Chapter 3 Approach and Methods

Water Quality Monitoring

As part of the water quality study for the Seven Mile Creek Watershed sediment and nutrient loadings were calculated at two tributaries (county drainage ditch 13 and 46a) and the main stem of the creek. In addition, fecal bacteria, dissolved oxygen, transparency tube readings, pH, conductivity, and temperature levels were studied. The information derived from water quality monitoring will:

- ❖ Help identify areas within the watershed that are contributing more or less of a particular pollutant of concern and therefore increase the efficiency of implementing sparse cost share dollars for remediation purposes.
- ❖ Allow water resource managers to rank Seven Mile Creek Watershed with other similar watersheds with the Middle MN River Basin in an effort to prioritize funding and clean up efforts.
- ❖ Help determine realistic Total Maximum Daily Load (TMDL) and water quality goals needed to meet local, state, and federal standards.

Three water quality monitoring sites were established within Seven Mile Creek Watershed. The three sites were selected based on spatial proximity to areas of environmental concern, feasibility of determining stream discharge relationships, and previous monitoring history. The three sites are characterized as Hwy 99, Cty RD 13, and mouth site and are labeled as sites 1, 2, 3, respectively. The locations of all water quality sampling sites are shown graphically on map 3, chapter 1 with respected subsheds. Detailed site descriptions can be found in section A of the appendix. Photos 5-7 at the end of this chapter are also included to portray the overall setting of monitoring sites as well as some of the equipment used in the study.

Basis for Site Selection

- Spatial proximity to capture entire minorshed
- Proximity to road or culvert
- Previous water quality study location
- Rating curve development feasibility

Specifics for each site. See map 3 chapter 1 for locations within watershed (photos of the sites are shown at the end of this chapter)

Site 1 is located downstream of State Highway 99 West of St. Peter near county ditch 13. Stage at site 1 is measured by a stilling well. A Cambell Scientific CR-500 records the changes in water level sent from a potentiometer housed in a wooden box atop of the stilling well. All of the equipment was installed in March of 2000. A staff gage was installed on the cement culvert as well.

> *Downstream of State Highway 99. Samples taken near Box culvert. Stream Flow taken upstream in ditch about 100 yards.*
> *Nicollet County, Oshawa Twp, T110, R27 Sec 23, NE1/4, SW1/4*

Site 2 is located downstream of County RD 13 near county ditch 46. The site contains a similar monitoring system to site 1. The only difference is that a Texas Instruments tipping bucket is installed to measure rainfall.

> *Downstream of Cty Rd 13. Stream flow taken just inside of box culvert on downstream side.*
> *Nicollet County, Oshawa Twp, T110, R27 Sec 23, SE1/4, SW1/4*

Site 3 is located in Seven Mile Creek County Park near the mouth of the watershed (near first foot bridge). A staff gage, and CR-10 data logger were installed to determine stage. A Texas Instruments tipping bucket rain gage was in operation at this site from 2000. An INW pressure transducer measures stage at this location.

> *Mouth site, upstream of first footbridge in County Park. Stream flows taken upstream of bridge about 50 yards.*
> *Nicollet County, Belgrade Twp, T109, R27 Sec 12, NW1/4, SW1/4*

**In year 2001 three automatic samplers (ISCO and SIGMA) were installed to refine loading estimates and examine polluto-graph characteristics. The sampling equipment is actuated by time paced. Both composite and discrete samples are taken, depending on the storm event.

Sampling Protocol

Samples were collected at all three sites during monthly scheduled times from March through October in 2000. **All loading rates and other calculations are based on the growing season of April 1 through September 30 (roughly 180 days).** In addition, water samples were collected over a range of river discharge conditions to characterize the change in water quality as the creek responded to both dry and wet conditions. Additional samples were taken at all three sites during low flow (baseflow conditions) to assess the influence of point sources of pollution such as septics. Conversely, samples were also taken during high flow to document the effects of non-point source pollution from storm water runoff. Strict attention was made during the monitoring season to gather a wide spectrum of climatic/flow conditions to insure the best possible representation of the water quality in the watershed at the time of the study.

