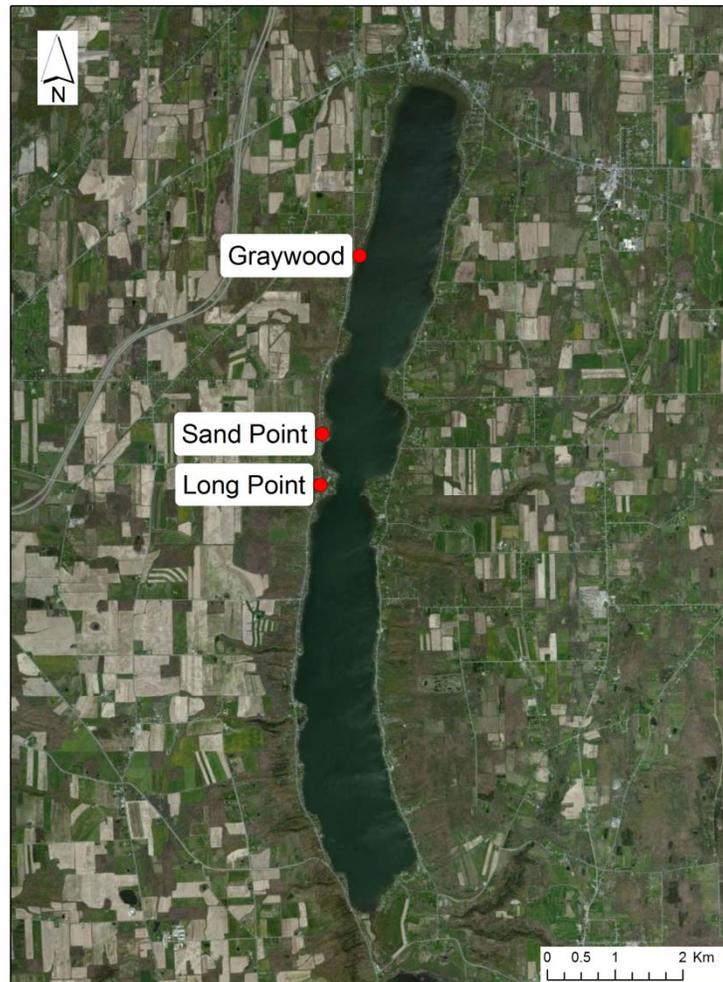


# Stream Water Quality Assessment of Long Point Gully, Graywood Gully, and Sand Point Gully: Conesus Lake Tributaries Spring 2012

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## Executive Summary

1. In 2011, Cottonwood Gully and North McMillan Creek were monitored to determine the status of these two watersheds of Conesus Lake using the newly developed Stream Water Index. In 2012, the goal was to implement the assessment tool in three additional watersheds: Long Point Gully, Sand Point Gully and Graywood Gully. The implementation of this tool allows the county to evaluate the status of Conesus Lake watersheds over time; that is, are they improving, getting worse, or not changing. An evaluation using a tool of this type should provide further direction to the Conesus Lake Watershed Management Plan.
2. Long Point Gully, Sand Point Gully, and Graywood Gully streams were monitored during the spring of 2012 for stream discharge, nutrients, sodium, and soil loss.
3. Each stream was evaluated using the Stream Watershed Index previously developed for Conesus Lake’s watersheds (Makarewicz *et al.* 2011).
4. In general, levels of nutrients and soils losses from Graywood, Long Point, and Sand Point Gullys were generally at or below levels observed during baseline conditions during the 2002 to 2007 period.
5. However, elevated levels of total phosphorus, soluble reactive phosphorus, nitrate and occasionally total Kjeldahl nitrogen were observed during rain events – especially during the rising limb of the stream hydrograph.

6. Sodium, a component of deicing salt, was elevated in the stream water of Sand Point and Long Point Gullies.

## **Recommendations**

1. The single largest factor in transporting nutrients is the flow of water. For both Long Point and Sand Point, efforts should be made to work with the Soil and Water Conservation District on methods that reduce water flow containing nutrients and soil and/or with methods that reduce the amount of nutrients being applied to the soil.
2. Sodium levels, a component of deicing salt, in stream water are increasing. This eventually leads to an increase in sodium concentrations in lake water. In fact, sodium levels have been increasing in Conesus Lake. A discussion is recommended with the Highway Department concerning the rate of application on deicing salt highways and impact on the lake.
3. The Stream Watershed Index appears to be a valuable tool in evaluating the watersheds of Conesus Lake, allowing comparisons with past data and thus assistance in decision making concerning watershed management. If financially appropriate, monitoring of watersheds should continue as a mechanism to evaluate land-use practices, to advocate changes, and to assist in future planning.

## **Introduction**

Previous reports documented substantial increases in the concentrations of nutrients and soil particles in streams during the summer of 2009 and 2010 (Makarewicz and Lewis 2009, 2010). At Graywood Gully, for example, concentrations of soil (TSS), total phosphorus (TP), soluble reactive phosphorus (SRP), total Kjeldahl nitrogen (TKN), and nitrate increased in the stream water. After a 5-year decrease at Cottonwood Gully (Makarewicz *et al.* 2009), nitrate concentration ( $\text{NO}_3+\text{NO}_2$ ) increased to levels not observed since 2003. Similar increases were observed in the Southwest, Sand Point, North Gully, Sutton Point, and Long Point subwatersheds. This was of concern as a general decrease in “concentrations” of nutrients and soil from managed watersheds was evident prior to 2009 due to management plans adopted during the USDA study (Makarewicz *et al.* 2009).

Several factors may have contributed to this observed increase in the concentration of dissolved and particulate material, some were natural (variation in rainfall amount and intensity); but others were affected by human actions (changes in land use or management practices). Although the increases observed in all the monitored streams may have been related to new or changing farming practices, it could not be ruled out that the significant rainfalls in the spring and early summer of 2009 were not the cause. A limitation of the approach taken in 2008 and 2009 was that discharge was not measured as it was in the USDA study. Concentration of analytes is a function of discharge from streams in agricultural watersheds; that is, as discharge increases, concentrations increase as more material is washed from the land and more material is dissolved. The observed increases could simply be due to the higher than usual rainfalls in May and especially in June. For example, the daily rate of precipitation in June was twice the rate for any other previous year since 2002; May precipitation was the highest since 2003. Also, a visual inspection of these watersheds in the summer of 2009 ruled out any major changes in land use. The increase in nutrient loss from all of the USDA watersheds during the summer of 2009 suggests that the approach taken of using only averaged concentration data over time to evaluate temporal trends may have been misinterpreted.

