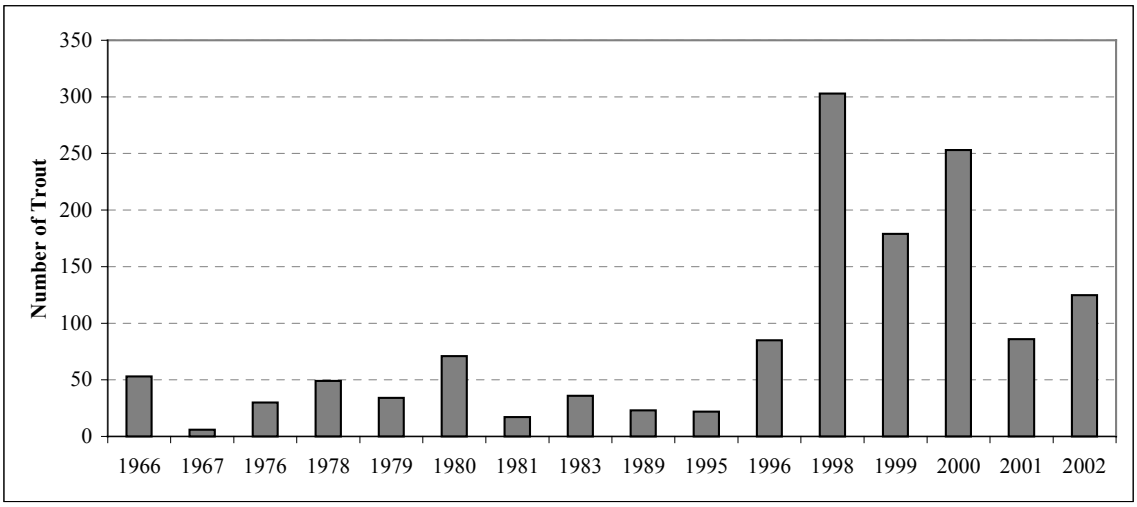


Figure 15: Historical electrofishing data (Source: DNR Fisheries)

The long-term outlook for natural reproduction is less clear. Historically, brown trout have reproduced in Brown's Creek in fairly limited numbers. However, since the DNR did not survey Brown's Creek every year until the late 1990's, it is difficult to know what happened in the years that they did not survey the stream. Natural reproduction is indicated by the presence of small brown trout, typically 4 or 5 inches at the time of fall surveys (see photo on the right). Fish biologists often refer to these small trout as 'young-of-the-year', because they haven't lived a full year. Stream surveys confirmed natural reproduction in 1966, 1976, 1989, 1998, 1999, 2000, and 2001. It is evident from the survey that 1998 was the best year for 'young-of-the-year trout', with 1999 not far behind. However, in 2001 and 2002, there was a noticeable lack of smaller fish, although the numbers of larger fish continued to be fairly high. Figure 16 shows more detailed information from the past eight years. Note fewer numbers of young-of-the-year trout in 2001 and 2002. Because they are smaller than the size of trout stocked, the presence of young-of-the-year trout indicates successful natural reproduction.

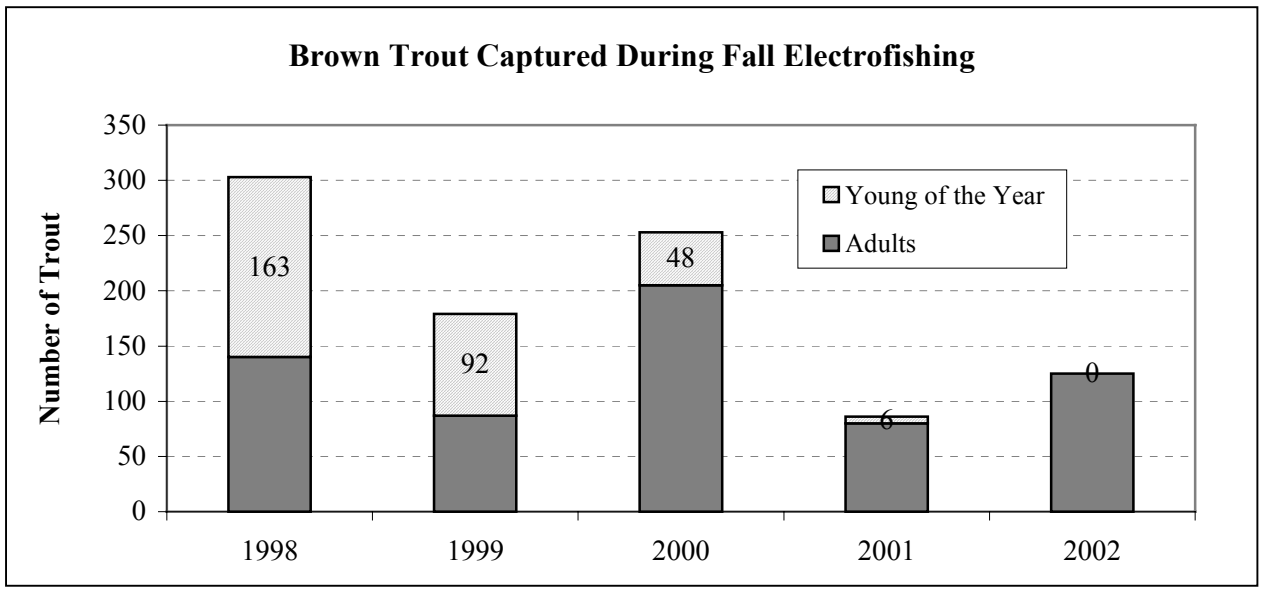


Figure 16: Electrofishing Results 1998-2002: Young of Year & Adult Brown Trout

Water quality, habitat quality and food availability are all factors that determine how well trout survive, grow, and reproduce. These factors vary from stream to stream, with each stream having a unique composition. Some streams are more subject to floods, others more prone to warm temperatures. In all trout streams, repeated periods of high streamflow and elevated water temperatures will take a toll on trout survival and reproduction. Year to year variability will result in a "bad" year now and then, but repeated bad years can indicate a negative trend in trout populations. Brown trout spawn in the fall by burying their eggs in gravel. The eggs develop slowly over the winter and typically hatch in March and April. At these early stages in their life, trout are not very effective swimmers. Some fish will simply die or be consumed by larger trout or other predators. High streamflows from snowmelt and rainfall can quickly sweep these small fry downstream and into the St. Croix River, essentially removing them from the population. In Brown's Creek, the spring of 2001 and 2002 both had high streamflows (Figure 27 and Figure 33), which may have contributed to poor egg and/or fry survival.

As discussed in the following section, sustained periods of increased water temperatures can also be stressful and even lethal to trout, particularly smaller fish. Warm temperatures affect small

fish more easily than larger ones. The recent lack of small trout may be due to increased water temperatures and streamflows in 2001 and 2002. These periods of high temperatures coincided with high streamflows, possibly compounding stress on fish.

3. TEMPERATURE DATA

Temperature in Brown's Creek has been monitored by several organizations since 1998 and summarized in a report by the Minnesota Department of Natural Resources. Temperatures are recorded in Brown's Creek to monitor existing conditions and to identify areas where warming or cooling may occur. Water temperatures less than 18°C are considered preferred, between 18 and 20°C are low impact, 20 to 25°C have a moderate impact, and greater than 25°C is considered high impact to trout. Temperature relations in trout streams are complex and depend on exposure time, conditions leading up to the exposure, the availability of refugia (small pockets of colder water), and other factors that are not easily identified. The same impact levels are used in the BCWD H&H study. Temperature data prior to 2001 comes from a Report on Water Temperatures for 1998 and 1999 in Brown's Creek, Washington County, Minnesota, by Jason Moeckel, MN DNR.

Sustained periods of increased water temperatures can be stressful and even lethal to trout, particularly smaller fish. Warm temperatures affect small fish more easily than larger ones. Water temperatures in a stream go up and down throughout the day. They are usually coolest in the early morning hours (about sunrise) and warmest in the late afternoon (about 5pm). Even during the warmest days, the cooler water during the night can serve as somewhat of a refuge for trout. Trout in Brown's Creek were exposed to much warmer water in 2001 and 2002 when compared to 2003-2005, even during the night and early morning hours when water temperatures are usually coolest (Figure 20). Both 2001 and 2002 had several days in which the maximum daily water temperatures exceeded 25 degrees Celsius (77º F) at both McKusick Rd and Hwy 96. The minimum daily temperature reached and exceeded 20 degrees in 2001 and 2002, but was never above 20 degrees Celsius in 2003-2005 (Figure 17). In 2003-2005, Brown's Creek experienced lower maximum daily water temperatures than in 2001 or 2002. The maximum daily temperature collected was 27.44 degrees Celsius at the HWY 15 site, 26.28 degrees Celsius at the McKusick Rd site and 22.94 degrees Celsius at the Hwy 96 site. In 2005, the Hwy 15 site and McKusick Road site experienced maximum daily temperatures were greater than 25 degrees Celsius. The Hwy 15 and the McKusick Road sites had 18 days and 2 days respectively where the daily maximum temperature exceeded 25 degrees Celsius. At this time, the Hwy 15 reach of

stream is not known to contain trout. At times, temperatures exceed 25 degrees Celsius in this particular reach and are not currently suitable for trout survival compared to the downstream, high-groundwater input reaches of Brown's Creek.

Water temperatures in a stream are influenced by a number of factors, but two of the most prominent are air temperature and the amount of solar radiation or direct sunlight that reaches the water. In general, days in which air temperatures meet or exceed 90º F are typically the days when water temperatures are highest. The more days with air temperature at 90º F or above, the more stressful the conditions in the stream for trout. Figures 17 and 18 show the correlation between the number of warm days and warm stream temperatures. Both 2001 and 2002 had above average number of these "hot days", while 2004 had the fewest days in the past 8 years (Figure 17 and Figure 18). The daily minimum temperature is described as the coldest the water was during a given 24-hour period. The percentage of groundwater contribution to the stream can also affect the influence of air temperature on water temperature.

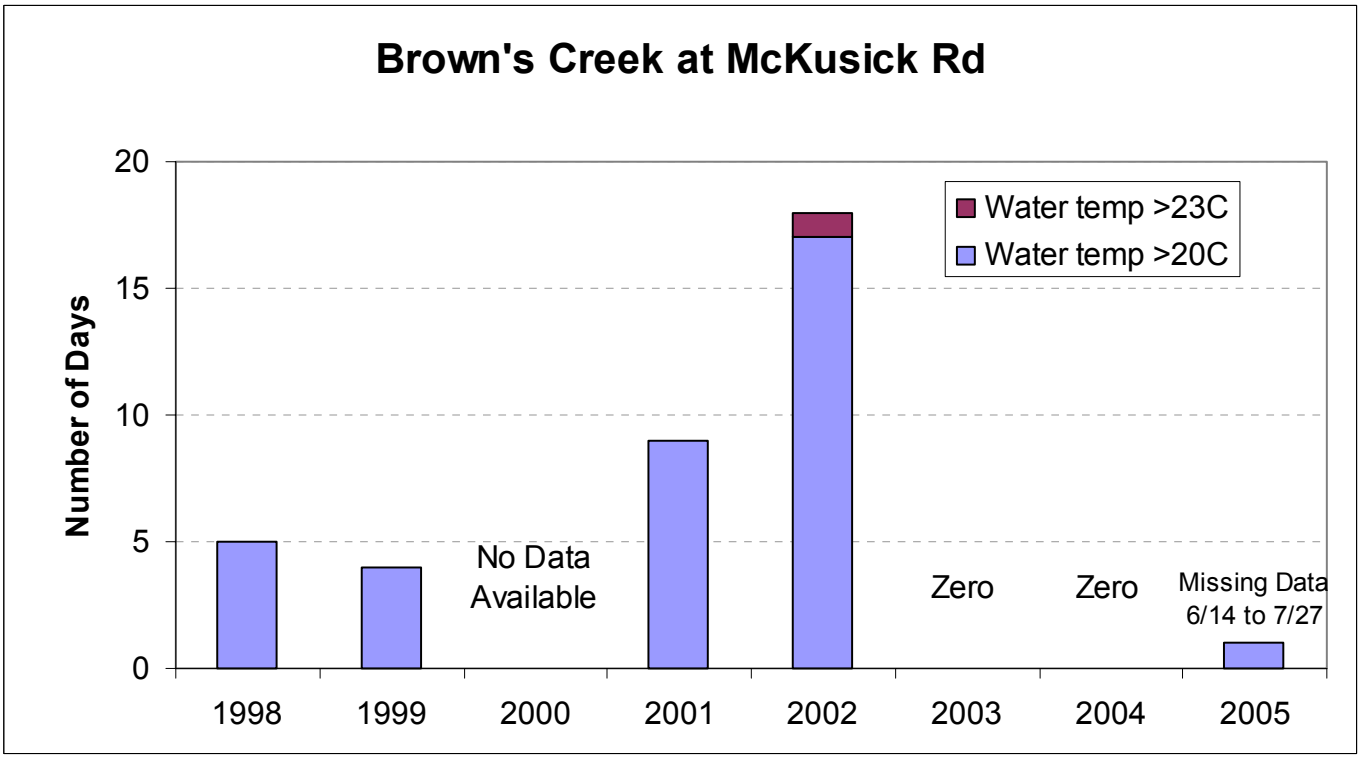


Figure 17: Occurrences of Brown's Creek Daily Minimum Water Temperature Greater than 20 and 23 degrees Celsius at McKusick Road

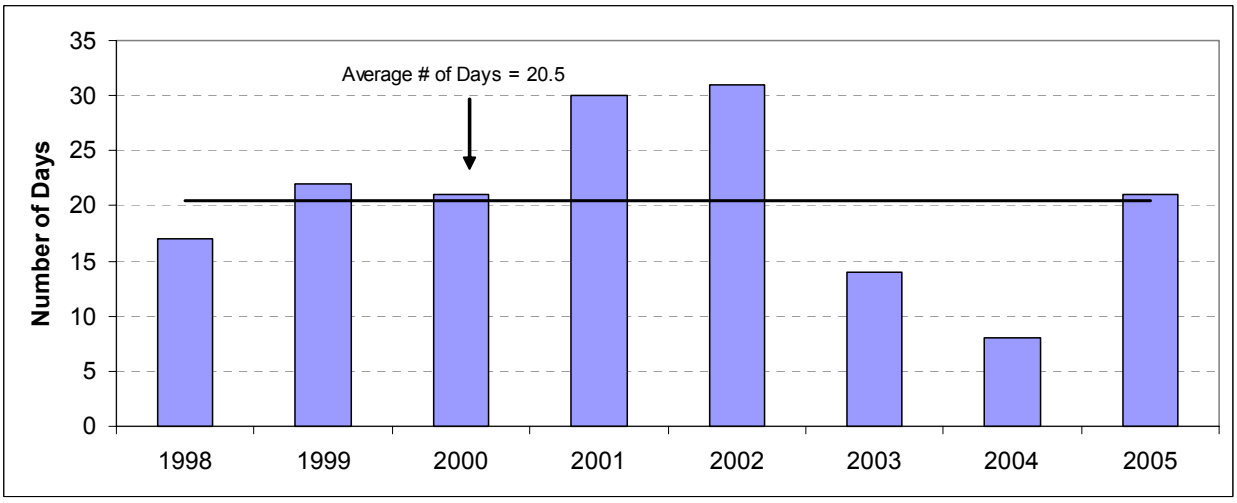


Figure 18: Days With Air Temperatures Over 90 Degrees Fahrenheit, Stillwater, MN (Source: National Weather Service)

At one time in its history, Brown's Creek was diverted into McKusick Lake, which supplied water to Stillwater residents. By 1955 fisheries managers recognized that warm lake water was putting a strain on the trout population in Brown's Creek. In an effort to reduce water temperatures for the benefit of trout, a dike was constructed to separate the stream from the lake and return the flow back to Brown's Creek. The dike still exists today.

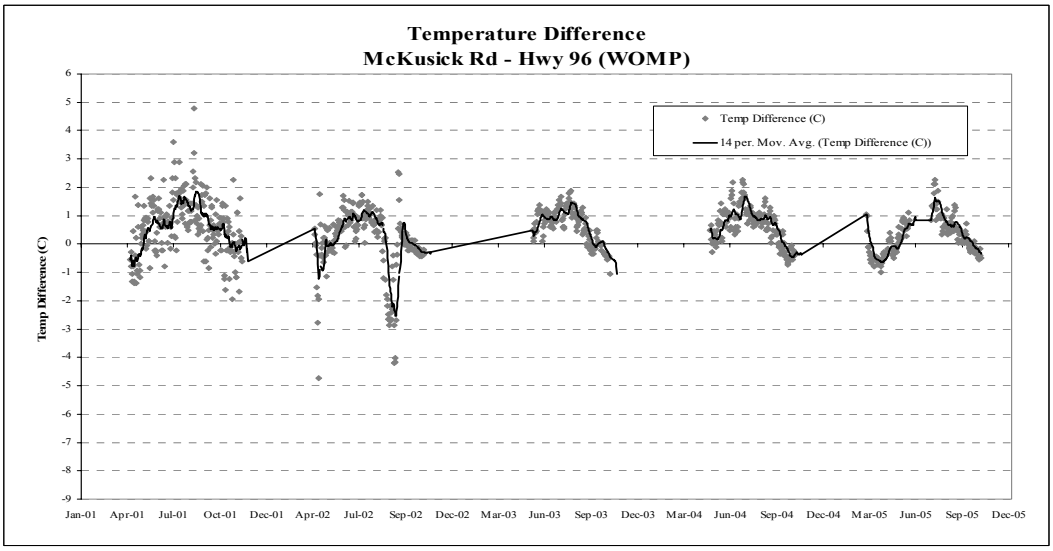


Figure 19: Temperature Differences between McKusick Rd & Hwy 96 (WOMP) Sites

Daily maximum and mean water temperatures generally decrease in the downstream direction of Brown's Creek in the summer months. Groundwater inputs generally contribute to thermal decreases in the summer and thermal increases in the winter. The portion of Brown's Creek from Oak Glen to the stone bridge is the most impacted by thermal warming, and despite increases in inputs from groundwater, according to the DNR, the temperature in this stretch had been noted to increase by as much as 2°C with an average increase of about 1°C.

Figure 19 shows the temperature differences between the McKusick Road site and the Hwy 96 (WOMP) site for periods of record when complete data has been available. The graph also shows a 14-day moving average line to better show the visual trend in the daily differences. The McKusick Road site is typically 1°C to 2°C greater than the Hwy 96 site, but has exceeded 2°C difference on many occasions.

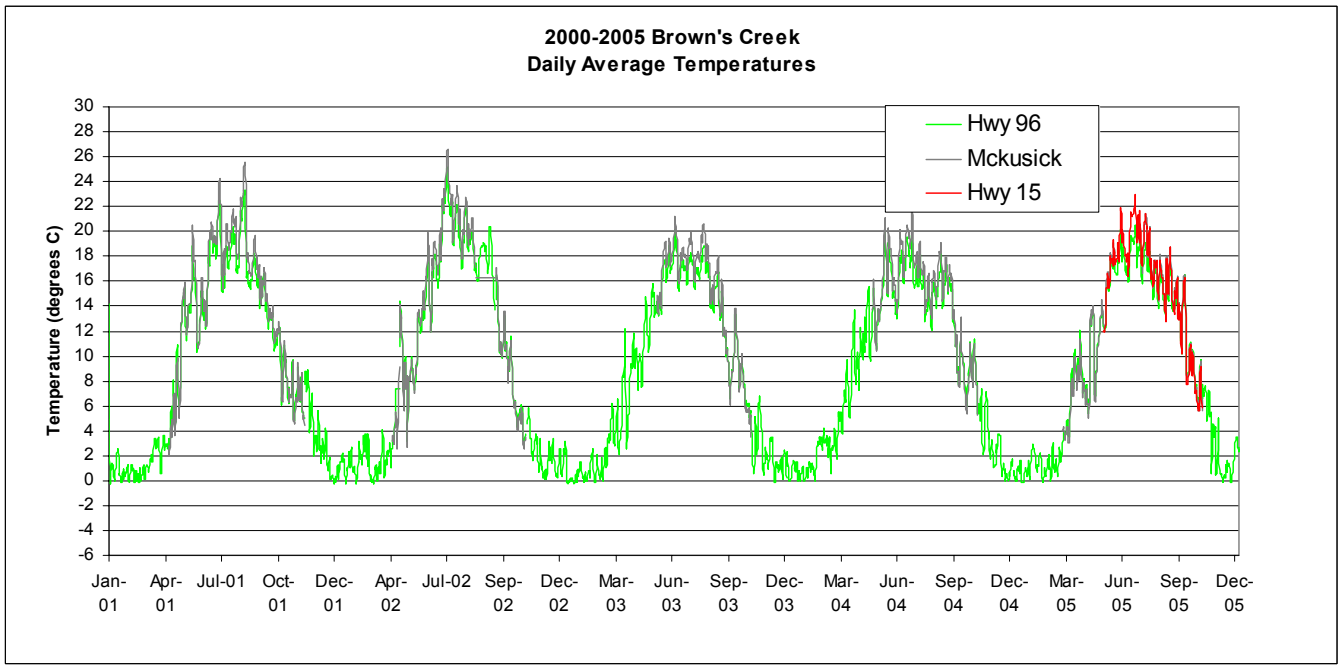


Figure 20: 2000-2005 Daily Average Temperatures

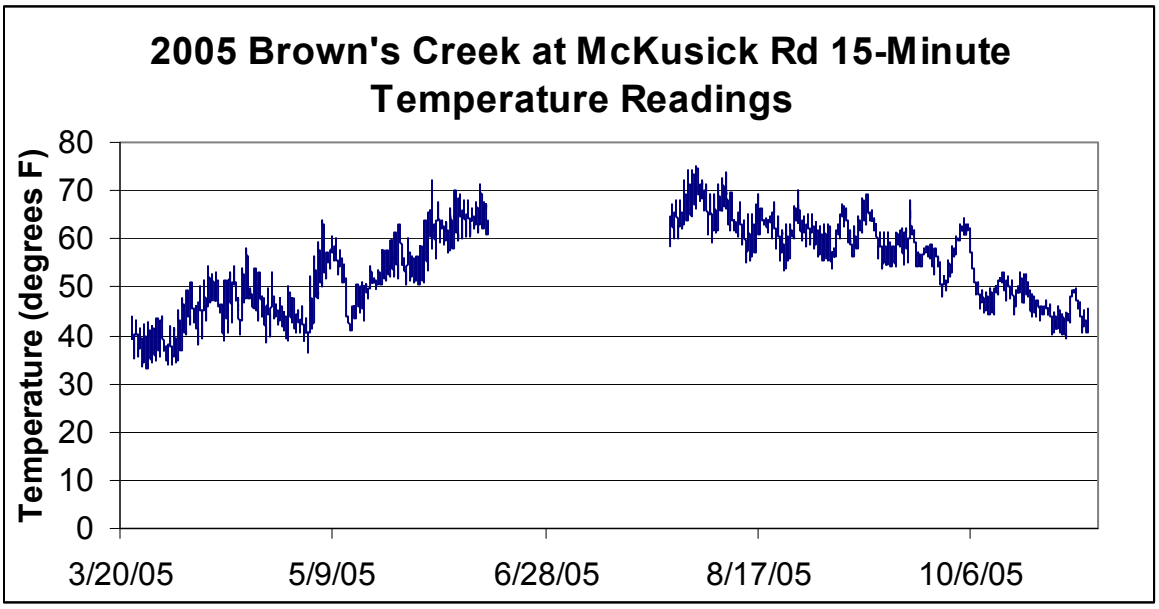


Figure 21: 2005 McKusick Road Temperature

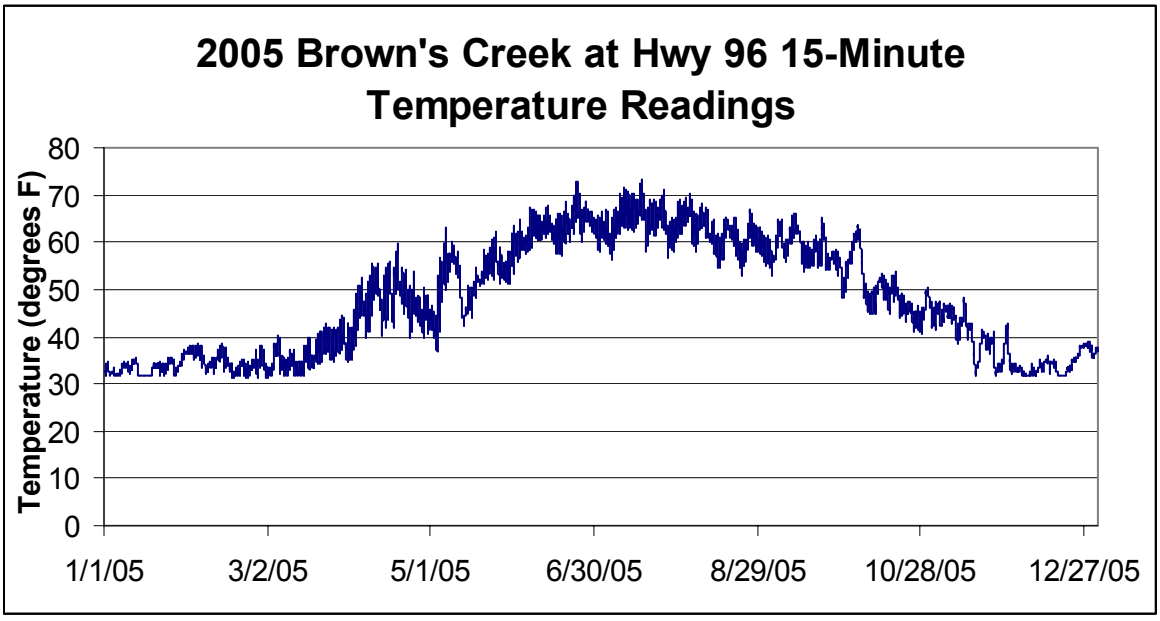


Figure 22: 2005 Hwy 96 (WOMP) Temperature

Efforts to improve habitat and water quality in Brown's Creek continue. With the goal of further reducing water temperatures and improving trout habitat, the city of Stillwater and the Minnesota DNR collaborated to construct a new stream channel along the Minnesota Zephyr rail line and

the Oak Glen Golf Course in 1999. This project created a new section of stream, 2,000 feet long (Figure 23), which replaces a 5,130-foot long section that flowed through the wetland just north of McKusick Lake and across the golf course (Figure 24). Water now moves through the new channel in about 30 minutes, compared with the 10 hours it took to flow through the wetland. This translates to cooler water, since it doesn't sit in the hot sun and warm up as it flows downstream. In addition, fish and insect habitat in the new channel is much better than in the old channel. The habitat is so much better that brown trout are now found farther upstream than ever before. Limiting high temperature inputs to Brown's Creek made additional improvements. During 2003, a project to divert suburban stormwater from Brown's Creek was completed. A ~2,000 acre area of Stillwater now is diverted into McKusick Lake and eventually to the St. Croix. This appears to have enhanced the thermal regime of the creek even more. Warming is still likely to occur in the area downstream of the realigned channel due to lack of shade and runoff from the golf course, but work is being done to address this issue. Recently the DNR and Trout Unlimited have worked with the golf course to improve trout habitat in what has been some of the poorest quality habitat for a number of years. Brown's Creek is probably at its thermal maximum for a cold-water stream, but continued efforts to improve shade through the golf course will likely improve temperature conditions.

Figure 23: New channel along the golf course. This photo shows the much-improved habitat, with many native shrubs and trees growing along the banks.

Figure 24: Old channel through golf course. Note lack of shade, and wide shallow channel.

4. MACROINVERTEBRATE DATA

Aquatic macroinvertebrate insects are small animal organisms that live their larval stage in a lake or stream. By identifying the types of macroinvertebrates present and their relative abundance, much can be revealed about water quality. Not all macroinvertebrates are equally affected by pollution. For example, stoneflies require clean, oxygenated water; whereas leeches and blackflies do not. Therefore, observed changes in macroinvertebrate communities can give information about changes in overall water quality.

Since the spring of 1998, volunteers have monitored Brown's Creek for macroinvertebrates and physical habitat in two locations. The volunteer-collected data will establish a long-term record about the stream's capacity to support various life forms, including trout. Site W3 is just over a mile from the mouth of Brown's Creek. Site W4 is near the mouth of Brown's Creek at Hwy 96. Both sites were monitored by students at Stillwater Area High School and led by teacher Andy Weaver. Site W4 could not be monitored in the spring of 2001 due to the flooding of Brown's Creek and tail water from the St. Croix River. A third sampling site (Site W8) at the creek crossing with Neal Avenue was added in spring of 2003 and is sampled by SAHS biology teacher Doug Long and his biology class. The WCD collected macroinvertebrate samples just upstream of Hwy 15 in order to provide data to better assess the classified impairment in this reach of stream. The Minnesota Pollution Control Agency classified the reach from Hwy 15 to the headwaters of the creek as impaired for aquatic life. The stressor in this reach is based on an index for biotic integrity of fish and macroinvertebrates not meeting the water quality and habitat criteria. All sites sampled by volunteers and the WCD were sampled using the multi-habitat sampling protocol.

Stream data was collected in the spring and fall including macroinvertebrate densities and diversity, physical characteristics of the stream, and observations about land use in the watershed. All monitoring used methods outlined in the National River Watch Network Benthic Macroinvertebrate Monitoring Manual, which includes using kick nets to collect

samples. These groups kick substrate, temporarily disturb vegetation, and scrub the rocks upstream from their nets and collect everything that washes into the nets. The procedure is repeated so that at least one replicate is collected. The National River Watch protocol recommends at least 100 insects collected per sample. All the data collectors observe and monitor the habitat surrounding the stream and score it for changes. After collection, samples are preserved, sorted, and identified to the family taxonomic level. Once the volunteers complete identification, the samples are sent to the WCD for quality control. At this point the WCD takes both the samples they collected and the volunteer collected samples and submits them to and outside source for QA/QC. In 2005, Byron Karns of the National Park Service provided quality control; verifying the identification of every macroinvertebrate turned in by the WCD and the volunteers. The WCD tracks and manages the collected data in a comprehensive database and submits the data to the Metropolitan Council.

The data from each site is analyzed by a number of criteria. The EPT represents the number of mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) families in each sample. These families represent the pollution intolerant macroinvertebrates. A higher EPT score reflects better water quality than a lower one. Another analytical tool is Hilsenhoff's Biotic Index, shown in Table 25. The biotic index summarizes the various pollution tolerance values of all families in a sample.

Table 26 lists macroinvertebrate sampling results for sites W3, W4, W8, and Hwy 15 for 1998-2005. The results from spring of 2001 for site W3 look unusual due to both the low number of organisms identified and the low biotic index, and should be viewed with the information that the river was flooded downstream during this time to the extent that sampling at site W4 was impossible.

Table 25: Evaluation of Water Quality Using Hilsenhoff's Biotic Index

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.0	Very poor	Severe organic pollution likely

The family biotic index (FBI) summarizes the various pollution tolerance values of all macroinvertebrate families in a sample; each macroinvertebrate family has a unique pollution tolerance value associated with it. FBI values range from 0 to 10, with *lower values reflecting higher water quality*. The FBI for W3 has ranged from 2.1 in 2001 to 4.4 in 2003, and the most recent sample was 3.7, in the very good range. The FBI for W4 ranges between 2.1 (excellent water quality) in 2000 to 4.8 (good water quality) in 2004. This site was in the good range in the spring of 2005 sample and in the excellent range in the fall of 2005. Site W8's FBI for the spring and fall samples were in the good range of characterized water quality. The FBI for W8 ranges between 3.2 (excellent water quality) in 2004 to 4.9 (good water quality). The FBI for Hwy 15 had a 4.9 (good water quality) and a 4.0 (very good water quality) in 2005.

Table 26: Volunteer and WCD Collected Macroinvertebrate Sampling Results

Site #	Date	# Organisms	EPT*	Hilsenhoff's Biotic Index*	Number of Families*	Dominant Family*	Dominant Family Tolerance Value*	Dominant Family %*
W3	5/98	195	8	3.2	17	Emidae	4	21.0
W3	10/98	194	7	3.7	10	Philoptomatidae	3	53.1
W3	5/99	218	7	3.9	11	Baetidae	4	38.1
W3	10/99	182	4	3.5	9	Philoptomatidae	3	34.5
W3	5/00	198	6	4.1	11	Chironomidae	6	31.6
W3	10/00	212	5	3.3	9	Philopotamidae	3	70.0
W3	5/01	75	6	2.1	9	Odontoceridae	0	41.3
W3	10/01	121	6	3.3	11	Baetidae	4	42.0
W3	5/02	116	4	3.9	9	Baetidae	4	28.4
W3	10/02	189	5	4.4	12	Baetidae	4	39.2
W3	5/03	122	5	4.4	9	Baetidae	4	28.7
W3	10/03	143	4	3.4	9	Philopotamidae	3	63.6
W3	5/04	96	6	3.9	11	Limnephilidae	4	31.3
W3	10/04	157	7	3.3	12	Philopotamidae	3	38.2
W3	5/05	315	5	4.8	14	Baetidae	4	27.3
W3	10/05	92	7	3.7	13	Elmidae	4	22.8
W4	5/98	172	7	3.0	11	Baetidae	4	24.4
W4	10/98	188	6	2.4	12	Glossomatidae	0	36.7
W4	4/99	232	5	4.4	10	Baetidae	4	42.7
W4	10/99	111	5	3.3	11	Perlodidae	2	40.0
W4	5/00	242	4	2.8	8	Perlodidae	2	46.0
W4	10/00	149	6	2.1	11	Brachycentridae	1	57.0
W4	5/01	Site Flooded—No macroinvertebrates found.						
W4	10/01	200	6	3.0	12	Brachycentridae	1	28.5
W4	5/02	90*	4	4.1	8	Baetidae	4	64.4
W4	10/02	204	4	4.3	9	Baetidae	4	62.3
W4	5/03	105	6	4.2	10	Chironomidae	6	28.6
W4	10/03	246	4	2.7	11	Brachycentridae	1	39.8
W4	5/04	89	6	3.8	11	Baetidae	4	25.8
W4	10/04	126	6	4.8	13	Chironomidae	6	29.6
W4	5/05	149	6	4.9	14	Chironomidae	6	34.9
W4	10/05	111	7	2.7	13	Brachycentridae	1	36.0
W8	5/03	106	2	4.4	7	Gammaridae	4	75.5
W8	10/03	107	4	3.8	6	Gammaridae	4	76.6
W8	5/04	119	4	4.2	10	Gammaridae	4	63.0
W8	10/04	72	2	3.2	6	Gammaridae	4	62.5
W8	5/05	129	5	4.9	12	Gammaridae	4	45.0
W8	10/05	101	1	4.5	6	Gammaridae	4	69.3
Hwy 15	4/05	154	4	4.9	8	Chironomidae	6	48.7
Hwy 15	10/05	112	5	4.0	9	Gammaridae	4	47.3

*Macroinvertebrate monitoring terms can be found in Appendix D

The dominant family percentage reflects the diversity of habitats for various macroinvertebrates within the stream. A low dominant family percentage reflects a good mix of organisms without one family dominating the stream. The dominant family percentage in W3 consistently reflects a good diversity of habitats, except for the fall of 2000 sample and fall of 2003 sample with greater than 60% Philopotamidae. The dominant family percentage in W4 reflects a good diversity of habitats, except for the fall of 2000 sample with nearly 60% Brachycentridae and the spring and fall samples of 2002 with greater than 60% Baetidae. Site W8 consistently reflects greater than 60% Gammaridae except in the spring 2005 sample, which suggests fewer habitats available for macroinvertebrates at this sampling site. The Hwy 15 site sampled by the WCD shows a dominant family percentage that reflects an average mix of organisms. The dominant family percentage at this site for both spring and fall, 2005 was nearly 50%. The dominant families for the spring and fall samples were Chironomidae and Gammaridae respectively. This may suggest differences in life cycles of organisms or some changes in dominant family during the year, and could also suggest that habitat changes during the year creating an environment where one family dominates the majority of the macroinvertebrate population. Appendix C shows all macroinvertebrate families collected in each sample.

B. CONCLUSIONS

The stream monitoring sites on Brown's Creek are producing valuable baseline water quality information that will be a helpful tool in determining a healthy balance of resources as the watershed continues to experience growth and changes in land use. To determine the health of the stream, discharge (base and storm), chemical, physical and biological parameters are compared on a year-to-year basis and with other streams in the region.

Baseflow at the mouth of the stream averaged approximately 7 cfs in 2001, 10 cfs in 2002, 7 cfs in 2003, 6.5 cfs in 2004, and 7 cfs in 2005. This reflects the observations from the previous years' monitoring efforts. While the base flow may fluctuate with climatic cycles, it provides a good point of reference for overall groundwater recharge to the stream. A drop in baseflow during periods of normal or high precipitation may suggest a loss of groundwater recharge in the watershed. It appears that the baseflow has remained relatively consistent for the past three years. In 2005, there were four large runoff events: 80 cfs on August 4th, 98 cfs on August 26th, 81 cfs on September 21st, and 108 cfs from the largest storm on the year on October 4th. All of these events were the result of high magnitude rainfall that fell in short amounts of time. The October 4th storm dominated the hydrology of Brown's Creek and most drainage areas in Washington County in 2005. Brown's Creek was at baseflow levels for the majority of the year.

While phosphorous has not been identified as a problem nutrient at the mouth or within other reaches of the stream, it is a common nutrient associated with lake eutrophication and is therefore routinely monitored in streams throughout the state. Total loading and loading per unit area are additional tools to help assess the health of the stream. During 2005, annual loading rates per unit area (Kg/ha) at all sites except the McKusick Road site were within the pasture land-use range (Figure 14). The McKusick Road site exhibited annual loading rates per unit area (Kg/ha), which were within the forest land-use range. In 2005, subwatershed drainage areas were refined from 2004 to provide more accurate annual loading rates. The average total phosphorus concentration in the stream

at the mouth was 0.26 mg/L in 2005. This is consistent with the high impact range according to the H&H study (Table 27).

Total suspended solids (TSS) concentration is a good measure of the particulate matter in the stream and can be correlated to disturbances within the watershed. The average TSS concentration in 2005 at the mouth was 184 mg/L, 109 mg/L at McKusick Road, and 81 mg/L at Hwy 15. The TSS concentrations at the mouth and McKusick Road were within the high impact range and the Hwy 15 site concentration was within the moderate impact range according to the H&H study (Table 27). For comparison during 2004, TSS concentrations averaged 78 mg/L at the mouth, and 83 mg/L at McKusick. Therefore turbidity or suspended solids are and should continue to be monitored for Brown's Creek.

