RWQMN – DCNR Technical Summary

June 2016

Background

There are 10 Susquehanna River Basin Commission (SRBC) Remote Water Quality Monitoring Network (RWQMN) stations that are located on Pennsylvania state forest lands and another six stations that either drain significant portions of state forests or are heavily drilled watersheds that flow downstream through state forest lands (Table 1). All of the stations are located in the North Central Appalachian level III ecoregion which is largely forested (Map 1).

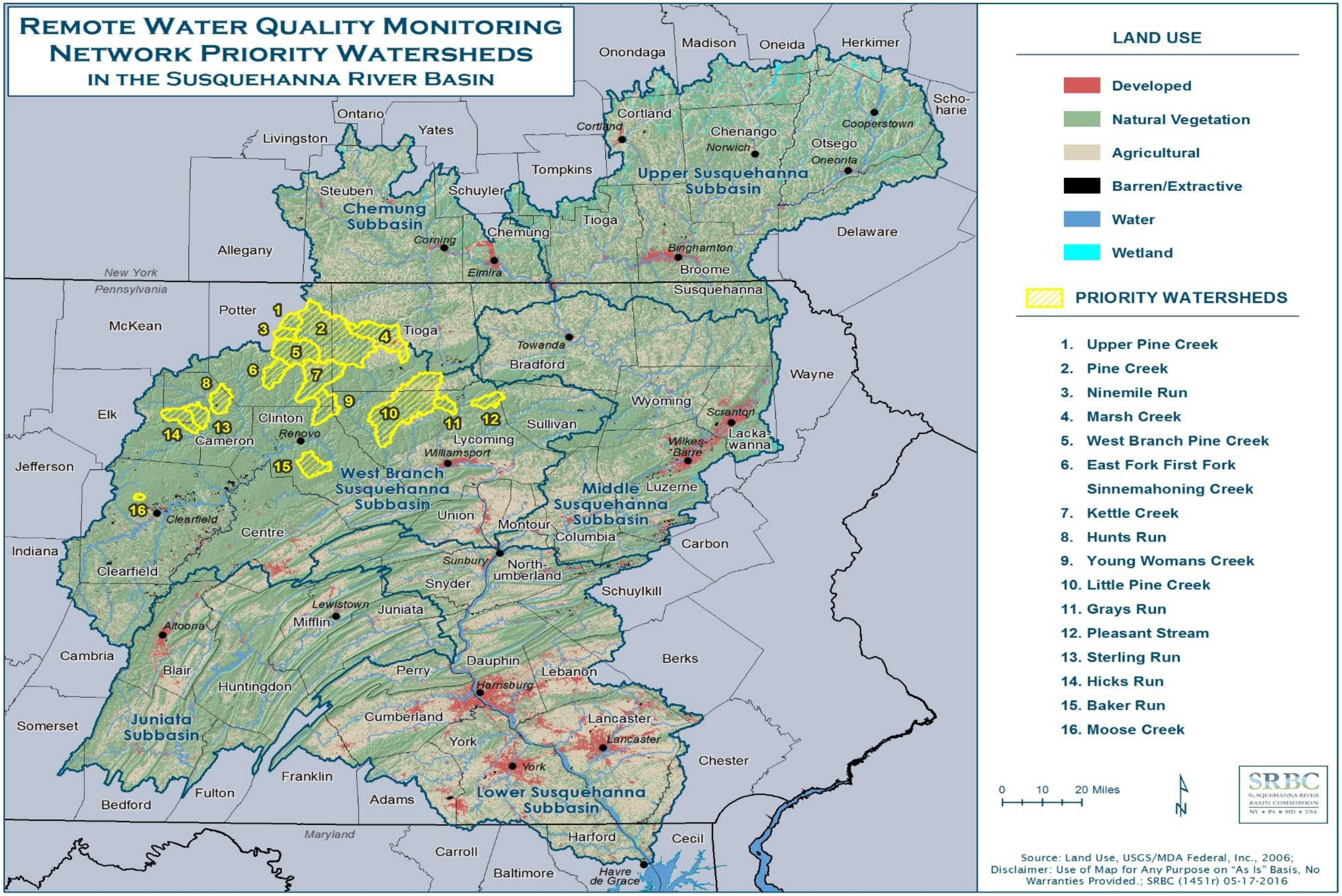
Table 1. DCNR Priority Watersheds

Watershed	Percent State Forest Lands	Fractured Well Density	Located on State Forest Lands
Baker Run	86	0.54	Yes
East Fork Sinnemahoning Creek	94	0.12	Yes
Grays Run	34	1.06	Yes
Hicks Run	34	0.18	Yes
Hunts Run	74	0	No
Kettle Creek	68	0.06	No
Little Pine Creek	13	0.91	Yes
Marsh Creek in Tioga Cnty	34	0.74	Yes
Moose Creek	98	0.33	Yes
Ninemile Run	73	0.19	Yes
Pine Creek	36	0.34	Yes
Pleasant Stream	82	0	No
Sterling Run	11	0.40	No
Upper Pine Creek	28	0	Yes
West Pine Creek	67	0.01	No
Young Womans Creek	98	0	No

The continuous monitoring stations were installed between 2010 and 2014, with the majority of the stations being installed in 2011 (all stations on state forest lands were installed in 2011). The stations monitor pH, temperature, dissolved oxygen (DO), specific conductance (SpCond), and turbidity at 5-minute intervals and the data are posted on a public website as provisional data. Because many of these stations have satellite telemetry, a 4-hr average is posted every four hours. Stations with cellular telemetry post all 5-minute readings every two hours to the website.

