Results

Base Flows

Base flow samples were collected in baseline conditions after there had been no significant rainfall for more than 10 consecutive days. Thirteen samples were taken on July 28-29, 2009, and the remaining three samples were collected on September 10, 2009, under very similar flow conditions. Only 8 percent of the parameters tested for all the sites exceeded water quality standards or levels of concern. During base flow, total phosphorus and total nitrogen were the two parameters that most consistently were above levels of concern for aquatic life. According to a USGS report (USGS, 1999), total phosphorus concentrations above 0.1 mg/l and total nitrogen above 1.0 mg/l are considered to be above natural background levels and are likely anthropogenically affected. This nitrogen and phosphorus can come from numerous sources, including effluent from wastewater treatment plants. Excess nutrients are harmful to streams, as high levels can lead to eutrophication. This abundant growth of algae and aquatic plants that may develop in nutrient-rich waters is often unsightly and decreases the value of waterbodies for recreation, fishing, and aesthetic enjoyment. Decomposing vegetation consumes large quantities of oxygen, which can lead to fish kills, foul odors and tastes, and increased water-treatment costs. Eight sites in the Lackawanna showed a concentration of total phosphorus above 0.1 mg/l and six of these sites (plus one additional site) also had total nitrogen concentrations above 1.0 mg/l during the baseline conditions.

Total aluminum was below the water quality standard (0.75 mg/l) at all sites during base flow, and iron was only above the water quality standard (1.5 mg/l) at the mouth of the Lackawanna River, which is expected since this site is downstream of the Old Forge borehole discharge. Total organic carbon (TOC), total dissolved solids (TDS), total suspended solids (TSS), zinc, and lead were all either under levels of concern or not detected at all. All sample results for copper, chromium, cadmium, and oil and grease came back below detection limits for the base flow sampling. Water temperature at all sampling locations was below 25°C, and dissolved oxygen levels varied from 5.7-9.7 mg/l. Turbidity was low at all sites, conductivity ranged from 180-760 mS/cm, and pH ranged from 6.1-7.6.

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For storm samples, iron, aluminum, nitrogen, phosphorus, and TSS were parameters of concern.

Stormflows

Two separate storms, one in December 2009 and one in March 2010, were sampled for this project. The December storm was a smaller rain event with about a half inch of rain in most areas, but less in others. Due to the short duration and smaller magnitude of this rain event, only half of the sites were sampled. In addition, staff deployed a YSI sonde downstream of Scranton at LAWR 7.0 to record continuous data during the storm. The second storm (March 2010) produced a longer and heavier rain event, with much of the watershed receiving an inch of rain or more in a 10-12 hour period. The March storm was representative of a high flow event for the Lackawanna River Watershed. Using statistics from the USGS gage at Old Forge, the average daily flow for March 23, 2010 (1840 cfs), would be equal to annual P4 flow and the peak flow from the storm (2890 cfs) would be equal to annual P1 flow. This means that based on probabilities from the past 72 years, flows are below these values 96 and 99 percent of the time, respectively. In addition, during the past ten years, only 3 percent of the days (125 days) have had higher average daily flow than during this storm event. For this storm, all sites were sampled, and most were sampled twice, with at least one sample collected on the rise of the hydrograph.

In the storm samples, 15 percent of the parameters for all sites exceeded water quality standards or levels of concern. These included iron, aluminum, nitrogen, phosphorus, and TSS. Total phosphorus typically increases during storms because phosphorus is linked to soil erosion and adheres to sediment particles. As erosion increases during high flows, more phosphorus is introduced into the system. During storms, nitrogen and TSS increased primarily due to the introduction of human sewage from CSOs. Iron and aluminum may be increased through CSO discharges, especially if they include industrial waste or overland runoff through old mining areas where exposed mine spoils lay bare and un-vegetated.

During storms, all sample results for chromium, cadmium, and oil and grease came back below detection limits for the stormflow sampling. There were two very low detections of copper during stormflow. The non-detection of oil and grease was likely the result of the timing of the sampling, which focused more on capturing the rise and peak of the storm, rather than the initial run-off that would contain a majority of the oil and grease from parking lots and roads. While no heavy metals were found in concentrations which were greater than water quality standards, zinc, copper, and lead were detected more frequently and in higher concentrations during stormflow than in base flow. There was a wide range in field chemistry from the storm samples as well, with conductivity values ranging from 60-500 mS/cm and turbidity from 3.3 – 105 NTU.