Table 27: Issues Matrix: Water Quality

	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)
Low Impact	0-0.15	0-30
Moderate Impact	0.15-0.25	30-100
High Impact	>0.250	>100

Brown's Creek Watershed District Hydrologic/Hydraulic Study, November 1999

Temperatures in Brown's Creek are at the thermal maximum for a cold-water stream. Maximum temperatures for young of the year Brown trout were regularly exceeded during the 2000-2002 seasons at both the mouth and at McKusick Road. However, in 2003 cooler temperatures and little stormwater runoff contributed no exceedences of the maximum temperature thresholds. In 2004 only two days exceeded the high-impact temperature threshold and in 2005, only the Hwy 15 site had temperatures that exceeded the high-impact temperature threshold. This reach of stream is not known to contain trout and temperatures are not currently suitable for trout survival compared to the downstream, high-groundwater input reaches of Brown's Creek. Continued efforts to improve shade throughout critical areas will likely improve temperature conditions.

Trout have been stocked annually in Brown's Creek since 1958 from the Highway 96 culvert to the stone bridge. Recent fish surveys show not only an increase in the numbers of trout, but also an increase in the age of the trout. Scale samples taken in 1998-2000 suggest that about 10% of the trout captured are age three or older, and 2% are five or older. This is typical of natural systems, and rare in the metro area. Possible factors contributing to the improving trout populations include improvements in habitat and water quality, and improvements in the genetic composition and diversity of the trout stocked.

Interpretation of macroinvertebrate sampling results in Brown's Creek shows the creek to have consistently good to excellent water quality. Hilsenhoff's biotic index, which summarizes the pollution tolerance of the families, reflects good to excellent water quality. Dominant family percentage has almost always been less than 50% at both downstream sampling locations, which shows that the stream has a diverse habitat to support a variety of organisms. The upstream sampling location has shown to have a slightly less diverse habitat with more than 50% dominant family percentage but still indicating good water quality. This habitat diversity is also reflected in the number of families observed as well as the EPT ratio.

Table 28. Comparison of 2005 Monitoring Data to BCWD 3rd Generation Management Plan Goals

BCWD 3rd Generation Management Plan Stream Goals	Brown's Creek at Hwy 15	Brown's Creek at McKusick Road	Brown's Creek at Neal Ave	Brown's Creek Outlet
Hilsenhoff Macroinvertebrate Familty Biotic Index (FBI) of 4.5 or lower	Spring FBI: 4.9, Fall FBI: 4.0	NA	Spring FBI: 4.9, Fall FBI: 4.5	Spring FBI: 4.9, Fall FBI: 2.7
Macroinvertebrate Dominant family percentage (DFP) of 50% or lower	Spring DFP: 48.7%, Fall DFP: 47.3%	NA	Spring DFP: 45.0%, Fall DFP: 69.3%	Spring DFP: 34.9%, Fall DFP: 36.0%
Maintain a minimum daily dissolved oxygen concentration of 7 mg/L	NA	68 days in 2005 lower than 7 mg/L	NA	NA
Maintain an instantaneous TSS concentration of 25 mg/L or lower	9 of 14 sample exceedences	10 of 17 sample exceedences	NA	8 of 19 sample exceedences
Temperatures should not be at or above the 20° C (68° F) limit more than 12 hours in a 24-hour time period, and never reach the trout high-impact temperature zone of 25° C (77° F)	22-12 hour period exceedences over 20° C (68° F), 18 days where temperatures were ≥ 25° C (77° F)	25-12 hour period exceedences over 20° C (68° F), 2 days where temperatures were ≥ 25° C (77° F)	NA	3-12 hour period exceedences over 20° C (68° F), 0 days where temperatures were ≥ 25° C (77° F)

C. RECOMMENDATIONS

- Continue to gather baseline water quality data at three sites on Brown's Creek as BCWD continues to become more developed.
- Continue phosphorus loading and total suspended solid analysis on Brown's Creek at mouth, McKusick Road, and Hwy 15 to monitor any potential trends.
- Implement more activities to de-list the headwaters of Brown's Creek from the MPCA's impaired waters list.
- Support continued biological monitoring of Brown's Creek through the volunteer efforts of Stillwater Area High School. This provides not only valuable baseline information about the stream, but also education opportunities to residents of and around Brown's Creek Watershed District.
- Work with the MN DNR to implement fisheries studies on the headwaters of Brown's Creek to determine the nature of the fish index for biotic integrity impairment in this reach of stream.
- Monitor how well the diversion structure is operating for limiting thermal impacts and nutrient impacts to Brown's Creek.
- Conduct macroinvertebrate monitoring at the McKusick Road site in order to assess watershed plan macroinvertebrate goal satisfaction.
- Install long-term dissolved oxygen sensors (luminescent sensors for accuracy without numerous recalibrations) at the Mouth and Hwy 15 stream sites in order to assess watershed plan dissolved oxygen goal attainment.
- Consider realignment of stream channel between Hwy 15 and Hwy 96 to improve temperatures, geomorphology, and habitat for aquatic biota.

APPENDIX A - WATER QUALITY DATA – BY LAKE, DATE, AND ANNUAL AVERAGE

Brown's Creek Watershed Lakes: Benz, Goggin's, Kismet, Long, and South School Section

Benz Lake
City of Grant

Vital Statistics

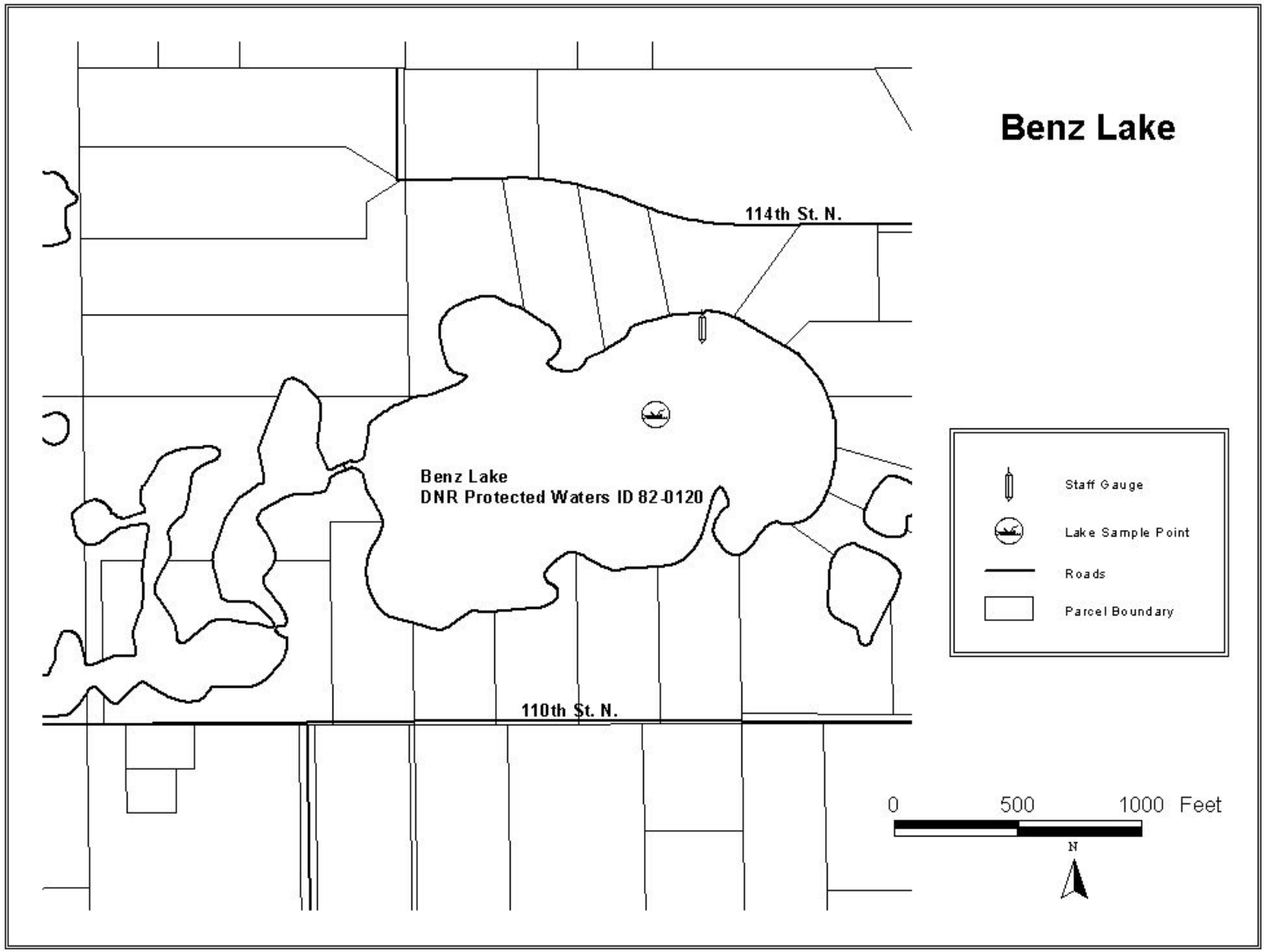
DNR ID #: 82-0120
LOCATION: SE$^{1/4}$ Section 2, T30N-R21W
MUNICIPALITY: City of Grant
LAKE SIZE: 37.6 Acres
MAXIMUM DEPTH: Not Available
ORDINARY HIGH WATER MARK: 954.07 Feet*
100-YEAR HIGH WATER LEVEL: 955.30 Feet
**Reduced by 4.84 feet due to benchmark error*

Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/L)	Surface Temperature Levels (Celsius)
4/11/2005	0.177	54	0.91	7.40	12.8
4/28/2005	0.120	22	1.22	6.34	11.2
5/11/2005	0.161	37	0.91	6.58	16.3
5/26/2005	0.159	23	0.91	3.93	16.8
6/8/2005	0.260	62	0.76	5.02	23.4
6/23/2005	0.142	84	0.76	9.29	26.6
7/5/2005	0.170	89	0.46	8.02	24.0
7/18/2005	0.211	120	0.46	5.92	27.9
8/5/2005	0.186	140	0.30	3.88	25.8
8/19/2005	0.150	140	0.46	5.87	23.4
8/31/2005	0.212	120	0.46	11.15	24.8
9/15/2005	0.138	100	0.46	5.26	21.5
9/30/2005	0.260	120	0.46	10.13	17.3
10/14/2005	0.197	94	0.46	9.18	14.3
2005 Average	0.182	86	0.64	7.00	20.4

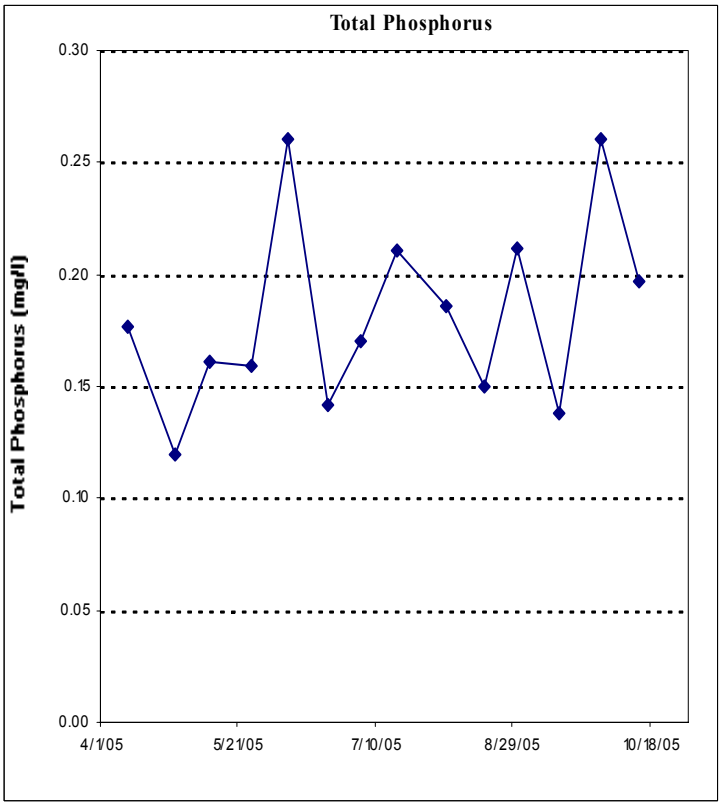
	High	High Date	Low	Low Date	Average
2005 Elevation (ft)	954.44	6/8/2005	953.75	9/14/2005	954.15

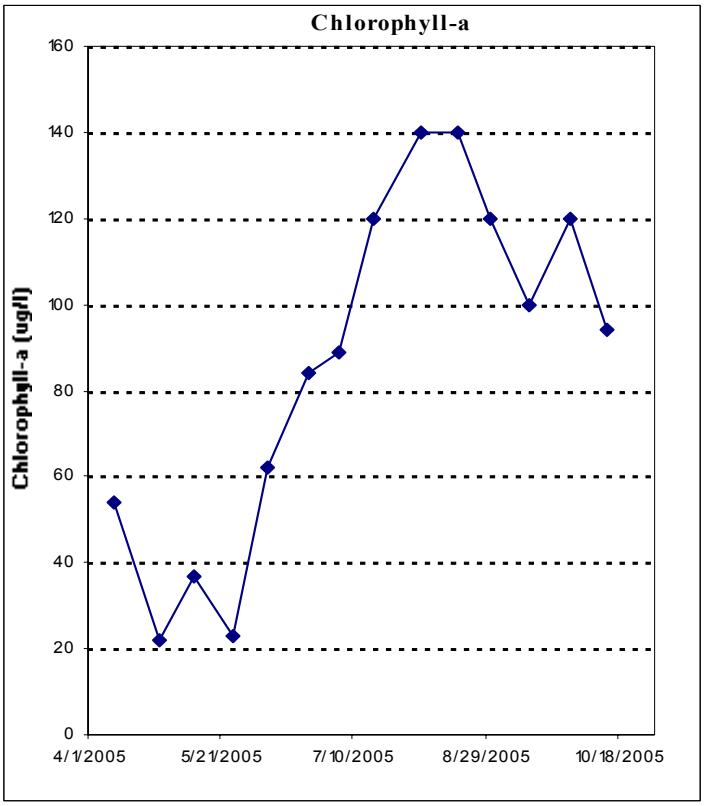
Lake Water Quality Summary

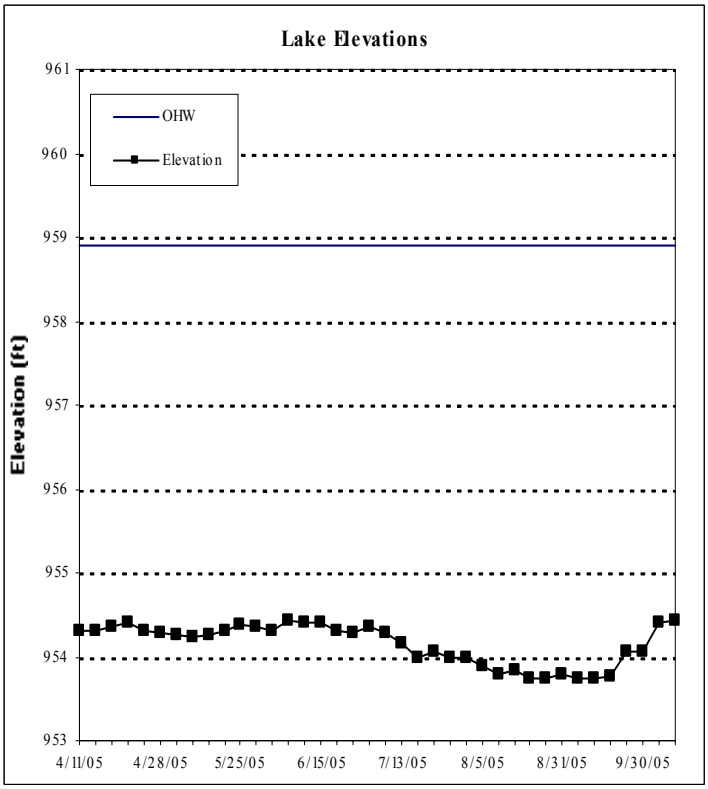
	Trophic Status	Lake Grades					
	2005	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Hypereutrophic	F	NA	NA	NA	NA	NA
Chlorophyll-*a* (ug/l)	Hypereutrophic	F	NA	NA	NA	NA	NA
Secchi disk (ft)	Hypereutrophic	F	NA	NA	NA	NA	NA
Overall	Hypereutrophic	F	NA	NA	NA	NA	NA

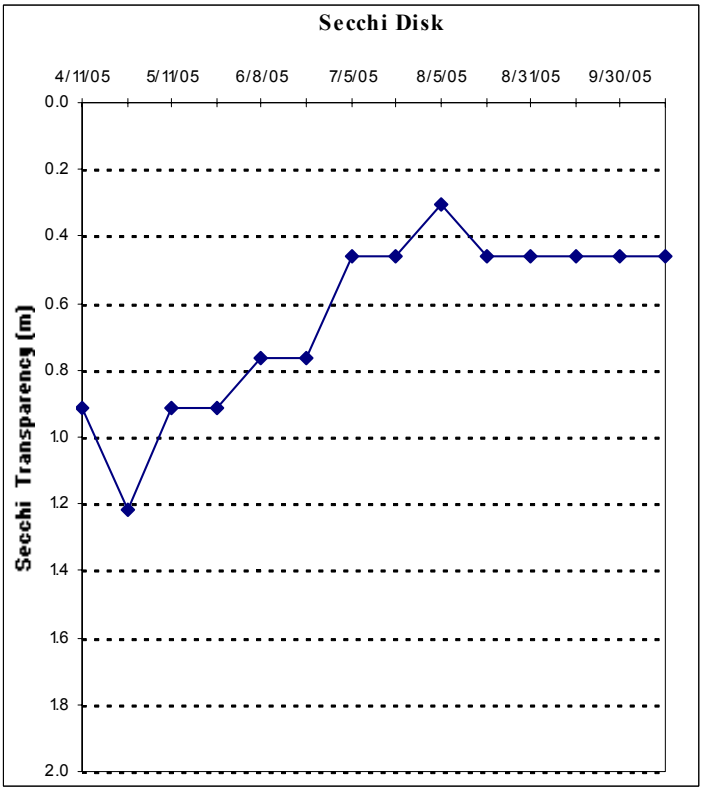

Benz Lake
114th St. N.
Benz Lake
DNR Protected Waters ID 82-0120
110th St. N.
Staff Gauge
Lake Sample Point
Roads
Parcel Boundary
0
500
1000 Feet
N

Benz Lake
City of Grant



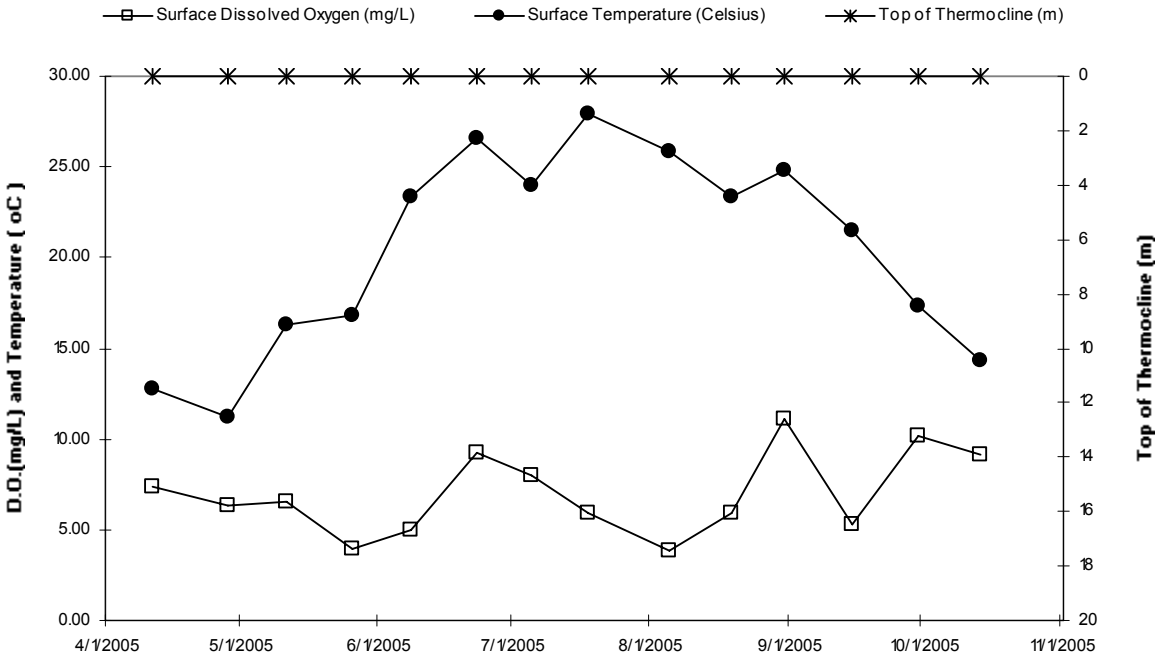






Benz Lake
City of Grant

Dissolved Oxygen, Temperature, and Top of Thermocline by Sampling Date

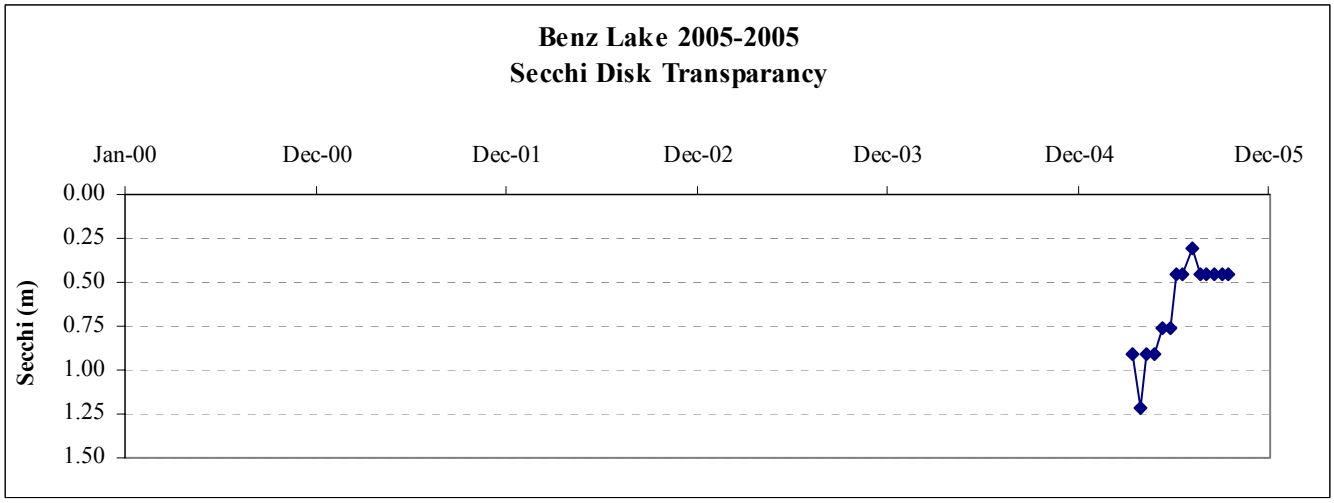


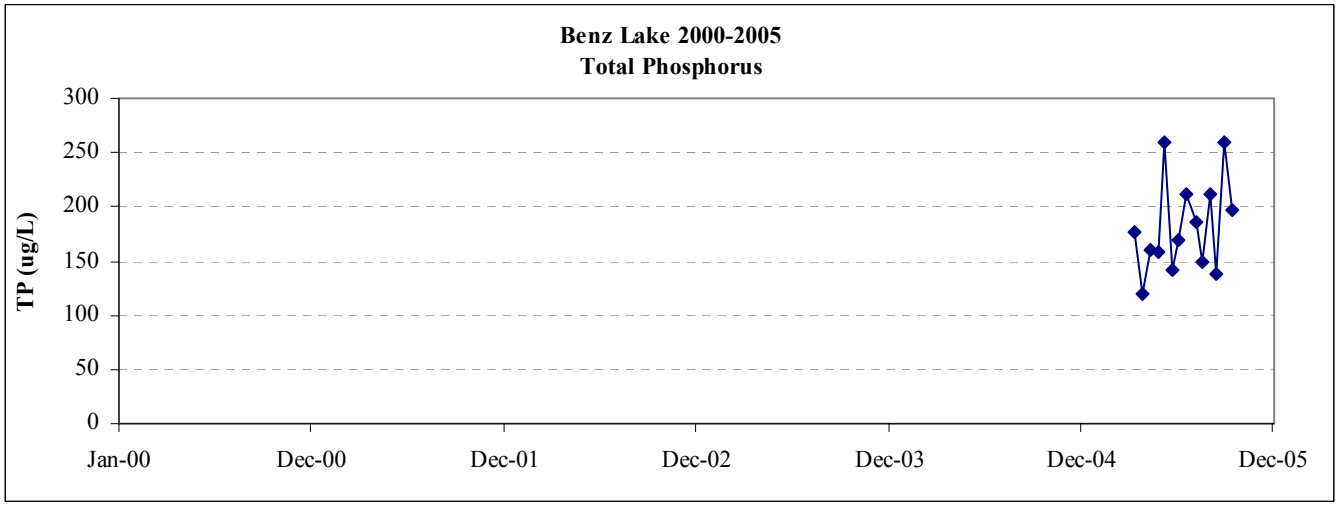
Dissolved Oxygen and Temperature Profile by Sampling Date and Depth

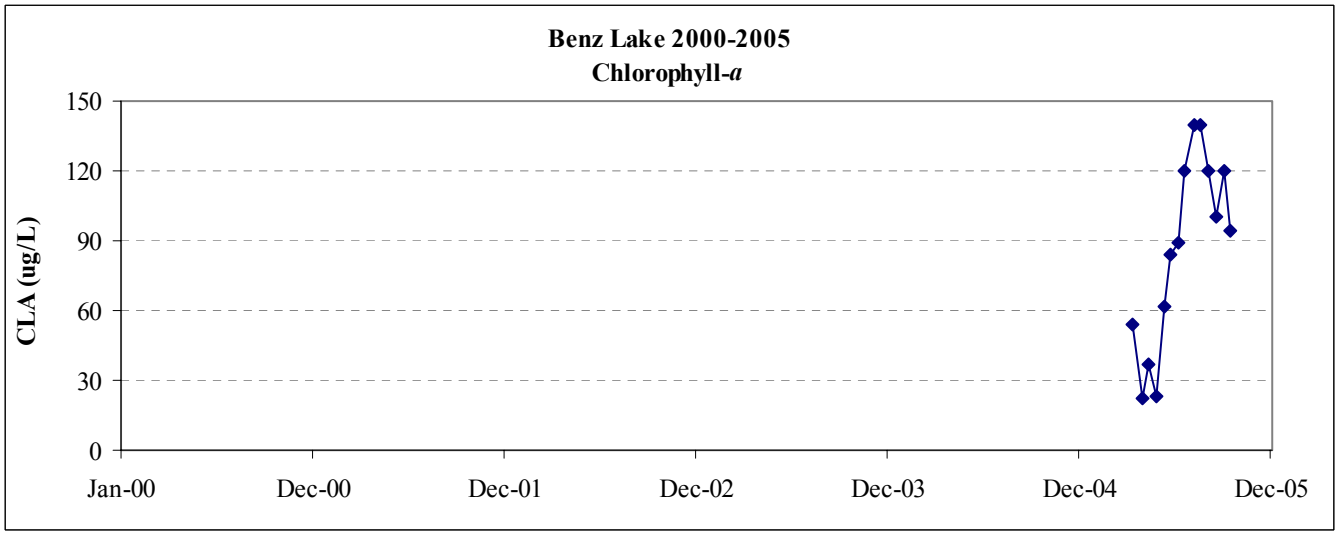
Sampling Date

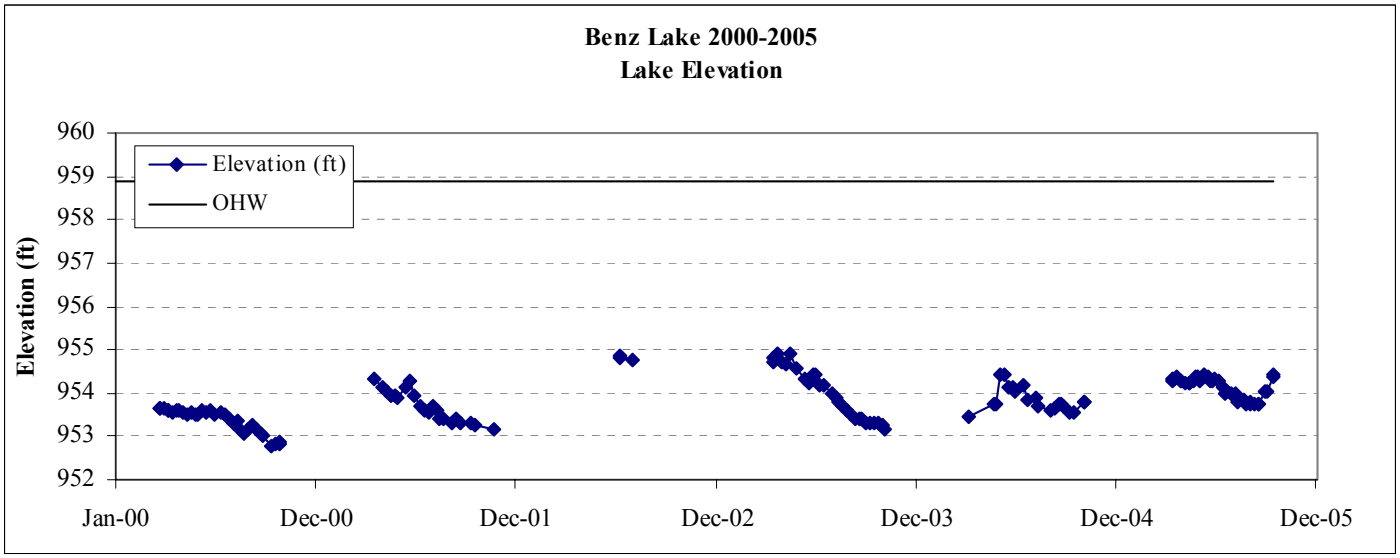
Depth (m)	4/11/2005		4/28/2005		5/11/2005		5/26/2005		6/8/2005		6/23/2005		7/5/2005		7/18/2005		8/5/2005		8/19/2005		8/31/2005		9/15/2005		9/30/2005		10/14/2005	
	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp
surface	7.40	12.8	6.34	11.2	6.58	16.3	3.93	16.8	5.02	23.4	9.29	26.6	8.02	24.0	5.92	27.9	3.88	25.8	5.87	23.4	11.15	24.8	5.26	21.5	10.13	17.3	9.18	14.3
1	7.40	12.7	6.15	11.2	6.28	16.2	3.77	16.7	5.06	23.3	8.40	26.5	6.11	23.6	5.72	27.9	2.91	25.7	5.00	23.3	11.46	24.6	5.24	21.4	10.12	17.1	8.83	14.0
2	7.37	12.6	6.09	11.2	5.86	16.0	3.60	16.6	3.42	22.8	0.42	24.5	4.13	23.5	5.35	27.9	2.04	25.5	3.70	23.3	6.23	22.4	4.89	21.3	8.87	16.5	8.03	13.8
3																												
4																												
5																												
6																												
7																												
8																												
9																												
10																												
No Thermocline Present (m)																												

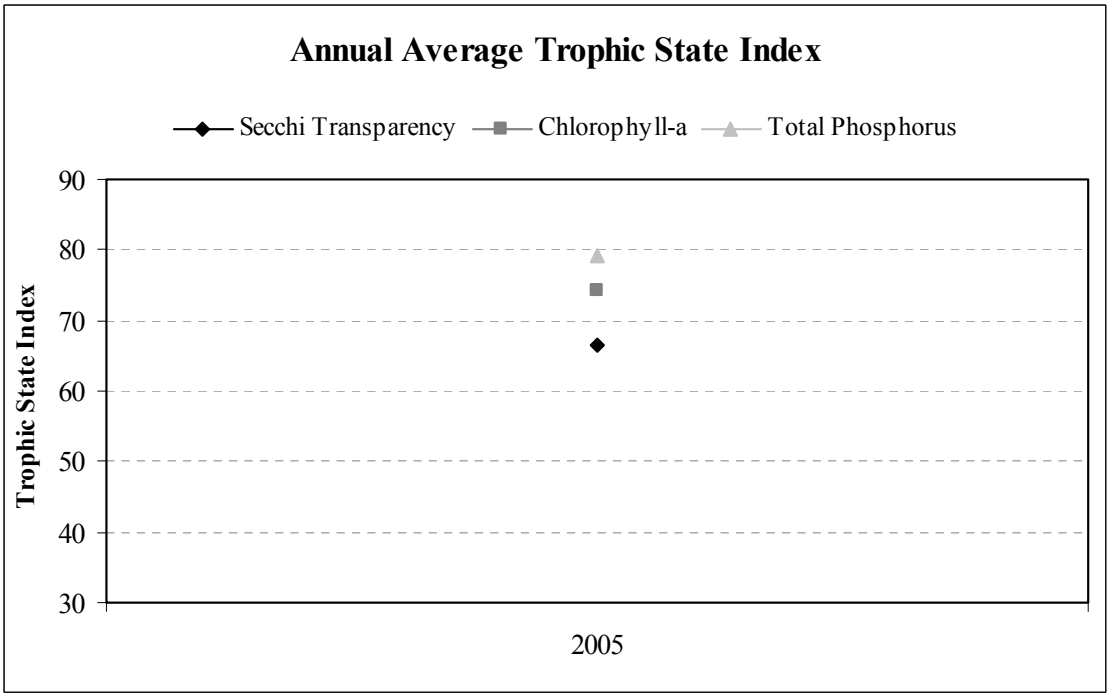
Benz Lake
City of Grant








Benz Lake 2000-2005
Lake Elevation
Elevation (ft)
OHW
960
959
958
957
956
955
954
953
952
Jan-00
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05


Annual Average Trophic State Index
Secchi Transparency
Chlorophyll-a
Total Phosphorus
Trophic State Index
90
80
70
60
50
40
30
2005

Goggin's Lake
May Township

Vital Statistics

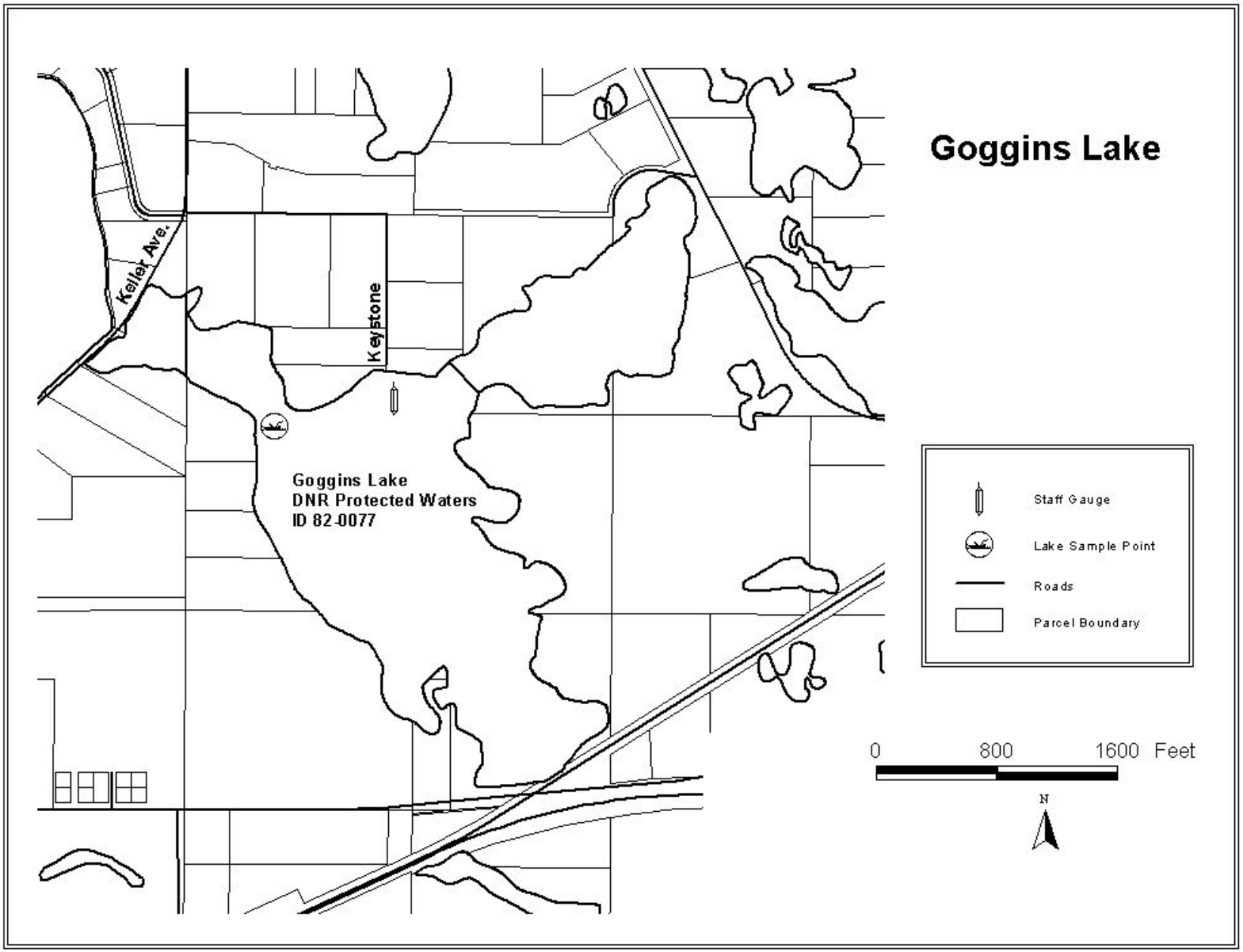
DNR ID #: 82-0077
LOCATION: NW$^{1/4}$ Section 31, T31N-R20W
MUNICIPALITY: May Township
LAKE SIZE: 41 Acres
MAXIMUM DEPTH: 15 ft
ORDINARY HIGH WATER MARK: 966.50 ft
100-YEAR HIGH WATER LEVEL: 972.20 Feet

Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/L)	Surface Temperature Levels (Celsius)
4/15/2005	0.104	17	1.68	6.83	12.4
4/28/2005	0.052	10	1.52	6.74	11.1
5/9/2005	0.042	6	2.13	6.32	15.3
5/26/2005	0.044	7	2.74	5.30	15.9
6/8/2005	0.045	9	2.74	4.74	22.4
6/23/2005	0.054	23	1.83	8.93	25.8
7/5/2005	0.092	67	0.76	9.36	23.1
7/25/2005	0.102	88	0.61	10.68	26.3
8/5/2005	0.094	74	0.46	4.94	24.8
8/17/2005	0.076	45	0.61	9.17	23.7
8/30/2005	0.082	36	0.61	10.07	24.7
9/15/2005	0.130	80	0.46	7.03	21.0
9/30/2005	0.154	62	0.46	9.51	16.2
10/14/2005	0.083	31	0.61	8.27	14.0
2005 Average	0.082	40	1.23	7.71	19.8

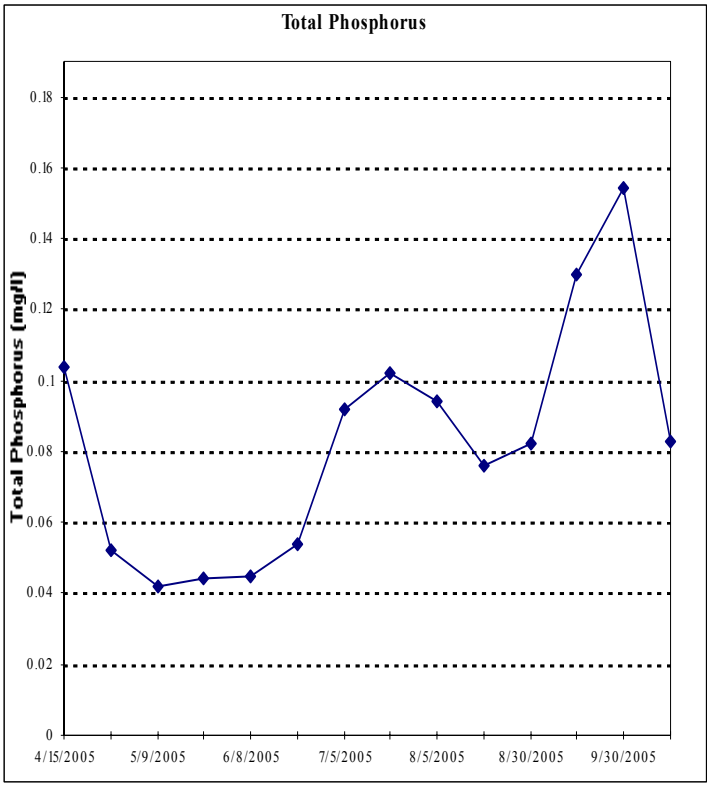
	High	High Date	Low	Low Date	Average
2005 Elevation (ft)	968.70	4/11/2005	967.52	9/15/2005	968.31

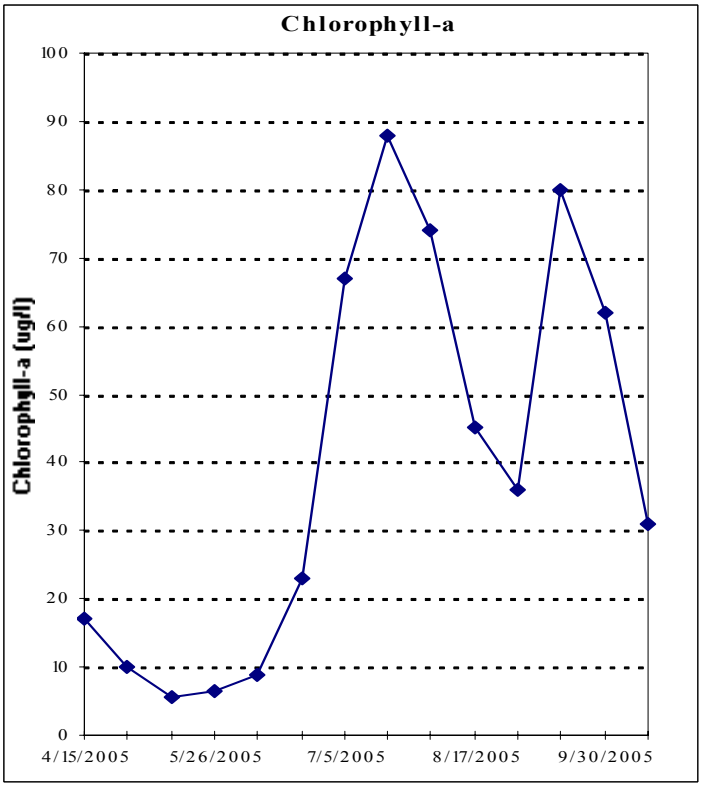
Lake Water Quality Summary

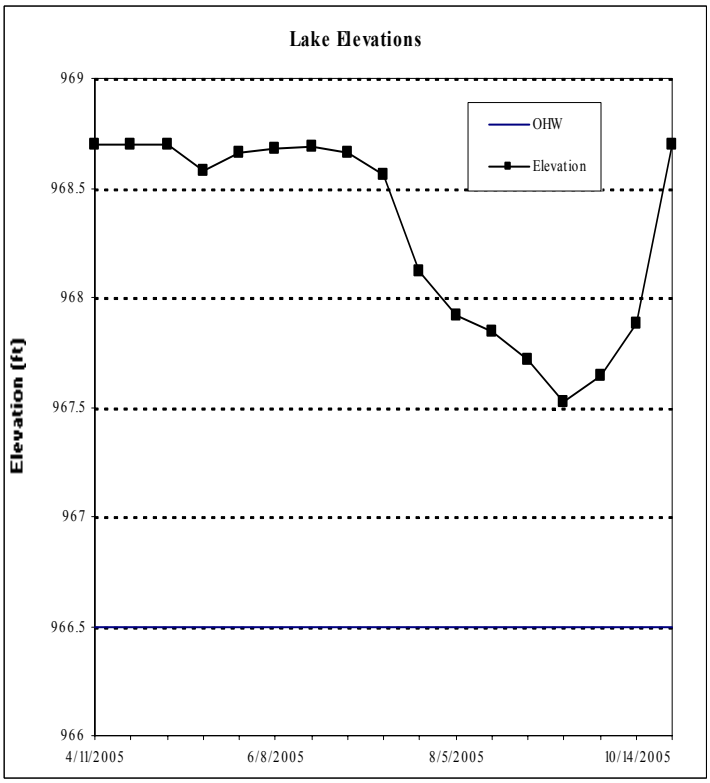
	Trophic Status	Lake Grades					
	2005	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Hypereutrophic	D	C	D	D	D	D
Chlorophyll-*a* (ug/l)	Hypereutrophic	C	C	C	C	C	C
Secchi disk (ft)	Eutrophic	C	D	D	D	D	D
Overall	Hypereutrophic	C-	C-	D+	D+	D+	D+

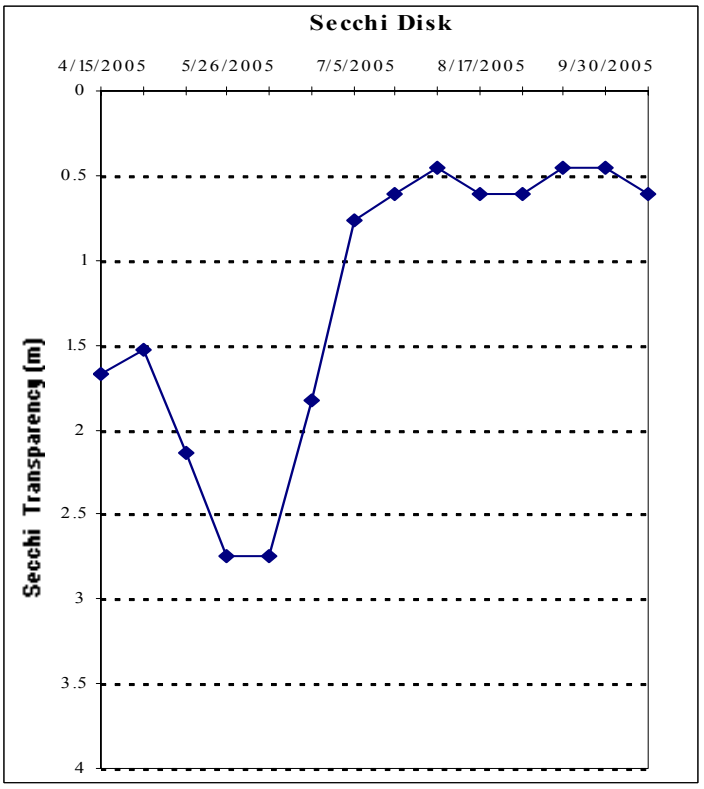

Goggins Lake
Keller Ave.
Keystone
Goggins Lake
DNR Protected Waters
ID 82-0077
Staff Gauge
Lake Sample Point
Roads
Parcel Boundary
0
800
1600 Feet
N

Goggin's Lake
May Township



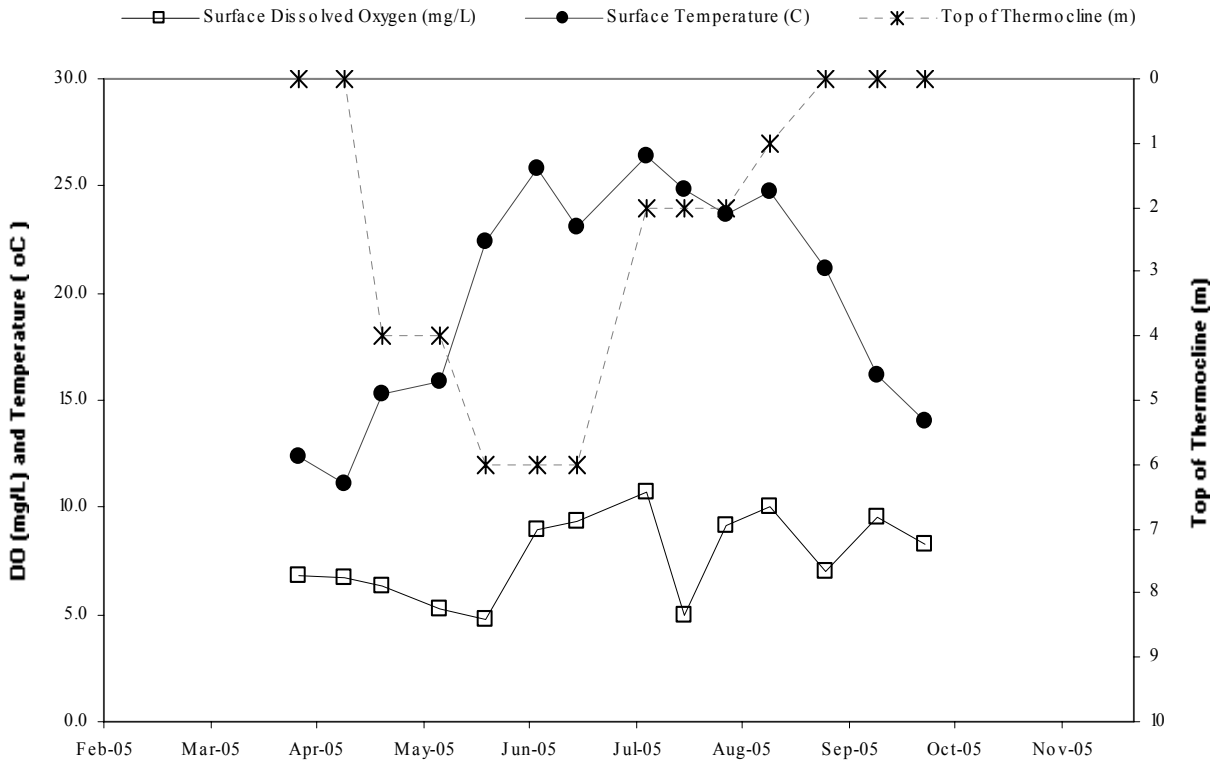






Goggin's Lake
May Township

Dissolved Oxygen, Temperature, and Top of Thermocline by Sampling Date

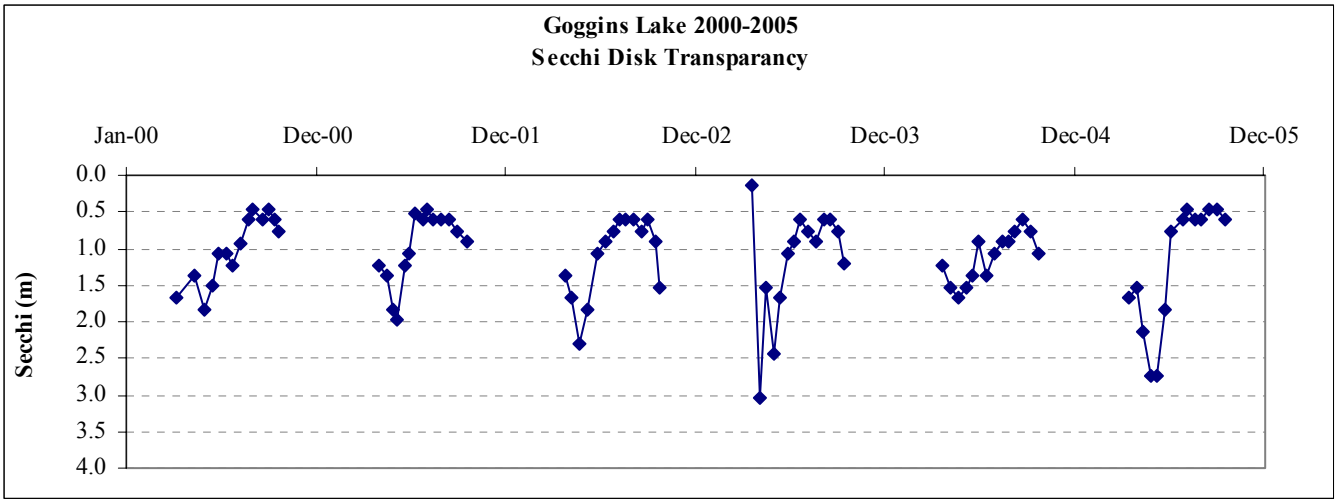


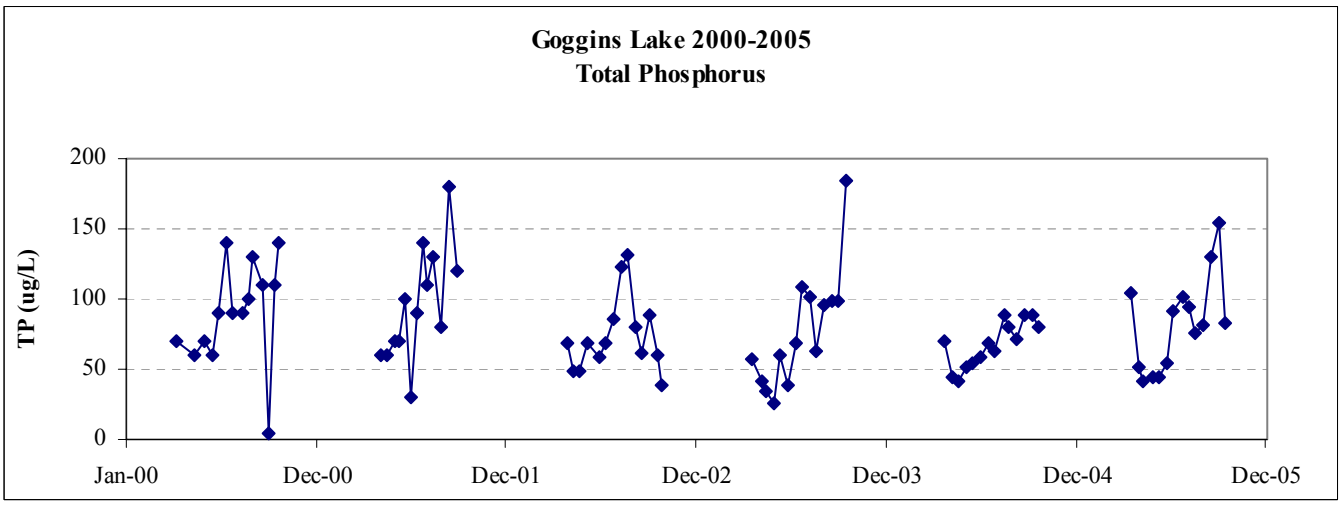
Dissolved Oxygen and Temperature Profile by Sampling Date and Depth

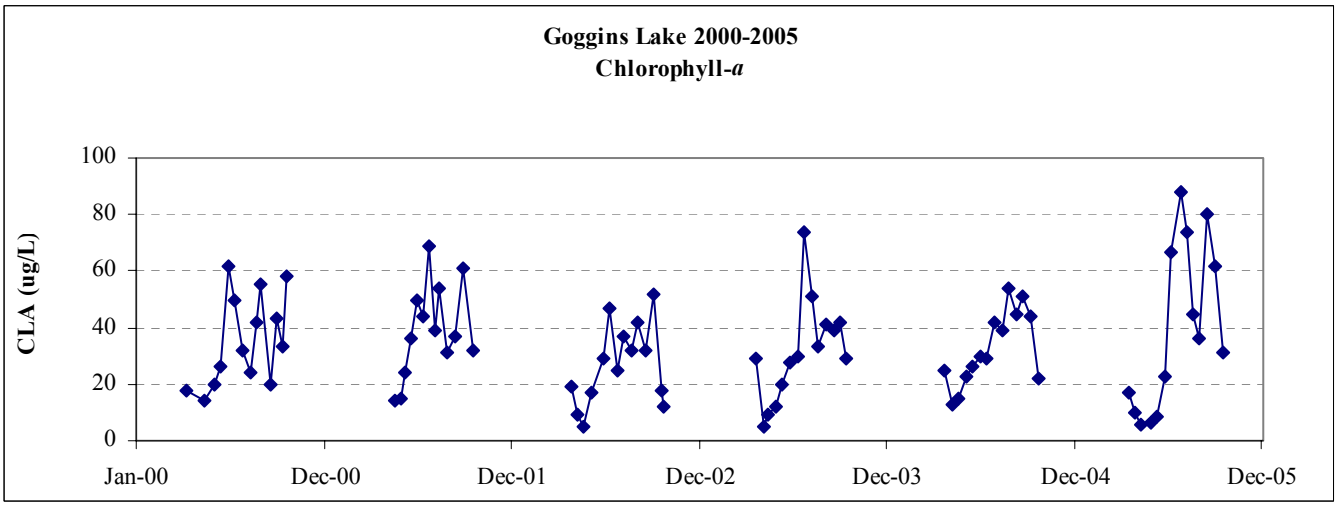
Sampling Date

Depth (m)	4/15/2005		4/28/2005		5/9/2005		5/26/2005		6/8/2005		6/23/2005		7/5/2005		7/25/2005		8/5/2005		8/17/2005		8/30/2005		9/15/2005		9/30/2005		10/14/2005	
	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp
surface	6.83	12.4	6.74	11.1	6.32	15.3	5.30	15.9	4.74	22.4	8.93	25.8	9.36	23.1	10.68	26.4	4.94	24.8	9.17	23.7	10.07	24.7	7.03	21.1	9.51	16.2	8.27	14.0
1	6.75	12.4	6.53	11.0	6.20	15.2	5.19	15.9	4.65	22.1	8.40	25.8	8.94	23.1	10.12	26.4	5.39	24.9	8.70	23.5	9.33	24.3	6.52	21.1	8.83	16.2	8.11	13.7
2	6.30	12.4	6.50	10.9	6.30	15.2	5.10	15.8	4.32	21.8	7.25	24.7	8.77	23.0	6.56	26.1	4.92	24.7	6.78	23.4	5.89	22.5	6.68	21.1	8.96	16.1	8.38	13.6
3	6.42	12.2	6.23	10.9	6.28	15.1	4.95	15.6	4.30	21.3	4.88	23.7	8.18	23.0	0.54	24.3	0.92	24.0	2.14	22.6	2.24	22.0	6.44	21.0	8.98	16.0	8.36	13.5
4	6.11	11.0	6.33	10.2	5.67	12.4	5.00	15.0	3.91	16.5	1.25	18.8	0.26	21.0	0.60	19.9	0.84	19.5	0.42	20.0	0.41	20.7	5.26	20.9	8.73	16.0	7.81	13.3
5	0.25	10.3	2.69	9.9	2.76	10.3	2.45	13.4	0.23	15.6	0.32	16.7	0.09	17.7	0.62	18.3									0.61	16.1	0.40	13.6
6																												
7																												
8																												
9																												
10																												
Top of Thermocline (m)	0		0		4		4		3		3		3		2		2		2		1		0		0		0	

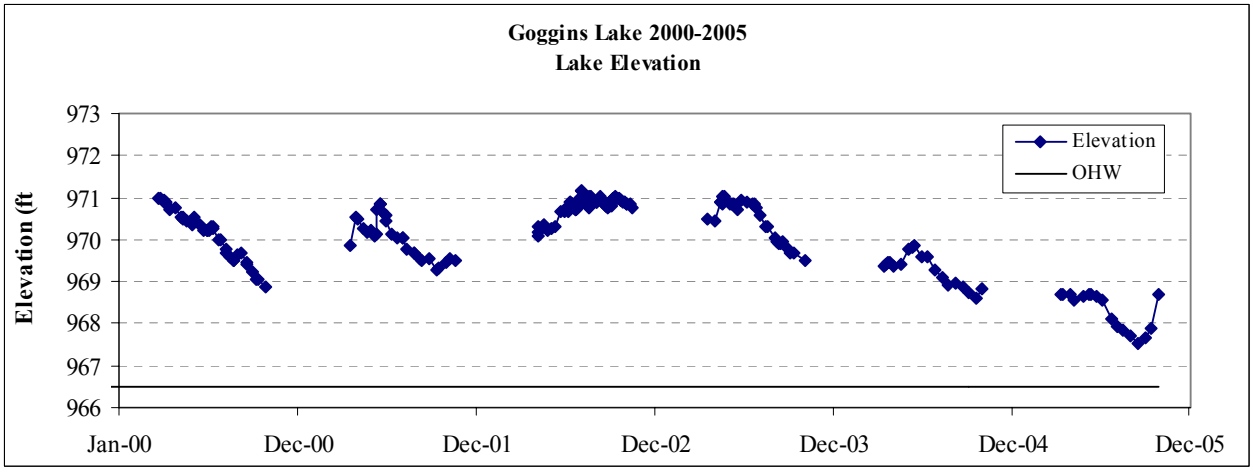
Goggin's Lake
May Township

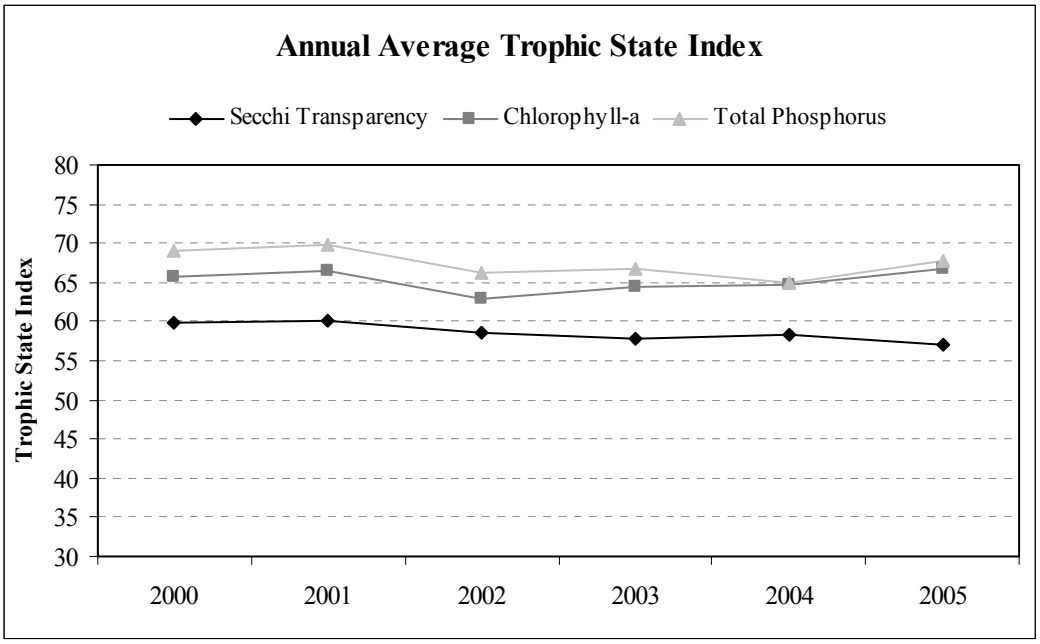






Goggin's Lake
May Township





Kismet Basin
City of Grant

Vital Statistics

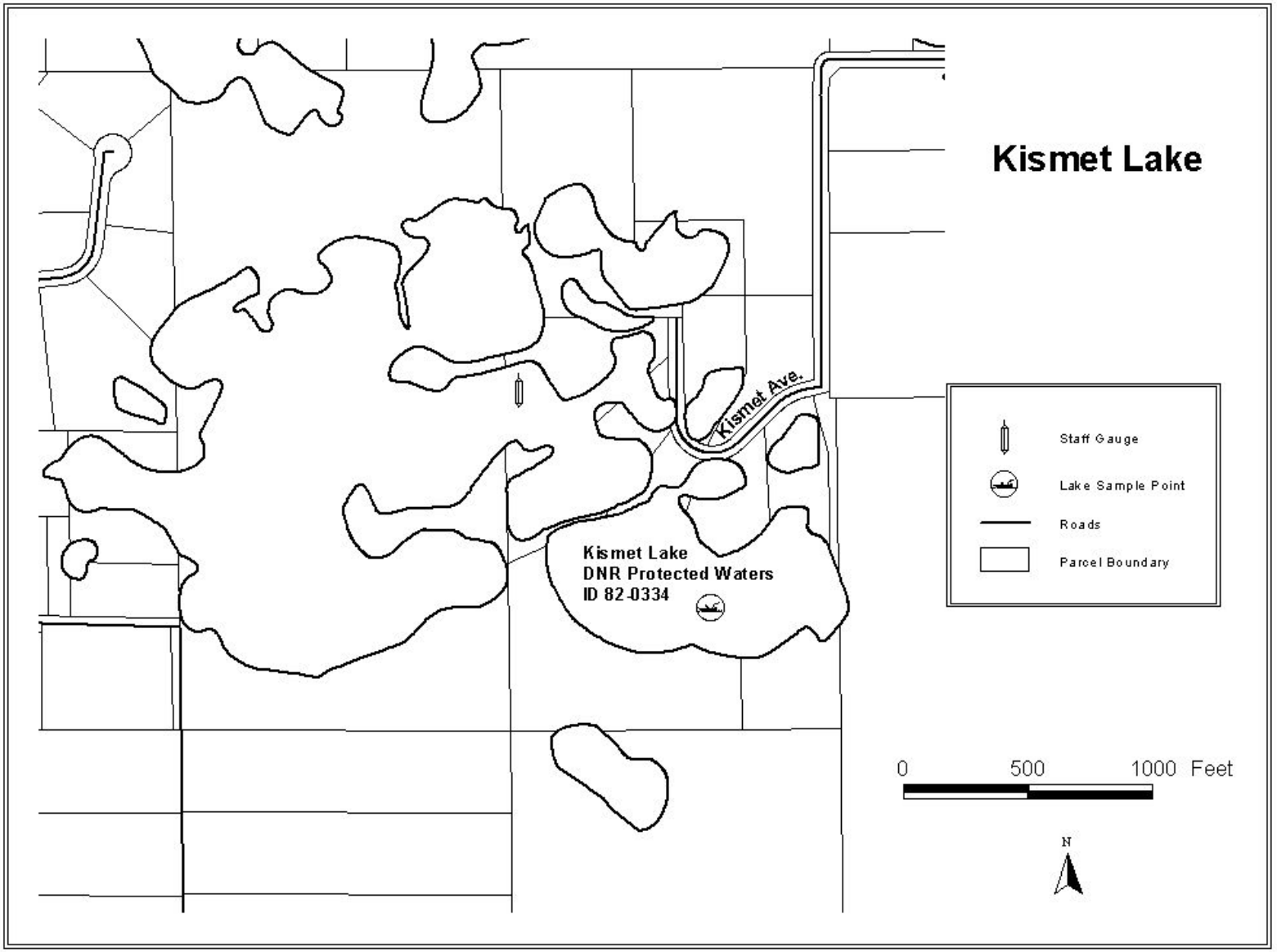
DNR ID #: 82-0334
LOCATION: $S^{1/2}$ Section 11, T30N-R21W
MUNICIPALITY: City of Grant
LAKE SIZE: 23 Acres
MAXIMUM DEPTH: 12 ft
ORDINARY HIGH WATER MARK: 943.50 ft
100-YEAR HIGH WATER LEVEL: 944.90 Feet

Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Chloride Ions (mg/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/L)	Surface Temperature Levels (Celsius)
4/11/2005	0.026	12	6	2.59	6.28	13.0
4/28/2005	0.033	13	8	2.13	6.30	11.2
5/11/2005	0.031	10	7	2.44	5.59	16.3
5/26/2005	0.032	10	5	2.29	4.67	17.3
6/8/2005	0.032	8	6	2.29	4.13	23.5
6/23/2005	0.027	8	5	2.13	8.13	27.7
7/5/2005	0.046	17	6	1.98	6.89	24.1
7/18/2005	0.033	11	6	2.29	7.51	28.4
8/5/2005	0.038	18	4	1.98	4.30	26.4
8/19/2005	0.034	39	5	1.52	5.72	23.5
8/31/2005	0.040	27	5	1.52	7.63	24.7
9/15/2005	0.038	41	7	1.52	4.72	21.5
9/28/2005	0.024	29	6	2.44	10.79	17.8
10/14/2005	0.036	28	5	1.83	8.83	14.1
2005 Average	0.034	19	6	2.07	6.54	20.7

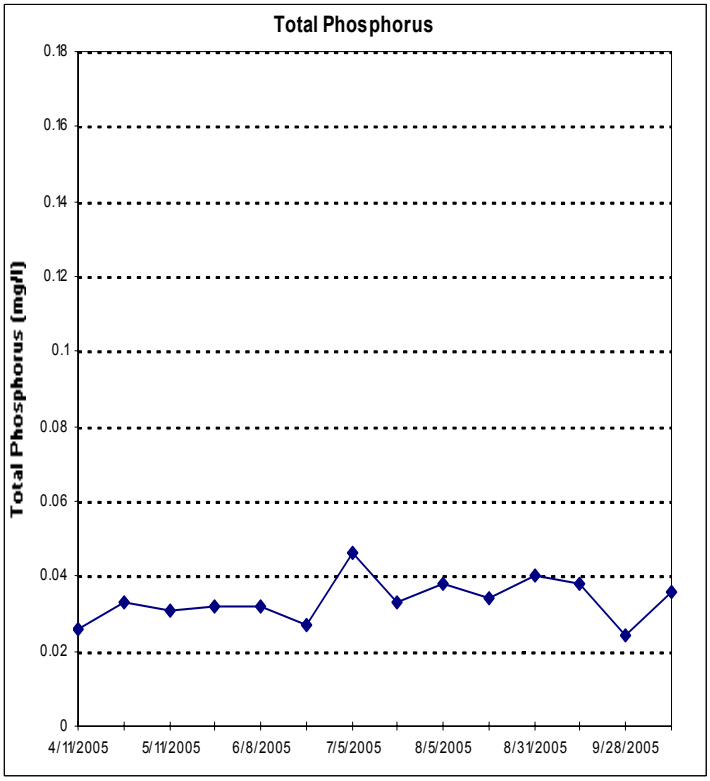
	High	High Date	Low	Low Date	Average
2005 Elevation (ft)	942.27	6/15/2005	941.47	9/18/2005	941.92

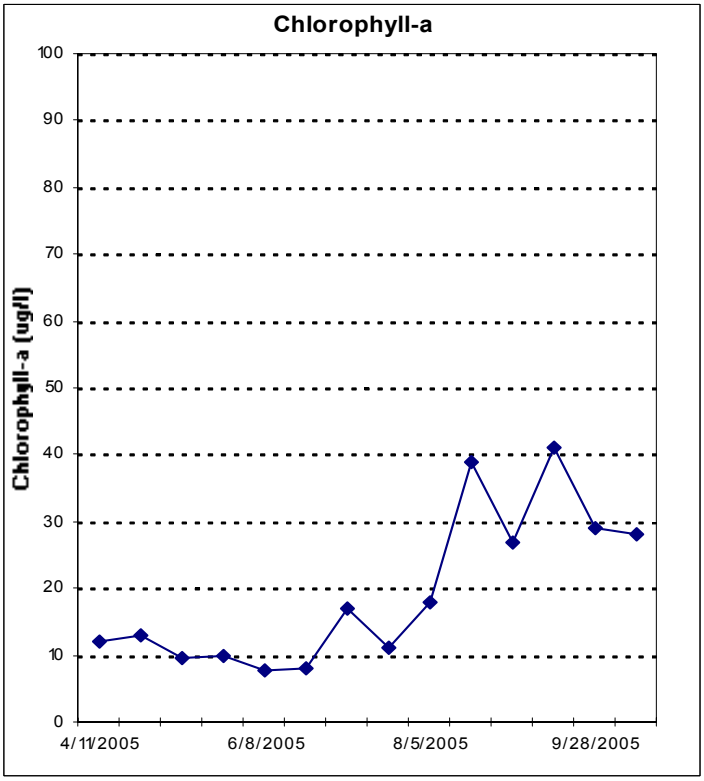
Lake Water Quality Summary

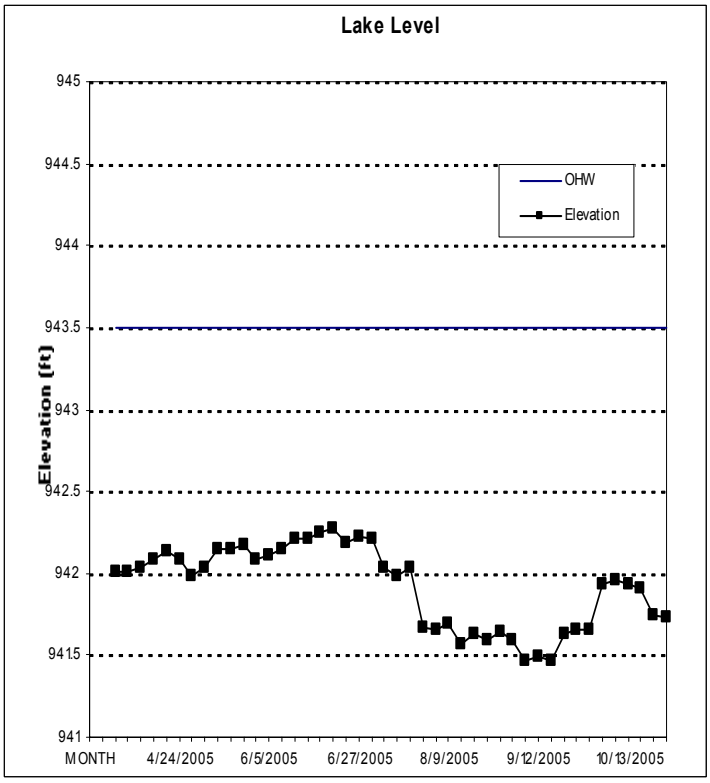
	Trophic Status	Lake Grades					
	2005	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Eutrophic	C	B	B	C	C	D
Chlorophyll-*a* (ug/l)	Eutrophic	B	A	B	B	C	D
Secchi disk (ft)	Mesotrophic	C	B	B	C	C	D
Overall	Eutrophic	C+	B+	B	C+	C	D

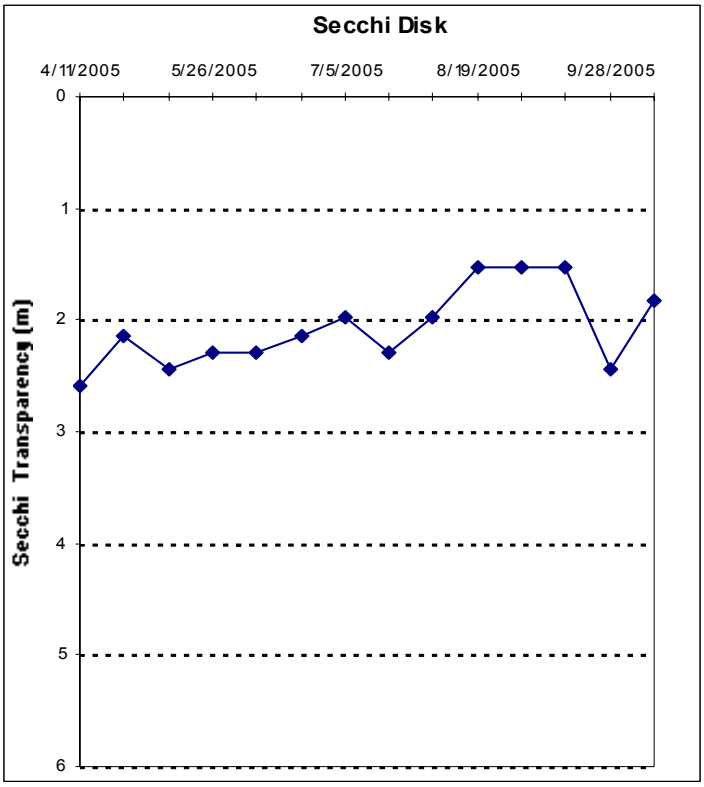

Kismet Lake
Kismet Ave.
Kismet Lake
DNR Protected Waters
ID 82-0334
Staff Gauge
Lake Sample Point
Roads
Parcel Boundary
0
500
1000 Feet
N