Continuous Water Chemistry Data

Natural gas drilling in the Susquehanna River Basin has brought three continuous monitoring parameters to the forefront: specific conductance, turbidity, and water temperature. Chemicals used in natural gas fracking have very high specific conductance concentrations and any spill or leak of these chemicals into the stream would influence the specific conductance of the stream.



Map 1. Land Use with Station Locations

Overall, the 16 stations exhibit low specific conductance concentrations (only three stations have average specific conductance values over 100) and do not see large changes even through different seasons and flow regimes. Box plots were used to show the monthly mean specific conductance concentrations at the sites (Figure 1). The box plots indicate little variability in specific conductance at the majority of the stations with the exception of Little Pine Creek, Marsh Creek in Tioga County, and Moose Creek. These stations not only show the most variability within the stations, but also have the highest average specific conductance concentrations. Little Pine Creek is a large watershed with the monitoring station being located downstream of reservoir. The station on Marsh Creek is located downstream of Wellsboro, Pa., which has numerous permitted dischargers. Moose Creek is a small watershed (3 mi^2) with one main impact – Interstate Route 80. Road salt is applied to Route 80 during the winter months and during snow melt and runoff, Moose Creek is impacted by the road salt.

Table 2. Average Continuous Parameter Values from Installation through December 31, 2015

Station	Specific Conductance µS/cm	Turbidity NTU	Temperature °C
Baker Run	28	4.35	9.201
East Fork Sinnemahoning Creek	43	2.939	9.47
Grays Run	31	2.911	9.262
Hicks Run	53	8.441	9.841
Hunts Run	35	2.639	8.899
Kettle Creek	56	4.205	9.728
Little Pine Creek	119	4.506	11.488
Marsh Creek –Tioga	175	20.595	10.644
Moose Creek	150	2.192	8.909
Ninemile Run	59	6.796	9.357
Pine Creek	89	23.843	10.198
Pleasant Stream	38	5.559	8.845
Sterling Run	78	5.647	9.625
Upper Pine Creek	79	3.457	9.437
West Branch Pine Creek	47	5.415	10.412
Young Womans Creek	39	2.012	9.149