Sampling for water quality parameters and flows under climatic conditions included:

- Early Spring (first storm after snow melt)
- Emergent Crop Period Storm
- High Evapo-transpiration (ET) - Low Flow (late July or early August)
- Post ET (fall) Low Flow (late fall)

In general, all three sites were sampled from early April through September. In 2000, a total of 15 grab samples were taken. In 2001 a total of 16 grab samples were taken with two additional taken from automatic samplers.

Monitoring Season

Monitoring season length is an important variable to consider when evaluating the reported data. Many of the organizations within the MN River Basin begin monitoring in early April and quit in early October. This period captures the months when loads are expected to be the highest for nutrients and sediment, and the time of year the majority of flow occurs. Seven Mile Creek monitoring runs from late March or early April through September or mid-October. The monitoring season is typically 180-200 days depending on weather conditions.

The advantages or justifications of a partial monitoring season are two fold. First, monitoring costs, time and equipment maintenance are reduced. Second, the vast majority of the flow in the Minnesota River Basin occurs approximately mid-March through mid-August. Most of the loads of the commonly monitored pollutants (sediment, phosphorus, nitrogen and fecal coliform bacteria) also pass through during this period. A disadvantage of partial year monitoring involves the potential for missing a portion of the annual load of the common pollutants. In Seven Mile, this is a lesser problem since all of the tributaries are intermittent in nature (dry up in the fall). Another potential complication relates to delays associated with getting station equipment established during high water or snow levels in the spring.

Monitoring Season Description

2000

Water quality sampling began early in early April and quickly subsided due to lack of significant rainfall. Although low flows were common until mid-May, sampling continued to characterize baseflow (groundwater) dominated conditions. A major rain event occurred May 17. Thereafter, precipitation patterns for the watershed began to normalize with more frequent and heavier rainfall frequencies. A total of 15 samples were taken with 33% taken in the month of June. At least one sample was taken every month from April through September. By mid-August the watershed and surrounding counties experienced below average rainfall, hence monitoring intensity decreased. By early September, low to zero flow conditions were present on all tributaries. This pattern continued through early November well after the growing season. Due to the flashy nature of the drainage system, it is recommended that auto-samplers be installed to refine pollutograph and loading estimates.

2001

The winter of 2001 was one for the record books. Above average snowfall and below normal temperatures resulted in one of the top 10 worst winters in Minnesota's recorded history. The high snowfall amounts allowed for spring snowmelt runoff monitoring, which has been a rarity the past several years. High snow pack levels and heavy rainfall amounts in late march and April resulted in very high flows for Seven Mile Creek and the Minnesota River. In early April the Minnesota had reached levels above or near 1997 flood levels. Flow equipment was up and running at all sites by April 13 and grab samples were taken at early snow melt conditions on April 3. However, by late April, site 3 in the park had to be removed for fear of destruction by spring flooding. The site was reinstalled three weeks later. Very high flows characterized Seven Mile Creek during the early part of the season, however by late July drought conditions were starting to become apparent. Low precipitation levels occurred from July through August. By September precipitation levels became near normal. A total of 16 grab samples were taken with a majority taken in April and May. Automatic samplers were installed at all three locations in mid-May. Two storms were utilized from the automatic instrumentation.

Water samples were sampled and analyzed according to methods adopted by the USGS MPCA, and US Environmental Protection Agency protocol. Collection of all grab samples followed protocols established by the Environmental Protection Agency[1].

Samples were field-tested using portable meters for pH, temperature, specific conductance, dissolved oxygen and transparency. Field meters were calibrated before each day of use. Samples were analyzed by the Brown Nicollet Environmental Health state certified lab in St. Peter, MN for the following parameters: total suspended solids, total phosphorus, ortho-phosphorus, nitrate-nitrogen, fecal coliform bacteria, and total coliform bacteria. Reporting units and methods are shown in table 14.