Kismet Basin
City of Grant

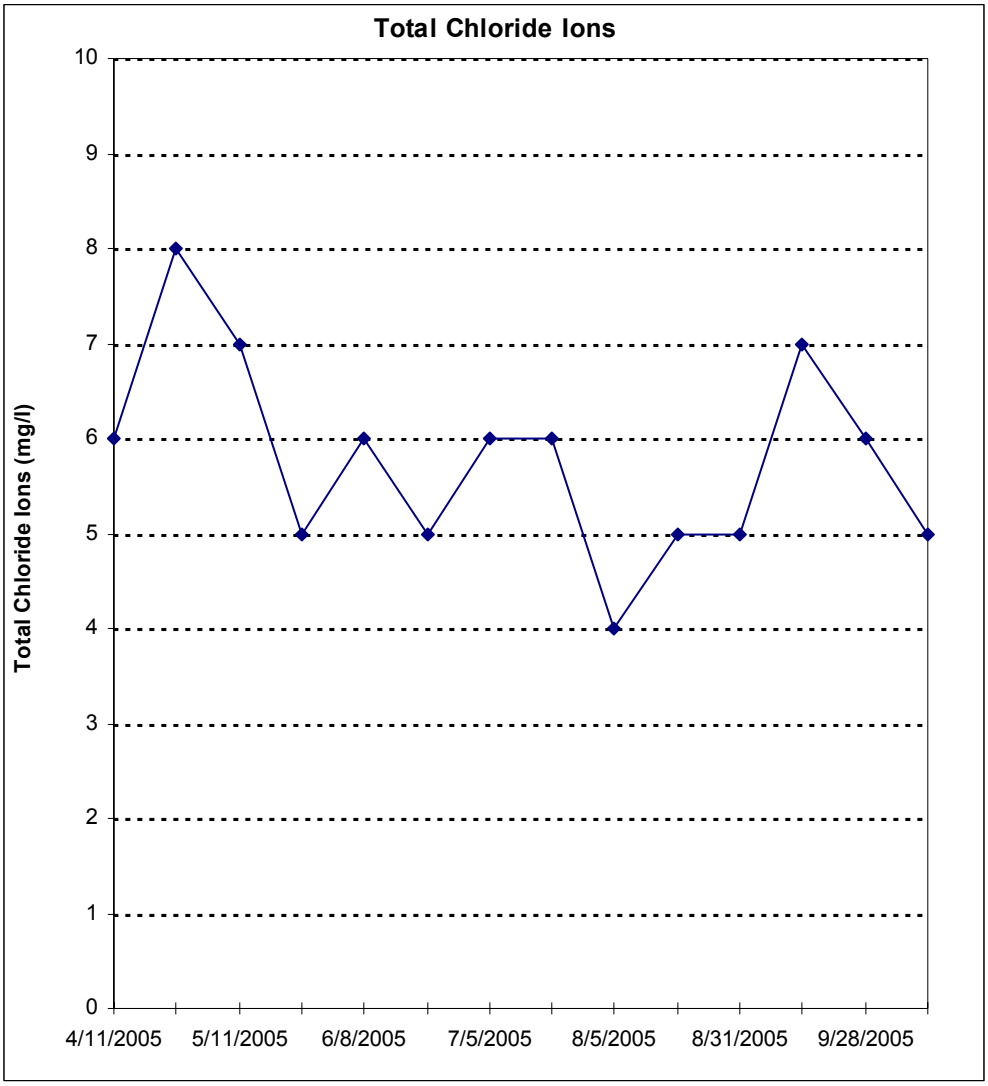






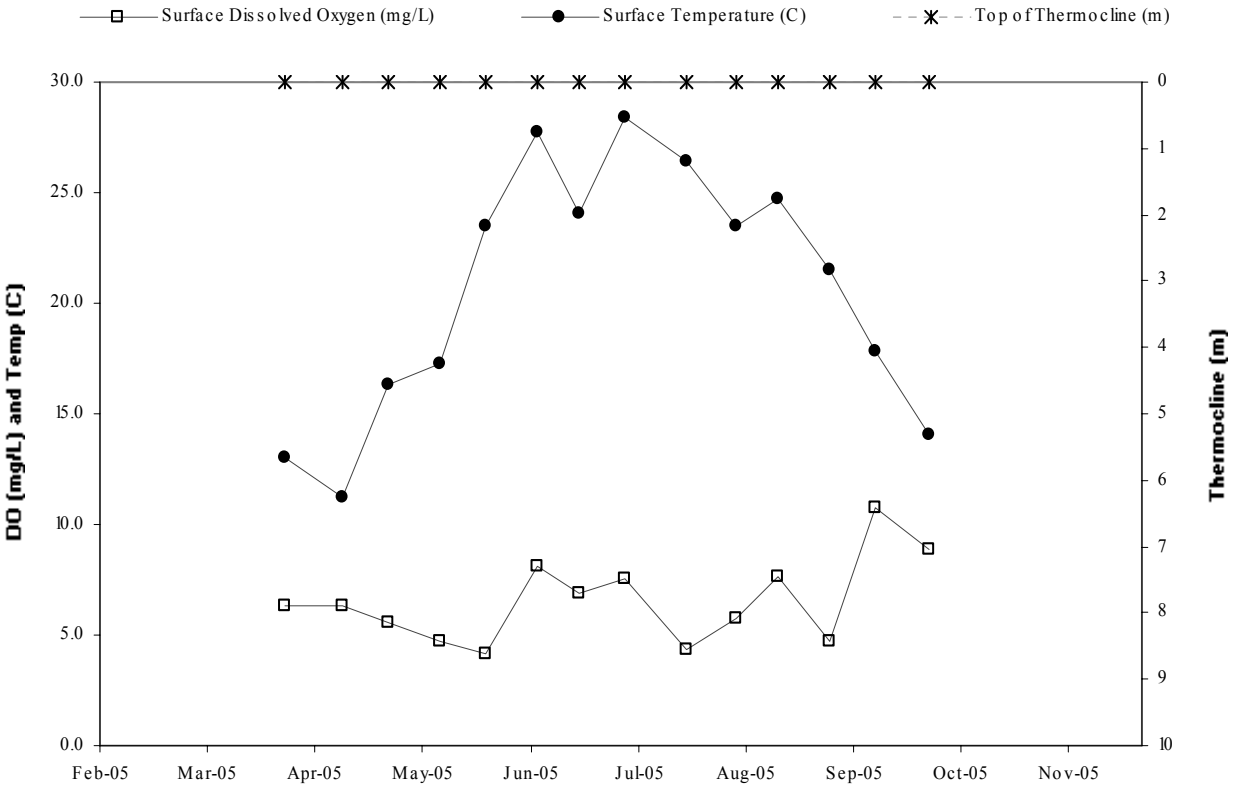


Kismet Basin
City of Grant



Kismet Basin
City of Grant

Dissolved Oxygen, Temperature, and Top of Thermocline by Sampling Date

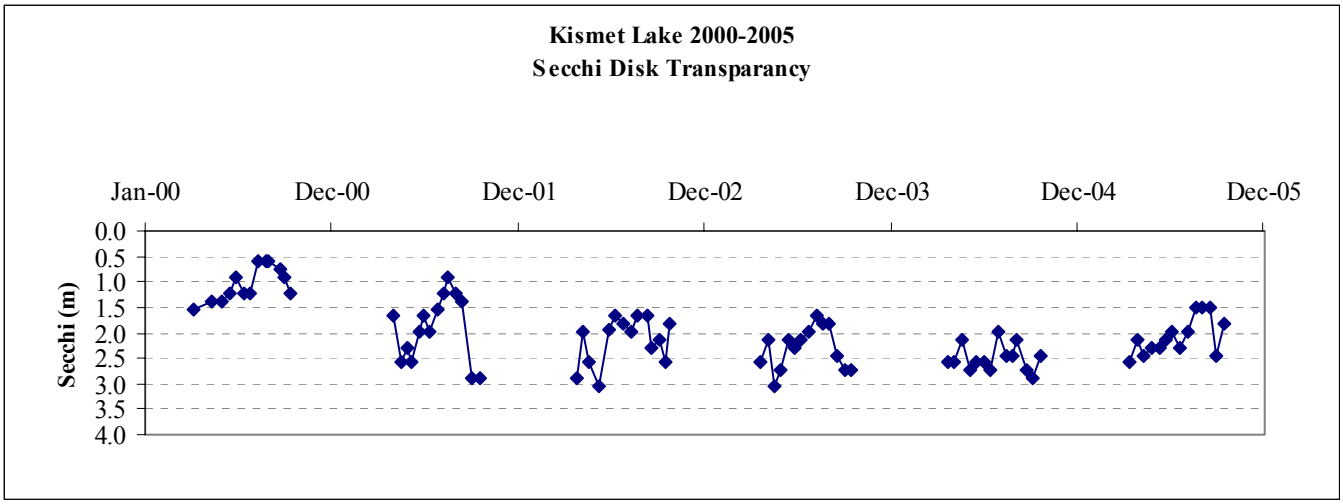


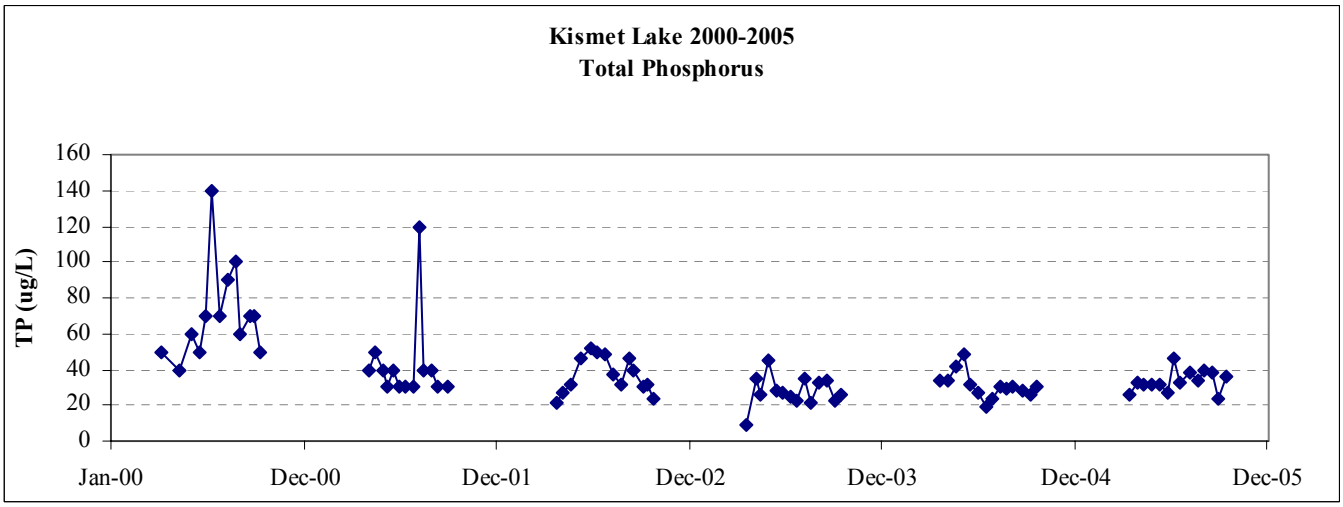
Dissolved Oxygen and Temperature Profile by Sampling Date and Depth

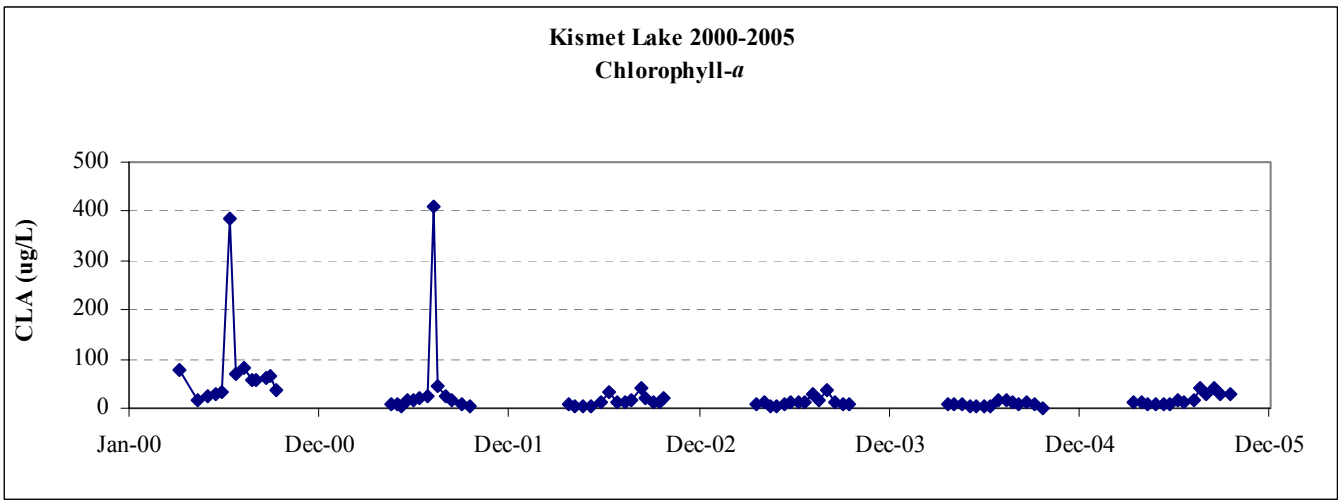
Sampling Date

Depth (m)	4/11/2005		4/28/2005		5/11/2005		5/26/2005		6/8/2005		6/23/2005		7/5/2005		7/18/2005		8/5/2005		8/19/2005		8/31/2005		9/15/2005		9/28/2005		10/14/2005	
	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp
surface	6.28	13.0	6.30	11.2	5.59	16.3	4.67	17.3	4.13	23.5	8.13	27.7	6.89	24.1	7.51	28.4	4.30	26.4	5.72	23.5	7.63	24.7	4.72	21.5	10.79	17.8	8.83	14.1
1	6.13	12.9	6.28	11.1	5.38	16.4	4.57	17.3	4.05	23.2	7.78	27.1	7.11	23.8	6.94	28.4	4.28	25.6	5.67	23.3	8.28	23.4	4.91	20.9	10.55	17.8	8.52	14.0
2	7.85	7.5	6.40	10.6	6.64	14.2	4.12	16.9	4.72	21.2	6.29	24.9	3.70	23.2	5.76	28.0	1.24	24.9	0.80	23.0	1.38	22.3	3.45	20.7	9.87	17.8	5.51	13.2
3			6.56	10.5			0.08	14.4	0.21	18.4	0.25	22.0					0.35	23.7	0.22	22.2	0.59	21.6	0.26	20.3	9.80	17.8	2.23	13.1
4																												
5																												
6																												
7																												
8																												
9																												
10																												
No Thermocline Present	0		0		0		0		0		0		0		0		0		0		0		0		0		0	

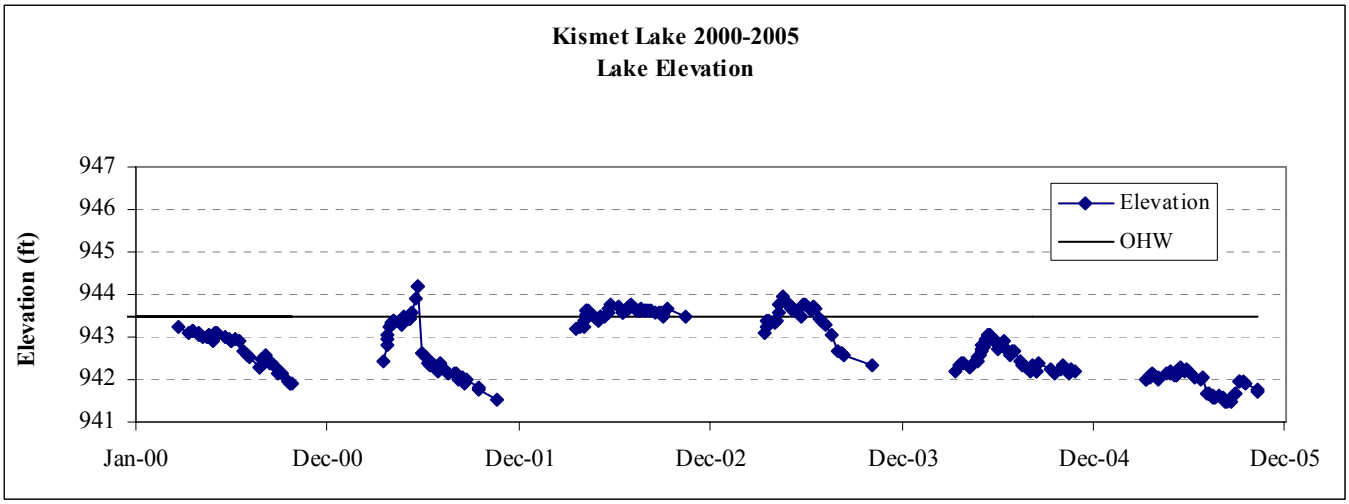
Kismet Basin
City of Grant

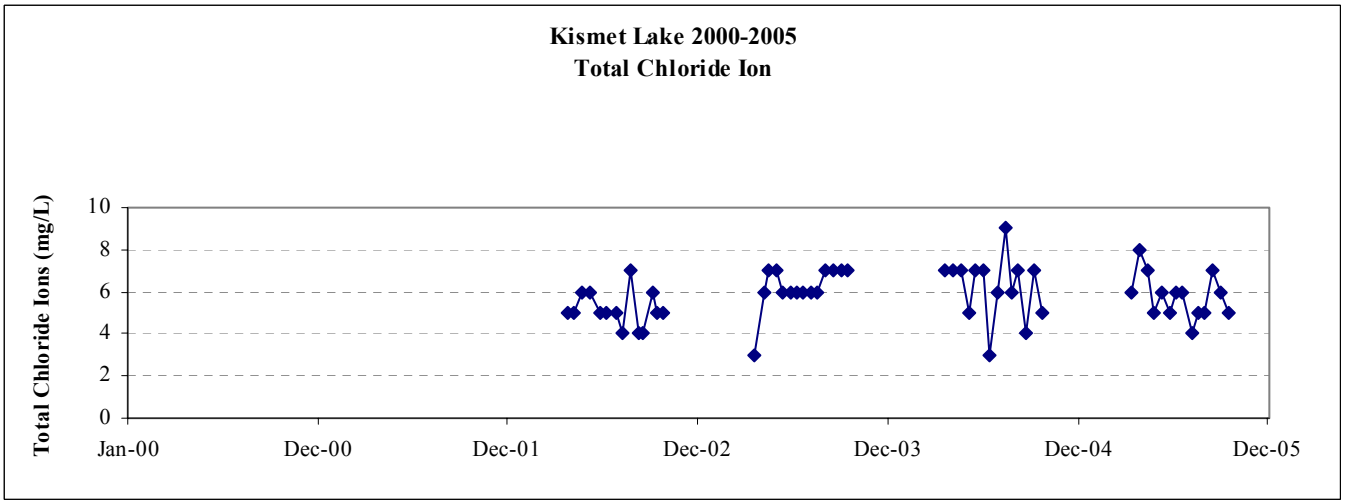




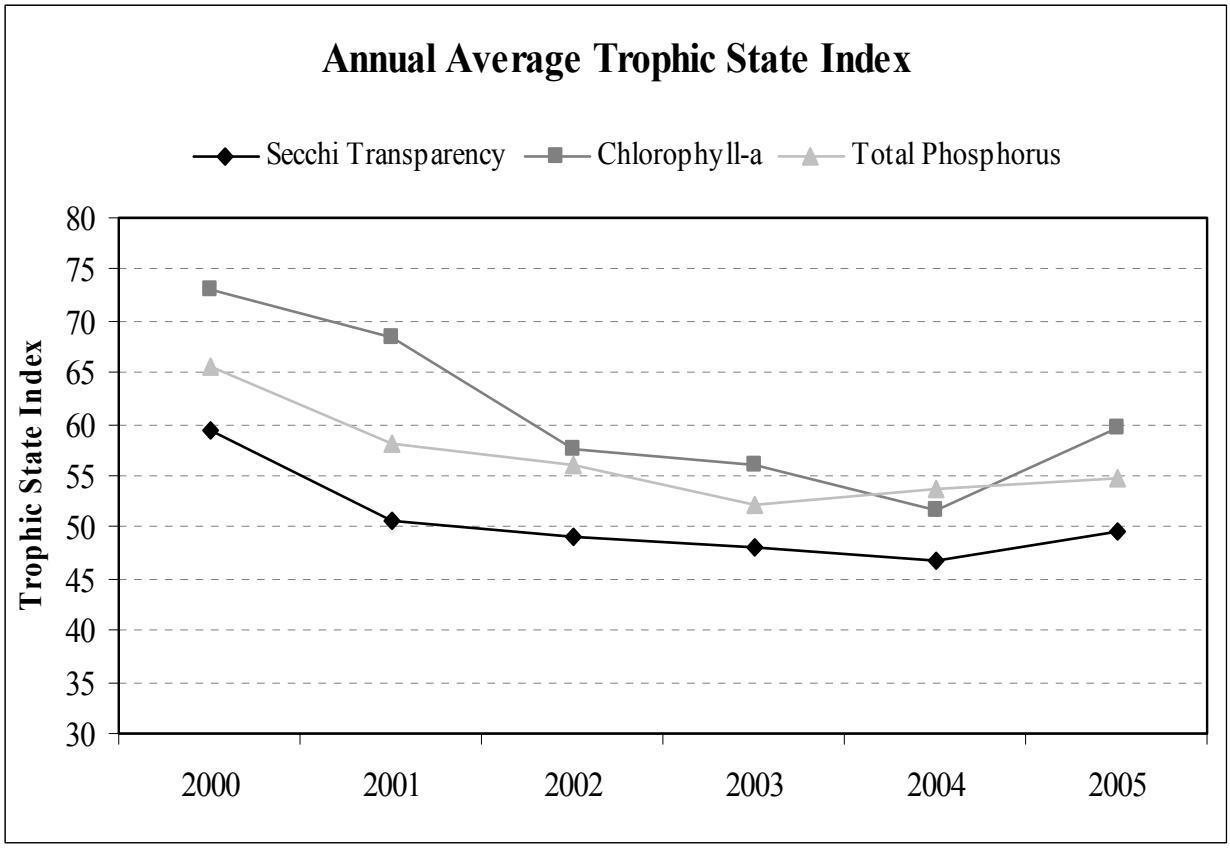


Kismet Basin
City of Grant





Kismet Basin
City of Grant



Long Lake
City of Stillwater

Vital Statistics

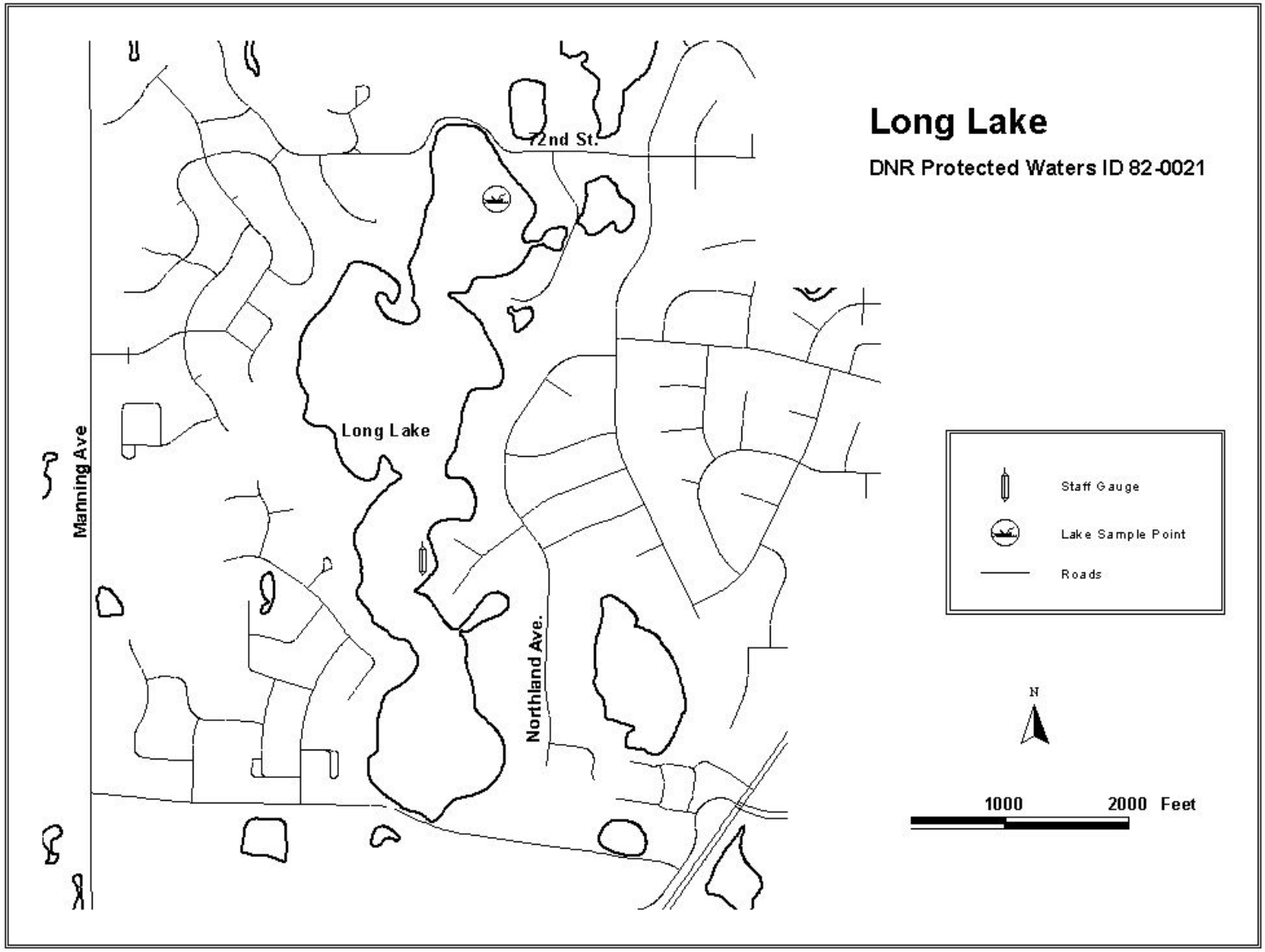
DNR ID #: 82-0021
LOCATION: Section 31, T30N-R20W
MUNICIPALITY: City of Stillwater
LAKE SIZE: 95 Acres
MAXIMUM DEPTH: 22 ft
ORDINARY HIGH WATER MARK: 891.50 ft
100-YEAR HIGH WATER LEVEL: 893.20 Feet

Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/L)	Surface Temperature Levels (Celsius)
4/11/2005	0.061	18	1.52	7.02	13.0
4/27/2005	0.058	22	1.22	5.80	11.8
5/11/2005	0.073	22	1.37	5.57	16.3
5/26/2005	0.044	17	1.68	4.68	17.6
6/7/2005	0.047	19	1.22	4.66	25.4
6/23/2005	0.059	46	0.76	10.03	26.1
7/8/2005	0.080	40	0.76	10.96	25.5
7/18/2005	0.066	43	0.76	7.58	28.5
8/3/2005	0.121	97	0.46	9.45	27.5
8/17/2005	0.076	130	0.30	11.85	25.4
8/31/2005	0.082	65	0.61	9.29	23.8
9/15/2005	0.079	72	0.61	6.78	21.8
10/3/2005	0.066	49	0.61	8.64	19.5
10/13/2005	0.048	45	0.91	10.71	14.7
2005 Average	0.069	49	0.91	8.07	21.2

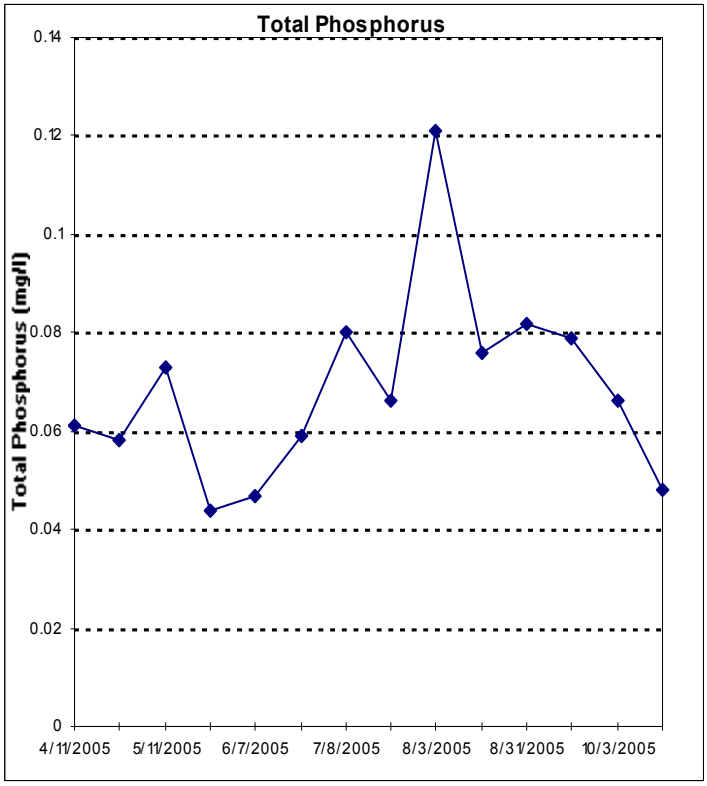
	High	High Date	Low	Low Date	Average
2005 Elevation (ft)	891.52	10/5/2005	889.44	7/21/2005	889.91

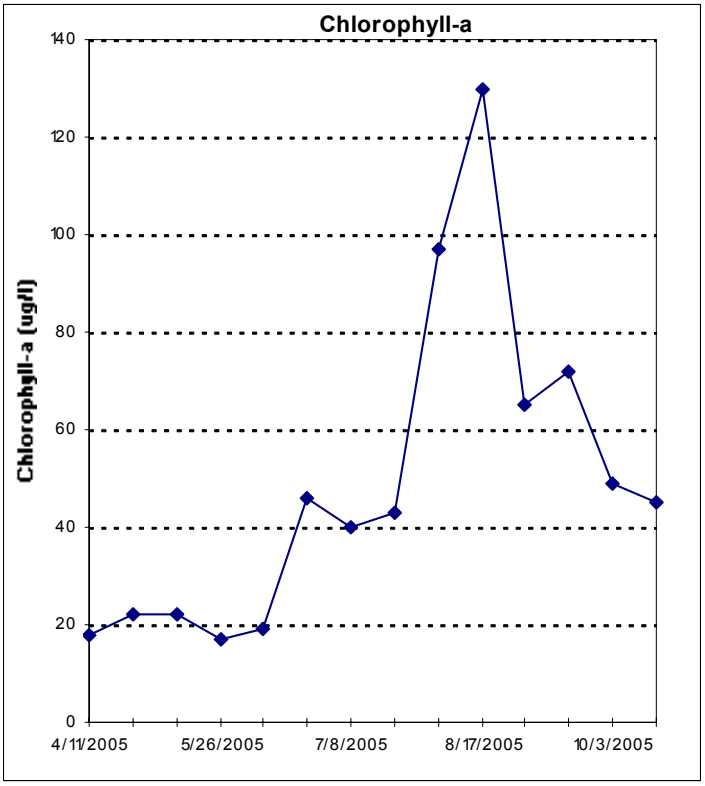
Lake Water Quality Summary

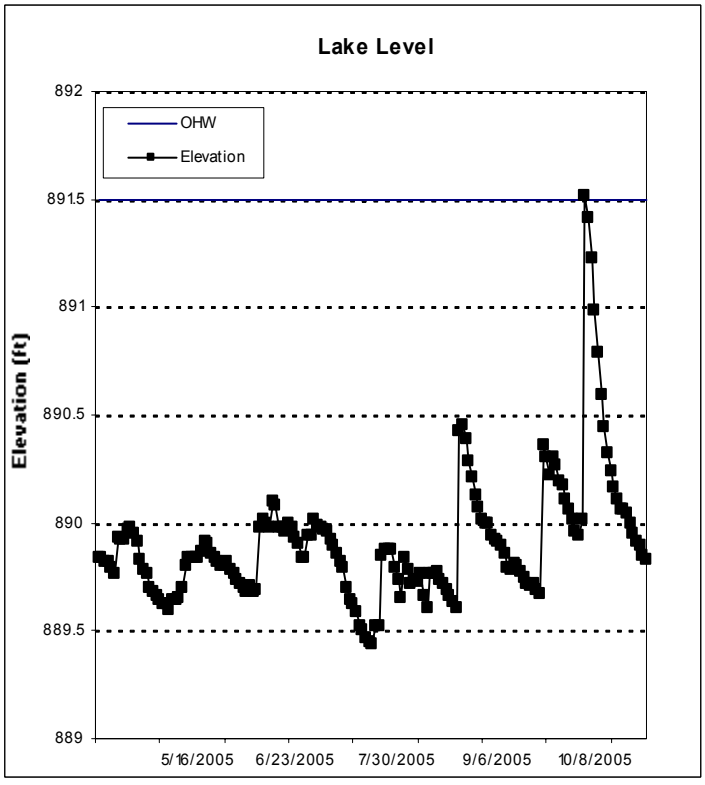
	Trophic Status	Lake Grades					
	2005	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Hypereutrophic	C	D	D	D	D	F
Chlorophyll-*a* (ug/l)	Hypereutrophic	C	C	D	D	F	F
Secchi disk (ft)	Eutrophic	C	C	F	F	F	F
Overall	Hypereutrophic	C-	C-	D-	D-	F	F

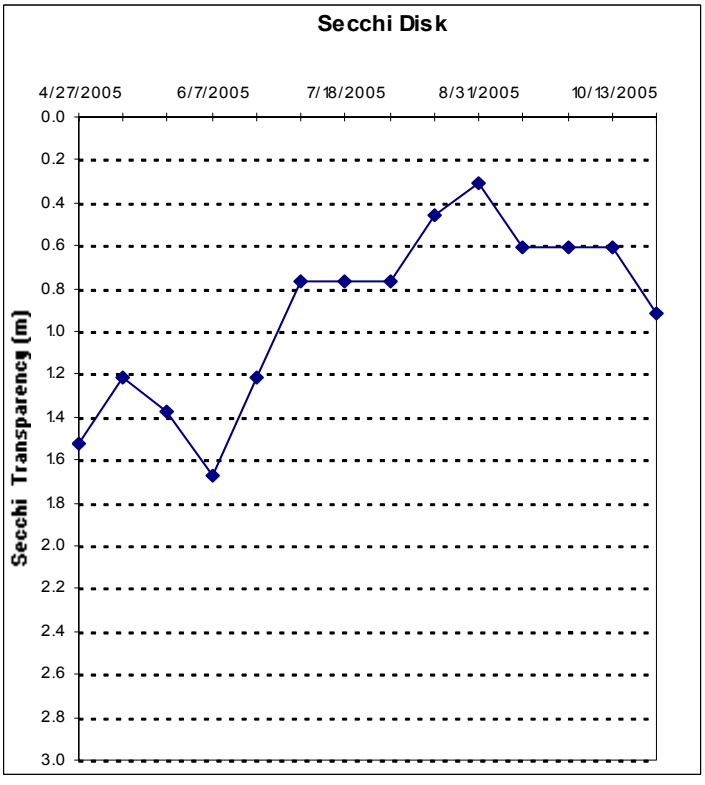

Long Lake
DNR Protected Waters ID 82-0021
72nd St.
Manning Ave
Long Lake
Northland Ave.
Staff Gauge
Lake Sample Point
Roads
N
1000
2000 Feet