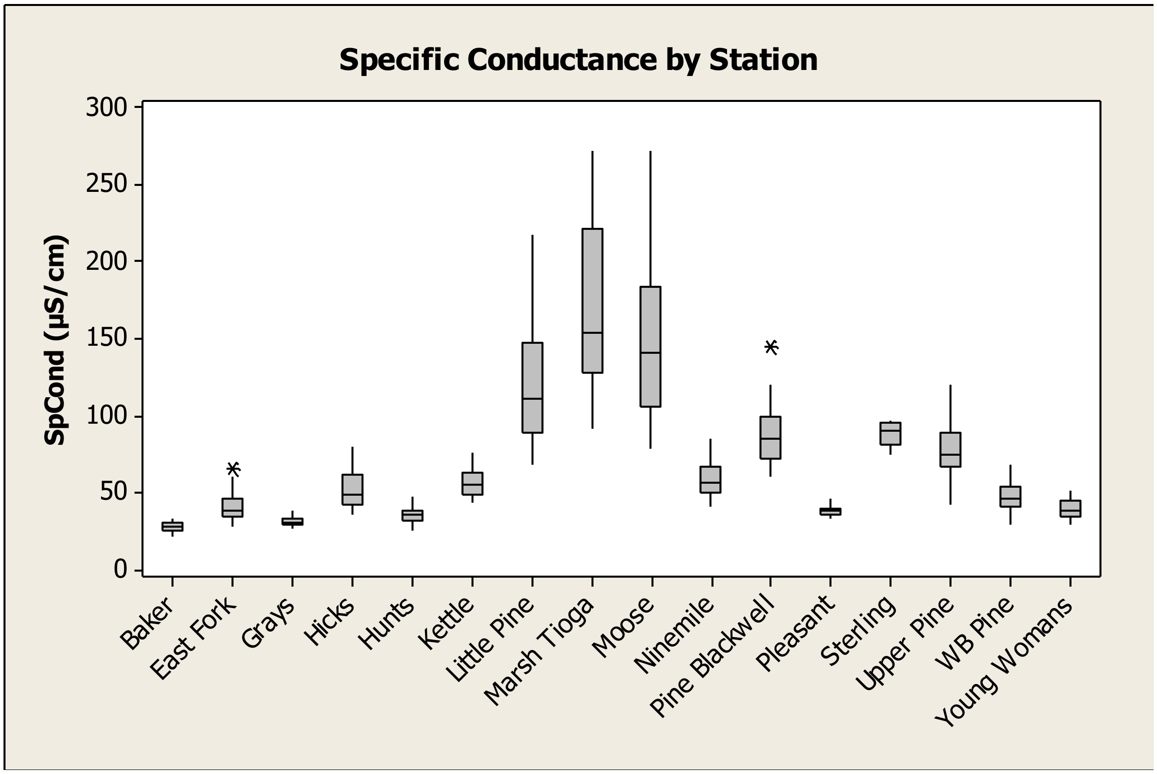


Figure 1. Box Plot of Average Monthly Specific Conductance Concentrations

Turbidity is a second parameter of concern related to natural gas drilling because additional infrastructure (roads, pipelines, pads, etc.) have potential to increase the volume of sediment in surface water systems. Additional sediment in streams will increase the turbidity levels. The monitoring stations are located in largely forested watersheds and have low average turbidity levels (Table 2). The highest average turbidity values are seen in Marsh Creek in Tioga County and Pine Creek. Marsh Creek is a slow, meandering stream impacted by agriculture and urban influences and Pine Creek is a large system, which tend to have higher turbidity values.

Figure 2 shows the variability of turbidity across the 16 stations. Pine Creek at Blackwell and Marsh Creek in Tioga County show the most variability in turbidity concentrations. These two sites are also significantly different (α=0.05) from the other 14 sites. Overall, turbidity concentrations are low at the monitoring sites, averaging less than 10 NTU at all the sites except for Pine Creek at Blackwell and Marsh Creek.

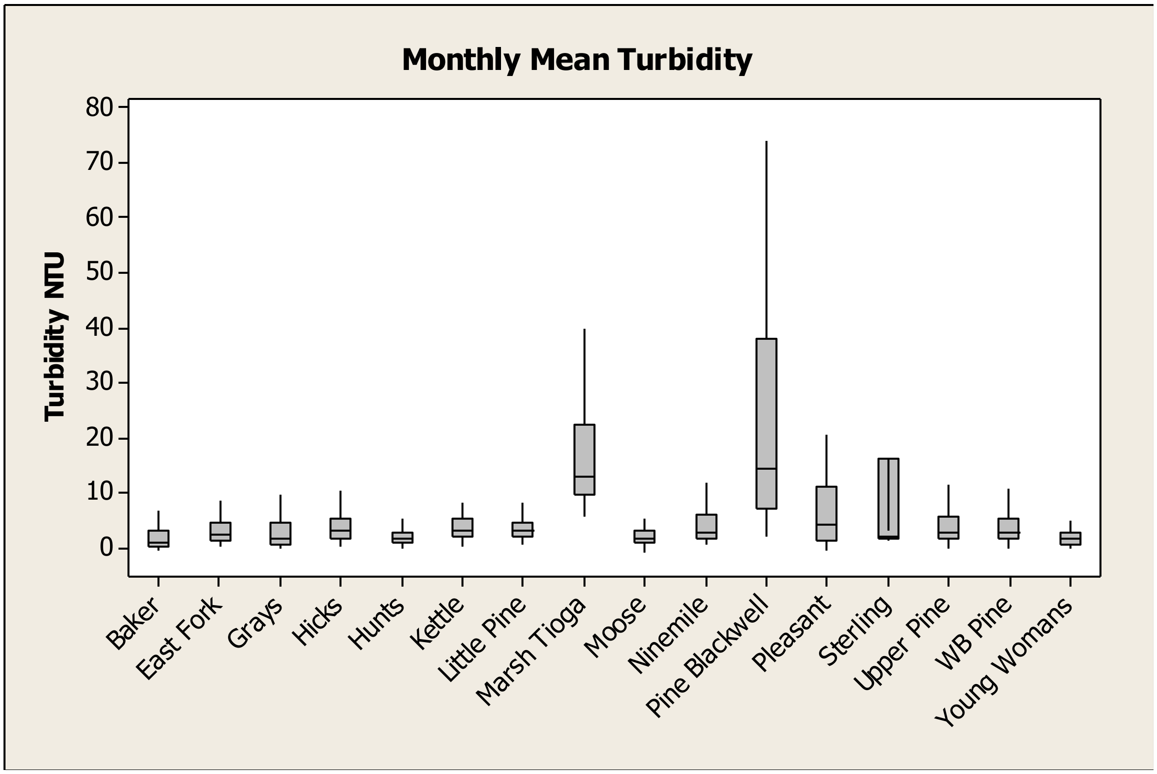


Figure 2. Box Plot of Average Monthly Turbidity Concentrations

Canopy cover within a watershed will help maintain a cooler stream temperature. Unconventional natural gas wells are located on large, cleared pads; in forested areas, trees must be removed to construct the pad site. As more pad sites are constructed in forested watersheds, it will be important to track stream temperature to see if it is rising as the percentage of forested land use is decreasing. The majority of the monitoring stations are located in densely forested watersheds providing cooler average streams temperatures (Table 2). There is no significant difference (α=0.05) in temperature between the 16 stations.