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[1] U.S., Environmental Protection Agency, Handbook for Sample Preservation of water and Wastewater. 1982.

Table 14

Reporting Units and Method

Constituent or physical Property	Reporting Unit	Laboratory Method
Bacteria, fecal coliform, membrane filter	Col/100ml	Membrane filter
Bacteria, fecal streptococci, membrane filter	Col/100ml	Membrane filter
Bacteria, total coliform, membrane filter	Col/100ml	Membrane filter
Discharge	ft^3/sec	Velocity meter
Dissolved oxygen (DO)	mg/L	Membrane electrode
Nitrogen, as No3-N	mg/l	Electrode or Hach Spectrophotometer
pH	Units	Electrometric
Phosphorus, dissolved ortho as P	mg/L	Hach manual digestion with automated color development
Phosphorus, total as P	mg/L	Hach manual digestion with automated color development
Sediment, suspended, concentration (TSS)	mg/L	Filtration and membrane
Specific Conductance	micromhos/cm	Wheatstone-Bridge meter
Transparency (tube)	Cm	
Water Temperature	°C	

Water Quality Monitoring Equipment

The instruments at the monitoring sites provided a detailed account of the conditions in the two major tributaries and creek 24 hours a day. The instruments continually monitored stage (water elevation) every 60 seconds. As of 2001, automatic samplers were installed at each of the three locations. An automatic sampler collects 24 water samples every two hours (default) from the river when pre-determined stage conditions are met. This sampling helps characterize storm runoff conditions to a higher degree. At sites 2 and 3 a rain gage was also installed to measure cumulative rainfall amounts and rainfall intensities. Rainfall amounts from Red Top Farms and a network of rain gage readers are used in addition to the monitoring sites. During a rain event, the rain gage at the monitoring site records every 0.01 inch of precipitation. In 2001, three automatic samplers were installed to help advance the understanding of the water chemistry during storm events. An ISCO 3700 portable sampler was installed at site 3 and 1. They are both owned by Nicollet County Environmental Services. At site 2 a SIGMA 900 portable sampler is used. It is currently being loaned through MET Council Mankato Field Office. The operation of all these instruments is coordinated by a CR-500 data logger, which also stores and outputs the data. The data logger program outputs a line of information every

15 minutes, including Julian date, time, automatic sampling data, and precipitation amounts. It also triggers the automatic sampler to start and stop sampling according to preset stage conditions. All of the data from the CR-500 was downloaded as a comma delimited ASCII file. PC208, a Cambell Scientific program, was used to manage and calculate the large data files.

Discharge Ratings

Stream flow at sites 1, 2, and 3 was determined by developing a stream-discharge relationship. PCA hydrologists and BNC staff determined the rating curves for all the sites during monitoring year 2000 and 2001. A total of seven discharge readings were used for 2000. High flow readings to refine the rating curve occurred in 2001. Due to flooding issues, beaver dams, and stream bank erosion, monitoring site 2 and site 3 is under consideration for relocation. Development and use of stage-discharge relationships required measurement of stage, datum, channel dimensions, water velocity and discharge as specified in the MPCA quality control manual and USGS protocol. Periodic readings were taken at each site with a reading near zero flow up to moderate and high flow conditions with wading rod and Price or Pygmy current meters. During high flow conditions a bridge board or crane apparatus was used.

Total discharge and instantaneous stage were plotted using USGS methods and power equations. The correlation coefficient, or R^2 values were calculated to describe the stage-discharge relationship.

Flow Conversion and Data Management

Average 15-minute stage readings were converted to flow through Cambell Scientific PC-208 software. The average 15-minute flow values were simultaneously converted to average daily flows by substitution into the derived rating equation. Precipitation data was also converted to total daily precipitation amounts. The data was then exported to Excel as an ASCII file and graphed/managed as an Excel workbook.