Leggetts Creek

Total nitrogen concentrations during base flow are four to five times higher in Leggetts Creek than anywhere else in the Lackawanna River Watershed.

Leggetts Creek Watershed is relatively small – slightly more than 18 square miles – but it has some of the highest nutrient concentrations in the Lackawanna River Watershed. Land use is 25 percent urban and suburban development (mostly adjacent to the stream corridor), 22 percent agriculture, and 45 percent forested. The sampling site is a few miles downstream of a wastewater treatment plant outfall, which could be a possible source of high nutrient concentrations. Total nitrogen concentrations during base flow are four to five times higher in Leggetts Creek than anywhere else in the Lackawanna River Watershed. In July 2009, total phosphorus was 0.87 mg/l (eight times greater than background levels) and total nitrogen was 5.2 mg/l (five times greater than background levels). Previous SRBC data confirm the same findings of very elevated nitrogen concentrations at this site during the summer months (Buda, 2009). Leggetts Creek also had the highest TDS concentrations, even greater than the site downstream of the Old Forge borehole, and conductance values were far higher than any other sampling location in the watershed. During storm events, water quality in Leggetts Creek exceeds even more standards. Total aluminum, total nitrogen, total phosphorus, and TSS concentrations were above water quality standards or levels of concern during both storms, and total iron was above water quality standards during the March 2010 storm. In addition, lead, TOC, zinc, and TDS concentrations were greater during stormflows but did not exceed standards. Suspended sediment concentration was also highest in Leggetts Creek.

Roaring Brook

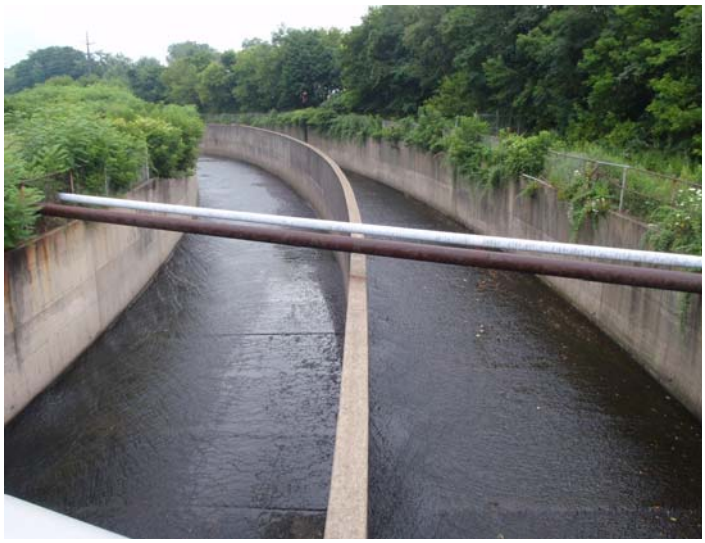
During base flow, Roaring Brook showed relatively high concentrations of iron — second only to the AMD-impacted site at the mouth of the Lackawanna River.

Roaring Brook drains an area more than 58 square miles and empties into the mainstem Lackawanna River in the city of Scranton through a concrete channel. The Roaring Brook Watershed is 12 percent urban and suburban development, with a majority of development located near the mouth in Scranton, 16 percent agriculture, and 64 percent forested. During base flow, Roaring Brook showed relatively high concentrations of iron – second only to the AMD-impacted site at the mouth of the Lackawanna River. Roaring Brook also was the only site that had aluminum values above the detection limit during base flow sampling. The lead concentration was 13 times higher in Roaring Brook than anywhere else in the watershed during base flow, although concentrations did not exceed water quality standards (65 µg/l). TSS levels in Roaring Brook were slightly above the water quality standard during base flow sampling. During stormflows, both nitrogen and phosphorus were above water quality levels of concern, as was TSS. Iron exceeded water quality standards during the larger storm in March 2010.

Spring Brook

Spring Brook was the only tributary that did not have any parameters that exceeded water quality standards or levels of concern during base flow or stormflow events.

Spring Brook was the only tributary that did not have any parameters that exceeded water quality standards or levels of concern during base flow or stormflow events. Spring Brook Watershed is mostly forested, and, of its more than 70-square-mile drainage area, less than 5 percent is comprised of urban land use. As a result, despite the fact that the lower reaches of Spring Brook are confined in a concrete channel between Old Forge and Duryea, the water quality is relatively good.



