Chapter 5

Results & Discussion

Diagnostic Study Results and Discussion

Water Quality Monitoring

Water quality monitoring in Seven Mile Creek Watershed focused on suspended sediments, nutrients, and bacteria. The values below represent grab samples and automatic sampling taken from three sites within the watershed. Parameters include: total suspended solids (TSS), nitrate-nitrogen (No2+No3-N), total phosphorus (TP), Ortho-phosphorus (PO_4), and Fecal Coliform bacteria. Other parameters can be found in tabular format (appendix C). Those include dissolved oxygen, temperature, transparency, and conductivity.

The results listed in the tables include samples taken from the monitoring period of the diagnostic study. Those years include 2000 and 2001. Since monitoring on Seven Mile has taken place since 1996 by BNC staff, graphs including all monitoring years are included in the graphs.

Sediments, phosphorus and bacteria are of concern to Seven Mile Creek when in large concentrations and over sustained periods of time.

Sediment–suspended soil particles that make rivers look muddy and turbid, restricts the ability of fish to spawn, limits biological diversity, and carries phosphorus into the river.

Nutrients

Phosphorus–stimulates the growth of algae. As algae die and decompose, oxygen levels in the water are lowered, which may kill fish and other aquatic organisms.

Nitrogen–can affect drinking water. At high enough concentrations, nitrate-nitrogen in drinking water can limit the ability of blood to carry oxygen in children. Recently researches have expressed concern about a possible link between nitrate and stomach/esophageal cancer. The magnitude of risk is not yet known. At times, SMC contributes to groundwater; therefore high nitrates in the creek become a groundwater issue. In surface water nitrogen contributes to a stratified zone of low oxygen known as hypoxia in the Gulf of Mexico-Mississippi River Delta.

Pathogens–bacteria and viruses that cause disease. The presence of fecal coliform bacteria may indicate that human and/or animal wastes are entering the river along with the possibility of pathogenic organisms. If people, especially children come in contact with pathogens, they might get sick.

Total Suspended Sediment

Total suspended sediment measurement in water refers to particles of soil and organic matter including algae cells that are suspended in solution. Sediment is the biggest pollutant found in the MN River. As mentioned earlier, excess sediment makes rivers look muddy and turbid, restricts the ability of fish to spawn, limits biological diversity, and carries phosphorus into the river. It also accelerates the need to dredge and clean drainage ditches, lakes and streams, which can be very costly to tax payers.

For reference it is estimated that pre-settlement monthly mean TSS levels were less than 10-100mg/l[1]. Total suspended sediment concentrations varied widely in the watershed over the study period. A table of statistics representing the grab sample concentrations can be found in table 17. Figure 7 is a graph of the fluctuating TSS concentrations on a log scale over time. In general TSS levels are the highest from site 3. It is thought the large amounts of flow from the two ditches help accelerate the bank erosion within the channel of Seven Mile Creek. Over 35% of the time the SMC was sampled, concentrations were above set limits and ecoregion values. Ecoregion values are taken from reference streams that are felt to be representative and reflect expected water quality for a particular region (See McCollar and Heiskary, 1993 for additional details). During storms of 1" or more TSS levels typically rise from below 100 mg/l to 250 mg/l or even more. Maximum values were seen as high as 2096 mg/l at site 3 during a summer runoff event in 2001. Typically, sites 1 and 2 had lower TSS levels than site 3 during storms. However, during low flow periods the upper sites had higher TSS levels due to organics attributed to algae growth. Median TSS concentrations for the three sites range from 10-14 mg/l with an interquartile range of 4-174 mg/l.

During storm events, suspended sediment increased substantially in the SMC watershed. An automatic sampler was installed at site 2 in 2000 to further document changes in nutrient and sediment concentrations. The sampler was programmed to take samples from the river every two hours for 24 hours soon after a major storm event. Typical of suspended sediment and phosphorus concentrations, TSS levels in the SMC reach a maximum when the stream discharge is at or near the peak. Figure 4 shows a typical TSS response found during a 1.6" storm over 2 days.

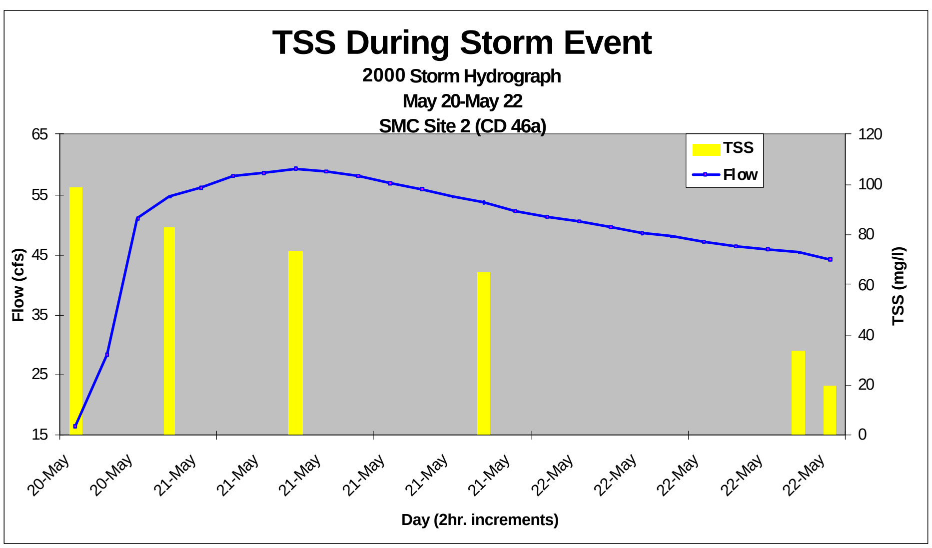


Figure 4. TSS and storm hydrograph

[1] Basin Information Document, MPCA.1997.

Nutrients

Nutrients are necessary for growth and maintenance of all life forms. However, nutrients can cause problems in aquatic systems when they are present in quantities that greatly exceed the amounts normally needed to sustain organisms living in the system. A process of nutrient enrichment (eutrophication) can cause production of algae and other aquatic plants to exceed desirable levels.[2] This study investigated two nutrients, phosphorus and nitrogen, which have been frequently identified as contributors to eutrophication when present in high quantities, and, in the case of un-ionized ammonia and nitrate, can be toxic. Besides being a concern for Seven Mile, elevated nutrient levels raise environmental concerns downstream. Within the past decade research and clean up efforts have concentrated on the MN River since it has been designated by the EPA as a heavily impaired water resource. A segment of the MN River from Mankato to Shakopee is a Total Maximum Daily Load designated reach. High nutrient levels and bacteria from tributaries have been identified as a major source for the water quality impairments. In addition, from a global perspective, recent concern over the “dead zone” (hypoxic zone-low oxygen levels) in the Gulf of Mexico has drawn attention to contributing areas of the Upper Midwest such as the MN River valley.

Nitrogen

Water samples were collected and analyzed for nitrogen in the form of Nitrate-Nitrogen. Nitrate in drinking water may cause methemoglominemia (Blue Baby Syndrome) in young children and a maximum nitrate concentration of 10 mg/l has been adopted to protect public health (MPCA, 1990). This level is also used as reference for surface waters.

Stream discharge during this part of the runoff is predominantly derived from subsurface drainage water by ditches and tiles. This suggests that much of the nitrate is reaching the river through a shallow subsurface pathway. Randall (1986) and Montgomery (1999 Red Top Farms Demonstration Project) reported average nitrate concentrations that ranged from 16 to 172 mg/l in tiles draining shallow ground water at agricultural experiment stations located in the Minnesota River Basin[3]. Other sources of nitrate include failing septics, runoff from feedlots, and natural derived sources. Figure 5 shows nitrate concentrations during a storm. The lower levels at the rise of the hydrograph indicate dilutions. As more water infiltrates through the soil profile, No_3 is pushed deeper into the soil, until it reaches drainage tile. From there it enters ditches and Seven Mile Creek.

Nitrate is considered one of the largest water quality concerns for the watershed. For its size, the watershed contributes very large nitrogen loadings and concentrations. Average concentrations ranged from 13-14 mg/l. Of the 40 samples taken, about 80% of the samples exceed the Western Corn Belt Ecoregion values. The highest concentrations observed were 27-28mg/l. Nitrate concentrations are generally very low during the pre-plant period. Concentrations peak around eary July and are directly correlated with rainfall. As crops enter full canopy in mid-August nitrate concentrations decrease substantially due to less rainfall and crop uptake of nitrogen sources within the soil profile.

---

[2] Minnesota River Assessment Report, Physical and Chemical Assessment. January 1994
[3] Red Top Farms Demo Site Synopsis, MN Department of Agriculture, 1999.

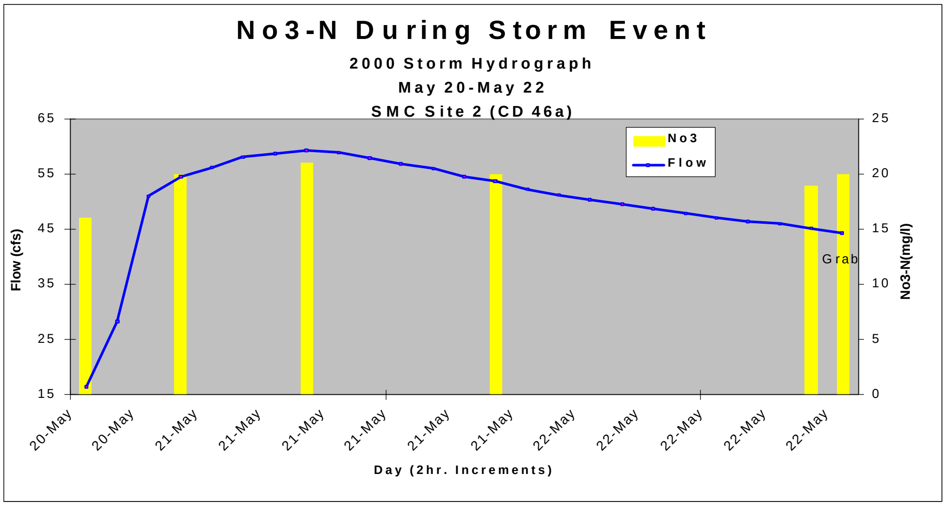


Figure 5. Nitrate-Nitrogen vs. time during 2000 storm event.

Phosphorus

Water samples were analyzed for both dissolved and particulate forms of phosphorus. Dissolved ortho-phosphorus (Po_4) is regarded as problematic because it is in a readily available form utilized by algae. Phosphorus in the particulate form can also be problematic because it can be transported as part of the suspended load, potentially affecting aquatic systems located further downstream. The combined amounts of dissolved and particulate phosphorus are termed total phosphorus. Ortho-phosphorus and total phosphorus concentrations found coming from the watershed are adding to the Minnesota River. Average total phosphorus concentrations found at the three monitoring sites ranged from 0.184 to 0.251 mg/l. About 60% of the total phosphorus was in the form of ortho or dissolved reactive phosphorus. Phosphorus and sediment were found to be directly correlated. Highest concentrations were found during low flow conditions, indicating septic system influences as well as natural phosphorus bio-geo-chemical processes during low dissolved oxygen or variable pH conditions.

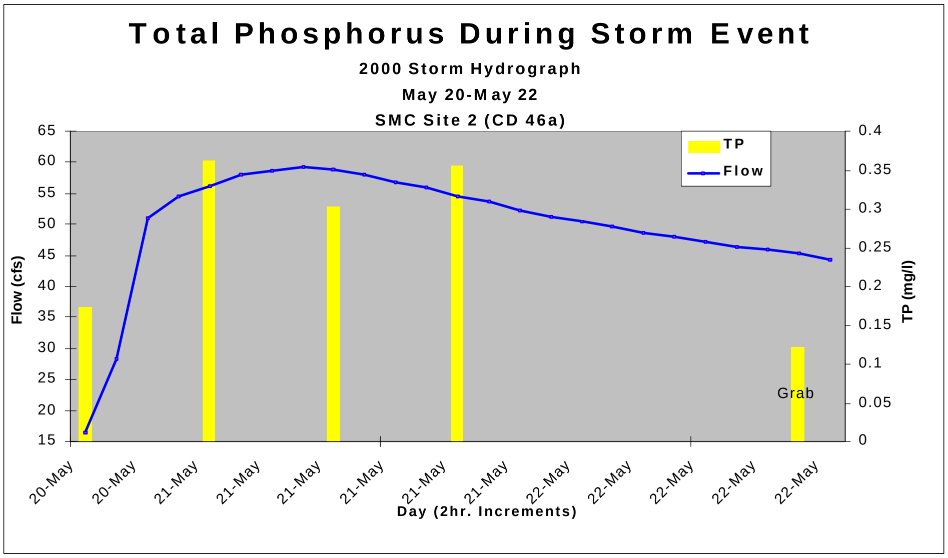


Figure 6. Total phosphorus vs. time during a 2000 storm event.

Bacteria

During the diagnostic study fecal coliform bacteria were tested. The presence of coliform bacteria may indicate that human and/or animal wastes are entering the river along with the possibility of pathogenic organisms. The potential presence of disease-causing organisms sometimes found with coliform bacteria limit the overall recreational suitability of the water for health and safety related reasons. Listed in Table 18 are fecal coliform levels found from 1996-2001. For reference, a public beach in Minnesota is closed if fecal coliform levels exceed a geometric mean of 200-col/100 ml with no less than five samples per month, or if a one-time sample exceeds 2000 col/100ml.

In Seven Mile Creek and the tributaries feeding it, geometric mean concentrations ranged from 200 to 300-col./100 ml. Concentrations during storms ranged from 100 to 14,000 col./100 ml indicating manure spreading acres or feedlot sources. Fecal bacteria during low flow conditions ranged from 10 to 800 col./100 ml. Higher levels during low flow periods (>200) indicate failing septic systems within the watershed.

Table 17

Total Suspended Solids (TSS, mg/L)

Site	Mean (mg/l)	Median (mg/l)	Max (mg/l)	Min (mg/l)	25%[1] (mg/l)	75%[1] (mg/l)	% of Samples Exceeding Limits[2]	% of samples Exceeding WCBP Ecoregion Average[3]	Count
Site 1	44	10	418	2	4	32	25	11	36
Site 2	170	14	711	1	5	95	39	30	23
Site 3	255	13	2096	2	4	174	43	38	42

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher 75 percentile values

[2]Limit of 30 mg/l (reference applied to permitted point source discharges)

[3] Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average based on 45.3 mg/l

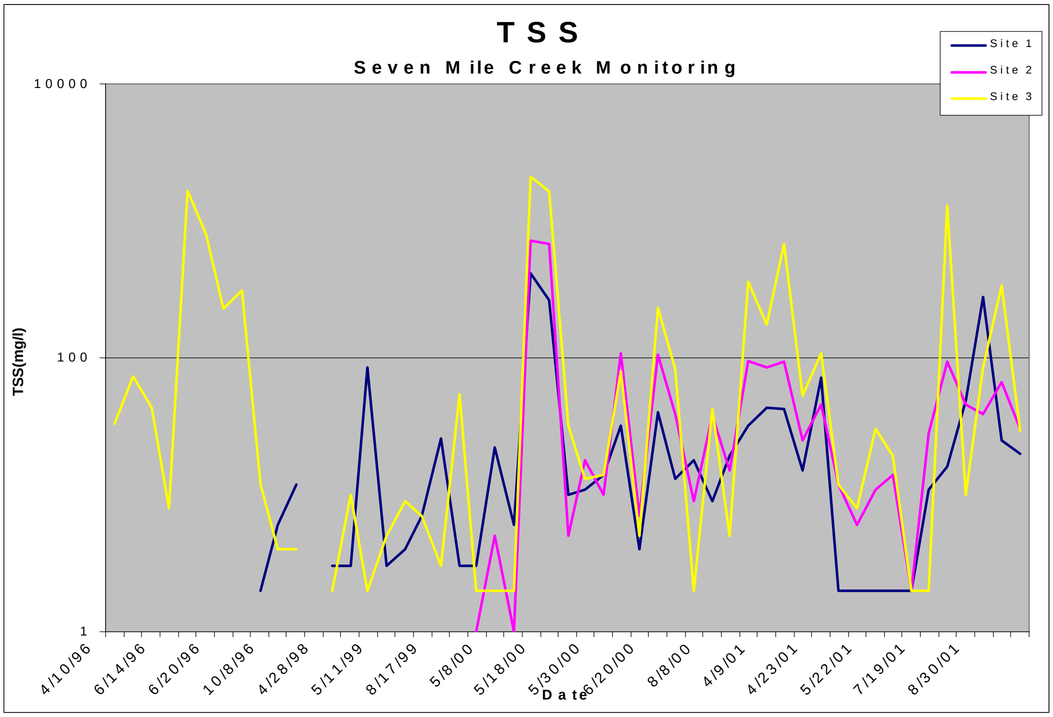


Figure 7: TSS concentrations vs. time.