Long Lake
City of Stillwater



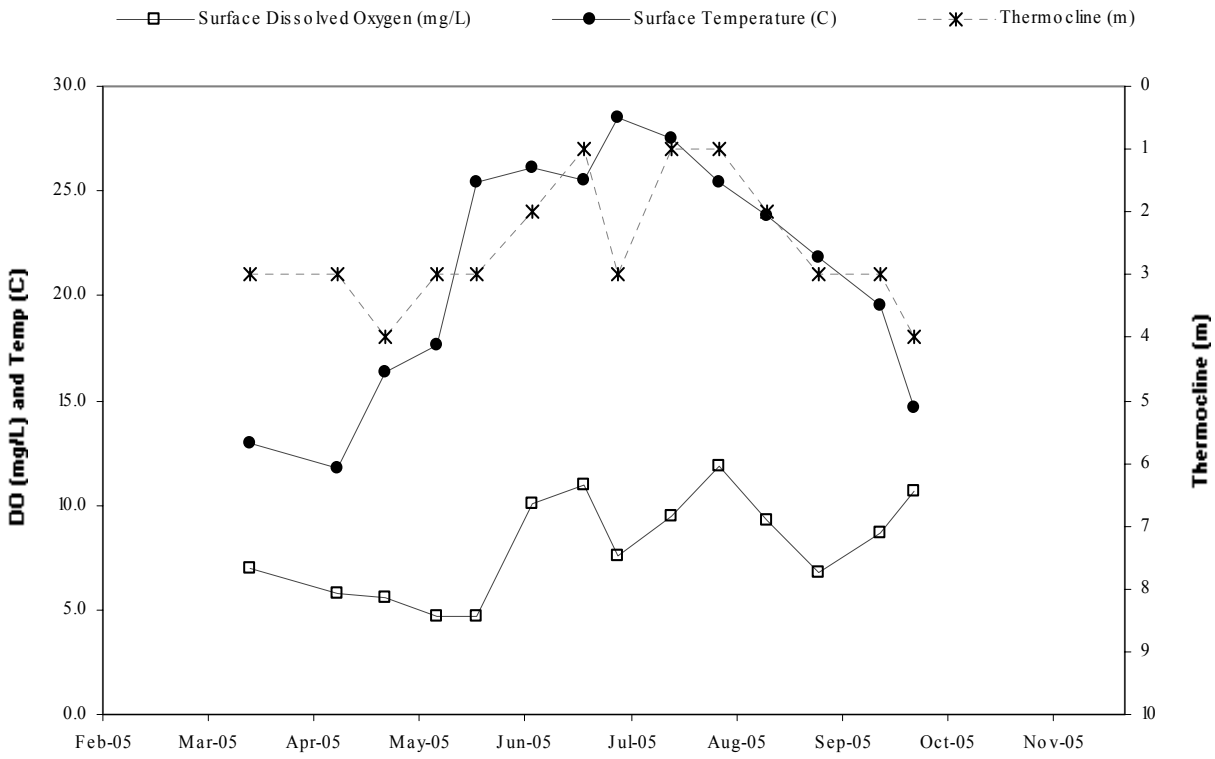






Long Lake
City of Stillwater

Dissolved Oxygen, Temperature, and Top of Thermocline by Sampling Date

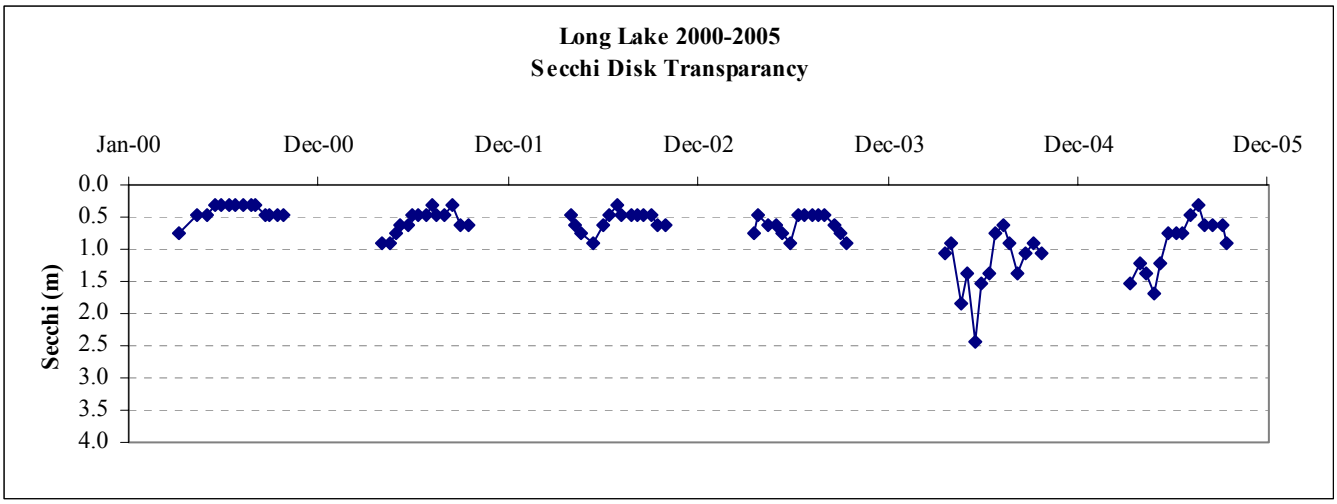


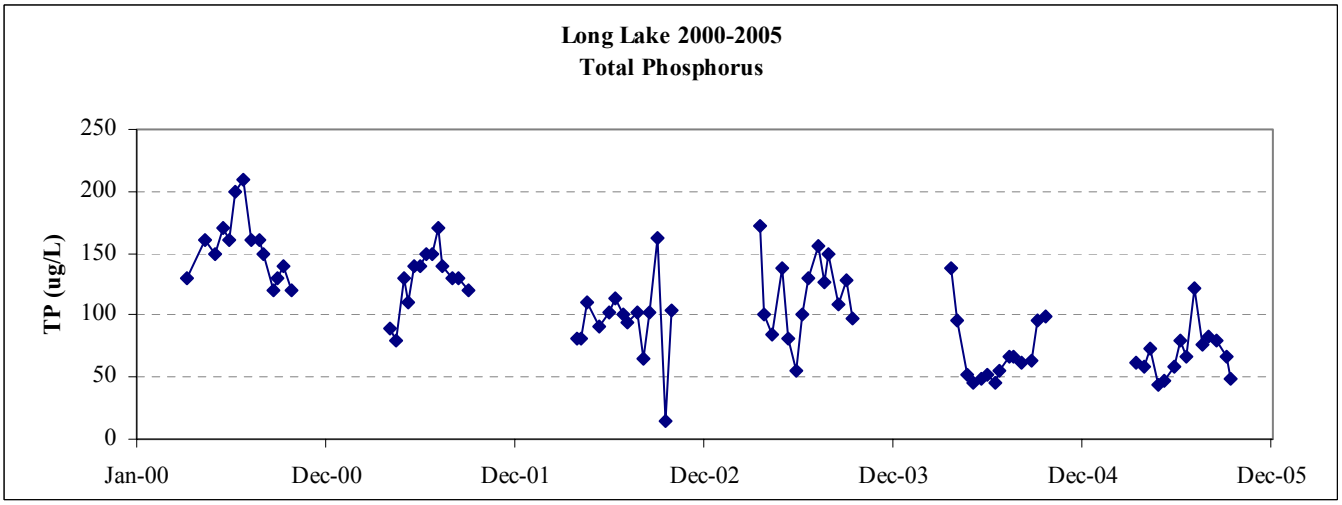
Dissolved Oxygen and Temperature Profile by Sampling Date and Depth

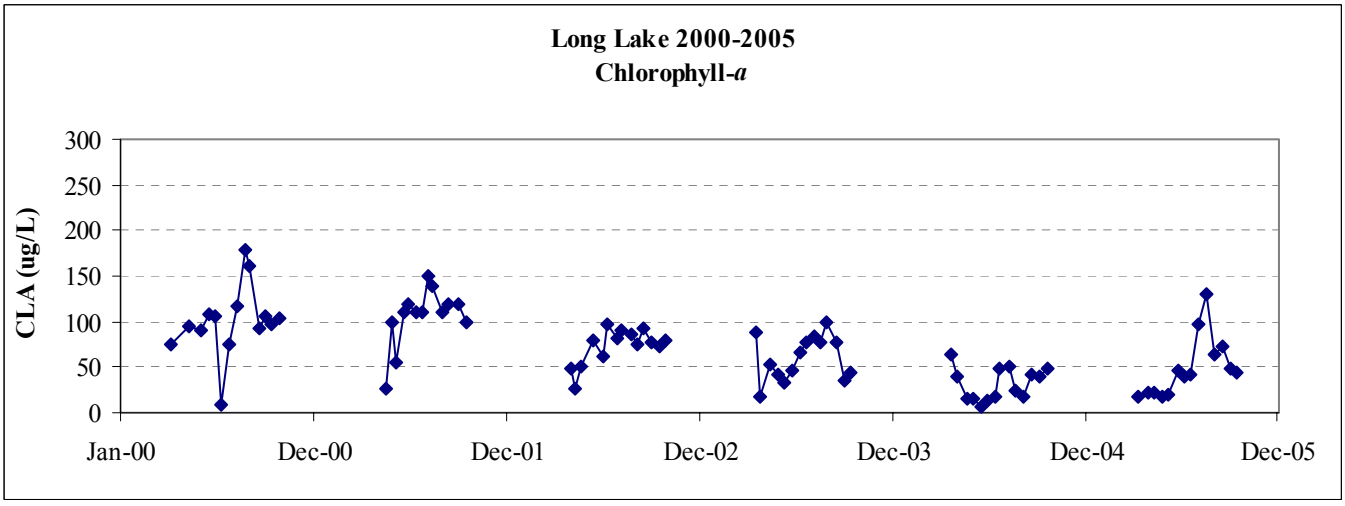
Sampling Date

Depth (m)	4/1/2005		4/27/2005		5/11/2005		5/26/2005		6/7/2005		6/23/2005		7/8/2005		7/18/2005		8/3/2005		8/17/2005		8/31/2005		9/15/2005		10/3/2005		10/13/2005	
	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp
surface	7.02	13.0	5.80	11.8	5.57	16.3	4.68	17.6	4.66	25.4	10.03	26.1	10.96	25.5	7.58	28.5	9.45	27.5	11.85	25.4	9.29	23.8	6.78	21.8	8.64	19.5	10.71	14.7
1	6.88	12.3	5.86	11.8	5.42	16.3	4.48	17.6	4.75	24.9	9.70	26.1	10.75	25.4	7.40	28.5	9.63	27.5	11.00	25.0	8.98	23.5	6.47	21.8	7.50	18.8	10.38	14.6
2	7.80	11.1	5.86	11.8	5.25	16.3	4.48	17.0	4.93	22.0	7.53	24.2	7.41	23.8	7.42	28.4	2.43	25.4	4.13	23.7	6.33	22.6	6.58	21.7	5.62	17.6	6.75	13.8
3	8.50	9.0	5.54	11.8	3.57	14.7	3.87	16.2	4.62	16.8	1.35	21.6	1.20	22.5	0.24	26.0	0.33	23.5	0.27	22.9	3.70	22.1	6.55	21.7	4.27	16.7	5.67	13.5
4	0.73	5.2	0.13	9.0	2.54	10.1	0.37	11.5	0.41	11.8	0.42	13.4	0.11	15.7	0.10	15.7	0.39	16.9	0.30	18.3	0.50	18.8	0.30	18.4	2.65	16.2	4.30	13.3
5	0.66	4.8	0.05	5.5	0.44	6.8	0.04	8.2	0.35	9.5	0.44	9.3	0.07	10.1	0.10	10.8	0.45	12.0	0.35	12.9	0.49	14.9	0.29	14.7	0.54	15.7	1.34	13.2
6	0.64	4.6	0.05	5.1	0.14	5.8			0.37	7.1	0.53	7.5	0.50	8.1	0.09	8.4	0.51	9.1	0.40	9.6	0.58	10.5	0.32	10.8	0.48	11.8	0.51	12.9
7																											0.43	11.4
8																												
9																												
10																												
Top of Thermocline (m)	3		3		4		3		3		2		1		3		1		1		2		3		3		4	

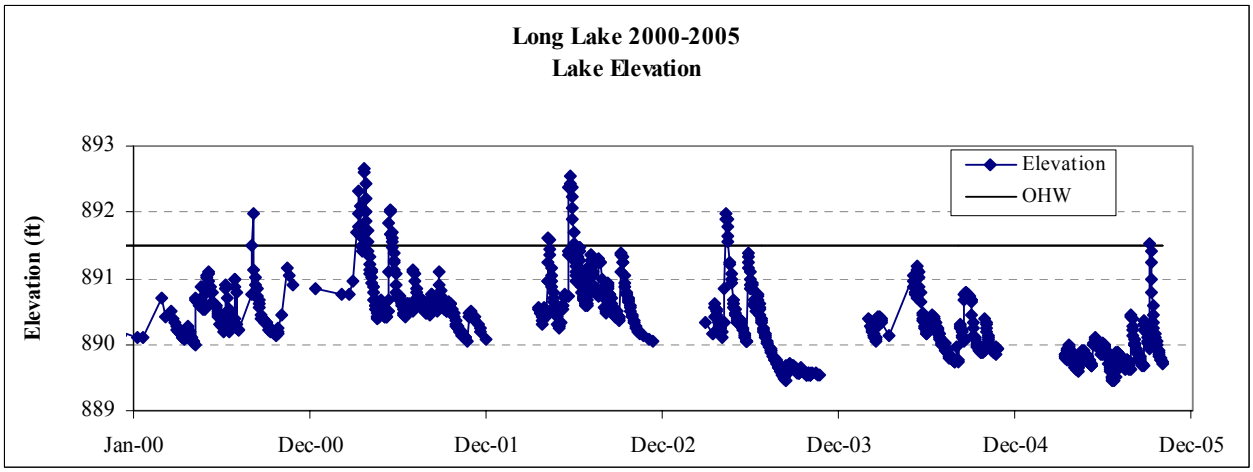
Long Lake
City of Stillwater

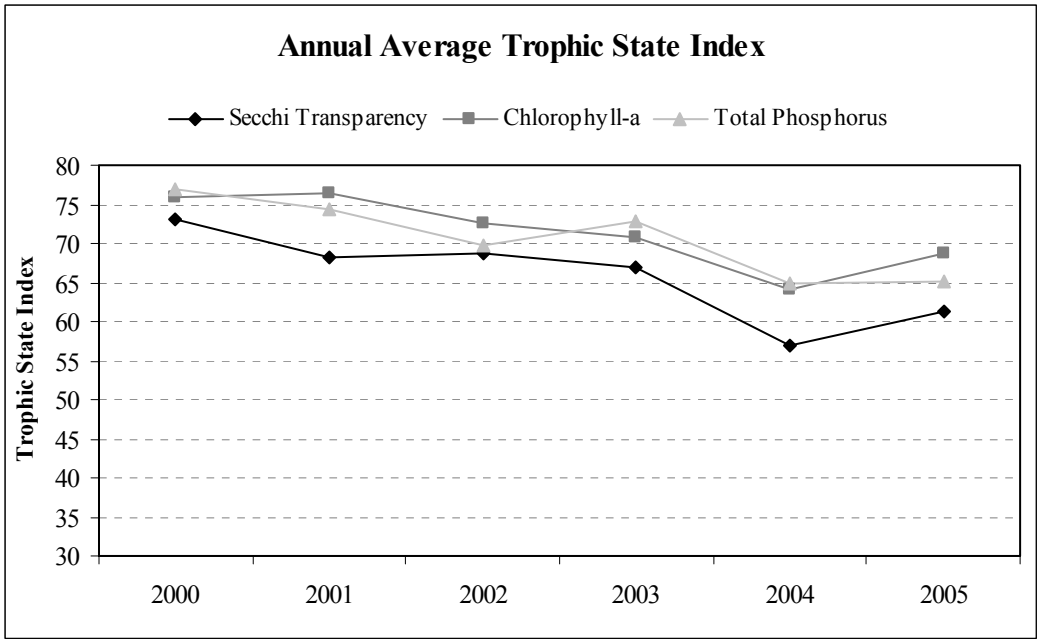






Long Lake
City of Stillwater





South School Section Lake

City of Withrow

Vital Statistics

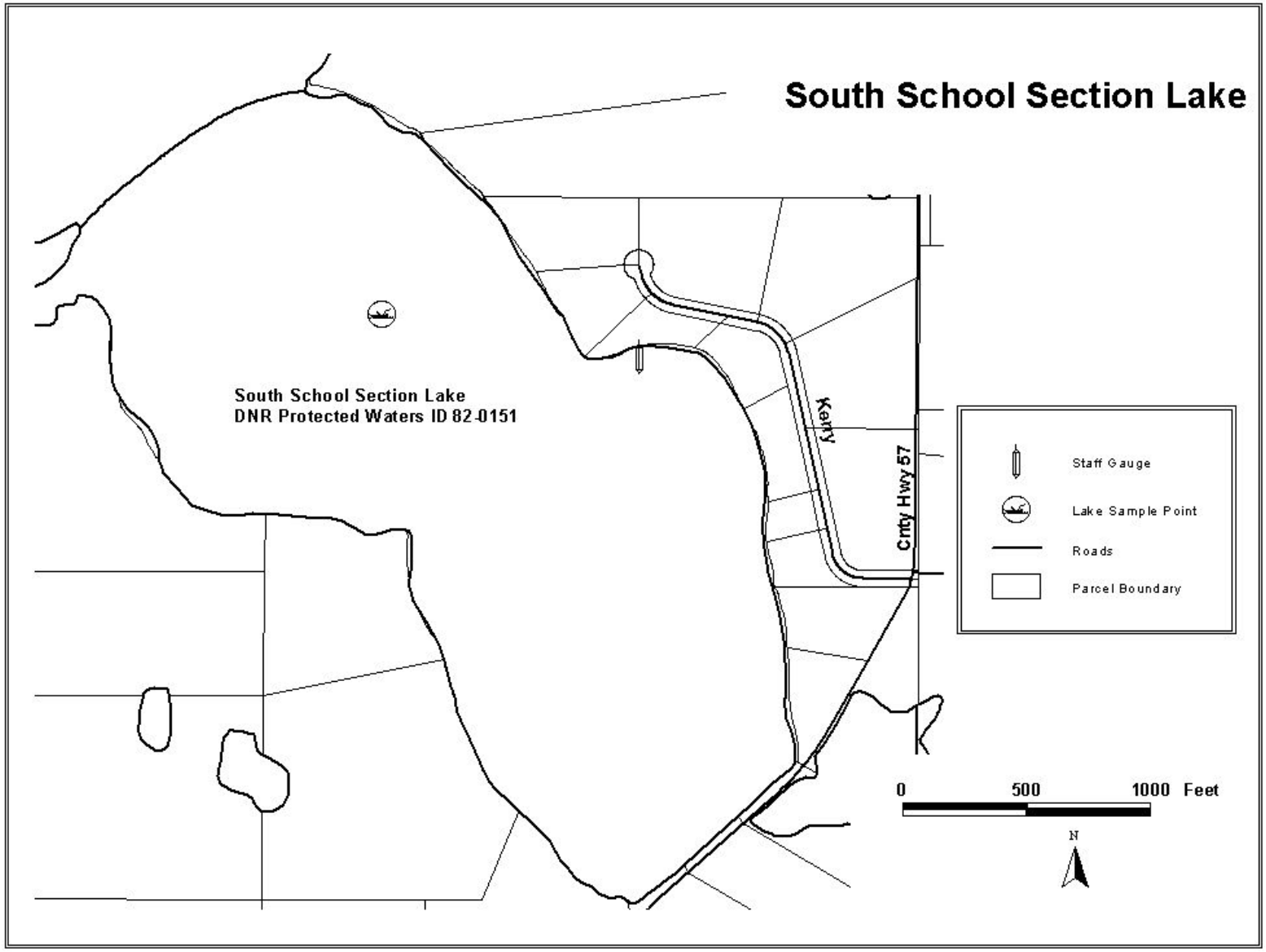
DNR ID #: 82-0151
LOCATION: S ½ Section 25, T31N-R21W
MUNICIPALITY: City of Withrow
LAKE SIZE: 124 Acres
MAXIMUM DEPTH: 26 ft
ORDINARY HIGH WATER MARK: 965.30 ft
100-YEAR HIGH WATER LEVEL: 972.20 Feet

Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/L)	Surface Temperature Levels (Celsius)
4/15/2005	0.026	12	5.79	6.90	10.5
4/28/2005	0.033	13	4.42	6.47	10.9
5/9/2005	0.031	10	5.18	6.49	13.9
5/26/2005	0.032	10	4.11	5.10	15.2
6/8/2005	0.032	8	3.96	4.71	21.3
6/23/2005	0.027	8	4.11	8.40	25.5
7/5/2005	0.046	17	1.83	7.53	23.0
7/25/2005	0.033	11	1.37	7.65	24.3
8/5/2005	0.038	18	0.91	4.64	24.9
8/19/2005	0.034	39	0.76	6.14	23.2
8/30/2005	0.040	27	0.76	11.10	24.6
9/15/2005	0.038	41	1.07	5.93	21.4
9/30/2005	0.024	29	1.22	8.75	17.4
10/14/2005	0.036	28	1.68	7.87	14.7
2005 Average	0.034	19	2.66	6.98	19.3

	High	High Date	Low	Low Date	Average
2005 Elevation (ft)	968.70	4/23/2005	967.84	9/15/2005	968.29

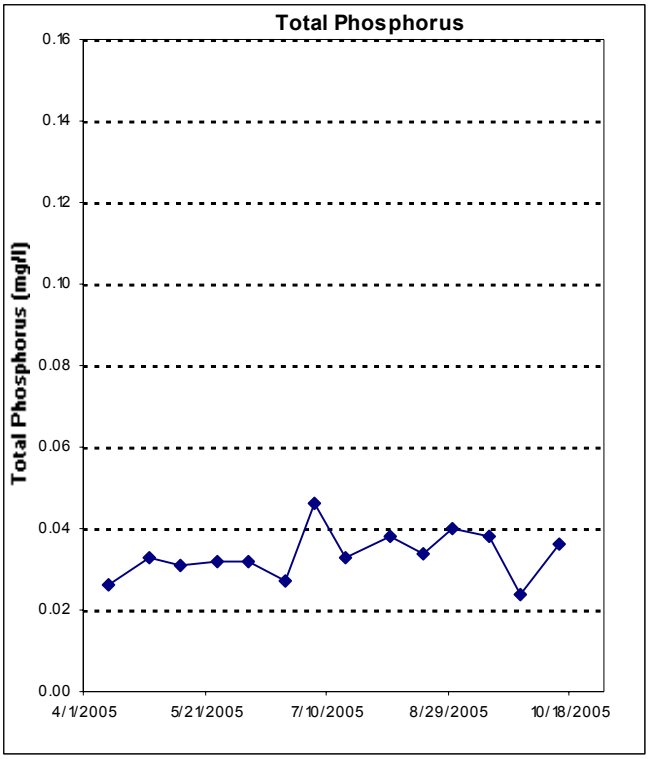
Lake Water Quality Summary

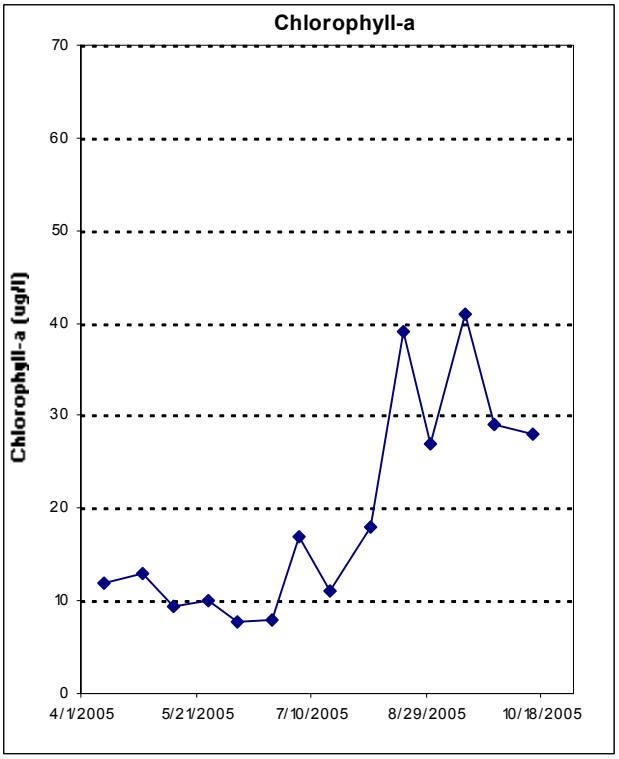
	Trophic Status	Lake Grades					
	2005	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Eutrophic	C	NA	NA	NA	NA	NA
Chlorophyll-*a* (ug/l)	Eutrophic	B	NA	NA	NA	NA	NA
Secchi disk (ft)	Mesotrophic	B	NA	NA	NA	NA	NA
Overall	Eutrophic	B-	NA	NA	NA	NA	NA

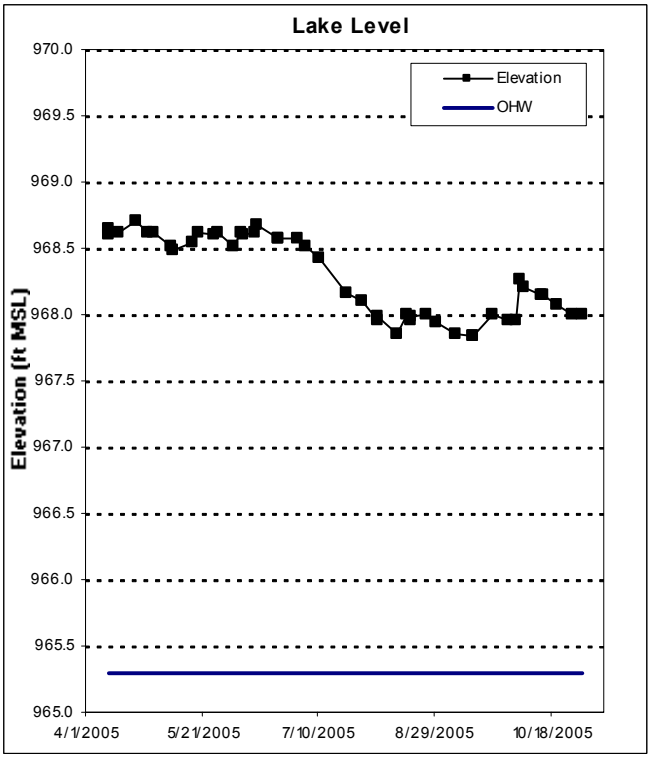

South School Section Lake
South School Section Lake
DNR Protected Waters ID 82-0151
Kelly
Cnty Hwy 57
Staff Gauge
Lake Sample Point
Roads
Parcel Boundary
0
500
1000 Feet
N

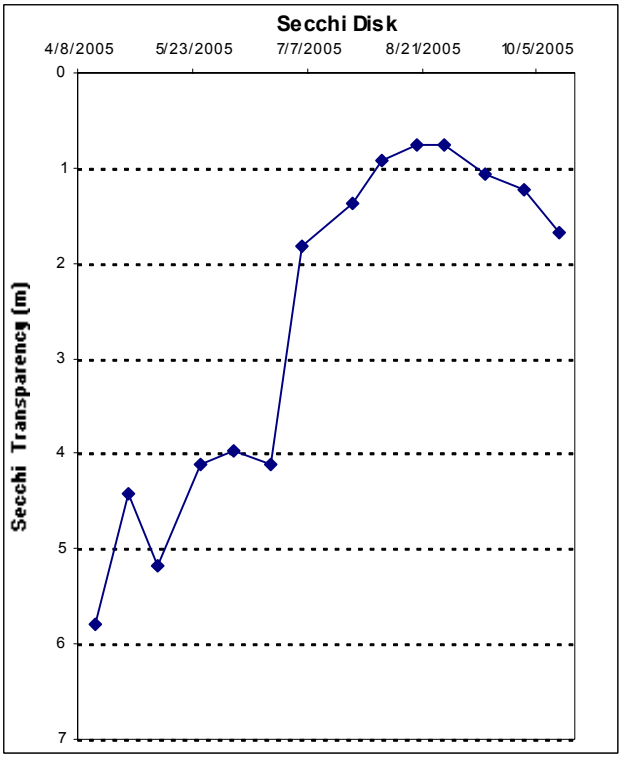
South School Section Lake

City of Withrow



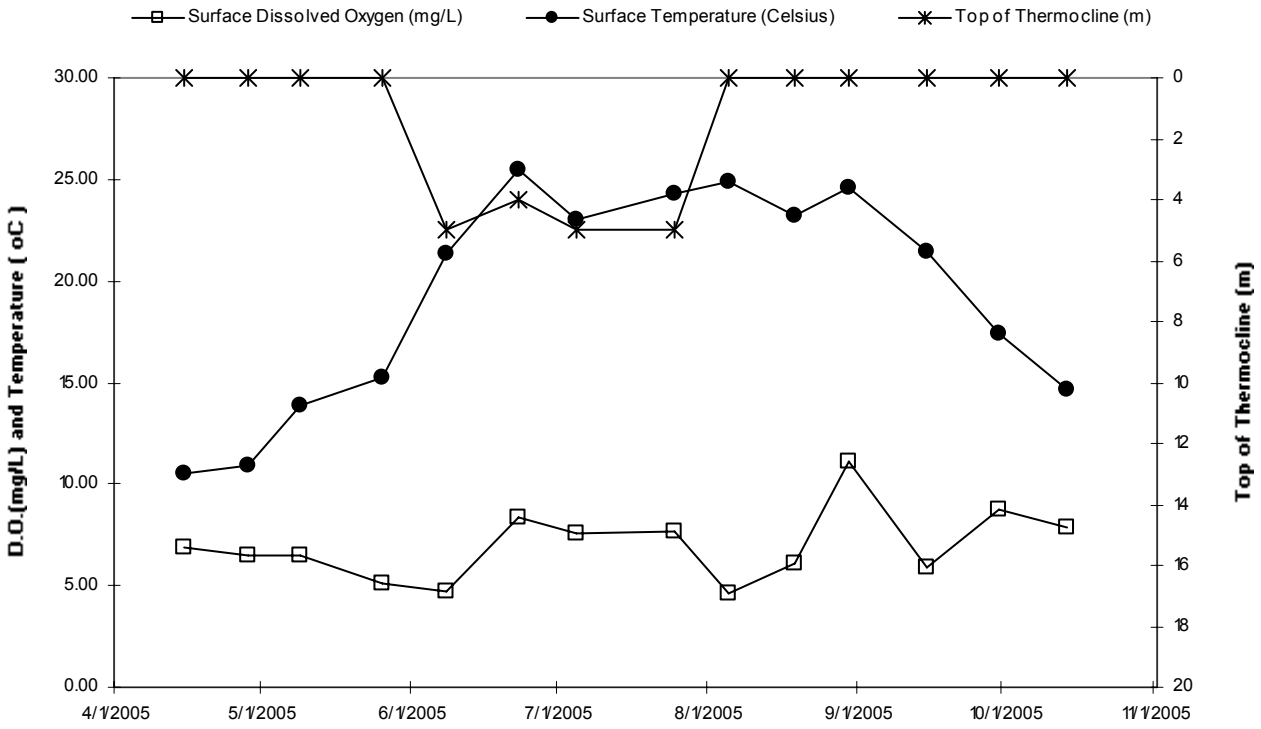






South School Section Lake
City of Withrow

Dissolved Oxygen, Temperature, and Top of Thermocline by Sampling Date

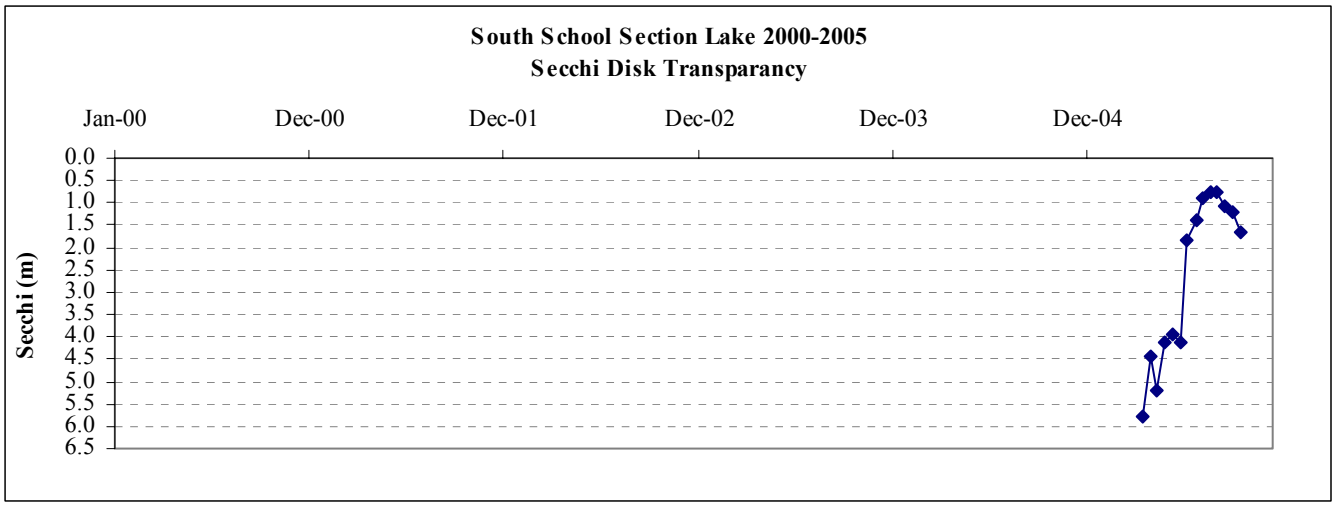


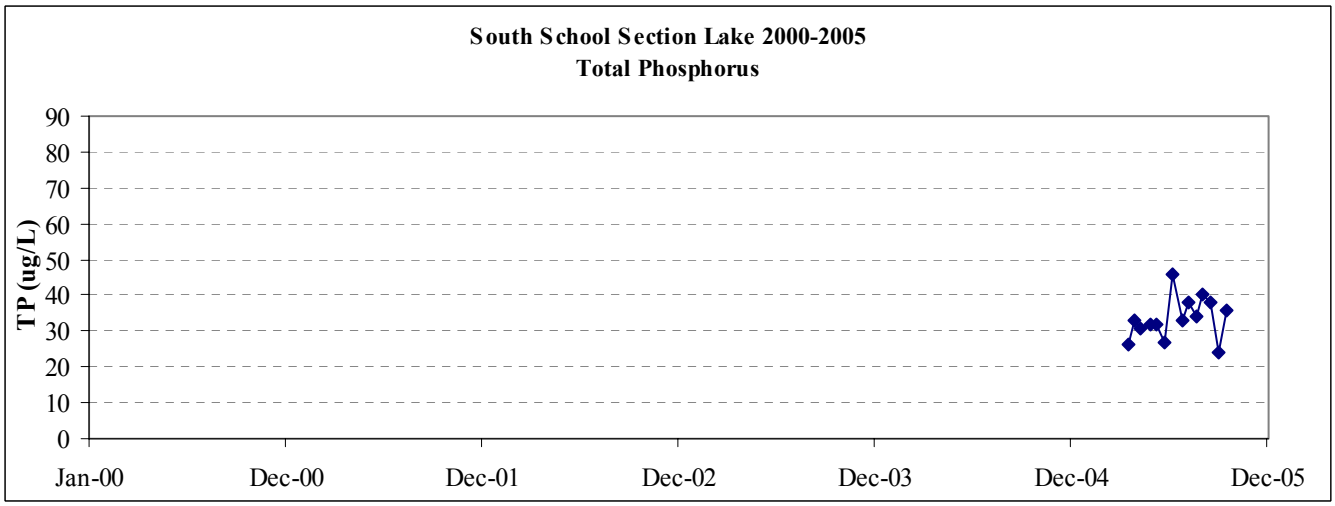
Dissolved Oxygen and Temperature Profile by Sampling Date and Depth

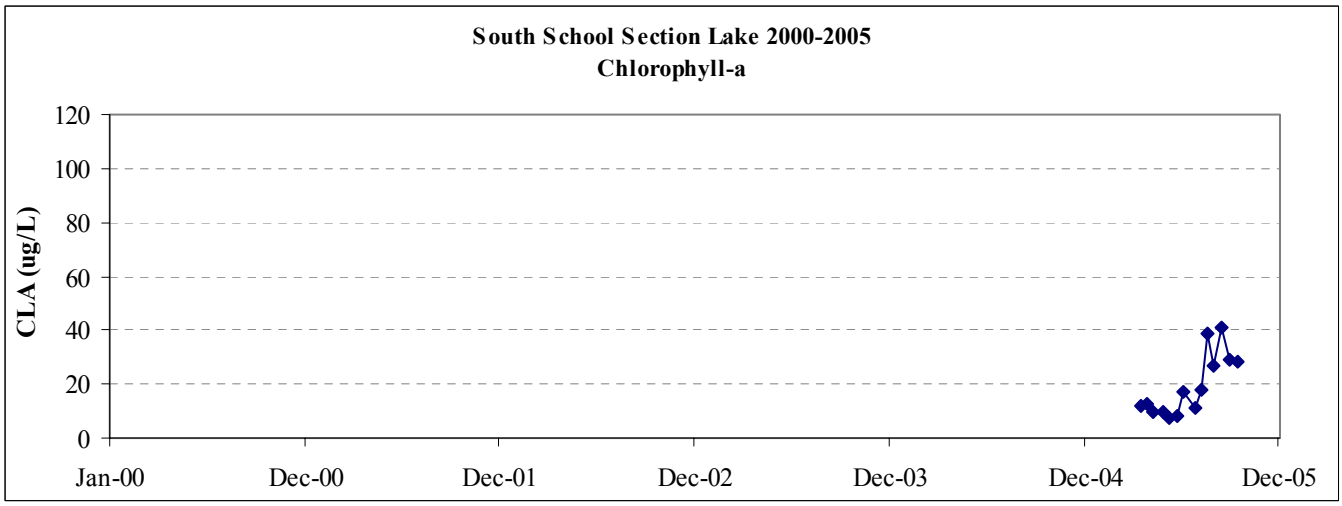
Sampling Date

Depth (m)	4/15/2005		4/28/2005		5/9/2005		5/26/2005		6/8/2005		6/23/2005		7/5/2005		7/25/2005		8/5/2005		8/19/2005		8/30/2005		9/15/2005		9/30/2005		10/14/2005	
	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp
surface	6.90	10.5	6.47	10.9	6.49	13.9	5.10	15.2	4.71	21.3	8.40	25.5	7.53	23.0	7.65	24.3	4.64	24.9	6.14	23.2	11.10	24.6	5.93	21.4	8.75	17.4	7.87	14.7
1	6.59	10.4	6.58	10.9	6.38	13.9	4.85	15.1	4.55	21.2	8.47	25.5	7.24	22.9	7.25	23.5	4.44	24.9	6.17	23.3	11.45	23.8	5.65	21.4	8.50	17.3	7.95	14.6
2	6.55	10.4	6.57	10.9	6.33	13.9	4.77	15.1	4.43	21.2	8.40	25.4	7.50	22.8	7.45	23.1	4.26	24.9	5.92	23.3	9.16	22.8	5.63	21.4	8.68	17.3	7.63	14.5
3	6.92	10.3	6.44	10.9	6.26	13.8	4.75	15.1	4.57	21.1	7.34	22.9	6.99	22.7	6.55	24.3	4.15	24.9	5.92	23.3	7.04	22.5	5.47	21.4	8.90	17.3	7.60	14.5
4	6.91	10.1	6.59	10.9	6.27	13.6	4.92	15.1	4.61	20.7	7.72	22.6	6.07	22.6	6.23	23.0	4.26	24.9	5.53	23.2	5.02	22.3	5.60	21.4	8.43	17.3	7.28	14.5
5	6.47	9.9	6.55	10.9	6.42	13.5	4.70	15.1	4.11	17.3	1.77	17.7	4.20	22.2	4.27	22.8	0.61	22.4	4.52	23.2	3.47	22.0	5.16	21.3	8.39	17.2	7.37	14.5
6	6.72	9.8	6.52	10.9	6.27	12.8	4.99	15.1	2.64	16.2	2.20	17.8	1.00	20.7	2.15	21.5			0.29	21.2	1.54	21.8	5.28	21.3	7.89	16.9	7.50	14.5
7	0.78	9.5	6.59	10.9	0.13	12.3	2.40	14.2	1.35	15.7	0.34	16.5	0.08	18.0	0.15	18.5									0.89	16.8	0.37	14.4
8			2.34	10.9																								
9																												
10																												
Thermocline Present (m)									5		4		5		5													

