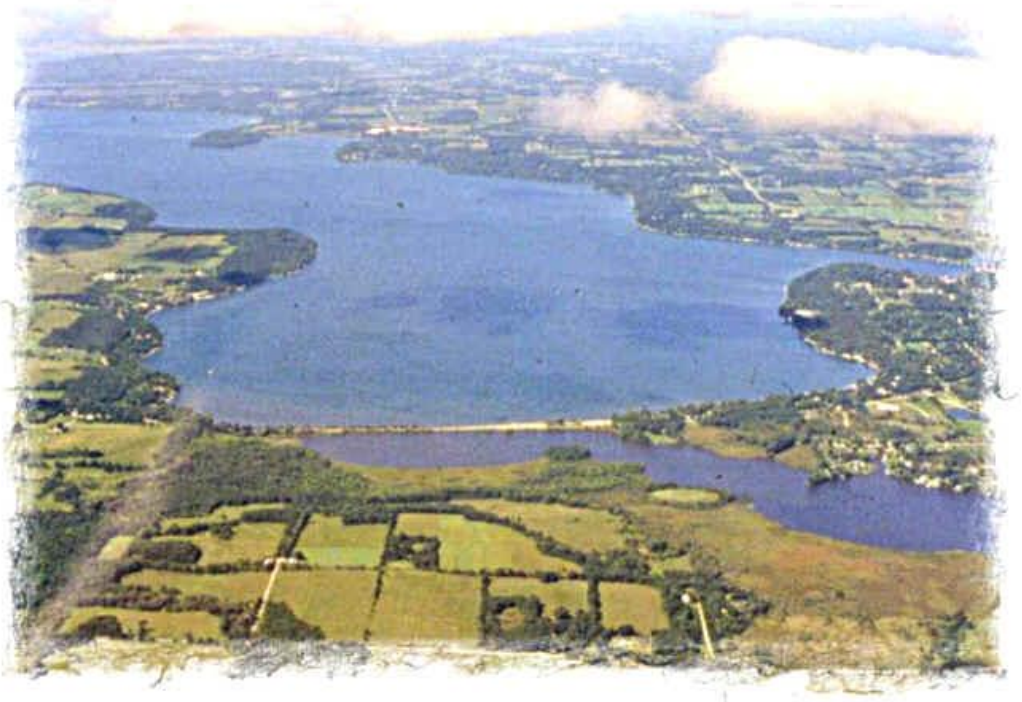
An Assessment of Hill, Roy, Silver, and Wuerches Creeks (303d Impaired Waters)



Wisconsin Department of Natural Resources

Ted Johnson – Water Resources Biologist
Adam Nickel – Water Resources Specialist
Eric Evensen – Water Resources Specialist

Background

The 2008 draft submittal of 303d impaired waters identifies eight waters bodies as being impaired in Green Lake County. Of these eight water bodies four of them including Hill, Roy, Silver, and Wuerches Creeks empty into Big Green Lake. Big Green Lake is also listed as impaired water for PCB pollutant and contaminated fish tissue impairment. Hill and Roy Creek are listed for sediment pollutant and degraded habitat impairment. Silver Creek is listed for sediment pollutant and degraded habitat along with elevated water temperature impairment. Wuerches Creek is listed for sediment and total phosphorus pollutant, degraded habitat, elevated water temperature, and low dissolved oxygen impairment. Implementing plans to improve these water bodies so they meet water quality standards is a priority. Through improving the water quality of these creeks the condition of Big Green Lake will also benefit.

In 1980 Big Green Lake was selected as a priority watershed under the Wisconsin Nonpoint Source Water Pollution Abatement Program. The primary objective of this program is to provide cost-sharing and technical assistance to local agencies for the control of nonpoint source pollution. Following the designation as a priority watershed, a priority watershed plan was written. There were four main goals outlined in the Big Green Lake Priority Watershed Project:

1. Reduce the concentrations of bacteria to "acceptable" levels.
2. Reduce the nutrient loading levels to streams from nonpoint sources by 40% on a yearly basis.
3. Increase the average transparency (secchi disk) readings within Big Green Lake during the open water times.
4. Halt the trend of increasing littoral zone establishment as a result of sediment loading to the lake.

The goal most associated with this report is reducing nutrient input into the lake from nonpoint sources by 40%. To reach this goal the installation of best management practices began on agricultural land within the watershed. While many of the projects were successful in limiting the nutrient levels entering Green Lake, much more needs to be done to prevent further runoff and erosion from taking place because these water bodies are still not meeting water quality standards.

.

To evaluate these 303d water bodies the following sampling protocol was carried out for each of the creeks:

1. Fish surveys for community assessment (IBI)
2. Macroinvertebrate collection
3. Qualitative habitat assessment
4. Continuous temperature monitoring
5. Phosphorus levels

All sampling was carried out according to Wisconsin DNR protocols.

Results
Hill Creek

Hill Creek measures 2 miles in length. It is an outlet of Little Twin Lake that flows in a northeasterly direction into Green Lake. The stream contains clear, hard water often polluted with agricultural runoff.

Fish Survey

Three fish assessments were conducted on Hill Creek during the summer months of 2011. Between the assessments largemouth bass, white sucker, yellow perch, black bullhead and bluegill were found most often. The Coldwater Index of Biotic Integrity (IBI) was calculated for all fish assessments. The assessment conducted on July 20, 2011 generated an IBI of 0 (very poor) while the assessment conducted on July 26, 2011 generated an IBI of 20 (poor). The assessment conducted on August 30, 2011 had an IBI of 10 (poor). These values would indicate that the stream section sampled has likely experienced high levels of environmental degradation.