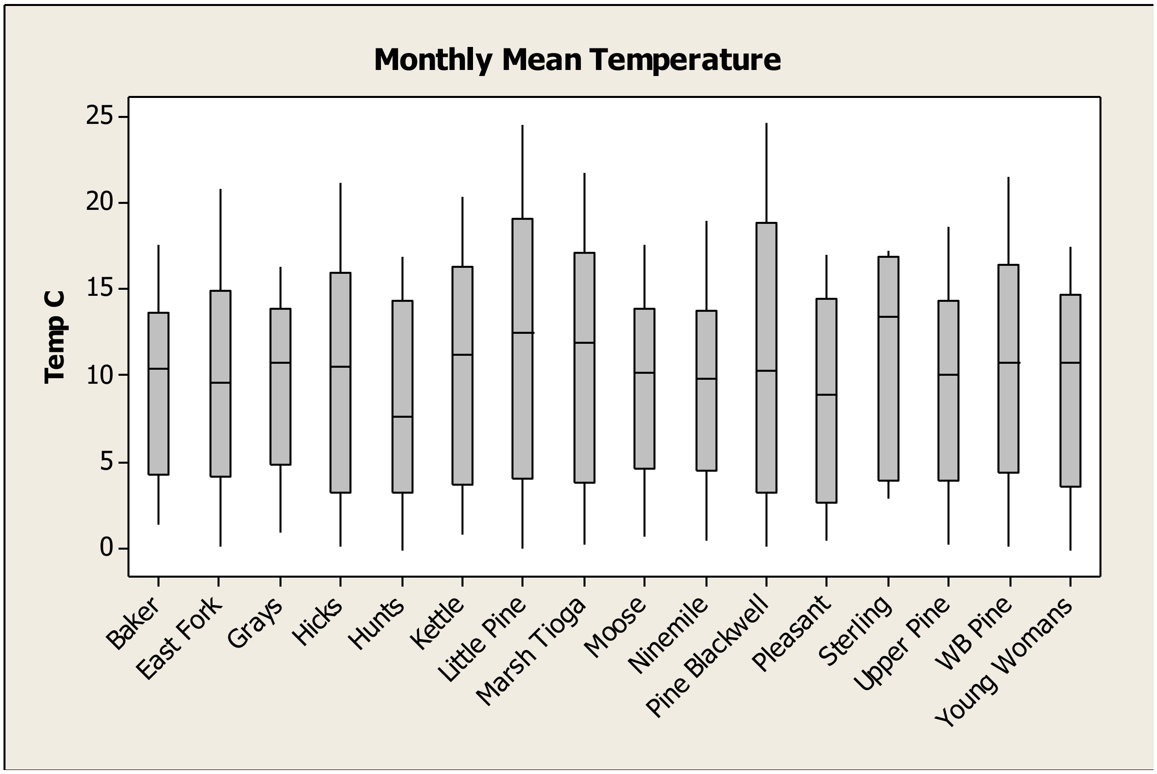


Figure 3. Box Plot of Average Monthly Temperature

Discrete Water Chemistry Data

Along with monitoring the stations continuously, SRBC staff collects grab samples on a quarterly basis to monitor metals, nutrients, major cations and anions, and radionuclides. A discharge measurement is also collected at this time. These samples represent a point-in-time analysis of the stream water chemistry and supplements the continuous water chemistry data being collected. Twenty-six parameters were collected with each grab sample (Table 3).

Table 3. Water Chemistry Parameters

Parameter	**Parameter**
Alkalinity	Lithium
Alkalinity, Bicarbonate	Magnesium
Alkalinity, Carbonate	Manganese
Aluminum	Nitrate
Barium	pH
Bromide	Phosphorus
Calcium	Potassium
Carbon Dioxide	Sodium
Chloride	Specific Conductance
Gross Alpha	Strontium
Gross Beta	Sulfate
Hot Acidity	Total Dissolved Solids
Iron	Total Organic Carbon

Only three of the 26 parameters did not meet water quality standards or levels of concern at all of the stations. Fourteen of the 16 stations have naturally low alkalinity, below the water quality standard of 20 mg/l, indicating the stations have a low buffering capacity. In streams with low buffering capacities, even a small introduction of acidic solutions could significantly alter the stream chemistry, having adverse impacts on aquatic life. Marsh Creek and Pine Creek are the only monitoring stations to have alkalinity concentrations averaging above the water quality standard, 43.3 mg/l and 23.9 mg/l, respectively.