In 2010, we reevaluated the stream concentration approach to assessment of stream water by converting the data in the amount of an analyte lost from a subwatershed and applying a statistical approach that accounts for discharge. This process adjusts or weights the mean concentration and load by discharge and produces an adjusted average loss from the watershed titled the marginal mean load. Increases in total phosphorus, soluble reactive phosphorus, total suspended solids (soil loss), and total Kjeldahl nitrogen were observed in 2009 using the summer data collected via the county sampling design. However, these increases were “not” statistically significant, which implies that we cannot be sure that the increases were not random effects.

Generally, these summer data do not strongly mimic the large declines resulting from BMPs implemented in these watersheds (Makarewicz *et al.* 2009). The reason for this

difference has to do with the data being used. In Makarewicz *et al.* (2009), weekly seasonal data were collected for an entire year. Many, if not all of the management plans implemented by the USDA project, were designed to reduce nutrient and soil losses via water being lost directly from the watershed. That is, water carrying nutrients or soil was generally directed to buffer strips, de-watered, infiltrated into the soil, etc. Results from BMPs would have a major effect during the winter and spring during the wet part of the year. During the summer when flows are low, these impacts from BMPs would not necessarily be observed. Also, planted vegetation in the summer is actively taking up nutrients and serving to retain soil on the land.

In 2011, the Conesus Lake work plan was changed to initiate a spring rather than a summer sampling period of creeks of concern. An index, the Stream Watershed Index, based on analyte concentration was successfully developed utilizing the spring 2003 to 2007 USDA data base. Such a tool would allow the county to evaluate the status of Conesus Lake subwatersheds; that is, are they improving, getting worse, or not changing and thus allow further development and direction of the Conesus Lake Watershed Management Plan.

The results from 2011 indicated that improvements in stream water quality observed during and after implementation of the USDA Best Management Plans were being maintained into 2011 for Cottonwood Gully and North McMillan Creek. Levels of total phosphorus, total suspended solids, total Kjeldahl nitrogen, sodium, and nitrate were at levels that indicate BMPs implemented earlier were successful. The results, however, for soluble reactive phosphorus, an element controlling phytoplankton growth in Conesus Lake, indicated that the loss of SRP from the watershed was often above historical concentrations from the 2003 to 2007 period – the period when BMPs were initiated. These results may represent new agriculture fertilization regime of crops in the watershed. As indicated previously, the watershed inspector could open a discussion with the Livingston County Soil and Water Conservation District personnel to determine if fertilization rates and applications have changed and perhaps develop a program to ameliorate the practice.

North McMillan Creek and its watershed are the most forested and had the least amount of agriculture of all the subwatersheds of Conesus Lake. This watershed was the control watershed used in the USDA study. In 2011, the spring data for TP, SRP, TKN, nitrate, and TSS indicated that the quality of the water leaving this watershed was not degraded and had not changed from the 2003 to 2007 period. The exception to this trend was sodium. Application of deicing salt on roads during the snow and ice period is quite common and expected by the public in the Finger Lakes Region. The data for North McMillan suggest that application rates and/or the number of applications may be higher than in the 2003 -2007 period. The sampling site for this location is near the bridge, and any snowmelt plus salt enters into the creek just above where the samples were taken. Previous reports (Makarewicz and Lewis 2009) have identified that deicing salt levels are slowly increasing over the past 50 years in the Conesus Lake water supply.

The 2012 objective was:

To extend the use of the Stream Watershed Quality Index and evaluate three other USDA streams during the spring of 2012 (Long Point Gully, Sand Point Gully, and Graywood Gully). Basically, the question is whether conditions in streams draining these watersheds are improving, getting worse, or not changing.

## **Methods**

Stream samples were taken at three former USDA monitoring sites (Makarewicz *et al.* 2009) at the base of the Long Point Gully, Sand Point Gully and the Graywood Gully subwatersheds (Fig. 1). Water samples were taken every Tuesday morning from 1 March to 8 May 2012. In addition, ISCO water samplers were placed in each stream to take samples during hydrometeorologic events that exceeded a rise in stream level of 1 inch/30 minutes and to monitor stream flow. For the three streams, a total of twenty one events and 30 nonevent water samples were taken, preserved, and analyzed using approved standard methods (USEPA 1979, APHA 1999). Sample water for dissolved nutrient analysis (SRP, NO<sub>3</sub>+ NO<sub>2</sub>) was filtered immediately on site with 0.45-µm MCI Magna Nylon 66 membrane filters and held at 4°C until analysis the following day.

Stream samples were analyzed for TP (APHA Method 4500-P-F), TKN (USEPA Method 351.2), NO<sub>3</sub>+ NO<sub>2</sub> (APHA Method 4500-NO<sub>3</sub>-F), and TSS (APHA Method 2540D). Except for TSS, analyses were performed on a Technicon AutoAnalyser II. Method Detection limits were as follows: SRP (0.48 µg P/L), TP (0.38 µg P/L), NO<sub>3</sub>+ NO<sub>2</sub> (0.005 mg N/L), TKN (0.15 µg N/L), and TSS (0.2 mg/L).

### **Quality Control:**

All water samples were analyzed at the Water Chemistry Laboratory at The College at Brockport, State University of New York (NELAC – EPA Lab Code # NY01449) within approved sample handling times. In general, this program includes biannual proficiency audits, yearly annual inspections and documentation of all samples, reagents, and equipment under good laboratory practices. All quality control (QC) measures are assessed and evaluated on an on-going basis. As required by NELAC and New York's ELAP certification process, method blanks, duplicate samples, laboratory control samples, and matrix spikes are performed at a frequency of one per batch of 20 or fewer samples. Field blanks (events and nonevents) are routinely collected and analyzed. Analytical data generated with QC samples that fall within prescribed acceptance limits indicate the test method was in control. For example, QC limits for laboratory control samples and matrix spikes are based on the historical mean recovery plus or minus three standard deviations. QC limits for duplicate samples are based on the historical mean relative percent difference plus or minus three standard deviations. Data generated with QC samples that fall outside QC limits indicate the test method was out of control. These data are considered suspect and the corresponding samples are reanalyzed. As part of the NELAC certification, the lab participates semi-annually in proficiency testing program (blind audits, Table 1) for each category of ELAP approval. If the lab fails the proficiency audit for an analyte, the lab director is required to identify the source and correct the problem to the certification agency.