Macroinvertebrate Sampling

Macroinvertebrate sampling from 2008 indicate Hill Creek has a Hilsenhoff Biotic Index (HBI) of 7.7 and a Shannon Diversity Index of 1.18. A HBI of 7.7 indicates poor water quality with very significant organic pollution. The Shannon Diversity Index indicates low diversity of macroinvertebrates. Both indices suggest that the sampled reach has poor water quality most likely due to agricultural practices.

Qualitative Habitat

The qualitative habitat rating total score was 58 (Fair-Good). In the sampling reach riparian buffer zones and bank erosion were rated as excellent while the width to depth ratio and habitat diversity had a rating of fair.

Temperature Monitoring

Water temperature was monitored during 2011 on Hill Creek. Results show that the water temperature rarely got above 70°F with a peak of around 70.5ºF on July 20th. The average water temperature from June through August is 57.1°F. Water temps in Hill Creek are low enough year round to support a trout population.

Water Quality

Total phosphorus levels were measured during the summer of 2011. Levels ranged from .06 - .18 mg/L of phosphorus in Hill Creek. Over nine different sampling events Hill Creek had an average phosphorus level of 0.104 mg/L. Wisconsin's water quality standard for small streams is 0.075 mg/L.

Flow rates can be used in conjunction with phosphorus levels to calculate the amount of phosphorus entering a water body over a given time frame. During a non rain event it has been calculated that approximately .8 lbs of phosphorus enter Green Lake every day from Hill Creek. After a rain event that number jumps up to approximately 2.4 lbs of phosphorus entering Green Lake every day. When 2.4 lbs of phosphorus enter Green Lake it has the potential of producing 730 – 1200 lbs of algae.

Total suspended solid (TSS) levels were also measured during this study. TSS levels ranged from 352 – 476 mg/L.

Roy Creek

Roy Creek is a tributary to Green Lake containing clear, hard water. The creek measures 8 miles in length from its headwaters till it flows into Green Lake. The stream bank consists mostly of upland hardwoods, farm pasture, and cultivated crops.

Fish Survey

A fish assessment was conducted in the summer of 2011 on Roy Creek. Four species were collected which included white sucker, central mudminnow, mottled sculpin and fathead minnow. The coldwater IBI for the creek section was 10, which is categorized as poor. A coldwater IBI rating of poor is usually indicative of major environmental degradation and is a sign that the biotic integrity has been severely reduced.

Macroinvertebrate Sampling

Macroinvertebrate sampling from 2009 indicate Roy Creek has a HBI of 4.80 and a Shannon Diversity Index of 1.63. A HBI of 4.8 indicates good water quality while still displaying some organic pollution. The Shannon Diversity Index indicates low diversity of macroinvertebrates.

Qualitative Habitat

Roy Creek received a total qualitative fish habitat score of 52. Bank erosion is extensive along the sampled reach and was rated poor. Roy Creek also rated as fair for fine sediments and available cover for fish. The only category where it was rated as excellent was riffle:riffle or bend:bend ratio.

Temperature Monitoring

Water temperature was monitored on Roy Creek during the summer of 2011. Due to technical difficulties with the temperature probe measurements were only gathered for the months of May and June. The average water temp for this time period was approximately 57.5°F with a peak temp of 69.82 on June 8th.

Water Quality

Total phosphorus levels were measured during the summer of 2011. Levels ranged from .13 - .44 mg/L of phosphorus in Roy Creek. Over eight different sampling events Hill Creek had an average phosphorus level of 0.200 mg/L. Wisconsin's water quality standard for small streams is 0.075 mg/L.

During a non rain event it was calculated that approximately 1.5 – 2.5 lbs of phosphorus enter Green Lake every day from Roy Creek. Since Roy Creek is a high gradient stream water can be carried to the lake much faster than other streams in the watershed. We were unable to get accurate measurements for how much phosphorus enters Green Lake after a rain event because of how fast the rain water can pass through the system. One can safely assume that the amount of phosphorus entering Green Lake would be 2-5 times greater during a rain event producing large amounts of algae.

Total suspended solid levels were also measured on Roy Creek. TSS levels in the creek ranged from 456 – 752 mg/L.

Silver Creek

Silver Creek begins in northwestern Fond du Lac County where it flows west to Green Lake. Silver Creek drains the largest of Green Lake's sub-watersheds. Much of the watershed is agriculture which is the main reason Silver Creek carries a significant phosphorus load to Green Lake. The watershed also includes the city of Ripon.

Fish Survey
A fish assessment was conducted in the summer of 2011 on Silver Creek. White sucker, central mudminnow and largemouth bass were the most common species found. The coldwater IBI was calculated to be 30 (fair). Silver creek received the highest IBI rating of the water bodies sampled. Intolerant and native stenothermal coldwater species were uncommon while tolerant eurythermal species or warmwater species were more abundant.

Macroinvertebrate Sampling
Macroinvertebrate sampling conducted in 2007 discovered HBI of 5.5 and a Shannon Diversity Index of 3.00. A HBI of 5.5 indicates good water quality while still displaying some organic pollution. The Shannon Diversity Index indicates relatively high diversity in the macroinvertebrate community.