Sodium and nitrate were the other two parameters to have at least one station exceed the water quality standard or level of concern. Moose Creek exceeds the water quality standard for sodium (20 mg/l). The average concentration for sodium at Moose Creek is 21.9 mg/l. Sources of sodium to surface water include road salt, wastewater treatment plants, water treatment plants, and water softeners (USEPA, 2003). Based on the land use and activities in Moose Creek, road salt is the likely source of sodium to the system as Interstate Route 80 borders the watershed.

The level of concern for nitrate (0.6 mg/l) is exceeded at Marsh Creek and Upper Pine Creek (0.66 mg/l and 0.75 mg/l, respectively). Marsh Creek has 12 permitted wastewater treatment plants located upstream of the monitoring station, has impairments from urban runoff, and agriculture comprises 22 percent of the land use. Upper Pine Creek has no stream impairments and is designated as a high-quality cold water fishery, but consistently (90 percent of samples) exceeded the level of concern for nitrate.

Continuous and discrete water chemistry samples at the monitoring stations indicate good water chemistry. Overall, little variability is seen in the continuous data and the streams are meeting water quality standards. Discrete water chemistry samples also indicate the streams are meeting water quality standards and levels of concern with a few exceptions.

Macroinvertebrates

Macroinvertebrates are commonly used as indicators of the biological health and integrity of streams. Much can be inferred about overall stream conditions by evaluating macroinvertebrate community assemblages which integrate local water quality and habitat conditions. Beginning in 2012, macroinvertebrates have been collected annually in October at all sixteen sites with the exception of those sites installed in later years. Sampling was conducted using the PADEP Freestone Streams (PADEP, 2013) collection protocol of compositing six D-frame kicks into one sample and subsampling to a 200 (+/- 20) individual count. Ideally, each of the six kicks targeted best available riffle habitat. At sites where riffles were infrequent, best available habitat (e.g., root wads, aquatic vegetation beds) was substituted for riffles. Subsampled organisms were identified by a certified taxonomist to genus when possible, with the exception of Chironomidae which remained at family level and Oligochaeta, which was identified to class. The taxa identified in the subsample were scored through a number of individual metrics which were combined to determine an Index of Biotic Integrity (IBI) score (PADEP, 2013). This score, based on a scale of 0-100, is a representation of the quality of the macroinvertebrate assemblage based on six separate metrics which describe different aspects of the community.

An IBI score above 80 is a general requirement for special designation and an IBI score below 43 is considered poor. All IBI scores for stream sampling locations, 2012-2015, were well above 43 and many sites scored over 80 (Figure 4). By the very nature of being on or surrounded by DCNR lands, most of these streams are in largely forested watersheds and support excellent biological communities. Of the 16 sites, all but three are located on stream segments that are currently designated as either Exceptional Value (EV) or High Quality (HQ) by PADEP. The three sites not currently EV or HQ are Little Pine Creek, Marsh Creek, and Sterling Run. Little Pine Creek and Marsh Creek consistently have the lowest IBI scores of any of the sixteen sites (Figure 4).