Table 18

Nitrate Nitrogen

Site	Mean (Mg/l)	Median (Mg/l)	Max (Mg/l)	Min (Mg/l)	25%[1] (Mg/l)	75%[1] (Mg/l)	% of Samples Exceeding Limits/Standards[2]	% of samples Exceeding WCBP Ecoregion Average[3]	Count
Site 1	13.2	13.8	27.0	.5	6.0	20.8	50	76	38
Site 2	12.8	9.9	27.5	1	8.9	19.3	33	83	24
Site 3	12.7	13.6	28.3	.9	8.0	17.5	52	86	44

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher percentile values

[2]Limit based on 10 mg/l

[3] Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average based on 4.8 mg/l

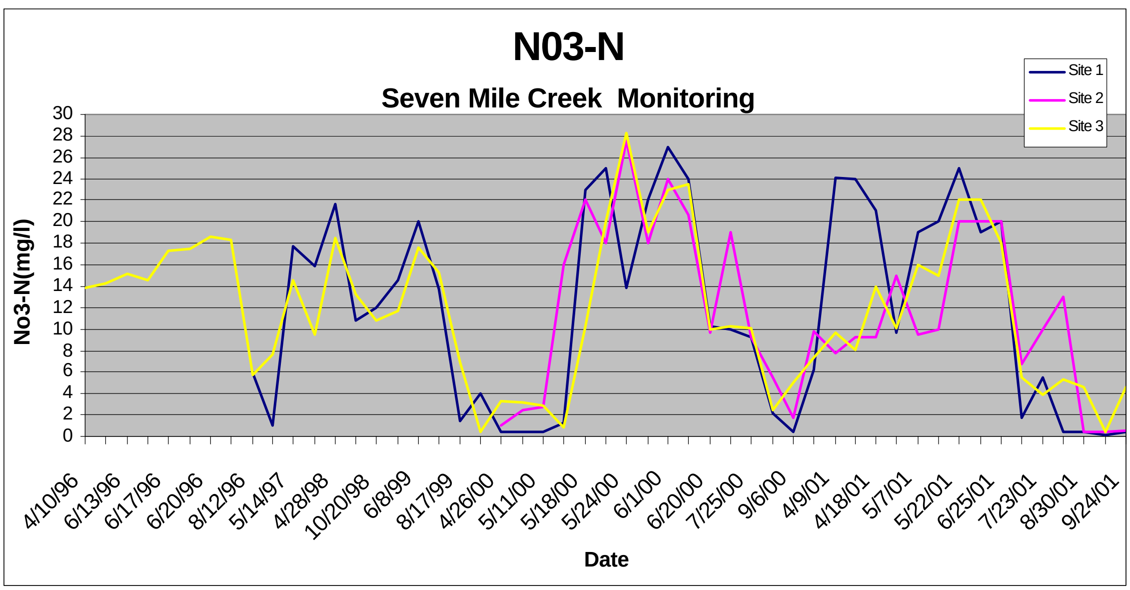


Figure 8. Nitrate concentrations vs. time.

Table 19

Total Phosphorus

Site	Mean (mg/L)	Median (mg/L)	Max (mg/L)	Min (mg/L)	25%[1]	75%[1]	% of samples Exceeding WCBP Ecoregion Average[2]	Count
Site 1	.251	.205	.664	.033	.150	.328	36	36
Site 2	.206	.212	.378	.035	.148	.298	39	23
Site 3	.184	.182	.499	.035	.122	.241	21	38

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher 75 percentile values

[2] Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average based on .280 mg/l

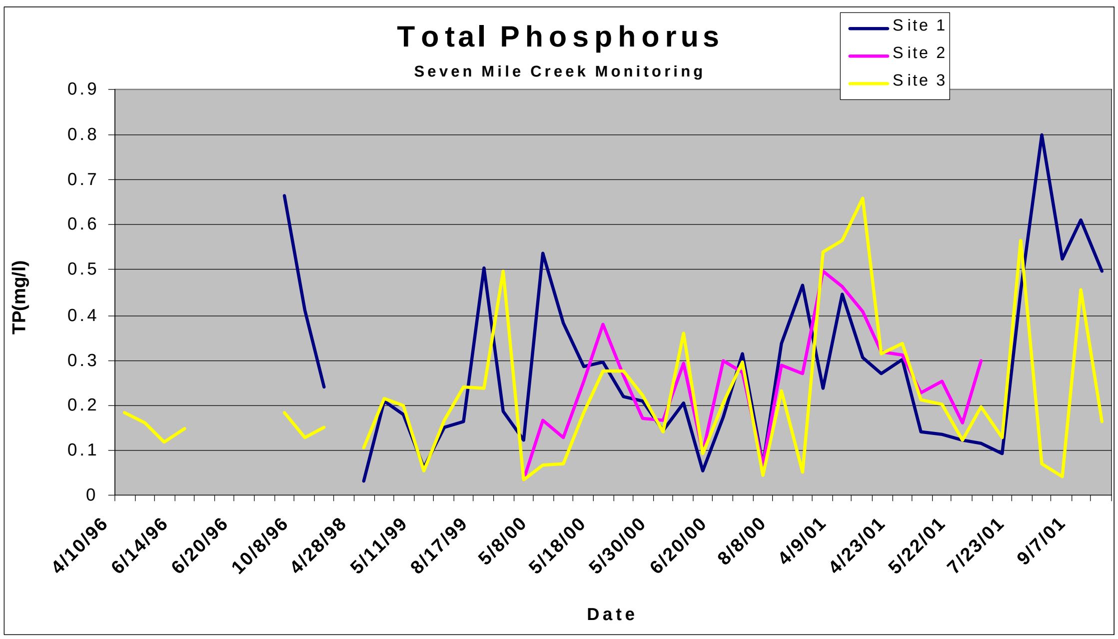


Figure 9. Total phosphorus concentrations vs. time.

Table 20

Ortho-Phosphorus

Site	Mean (mg/L)	Median (mg/L)	Max (mg/L)	Min (mg/L)	25%[1]	75%[1]	% of Samples Exceeding Limits/Standards	% of samples Exceeding WCBP Ecoregion Average	Count
Site 1	.133	.098	.391	.003	.028	.232	Na	Na	36
Site 2	.127	.091	.332	.019	.043	.239	Na	Na	23
Site 3	.084	.052	.300	.003	.015	.179	Na	Na	38

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher 75 percentile values

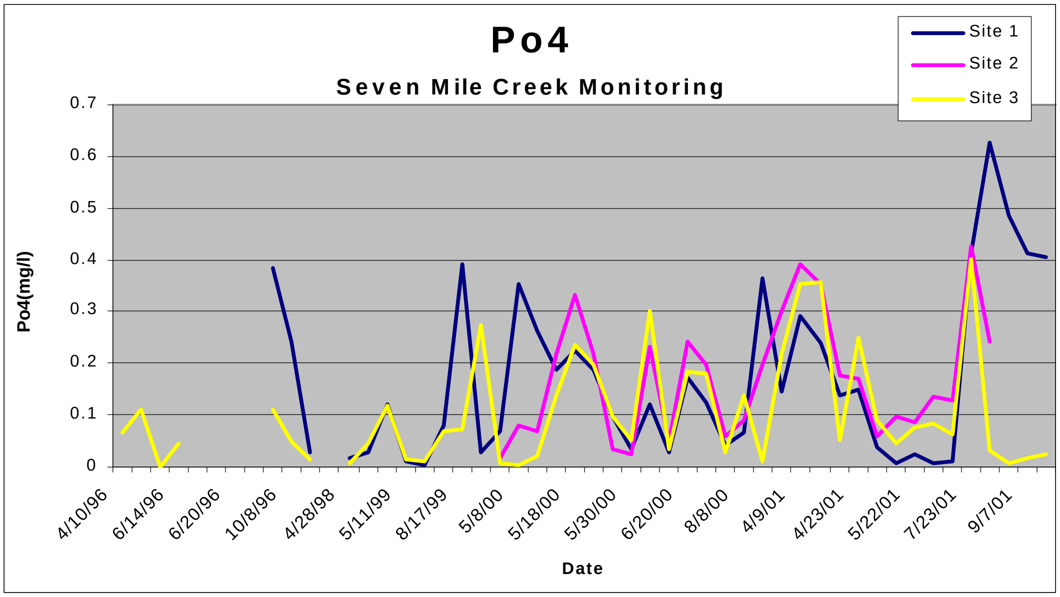


Figure 10. Ortho-phosphorus levels vs. time.

Table 21

Fecal Coliform Bacteria

Site	Mean (col./100ml)	Median (col./100ml)	Max (col./100ml)	Min (col./100ml)	25%[1] (col./100ml)	75%[1] (col./100ml)	% of Samples Exceeding Limits[2]	% of samples Exceeding WCBP Ecoregion Average[3]	Geometric Mean	Count
Site 1	1812	200	23900	10	100	1100	10	43	269	21
Site 2	1216	435	13600	20	125	675	14	64	314	22
Site 3	1420	100	12400	10	75	550	22	39	198	23

[1] Inter-quartile ranges determined by sorting the lower 25 percentile values and higher percentile values

[2]Limit based on 2000 col/100ml

[3] Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average based on 230 col/100ml

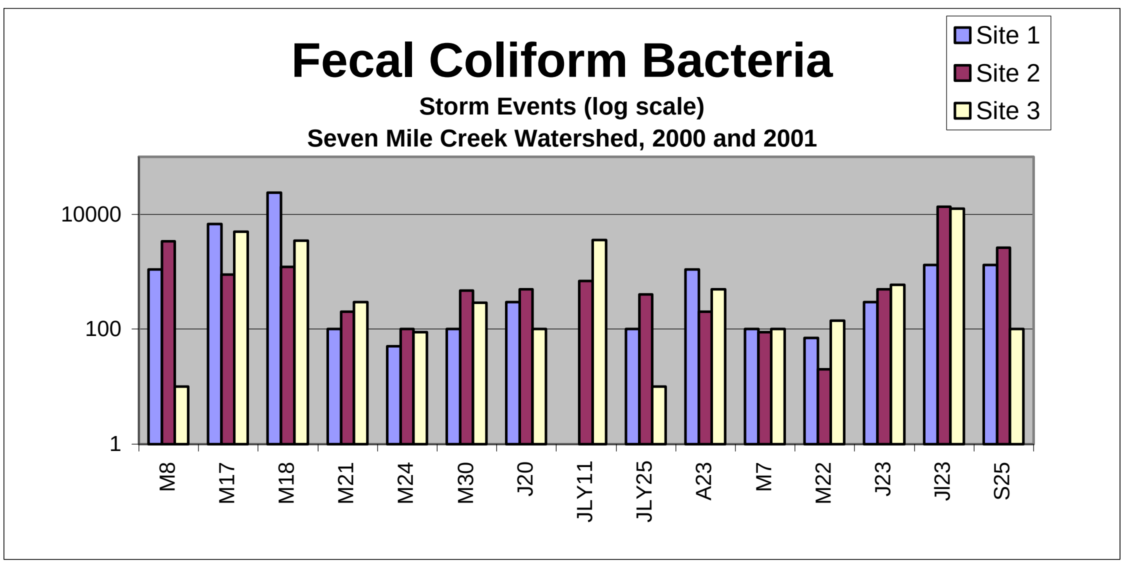


Figure 11. Fecal Coliform levels on various sampling dates for Seven Mile Creek.

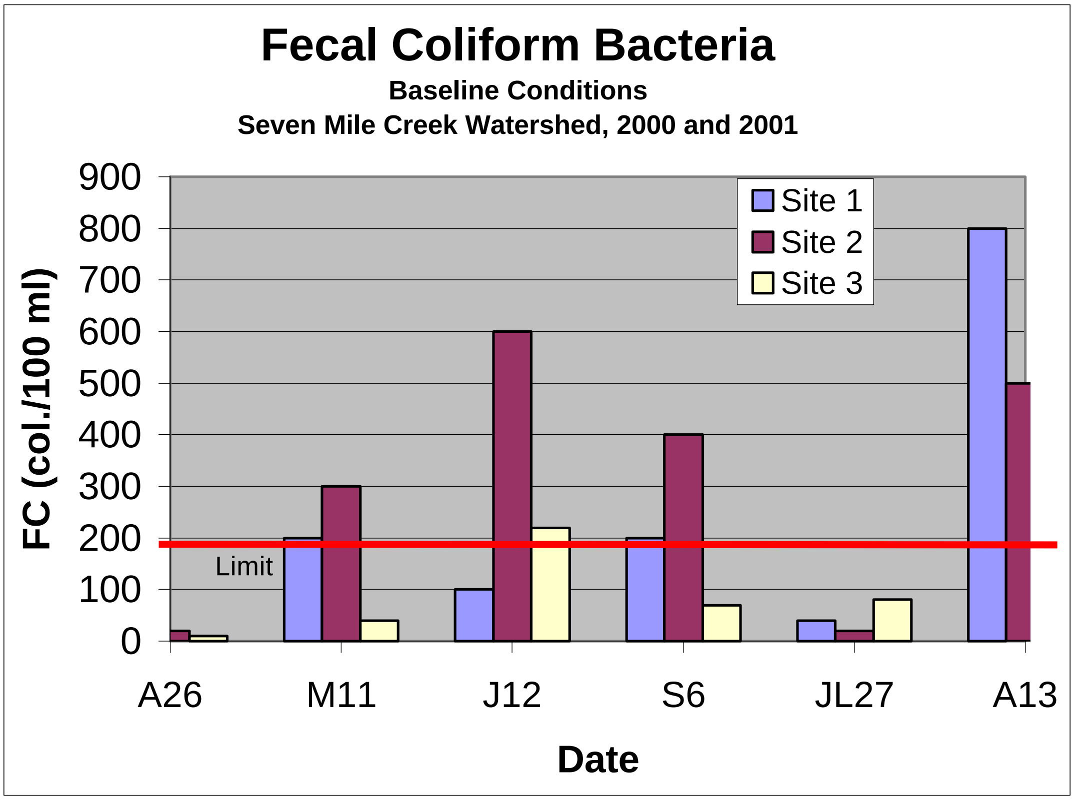


Figure 12. Fecal Coliform levels with reference to upper allowable limit.

Extreme flow conditions are common in the Seven Mile Creek Watershed. Extreme low flows are common during April, May and June, but by August, flows are reduced to less than three cubic feet per second. In general, the hydrographs are flashy in nature. During a storm event, the river rises quickly and recedes just as fast. Figures 13-15 show the three major climactic periods in the watershed. Changes in climate (water cycle), growth of crops, and antecedent moisture conditions help explain this. Topography of the river course also helps explain the gradual increase and decrease of river flows in the watershed. Below are storm hydrographs taken during different parts of the growing season. Flows are very high in the early part of the season. Any additional precipitation causes a rapid, flashy response to the hydrograph. However, as the summer progresses and crops are at full canopy, precipitation within the watershed has little affect on the stream.