Qualitative Habitat
The total qualitative habitat rating was 62 (Fair-Good) on Silver Creek. Riparian buffers were the only category rated as excellent, while habitat diversity was low and fine sediments were extensive. Gravel substrate was very sparse at this station limiting the chances of trout spawning success.

Temperature Monitoring
Temperature monitoring was conducted on Silver Creek. The highest temperatures were recorded during the summer months of July and August with a peaking temperature of 86°F. The average temperature from June through August was 71.3°F. Temperature sensors were located in the lower reaches of the creek; cooler temperatures can be expected in the higher reaches of the creek. Silver Creek is still listed as a trout stream in the Wisconsin trout regulations.

Water Quality
Total phosphorus was measured during the summer of 2011 on Silver Creek. Levels ranged from .099 - .56 mg/L of phosphorus. Over nine sampling events Silver Creek had the highest phosphorus levels of any of the creeks sampled. The average was 0.224 mg/L. Wisconsin's water quality standard for small streams is 0.075 mg/L.
When using flow measurements and phosphorus levels it was calculated that during a non rain event approximately 13 lbs of phosphorus enter Green Lake every day from Silver Creek. After a rain event that number jumps up to 72 lbs of phosphorus entering Green

Lake every day. 72 lbs of phosphorus has the ability to produce 21,000 – 37,000 lbs of algae.
Total suspended solids were also measured in Silver Creek. TSS levels in the creek ranged from 466 – 700 mg/L.

Wuerches Creek

Wuerches creek is an 8 mile continually flowing stream that enters the Green Lake County Park marsh area. A small number of cattle are pastured in the immediate stream area and row cropping occurs near the stream course in some areas.

Fish Survey
A fish assessment was conducted on Wuerches Creek during the summer of 2011. Only two species of fish were found, mottled sculpin and central mudminnow. The coldwater IBI for the Wuerches Creek reach was calculated to be 20 (poor), indicating major environmental degradation.

Macroinvertebrate Sampling
Macroinvertebrate sampling from 2007 provided an HBI of 5.79 and a Shannon Diversity Index of 3.45. The HBI indicates fair water quality and fairly significant organic pollution. The Shannon Diversity Index indicates relatively high diversity of the macroinvertebrate community.

Qualitative Habitat
Wuerches Creek had a qualitative habitat rating total score of 72. The sampling station had no significant bank erosion and habitat diversity was high. The creek is moderately deep and narrow with a width/depth ratio scoring in the fair category.

Temperature Monitoring
Temperature monitoring was conducted on Wuerches Creek in 2011. The highest temperatures were recorded in June and July with a peaking temperature of 73°F. The average water temperature from June to August was 61.3°F.

Water Quality
Total phosphorus was measured during the summer of 2011 on Wuerches Creek. Levels ranged from .07 - .7 mg/L of phosphorus. Wuerches Creek had an average phosphorus level of 0.168 over eight sampling events. Wisconsin's water quality standard for small streams is 0.075 mg/L.
During a non rain event approximately 1.1 lbs of phosphorus was calculated to enter Green Lake every day from Wuerches Creek. This creek is a higher gradient system. Water from rain events is able to flow through the system and into Green Lake very quickly. After a rain event we calculated the amount of phosphorus entering the lake to be about 1.5 lbs per day. Due to the high gradient of the creek we believe that we missed the majority of the phosphorus entering the lake after the rain event. This is assumed because the flow of the creek was back down to base flow after receiving 2.95 inches of rain in the previous 48 hours.

Total suspended solid levels were measured during the summer of 2011 as well. Levels ranged from 476 – 524 mg/L on Wuerches Creek.

Nitrogen/Phosphorus

When temperature profiles are examined for the streams studied they have the potential to support salmonid populations and some have historic records of supporting trout populations. Our study found no salmonid species in any of the streams. Other factors must be limiting salmonid production. Research done by Garrison et al. 2007 found a link between nutrient levels and fish in wadable streams. Percentages of carnivourous, intolerant, and omnivorous fishes, index of biotic integrity, and salmonid abundance were fish measures correlated with the most nutrient measures (Garrison et al. 2007). Phosphorous sampling in our study and nitrogen sampling done by Matt Diebel of WDNR and Science Services show elevated levels of both nutrients. Elevated nutrient levels are most likely due to agricultural practices in the watershed and research suggests that these nutrient levels could be causing the lack of salmonid species in these streams.

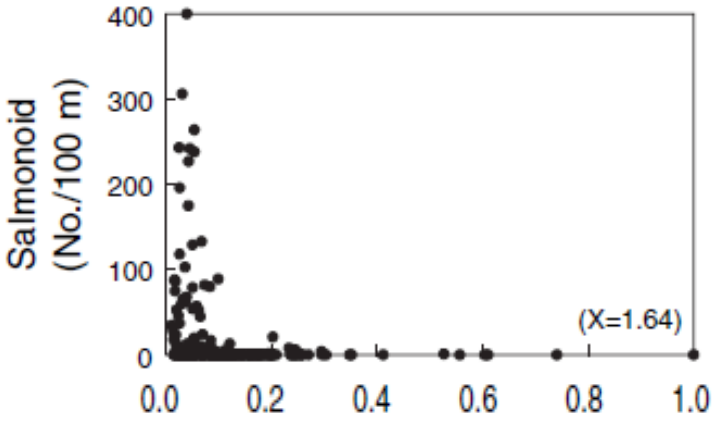


Figure 1: Plot between seasonal median of total phosphorus (mg/l) versus abundance of Salmonoid fishes. (Garrison et al. 2007)