Field Equipment

Instruments used to determine field parameters include an Orion 835a D.O./Temp probe, Hach conductivity meter, MPCA transparency tube, and ISFET model IQ125 pH meter. Both the dissolved oxygen and pH meter were calibrated before each use. Current readings were taken using AA Price (>1.5’) or Pygmy (<1.5’) meter with a 6’ wading rod. During high flows, velocities were measured using a bridgeboard apparatus.

Water Sample Analysis

All parameters were tested by the state certified Brown Nicollet Environmental Health (BNEH) laboratory in St. Peter, MN. The lab is used jointly by Public Works wastewater staff and the BNC Water Board. Transportation of samples from field to lab was done by project staff. Samples were transported in ice filled coolers, and analyzed within 12-24 hours of sample collection. Since the lab and watershed is within close proximity, many of the samples were analyzed within 12 hours.

The BNEH lab is a certified state lab. Therefore the lab is open to audit by the MPCA, and Minnesota Department of Health. **Minnesota State lab number is 027-103-259 and EPA lab code is MN00090.**

Quality Assurance

Only approved laboratory and field methodology was used in the capture of water quality data. Clear and accurate data was the continuous objective. In the event that errors did occur, they were identified and corrected. Spikes, duplicates and blanks are run every ten samples. Both field and laboratory staff were readily able to identify outliers. When these emerged, re-sampling was performed as soon as possible, instruments were checked, and/or unusual circumstances (such as rainfall dilution or contamination by a point source) were identified and annotated.

Runoff and Yield Normalization Defined

Runoff is that part of precipitation that appears in rivers and streams, including base flow, storm flow, flow from ground water, flow from point sources, and so on. Essentially it is all the flow passing a particular location along the river. By evaluating runoff, comparisons can be made of the relative amount of water coming out of the individual watersheds. To calculate growing season runoff, we add up the total flow or amount of water that came past the station during the monitored period. This value is converted to acre-inches of water, then divided by the total number of contributing acres, thus converting to inches of runoff.

Example:

Take for example year 2001 flow data for site 3 of the watershed. It was found that a total of 16,371 cubic feet of water entered the MN River from the Seven Mile Creek Watershed from April-Sept. The first step to determine runoff from a watershed is to convert cubic feet per second (cfs) to acre-feet. This translates into a conversion factor which is the following: 16371*60*60*24/43,560=32,472 acre-feet. This is basically the amount of area in acres that would be covered by water at a depth of one foot. The next step is to convert acre-feet to runoff: 32,472acre-feet/23,551acres in watershed*12=16.5 inches of runoff. In the truest sense this does not represent the actual amount of water that ran off the surface of the land. Research shows that for this area around 1/6 of the runoff goes to surface water runoff. So if there is six inches of runoff, about 1 inch is in the form of actual runoff and the remaining five inches is in the form of shallow subsurface tile flow tributaries and groundwater near the stream.

Conceptually, this is equivalent to redistributing all the flow out equally over the watershed, then measuring the depth in inches. Typically, the more precipitation that occurs in the basin, the more runoff there will be. However, the timing and intensity of the precipitation, antecedent soil moisture conditions, soil types, land slopes as well as several other factors can dramatically influence the final runoff number.

Yield Normalization

By evaluating runoff as well as the mass or load simultaneously, we can better determine if a particular watershed had higher or lower loads simply because it was wetter than the comparative watersheds or whether it was actually related to land use characteristics. In general, runoff tends to be quite high in Seven Mile Creek due to the clay soils and curve numbers (see map 9, chapter 2). However, the high amount of private sub-surface tile drainage tends to decrease the long-term effect of these high curve numbers.

Storm Event Sampling Methodology

Grab sampling and automatic samplers are the two methods of storm event sampling utilized in the Minnesota River Basin. Automatic sampler collection is typically supplemented by grab samples during non-event (baseflow) periods. The objective of the automatic sampler methodology is to completely characterize the entire stormflow volume with either equal-time increment (ETI) sampling or equal-flow increment (EFI) sampling. Generally with ETI sampling, the autosampler is used to collect discrete grab samples during the stormflow event at a pre-specified sampling time interval, for instance every hour. Those grabs can then be composited based upon flow or used as discrete samples. In year 2001, automatic samplers were added to increase the precision of the water chemistry during storm events. The equal-time increment sampling method was used. The samplers were set to trigger at a pre-defined stage. At site 3 the sampler instrumentation was set to activate when the lowest recorded stage value exceeded 0.5 feet. At site 1 and 2 it was set at 0.25 feet. These threshold levels were adjusted throughout the year, pending on the four climatic periods.