Ground water dominates the flows in watershed 3 and sustains the flow throughout the entire year. Little information is known about the stream upwelling and down welling processes. It is known that at times, typically later parts of the growing season, that surface water losses occur due in part to the fractured bedrock, sandstone and gravel alluvial materials found in the lower reach of the watershed. Sub watershed 3 is at the mouth of the creek with a fall of 210 feet down through Jordan sandstone features. The characteristics of flow pathways posed an interesting problem as there is a small loss of water (losing reach) in the channel as it travels from the mouth of watershed 1 and 2 to the monitoring station in subwatershed 3. By checking the hydrograph flows in subwatershed 3 against the combined hydrograph flows of subwatershed 1 and 2, it was found that for periods of time, on the tail of the hydrograph during storm events and also during base flow periods, watershed 3 yielded less than 1 and 2. At first glance this is a major concern for sediment, phosphorus and nitrogen projections. However, through the following discussions it becomes clear that the overall projection for sediment and phosphorus is likely affected less than 5% by this feature.

Photo 8. Spring snow melt conditions in the park on April 4, 2001.

Photo 9. Spring snow melt, Site 1 Highway 99.

Examples of flashy nature of flows-- spring, mid-summer, and late summer.

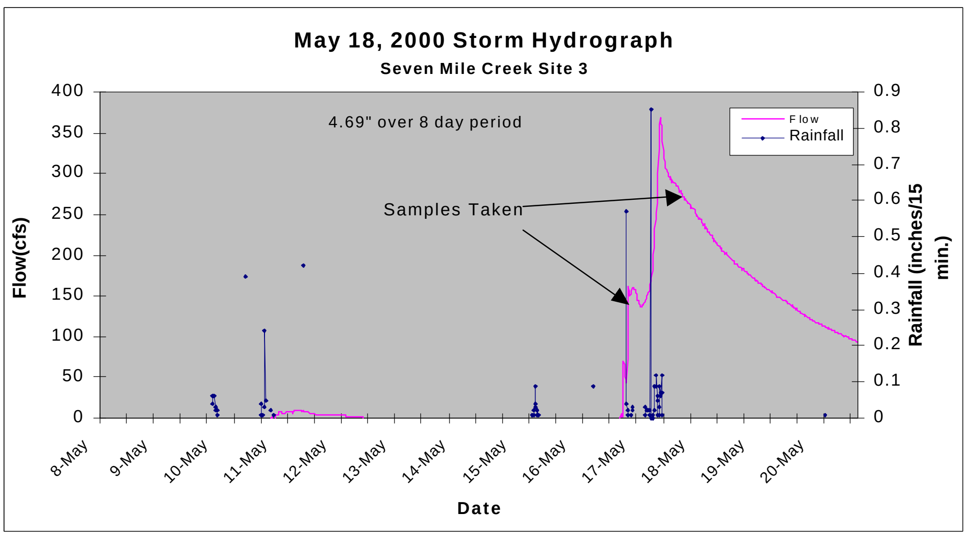


Figure 13. Seven Mile Creek hydrograph in early summer before crop canopy formed. Very high flows.

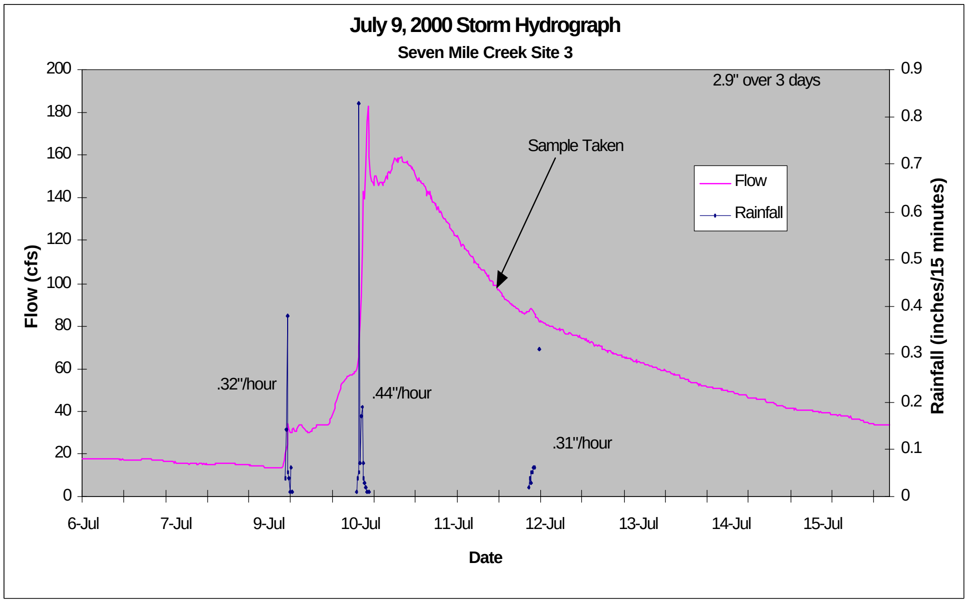


Figure 14. Seven Mile Creek hydrograph in mid-summer; crop canopy almost enclosed. High flows.

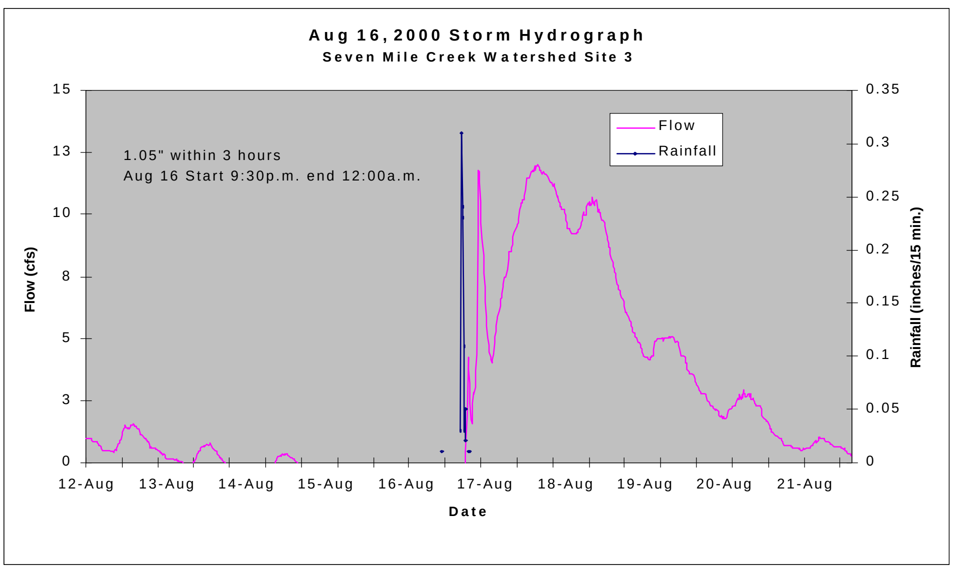


Figure 15. Seven Mile Creek hydrograph in late summer; evapotranspiration at peak within the watershed. Low flows-much less flashy even with an inch of rain.

Table 22. 2000 and 2001 flow stats.

2000 flow stats

Site	Mean (cfs)	Med. (cfs)	Max (cfs)	Month of Max Occurrence	Min (cfs)	Month of Min Occurrence	Total Precip.	Total Runoff (inches)	% Runoff
Site 1	9	0	120	May	0	April	20.34	3.84	18.8
Site 2	8	0	69	May	0	April	20.34	3.62	17.8
Site 3	19	1.1	229	May	3	April	20.34	3.53	17.5

[1] April through September

2001 flow stats

Site	Mean (cfs)	Med. (cfs)	Max (cfs)	Month of Max Occurrence	Min (cfs)	Month of Min Occurrence	Total Precip.	Total Runoff (inches)	% Runoff*
Site 1	43.8	18.8	235	April	.05	September	21.4	19.2	
Site 2	8	9.4	170	April	0	September	21.4	16.5	
Site 3	89.4	21.3	474	April	3	September	21.4	16.6	

[1] April through September

*Beacause total precipitation does not include the very large snowmelt contributions from the winter of 2000 and 2001, % runoff values are not calculated

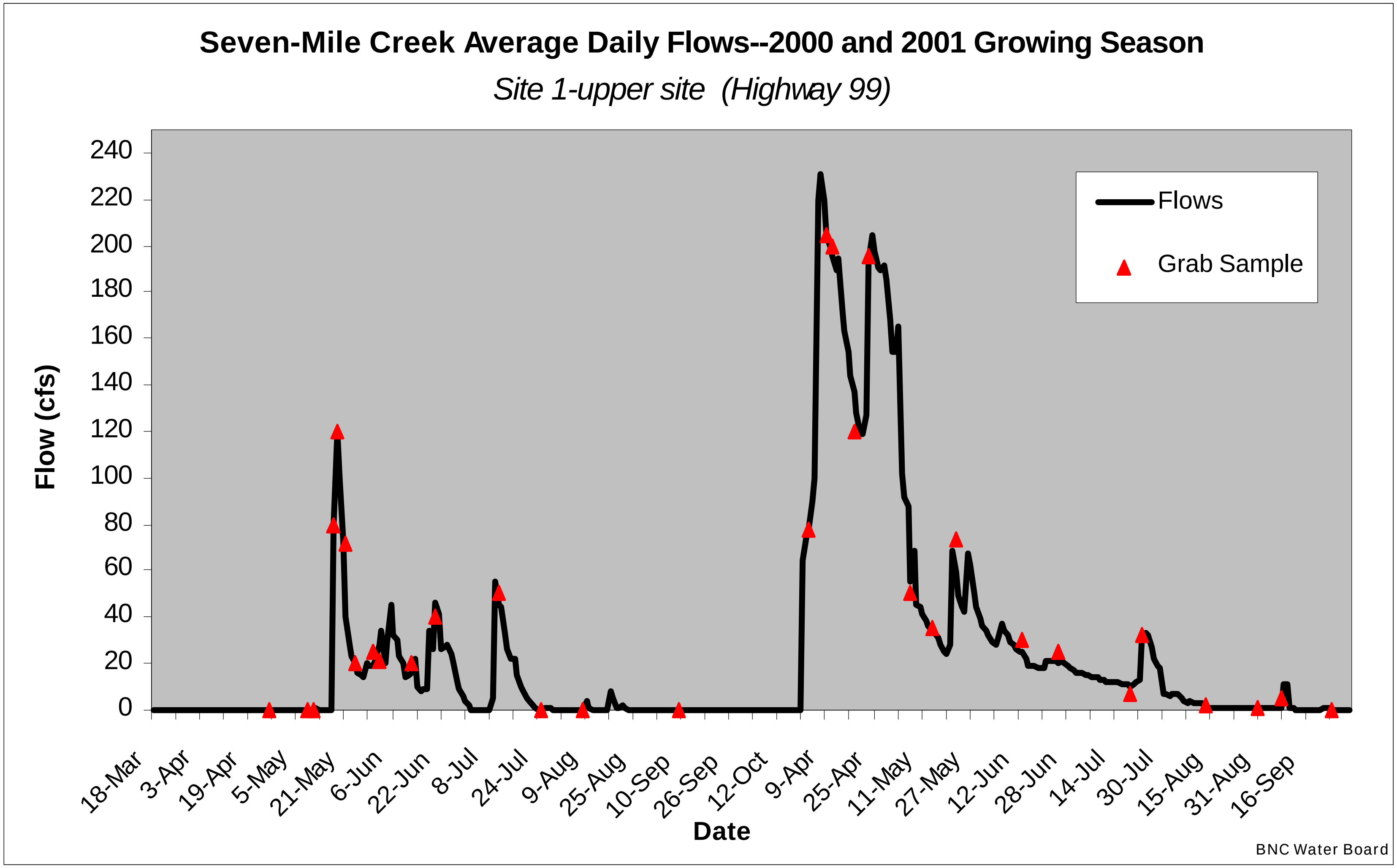


Figure 16. Site 1 hydrograph.

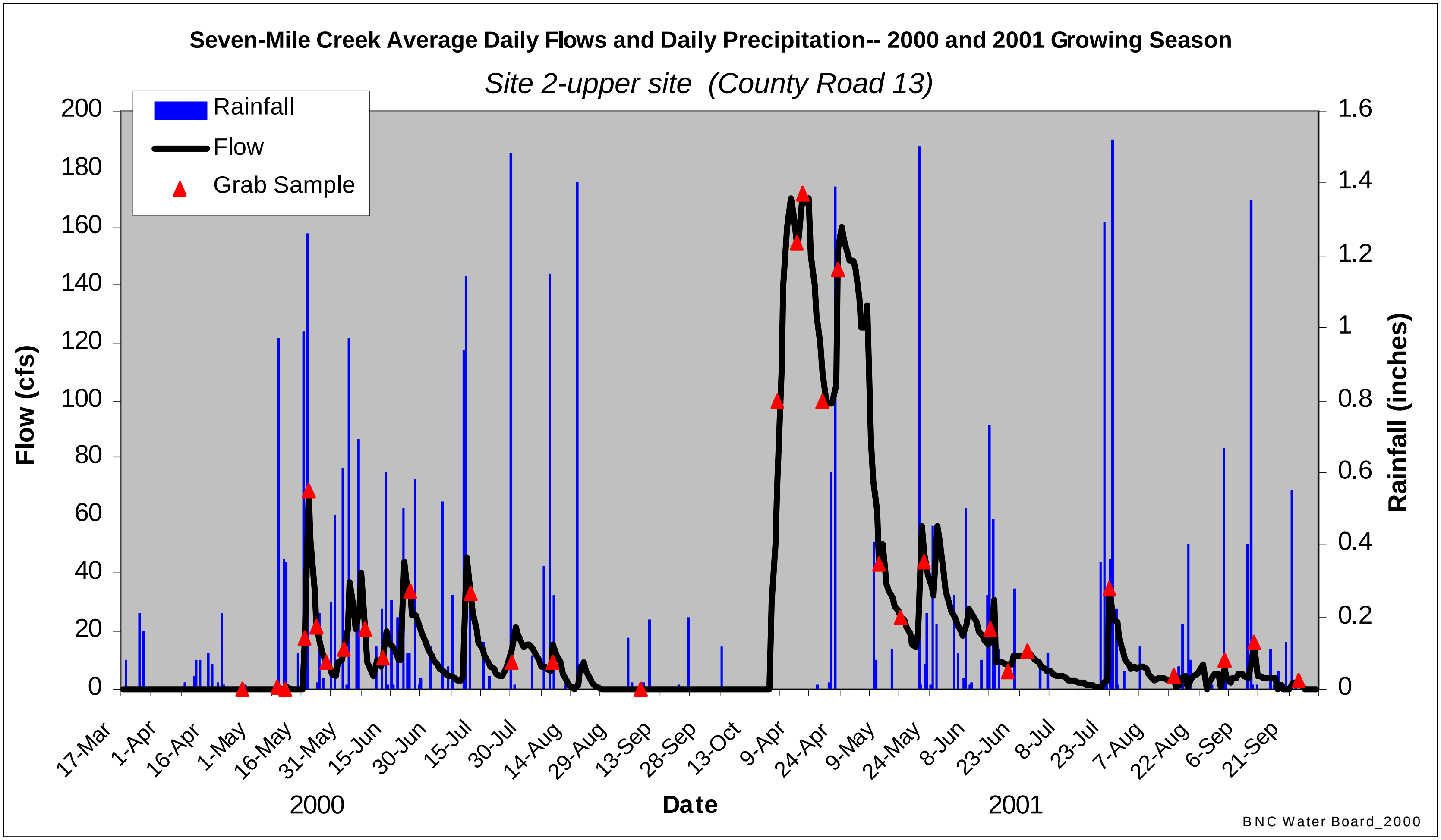


Figure 17. Site 2 hydrograph.