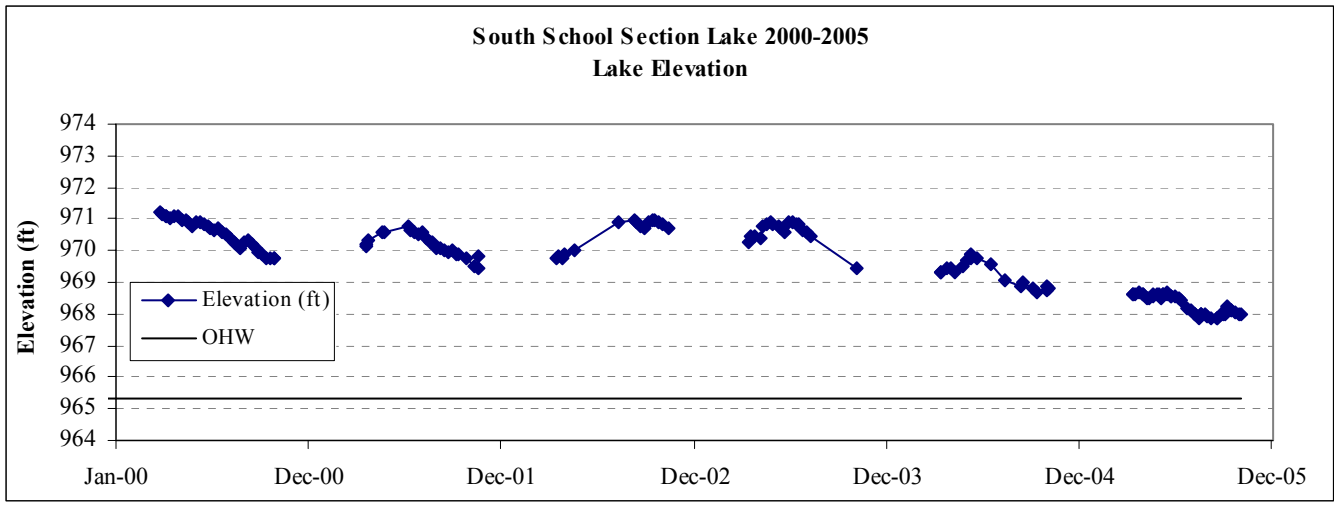
South School Section Lake
City of Withrow

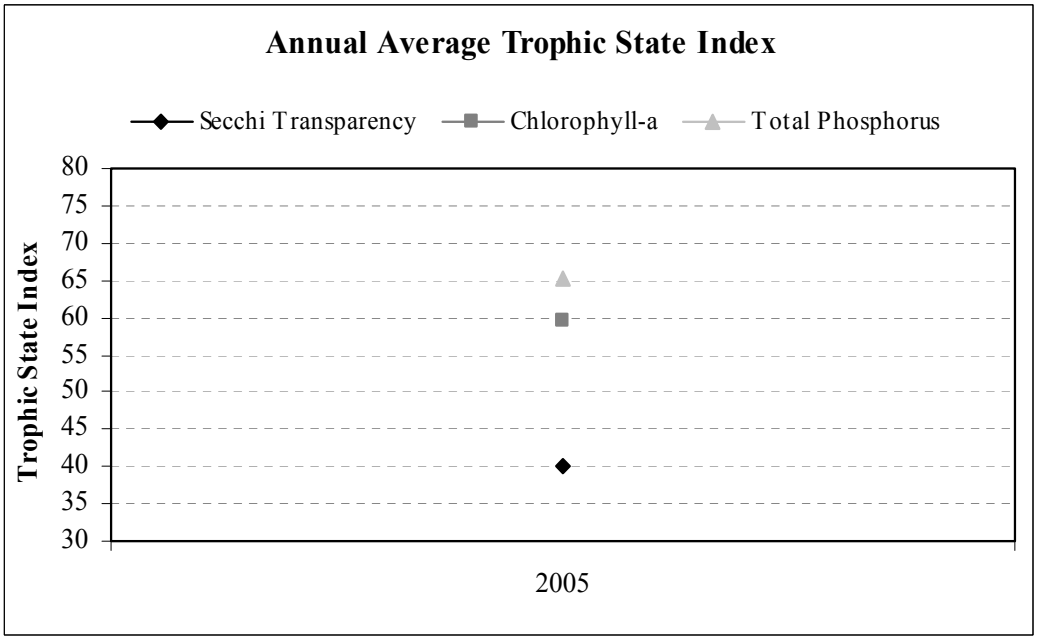






South School Section Lake
City of Withrow





APPENDIX B – BROWN'S CREEK HISTORICAL FLOW AND WATER QUALITY DATA (1998-2004)

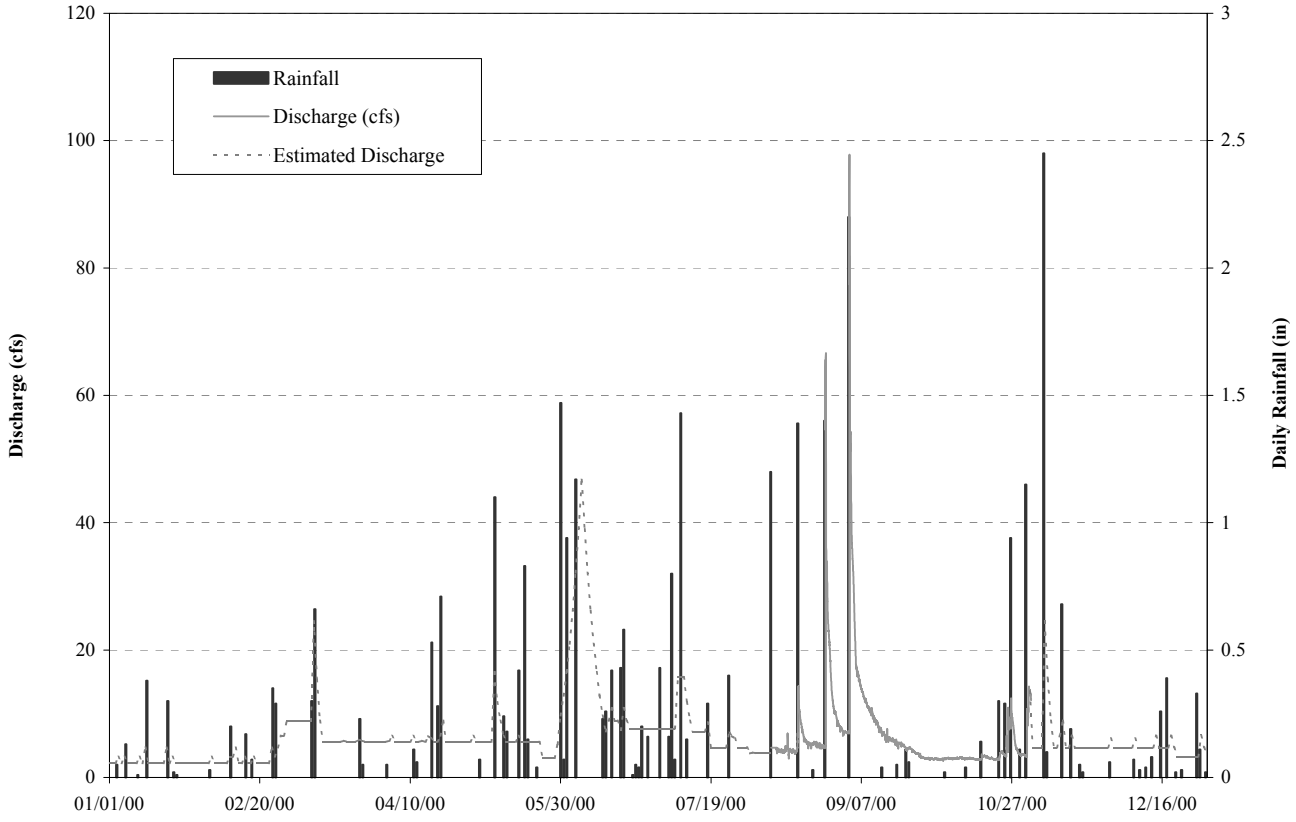


Figure 25: 2000 Brown's Creek at McKusick Road Discharge and Rainfall

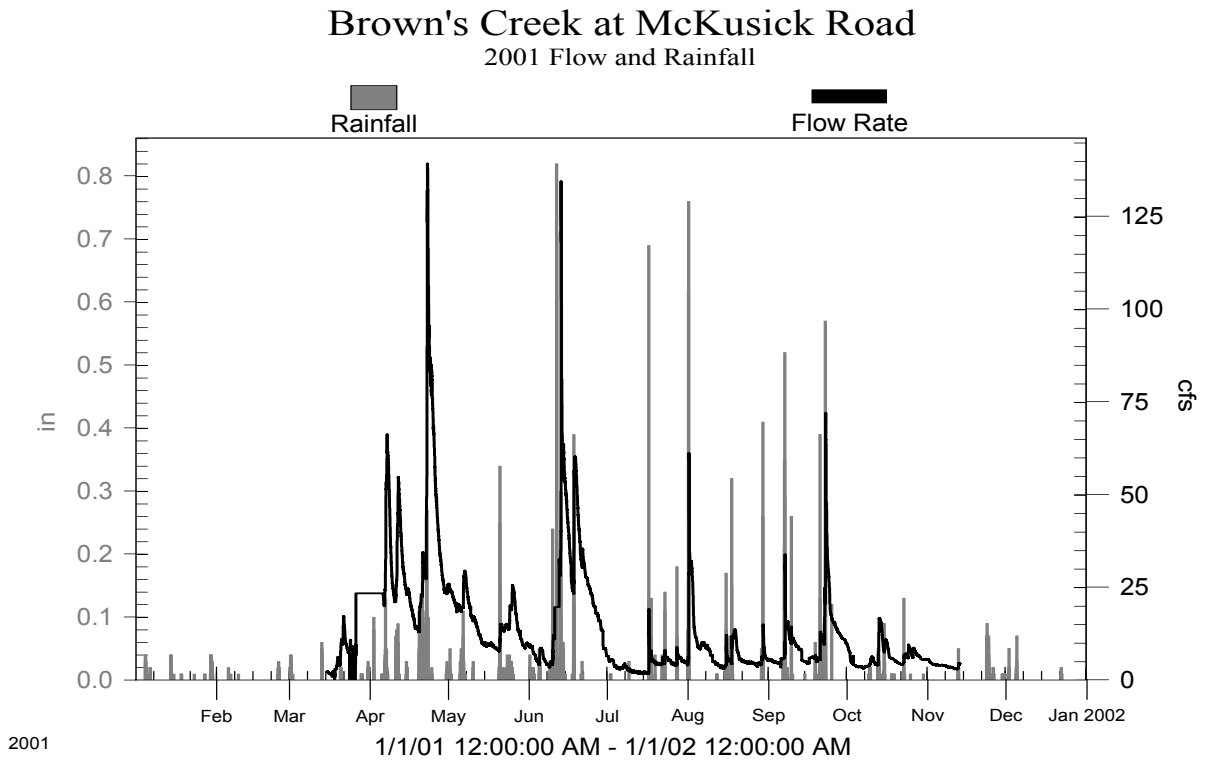


Figure 26: 2001 Brown's Creek at McKusick Road Discharge and Rainfall

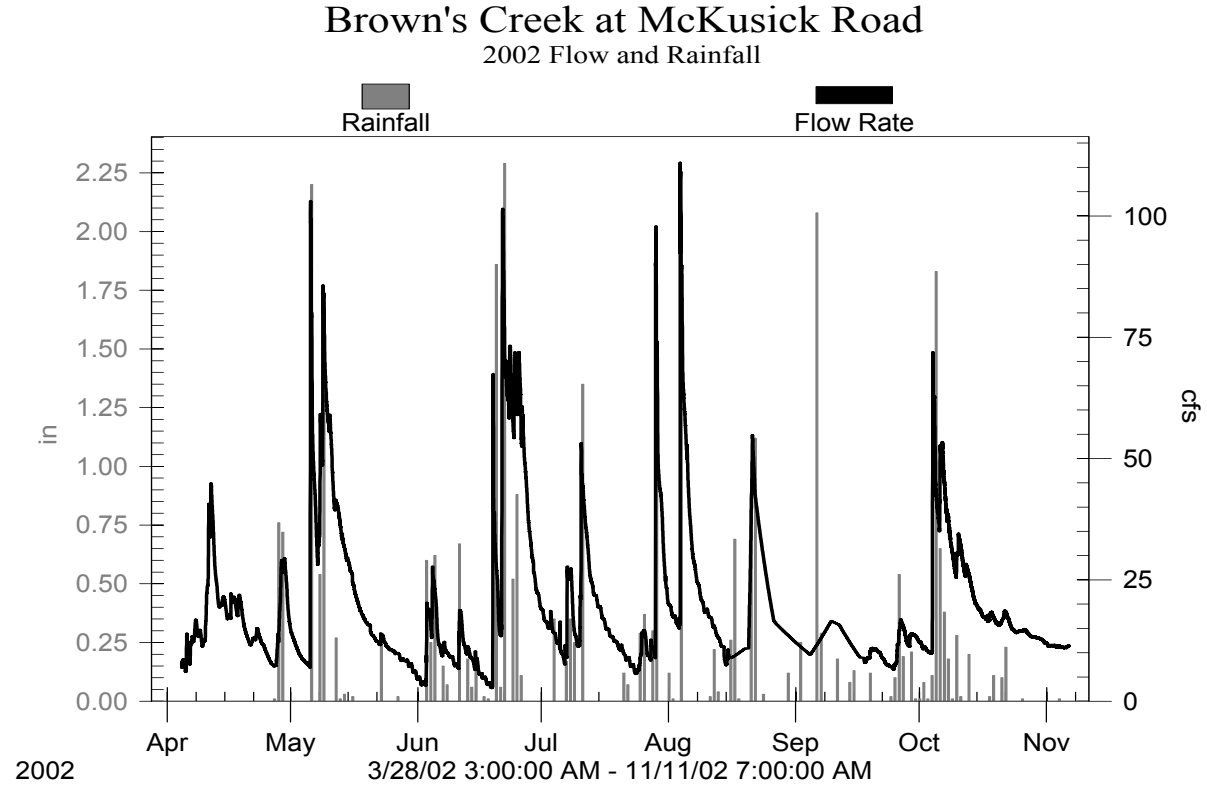


Figure 27: 2002 Brown's Creek at McKusick Road Discharge and Rainfall

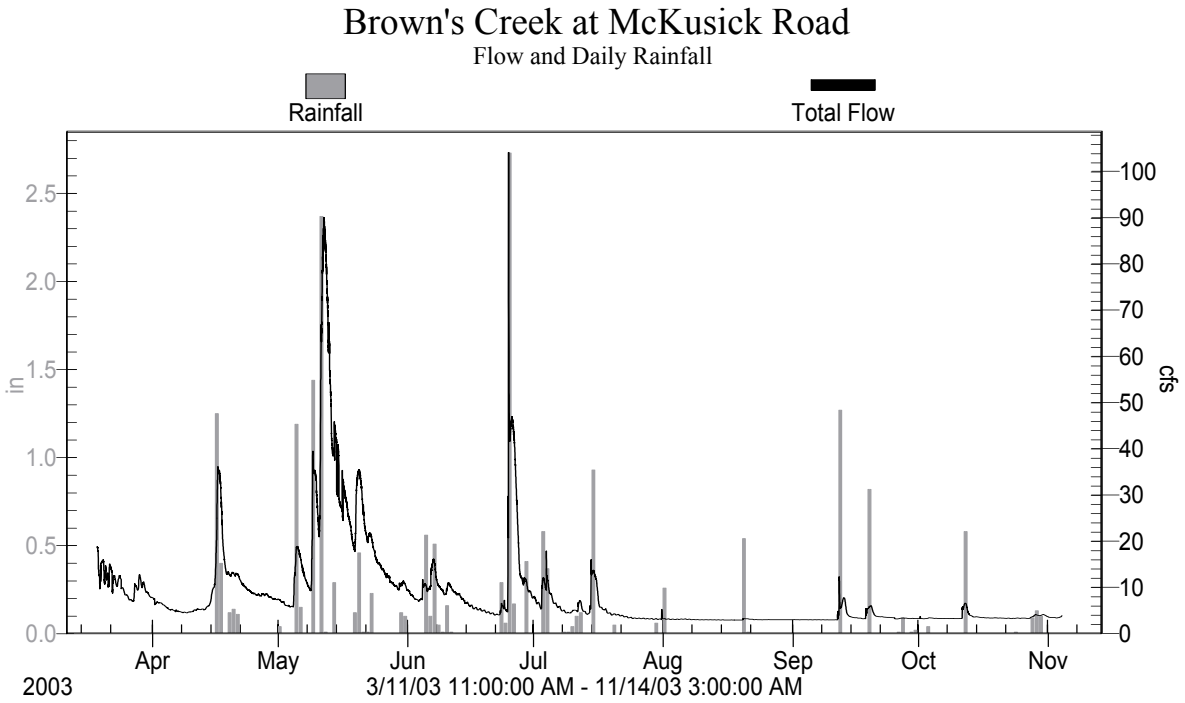


Figure 28: 2003 Brown's Creek at McKusick Road Discharge and Rainfall

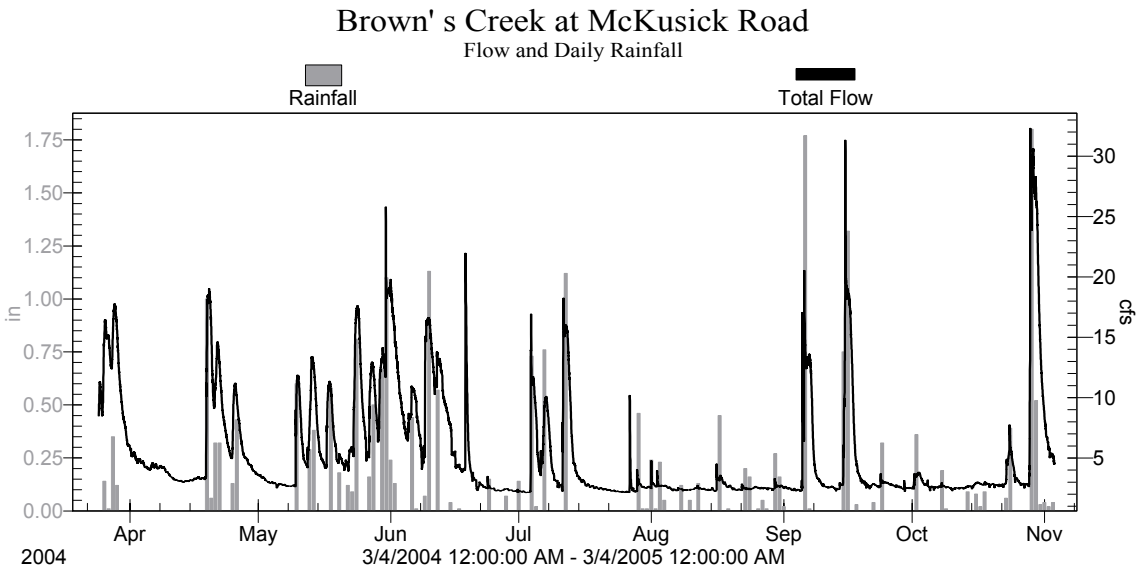


Figure 29: 2004 Brown's Creek at McKusick Road Discharge and Rainfall

Table 29: Brown's Creek at McKusick Road 2000 Total Phosphorus Loading (TP)

Type	Sampling Interval		TP (mg/L)	TSS (mg/L)	Loading Interval		Total Discharge (cf)	TP (lb)
	Start	End			Start	End		
					Interval		Interval (cf)	Interval TP(lb)
Storm Grab 1	*6/6/00 10:50*		*0.350*	*180*				
Storm Grab 2	*6/14/00 11:50*		*0.150*	*19*				
Storm Grab 3	*6/16/00 11:20*		*0.150*	*24*				
Storm Grab 4	*6/19/00 12:20*		*0.130*	*15*				
Storm Grab 5	*6/20/00 14:40*		*0.220*	*62*				
Base Grab 1	*6/22/00 8:00*		*0.150*	*16*				
Baseflow Composite 1	*7/24/00 12:30*	*7/24/00 13:50*	*0.091*	*4*			*16,000*	*0.1*
Stormflow Composite 1	*7/26/00 12:26*	*7/27/00 8:35*	*0.140*	*20*	*7/26/00*	*7/27/00*	*4,000*	*0.0*
Base Grab 2	8/9/00 12:45		0.099	2	7/27/00	8/9/00	618,143	3.8
Estimated Baseflow			0.147	40	8/9/00	8/16/00	2,600,954	23.9
Storm Grab 6	8/17/00 17:00		0.120	7	8/16/00	8/17/00	921,457	6.9
Base Grab 3	8/25/00 10:00		0.120	4	8/17/00	8/25/00	3,763,721	28.2
Estimated Baseflow			0.147	40	8/25/00	8/28/00	262,326	2.4
Storm Grab 7	8/28/00 12:30		0.180	12	8/28/00	8/28/00	5,290,064	59.5
Estimated Baseflow			0.147	40	8/28/00	9/2/00	3,864,555	35.5
Baseflow Composite 2	9/2/00 23:00	9/3/00 0:33	0.340	240	9/2/00	9/3/00	404,572	8.6
Base Grab 4	9/18/00 10:40		0.091	28	9/3/00	9/18/00	17,953,553	102.1
Base Grab 5	10/10/00 13:20		0.065	4	9/18/00	10/10/00	6,808,333	27.7
Estimated Baseflow			0.147		10/10/00	10/23/00	3,398,115	31.2
Baseflow Composite 3	10/23/00 14:18	10/24/00 10:39	0.085	8	10/23/00	10/24/00	286,360	1.5
Estimated Baseflow			0.147	40	10/24/00	10/25/00	453,648	4.2
Storm Composite 2	10/25/00 20:54	10/26/00 17:27	0.150	28	10/25/00	10/26/00	630,483	5.9
Estimated Baseflow			0.147	40	10/26/00	11/1/00	2,309,672	21.2
Storm Composite 3	11/1/00 2:39	11/1/00 10:00	0.220	52	11/1/00	11/2/00	1,342,093	18.5
		Grab Averages	0.147	31				

Estimated baseflow TP is average of grabs taken in 2000

**Italicized samples are samples taken before continuous flow monitored

8/8/00 - 11/2/00 Total (cf)	50,928,048	
8/8/00 - 11/2/00 Total TP(lb)		381.2
Brown's Creek Watershed Total Acres		12,502
8/8/00 - 11/2/00 Measured Total TP(lb)/Acre		0.03
8/8/00 - 11/2/00 Measured Total TP(Kg)/ha		0.03

Table 30: Brown's Creek at McKusick Road 2001 Total Suspended Solids (TSS) and Phosphorus Loading (TP)

Type	Sampling Interval		TP* (mg/L)	TSS* (mg/L)	Loading Interval		Total Discharge (cf)	TP (lb)	TSS (lb)
	Start	End			Start	End			
BASE			*0.07*	13	1/1/01 0:15	3/15/01 17:30	*10,829,340*	47	8788
SNOWMELT			*0.19*	*35*	3/15/01 17:45	3/18/01 23:45	540,470	6.4	1,181
Snowmelt Grab	3/21/01 12:55	NA	0.22	40	3/19/01 0:00	3/23/01 23:45	3,755,161	52	9377
SNOWMELT			*0.19*	*35*	3/24/01 0:00	3/31/01 23:45	12,162,894	144	26575
Snowmelt Grab	4/2/01 12:00	NA	0.16	24	4/1/01 0:00	4/4/01 23:45	8,082,893	81	12110
Snowmelt Grab	4/5/01 13:45	NA	0.20	41	4/5/01 0:00	4/6/01 23:45	4,034,343	50	10326
STORM			*0.14*	*270*	4/7/01 0:00	4/8/01 23:45	8,945,174	78	150771
BASE			*0.07*	*13*	4/9/01 0:00	4/11/01 9:45	5,280,560	24	4285
Storm Grab	4/12/01 11:40	NA	0.14	270	4/11/01 10:00	4/13/01 13:00	7,929,237	69	133,648
Base Composite	4/18/01 15:55	4/19/01 5:08	0.07	13	4/13/01 13:15	4/21/01 5:00	13,516,744	61	10,969
Storm Grab	4/24/01 17:10	NA	0.13	110	4/21/01 5:15	4/28/01 20:00	37,627,429	305	258,383
Base Composite	5/4/01 11:45	5/6/01 19:07	0.07	12	4/28/01 20:15	5/6/01 20:00	15,366,103	62	11,511
STORM			*0.10*	*18*	5/6/01 20:15	5/10/01 17:00	7,438,331	45	8,358
BASE			*0.07*	*13*	5/10/01 17:15	5/21/01 10:00	9,991,801	45	8,109
Storm Composite	5/22/01 10:14	5/24/01 12:59	0.10	18	5/21/01 10:15	5/28/01 0:00	9,694,727	58	10,894
BASE			*0.07*	*13*	5/28/01 0:15	6/5/01 15:00	6,411,145	29	5,203
Storm Composite	6/5/01 16:51	6/7/01 10:25	0.13	22	6/5/01 15:15	6/7/01 10:30	1,052,974	9	1,446
BASE			*0.07*	*13*	6/7/01 10:45	6/10/01 5:00	1,021,544	5	829
Storm Composite	6/12/01 14:12	6/12/01 22:19	0.21	110	6/10/01 5:15	6/14/01 8:00	11,995,023	157	82,368
Storm Grab	6/19/01 15:10	NA	0.14	18	6/14/01 8:15	6/22/01 12:00	28,840,242	252	32,407
BASE			*0.07*	*13*	6/22/01 12:15	6/29/01 12:15	12,507,114	56	10,150
Base Composite	6/29/01 12:31	7/2/01 9:57	0.30	170	6/29/01 12:30	7/2/01 10:00	1,743,677	33	18,505
Base Composite	7/9/01 15:55	7/11/01 12:20	0.11	9	7/2/01 10:15	7/17/01 3:00	3,665,874	25	2,060
Storm Composite	7/17/01 3:07	7/17/01 11:17	0.32	120	7/17/01 3:15	7/18/01 12:00	777,497	16	5,824
BASE			*0.07*	*13*	7/18/01 12:15	7/23/01 14:45	2,070,894	9	1,681
Storm Composite	7/23/01 14:57	7/26/01 12:10	0.10	10	7/23/01 15:00	7/26/01 12:15	1,310,368	8	818
BASE			*0.07*	*13*	7/26/01 12:30	8/1/01 8:45	2,582,576	12	2,096
Storm Composite	8/1/01 8:57	8/1/01 18:43	1.00	440	8/1/01 9:00	8/2/01 4:30	2,597,757	162	71,354
STORM			*0.15*	*31*	8/2/01 4:45	8/4/01 0:00	3,385,578	32	6,552
BASE			*0.07*	*13*	8/4/01 0:15	8/15/01 20:00	6,853,222	31	5,562
Storm Composite	8/15/01 20:37	8/16/01 19:03	0.15	31	8/15/01 20:15	8/16/01 19:00	520,663	5	1,008
BASE			*0.07*	*13*	8/16/01 19:15	8/17/01 20:15	465,112	2	377
Storm Composite	8/17/01 20:31	8/19/01 12:07	0.15	24	8/17/01 20:30	8/20/01 10:00	2,344,827	22	3,513
Base Composite	8/22/01 14:21	8/24/01 13:44	0.10	8	8/20/01 10:15	8/29/01 22:45	3,950,261	23	1,973
STORM			*0.15*	*24*	8/29/01 23:00	8/30/01 22:00	739,260	7	1,108
BASE			*0.07*	*13*	8/30/01 22:15	9/7/01 9:00	3,394,788	15	2,755
STORM			*0.15*	*24*	9/7/01 9:15	9/10/01 7:30	3,409,057	32	5,108
Base Composite	9/18/01 12:23	9/20/01 11:09	0.06	12	9/10/01 7:45	9/20/01 21:15	6,153,511	22	4,610
STORM			*0.15*	*24*	9/20/01 21:30	9/25/01 15:00	9,120,864	85	13,665
Base Composite	10/4/01 15:02	10/8/01 9:45	0.06	14	9/25/01 15:15	10/13/01 7:00	10,856,552	39	9,488
Storm Composite	10/13/01 11:41	10/14/01 6:05	0.12	42	10/13/01 7:15	10/17/01 18:00	4,184,112	31	10,970
BASE			*0.07*	*13*	10/17/01 18:15	11/13/01 13:15	11,726,949	53	9,517
BASE			*0.07*	*13*	11/13/01 13:30	12/31/01 23:45	*7,050,282*	31	5,722

*Italics indicate estimated concentrations based on average base and storm flow concentrations

3/15/01-11/13/01 Total Discharge (cf)	288,047,312		
3/15/01-11/13/01 Total (lb)		2,329	981,952
Browns Creek Watershed Total Acres		12,502	12,502
3/15/01-11/13/01 Total lb/Acre		0.19	78.5
3/15/01-11/13/01 Total kg/ha		0.21	88.0

Table 31: Brown's Creek at McKusick Road 2002 Total Suspended Solids (TSS) and Phosphorus Loading (TP)

	Sample Collection Time						Loading Interval				
Sample Type	**Start Date**	**Start Time**	**End Date**	**End Time**	**TP (mg/L)**	**TSS (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval TP (lb)**	**Interval TSS (lb)**
BASE					*0.11*	*15.3*	*1/1/02 0:00*	*3/10/02 0:00*	*54,276,565*	*373*	*51,942*
Snowmelt Grab	*3/13/02*	*13:30*	*3/13/02*	*13:30*	*0.46*	*80.0*	*3/10/02 0:15*	*3/16/02 21:45*	*8,184,513*	*233*	*40,874*
BASE					*0.11*	*15.3*	*3/16/02 22:00*	*3/27/02 12:45*	*9,574,147*	*66*	*9,162*
Snowmelt Grab	*3/28/02*	*14:30*	*3/28/02*	*14:30*	*0.70*	*307.0*	*3/27/02 13:00*	*3/31/02 3:15*	*10,447,376*	*457*	*200,222*
BASE					*0.10*	*15.3*	*3/31/02 3:30*	*4/4/02 11:30*	*4,966,467*	*31*	*4,753*
Snowmelt Grab	4/8/02	11:40	4/8/02	11:40	0.15	21.0	4/4/02 11:45	4/10/02 10:15	6,038,007	58	7,916
Storm Grab	4/11/02	16:05	4/11/02	16:05	0.41	256.0	4/10/02 10:30	4/13/02 15:30	8,282,700	211	132,367
Storm Grab	4/18/02	17:25	4/18/02	17:25	0.18	32.0	4/13/02 15:45	4/21/02 9:15	12,087,320	137	24,146
Base Composite	4/22/02	13:06	4/23/02	15:30	0.13	17.0	4/21/02 9:30	4/27/02 7:15	5,579,754	46	5,921
STORM					*0.46*	*205.3*	*4/27/02 7:30*	*5/1/02 6:30*	*6,750,247*	*194*	*86,524*
BASE					*0.11*	*15.3*	*5/1/02 6:45*	*5/5/02 17:45*	*3,735,579*	*26*	*3,575*
Storm Composite	5/5/02	18:36	5/6/02	2:36	0.83	580.0	5/5/02 18:00	5/7/02 13:00	8,091,950	419	292,987
STORM					*0.46*	*205.3*	*5/7/02 13:15*	*5/8/02 16:00*	*4,053,185*	*116*	*51,954*
Storm Composite	5/8/02	19:15	5/9/02	3:15	0.55	276.0	5/8/02 16:15	5/15/02 6:30	26,132,060	892	450,245
BASE					*0.11*	*15.3*	*5/15/02 6:45*	*6/2/02 22:45*	*19,600,940*	*135*	*18,758*
Storm Composite	6/3/02	1:55	6/4/02	9:30	0.23	78.0	6/2/02 23:00	6/4/02 10:00	2,068,631	30	10,073
Storm Composite	6/4/02	10:21	6/5/02	9:37	0.27	70.0	6/4/02 10:15	6/7/02 16:30	4,378,301	73	19,132
BASE					*0.11*	*15.3*	*6/7/02 16:45*	*6/10/02 22:00*	*2,401,001*	*16*	*2,298*
STORM					*0.46*	*205.3*	*6/10/02 22:15*	*6/13/02 17:15*	*3,090,812*	*89*	*39,618*
BASE					*0.11*	*15.3*	*6/13/02 17:30*	*6/19/02 3:45*	*2,691,311*	*18*	*2,576*
Storm Composite	6/19/02	5:06	6/19/02	18:12	0.67	247.0	6/19/02 4:00	6/20/02 23:30	4,398,503	184	67,822
Storm Composite	6/21/02	9:04	6/21/02	15:46	0.44	254.0	6/20/02 23:45	6/28/02 1:15	35,962,650	979	570,232
BASE					*0.11*	*15.3*	*6/28/02 1:30*	*7/7/02 5:45*	*13,911,100*	*96*	*13,313*
STORM					*0.46*	*205.3*	*7/7/02 6:00*	*7/10/02 4:00*	*4,792,912*	*138*	*61,435*
Storm Composite	7/10/02	16:07	7/11/02	10:30	0.46	103.0	7/10/02 4:15	7/13/02 23:00	10,019,890	288	64,427
BASE					*0.11*	*15.3*	*7/13/02 23:15*	*7/28/02 18:00*	*15,390,680*	*106*	*14,729*
Storm Composite	7/28/02	18:52	7/29/02	4:59	0.54	189.0	7/28/02 18:15	8/3/02 12:15	15,189,890	514	179,219
Storm Composite	8/3/02	18:36	8/4/02	3:08	0.42	161.0	8/3/02 12:30	8/7/02 22:15	17,819,100	463	179,093
Base Composite	*8/14/02*	*12:16*	*8/15/02*	*4:31*	*0.11*	*14.0*	*8/7/02 22:30*	*8/20/02 10:45*	*15,907,452*	*104*	*13,903*
STORM					*0.46*	*205.3*	*8/20/02 11:00*	*8/26/02 14:30*	*13,806,653*	*396*	*176,973*
BASE					*0.11*	*15.3*	*8/26/02 14:45*	*9/4/02 11:00*	*9,726,751*	*67*	*9,308*
STORM					*0.46*	*205.3*	*9/4/02 11:15*	*9/11/02 18:30*	*17,345,196*	*498*	*222,330*
BASE					*0.11*	*15.3*	*9/11/02 18:45*	*9/24/02 19:30*	*4,548,406*	*31*	*4,353*
STORM					*0.46*	*205.3*	*9/24/02 19:45*	*10/1/02 1:00*	*6,902,490*	*198*	*88,476*
BASE					*0.11*	*15.3*	*10/1/02 1:15*	*10/4/02 1:45*	*2,816,168*	*19*	*2,695*
Storm Composite	10/4/02	5:21	10/4/02	18:34	0.48	218.0	10/4/02 2:00	10/5/02 22:30	7,283,991	220	99,127
STORM					*0.46*	*205.3*	*10/5/02 22:45*	*10/14/02 4:45*	*23,425,910*	*673*	*300,272*
Base Composite	10/23/02	12:22	10/25/02	10:40	0.09	15.0	10/14/02 5:00	11/6/02 11:15	29,431,740	169	27,560
BASE					*0.11*	*15.3*	*11/6/02 11:30*	*12/31/02 23:45*	*21,582,450*	*148*	*20,654*
Storm Average					0.46	205.3					
Base Average					0.11	15.3					
Snowmelt Average					0.44	136.0					
Total Average					0.31	122.0					
Total									**472,692,798**	8,912	3,570,963
Brown's Creek Major Subwatershed Total Acres									12,502		
Total TP/TSS(lb/ac/yr)										0.71	285.63
Total TP/TSS (kg/ha/yr)										0.80	320.14

*Italics indicate estimated concentrations based on average base and storm flow concentrations

**Discharge values and concentrations within the periods 1/1/02 0:15-4/4/02 11:30 and 8/16/02 21:15-9/18/02 21:45 are estimates based on Hwy. 96 site

Table 32: Brown's Creek at McKusick Road 2003 Total Suspended Solids (TSS) and Phosphorus Loading (TP)

	Sample Collection Time						Loading Interval				
Sample Type	**Start Date**	**Start Time**	**End Date**	**End Time**	**TP (mg/L)**	**TSS (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval TP (lb)**	**Interval TSS (lb)**
Base grab	1/22/03	9:23	1/22/03	9:23	0.04	11	1/1/03 0:00	2/1/03 9:30	9,494,100	22	6,519
Base grab	2/14/03	11:45	2/14/03	11:45	0.10	12	2/1/03 9:45	3/1/03 11:45	8,492,400	52	6,362
BASE					*0.09*	*14*	*3/1/03 12:00*	*3/15/03 0:00*	*4,082,400*	23	3,568
Snowmelt grab	3/17/03	10:30	3/17/03	10:30	0.35	48	3/15/03 0:15	3/25/03 0:15	12,574,800	276	37,680
BASE					*0.09*	*14*	*3/25/03 0:30*	*3/27/03 12:00*	*1,703,195*	10	1,489
Storm grab	3/31/03	12:30	3/31/03	12:30	0.07	11	3/27/03 12:15	3/31/03 12:30	3,408,306	14	2,340
BASE					*0.09*	*14*	*3/31/03 12:45*	*4/14/03 14:45*	*6,858,735*	39	5,994
Storm composite	4/16/03	7:11	4/17/03	3:17	0.45	192	4/14/03 15:00	4/17/03 10:00	4,553,664	129	54,579
BASE					*0.09*	*14*	*4/17/03 10:15*	*5/4/03 16:45*	*14,572,606*	82	12,736
Storm composite	5/4/03	20:50	5/6/03	18:59	0.17	56	5/4/03 17:00	5/8/03 20:45	4,907,705	53	17,157
Storm composite	5/9/03	2:27	5/10/03	2:19	0.75	147	5/8/03 21:00	5/10/03 21:15	4,870,620	229	44,696
STORM					*0.34*	*100*	5/10/03 21:30	*5/13/03 2:30*	*13,430,070*	285	83,839
Base grab	5/15/03	15:50	5/15/03	15:50	0.11	29	5/13/03 2:45	5/19/03 9:45	17,898,310	124	32,402
STORM					*0.34*	*100*	*5/19/03 10:00*	*5/21/03 4:00*	*4,775,774*	101	29,813
BASE					*0.09*	*14*	*5/21/03 4:15*	*6/4/03 13:45*	*16,295,220*	92	14,241
STORM					*0.34*	*100*	*6/4/03 14:00*	*6/8/03 1:30*	*3,571,114*	76	22,293
BASE					*0.09*	*14*	*6/8/03 1:45*	*6/10/03 4:00*	*1,732,226*	10	1,514
STORM					*0.34*	*100*	*6/10/03 4:15*	*6/11/03 8:15*	*1,033,362*	22	6,451
BASE					*0.09*	*14*	*6/11/03 8:30*	*6/24/03 22:45*	*7,051,451*	40	6,163
Storm composite	6/24/03	23:50	6/26/03	14:39	0.51	290	6/24/03 23:00	6/26/03 17:00	6,654,217	211	120,465
BASE					*0.09*	*14*	*6/26/03 17:15*	*6/29/03 11:00*	*4,039,685*	23	3,531
BASE					*0.09*	*14*	*6/29/03 11:15*	*7/3/03 0:45*	*2,387,854*	13	2,087
Storm composite	7/3/03	2:55	7/5/03	3:13	0.26	36	7/3/03 1:00	7/5/03 4:00	1,967,080	32	4,421
BASE					*0.09*	*14*	*7/5/03 4:15*	*7/14/03 16:15*	*4,463,698*	25	3,901
Storm composite	7/14/03	20:24	7/16/03	13:47	0.26	56	7/14/03 16:30	7/16/03 14:00	1,913,718	32	6,690
Base composite	7/29/03	9:46	7/31/03	1:47	0.09	11	7/16/03 14:15	8/3/03 2:45	5,707,978	32	3,920
Base composite	8/7/03	14:08	8/11/03	12:18	0.09	13	8/3/03 3:00	8/17/03 9:00	3,757,286	20	3,049
Base composite	8/26/03	10:59	8/28/03	8:52	0.08	12	8/17/03 9:15	9/1/03 11:15	3,978,872	20	2,981
Base composite	9/5/03	8:51	9/8/03	12:52	0.08	9	9/1/03 11:30	9/11/03 18:15	2,675,143	14	1,503
Storm composite	9/11/03	19:11	9/12/03	5:06	0.30	78	9/11/03 18:30	9/13/03 10:30	913,223	17	4,447
BASE					*0.09*	*14*	*9/13/03 10:45*	*9/18/03 13:45*	*1,679,385*	9	1,468
Storm grab	9/19/03	9:30	9/19/03	9:30	0.17	19	9/18/03 14:00	9/19/03 21:45	628,100	7	745
Base composite	10/3/03	15:22	10/6/03	9:49	0.09	14	9/19/03 22:00	10/11/03 13:00	6,426,140	36	5,616
Storm composite	10/11/03	14:32	10/12/03	13:11	0.16	26	10/11/03 13:15	10/12/03 12:15	491,678	5	798
Base grab	10/28/03	8:00	10/28/03	8:00	0.09	15	10/12/03 12:30	11/4/03 9:30	7,132,971	40	6,679
BASE					*0.09*	*14*	*11/4/03 9:45*	*12/31/03 23:45*	*14,925,600*	84	13,044
Storm Average					0.34	100					
Base Average					0.09	14					
Snowmelt Average					0.35	48					
All Average					0.19	46					
Total									**211,048,686**	2,297	575,181
Brown's Creek Major Subwatershed Total Acres									12,502		
Total TP/TSS(lb/ac/yr)										0.18	46.01
Total TP/TSS (kg/ha/yr)										0.21	51.57