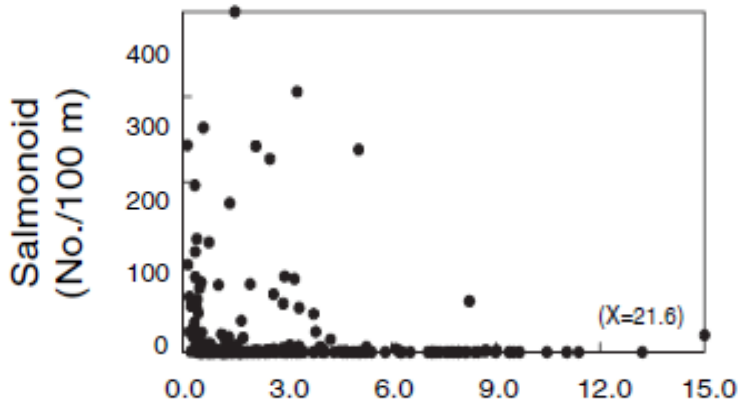


Figure 2: Plot between seasonal median of total nitrogen (mg/l) versus abundance of salmonoid fishes. (Garrison et al. 2007)

Phosphorous levels were previously discussed for each stream but nitrogen levels were not discussed. Nitrogen levels were collected on Hill Creek, Roy Creek and Dakin Creek. Currently Wisconsin does not have a water quality standard for nitrogen. Garrison et al. 2007 calculated a 25th percentile threshold for the Southeast Wisconsin Till Plains (SWTP) to be 2.02 (mg/L) for total nitrogen. Though this is not a statewide standard it is a good reference threshold to compare nitrogen data to in the region. All the recent nitrogen data collected by Diebel shows nitrogen levels far in accidence of the threshold.

Date	TKN (mg/L)	NO3 + NO2 (mg/L)	TN (mg/L)
08/30/2011 11:30	0.61	6.55	7.16
11/07/1990 11:40	1.1	0.5	1.6
11/07/1990 11:35	1.2	0.5	1.7
11/07/1990 11:30	1.2	0.5	1.7
11/07/1990 12:35	1.1	0.49	1.59
11/07/1990 12:40	1.1	0.5	1.6
11/07/1990 12:30	1	0.5	1.5

Table 1: Hill Creek nitrogen data

Date	TKN (mg/L)	NO3 + NO2 (mg/L)	TN (mg/L)
05/18/2011 12:20	0.28	11.3	11.58
06/16/2011 17:55	0.77	12.6	13.37
07/14/2011 13:30	1.01	12.8	13.81
08/16/2011 9:35	1.14	13.5	14.64
09/14/2011 17:57	0.36	13.4	13.76
10/13/2011 9:29	0.72	9.69	10.41

Table 2: Roy Creek nitrogen data

Date	TKN (mg/L)	NO3 + NO2 (mg/L)	TN (mg/L)
09/09/2010 8:50	0.29	15	15.29
07/22/2010 9:15	0.32	14.8	15.12
06/15/2010 9:15	1.57	10.9	12.47
04/21/2010 9:45	0.55	14.5	15.05
03/17/2010 10:15	0.21	15.2	15.41
02/25/2010 9:45	ND	16	16
01/12/2010 9:30	ND	14.5	14.5
12/16/2009 9:45	ND	13.3	13.3
11/12/2009 11:55	0.27	13.8	14.07
10/19/2009 10:15	0.27	13.8	14.07
08/12/2010 10:15	0.15	13.8	13.95
05/12/2010 9:15	0.42	13.8	14.22
09/14/2011 16:54	ND	14.4	14.4
08/16/2011 10:25	0.18	13.8	13.98

10/13/2011 10:49	0.31	12.3	12.61
07/14/2011 12:30	0.28	14	14.28
06/16/2011 16:47	0.51	13.1	13.61
05/18/2011 13:30	0.28	13	13.28

Table 3: Dakin Creek nitrogen data

Recommendations

All of the streams sampled in the study displayed elevated levels of phosphorus and total suspended solids. Considering the amount of agriculture taking place in the Green Lake watershed and adjacent to the streams sampled, elevated phosphorus and TSS levels are most likely due to agricultural runoff.

One recommendation is the implementation of agricultural Best Management Practices (BMP's) and nonpoint source pollution control. BMP's on agricultural land are aimed at reducing runoff and erosion. Water from precipitation events that does not immediately infiltrate the soil flows over land picking up nutrients and sediment, carrying it to the nearest stream. These large amounts of pollutant filled water cause erosion of stream banks which only increases the amount of sediment in the streams. The nutrients and sediment is then carried to the nearest lake, Big Green Lake in this case, where it collects causing major water quality impacts. Some of the practices are geared toward reducing rain drop energy; some reduce runoff through filtration, while others actually collect runoff.

Best Management Practice options are listed below:

1. Grassed waterways
2. Buffer strips
3. Sediment basins
4. Row cropping
5. No till practices (conservation tillage)
6. Bank stabilization
7. Barnyard runoff management
8. Contour farming
9. Terraces
10. Crop rotation
11. Wetland construction
12. Pasture management: Prescribed grazing system
13. Cover crops
14. Manure application management
15. Critical area planting

Approaches to farming that seek to minimize use of agricultural chemicals and fertilizers without sacrificing economic viability are strongly recommended. These approaches are known as "Sustainable Agriculture," and "Integrated Farm Management." The goals of the various systems are to minimize chemical input and maintain environmental quality and agricultural productivity (Manual of Best Management Practices 2011).