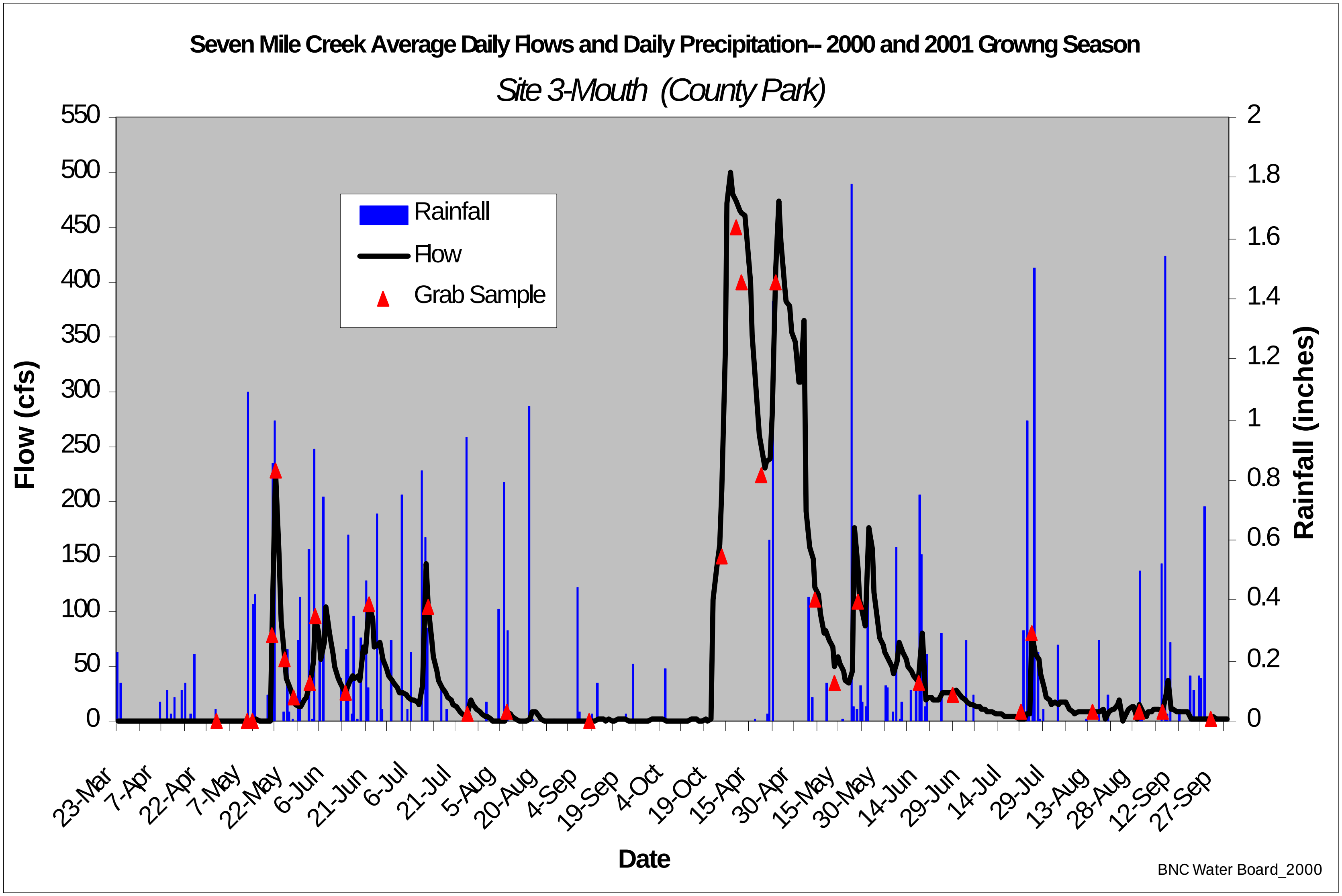


Figure 18. Site 3 hydrograph.

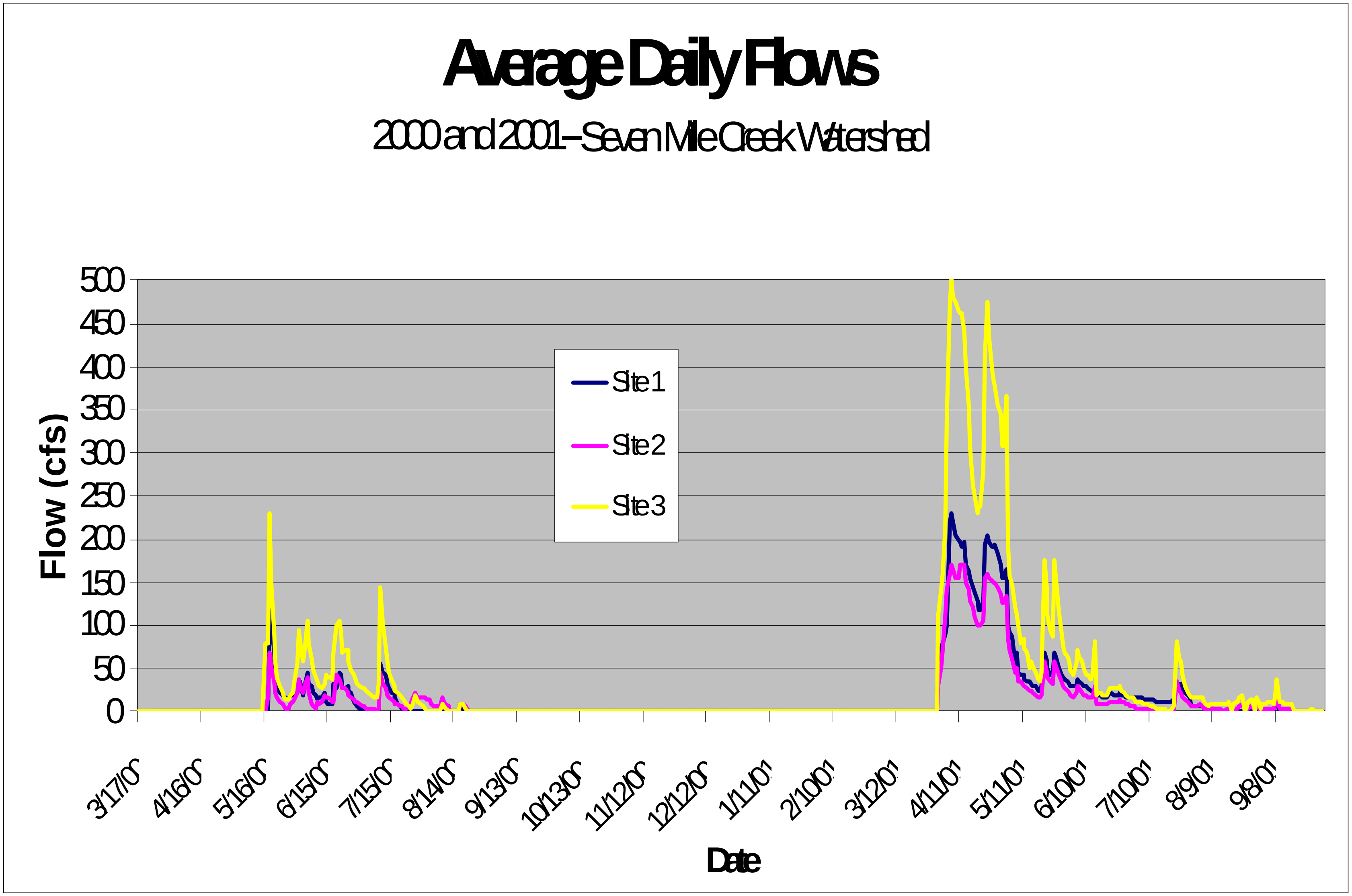


Figure 19. Average daily flows for each site vs. time.

Photo 10. Stream flows taken for stage-discharge rating curve development during higher flows at site 1 on CD 13.

Pollutant Loading Estimates

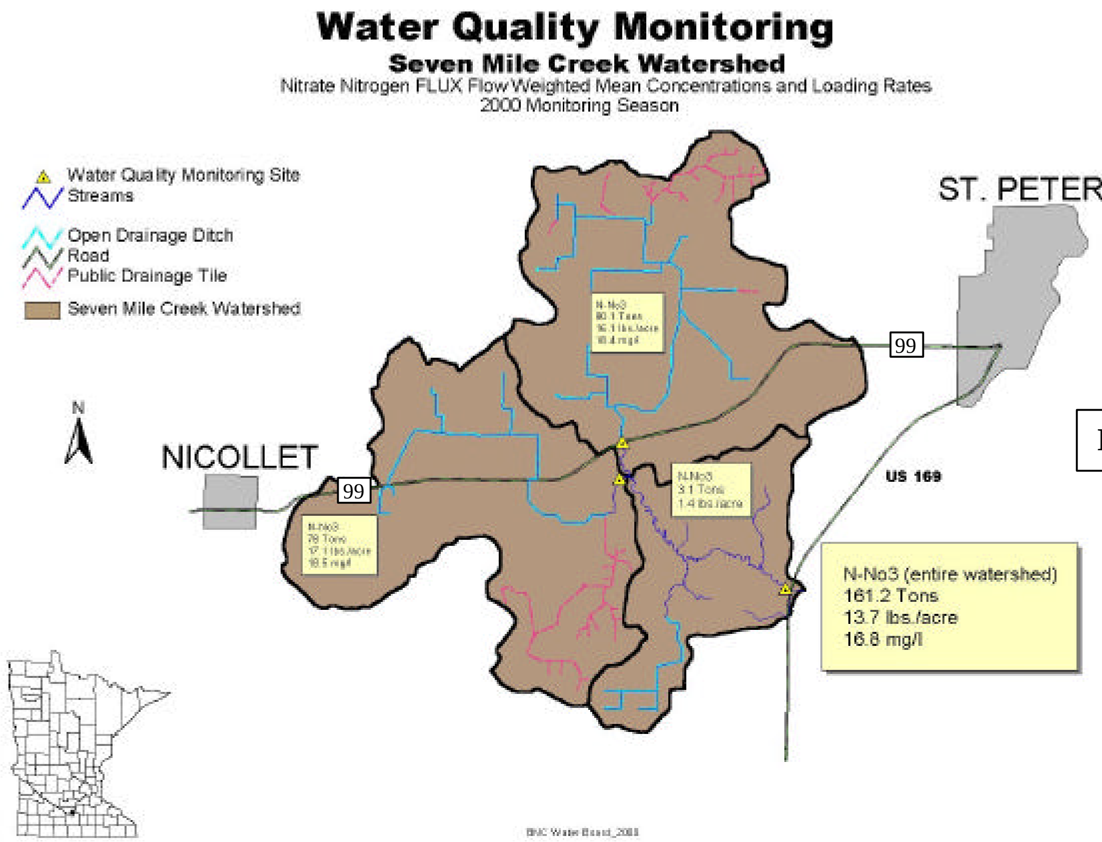
FLUX - - Flow Weighted Mean Concentrations and Yields

As reported earlier, the 2000, and 2001 sampling seasons were different in terms of rainfall, flow, and amount of samples taken. Consequently, loading estimates will vary considerably between monitoring years (figure 20). In addition to climatic differences and therefore overall runoff, the timing of grab sampling can sometimes overestimate or underestimate the amount of a particular water parameter of concern. As can be seen from the hydrographs the red triangles indicate when the samples were taken in terms of water flow conditions. Ideally, grab samples should be taken during a variety of flow conditions.

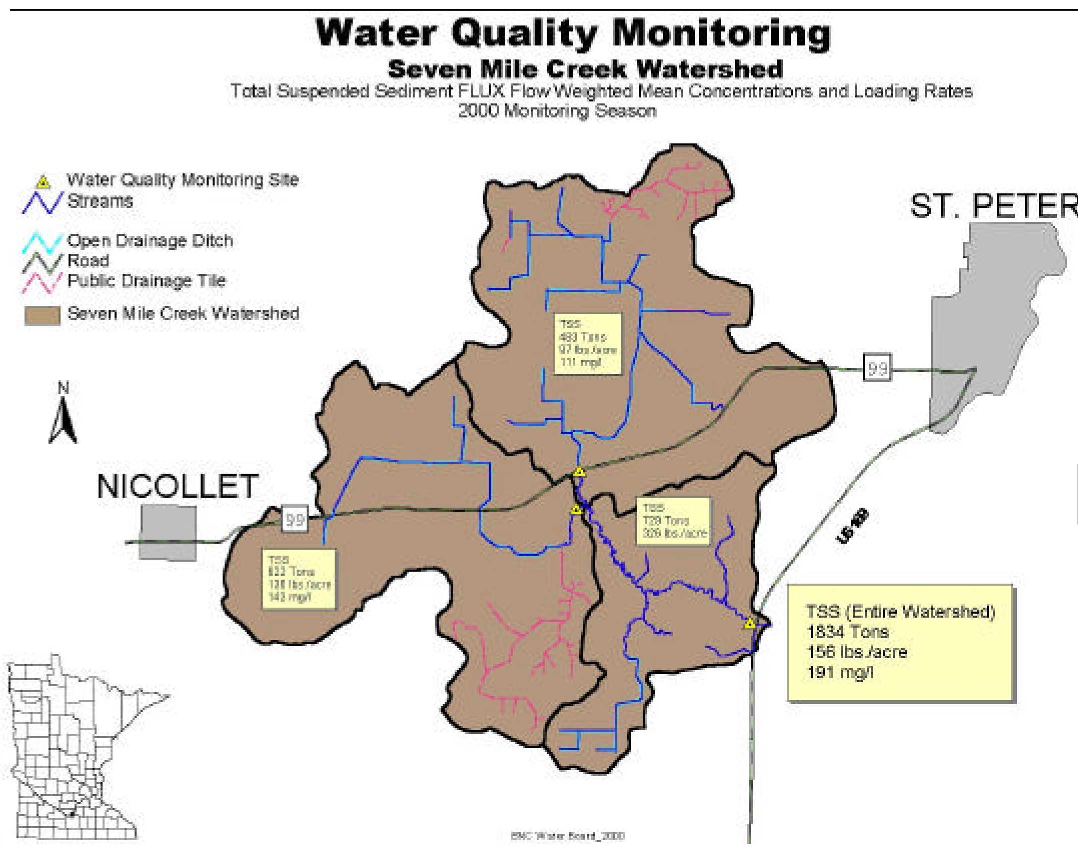
A combination of two years worth of data with a greater number of samples taken during a wide variety of flow, groundwater/base flow and runoff dominated conditions have resulted in a more accurate portrayal of the chemical and physical makeup of the SMC resource during the study.