## **Results and Discussion**

### **Trial Use of a Stream Watershed Index**

In 2011, we developed a graphical index of discharge versus concentration based on spring data from 2002 to 2006 (Makarewicz *et al.* 2011). Figure 2 shows the Cottonwood Gully data grouped by regression lines using the Pre-BMP and Post-BMP data from the USDA work of Makarewicz *et al.* (2009). From this graphic, it is evident analyte concentration varied over time and with discharge - in general, the higher the discharge the higher the analyte concentration. Also, concentration was higher early in the USDA study period prior to BMP introduction and was reduced after the BMPs were implemented.

This approach was further modified in Figure 3. This figure represents the regression line of all measurements at Cottonwood Gully made during the spring period of 2003 to 2007. The curved lines below and above the middle line represent the 99% confidence interval. If an analyte concentration is in the dark red area and above the upper 99% confidence interval, the water quality of this stream discharging into Conesus Lake would be considered degraded or having a reduction in water quality compared to the 2003-2007 period. If the analyte concentration was below the lower 99% confidence interval and in the green area, water quality of the stream discharging into Conesus Lake is improving. If analyte concentrations fall within the 99% confidence interval, there is no certainty whether the stream water is improving or degrading. For example, the data for spring 2011 are plotted as triangles. The preponderance of the points is in the green area of the graph suggesting the loss of total phosphorus from the Cottonwood watershed is below the Pre-BMP period; thus the water quality of the stream is better than it was historically and therefore improving. This approach provides a mechanism to evaluate trends, improving, not changing, or degrading, in a given watershed over time as compared to the 2003-2007 baseline period.

## **Monitoring Trends**

### Sand Point Gully

Sand Point Gully is a small watershed (188 ha) located on the western shore of Conesus Lake (Fig. 1). From 2002 to 2007, the mean concentrations of TP, SRP, TKN and TSS did not change, while nitrate concentrations significantly decreased. During

this period, a rotational grazing plan was instituted that included fencing strips so strips could be rotated and water throughs could be provided for cattle. Two gully plugs were installed and tiles were also installed in a small portion of the watershed in 2002. Based on recent casual observations of this area, much of this area has returned to early growth forest.

The 2012 results (Table 2, Fig. 4) indicate the following: for TP, SRP, TSS, nitrate, and TKN, 85% of the samples taken were either in the green or pink area of Figure 4. This result suggests that water draining from this watershed is generally as good in quality or better than the 2003 to 2007 period. On three occasions (24 and 25 April 2012 and 4 May 2012) during hydrometeorological events (Table 5) and especially during the rising portion of the stream hydrographs (Table 2), nutrient and soil concentrations were often elevated and into the red zone (degrading conditions) as shown in Figure 4. This result suggests that during rain events (and probably snowmelts), nutrients and materials are still being lost at a level that is historically high for this watershed. Management practices that hold or retain water on the watershed for a longer period of time are suggested. Such a practice would allow water to percolate through the soil and partially remove nutrients through adsorption to soil particles.

Unlike nutrient and soil losses, the loss of sodium from the watershed to the lake has increased. Over 50% of the samples taken (Fig. 4) indicate that for Sand Point Gully sodium levels in the stream water are higher than what historically has been observed. Application of deicing salt on roads during the snow and ice period is quite common and expected by the public in the Finger Lakes Region. The sampling site for this location is near the bridge, and any snowmelt plus salt enters into the creek just above where the samples were taken. A similar observation occurred last year for North McMillan Creek (Makarewicz et al. 2011). Previous reports have identified that deicing salt levels have slowly increased over the past 50 years (Makarewicz and Lewis 2009) in the Conesus Lake water supply.

### Long Point Gully

Dairy cattle were removed from the Long Point Gully watershed in 2002, and there was a 37% reduction in crop acreage by 2003. Major reductions in nitrate (42%), TP (36%), and SRP (53%) concentrations were observed within a year of implementation. In 2012, losses of soil from the watershed were generally below historical concentrations - only 11% of the samples exceeded the red zone of “degrading” historical levels (Fig. 5, Table 3). For TP, SRP, and TKN about 20% of the samples, all during events, exceeded historical levels of good or improving water quality. Over 50% of the nitrate levels, including nonevent and events, were in the red zone (degrading) for water quality with concentrations exceeding 4 mg/L. Such high levels suggest over fertilization of soils via inorganic fertilizers and possibly manure spreading. A discussion with Soil and Water Conservation District personnel is encouraged to determine sources and practices.

Over 72% of the sodium stream samples taken were in the red zone (degrading conditions) for sodium. A similar result was observed at Sand Point suggesting the rates of application of deicing salt are increasing in the watershed. Since this past winter had the lowest snow levels in years, a discussion with the highway department on salt application to the highways should be undertaken.

### Graywood Gully

As part of the USDA project, extensive BMPs were applied to this watershed dominated by agriculture in 2002 and 2003. Major decreases in all nutrient and soil losses were observed when the BMPs were initiated. In the spring of 2012, 86% of the stream samples were in the green zone (improving conditions) or pink zone (no change) compared to historical conditions of TP, nitrate, TSS, and sodium (Fig. 6, Table 4). However, SRP and TKN concentrations were elevated and in the red zone (degrading conditions) ~ 28% of the time samples. All of these elevated levels occurred during event (rain) conditions. This result suggests that during rain events (and probably snowmelts), nutrients and materials are still being lost at a level that is historically high for this watershed. Management practices that hold or retain water on the watershed

for a longer period of time are suggested. Such practices would allow the water to percolate into the ground and nutrients be partially removed from the water.