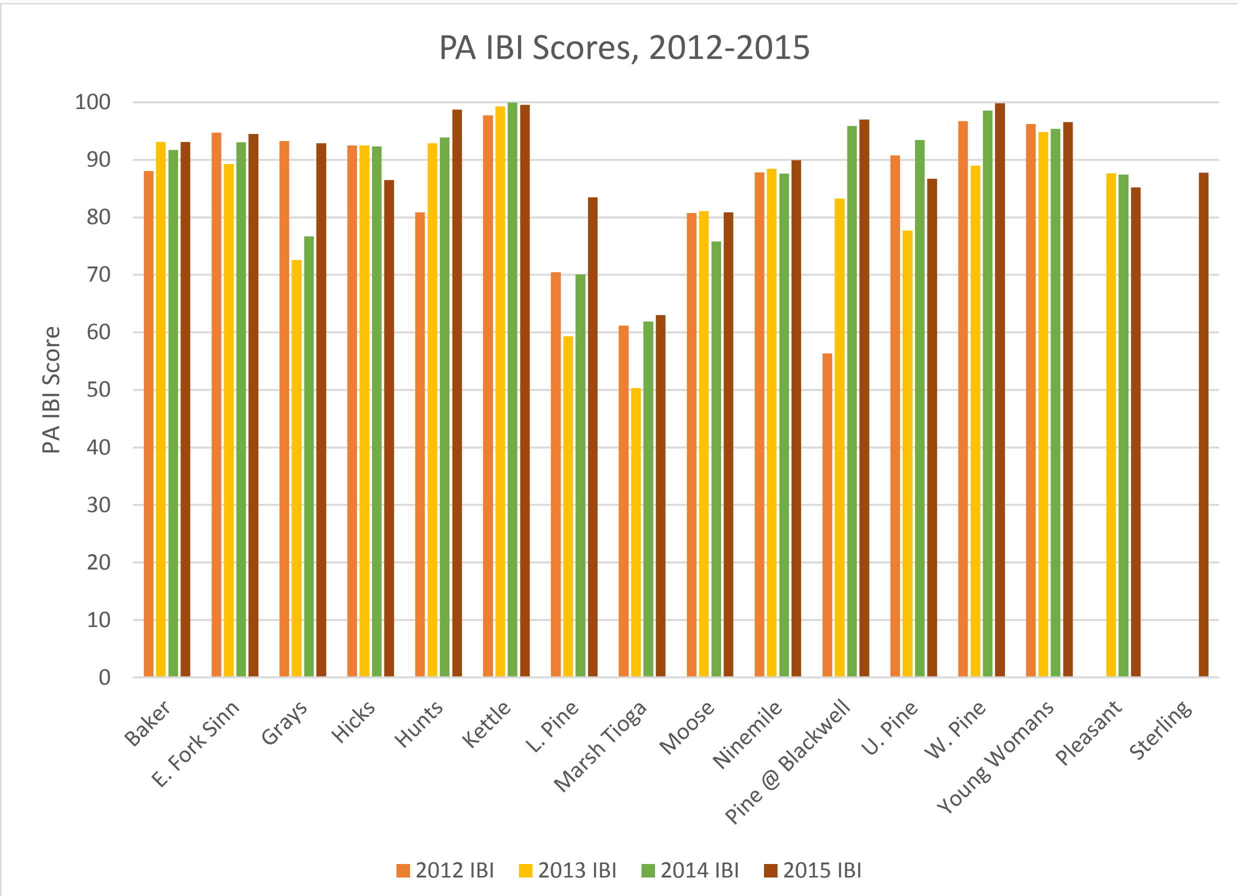


Figure 4. Summary of PA IBI Scores from 2012-2015 at DCNR Sites

Nonmetric multidimensional scaling (NMDS) was used to visually compare macroinvertebrate assemblage similarity. NMDS is a distance-based ordination method based on a similarity matrix that compares common taxa and abundance of those taxa between samples. By using the resulting similarity matrix as a basis, the NMDS plot uses proximity as a measure of similarity. Sites that fall nearest each other on the NMDS ordination plot are most similar. By assigning explanatory factors to each sample (e.g. year, size, ecoregion) plots can be used to assess groupings within all samples. In addition to generally high IBI scores across the board, macroinvertebrate communities were largely consistent from year to year at a majority of sites

(Figure 5). A few things of note from Figure 5, three sites (Little Pine Creek, Marsh Creek, and Moose Creek) cluster only with that site and away from the rest of the sites. Little Pine Creek and Marsh Creek are not EV or HQ so a different mix of taxa is not unexpected. Moose Creek is considerably smaller than any of the other sites, with just a 3-square-mile drainage area, and it also has a different chemical signature than other sites, so this site clustering out was also not surprising. Pine Creek at Blackwell is the largest site within these 16, with a drainage area of 385 square miles. It shows an interesting pattern of biological similarity with 2012 and 2013 plotting close together but away from the larger cluster and 2014 and 2015 clustering very close together and showing greater similarity to the larger cluster of sites. Results of an analysis of similarity test showed there was no significant difference in macroinvertebrate assemblages among years but assemblages were significantly different depending on drainage areas ($p = 0.001$). To illustrate the clustering of sites by drainage size, the symbology of the NMDS plot was changed to indicate three classes of watershed size (Figure 6). Results suggest that active gas drilling within the watershed did not have a measurable impact on macroinvertebrate community structure (Figure 7).