With EFI sampling, composite samples are collected throughout the event with discrete sub-samples representing equal volumes of flow. For example, 200 ml of river water may be collected for every 1,000 cfs of flow resulting in one composite sample that represents several days (or hours on smaller streams) of flow. In theory, EFI composite sampling gives greater data resolution as all flow conditions are represented in one sample.

However, auto-samplers have inherent problems associated with their use. They are very high maintenance. A major maintenance issue associated with autosampler use relates to controlling sample intake tube location to collect samples from the most representative portion of the stream and premature battery failures. This can be a significant challenge during times of rapidly changing flow. Also of potential concern are issues associated with maintaining adequate velocities in the sample tube, potential contamination sources in the sampler/tubing and maintaining a relatively clean intake orifice.

There are also problems associated with collecting samples without automatic equipment. Small stream systems can be very flashy in nature, and the risk of missing the peak or a major portion of the hydrograph is great, especially when the peak occurs at night. Larger river systems have storm hydrographs that can last for weeks. During these periods, it can be difficult to accurately assess the timing and number of grab samples necessary to accurately characterize the flow. In addition there are complexities associated with sampling methods, equipment and the most appropriate location to collect the grab storm sample.

Sediment and Nutrient Modeling

A variety of assessment tools were integrated into this watershed project to help interpret the water quality data for realistic water quality goal setting and implementation plan development. A "behind the envelope" model was developed by Jim Klang and Kevin Kuehner to help assess sediment and phosphorus sources and relative contributions within the wateshed based on delivery pathways. Nitrogen mass balance methodologies developed by professors and researches in the mid-west were used to assess the nitrogen sources within the watershed. Descriptions of the methodologies and results can be found in chapter 6.

Loading Estimates

A load is a measure of mass passing a specific location that occurs over a specified amount of time. Loading estimates for most of the projects are provided in tables 23-28, Chapter 5. FLUX, an interactive program that allows users to estimate loads and flow weighted mean concentrations from grab sample concentration data and continuous flow records over the sampling period, was the primary calculation method in the basin for 2000. For a more detailed explanation of FLUX calculations see appendices D, E and G.

Because FLUX is designed to utilize daily flow averages coupled with grab sample chemistry data, flow composited samples that were collected over a period of greater than one day required slight adjustments when preparing the FLUX input files. This adjustment consisted of selecting a day to represent the sample (generally the last full day of the composite) and calculating an instantaneous flow. Instantaneous sample flows were derived by dividing the total flow volume in cubic feet for the composite by the total number of seconds elapsed during the composite collection period to give an average composite flow in cubic feet per second (cfs). A potential complication of this methodology is that the concentration range from low to high is theoretically smaller with composite samples than with grab samples. As such, automated composite samples, while better at characterizing total flow concentrations, do not represent either the maximum or minimum concentration at one point in time on an event hydrograph.

Flow Weighted Mean Concentrations and Loading Rates

FLUX Calculations

Individual water samples, particularly those with no associated flows, gives only a snap shot in time of water quality conditions. Large variations in climatic conditions, and therefore flows can influence the chemical and physical make up of riverine systems on a daily or even hourly basis. To obtain a better representation of water quality during a particular season, flow weighted mean concentrations (FWMC) and mass and loading rates (e.g. tons of sediment per day) are often used to help accurately portray water quality. A statistical computer model, FLUX Version 5.1, was used to determine FWMC's and loading rates for Seven Mile.