### **Conclusions/Limitations**

Much of the following has been discussed previously (Makarewicz *et al.* 2011). The preferred approach to evaluate the streams is to sample the entire year during nonevents and events as was done during the USDA project (Makarewicz *et al.* 2009). However, the cost of this approach is beyond the means of Livingston County. As an alternate approach, the Stream Water Quality Assessment Index was developed and appears to be a viable tool for evaluating the water quality of the USDA streams. Any decisions on water quality should be based on the preponderance of sampling results (points) for a given period of time. The larger the number of sampling points over various flow or discharge regimes, the better this tool will be for evaluating status of the streams. With a smaller number of sampling points, a greater amount of uncertainty will be introduced into the evaluation of the stream and watershed, as variability in discharge and analyte measurements over a day can be quite large – especially during events. In the work completed in 2011 and 2012, discharge was measured over an entire day using an automated recorder. Flow measurements should be based minimally on hourly measurements of discharge to calculate a daily discharge. This is especially true for rain/melt events. Lastly, the Stream Water Quality Assessment was developed for the spring period and not for other periods of time. It is not appropriate to use during other seasons. The assumption is that conditions observed in the spring do reflect conditions over the entire year.

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**Table 1. Proficiency audit of the Water Quality Laboratory at The College at Brockport.**

**WADSWORTH CENTER  
NEW YORK STATE DEPARTMENT OF HEALTH  
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM**

**New York ELAP Proficiency Test Report**

Lab Id: 11439	SUNY BROCKPORT 125 LENNON HALL	Shipment Date : 17-Jan-2012
EPA Lab Code: NY01449	SUNY BROCKPORT BROCKPORT, NY 14420 (585) 395-5747	Closing Date : 01-Mar-2012
	Director: DR. JOSEPH C. MAKAREWICZ	Score Date : 21-Mar-2012

ELAP is an AZLA accredited Proficiency Testing Provider. Certificate Number 1785.01
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Shipment: 350      Non Potable Water Chemistry

Analyte Name	Units	Sample ID	Test Method	Prep Method	Result/Analysis Date	Mean/Assigned Value	Standard Deviation/Fixed %	Acceptance Limits	Score
<b>Sample: Non Potable Water Inorganic Nutrients</b>									
Nitrate (as N) Analyte Code: 1810	mg/L	5007	SM 18-21 4500-NO3 F (00)		36.71 2/15/2012	35.6 35.9	2.55	28.0 - 43.3	Satisfactory <i>90 passed out of 94 reported results.</i>
Orthophosphate (as P) Analyte Code: 1870	mg/L	5007	SM 18-21 4500-P F		4.11 2/15/2012	4.16 4.14	0.249	3.41 - 4.90	Satisfactory <i>78 passed out of 80 reported results.</i>
<b>Sample: Non Potable Water Minerals II</b>									
Sodium, Total Analyte Code: 1155	mg/L	5037	SM 18-21 3111B (99)		58.9 2/29/2012	57.0 57.1	2.85	48.5 - 65.6	Satisfactory <i>59 passed out of 63 reported results.</i>
<b>Sample: Non Potable Water Nitrite</b>									
Nitrite as N Analyte Code: 1840	mg/L	5041	SM 18-21 4500-NO2 B (00)		2.614 2/15/2012	2.51 2.51	0.13	2.12 - 2.90	Satisfactory <i>82 passed out of 84 reported results.</i>
<b>Sample: Non Potable Water Organic Nutrients</b>									
Kjeldahl Nitrogen, Total Analyte Code: 1795	mg/L	5004	EPA 351.2 Rev. 2.0		13.95 2/28/2012	12.8 13.1	1.38	8.69 - 17.0	Satisfactory <i>68 passed out of 69 reported results.</i>
Phosphorus, Total Analyte Code: 1910	mg/L	5004	SM 18-21 4500-P F		7.62 2/24/2012	7.36 7.33	0.437	6.05 - 8.67	Satisfactory <i>78 passed out of 86 reported results.</i>
<b>Sample: Non Potable Water Residue</b>									
Solids, Total Suspended Analyte Code: 1960	mg/L	5002	SM 18-21 2540D (97)		42.3 2/8/2012	42.4 44.2	2.91	33.6 - 51.1	Satisfactory <i>167 passed out of 171 reported results.</i>

Table 2. Data collected during the spring (1 March to 8 May 2012) at the Sand Point watershed of Conesus Lake. NT= Not Taken. TP=total phosphorus, TSS=total suspended solids, TKN= total Kjeldahl nitrogen, SRP=soluble reactive phosphorus. R= the rising portion of the stream hydrograph, F= the falling portion of the stream hydrograph. G= a grab sample taken during the event.

Date		TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
3/6/2012	Non-event	11.9	0.99	1.6	234	44.31	5.6
3/13/2012	Non-event	35.6	0.19	6.5	256	43.41	4.6
3/19/2012	Non-event	10.4	0.24	1.7	281	47.74	3.2
3/27/2012	Non-event	10.7	0.49	0.4	366	39.43	6.5
4/3/2012	Non-event	12.1	0.36	1.4	322	48.44	5.1
4/10/2012	Non-event	10.9	0.21	2.2	241	31.44	3.4
4/17/2012	Non-event	17.0	0.38	1.5	223	31.08	10.7
4/22/2012	Non-event	29.2	0.32	2.9	399	55.28	13.4
4/23/2012	Non-event	366.6	0.67	287.5	6976	41.73	8.4
4/24/2012	Event (G)	57.4	2.07	12.7	717	50.89	21.0
4/24/2012	Event (F)	76.4	1.60	21.0	798	57.23	26.3
4/24/2012	Event (R)	326.9	0.99	208.0	2497	50.89	26.6
4/25/2012	Event (F)	62.9	1.61	18.2	706	32.22	23.0
4/25/2012	Event (G)	44.9	1.53	5.3	758	31.54	19.1
4/25/2012	Event (R)	366.6	2.36	357.0	2387	31.49	20.9
5/1/2012	Non-event	24.9	0.34	8.3	538	41.47	9.4
5/4/2012	Event (R)	375.8	0.67	307.0	703	19.12	70.0
5/4/2012	Event (F)	75.0	0.52	22.8	1124	28.67	40.5
5/8/2012	Non-event	50.2	0.47	12.2	2753	33.48	22.7

Table 3. Data collected during the spring (1 March to 8 May 2012) at the Long Point watershed of Conesus Lake. NT=Not Taken. TP=total phosphorus, TSS=total suspended solids, TKN= total Kjeldahl nitrogen, SRP=soluble reactive phosphorus. R= the rising portion of the stream hydrograph, F= the falling portion of the stream hydrograph. G= a grab sample taken during the event.