Another recommendation is to install inline sediment traps on the streams. Sediment traps are placed near the streams entrance to the lake and cause stream flow to slow. The reduced stream flow allows much of the sediment in the stream to settle out before reaching the lake. The sediment trap would need to be accessible by heavy equipment to allow the trap to be emptied every so often. The only problem with inline sediment traps is that they are not improving the real problem that the streams have. Too much sediment and phosphorus is allowed to enter the streams and inline sediment traps are not geared toward preventing that, they only prevent sediment from reaching the lake.

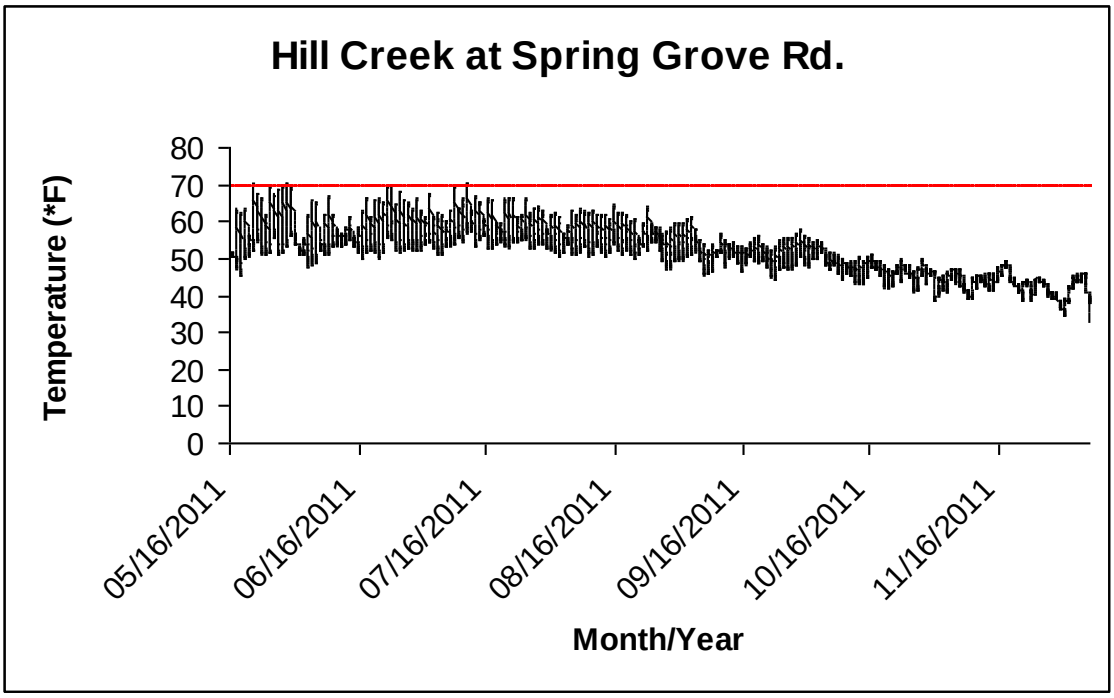


Figure 3: Temperature monitoring on Hill Creek at Spring Grove Road crossing from May to December of 2011.

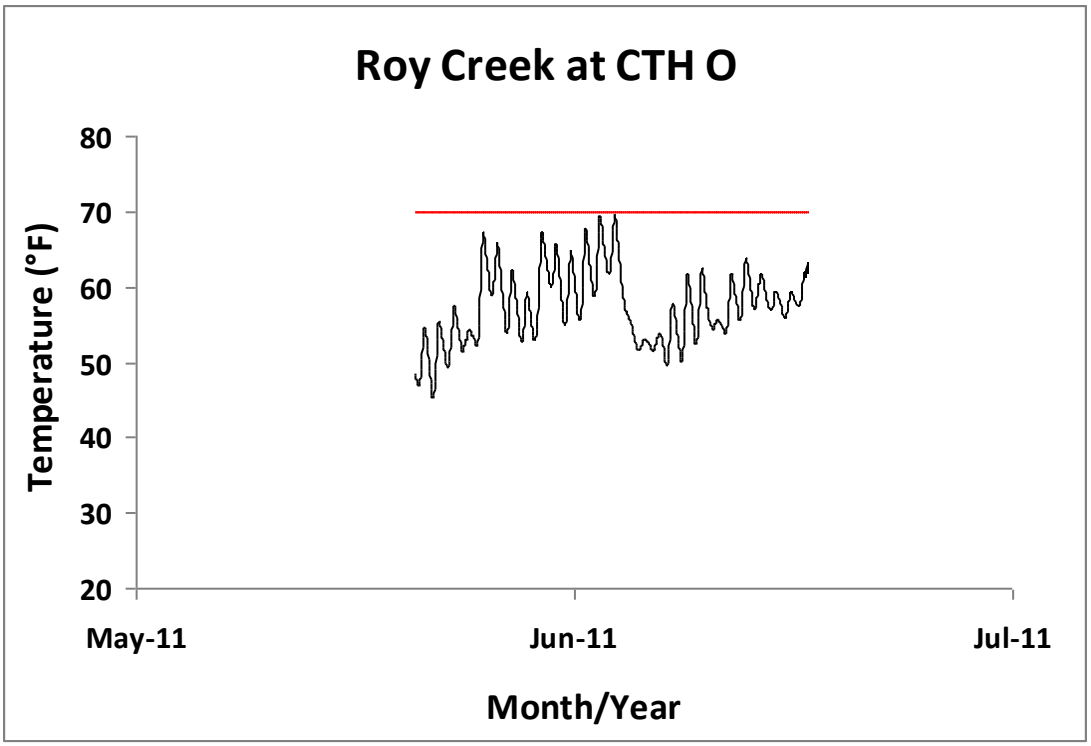


Figure 4: Temperature monitoring on Roy Creek at County Highway O crossing from May to June of 2011.