FLUX is an interactive program developed by the U.S. Army Corp of Engineers that allows the user to estimate loadings from grab sample concentration data and continuous flow records.[2] It is designed for use in estimating loadings of nutrients or other water quality components passing a tributary sampling station over a given period of time. The estimates are based on flow-weighted average concentrations multiplied by the mean flow over the monitoring period. Data requirements include:

- Grab sample water chemistry results, typically measured at a weekly to monthly frequency for the growing season
- Water sample results from several storm events
- Corresponding flow measurements (instantaneous or daily-mean values)
- Complete flow record for the period of interest

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[2] Department of the Army, U.S. Army Corp of Engineers, Empirical Methods for predicting Eutrophication in Impoundments, Report 4, Phase3, Application Manual,1987..

Using six calculation techniques, FLUX maps the flow/concentration relationship developed from the sample record onto the entire flow record to calculate total mass discharge and associated error statistics. An option to stratify the statistics into groups based upon flow, date, and or season is also possible. In many cases stratification allows one to decrease the coefficient of variance and thereby increase the accuracy and precision of FWMC and loading rates. Flux also provides information, which can be used to improve the efficiencies of future monitoring programs.[3]

Loading Terms Defined

As defined above, a “load” is an estimate of the total amount of material or mass coming out of a specific watershed or passing a specific point. A better way of assessing loads and comparing watersheds of different sizes is to determine the “yield” or the mass per unit area (such as lbs./acre) coming out of the individual watershed. This normalizes the mass on an area basis and allows for a more relative comparison between all the watersheds. Yield is calculated by dividing the total mass or load associated with the time frame of interest by the area (acres) in the respective watershed. When comparing Seven Mile Creek with other watersheds, yields are further reduced by dividing them by the number of inches of runoff for the respective watershed, producing a “normalized yield”. As such, when yields are normalized one must keep in mind the geographic differences in precipitation and runoff. Similar to normalized yields, “flow weighted mean concentrations” (FWMC) are calculated by dividing the total mass or load for the given time period by the total flow. The FWMC is mass normalized for flow.

Ecoregions and Stream Water Quality

MPCA Ecoregion values from minimally impacted streams were used to further refine the categories.[4] In Minnesota there are 7 defined ecoregions. The SMC is part of the Western Corn Belt Plains ecoregion. Summer mean values from 1970-1992 were used to help determine the categories.

The U.S. Environmental Protection Agency has divided the continental United States into ecoregions based on soils, geomorphology, land use, and potential natural vegetation. For Minnesota, this results in seven fairly distinct ecoregions (map 25). For example, the Northern Lakes and Forests ecoregion (NLF) is predominantly forested with numerous lakes and covers the northeastern part of MN. The Western Corn Belt Plains ecoregion, located in the southern third of MN, has rolling terrain and is extensively cultivated with row crops. Land use, topography, and water quality characteristics of the ecoregions were reviewed to assess the non-point source pollution problems across the state. This review can be found in a 1993 MPCA report by McCollor and Heiskary. The ecoregion framework provides a good basis for evaluating differences and similarities in Minnesota’s streams. Reference streams, which are felt to be representative and reflect expected water quality for a region, were sampled by the MPCA to characterize stream conditions for each ecoregion. This provides a baseline with which to compare other streams. In other words, the reference streams are one yardstick by which to measure other streams. Table 15 lists the typical total phosphorus, total suspended solids, and turbidity for reference streams in six ecoregions[5].

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[3] FLUX Stream Loaf Computations Version 4.5 Environmental Laboratory USAE Waterways Experiment Station Vicksburg MS, 1995.

[4] Water Quality Division, Selected Water Qualtity Characteristics of Minimally Impacted Streams from Minnesota’s Seven Ecoreresions. February 1993.

[5] MPCA, 1998 Report on the Water Quality of MN Streams, Environmental Outcomes Division, 1998.

Ecoregions are based on similarities of land use, soils, land surface form, and potential natural vegetation. Water Quality information from minimally impacted streams by the MPCA within these regions is used to assess the degree of impairment on a water resource.

Map 25

Minnesota's Seven Ecoregions. Mapped by USEPA.