Date		TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
3/6/2012	Non-event	17.3	4.83	3.6	< 150	48.33	13.8
3/13/2012	Event (R)	457.5	3.88	26.0	355	63.18	187.4
3/13/2012	Event (G)	27.2	3.42	10.0	219	60.06	6.3
3/13/2012	Event (F)	38.5	3.68	2.5	1809	64.89	28.0
3/19/2012	Non-event	11.4	2.85	1.2	314	57.29	6.5
3/27/2012	Non-event	11.9	2.84	0.8	289	45.87	10.7
4/3/2012	Non-event	16.4	2.98	3.5	248	60.70	10.9
4/10/2012	Non-event	25.0	2.73	7.5	424	46.80	11.6
4/17/2012	Non-event	23.1	1.97	3.2	270	48.35	22.2
4/22/2012	Non-event	26.8	1.75	2.6	362	52.80	14.1
4/24/2012	Event (G)	150.5	5.79	96.8	1388	59.67	36.5
4/25/2012	Event (R)	497.8	6.23	408.0	1274	39.44	82.1
4/25/2012	Event (G)	149.7	7.25	11.6	1871	36.12	110.7
4/25/2012	Event (F)	262.3	6.97	61.7	2450	30.46	181.2
5/1/2012	Non-event	30.2	4.39	3.6	388	54.29	13.0
5/4/2012	Event (R)	543.5	6.37	305.0	860	29.73	28.1
5/4/2012	Event (F)	899.8	6.29	13.8	1124	37.46	18.2
5/8/2012	Non-event	56.7	4.74	12.3	2563	45.13	24.3

Table 4. Data collected during the spring (1 March to 8 May 2012) at the Graywood watershed of Conesus Lake. TP=total phosphorus, TSS=total suspended solids, TKN= total Kjeldahl nitrogen, SRP=soluble reactive phosphorus. R= the rising portion of the stream hydrograph, F= the falling portion of the stream hydrograph. G= a grab sample taken during the event.

Date		TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
3/6/2012	Non-event	83.5	10.61	2.7	< 150	41.27	76.0
3/13/2012	Non-event	238.7	8.24	9.0	237	44.31	74.6
3/19/2012	Non-event	113.5	7.62	15.8	179	46.17	93.2
3/27/2012	Non-event	105.7	6.34	14.4	201	45.64	92.0
4/3/2012	Non-event	134.7	4.94	7.5	248	41.87	104.5
4/10/2012	Non-event	88.5	5.28	7.8	< 150	47.30	84.4
4/17/2012	Non-event	117.8	3.49	9.6	292	63.49	91.7
4/22/2012	Non-event	178.1	3.38	8.6	351	48.35	126.1
4/24/2012	Event (G)	512.1	14.09	95.0	1234	20.97	371.4
4/25/2012	Event (F)	317.1	9.50	32.7	640	31.44	274.7
4/25/2012	Event (G)	196.3	8.76	17.2	607	34.75	182.2
4/25/2012	Event (R)	505.2	12.16	162.0	1523	22.58	321.1
5/1/2012	Non-event	230.6	4.83	14.7	732	39.00	141.5
5/8/2012	Non-event	262.6	3.92	47.4	988	33.72	157.9



Table 5. Rainfall data from the National Weather Service in Rochester, NY.

Day	2010	2011	2012		Day	2010	2011	2012		Day	2010	2011	2012
	Precip. (in)	Precip. (in)	Precip. (in)			Precip. (in)	Precip. (in)	Precip. (in)			Precip. (in)	Precip. (in)	Precip. (in)
3/1	0.00	0.00	0.15		4/1	0.00	0.03	0.22		5/1	0.00	0.00	0.06
3/2	0.00	0.00	0.07		4/2	0.00	0.00	0.00		5/2	0.00	0.10	0.01
3/3	0.00	0.00	0.02		4/3	0.00	0.11	0.00		5/3	0.12	0.73	0.21
3/4	0.00	0.04	0.17		4/4	0.00	0.34	0.00		5/4	0.14	0.00	0.03
3/5	0.00	0.32	0.00		4/5	0.00	0.07	0.00		5/5	0.67	0.00	0.00
3/6	0.00	0.45	0.00		4/6	0.47	0.01	0.00		5/6	0.10	0.00	0.00
3/7	0.00	0.00	0.00		4/7	0.25	0.00	0.00		5/7	0.49	0.00	0.31
3/8	0.00	0.00	0.24		4/8	0.04	0.00	0.03		5/8	0.03	0.00	0.41
3/9	0.00	0.25	0.01		4/9	0.01	0.00	0.00		5/9	0.04	0.00	0.00
3/10	0.00	0.38	0.00		4/10	0.00	0.00	0.02		5/10	0.00	0.00	0.00
3/11	0.01	0.06	0.00		4/11	0.00	0.00	0.04		5/11	0.15	0.00	0.00
3/12	0.03	0.00	0.00		4/12	0.00	0.00	0.00		5/12	0.07	0.00	0.00
3/13	0.37	0.00	0.06		4/13	0.00	0.90	0.00		5/13	0.48	0.61	0.00
3/14	0.30	0.02	0.00		4/14	0.00	0.00	0.00		5/14	0.00	0.09	0.00
3/15	0.04	0.01	0.00		4/15	0.00	0.00	0.05		5/15	0.00	1.07	0.00
3/16	0.00	0.07	0.04		4/16	0.13	0.52	0.01		5/16	0.00	0.15	0.00
3/17	0.00	0.00	0.00		4/17	0.00	0.04	0.00		5/17	0.00	0.08	0.00
3/18	0.00	0.00	0.02		4/18	0.06	0.08	0.00		5/18	0.22	0.05	0.00
3/19	0.00	0.00	0.00		4/19	0.00	0.11	0.00		5/19	0.00	0.09	0.00
3/20	0.00	0.00	0.00		4/20	0.00	1.41	0.00		5/20	0.00	0.08	0.00
3/21	0.00	0.44	0.00		4/21	0.00	0.00	0.61		5/21	0.01	0.13	0.14
3/22	0.49	0.00	0.00		4/22	0.00	0.06	0.14		5/22	0.02	0.00	0.02
3/23	0.39	0.41	0.00		4/23	0.00	0.60	1.58		5/23	0.01	0.14	0.00
3/24	0.01	0.00	0.02		4/24	0.00	0.00	0.08		5/24	0.00	0.00	0.00
3/25	0.06	0.00	0.08		4/25	0.55	0.88	0.02		5/25	0.00	0.16	0.08
3/26	0.00	0.00	0.00		4/26	0.01	0.25	0.06		5/26	0.00	0.08	0.00
3/27	0.00	0.00	0.00		4/27	0.04	0.40	0.00		5/27	0.00	0.96	0.00
3/28	0.35	0.00	0.14		4/28	0.00	0.00	0.00		5/28	0.00	0.00	0.00
3/29	0.04	0.00	0.07		4/29	0.00	0.00	0.00		5/29	0.00	0.28	0.11
3/30	0.00	0.04	0.17		4/30	0.00	0.00	0.19		5/30	0.00	0.00	0.00
3/31	0.00	0.18	0.02							5/31	0.00	0.00	0.00
Sum	2.09	2.67	1.28			1.56	5.81	3.05			2.55	4.80	1.38