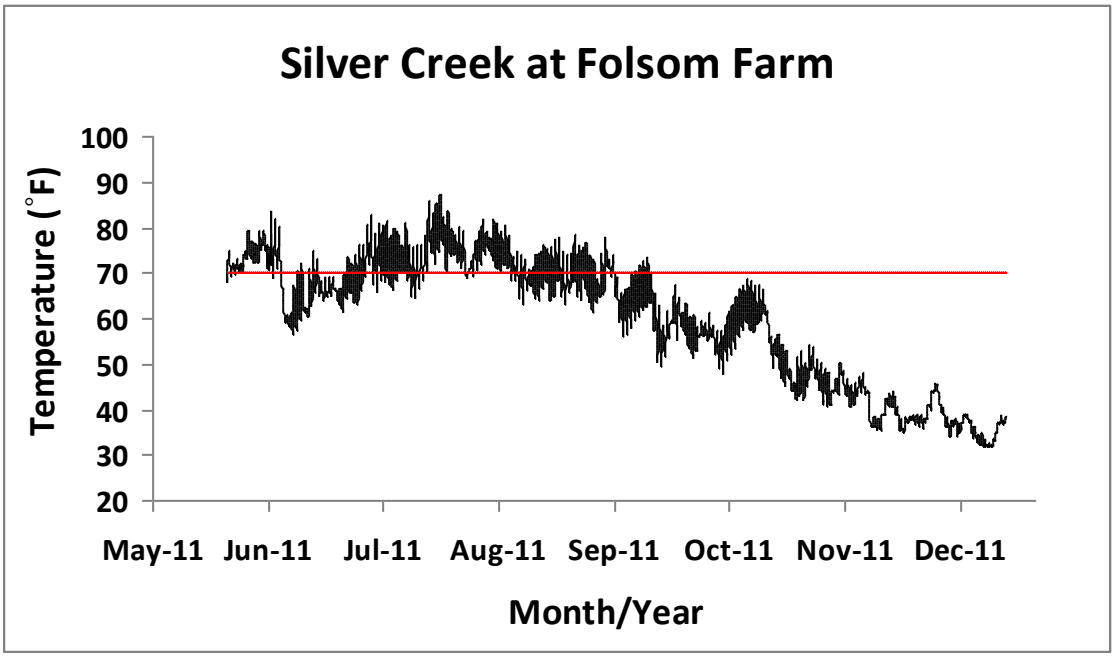


Figure 5: Temperature monitoring on Silver Creek at Folsom Farm from May to December of 2011.

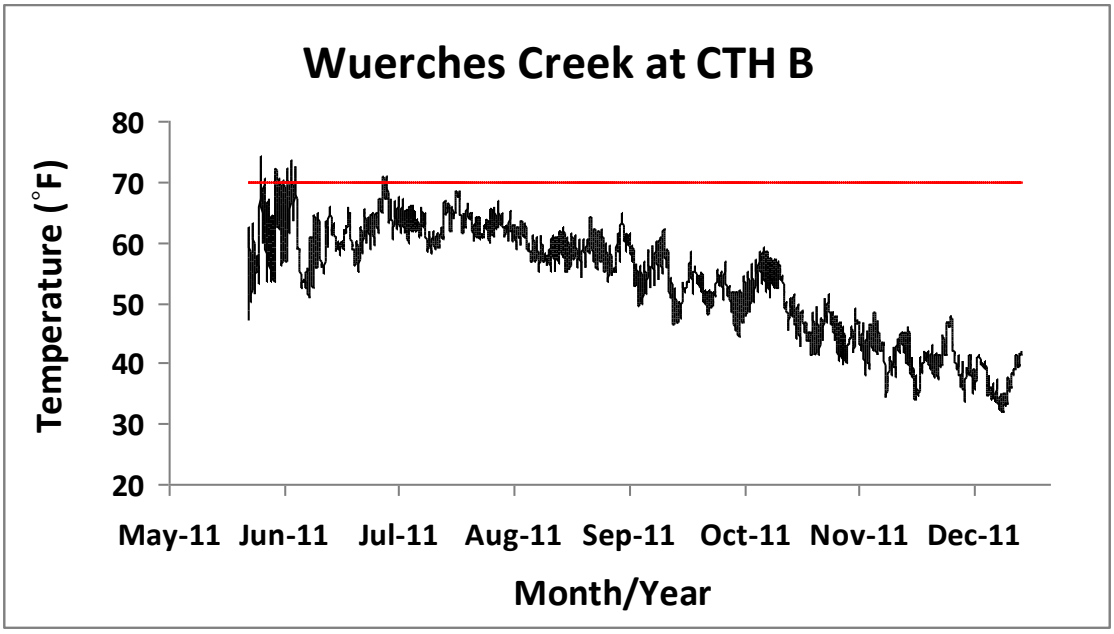


Figure 6: Temperature monitoring on Wuerches Creek at County Highway B crossing from May to December of 2011.