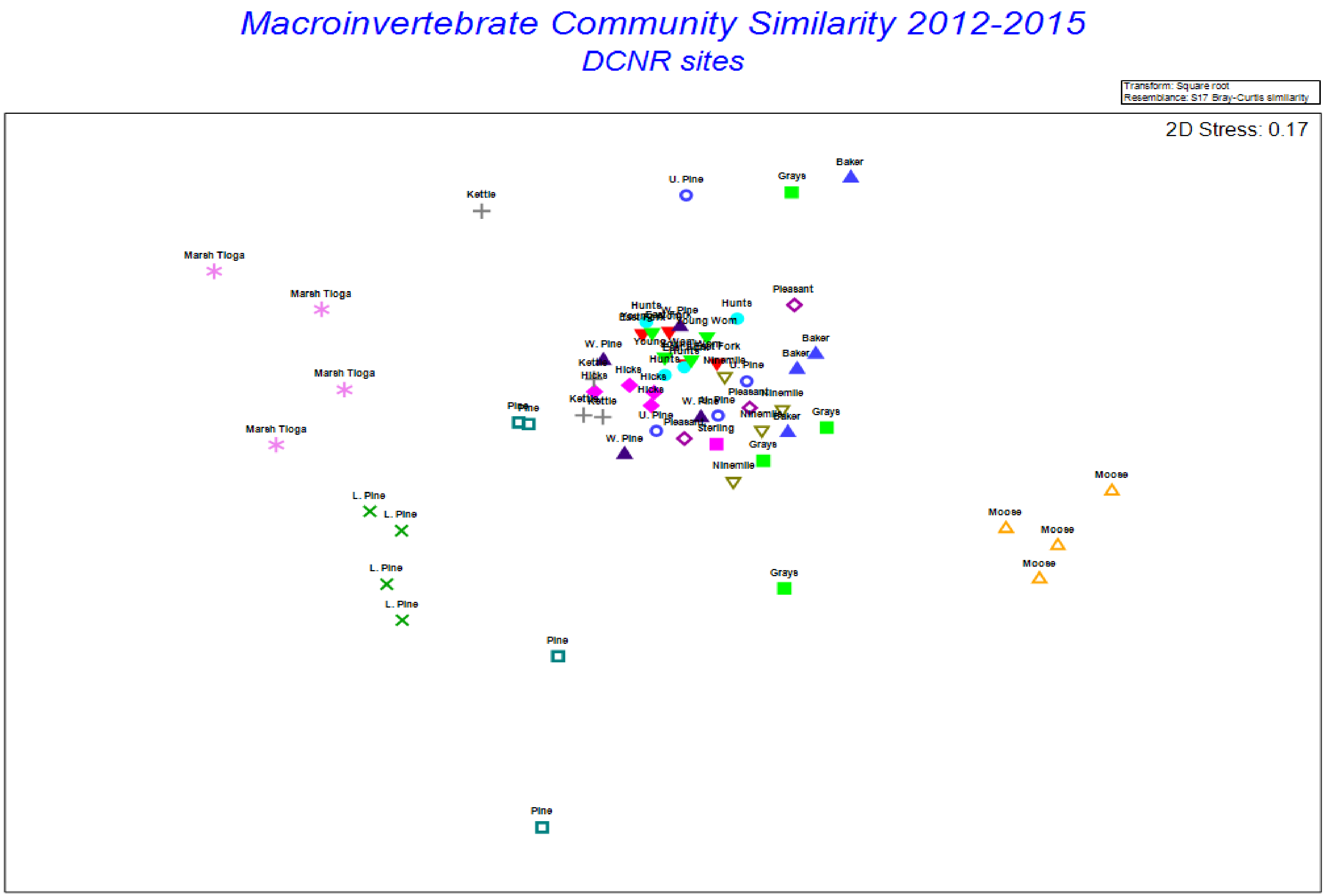


Figure 5. NMDS Plot of Macroinvertebrate Assemblage Similarity by Site, 2012-2015

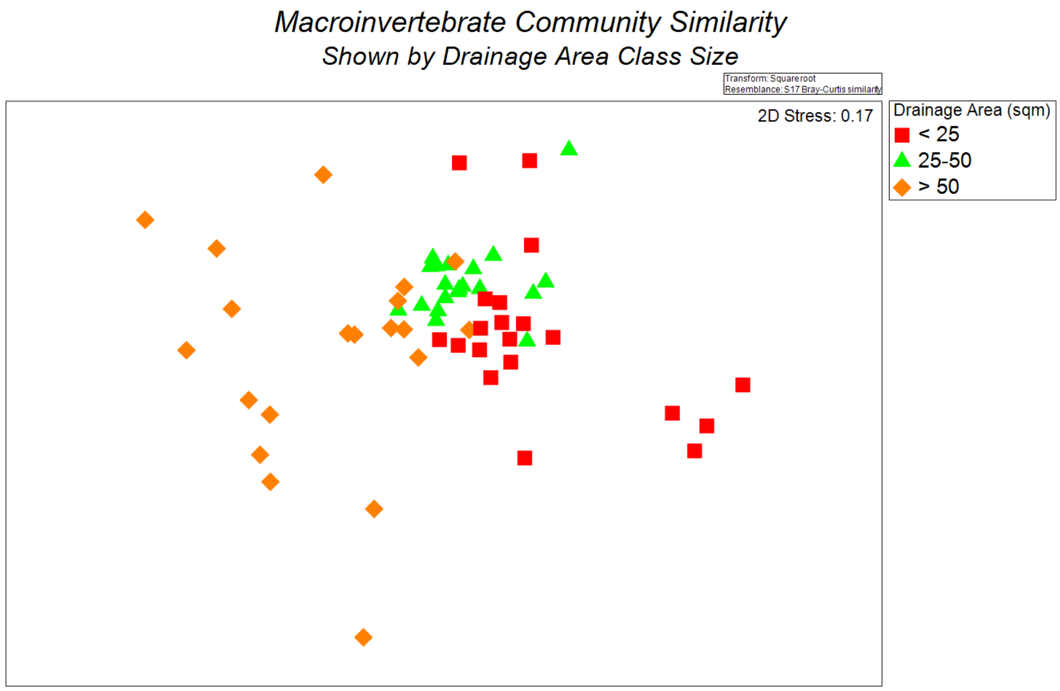


Figure 6. NMDS Plot Showing Similarity in Macroinvertebrate Assemblages by Drainage Area Size