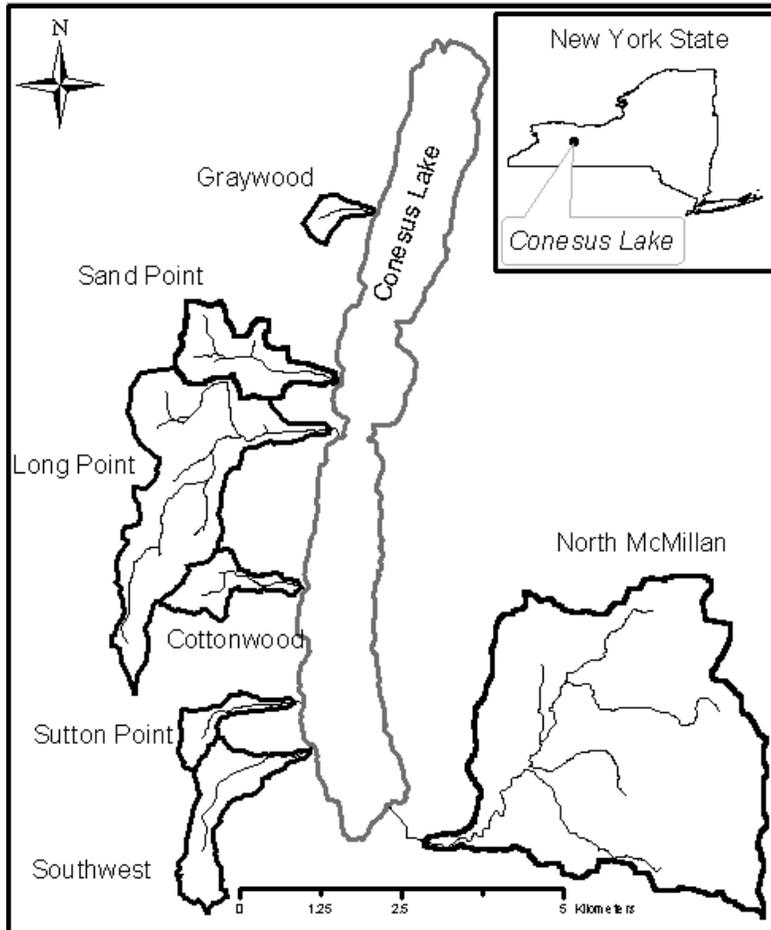


Figure 1. USDA sampling sites of Makarewicz *et al.* (2009).

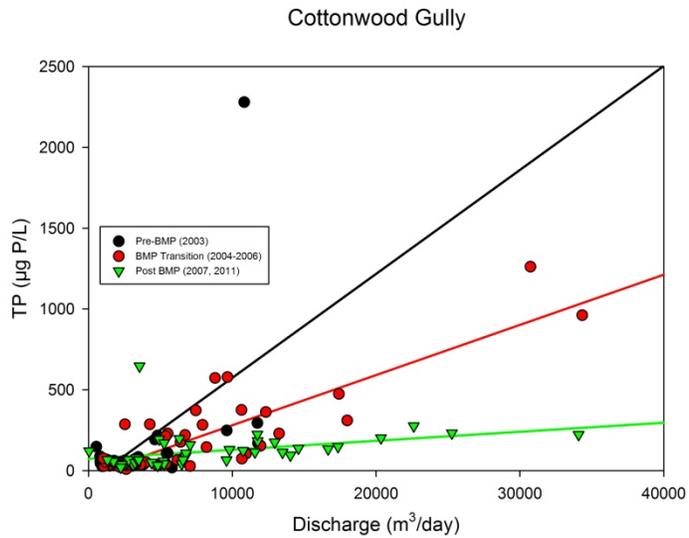


Figure 2. Cottonwood Gully spring discharge versus total phosphorus (TP) concentration for the 2003 to 2006 and 2011 period. Lines plotted are regression lines for the Pre-BMP period, Post-BMP period, and the transition period.

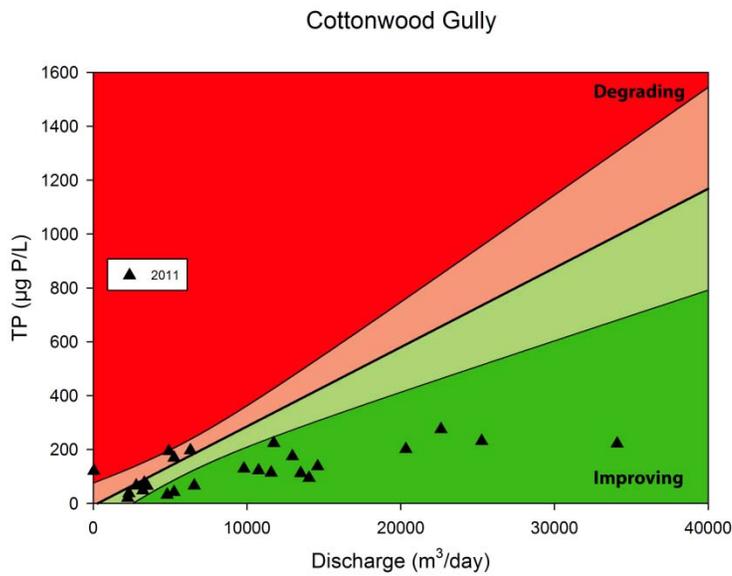


Figure 3. Cottonwood Gully Stream Water Quality Assessment Index. The triangles represent samples taken in 2011. See text for further explanation of the graph. TP=total phosphorus.