*Italics indicate estimated concentrations based on average base and storm flow concentrations

Table 33: Brown's Creek at McKusick Road 2004 Total Suspended Solids (TSS) and Phosphorus Loading (TP)

	Sample Collection Time						Loading Interval				
Sample Type	Start Date	Start Time	End Date	End Time	TP (mg/L)	TSS (mg/L)	Start	End	Interval Volume (cf)	Interval TP (lb)	Interval TSS (lb)
BASE					*0.15*	*16*	*1/1/2004 0:00*	*1/4/2004 22:00*	*676,800*	*6.35*	*687*
SNOWMELT					*0.22*	*42*	*1/4/2004 22:15*	*1/6/2004 0:15*	*936,000*	*12.88*	*2,454*
BASE					*0.15*	*16*	*1/6/2004 0:30*	*1/18/2004 18:30*	*2,203,200*	*20.66*	*2,235*
SNOWMELT					*0.22*	*42*	*1/18/2004 18:45*	*1/20/2004 0:45*	*756,000*	*10.41*	*1,982*
BASE					*0.15*	*16*	*1/20/2004 1:00*	*1/21/2004 21:00*	*316,800*	*2.97*	*321*
SNOWMELT					*0.22*	*42*	*1/21/2004 21:15*	*1/23/2004 2:15*	*730,800*	*10.06*	*1,916*
BASE					*0.15*	*16*	*1/23/2004 2:30*	*2/3/2004 22:00*	*2,041,200*	*19.15*	*2,071*
SNOWMELT					*0.22*	*42*	*2/3/2004 22:15*	*2/4/2004 13:15*	*972,000*	*13.38*	*2,548*
BASE					*0.15*	*16*	*2/4/2004 13:30*	*2/14/2004 21:30*	*1,785,600*	*16.75*	*1,811*
SNOWMELT					*0.22*	*42*	*2/14/2004 21:45*	*2/15/2004 13:15*	*613,800*	*8.45*	*1,609*
BASE					*0.15*	*16*	*2/15/2004 13:30*	*2/28/2004 15:30*	*2,260,800*	*21.21*	*2,293*
Snowmelt grab	3/1/2004	11:20	3/1/2004	11:20	0.22	24	2/28/2004 15:45	3/3/2004 1:45	2,656,800	37.15	3,980
BASE					*0.15*	*16*	*3/3/2004 2:00*	*3/10/2004 13:00*	*1,288,800*	*12.09*	*1,307*
Snowmelt grab	3/11/2004	14:00	3/11/2004	14:00	0.22	60	3/10/2004 13:15	3/12/2004 11:15	1,656,000	22.43	6,203
BASE					*0.15*	*16*	*3/12/2004 11:30*	*3/17/2004 14:45*	*887,400*	*8.32*	*900*
SNOWMELT					*0.22*	*42*	*3/17/2004 15:00*	*3/20/2004 21:00*	*3,088,800*	*42.52*	*8,099*
BASE					*0.15*	*16*	*3/20/2004 21:15*	*3/24/2004 16:00*	*651,600*	*6.11*	*661*
STORM					*0.30*	*110*	*3/24/2004 16:15*	*3/29/2004 9:15*	*5,635,952*	*105.47*	*38,810*
BASE					*0.15*	*16*	*3/29/2004 9:30*	*4/18/2004 9:30*	*7,668,144*	*71.92*	*7,779*
Storm composite	4/18/2004	20:18	4/20/2004	2:36	0.52	198	4/18/2004 9:45	4/20/2004 2:00	1,959,969	63.87	24,226
Storm composite	4/21/2004	7:35	4/21/2004	19:43	0.16	119	4/20/2004 2:15	4/22/2004 13:00	2,497,163	25.57	18,551
BASE					*0.15*	*16*	*4/22/2004 13:15*	*4/24/2004 21:30*	*2,529,277*	*23.72*	*2,566*
STORM					*0.30*	*110*	*4/24/2004 21:45*	*4/26/2004 14:15*	*1,385,690*	*25.93*	*9,542*
Base composite	5/4/2004	16:20	5/7/2004	11:55	0.23	14	4/26/2004 14:30	5/9/2004 17:15	4,023,419	56.76	3,516
Storm composite	5/9/2004	18:24	5/10/2004	15:13	0.39	135	5/9/2004 17:30	5/12/2004 9:00	1,751,599	42.21	14,762
Storm composite	5/13/2004	9:34	5/14/2004	5:47	0.26	76	5/12/2004 9:15	5/14/2004 11:30	1,773,453	29.23	8,414
BASE					*0.15*	*16*	*5/14/2004 11:45*	*5/17/2004 0:15*	*1,229,092*	*11.53*	*1,247*
STORM					*0.30*	*110*	*5/17/2004 0:30*	*5/18/2004 17:15*	*1,411,318*	*26.41*	*9,718*
BASE					*0.15*	*16*	*5/18/2004 17:30*	*5/23/2004 7:15*	*2,007,981*	*18.83*	*2,037*
Storm composite	5/23/2004	16:31	5/24/2004	13:44	0.26	124	5/23/2004 7:30	5/24/2004 19:45	1,987,420	32.38	15,384
BASE					*0.15*	*16*	*5/24/2004 20:00*	*5/26/2004 22:30*	*1,440,256*	*13.51*	*1,461*
STORM					*0.30*	*110*	*5/26/2004 22:45*	*5/28/2004 5:15*	*1,275,682*	*23.87*	*8,784*
BASE					*0.15*	*16*	*5/28/2004 5:30*	*5/29/2004 4:30*	*696,027*	*6.53*	*706*
STORM					*0.30*	*110*	*5/29/2004 4:45*	*5/30/2004 19:15*	*1,697,078*	*31.76*	*11,686*
Storm composite	5/30/2004	20:50	5/30/2004	20:50	0.50		5/30/2004 19:30	6/1/2004 8:15	2,496,021	77.91	0
BASE					*0.15*	*16*	*6/1/2004 8:30*	*6/5/2004 0:00*	*3,462,877*	*32.48*	*3,513*
STORM					*0.30*	*110*	*6/5/2004 0:15*	*6/7/2004 1:30*	*1,679,861*	*31.44*	*11,568*
BASE					*0.15*	*16*	*6/7/2004 1:45*	*6/8/2004 7:00*	*739,356*	*6.93*	*750*
Storm composite	6/9/2004	4:26	6/10/2004	9:18	0.30	76	6/8/2004 7:15	6/10/2004 10:00	2,205,528	41.30	10,464
BASE					*0.15*	*16*	*6/10/2004 10:15*	*6/18/2004 10:30*	*5,759,439*	*54.02*	*5,843*
Base composite	6/24/2004	12:33	6/28/2004	5:24	0.12	14	6/18/2004 10:45	7/3/2004 18:15	3,954,722	28.64	3,456
Storm composite	7/3/2004	19:00	7/6/2004	11:32	0.29	120	7/3/2004 18:30	7/4/2004 15:30	4,036,477	72.57	30,238
BASE					*0.15*	*16*	*7/4/2004 15:45*	*7/6/2004 2:45*	*784,001*	*7.35*	*795*
Storm composite	7/6/2004	16:48	7/8/2004	9:14	0.19	55	7/6/2004 3:00	7/8/2004 10:00	1,497,592	17.67	5,142
BASE					*0.15*	*16*	*7/8/2004 10:15*	*7/11/2004 5:45*	*795,957*	*7.47*	*807*
Storm composite	7/11/2004	7:51	7/12/2004	13:55	0.31	98	7/11/2004 6:00	7/13/2004 1:15	2,203,893	42.79	13,483
Base composite	7/22/2004	13:47	7/25/2004	13:21	0.17	24	7/13/2004 1:30	7/26/2004 22:15	3,403,307	35.27	5,099
STORM					*0.30*	*110*	*7/26/2004 22:30*	*7/27/2004 0:30*	*15,561*	*0.29*	*107*
BASE					*0.15*	*16*	*7/27/2004 0:45*	*9/5/2004 4:30*	*8,852,624*	*83.03*	*8,980*
Storm composite	9/5/2004	7:42	9/6/2004	6:08	0.26	102	9/5/2004 4:45	9/7/2004 6:00	2,127,673	35.07	13,548
BASE					*0.15*	*16*	*9/7/2004 6:15*	*9/14/2004 20:45*	*2,267,054*	*21.26*	*2,300*
Storm composite	9/15/2004	7:03	9/16/2004	10:16	0.27	90	9/14/2004 21:00	9/16/2004 13:30	2,403,099	40.05	13,501
Base composite	10/12/2004	12:05	10/14/2004	10:36	0.09	13	9/16/2004 13:45	10/22/2004 22:45	9,589,567	55.67	7,782
Storm composite	10/23/2004	13:24	10/24/2004	8:56	0.11	23	10/22/2004 23:00	10/24/2004 9:00	637,590	4.46	915
BASE					*0.15*	*16*	*10/24/2004 9:15*	*10/28/2004 10:00*	*1,108,278*	*10.40*	*1,124*
Storm composite	10/28/2004	13:15	10/29/2004	4:48	0.37	218	10/28/2004 10:15	10/30/2004 17:15	4,884,859	112.52	66,478
BASE					*0.15*	*16*	*10/30/2004 17:30*	*11/18/2004 23:30*	*6,580,480*	*61.72*	*6,675*
STORM					*0.30*	*110*	*11/18/2004 23:45*	*11/22/2004 21:45*	*2,030,400*	*38.00*	*13,982*
BASE					*0.15*	*16*	*11/22/2004 22:00*	*12/13/2004 12:30*	*6,230,700*	*58.44*	*6,321*
SNOWMELT					*0.22*	*42*	*12/13/2004 12:45*	*12/14/2004 12:45*	*432,000*	*5.95*	*1,133*
BASE					*0.15*	*16*	*12/14/2004 13:00*	*12/18/2004 19:30*	*1,107,000*	*10.38*	*1,123*
SNOWMELT					*0.22*	*42*	*12/18/2004 19:45*	*12/19/2004 12:45*	*306,000*	*4.21*	*802*
BASE					*0.15*	*16*	*12/19/2004 13:00*	*12/22/2004 13:00*	*777,600*	*7.29*	*789*
SNOMELT					*0.22*	*42*	*12/22/2004 13:15*	*12/24/2004 17:15*	*936,000*	*12.88*	*2,454*
BASE					*0.15*	*16*	*12/24/2004 17:30*	*12/31/2004 23:45*	*1,881,900*	*17.65*	*1,909*
Storm Average					0.30	110					
Base Average					0.15	16					
Snowmelt Average					0.22	42					
All Average					0.21	52					
Total									**149,679,336**	1,916	461,349
Brown's Creek Major Subwatershed Total Acres									12,502		
Total TP/TSS(lb/ac/yr)										0.15	36.90
Total TP/TSS (kg/ha/yr)										0.17	41.36

*Italics indicate estimated concentrations based on average base and storm flow concentrations

Table 34: Brown's Creek at McKusick Road 2004 Primary Chemistry Results

Sample Type	Start Date	Start Time	End Date	End Time	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Fecal Coliform (#/100 mL)
Snowmelt grab	3/1/2004	11:20	3/1/2004	11:20	24	12	1.50	0.22	
Snowmelt grab	3/11/2004	14:00	3/11/2004	14:00	60	30	1.70	0.22	
Storm composite	4/18/2004	20:18	4/20/2004	2:36	198	84	3.50	0.52	
Storm composite	4/21/2004	7:35	4/21/2004	19:43	119	41	1.40	0.16	
Base composite	5/4/2004	16:20	5/7/2004	11:55	14	7	0.19	0.23	
Storm composite	5/9/2004	18:24	5/10/2004	15:13	135	61	2.80	0.39	
Storm composite	5/13/2004	9:34	5/14/2004	5:47	76	34	1.80	0.26	
Storm composite	5/23/2004	16:31	5/24/2004	13:44	124	49	1.90	0.26	
Storm composite	5/30/2004	20:50	5/30/2004	20:50			2.90	0.50	
Fecal grab	6/8/2004	10:00	6/8/2004	10:00					200
Storm composite	6/9/2004	4:26	6/10/2004	9:18	76	25	1.60	0.30	
Base composite	6/24/2004	12:33	6/28/2004	5:24	14	8	0.52	0.12	
Storm composite	7/3/2004	19:00	7/6/2004	11:32	120	62	1.90	0.29	
Storm composite	7/6/2004	16:48	7/8/2004	9:14	55	22	1.30	0.19	
Storm composite	7/11/2004	7:51	7/12/2004	13:55	98	35	1.80	0.31	
Fecal grab	7/15/2004	9:30	7/15/2004	9:30					310
Base composite	7/22/2004	13:47	7/25/2004	13:21	24	11	0.64	0.17	
Fecal grab	8/12/2004	7:45	8/12/2004	7:45					250
Storm composite	9/5/2004	7:42	9/6/2004	6:08	102	37	1.70	0.26	
Storm composite	9/15/2004	7:03	9/16/2004	10:16	90	39	1.80	0.27	
Fecal grab	9/27/2004	9:15	9/27/2004	9:15					65
Base composite	10/12/2004	12:05	10/14/2004	10:36	13	5	0.44	0.09	
Storm composite	10/23/2004	13:24	10/24/2004	8:56	23	8	0.62	0.11	
Storm composite	10/28/2004	13:15	10/29/2004	4:48	218	58	2.30	0.37	
Average					**83**	**33**	**1.62**	**0.26**	**206**

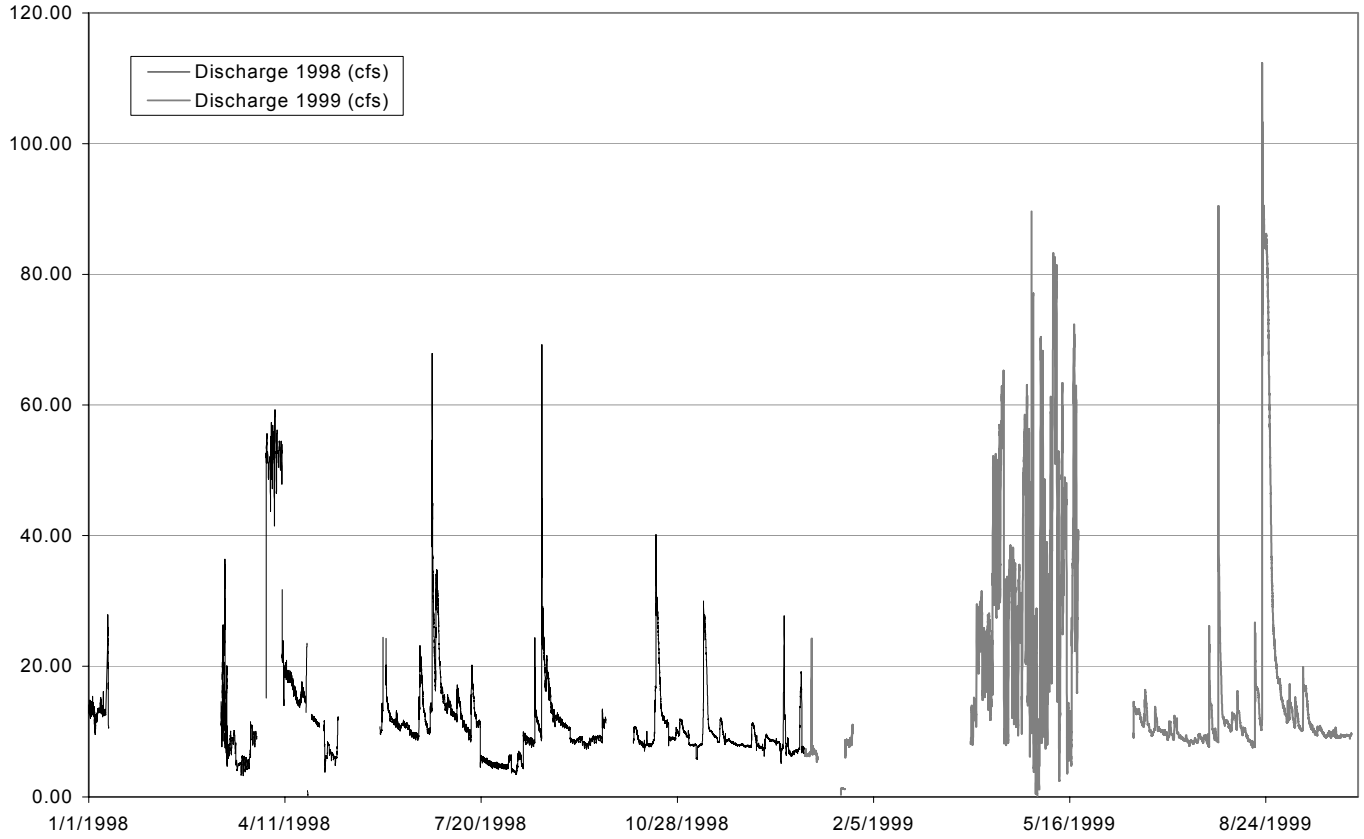


Figure 30: Brown's Creek at Mouth (Highway 96) 1998-1999 Discharge

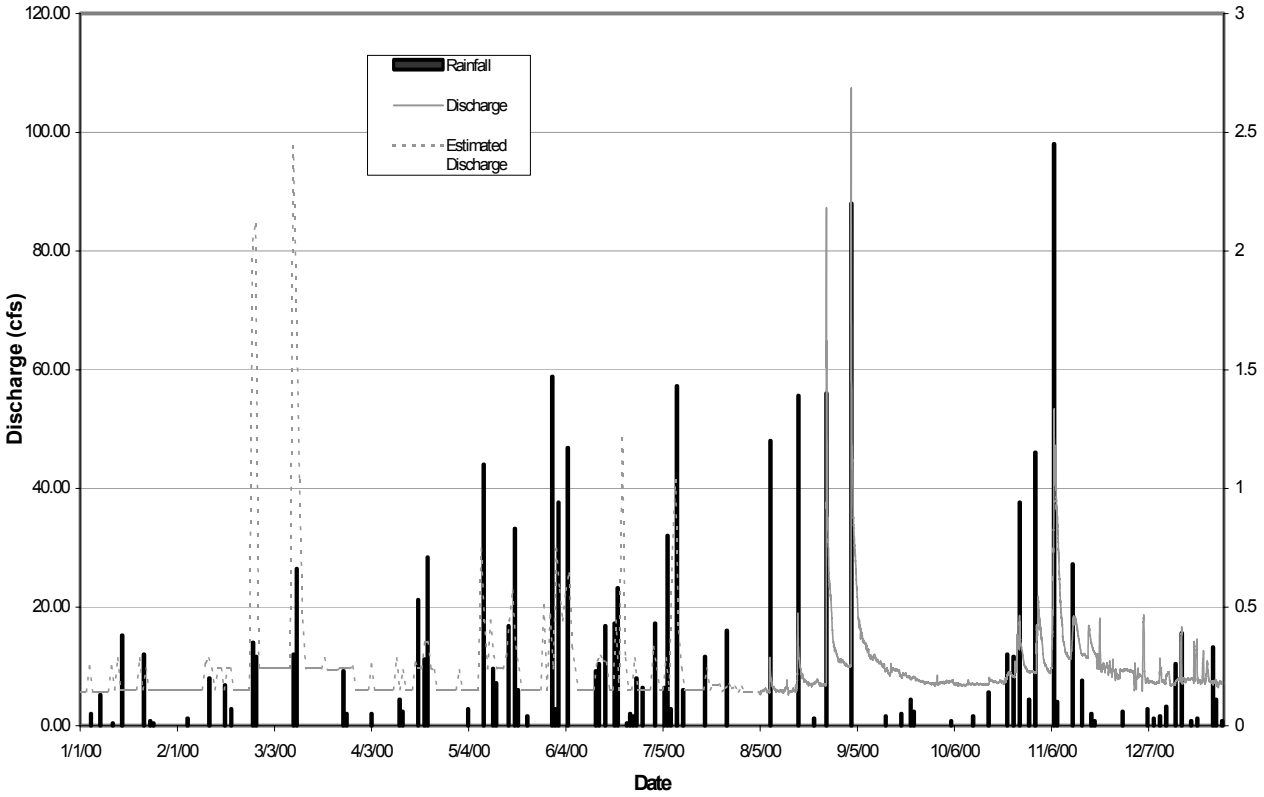


Figure 31: Brown's Creek at Mouth (Highway 96) 2000 Continuous Flow and Rainfall

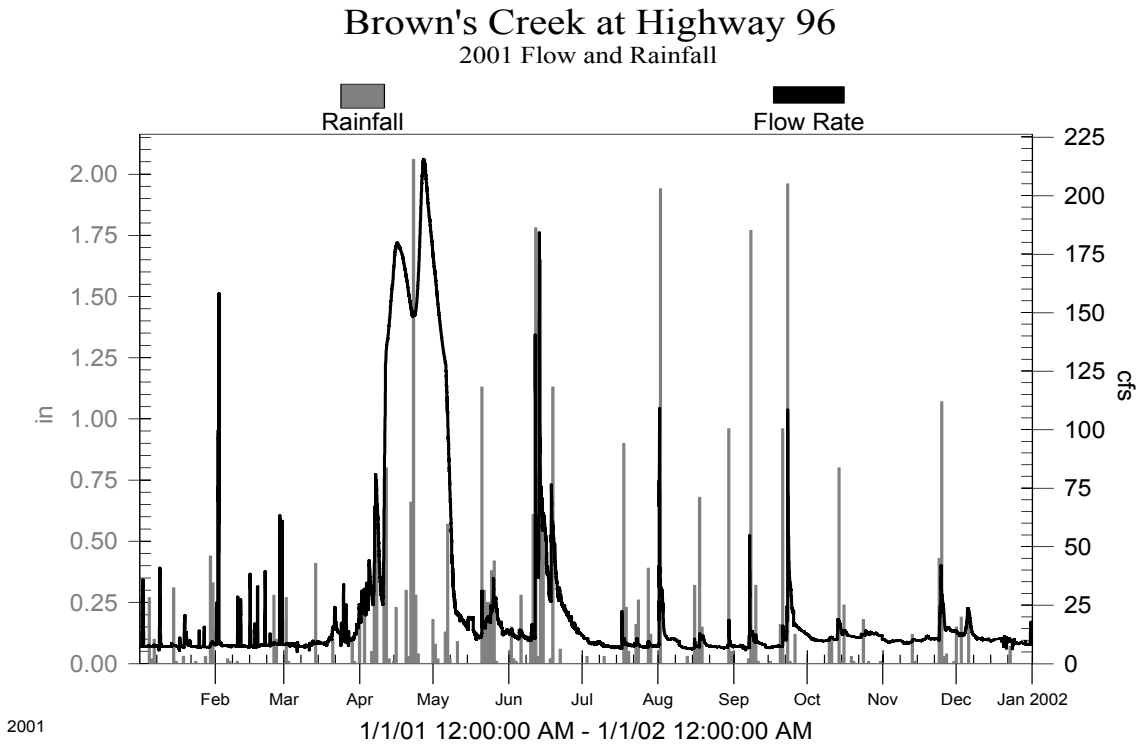


Figure 32: Brown's Creek at Mouth (Highway 96) 2001 Continuous Flow and Rainfall

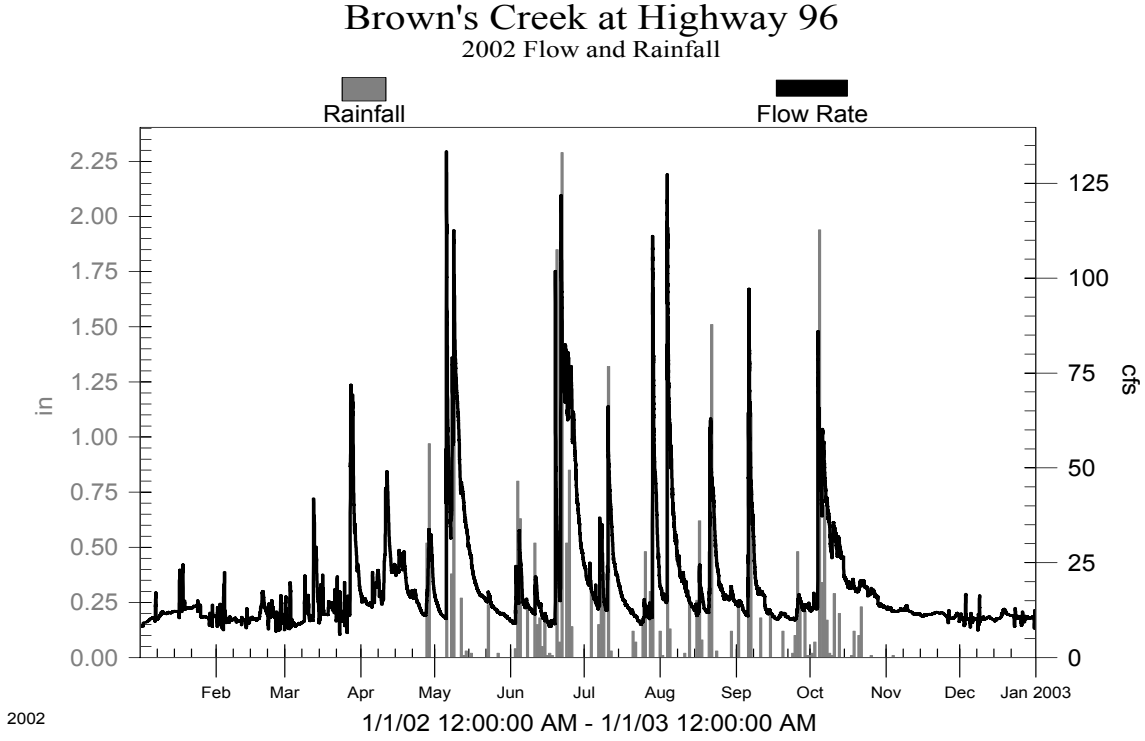


Figure 33: Brown's Creek at Mouth (Highway 96) 2002 Continuous Flow and Rainfall

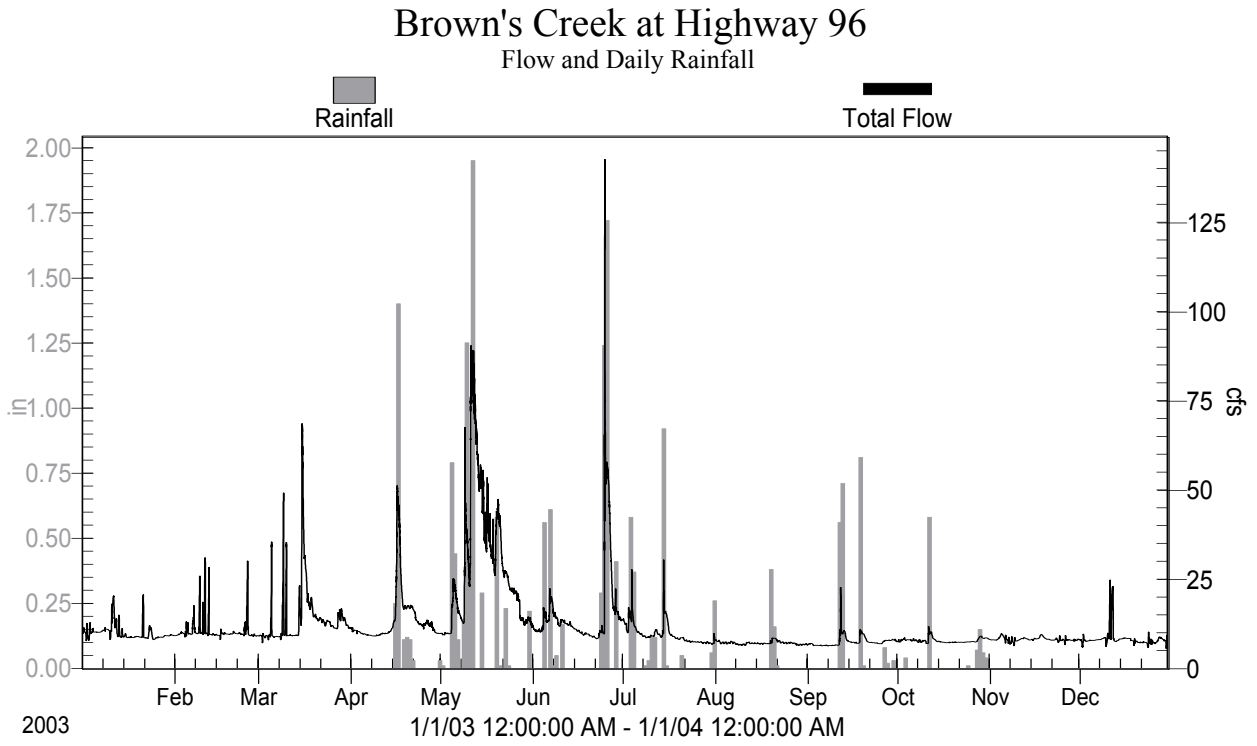


Figure 34: Brown's Creek at Mouth (Highway 96) 2003 Continuous Flow and Rainfall

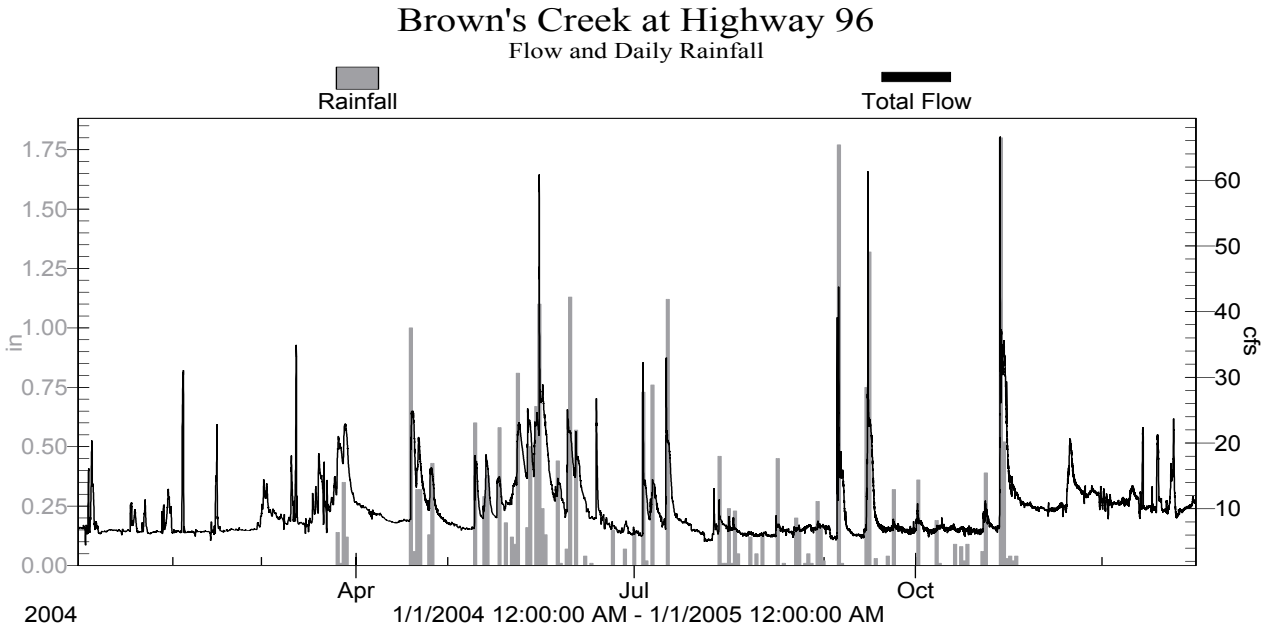


Figure 35: Brown's Creek at Mouth (Highway 96) 2004 Continuous Flow and Rainfall

Table 35: Brown's Creek at Highway 96 2000 Total Phosphorus Loading (TP)

					Interval			
Sample events	Date	Time	Flow (cfs)	T.P. (mg/L)	Start Date & time	End Date & time	Interval (cf)	Interval TP(lb)
Base Grab	*2/25/00*	*10:45*		4.40				
Base Grab	*3/28/00*	*15:00*		0.10				
Base Grab	*4/17/00*	*14:15*		0.08				
Storm Grab	*4/20/00*	*10:40*		0.12				
Storm Grab	*5/8/00*	*13:00*		0.17				
Storm Grab	*5/12/00*	*14:25*		0.19				
Storm Grab	*5/16/00*	*13:15*		0.11				
Storm Grab	*5/18/00*	*13:30*		0.18				
Storm Grab	*5/30/00*	*10:50*		0.40				
Storm Grab	*6/5/00*							
Storm Grab	*6/14/00*	*10:30*		0.15				
Storm Grab	*6/16/00*	*11:05*		0.16				
Storm Grab	*7/10/00*	*12:50*		0.22				
Base Grab	*7/24/00*	*9:50*		0.08				
Estimated Baseflow	8/4/00	9:30	9.2	0.15	8/4/00 9:30	8/7/00 23:15	1,798,739	16.9
Storm Grab	8/8/00	11:45	8.4	0.05	8/7/00 23:30	8/8/00 7:30	258,458	0.8
Estimated Baseflow				0.15	8/8/00 7:45	8/16/00 17:15	4,409,427	41.3
Storm Grab	8/17/00	10:54	11.0	0.07	8/16/00 17:30	8/17/00 16:30	1,005,890	4.4
Base Grab	8/25/00	9:40	6.2	0.15	8/17/00 16:45	8/26/00 1:30	5,323,978	49.9
Storm Grab	8/28/00	11:00	12.9	0.16	8/26/00 1:45	8/27/00 21:45	4,886,983	48.9
Estimated Baseflow				0.15	8/27/00 22:00	9/2/00 22:00	5,902,845	55.3
Storm Grab	9/5/00	16:00	24.5	0.14	9/2/00 22:15	9/7/00 7:30	9,745,500	85.3
Base Grab	10/20/00	11:40	11.6	0.15	9/7/00 7:45	10/20/00 7:45	30,422,890	285.2
Base Grab	10/24/00	10:00		0.15	10/20/00 8:00	10/24/00 8:00	2,759,560	25.9
Estimated Baseflow				0.15	10/24/00 8:15	10/25/00 4:45	599,591	5.6
Composite	10/25/00	23:33-21:11		0.41	10/25/00 5:00	10/28/00 2:30	3,148,976	80.7
Estimated Baseflow				0.15	10/28/00 2:45	11/1/00 2:30	3,195,217	30.0
Composite	11/1/00	5:50-18:09		0.78	11/1/00 2:45	11/2/00 14:45	2,233,327	108.9
Estimated Baseflow				0.15	11/2/00 15:00	11/5/00 15:15	2,789,628	26.2
Composite	11/6/00	4:32-10:33		0.11	11/5/00 15:30	11/6/00 22:30	2,470,829	17.0
Composite	11/7/00	16:54-8:53		0.18	11/6/00 22:45	11/8/00 21:45	5,561,275	62.6
Estimated Baseflow				0.15	11/8/00 21:45	12/31/00 23:45	44,269,150	415.1
		Grab Average		0.15				
		8/4/00 - 12/31/00 Total (cf)					130,782,263	
		8/4/00 - 12/31/00 Total TP(lb)						1,360
		Brown's Creek Watershed Total Acres						13,491
		8/4/00 - 12/31/00 Measured Total TP(lb)/Acre						0.10
		8/4/00 - 12/31/00 Measured Total TP(Kg)/ha						0.11

Baseflow TP is average of grabs taken in 2000

**Italicized samples are *samples taken before continuous flow monitored*

Table 36: Brown's Creek at Mouth (Highway 96) 2001 Total Suspended Solids (TSS) and Phosphorus Loading (TP)