Relative Water Quality in the Watershed for 1999 Monitoring Season

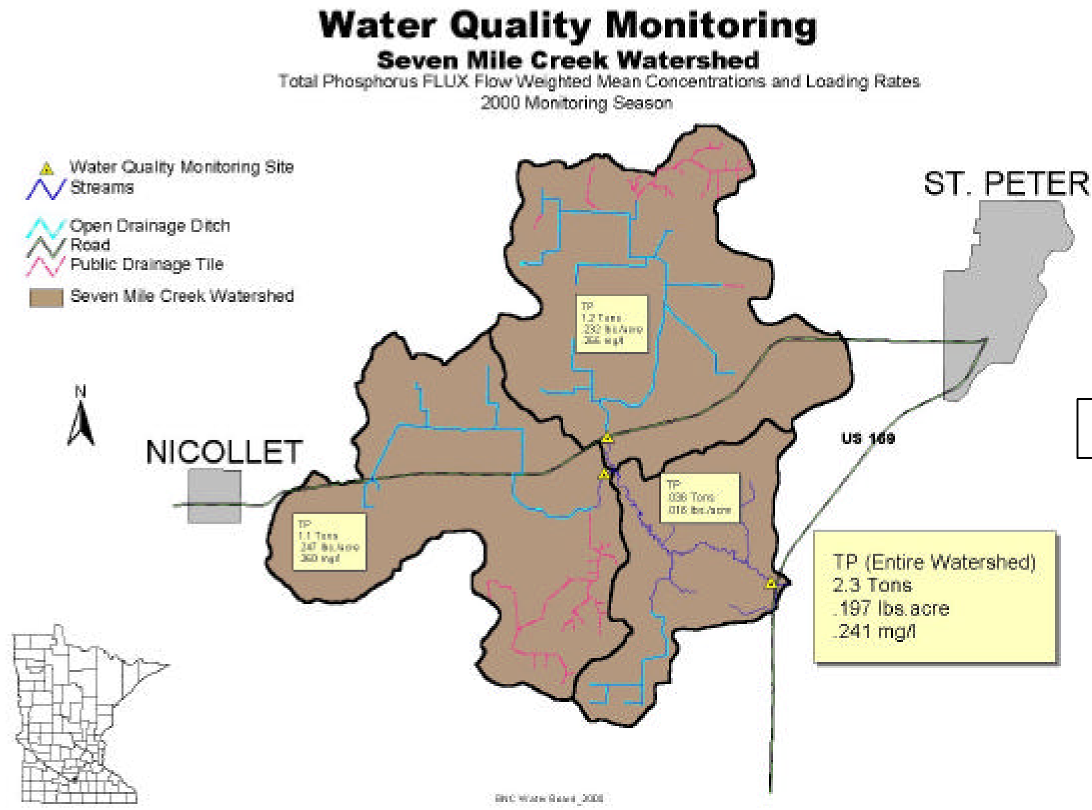
Spatial Representation of Water Quality


Water Quality Monitoring
Seven Mile Creek Watershed
Nitrate Nitrogen FLUX Flow Weighted Mean Concentrations and Loading Rates
2000 Monitoring Season
Water Quality Monitoring Site
Streams
Open Drainage Ditch
Road
Public Drainage Tile
Seven Mile Creek Watershed
N
NICOLLET
ST. PETER
99
99
US 169
N-No3 (entire watershed)
161.2 Tons
13.7 lbs./acre
16.8 mg/l

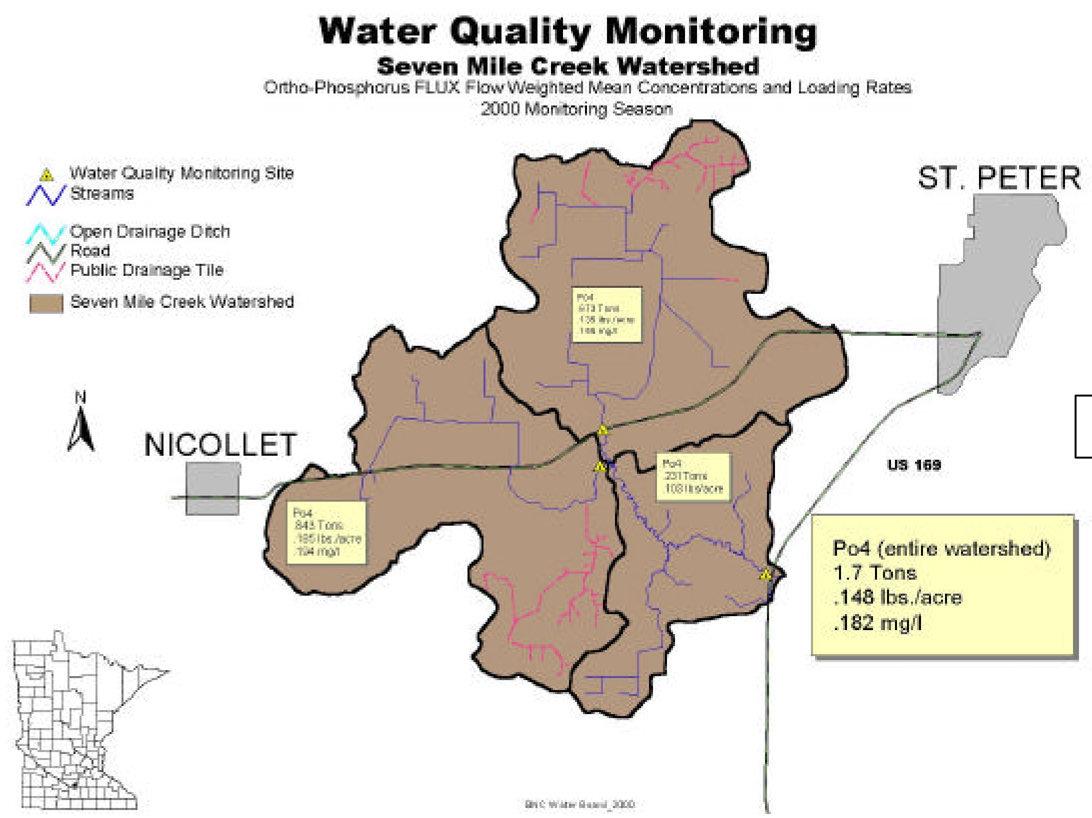
Map 26


Water Quality Monitoring
Seven Mile Creek Watershed
Total Suspended Sediment FLUX Flow Weighted Mean Concentrations and Loading Rates
2000 Monitoring Season
Water Quality Monitoring Site
Streams
Open Drainage Ditch
Road
Public Drainage Tile
Seven Mile Creek Watershed
N
NICOLLET
ST. PETER
99
99
TSS
483 Tons
97 lbs./acre
111 mg/l
TSS
822 Tons
138 lbs./acre
142 mg/l
TSS
729 Tons
328 lbs./acre
TSS (Entire Watershed)
1834 Tons
156 lbs./acre
191 mg/l

Map 27


Water Quality Monitoring
Seven Mile Creek Watershed
Total Phosphorus FLUX Flow Weighted Mean Concentrations and Loading Rates
2000 Monitoring Season
Water Quality Monitoring Site
Streams
Open Drainage Ditch
Road
Public Drainage Tile
Seven Mile Creek Watershed
N
NICOLLET
ST. PETER
US 169
TP
1.2 Tons
TP
1.1 Tons
TP
.036 Tons
.016 lbs./acre
TP (Entire Watershed)
2.3 Tons
.197 lbs.acre
.241 mg/l

Map 28


Water Quality Monitoring
Seven Mile Creek Watershed
Ortho-Phosphorus FLUX Flow Weighted Mean Concentrations and Loading Rates
2000 Monitoring Season
Water Quality Monitoring Site
Streams
Open Drainage Ditch
Road
Public Drainage Tile
Seven Mile Creek Watershed
N
NICOLLET
ST. PETER
US 169
Po4
Po4
.231 Tons
Po4
.843 Tons
Po4 (entire watershed)
1.7 Tons
.148 lbs./acre
.182 mg/l

Map 29

2000

Table 23

Flow Weighted Mean Concentrations (mg/l)

Site	TSS	No3	TP	Po4
Site 1	111	18.4	.266	.155
Site 2	143	18.5	.260	.194
Site 3	191	16.8	.241	.182

Table 26

Yield (lbs/acre)

Site	TSS	No3	TP	Po4
Site 1	97	16.1	.232	.135
Site 2	136.4	17.1	.247	.185
Site 3	155.7	13.7	.197	.148

Table 32

Normalized Yield (lbs/acre/inch of runoff)

Site	TSS	No3	TP	Po4
Site 1	25.3	4.4	.060	.040
Site 2	37.7	4.7	.068	.051
Site 3	44.1	3.9	.056	.042

2001

Table 24

Flow Weighted Mean Concentrations (mg/l)

Site	TSS	No3	TP	Po4
Site 1	34.8	17.7	.281	.153
Site 2	51.2	11.2	.363	.239
Site 3	262.5	10.5	.438	.295

Table 27

Yield (lbs./acre)

Site	TSS	No3	TP	Po4
Site 1	151.4	77	1.22	.665
Site 2	191.2	41.7	1.36	.895
Site 3	984.4	39.4	1.64	1.10

Table 32

Normalized Yield (lbs/acre/ inch of runoff)

Site	TSS	No3	TP	Po4
Site 1	7.9	4.0	.064	.035
Site 2	11.7	2.5	.082	.054
Site 3	59.3	2.4	.100	.070

2002

Table 25

Flow Weighted Mean Concentrations (mg/l)

Site	TSS	No3	TP	Po4
Site 1				
Site 2				
Site 3				

Table 28

Yield (lbs/acre)

Site	TSS	No3	TP	Po4
Site 1				
Site 2				
Site 3				

Table 32

Normalized Yield (lbs/acre/ inch of runoff)

Site	TSS	No3	TP	Po4
Site 1				
Site 2				
Site 3				

Table 29

Average FWMC for 2000 and 2001 (mg/l)

Site	TSS	NO3	TP	Po4
Site 1	73	18.1	0.274	0.154
Site 2	97	14.9	0.312	0.217
Site 3	588	13.7	0.941	0.591

Mean 1970-1992 Annual Western Corn Belt Plains Ecoregion Average for:

TSS = 45.3 mg/l

Nitrate = 4.8 mg/l

TP = .280

Table 30

Average Yield for 2000-and 2001 (lbs/acre)

Site	TSS	NO3	TP	Po4
Site 1	124	47.0	0.726	0.400
Site 2	164	29.4	0.804	0.540
Site 3	570	26.6	0.912	0.624

Average Normalized Yield for 2000 and 2001 (lbs/acre/inch of runoff)

Site	TSS	NO3	TP	Po4
Site 1	16.6	4.2	0.062	0.038
Site 2	24.7	3.6	0.075	0.053
Site 3	51.7	3.2	0.156	0.056

Summary of pollutant loads

A primary goal of this study was to examine specific pollutants, the processes affecting their transport, and appropriate measures to reduce their delivery to the water resource. Examination of the relative amount of pollutant load assists in accomplishing this goal. Below is a brief summary of the loading rates for the SMC.

Sediment

When each of the three watersheds are separated out, it is found that watershed 3 is the largest contributor of sediment. Most of this sediment is thought to be derived from bank erosion sources. When comparing the upper two watersheds, watershed 2 is on average, a higher loader of sediments. Again, most of this is derived from bank erosion in the lower un-ditched riparian corridor near the lower section of the watershed, upstream of monitoring site 2. Average flow weighted concentrations (FWMC) during the two year study were found to be 73, 97 and 227 mg/l at sites 1, 2 and 3 respectfully. The watershed yielded an average of about 52 lbs/acre/inch of runoff or 570 lbs/acre.

Phosphorus

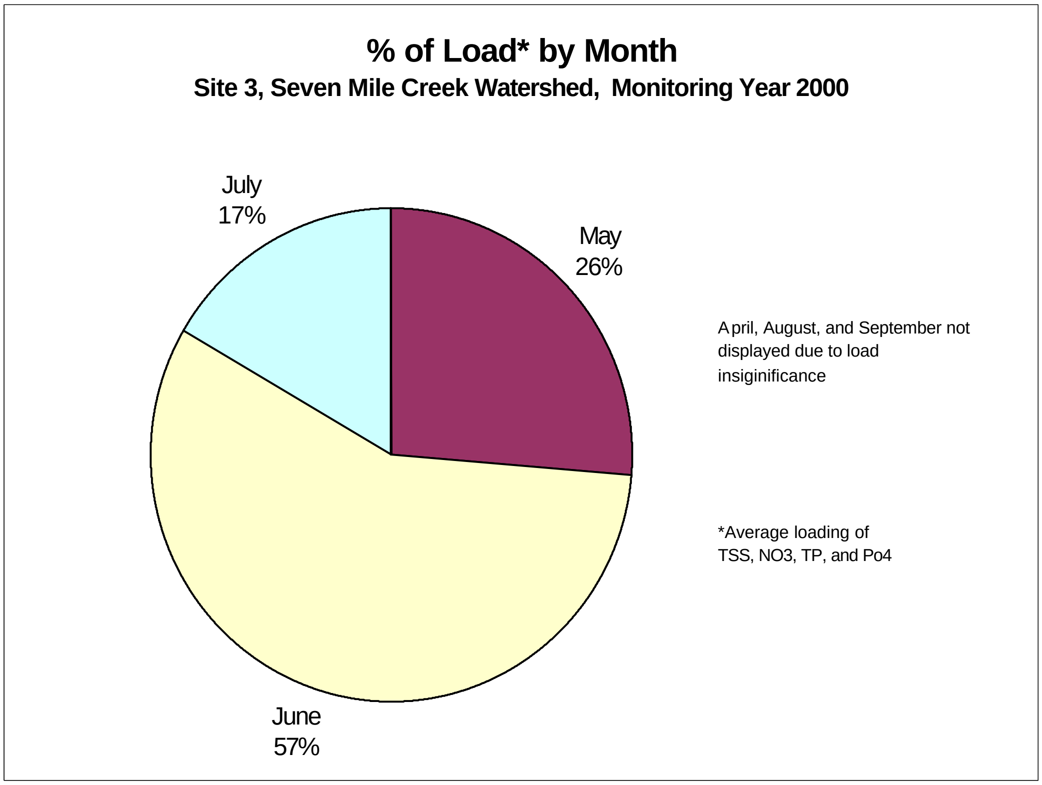
Average FWMC for the watershed were 0.340 mg/l for TP and 0.239 for ortho-phosphorus. About 60-70% of the total was found to be in the dissolved reactive form. It appears that watershed 1 and watershed 2 had virtually the same concentrations. These concentrations are adding to the MN River. Average concentrations on the MN River are 0.230 mg/l. The watershed loads approximately 0.156 lbs/acre/inch of runoff for total phosphorus and 0.056 lbs/acre/inch of runoff of ortho-phosphorus or 0.912 and 0.624 pounds per acre respectfully.

Nitrates

Nitrates are considered excessively high for this size of watershed. It confirms other watershed studies around the Midwest that small watersheds can be significant loaders of nitrates in agricultural environments. An average concentration of 14 mg/l was found for the watershed. Watershed 1 appears to have the highest concentrations with 18 mg/l compared to watershed 2 with 15 mg/l. Seven Mile Creek yielded approximately 3.2 pounds per acre/inch of runoff (27 pounds/acre or 318 tons) to the MN River during the growing season. These high numbers of nitrate nitrogen indicate virtually no de-nitrification is occurring within the watershed and surpluses of nitrogen are in excess of what plants need within the watershed.

Time Series

The majority of nutrient and sediment load came during the months with the most rainfall and snowmelt occurred. This information is utilized when considering remediation methods. By far the majority of sediment, phosphorus and nitrates are delivered to the MN River by Seven Mile Creek in just three months. Those months are typically April, May and June. BMPs that address these months should be utilized. In 2000, about 60% of the pollutants measured, entered the MN River in May, June, and July. In 2001, over 70% of the pollutants measured occurred in April. This is much more representative of pollutant loading in Seven Mile Creek since 2000 had virtually no snow melt.