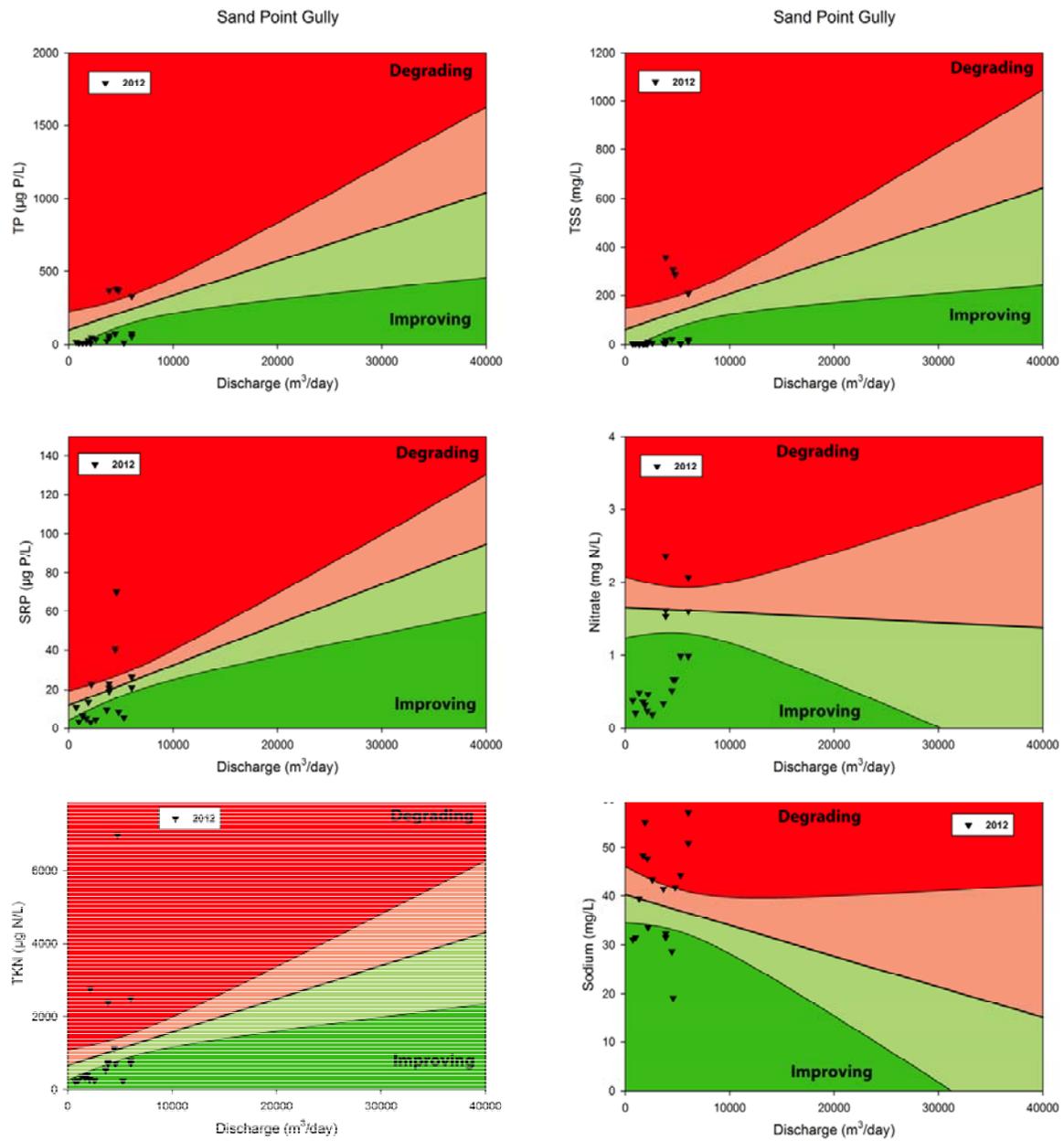


Figure 4. Sand Point Gully Stream Water Quality Assessment Index for total phosphorus, soluble reactive phosphorus (TP), total suspended solids (TSS), nitrate, total Kjeldahl nitrogen (TKN), and sodium.