Type	Sampling Interval		TP (mg/L)	TSS (mg/L)	Loading Interval		Total Discharge (cf)	TP (lb)	TSS (lb)
	Start	End			Start	End			
Base Est			*0.13*	*14*	1/1/01 0:15	3/20/01 12:00	63,553,540	527	56,110
Snowmelt	3/20/01 15:00	3/20/01 15:00	0.23	64	3/20/01 12:15	3/27/01 1:00	8,025,838	115	32,065
Snowmelt	3/29/01 12:50	3/29/01 12:50	0.08	11	3/27/01 1:15	3/30/01 12:30	3,260,507	16	2,239
Snowmelt	3/30/01 22:39	4/2/01 22:26	0.49	360	3/30/01 12:45	4/2/01 22:30	6,225,943	190	139,918
Snowmelt	4/2/01 22:25	4/5/01 13:53	0.44	321	4/2/01 22:45	4/6/01 12:30	9,475,984	260	189,887
Snowmelt,Storm	4/6/01 12:30	4/7/01 19:20	0.91	281	4/6/01 12:45	4/7/01 19:45	6,228,077	354	109,251
Snowmelt	4/7/01 19:50	4/9/01 3:23	0.31	68	4/7/01 20:00	4/10/01 10:00	10,076,570	195	42,775
Storm	4/10/01 18:51	4/12/01 6:41	0.46	327	4/10/01 10:15	4/12/01 21:45	22,645,130	650	462,263
Snowmelt	4/13/01 11:00	4/13/01 11:00	0.12	14	4/12/01 22:00	4/14/01 1:00	14,661,540	110	12,814
Snowmelt	4/14/01 16:00	4/14/01 16:00	0.15	89	4/14/01 1:15	4/14/01 22:00	12,198,470	114	67,774
Snowmelt	4/16/01 13:30	4/16/01 13:30	0.53	70	4/14/01 22:15	4/17/01 21:30	45,417,030	1,503	198,465
Snowmelt	4/18/01 12:00	4/18/01 12:00	0.12	32	4/17/01 21:45	4/23/01 1:30	72,131,500	540	144,093
Storm	4/25/01 15:30	4/25/01 15:30	0.39	224	4/23/01 1:45	4/30/01 18:30	123,411,930	3,005	1,725,725
Snowmelt Est			*0.34*	*159*	4/30/01 18:45	5/7/01 9:15	81,433,510	1,748	810,244
Storm Est			*0.58*	*410*	5/7/01 9:30	5/11/01 6:15	13,821,520	498	353,650
Base Est			*0.13*	*14*	5/11/01 6:30	5/20/01 17:30	13,352,610	111	11,789
Storm	5/22/01 10:40	5/22/01 10:40	0.13	30	5/20/01 17:45	5/29/01 16:00	15,111,170	123	28,300
Base	6/6/01 10:21	6/6/01 10:21	0.11	18	5/29/01 16:15	6/11/01 15:30	13,992,140	96	15,723
Storm	6/11/01 18:30	6/12/01 21:39	1.60	1320	6/11/01 15:45	6/13/01 0:45	6,183,204	618	509,512
Storm	6/13/01 10:39	6/14/01 11:32	0.81	648	6/13/01 1:00	6/18/01 4:30	24,757,120	1,252	1,001,479
Storm Est			*0.58*	*410*	6/18/01 4:45	6/23/01 5:00	16,719,840	602	427,809
Base	6/29/01 9:40	6/29/01 9:40	0.30	19	6/23/01 5:15	7/6/01 8:00	16,229,260	304	19,249
Base	7/13/01 18:30	7/16/01 7:11	0.13	11	7/6/01 8:15	7/16/01 14:45	6,829,937	55	4,690
Storm	7/17/01 4:33	7/18/01 6:59	0.21	68	7/16/01 15:00	7/18/01 7:45	1,333,332	17	5,660
Base Est			*0.13*	*14*	7/18/01 8:00	8/1/01 6:45	9,431,251	78	8,327
Storm	8/1/01 9:58	8/2/01 7:02	0.72	406	8/1/01 7:00	8/3/01 11:45	5,964,576	268	151,172
Base	8/13/01 9:11	8/14/01 8:26	0.07	11	8/3/01 12:00	8/17/01 17:00	10,487,870	46	7,202
Storm	8/18/01 0:42	8/18/01 0:42	0.28	*410*	8/17/01 17:15	8/21/01 4:30	2,923,177	51	74,818
Base	8/28/01 9:27	8/29/01 8:53	0.14	26	8/21/01 4:45	8/29/01 22:15	5,410,717	47	8,782
Storm Est			*0.58*	*410*	8/29/01 22:30	8/31/01 2:00	948,167	34	24,261
Base Est			*0.13*	*14*	8/31/01 2:15	9/7/01 5:00	4,394,771	36	3,880
Storm Est			*0.58*	*410*	9/7/01 5:15	9/10/01 19:30	3,771,030	136	96,489
Base	9/18/01 9:20	9/19/01 8:30	0.10	11	9/10/01 19:45	9/20/01 17:30	6,485,526	40	4,454
Storm	9/22/01 23:08	9/23/01 15:13	0.59	256	9/20/01 17:45	9/26/01 0:45	11,121,860	410	177,739
Base	11/9/01 13:35	11/9/01 13:35	0.08	3	9/26/01 1:00	11/23/01 14:15	57,117,050	285	10,697
Storm Est			*0.58*	*410*	11/23/01 14:30	11/26/01 14:00	5,650,514	203	144,579
Base	12/17/01 13:40	12/17/01 13:40	*0.13*	7	11/26/01 14:15	12/31/01 23:45	34,831,420	283	15,221
						TOTAL	765,613,631	14,922	7,099,104

Avg. Base	0.13	14
Avg. Storm	0.58	410
Avg. Snowmelt	0.36	164
Avg. All	0.37	205

*Italicized values are estimates based on storm and baseflow averages

1/1/01 - 12/31/01 Total (cf)	765,613,631	
1/1/01 - 12/31/01 Total TP(lb)		14,922
Brown's Creek Watershed Total Acres		13,491
1/1/01 - 12/31/01 Measured Total TP(lb)/Acre		1.11
1/1/01 - 12/31/01 Measured Total TP(Kg)/ha		1.24

Table 37: Brown's Creek at Mouth (Highway 96) 2002 Total Suspended Solids TSS) and Phosphorus Loading (TP)

	Sample Collection Time						Loading Interval				
Sample Type	**Start Date**	**Start Time**	**End Date**	**End Time**	**TP (mg/L)**	**TSS (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval TP (lb)**	**Interval TSS (lb)**
Base Grab	1/17/02	11:10	1/17/02	11:10	0.08	13.0	1/1/02 0:00	2/18/02 12:15	46,982,170	235	38,128
SNOWMELT					*0.38*	*240.3*	*2/18/02 12:30*	*2/22/02 4:00*	*4,214,985*	*100*	*63,229*
Base Grab	2/25/02	14:40	2/25/02	14:40	0.10	8.0	2/22/02 4:15	3/2/02 20:45	8,109,107	49	4,050
SNOWMELT					*0.38*	*240.3*	*3/2/02 21:00*	*3/3/02 12:15*	*865,688*	*5*	*665*
BASE					*0.10*	*12.3*	*3/3/02 12:30*	*3/12/02 12:45*	*7,990,672*	*190*	*119,868*
Snowmelt Grab	3/13/02	10:00	3/13/02	10:00	0.39	54.0	3/12/02 13:00	3/16/02 21:45	7,104,031	171	23,948
BASE					*0.10*	*12.3*	*3/16/02 22:00*	*3/27/02 12:45*	*11,435,360*	*71*	*8,781*
Snowmelt Grab	3/28/02	13:30	3/28/02	13:30	0.65	640.0	3/27/02 13:00	3/31/02 3:15	11,846,530	479	473,301
BASE					*0.10*	*12.3*	*3/31/02 3:30*	*4/5/02 15:00*	*7,202,608*	45	5,530
Snowmelt Grab	4/8/02	11:30	4/8/02	11:30	0.12	27.0	4/5/02 15:15	4/10/02 12:00	7,512,494	56	12,662
Storm Grab	4/11/02	15:40	4/11/02	15:40	0.36	226.0	4/10/02 12:15	4/16/02 12:15	14,861,780	332	209,675
Storm Grab	4/18/02	17:00	4/18/02	17:00	0.14	34.0	4/16/02 12:30	4/19/02 12:15	6,530,785	56	13,862
BASE					*0.10*	*12.3*	*4/19/02 12:30*	*4/21/02 5:15*	*2,479,502*	*15*	*1,904*
Storm Grab	4/22/02	12:00	4/22/02	12:00	0.09	11.0	4/21/02 5:30	4/23/02 13:45	3,422,669	20	2,350
BASE					*0.10*	*12.3*	*4/23/02 14:00*	*4/26/02 21:00*	*3,681,427*	*23*	*2,827*
STORM					*0.43*	*326.5*	*4/26/02 21:15*	*5/1/02 19:45*	*8,865,152*	*238*	*180,691*
BASE					*0.10*	*12.3*	*5/1/02 20:00*	*5/5/02 18:00*	*4,003,712*	*25*	*3,074*
Storm Composite	5/8/02	4:04	5/9/02	15:50	0.46	648.0	5/5/02 18:15	5/17/02 18:30	48,861,710	1,397	1,976,561
BASE					*0.10*	*12.3*	*5/17/02 18:45*	*6/2/02 23:30*	*18,501,900*	*116*	*14,207*
Storm Composite	6/3/02	4:53	6/3/02	21:31	0.14	187.0	6/2/02 23:45	6/4/02 7:45	2,113,554	18	24,673
Storm Composite	6/4/02	11:13	6/5/02	15:46	0.38	246.0	6/4/02 8:00	6/5/02 23:45	3,303,421	78	50,730
BASE					*0.10*	*12.3*	*6/5/02 0:00*	*6/10/02 22:45*	*7,448,887*	*47*	*5,720*
STORM					*0.43*	*326.5*	*6/10/02 23:00*	*6/13/02 10:00*	*3,421,893*	*92*	*69,745*
BASE					*0.10*	*12.3*	*6/13/02 10:15*	*6/19/02 3:30*	*4,823,023*	*30*	*3,703*
Storm Composite	6/19/02	5:22	6/19/02	12:40	0.92	634.0	6/19/02 3:45	6/21/02 3:45	5,628,070	325	222,749
Storm Composite	6/21/02	10:08	6/21/02	13:29	0.54	331.0	6/21/02 4:00	7/1/02 22:15	50,481,270	1,702	1,043,097
BASE					*0.10*	*12.3*	*7/1/02 22:30*	*7/6/02 11:15*	*6,843,122*	*43*	*5,254*
STORM					*0.43*	*326.5*	*7/6/02 11:30*	*7/8/02 18:15*	*4,828,183*	*130*	*98,409*
BASE					*0.10*	*12.3*	*7/8/02 18:30*	*7/10/02 2:30*	*1,630,376*	*10*	*1,252*
Storm Composite	7/10/02	17:17	7/10/02	20:49	*0.43*	*326.5*	7/10/02 2:45	7/16/02 12:15	15,106,120	405	307,895
BASE					*0.10*	*12.3*	*7/16/02 12:30*	*7/28/02 18:15*	*59,704,935*	*373*	*45,844*
Storm Composite	7/28/02	19:58	7/29/02	11:37	0.63	387.0	7/28/02 18:15	7/31/02 19:15	12,046,700	471	291,035
BASE					*0.10*	*12.3*	*7/31/02 19:30*	*8/3/02 10:00*	*4,179,034*	*26*	*3,209*
Storm Composite	8/3/02	19:24	8/4/02	8:55	*0.43*	323.0	8/3/02 19:00	8/9/02 1:15	20,555,635	552	414,477
Base Composite	8/14/02	8:03	8/14/02	10:49	0.12	13.0	8/9/02 1:30	8/16/02 18:15	3,051,950	22	2,477
STORM					*0.43*	*326.5*	*8/16/02 18:30*	*8/18/02 6:30*	*2,286,302*	*61*	*46,600*
BASE					*0.10*	*12.3*	*8/18/02 6:45*	*8/20/02 19:00*	*2,771,217*	*17*	*2,128*
STORM					*0.43*	*326.5*	*8/20/02 19:15*	*8/26/02 0:15*	*14,516,170*	*390*	*295,871*
BASE					*0.10*	*12.3*	*8/26/02 0:30*	*9/5/02 16:45*	*13,577,650*	*85*	*10,425*
Storm Composite	9/6/02	2:32	9/6/02	11:56	0.72	590.0	9/5/02 17:00	9/9/02 4:30	12,201,054	545	449,382
BASE					*0.10*	*12.3*	*9/9/02 4:45*	*10/4/02 0:30*	*32,839,563*	*205*	*25,216*
Storm Composite	10/4/02	6:17	10/4/02	10:00	0.76	628.0	10/4/02 0:45	10/16/02 22:30	38,496,480	1,834	1,509,201
Base Composite	10/25/02	15:36	10/28/02	15:49	0.10	15.0	10/16/02 22:45	11/4/02 7:00	25,851,924	157	24,208
BASE					*0.10*	*12.3*	*11/4/02 7:15*	*12/31/02 23:45*	*54,688,680*	*341*	*41,992*
Storm Average					0.43	326.5					
Base Average					0.10	12.3					
Snowmelt Average					0.38	240.3					
Total Average					0.28	174.2					
Total									**626,867,495**	11,579	8,150,602
Brown's Creek Major Subwatershed Total Acres									13,491		
Total TP/TSS (lb/ac/yr)										0.86	604.15
Total TP/TSS (kg/ha/yr)										0.96	677.15

*Italics indicate estimated concentrations based on average base and storm flow concentrations

Table 38: Brown's Creek at Mouth (Highway 96) 2003 Total Suspended Solids TSS) and Phosphorus Loading (TP)

	Sample Collection Time						Loading Interval				
Sample Type	**Start Date**	**Start Time**	**End Date**	**End Time**	**TP (mg/L)**	**TSS (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval TP (lb)**	**Interval TSS (lb)**
Base grab	1/22/03	9:15	1/22/03	9:15	0.08	11	1/1/03 0:00	2/1/03 0:00	26,451,670	127	18,164
Base grab	2/14/03	11:35	2/14/03	11:35	0.03	11	2/1/03 0:15	3/14/03 9:30	36,397,570	70	24,994
Snowmelt grab	3/17/03	10:10	3/17/03	10:10	0.31	61	3/14/03 9:45	3/18/03 9:30	9,183,821	179	34,972
Storm grab	3/31/03	15:35	3/31/03	15:35	0.09	28	3/18/03 9:45	4/14/03 17:15	27,415,110	154	47,920
Storm composite**	4/16/03	7:11	4/17/03	3:17	0.45	192	4/14/03 17:30	4/17/03 20:00	7,158,824	202	85,804
BASE					*0.09*	*16*	*4/17/03 20:15*	*5/4/03 17:30*	*18,958,225*	*105*	*18,581*
Storm composite	5/5/03	4:56	5/6/03	12:39	0.17	207	5/4/03 17:45	5/6/03 16:00	3,367,651	36	43,518
BASE					*0.09*	*16*	*5/6/03 16:15*	*5/8/03 23:30*	*2,901,347*	*16*	*2,844*
Storm grab	5/12/03	15:45	5/12/03	15:45	0.24	112	5/8/03 23:45	5/13/03 21:00	23,280,930	355	162,774
Storm grab	5/15/03	15:30	5/15/03	15:30	0.11	37	5/13/03 21:15	5/19/03 10:00	18,924,040	132	43,710
STORM					*0.23*	*99*	*5/19/03 10:15*	*5/21/03 20:30*	*8,178,877*	*120*	*50,343*
BASE					*0.09*	*16*	*5/21/03 20:45*	*6/4/03 14:00*	*19,912,380*	*111*	*19,516*
STORM					*0.23*	*99*	*6/4/03 14:15*	*6/9/03 3:30*	*6,113,705*	*90*	*37,631*
BASE					*0.09*	*16*	*6/9/03 3:45*	*6/24/03 23:30*	*14,630,945*	*81*	*14,340*
Storm composite**	6/24/03	23:50	6/26/03	14:39	0.51	290	6/24/03 23:45	6/27/03 3:15	10,094,720	321	182,751
BASE					*0.09*	*16*	*6/27/03 3:30*	*7/3/03 1:45*	*7,863,330*	*44*	*7,707*
Storm composite**	7/3/03	2:55	7/5/03	3:13	0.26	36	7/3/03 2:00	7/5/03 15:30	2,092,414	34	4,702
BASE					*0.09*	*16*	*7/5/03 15:45*	*7/14/03 18:30*	*8,443,557*	*47*	*8,275*
Storm composite**	7/14/03	20:24	7/16/03	13:47	0.26	56	7/14/03 18:45	7/16/03 14:00	1,828,733	30	6,393
Base grab	7/22/03	10:50	7/22/03	10:50	0.11	8	7/16/03 14:15	7/22/03 21:30	5,195,676	37	2,595
Base composite	7/29/03	8:40	7/30/03	22:40	0.15	28	7/22/03 21:45	7/31/03 14:00	5,470,621	51	9,562
Base grab	8/11/03	15:40	8/11/03	15:40	0.05	4	7/31/03 14:15	8/26/03 9:00	16,018,010	45	4,000
Base composite	8/26/03	9:17	8/27/03	13:08	0.12	36	8/26/03 9:15	9/5/03 8:30	5,803,936	43	13,043
Base composite	9/5/03	8:35	9/8/03	7:16	0.08	10	9/5/03 8:45	9/11/03 2:30	3,183,707	16	1,987
Base grab	9/11/03	8:40	9/11/03	8:40	0.09	17	9/11/03 2:45	9/11/03 18:30	369,983	2	393
Storm grab	9/12/03	13:10	9/12/03	13:10	0.13	17	9/11/03 18:45	9/12/03 13:30	766,986	6	814
BASE					*0.09*	*16*	*9/12/03 13:45*	*9/18/03 14:00*	*4,146,356*	*23*	*4,064*
Storm grab	9/19/03	8:25	9/19/03	8:25	0.11	11	9/18/03 14:15	9/19/03 21:15	1,106,712	8	760
Base composite	10/6/03	16:35	10/7/03	8:15	0.10	22	9/19/03 21:30	10/11/03 13:30	14,324,320	93	19,673
STORM					*0.23*	*99*	*10/11/03 13:45*	*10/11/03 19:15*	*197,204*	*3*	*1,214*
Base grab	10/28/03	9:00	10/28/03	9:00	0.08	10	10/11/03 19:30	12/11/03 4:45	41,712,450	208	26,039
SNOWMELT					*0.31*	*61*	*12/11/03 5:00*	*12/12/03 13:30*	*2,047,398*	*40*	*7,796*
BASE					*0.09*	*16*	*12/12/03 13:45*	*12/31/03 23:45*	*12,913,210*	*72*	*12,656*
Storm Average					0.23	99					
Base Average					0.09	16					
Snowmelt Average					0.31	61					
All Average					0.16	51					
Total									**366,454,418**	2,902	919,534
Brown's Creek Major Subwatershed Total Acres									13,491		
Total TP/TSS (lb/ac/yr)										0.22	68.16
Total TP/TSS (kg/ha/yr)										0.24	76.39

*Italics indicate estimated concentrations based on average base and storm flow concentrations

**Values and sampling intervals in gray areas are from the upstream McKusick Rd. stream site and were used because of equipment malfunction

Table 39: Brown's Creek at Mouth (Highway 96) 2004 Total Suspended Solids TSS) and Phosphorus Loading (TP)

	Sample Collection Time						Loading Interval				
Sample Type	Start Date	Start Time	End Date	End Time	TP (mg/L)	TSS (mg/L)	Start	End	Interval Volume (cf)	Interval TP (lb)	Interval TSS (lb)
BASE					*0.10*	*13*	*1/1/2004 0:00*	*1/4/2004 22:00*	*2,477,253*	*14.89*	*2,010*
SNOWMELT					*0.20*	*46*	*1/4/2004 22:15*	*1/6/2004 0:15*	*1,293,705*	*15.83*	*3,715*
BASE					*0.10*	*13*	*1/6/2004 0:30*	*1/18/2004 1:45*	*7,051,449*	*42.39*	*5,723*
SNOWMELT					*0.20*	*46*	*1/18/2004 2:00*	*1/19/2004 23:30*	*1,452,848*	*17.78*	*4,172*
Base Grab	1/21/04	9:00	1/21/04	9:00	0.06	17	1/19/2004 23:45	1/21/2004 20:00	1,052,644	3.88	1,117
SNOWMELT					*0.20*	*46*	*1/21/2004 20:15*	*1/23/2004 2:15*	*897,969*	*10.99*	*2,579*
BASE					*0.10*	*13*	*1/23/2004 2:30*	*1/28/2004 18:45*	*3,221,419*	*19.37*	*2,614*
SNOWMELT					*0.20*	*46*	*1/28/2004 19:00*	*1/31/2004 19:00*	*2,442,131*	*29.88*	*7,013*
BASE					*0.10*	*13*	*1/31/2004 19:15*	*2/3/2004 22:00*	*1,744,852*	*10.49*	*1,416*
SNOWMELT					*0.20*	*46*	*2/3/2004 22:15*	*2/4/2004 14:00*	*1,339,581*	*16.39*	*3,847*
BASE					*0.10*	*13*	*2/4/2004 14:15*	*2/14/2004 21:45*	*5,797,978*	*34.86*	*4,705*
SNOWMELT					*0.20*	*46*	*2/14/2004 22:00*	*2/15/2004 13:00*	*830,596*	*10.16*	*2,385*
BASE					*0.10*	*13*	*2/15/2004 13:15*	*2/28/2004 12:45*	*7,615,111*	*45.78*	*6,180*
Snowmelt Grab	3/1/04	11:05	3/1/04	11:05	0.27	53	2/28/2004 13:00	3/3/2004 8:45	3,373,189	56.01	11,160
BASE					*0.10*	*13*	*3/3/2004 9:00*	*3/10/2004 13:00*	*5,380,309*	*32.34*	*4,366*
Snowmelt Grab	3/11/04	14:05	3/11/04	14:05	0.13	39	3/10/2004 13:15	3/12/2004 10:30	2,281,915	17.95	5,556
BASE					*0.10*	*13*	*3/12/2004 10:45*	*3/16/2004 10:15*	*2,699,211*	*16.23*	*2,191*
SNOWMELT					*0.20*	*46*	*3/16/2004 10:30*	*3/20/2004 11:30*	*3,836,472*	*46.94*	*11,017*
BASE					*0.10*	*13*	*3/20/2004 11:45*	*3/23/2004 13:00*	*2,899,808*	*17.43*	*2,353*
STORM					*0.42*	*143*	*3/23/2004 13:15*	*3/27/2004 18:15*	*5,608,697*	*148.43*	*50,098*
STORM					*0.42*	*143*	*3/27/2004 18:30*	*3/29/2004 2:30*	*2,477,727*	*65.57*	*22,131*
BASE					*0.10*	*13*	*3/29/2004 2:45*	*4/18/2004 19:45*	*17,132,660*	*103.00*	*13,904*
Storm Composite	4/19/04	11:26	4/20/04	7:18	0.40	167	4/18/2004 20:00	4/20/2004 16:30	3,297,983	82.97	34,382
Storm Composite	4/21/04	3:44	4/22/04	3:13	0.15	67	4/20/2004 16:45	4/22/2004 4:45	2,279,295	21.91	9,533
BASE					*0.10*	*13*	*4/22/2004 5:00*	*4/24/2004 19:00*	*2,732,294*	*16.43*	*2,217*
STORM					*0.42*	*143*	*4/24/2004 19:15*	*4/26/2004 3:15*	*1,654,085*	*43.77*	*14,775*
Base Composite	5/4/04	18:14	5/7/04	12:06	0.09	23	4/26/2004 3:30	5/9/2004 14:30	9,286,619	51.02	13,334
Storm Composite	5/9/04	19:55	5/10/04	13:15	0.43	188	5/9/2004 14:45	5/10/2004 17:15	1,391,133	37.34	16,326
BASE					*0.10*	*13*	*5/10/2004 17:30*	*5/12/2004 13:30*	*1,546,133*	*9.29*	*1,255*
Storm Composite	5/13/04	9:31	5/14/04	7:23	0.29	107	5/12/2004 13:45	5/14/2004 7:30	2,109,912	38.72	14,093
BASE					*0.10*	*13*	*5/14/2004 7:45*	*5/17/2004 0:00*	*2,321,344*	*13.96*	*1,884*
STORM					*0.42*	*143*	*5/17/2004 0:15*	*5/18/2004 2:15*	*1,327,170*	*35.12*	*11,854*
BASE					*0.10*	*13*	*5/18/2004 2:30*	*5/23/2004 9:30*	*5,355,282*	*32.19*	*4,346*
Storm Composite	5/23/04	9:52	5/24/04	13:13	0.14	50	5/23/2004 9:45	5/24/2004 14:00	2,097,121	18.59	6,546
Storm Grab	5/24/04	16:00	5/24/04	16:00	0.49	216	5/24/2004 14:15	5/25/2004 20:45	2,161,021	66.24	29,139
BASE					*0.10*	*13*	*5/25/2004 21:00*	*5/26/2004 23:30*	*1,496,288*	*9.00*	*1,214*
STORM					*0.42*	*143*	*5/26/2004 23:45*	*5/27/2004 17:30*	*1,459,462*	*38.62*	*13,036*
BASE					*0.10*	*13*	*5/27/2004 17:45*	*5/29/2004 4:45*	*2,409,304*	*14.48*	*1,955*
Storm Composite	5/30/04	21:21	5/30/04	22:54	1.15	142	5/29/2004 5:00	6/2/2004 7:30	8,832,517	634.09	78,296
Base and Fecal Grab	6/8/04	10:30	6/8/04	10:30	0.16	21	6/2/2004 7:45	6/9/2004 0:15	7,500,061	74.91	9,832
STORM					*0.42*	*143*	*6/9/2004 0:30*	*6/13/2004 11:45*	*7,140,579*	*188.96*	*63,781*
BASE					*0.10*	*13*	*6/13/2004 12:00*	*6/18/2004 12:00*	*4,617,365*	*27.76*	*3,747*
STORM					*0.42*	*143*	*6/18/2004 12:15*	*6/18/2004 20:00*	*599,615*	*15.87*	*5,356*
Base Composite	6/24/04	14:42	6/28/04	8:06	0.11	17	6/18/2004 20:15	7/3/2004 18:30	9,353,324	64.81	9,926
Storm Composite	7/3/04	20:29	7/5/04	4:11	0.32	130	7/3/2004 18:45	7/7/2004 17:30	4,192,204	84.01	34,021
BASE					*0.10*	*13*	*7/7/2004 17:45*	*7/11/2004 6:00*	*2,780,432*	*16.71*	*2,256*
Storm Composite	7/11/04	8:05	7/11/04	12:00	0.43	140	7/11/2004 6:15	7/12/2004 11:45	2,250,245	60.68	19,666
Base and Fecal Grab	7/15/04	10:30	7/15/04	10:30	0.15	15	7/12/2004 12:00	7/22/2004 9:15	7,323,676	67.21	6,858
Base Composite	7/22/04	9:41	7/26/04	7:55	0.10	8	7/22/2004 9:30	8/12/2004 7:30	11,761,440	74.89	5,874
Base and Fecal Grab	8/12/04	8:00	8/12/04	8:00	0.07	1	8/12/2004 7:45	9/5/2004 6:45	13,862,810	57.12	865
Storm Composite	9/5/04	8:32	9/7/04	8:21	0.41	154	9/5/2004 7:00	9/6/2004 11:00	1,829,889	46.26	17,592
BASE					*0.10*	*13*	*9/6/2004 11:15*	*9/14/2004 21:15*	*5,568,877*	*33.48*	*4,519*
Storm Composite	9/15/04	3:44	9/16/04	12:20	0.34	158	9/14/2004 21:30	9/16/2004 14:30	3,441,218	73.90	33,942
Base and Fecal Grab	9/27/04	10:30	9/27/04	10:30	0.08	5	9/16/2004 14:45	10/6/2004 4:15	12,694,320	64.98	3,962
Base Composite	10/12/04	12:50	10/14/04	7:10	0.10	13	10/6/2004 4:30	10/28/2004 10:15	13,603,172	84.07	11,040
Storm Composite	10/28/04	13:49	10/29/04	10:28	0.52	198	10/28/2004 10:30	10/30/2004 19:45	6,335,747	206.06	78,312
BASE					*0.10*	*13*	*10/30/2004 20:00*	*11/19/2004 7:00*	*18,472,310*	*111.05*	*14,991*
STORM					*0.42*	*143*	*11/19/2004 7:15*	*11/21/2004 14:45*	*3,277,310*	*86.73*	*29,273*
BASE					*0.10*	*13*	*11/21/2004 15:00*	*12/13/2004 8:30*	*22,220,780*	*133.58*	*18,033*
SNOWMELT					*0.20*	*46*	*12/13/2004 8:45*	*12/14/2004 11:45*	*1,344,025*	*16.44*	*3,860*
BASE					*0.10*	*13*	*12/14/2004 12:00*	*12/18/2004 19:30*	*3,786,603*	*22.76*	*3,073*
SNOWMELT					*0.20*	*46*	*12/18/2004 19:45*	*12/19/2004 10:45*	*1,009,385*	*12.35*	*2,899*
BASE					*0.10*	*13*	*12/19/2004 11:00*	*12/22/2004 12:45*	*2,807,209*	*16.88*	*2,278*
SNOWMELT					*0.20*	*46*	*12/22/2004 13:00*	*12/24/2004 14:30*	*2,547,012*	*31.16*	*7,314*
Base Grab	12/27/04	15:00	12/27/04	15:00	0.05	10	12/24/2004 14:45	12/31/2004 23:45	6,502,682	19.89	4,059
Storm Average					0.42	143					
Base Average					0.10	13					
Snowmelt Average					0.20	46					
All Average					0.22	59					
Total									**311,486,775**	3,633	821,769
Brown's Creek Major Subwatershed Total Acres									13,491		
Total TP/TSS (lb/ac/yr)										0.27	60.91
Total TP/TSS (kg/ha/yr)										0.30	68.27

*Italics indicate estimated concentrations based on average base and storm flow concentrations

Table 40: Brown's Creek at Mouth (highway 96) 2004 Primary Chemistry Results

Parameter	Storm Flow Average	Base Flow Average	Average (all samples)
TSS (mg/L)	143	13	59
VSS (mg/L)	51	5	28
TKN (mg/L)	2.49	0.40	1.50
TP (mg/L)	0.42	0.10	0.22
Fecal Coliform (#/100 mL)	--	--	127
COD (mg/L)	97	17	59
Alkalinity (mg/L)	116	184	146
Hardness (mg/L)	131	198	160

APPENDIX C – MACROINVERTEBRATE DATA

Brown's Creek Site W3 Macroinvertebrates Found

Date	5/6/98	10/7/98	4/29/99	10/15/99	5/2/00	10/5/00	5/11/01	10/16/01	5/2/02	10/2/02	5/7/03	10/7/03	5/10/04	10/12/04	5/5/05	10/14/05
Baetidae	19	22	83	28	58	25	12	51	33	74	35	7	22	30	86	16
Heptageniidae			2							2				1	2	6
Chloroperlidae								6								
Perlodidae	17	3	24	9	43	4	10		32		23	2	10	8		4
Pteronarcyidae	2															
Brachycentridae		14			1	3		13		10				2		6
Glossosomatidae	26	13	7				1	4					1	8	5	3
Hydropsychidae	20	14	26	18	16	12	3	10	13	7	10	15	17	14	18	4
Limnephilidae	1				2						11		30			
Odontoceridae							31									
Philpotamidae	1	70	10	60	2	150	6	13	3	12	8	91	2	60		7
Phryganeidae															1	
Uenoidae	50		1													
Athericidae				1	1			1		1						
Empididae	1		1													
Simuliidae	1	4	9		3			1		51		7	1		85	1
Tabanidae																
Tipulidae	4	4		3	4		1	2	2	1		14	4	12	16	11
Chironomidae, Other	1	2	15		60	3	5	0	27	6	20		5	2	53	1
Elmidae	41	55	38	53	6	13	6	15	4	16	5	5	1	13	2	21
Hydrophilidae															2	
Gammaridae	1			1				5		8	8	1		4	39	7
Asellidae	5			1		1		5	1						1	
Oligochaeta	4	2	2	1		1		1	1	1	2	1	3	3	2	5
Gastropoda	1	1													3	
Other_1								1		4						
TOTAL	**195**	**205**	**218**	**175**	**196**	**212**	**75**	**127**	**116**	**189**	**122**	**143**	**96**	**157**	**315**	**92**

Brown's Creek Site W4 Macroinvertebrates Found

Date	5/6/98	10/7/98	4/28/99	10/13/99	5/3/00	10/11/00	10/16/01	5/2/02	10/2/02	5/7/03	10/7/03	5/10/04	10/12/04	5/5/05	10/18/05
Baetidae	42	16	99	6	60	30	50	58	127	27	57	23	32	46	6
Heptageniidae														1	3
Heptageniidae										3		1			
Chloroperlidae							4								
Perlodidae	12	4	12	40	82	12		10		17		6	6	7	3
Brachycentridae		13		13		85	57		8		98		19		40
Glossosomatidae	29	69	9			13	4				10	6	1	3	8
Hydropsychidae	35	11		1	15	6	21	1	3	19	30	14	7	6	2
Hydroptilidae			5												
Limnephilidae	2		1	2	17			1		1		17	1		
Philpotamidae	10	1				5	26		3	2					10
Phryganeidae														2	
Uenoidae	26														
Athericidae							1						1		
Simuliidae	1	5	1	1					28		6		3	6	2
Empididae											2			6	
Tipulidae	2	5	1		9	1	5			2	2	1	5	5	16
Chironomidae, Other	2	2	65	3	32		1	11		30	1	6	37	52	
Elmidae	11	58	36	36	19	12	4	7	18	3	18	12	2	3	10
Calopterygidae				1											
Gammaridae						5	22		10		21	2	5	3	3
Talitridae				2											
Asellidae				6		1	5	1	2		1		1	3	5
Cambaridae															
Oligochaeta		2	3		5	3	1	1	5	1		1	6	6	3
Gastropoda		2													
Other_1							1								
TOTAL	**172**	**188**	**232**	**111**	**239**	**173**	**202**	**90**	**204**	**105**	**246**	**89**	**126**	**149**	**111**

Brown's Creek Site W8 Macroinvertebrates Found

Date	5/8/2003	10/4/2003	5/6/2004	10/7/2004	5/5/2005	10/13/2005
Baetidae		7	2		5	10
Heptageniidae	1	2				
Perlodidae			2			
Branchycentridae				23	1	
Hydropsychidae	5	5	4	1	3	
Uenoidae					1	
Limnephilidae		7	22	0	4	
Aeshnidae			2			
Dixidae						1
Simuliidae					13	
Tabaindae	1					
Chironomidae, Other	15		2		34	
Elmidae	1	4	2	1	1	1
Gammaridae	80	82	75	45	58	70
Asellidae				1		
Oligochaeta				1	1	
Gastropoda	3		7		4	2
Pelecypoda						17
Pelycopoda			1		3	
TOTAL	**106**	**107**	**119**	**72**	**129**	**101**

Brown's Creek Hwy 15 Site Macroinvertebrates Found

Date	4/21/2005	10/20/2005
Baetidae		7
Heptageniidae		1
Branchycentridae		3
Glossosomatidae		2
Hydropsychidae	6	12
Hydroptilidae	1	
Limnephilidae	3	
Uenoidae	10	
Tipulidae		3
Chironomidae, Other	75	
Elmidae	1	26
Gammaridae	57	53
Talitridae		
Asellidae		5
Pelecypoda	1	
TOTAL	154	112

APPENDIX D – MACROINVERTEBRATE MONITORING TERMS

Macroinvertebrate Monitoring Terms

Complete Metamorphosis - occurs in the orders Diptera, Megaloptera, Coleoptera, Trichoptera and Lepidoptera. The life cycle includes the following stages: egg, larva, pupa and adult. This program monitors the larval stage of development.

Trichoptera (caddisfly) larva

Trichoptera (caddisfly) Adult

Dominant Family -The family which comprises the largest single portion of the invertebrate sample.

Dominant Family % Overall - The dominant family's percentage of the total invertebrate sample.

EPT - The number of mayfly (**E**phemeroptera), stonefly (**P**lecoptera), and caddisfly (**T**richoptera) families in the sample. These families represent the pollution intolerant insects. A higher EPT score reflects better water quality than a lower one.

Family Biotic Index (FBI) - Summarizes the various pollution tolerance values of all families in a sample. FBI ranges from 0 to 10, with lower values reflecting higher water quality. Each macroinvertebrate family has a unique pollution tolerance value associated with it. Pollution intolerant families such as stoneflies can only survive in excellent water quality. Pollution tolerant organisms such as leeches and aquatic earthworms can live in poor quality water.

Evaluation of water quality using Hilsenhoff's Family Level Biotic Index

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very good	Possible slight organic pollution
4.26-500	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.0	Very poor	Severe organic pollution likely

Habitat Score- Reflects the suitability of a site to host invertebrates regardless of water quality. Ideal stream habitat includes things such as a rocky bottom with low sedimentation and good water flow. Twelve habitat characteristics are examined out in the field and rated on a scoring worksheet. A higher habitat score reflects better quality habitat than a lower one. A "0" reported for habitat indicates that the habitat was not scored for that sampling season.

Hester-Dendy Multi-plate Sampler- these samplers consist of round hardboard tiles stacked on a long eyebolt. The eyebolt is then attached to a cement block with a wing nut and placed in the river 4-5 weeks before sampling.

Incomplete Metamorphosis - occurs in the Ephemeroptera, Plecoptera, Odonata and Hemiptera. The life cycle includes the following stages: egg, early instar larva, late instar larva and adult. This program monitors the larval stage of development.

Number of Families - The number of different benthic macroinvertebrate families found at the site. In general, more diversity is better. Therefore a larger number of families reflect a healthier community than a smaller number. The number of families from the sites sampled in this report ranges from four to seventeen.

Number of Organisms Identified- In the "About the Results" section for each site, occasionally there is a comment about the number of organisms identified. For the protocol that we use, it has been determined that a minimum of 100 organisms per replicate is required to confidently make an assessment. When less than 100 per replicate organisms are collected, the information is still useful, but we cannot be as confident about characterizing the site's health.

Organic Pollution – This type of pollution comes from municipal and on site sewage, animal manure, and food processing facilities. Adding these materials to the stream increases aquatic plant growth, decreases dissolved oxygen, and increases macroinvertebrates that filter organic matter from the water column or gather dead and decaying plant growth.

Water Quality - refers to anything that might affect the invertebrates living in the river for part of their life cycle (such as nutrients, oxygen, sediment, organic pollution, toxins, stream flow, and quality of habitat).