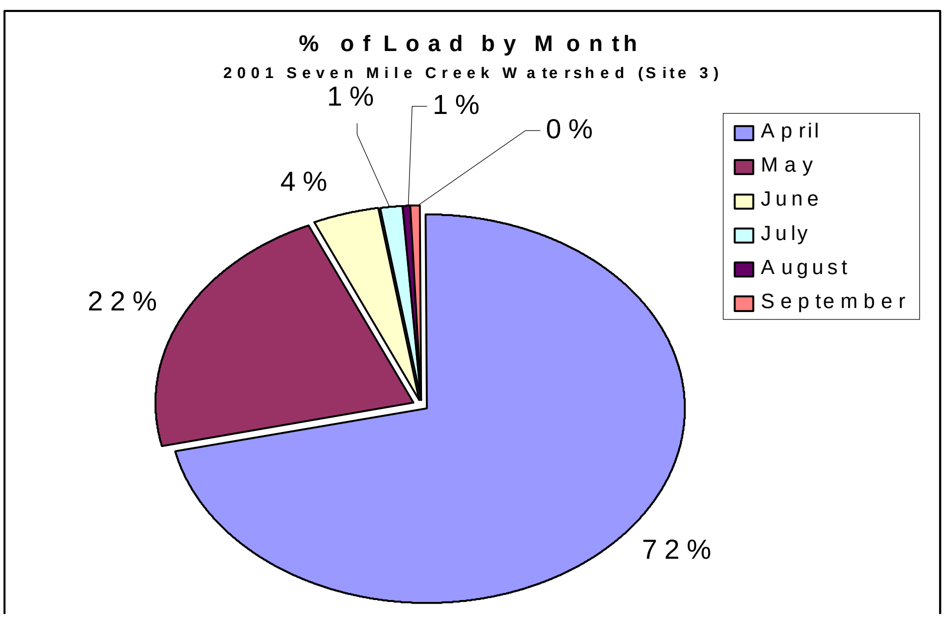


Figure 20. Percent of pollutant load by month for the 2000 and 2001 growing seasons.

Appreciable differences in yield exist between monitoring years. Figures 20-22 show the differences in loading rates between various parameters in 2000 and 2001. These figures further demonstrate of many years worth of monitoring over various climatic conditions to get a true representation of the water quality at a watershed scale. Overall during the monitoring period of Seven Mile Creek, an average to below average runoff year was monitored in 2000, and an above average runoff year was monitored in 2001 due to heavy snowmelt conditions. The combination of both monitoring years is a better representative of the water quality within the watershed. In general, yield is directly correlated with concentration for all parameters except nitrogen. In 2001, No_3 has an inverse relation. This can be explained by dilutional processes. Higher flows in 2001 are in effect diluting the No_3.

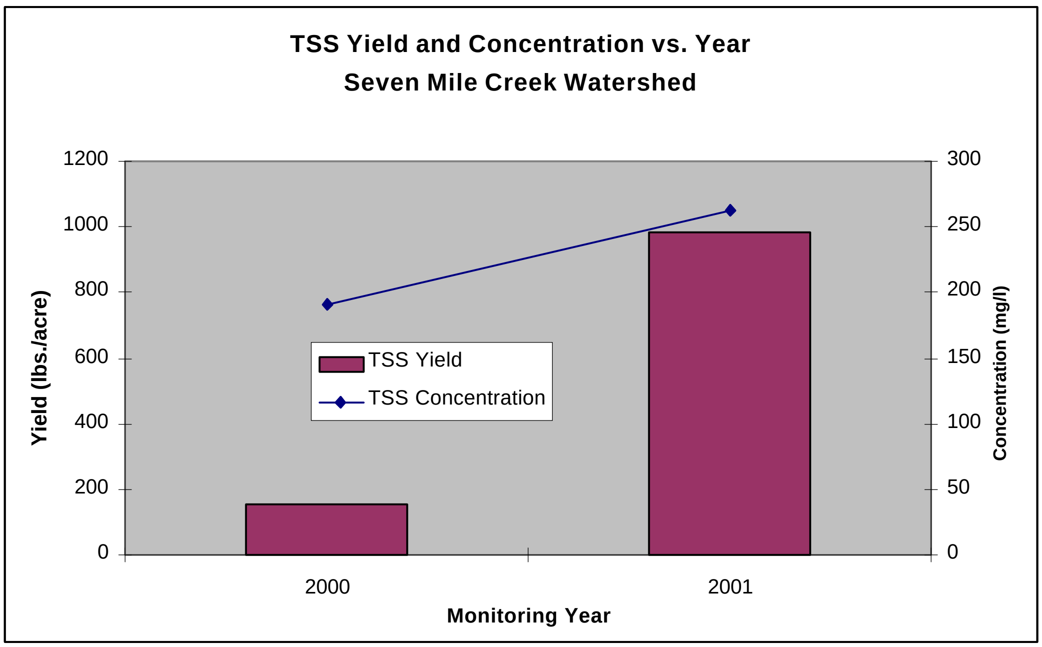


Figure 21. TSS vs. monitoring year.

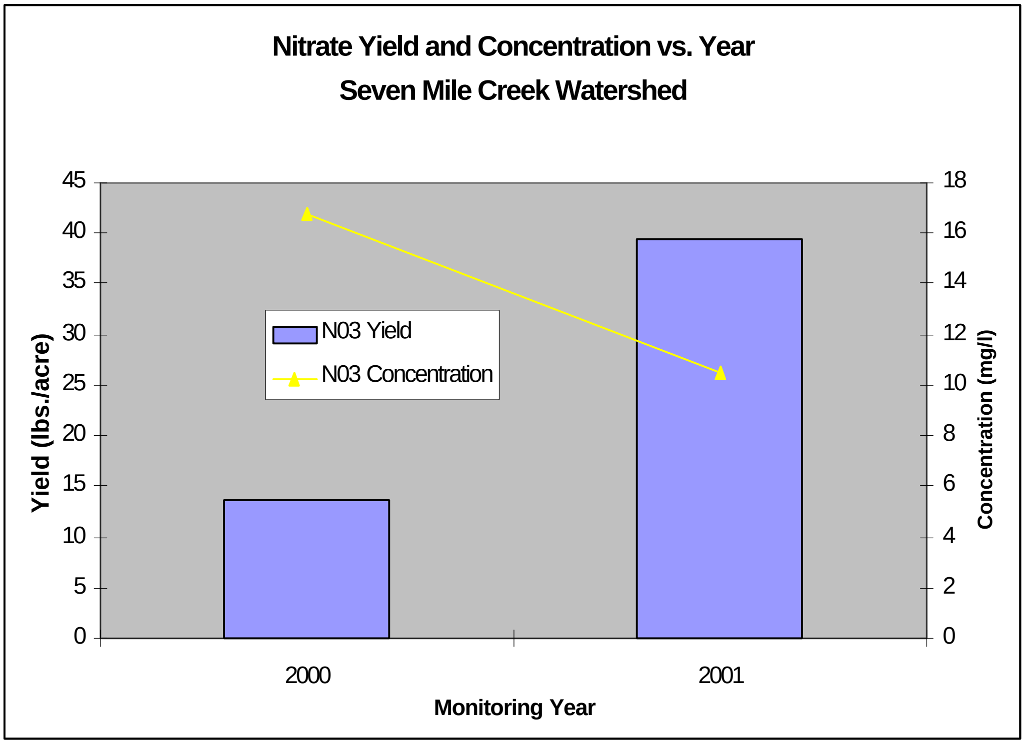


Figure 22. Nitrate vs. monitoring year.

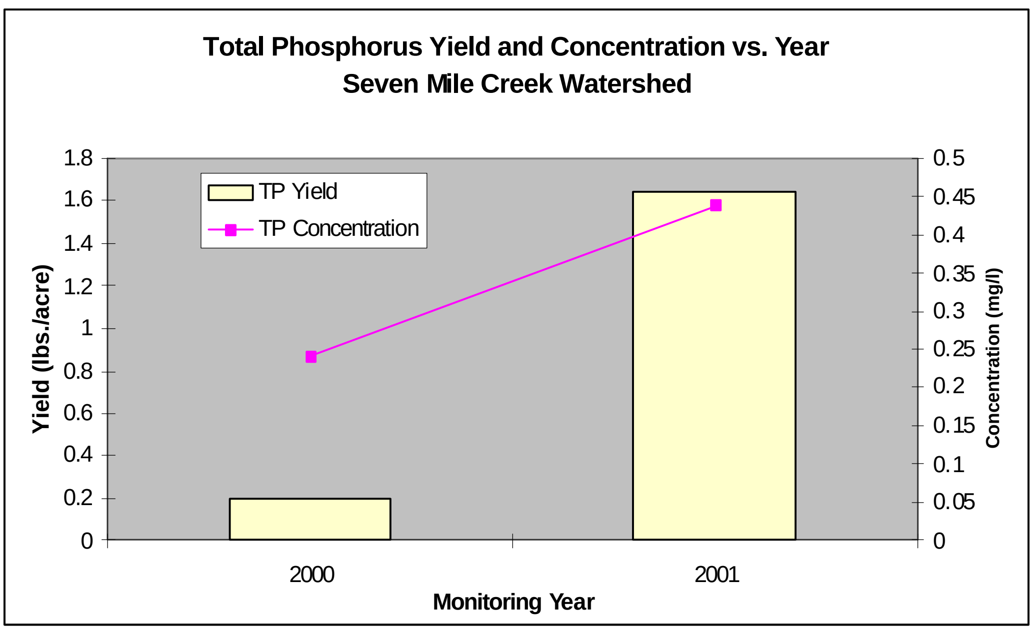


Figure 23. Total phosphorus vs. monitoring year.

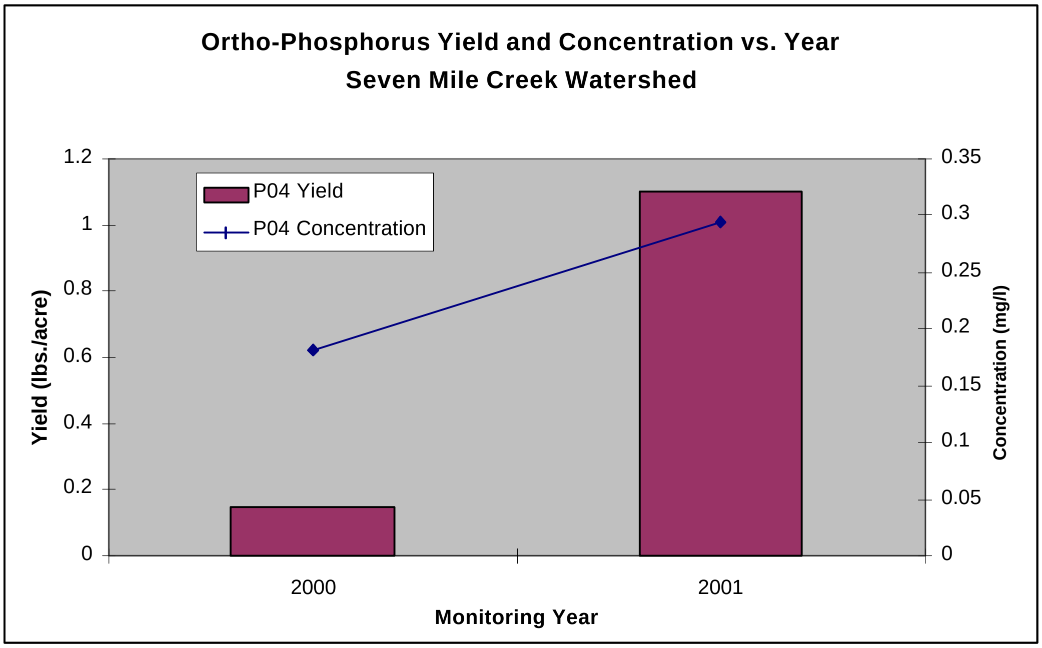


Figure 24. Ortho-phosphorus vs. monitoring year.

2000 Watershed Comparisons

This section of the report presents results from many of the current monitoring projects in the Basin. Graphics are set up to allow comparative review of the data and are organized from upstream to downstream locations along the Minnesota River. Data were collected and compiled by the respective monitoring organizations. Data were organized by Department of Agriculture and Met Council Field office staff.

Like SMC, several other watersheds have performed water quality studies either through Clean Water Partnerships or other similar programs. To understand how the SMC ranks with other watersheds, data from those projects were included in this report for comparative purposes. Watershed technicians, engineers and CWP staff affiliated with the projects, submitted the yield data in 2000. Methods, monitoring season, and approaches for calculating yields are assumed to be similar and/or identical to the SMC. Values shown (figures 25-27) below represent the normalized yield and Flow Weighted Mean Concentrations at the mouth of the watershed for 2000 during April- Sept.

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, giving a “normalized yield”. As such, when yields are normalized one must keep in mind the geographic differences in precipitation and runoff.

As can be seen from the following graphs, Seven Mile is a “heavy loader” of nitrates for its size. When compared with other watersheds nitrate yields and concentrations really stand out. Figure 29 presents results for NO3-N yield for the reporting tributaries and main stem sites. Figure 30 also reports the growing season runoff value in inches for the year 2000. The Le Sueur River had the highest yield at 16.99 lbs./acre. Seven Mile Creek had the next highest estimated yield at 13.03 lbs./acre. Inspection of the runoff data presented in figure 30 indicates that Seven Mile Creek had approximately the same amount of runoff as did the Blue Earth River, but over twice the yield.

Normalized yields for nitrates are shown in figure 29. Seven Mile Creek results clearly standout with respect to normalized yield at 3.84 lbs./acre/inch of runoff. Watershed size and subsurface drainage pathway are suspected to be the main reason for high levels of nitrates. In Seven Mile, nitrogen applied from fields has a much more direct pathway from the soil profile –to the sub-surface drainage—to the ditches and eventually the creek. In other watersheds, dilution and natural de-nitrification processes during transport through the watersheds take effect, thereby reducing nitrogen overall effect on the MN River.

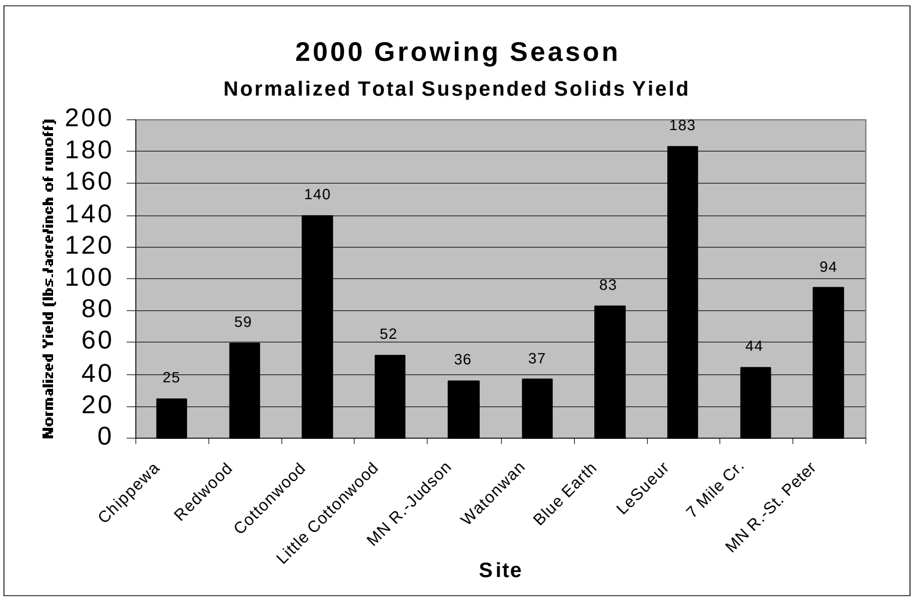


Figure 25. TSS yield comparison.

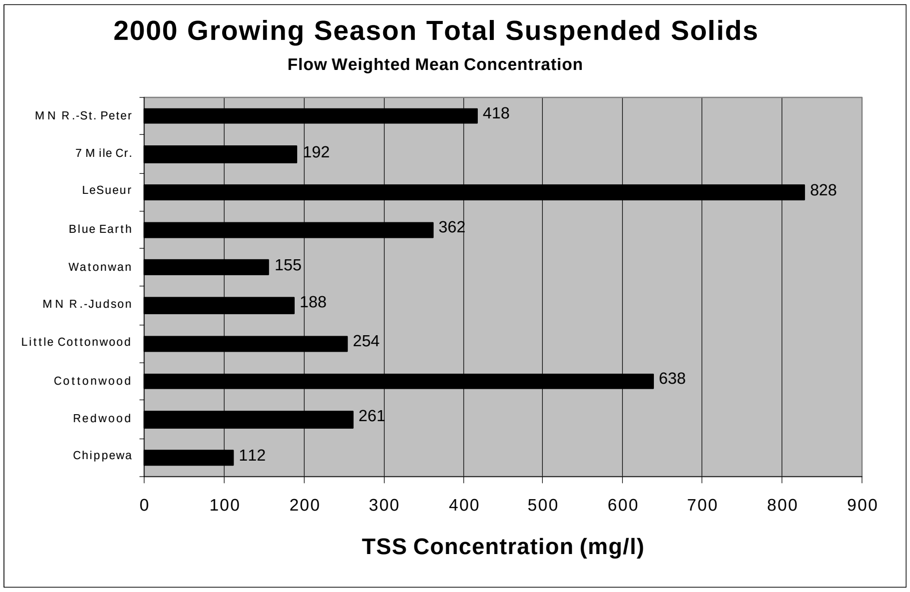


Figure 26. TSS concentration comparison.