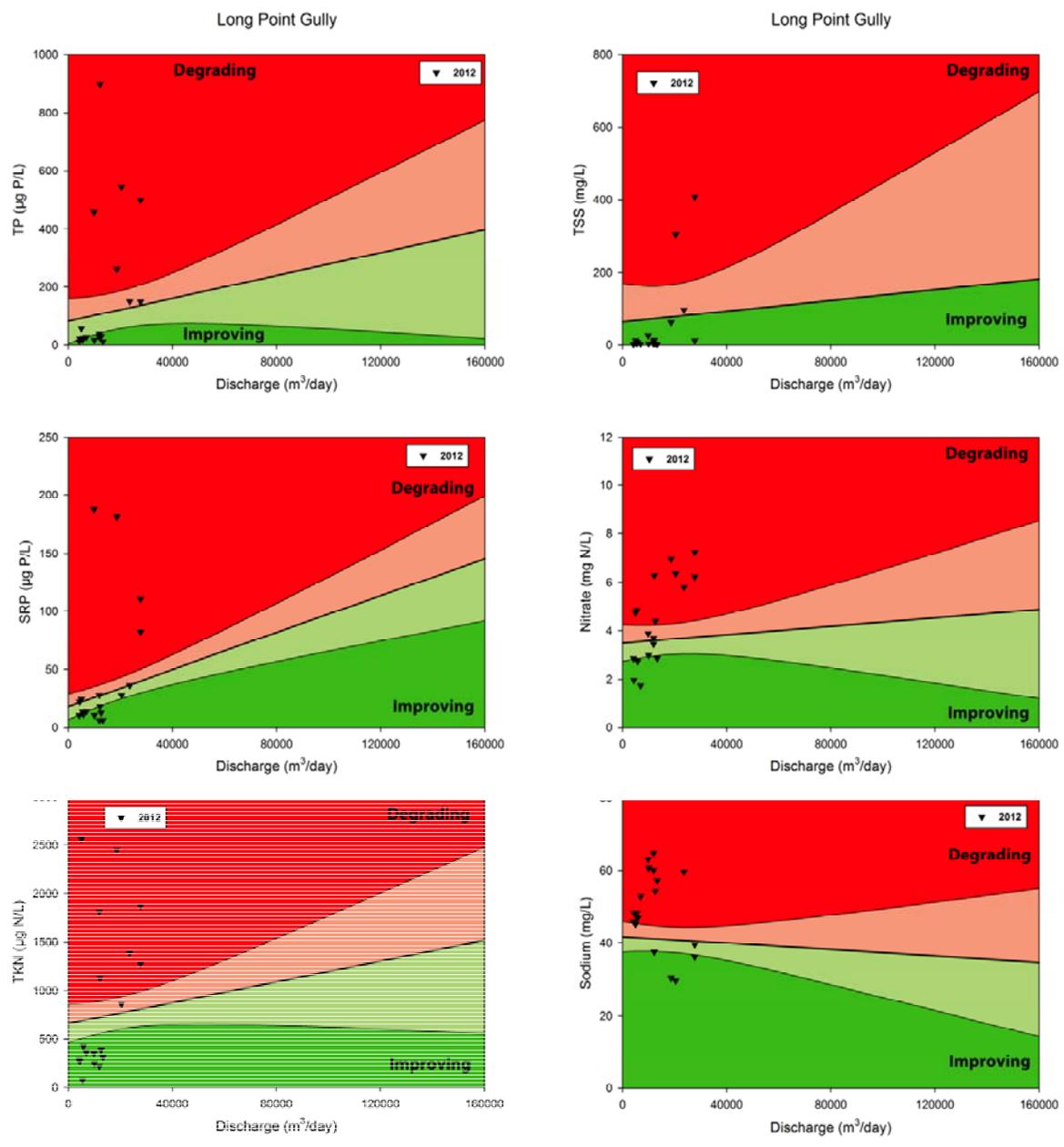


Figure 5. Long Point Gully Stream Water Quality Assessment Index for total phosphorus (TP), soluble reactive phosphorus (SRP), total suspended solids (TSS), nitrate, total Kjeldahl nitrogen (TKN), and sodium.

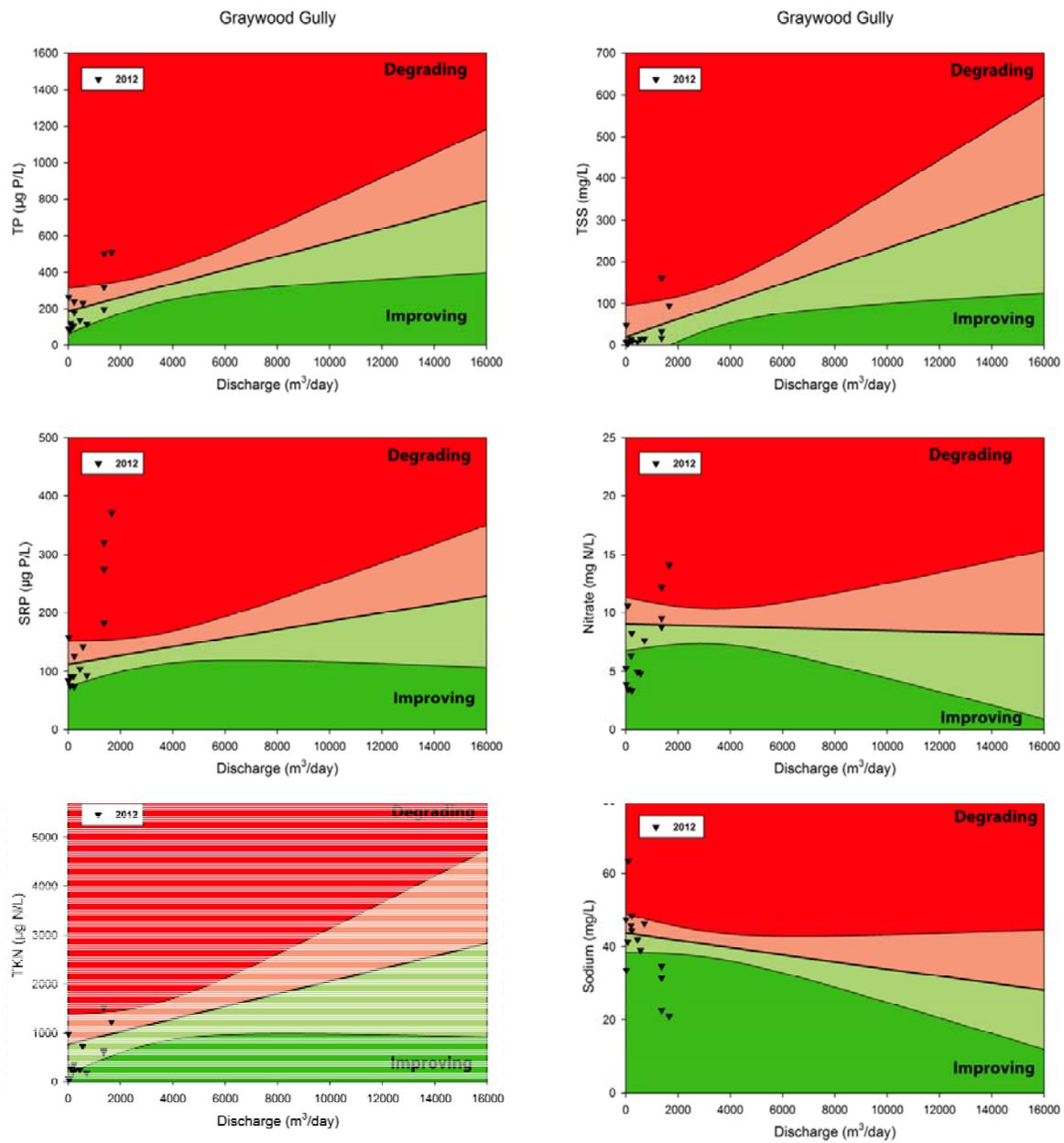


Figure 6. Graywood Gully Stream Water Quality Assessment Index for total phosphorus, soluble reactive phosphorus (SRP), total suspended solids (TSS), nitrate, total Kjeldahl nitrogen (TKN), and sodium.