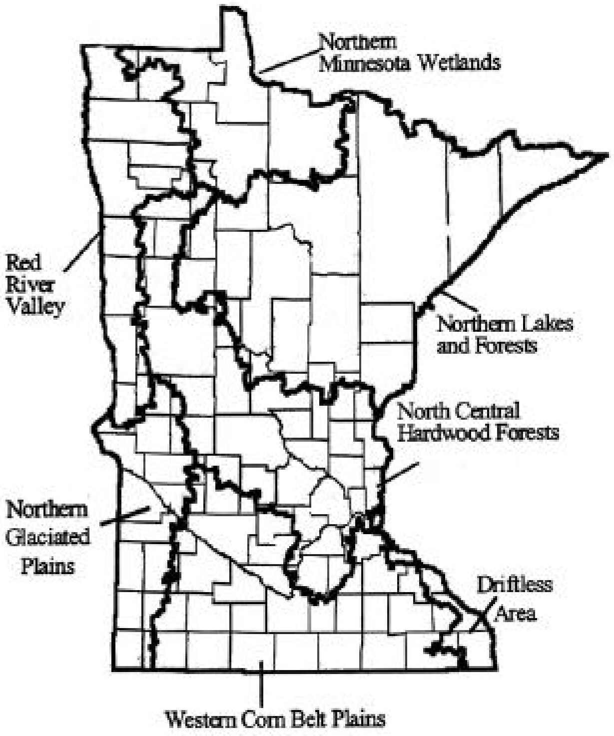

Table 15 Interquartile Range of Concentrations for Reference Streams in Minnesota by Ecoregion.[1] Distributions of annual data from 1970-1992 (McCollor and Heiskary, 1993; note 1 mg/L = 1 ppm = 1,000 ppb)

	Total Phosphorus (mg/L)			Total Suspended Solids (mg/L)			Turbidity (NTU)		
Region/ Percentile	**25%**	**50%**	**75%**	**25%**	**50%**	**75%**	**25%**	**50%**	**75%**
NLF	0.02	0.04	0.05	1.8	3.3	6.0	1.7	2.5	4.3
NMW	0.04	0.06	0.09	4.8	8.6	16.0	4.1	6.0	10.0
NCHF	0.06	0.09	0.15	4.8	8.8	16.0	3.0	5.1	8.5
NGP	0.09	0.16	0.25	11.0	34.0	63.0	5.6	15.0	23.5
RRV	0.11	0.19	0.30	11.0	28.0	59.0	6.0	12.0	23.0
WCBP	0.16	0.24	0.33	10.0	27.0	61.0	5.2	12.0	22.0

[1] Interquartile range is determined by sorting measures from lowest to highest and represents those measures between the 25th and 75th percentile.

Site 1

Photo 5. Monitoring site 1 near State Highway 99. Contains rain gauge, CR-10 data logger and stilling well. A stilling well is comprised of an 8” PVC pipe with 1” holes submerged into the stream, float, cable, and communication device (potentiometer). When the float rises, the attached cable turns the potentiometer wheel located in the housing box. A complete revolution equals a one-foot increase in stage. Stage values are recorded every 180 seconds and averaged to a 15-munute interval. Values are recorded continuously. The stage value is recorded in the data logger and downloaded via a storage modular and eventually to personal computer. Stage values are then converted to flow via the rating curve developed for the site. The data logger is run by a sealed NICAD 12-volt rechargeable battery.

Site 2

Photo 6. Monitoring site 2 near Nicollet County RD 13. Installation in March of 2000. Equipment is similar to site 1, however a tipping rain gauge is installed to measure rainfall intensities and totals. During a rain event, the rain gauge at the monitoring site records every 0.01-inch of precipitation.

Site 3

Photo 7. Monitoring site 3 in Seven Mile Creek County Park. Stage is measured by an INW pressure transducer submerged in the creek and attached to the staff gage. A rain gauge is also located at this site. Picture shows ISCO sampler results and housing box after a May 22, 2001 storm.