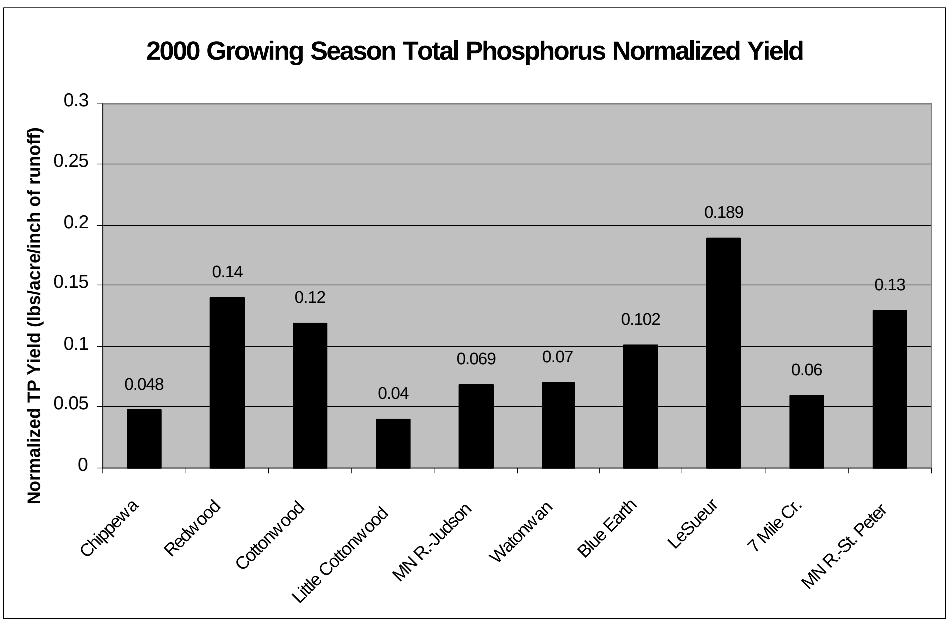


Figure 27. Total phosphorus normalized yield for 2000.

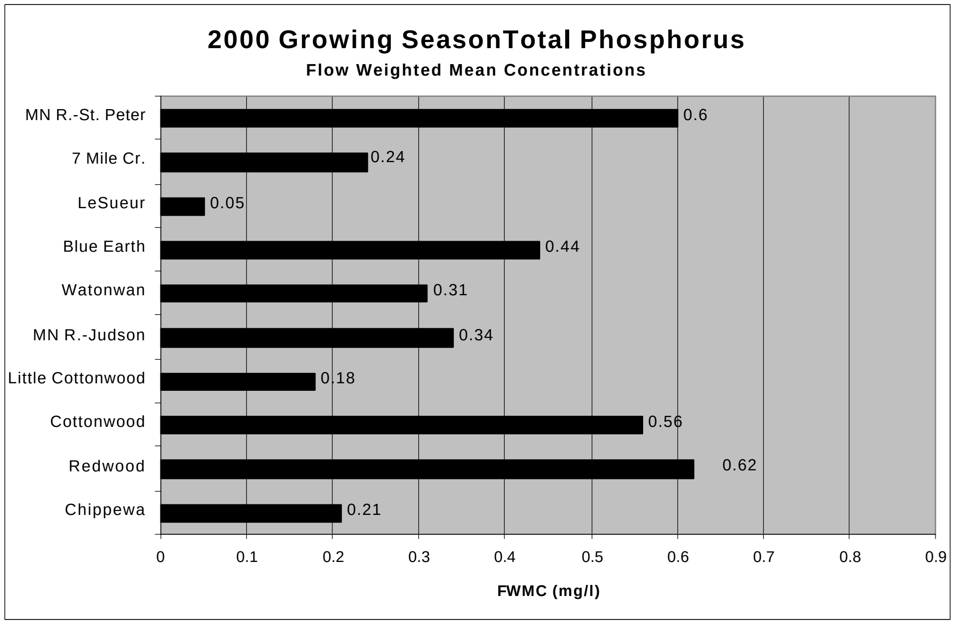


Figure 28. Total Phosphorus for 2000.

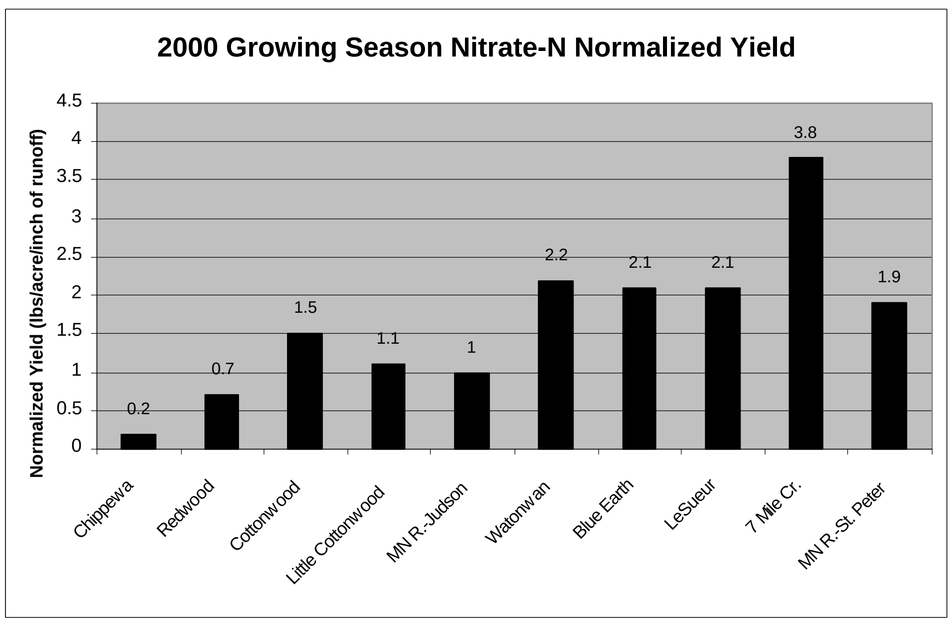


Figure 29. Normalized yield for nitrate nitrogen for 2000.

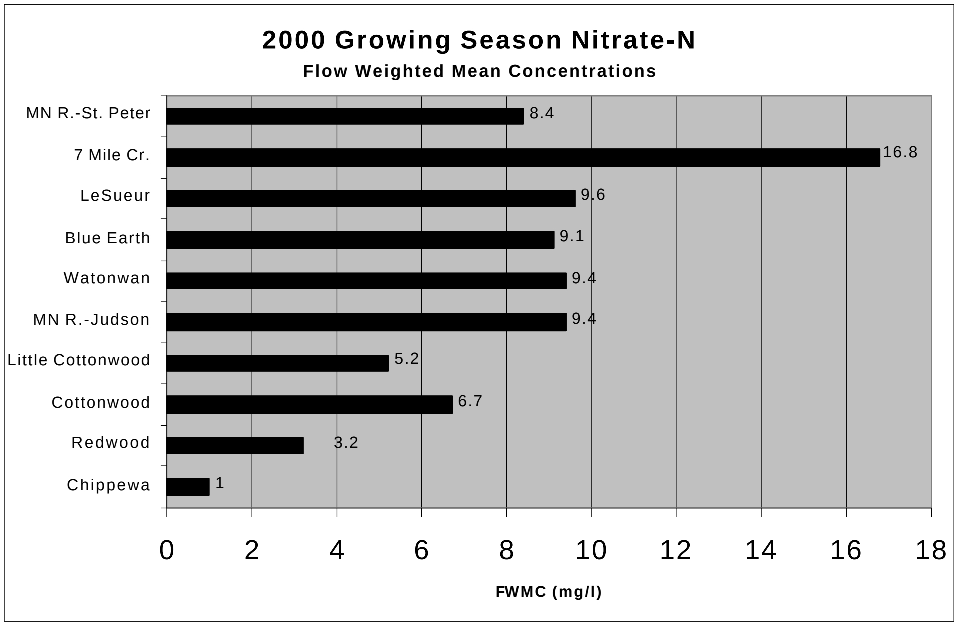


Figure 30. NO3-N comparison.

TSS vs. Transparency Tube Readings

Information adopted from MPCA 1998 report on water quality of MN streams[4]

The transparency tube was developed in Australia as a tool for measuring stream water clarity, which serves as a basic indicator of water quality. The tube is 2 feet long X 1.5 inch diameter, made of clear plastic, and has a release valve at the bottom. A stopper inserted at one end of the tube is painted black and white so that when you look down into the tube a distinct symbol is visible at the bottom. To measure water clarity, the tube is filled with water collected from a stream or river. Looking down into the tube, water is released through the valve until the black and white symbol is visible. The depth of the water when the symbol becomes visible is recorded in centimeters, which are marked on the side of the tube. If the symbol is visible when the tube is full, the transparency is "> than 60" cm. A greater transparency reading in centimeters reflects higher water quality.

In various studies conducted by the MPCA on Minnesota streams it was found that transparency and total suspended solids were interrelated. Based on preliminary work conducted during 1997, MPCA staff identified significant relationships between transparency tube measurements, TSS, and turbidity. These relationships are reflected by the high correlation coefficients (R^2) between transparency tube readings and TSS (r^2=0.75) and turbidity (r^2=0.86). Correlation coefficients provide a numerical measure of the strength of relationship between two factors. The significant relationships described above suggest the potential to predict stream TSS or turbidity based on transparency tube measurements. Understanding the interaction among transparency, TSS, and turbidity could provide a

[4] 1998 Report on the Water Quality of Minnesota Streams, MPCA, Environmental Outcomes Division December 1999.

basis for characterizing the health of a stream relative to existing water quality standards, such as the 25 NTU turbidity standard; or by comparisons to ecoregion “yardsticks” as compiled from reference streams (table 15, chapter 3). For example, TSS in the 10-60 mg/l is typical for streams in the WCBP eco-region. In terms of transparency, this corresponds to measurements in the 45 to 15 cm range for the WCBP.

TSS vs. Transparency Specific to SMC

Similar to MCPA methods of correlating TSS with T-tube readings, a correlation was conducted using data specific to the SMC. The T-tube readings were correlated with TSS lab results. Figure 31 represents the results of the correlation. 67 T-tube readings were utilized in the correlation. The r^2 value or tightness of fit, of 0.81 shows a very good correlation between TSS lab readings and in field transparency readings. The average t-tube reading of 36 cm was found during the two year study. A river specific relationship between TSS and transparency is of great value to the project since the simple and quick T-tube test could be substituted for more expensive TSS laboratory procedures in the future. It also increases the value of watershed volunteers using T-tubes, water quality awareness, and refinements to BMP implementation.

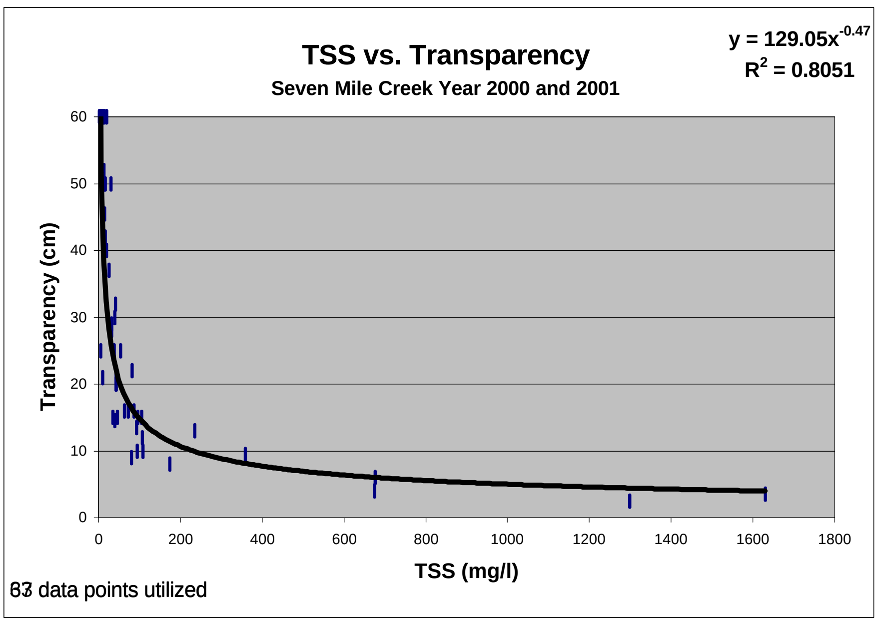


Figure 31. TSS and transparency relationship for Seven Mile.

2001 Conservation Tillage Survey Results

Every spring since 1995, local government staff in Minnesota’s agricultural counties have driven along a designated route to build an annual record of crops grown, tillage type, and surface residue remaining after planting. In the spring of 2001 Kevin Ostermann of the Nicollet county Soil and Water Conservation District and Kevin Kuehner of BNC Water Board conducted a similar survey in the Seven Mile Creek Watershed. Results of the data have numerous uses. Some of the uses include: help in the targeting, prioritizing, and promotion of conservation tillage, general agricultural practices and helps managers refine

“C” factors for use in the Revised Universal Soil Loss Equation. The data also enables conservation staff to monitor outcomes from tillage programs, and recognize the success or failure of agricultural producers meeting crop residue targets.

What was surveyed

• Present Crop/T Level	• Percent slope/Slope Length
• Previous Crop/K factor	• P-Factor/Drainage Outlet
• Tillage System/Residue Cover	• Ephemeral Erosion

How the watershed was surveyed

The route in Seven Mile Creek watershed was designed as grid that equally represents all cultivated areas. Conservation tillage survey staff stopped every half mile to record field conditions to the left and right of the road. The transect survey route covered over 60 miles and surveyed approximately 60% of the cultivated land within the watershed utilizing 311 survey points. Some data points were not utilized in the analysis since some fields were not planted. With over 300 field observations in the watershed, the data represents a statistical average of the entire cropland area. This tillage transect survey procedure was developed by the Department of Agronomy at Purdue University and transferred to staff in MN by the Board of Water and Soil Resources.

The results are entered on forms that are scanned into a computer program that aids in summarizing the data. The data point locations and attributes were then transferred into GIS database which can be seen below. Each data point is associated with its field, slope length, and steepness and other USLE based erosion information. Since field information is not available from the Farm Services Agency in digital format, parcel information was used as a field boundaries.

Trends in crop residue management are summarized using a method that calculates the percent of fields in the corn-soybean rotation that meet crop residue targets. It is computed as the average of the percent of corn acres planted into >15% residue, and the percent of soybean acres planted into >30% residue. The amount of residue left on the surface depends on many factors, most importantly opportunity to till (based on weather conditions) and intent to maintain residue.

Map 30 shows the survey route with survey points and the results of the survey can be found in table 31.

Results

It was estimated that approximately 65% of the fields surveyed in the spring of 2001 were meeting residue targets, while 35% of the fields were below residue targets. A majority of the fields that were not meeting conservation tillage targets were fields that were planted with soybeans the previous year. Of the 20,000 cultivated acres, corn and soybeans accounted for 99% of the crops planted and about 96% of the fields were in a corn and soybean rotation within the watershed. Around 53% of the fields were planted with beans, 46% corn and the remainder in peas or hay.