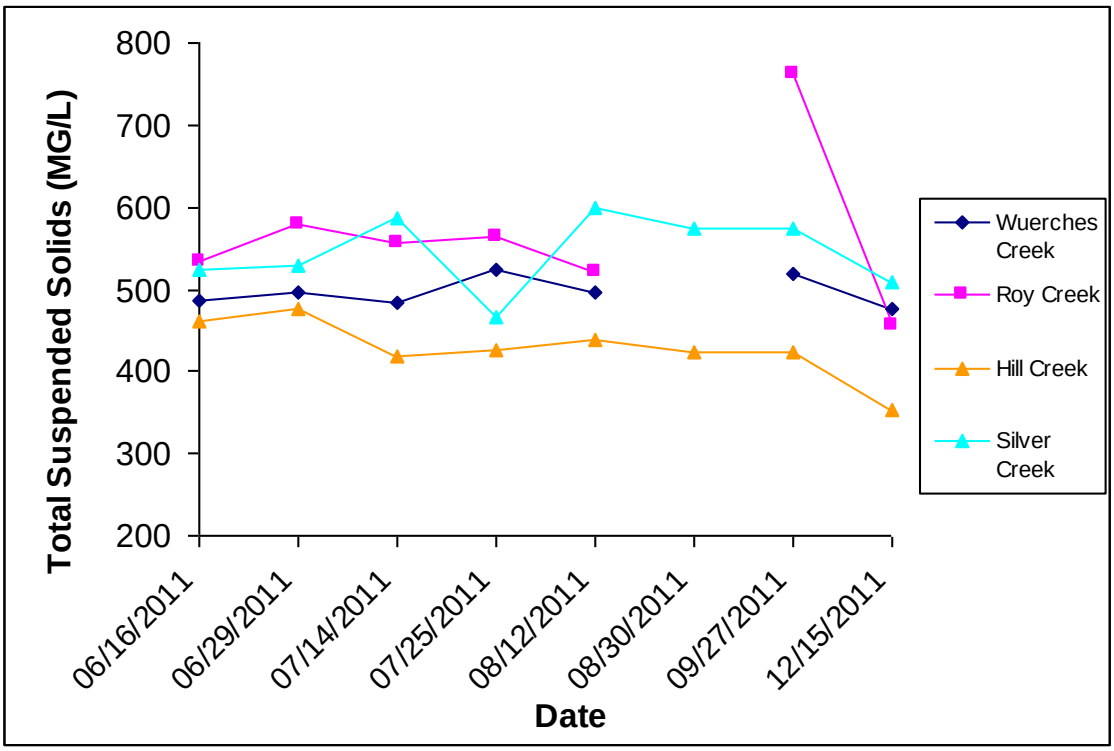


Figure 7: Total suspended solids in milligrams per liter for Wuerches, Roy, Hill and Silver creeks.

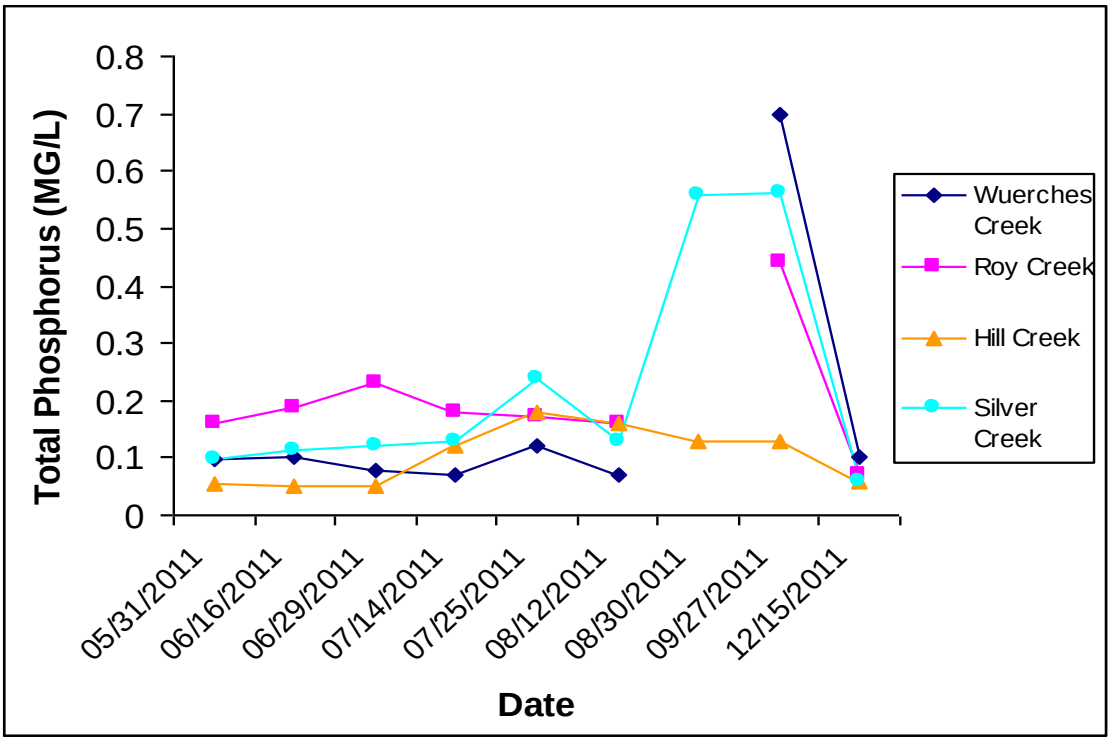


Figure 8: Total phosphorus in milligrams per liter for Wuerches, Roy, Hill and Silver creeks.