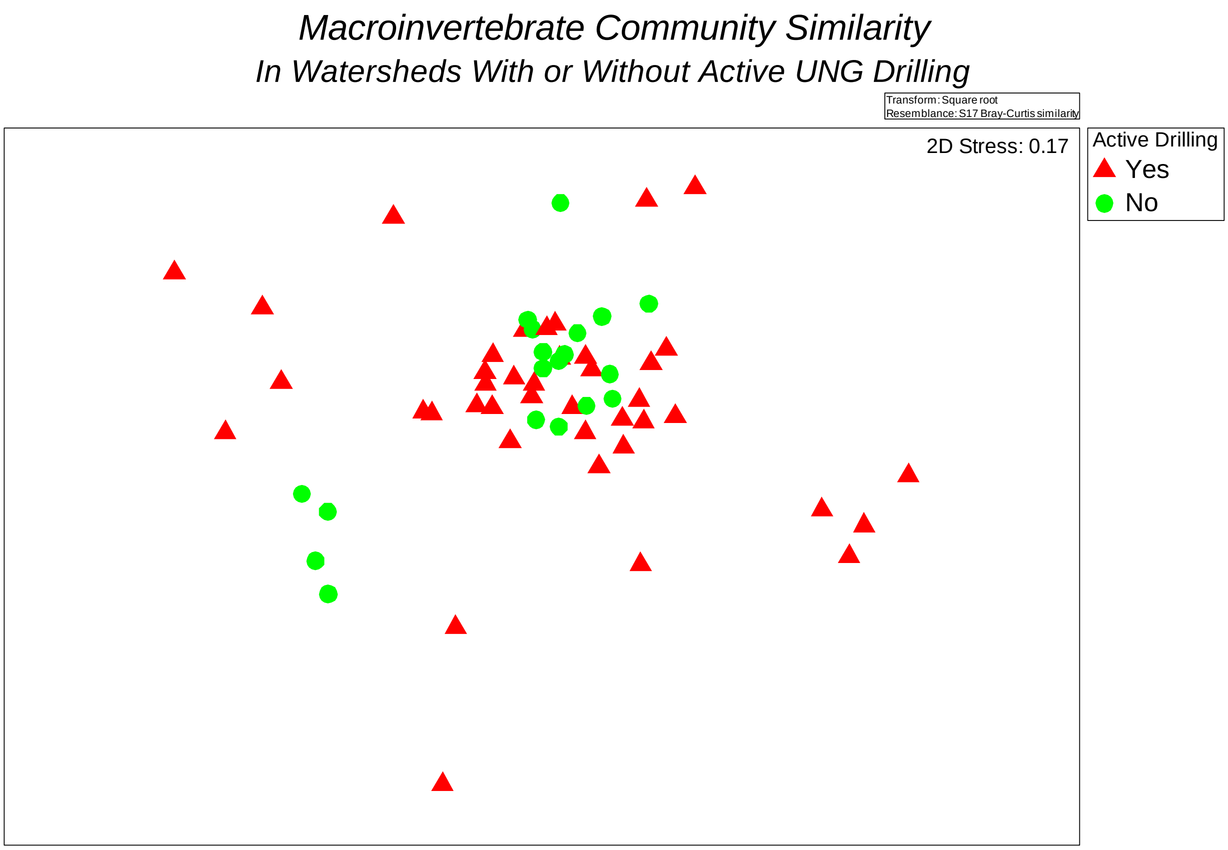


Figure 7. NMDS Plot Showing Similarity in Macroinvertebrate Assemblages in Watersheds With and Without Active UNG Drilling

Overall, macroinvertebrate communities in the 16 sites on DCNR lands support excellent macroinvertebrate assemblages and have maintained consistent IBI and supporting metric scores from 2012-2015.

Future Analysis

SRBC is continuing to monitor the water chemistry and biological health of these 16 stations. Water chemistry is monitored on a continuous basis and macroinvertebrates are sampled on a bi-annual basis. In addition to collecting the data, there are several efforts in place working to analyze the data. With the exception of Sterling Run, the stations have three or more years of data allowing staff to begin to look at water quality trends. SRBC will be releasing a report in late summer 2016 on water quality trends at all the continuous monitoring stations which includes the stations located on state forest lands. Macroinvertebrates have been analyzed at all stations for samples collected in 2011 through 2014 (SRBC internal document). Several analytical approaches were used on the data to identify links between water quality and biological assemblages, both community level relative abundance data and aggregated descriptive metrics. As further data are collected at the monitoring stations, SRBC will continue to add these data to the existing analyses and expand into new data analyses.

References

Pennsylvania Department of Environmental Protection. 2013. A Benthic Macroinvertebrate Index of Biotic Integrity for Wadeable Freestone Riffle--Run Streams in Pennsylvania. Pennsylvania Department of Environmental Protection. Division of Water Quality Standards.

United States Environmental Protection Agency. 2003. Office of Water. Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Sodium. http://water.epa.gov/action/advisories/drinking/upload/2003_03_05_support_cc1_sodium_dwreport.pdf.