The conservation tillage survey of 2001 showed a majority of the producers are utilizing conservation tillage. However the results need to be checked every year to verify residue levels. It is hoped that new technologies such as satellite imagery can be used to further the knowledge and accuracy of tillage levels on a minor watershed scale. This could save large amounts of time and money. Currently, the use of satellite imagery is being looked at as a possible tool by the BNC Water Board, BWSR, NASA and other conservation agencies within Minnesota.

A possible best management practice that can still be promoted is "no-fall tillage of soybean ground" or "one pass cultivation." Another potential BMP is strip tillage. Since no till is not feasible for this area (soil temperature concerns and wet soil conditions limit its use) however strip tillage is thought to be a viable alternative. It was found that those fields where the previous crop were soybeans, conservation tillage levels dropped to <10% residue. Soybean ground is typically more conducive to water and wind erosion anyway so this potential BMP could prevent accelerated soil erosion due to agricultural practices.

Conservation Tillage: Leaving last year's crop residue before and during planting operations provides cover for the soil at a critical time of the year. The residue is left on the surface by reducing tillage operations and turning the soil less. Pieces of crop residue shield soil particles from rain and wind until plants can produce a protective canopy. Crop residue management includes no-till, muclh till, ridge till and strip till.

Conservation Tillage Defined: Any tillage and planting system that covers 30 percent or more of the soil surface with crop residue, after planting, to reduce soil erosion by water.

In the Seven Mile watershed conservation tillage analysis, where previous crop was soybeans at least 15% residue must be maintained and when previous crop is corn at least 30% must be maintained.

Seven Mile Creek Watershed, Nicollet County, Tillage Transect Survey Results
Completed by: Kevin Kuehner and Kevin Osterman, May 30, 2001

Number of Sample Points	168
Number of Sample Points Utilized	156

Estimated cultivated acres surveyed in watershed(based on parcels)	11974
Estimated acres of cultivated land in watershed	20181

% of area surveyed	59

Residue	Fields	%
0-15%	37	23.72
16-30%	64	41.03
31-50%	44	28.21
51-75%	11	7.05

	%
% of fields surveyed **out** of conservation tillage*	35
% of fields surveyed **in** conservation tillage*	65

2001 Crop	Fields	%
Beans	85	52.80
Corn	74	45.96
Hay	2	1.24

2000 Crop	Fields	%
Beans	76	48.72
Corn	82	52.56
Other	3	1.92

Number of fields following corn soybean rotation	149
% of fields following corn/soybean rotation	95.51

Tillage	Acres
High	4535
Moderate	5380
Low	3253

C Factor

Corn Year (Previous Crop=Soybeans)

% of fields in conservation tillage	71.23

	Residue	*Fields*	*% Area*	*Area*	*C Factor*	*Area Weighted*
	0-15%	21	29	0.29	0.21	0.060410959
	16-30%	46	63	0.63	0.14	0.088219178
	>30%	6	8	0.08	0.13	0.010684932
Total		73	100			0.159315068

C Factor	0.16

Bean Year (Previous Crop=Corn)

% of fields in conservation tillage	59.04

	Residue	*Fields*	*% Area*	*Area*	*C Factor*	*Area Weighted*
	0-15%	16	19	0.19	0.15	0.028915663
	16-30%	18	22	0.22	0.11	0.023855422
	>30%	49	59	0.59	0.07	0.041325301
Total		83	100			0.094096386

C Factor	0.09

**Average C factor for cultivated land in Seven Mile Watershed (.09+.16/2)	0.13

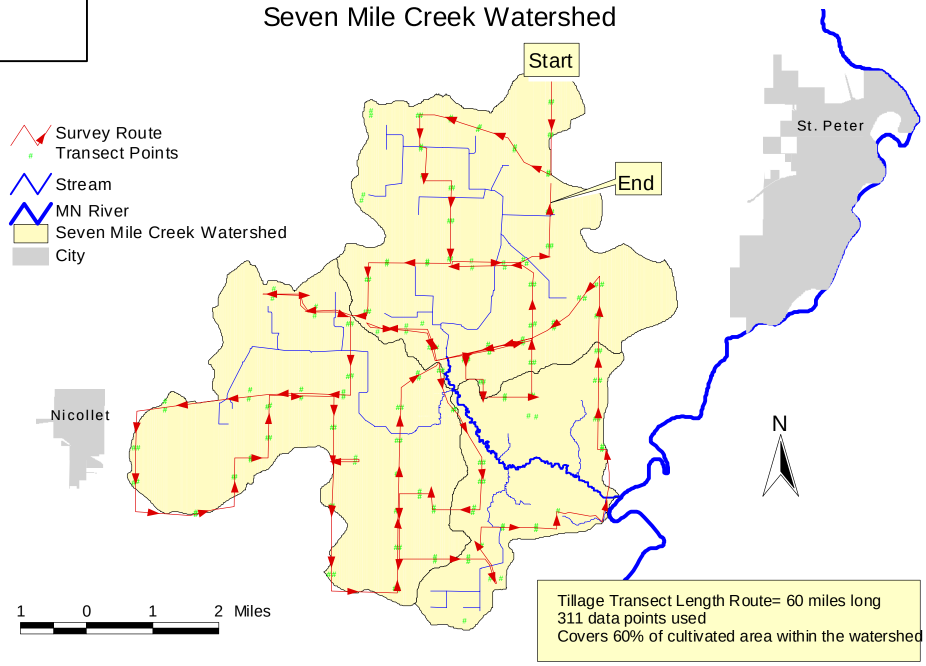
*"in conservation tillage"=computed as the average of the percent of corn acres planted into >15% residue,
and the percent of soybean acres planted into >30% residue.
**C factor values taken from RUSLE 1.5 and 1997 USDA-NRCS-MN Technical Guide, Sec. I-C
Assumed yield level High, corn/soybean rotation, fall and spring mulch till, Table 4H

Table 31. Tillage transect survey results.

Map 30

Tillage Transect Survey Points and Route

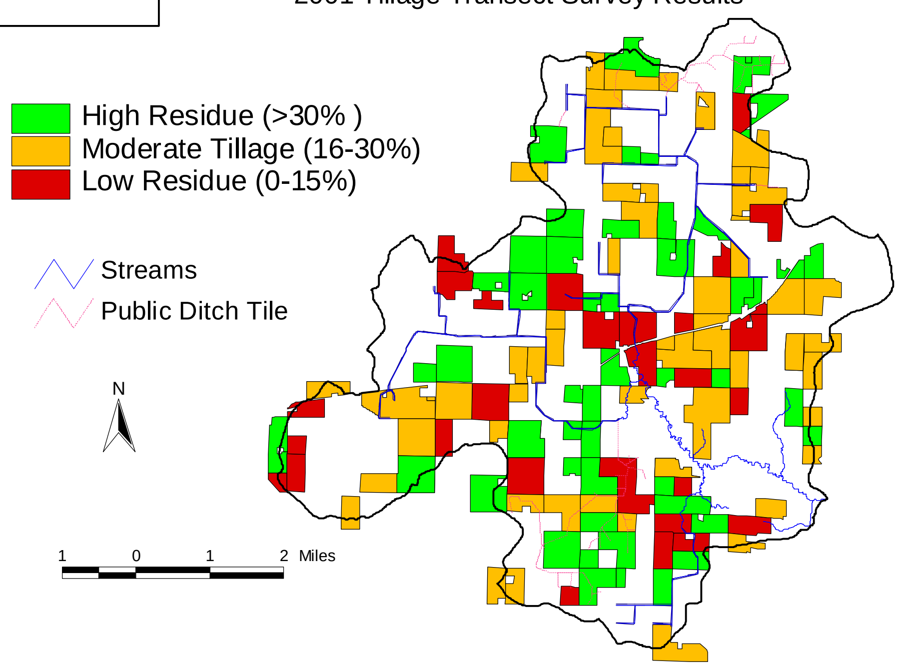
Seven Mile Creek Watershed



Map 31

Seven Mile Creek Watershed

2001 Tillage Transect Survey Results



2001 Watershed Inventories and Open Tile Intake Survey Results

Adequate soil drainage is an important consideration for profitable corn and soybean production on many Minnesota landscapes and soils. Internal soil drainage can be enhanced by using subsurface pattern tiling. In depressional areas with no surface drainage pathway, inlets to underground tile are often used to conduct water off the field. There has been some concern that this provides a direct pathway for pollutants associated with surface runoff to enter Seven Mile Creek. Research by University of Minnesota Scientists have found that on average about 20% of the sediment and particulate phosphorus is delivered to open surface inlets within the depressional areas of fields during rain storms[5]. Realizing the potential impact of open tile intakes on water quality within the watershed a road survey was conducted to survey the number of open tile intakes per square mile and the average open intake watershed acreage. Jim Klang of the MPCA and Kevin Kuehner of BNC Water Board conducted the survey in each of the three minor watersheds in late May of 2001. Results of the survey were used as an input value for the sediment and Phosphorus delivery modeling using RUSLE and CREAMs. In addition, replacement costs were also estimated.

Results of the survey indicated that there are about 9 intakes per square mile on cultivated acres within the watershed with an average drainage area of 10 acres in size. It is estimated that approximately 300 open intakes exist within the watershed. Research is showing from Carver County that replacing open intakes with gravel inlets will reduce sediment that is delivered to the inlets by about 50% and particulate phosphorus by about 60%. The average cost of replacement is around $200/inlet. If all open inlets were replaced it would cost around $60,000. Normally 75% would be cost-shared under watershed projects so this would result in a total cost to the watershed of $45,000.

While conducting the open intake survey other inventories were taken at the same time.

- Stream Bank Erosion Survey. Length, width, height and recession were measured at various locations within the lower reaches of minorshed 2 and upper reaches of minorshed 3. Recession was estimated by looking at the exposed root structure of trees. Diameter and tree species was noted. Based on the tree size diameter age was determined (Mankato DNR Forestry Tables), and therefore bank erosion recession was estimated. Total volume was computed from stream bank erosion site measurements. An average of 75 lbs/cubic feet of soil was used for mass calculations of bank erosion volumes. Stream bank erosion values were used for sediment delivery modeling.
    - Lower reach of CD 46a
- Stream Bank Erosion and County Ditch Total Phosphorus Soil Tests. Various stream bank erosion sites were sampled within the watersheds. Topsoil samples were composited for each of the three minors and sub-soil samples were composited for each of the minors. MVTL labs in Mankato tested the soil samples. Results were integrated into phosphorus delivery modeling.
- Wet cultivated areas-potential wetland restoration/construction sites

---

[5] 2000. Evaluation of the Impact on Runoff Losses and Profitability by replacing Open Surface Tile Inlets with Gravel Inlets. John Moncrief, Andry Ranaivoson.

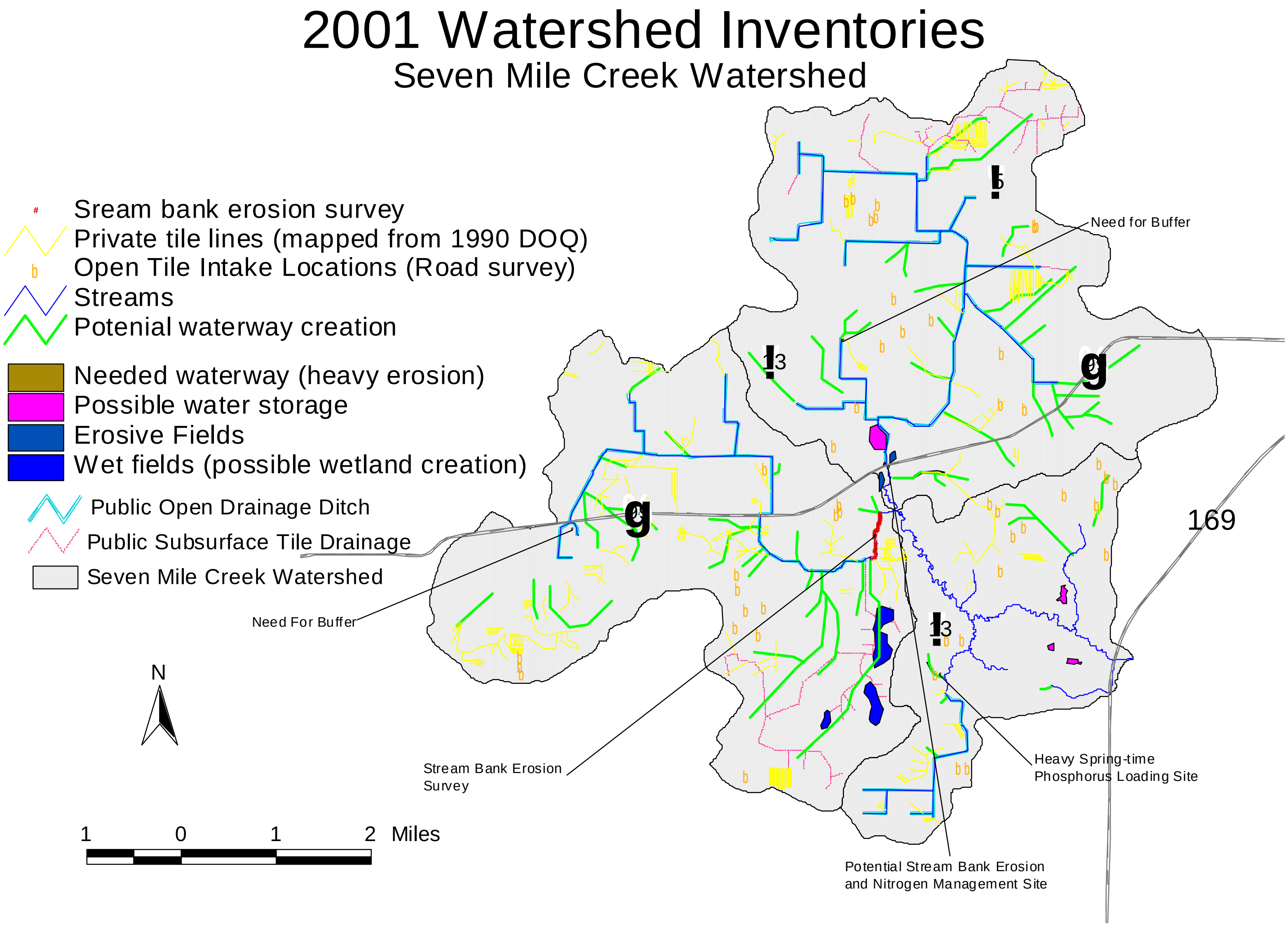
- Private Tile Lines (assessed from 1990 DOQ air photos)
- Potential Waterway Locations (1990 DOQ and 30 Meter USGS DEMs)

Results of the survey can be seen on map 32.

Open Intakes	9 open intakes/per square mile
Stream Bank Erosion Site (county road 13, lower reach of County Ditch 46a	Estimated at 256 tons/year/10year recession period (high end)
Stream Bank Erosion Soil Tests	Average of 1.0 lbs./ton of soil for stream bank erosion sites, 1.25 lbs./ton of soil for upland areas near stream bank erosion site

Photo11. Stream bank erosion soil samples.

Photo12. Stream bank erosion site.



2001 Watershed Inventories
Seven Mile Creek Watershed
Sream bank erosion survey
Private tile lines (mapped from 1990 DOQ)
Open Tile Intake Locations (Road survey)
Streams
Potenial waterway creation
Needed waterway (heavy erosion)
Possible water storage
Erosive Fields
Wet fields (possible wetland creation)
Public Open Drainage Ditch
Public Subsurface Tile Drainage
Seven Mile Creek Watershed
Need for Buffer
Need For Buffer
169
N
Stream Bank Erosion Survey
Heavy Spring-time Phosphorus Loading Site
Potential Stream Bank Erosion and Nitrogen Management Site
1 0 1 2 Miles