Wuerches Creek	05/31/2011	06/16/2011	06/29/2011	07/14/2011	07/25/2011
Temperature © (Field)	20.6		17.6	16.7	17
Conductivity (UMHOS/CM)	723	728	758	752	762
Dissolved Oxygen (MG/L)	14.3		10	7.7	5.8
DO Percent Saturation	159.5		106	80	60
PH	8.1	8.19	7.8	7.7	7.7
Transparency Tube (cm)	>120	>120	>120	>120	>120
Alkalinity (MG\L)		301			
Flow (m^3/sec)			0.07487	0.08235	0.06427

Table 4: Water quality data collected from Wuerches Creek upstream from the County highway B road crossing.

Roy Creek	05/31/2011	06\16\2011	06/29/2011	07/14/2011	07/25/2011
Temperature © (Field)	17.8		14.5	16	16.9
Conductivity (UMHOS/CM)	719	723	736	736	739
Dissolved Oxygen (MG/L)	7.4		8.9	8.7	8.5
DO Percent Saturation	81.2		87.9	89.1	87.8
PH	8.2	8.27	8.2	8.3	8.3
Transparency Tube (cm)	30	100	10	13	15
Alkalinity (MG\L)		285			
Flow (m^3/sec)			0.065799	0.04182	0.038086

Table 5: Water quality data collected from Roy Creek upstream from the County highway O road crossing.

Hill Creek	5/31/11	6/16/11	6/29/11	7/14/11	7/25/11
Temperature © (Field)	15		13.1	22.5	23.1
Conductivity (UMHOS/CM)	705	713	717	609	611
Dissolved Oxygen (MG/L)	9.8		11.5	9.2	6.8
DO Percent Saturation	98.2		109.1	107.1	78.7
PH	8.3	8.39	8.4	8.3	7.9
Transparency Tube (cm)	90	90	100	80	40
Alkalinity (MG\L)		255			
Flow (m^3/sec)				0.03648	0.07093

Table 6: Water quality data collected from Hill Creek upstream from the Spring Grove road crossing.

Silver Creek	05/31/2011	06\16\2011	06/29/2011	07/14/2011	07/25/2011
Temperature © (Field)	20.7		22.4	20.8	23.8
Conductivity (UMHOS/CM)	830	812	825	910	657
Dissolved Oxygen (MG/L)	8.1		8.9	8.4	4.1
DO Percent Saturation	95		104.3	105.5	48.4
PH	8	8.35	8.2	8.3	7.9
Transparency Tube (cm)	60	60	60	50	35
Alkalinity (MG\L)		295			
Flow (m^3/sec)			0.54851	0.54557	1.591146

Table 7: Water quality data collected from Silver Creek from Folsom Farm and Zeratsky Farm.

Fish Survey Information	Creek Name					
Species Name	Hill (7/20/11)	Hill (7/26/11)	Hill (8/30/11)	Roy	Silver	Wuerches
Bluegill *(Lepomis macrochirus)*			4		9	
Black Bullhead *(Ameiurus melas)*			4			
White Sucker *(Catostomus commersoni)*	4		2	12	45	
Yellow Perch *(Perca Flavescens)*			5		2	
Largemouth Bass *(Micropterus salmoides)*		3	2		25	
Northern Pike *(Esox Lucius)*			2		5	
Creek Chub *(Semotilus atromaculatus)*			1		7	
Brown Trout *(Salmo trutta)*			2			
Green Sunfish *(Lepomis cyanellus)*		1	2		1	
Mottled Sculpin *(Cottus bairdi)*				11		30
Central Mudminnow *(Umbra limi)*				7	16	10
Fathead Minnow *(Pimephales promelas)*				6		
Smallmouth Bass *(Micropterus dolomieu)*					2	
Muskellunge *(Esox masquinongy)*					4	
Yellow Bullhead *(Ameiurus natalis)*					2	
Log Perch *(Percina caprodes)*					5	
Black Crappie *(Pomoxis nigromaculatus)*					2	
Johnny Darter *(Ethostoma nigrum)*					2	
Hognose Sucker *(Hypentelium nigricans)*					1	
Golden Shinner *(Notemigonus crysoleucas)*					2	

Table 8: Fish collected during backpack electrofishing surveys conducted on Hill, Roy, Silver and Wuerches Creeks.

References

EQIP Water Quality Initiative: Big Green Lake Watershed. 2011. NRCS.

Garrison, P. J., D. M. Robertson, and L. Wang. 2007. Linkages Between Nutrients and Assemblages of Macroinvertebrates and Fish in Wadeable Streams: Implications to Nutrient Criteria Development. Environ Manage 39:194-212.

Manual of Best Management Practices (bmps) for Agriculture in New Hampshire. 2011. Agricultural Best Management Practices Task Force, NRCS, and New Hampshire Department of Agriculture, Markets, and Food. Available: http://agriculture.nh.gov/divisions/markets/documents/bmp.pdf. (August 2012).

The State of the Upper Fox River Basin. 2001. Wisconsin Department of Natural Resources in cooperation with the Upper Fox River Basin Partnership Team and Stakeholders. Available: http://dnr.wi.gov/water/basin/upfox/upfox1.pdf. (August 2012).