Mainstem Lackawanna River Sampling Sites

LAWR 35.2 (North of Forest City)

The most upstream site on the Lackawanna River was north of Forest City and was chosen as a control or reference site, as it is located in a primarily forested area above the greater Scranton metro area and above CSO influences. During base flow conditions, this site had no parameters that exceeded water quality standards or levels of concern. Macroinvertebrates were sampled here during base flow conditions, and the results showed a slightly impaired biological community due to a high percentage of one genus from the Philopotamidae family of caddisflies. Taxa richness, species diversity, Hilsenhoff score, percentage of EPT taxa, and percent Chironomidae all compare closely to the best sites of this size in the entire Middle Susquehanna Subbasin. During stormflows, the water quality at this site did not differ greatly from base flow as all parameters remained below water quality standards and level of concern. These results demonstrate the benefits that the stream receives from forested riparian buffers, a less impervious drainage area, and no CSO inputs.

Chosen as control or reference site — primarily forested area.

No parameters above standards — these results demonstrate the benefits that the stream receives from forested riparian buffers, a less impervious drainage area, and no CSO inputs.

LAWR 31.0 (Morse Street Bridge)

The next site was located at the Morse Street bridge upstream of Carbondale. During base flow, water quality at this site was quite good with no parameters exceeding limits. The substantial riparian buffer along the right bank is beneficial to maintaining good water quality even in an otherwise residential and industrial area. Even in stormflows, there were few water quality exceedances and minimal increases in sediment and turbidity. Total phosphorus and TSS were slightly over levels of concern during the December storm, but all other parameters were well within limits during both high flow events.

LAWR 28.2 (Pike Street, Carbondale)

This site was located downstream of Carbondale at Pike Street and was chosen to capture any water quality impacts coming from Carbondale. Compared to the upstream site (LAWR 31.0), base flow conditions were very similar with the exception of total phosphorus, which was 10 times higher at LAWR 28.2 than upstream at LAWR 31.0. Exact reasons for this are unknown, but phosphorus is a common constituent of fertilizers, organic wastes in sewage, and industrial effluent and could be entering the Lackawanna River Watershed by numerous means in this reach. During stormflows, concentrations of most parameters, including total aluminum, total iron, total nitrogen, total phosphorus, TOC, and TSS were all higher than at the upstream sampling location, although only TSS was above water quality standards. The drainage area between these two sites is comprised of, almost exclusively, the high density development of Carbondale. Macroinvertebrates also were sampled at LAWR 28.2 during base flow. Biological conditions at this site were rated as slightly impaired with a high percentage of mayflies and high taxa richness (18) for an urbanized stream. However, there was a fairly high percentage of Chironomidae, which brought the overall score down to slightly impaired.

LAWR 25.6 (Poplar Street, Mayfield)

Nutrient and metals concentrations were far below standards or levels of concern for baseline samples. During high flow events, this site marked the first of the sites to have aluminum and iron concentrations above water quality standards.

The next downstream site on the Lackawanna River was in Mayfield at Poplar Street. As a flood control prevention measure, the river in this reach is confined to a concrete channel. Water quality during baseline conditions was largely unremarkable, with nutrient and metals concentrations far below standards or levels of concern. The elevated phosphorus concentrations seen upstream were not seen at this sampling location during base flow. However, during high flow events, this site marked the first of the sites to have aluminum and iron concentrations above water quality standards. These exceedances occurred only during the larger storm and close to the peak of the flow.

Concentrations of nitrogen and phosphorus were two and three times higher than base flow but still not over the levels of concern. TSS concentrations exceeded levels of concern during both storms.

LAWR 23.0 – LAWR 17.9 (Archbald, Jessup, Olyphant)

The next three downstream sites had very similar water quality conditions during base flow and stormflow conditions. These sites were located at Gilmartin Street in Archbald, at Bridge Street in Jessup, and at Lackawanna Avenue in Olyphant, respectively. In base flow conditions at all three sites, no parameters exceeded water quality standards or levels of concern. However, as was the case upstream at LAWR 25.6, aluminum, iron, and TSS concentrations exceeded water quality standards during the March storm. Lead was only detected in the stormflow samples. Nitrogen and phosphorus were found at higher concentrations but did not exceed background levels during storm conditions.

LAWR 14.2 (Parker Street, N. Scranton)

During storms, suspended sediment concentration was one of the highest on the mainstem Lackawanna River.

The next site was located downstream of Leggetts Creek at Parker Street in north Scranton. Starting with samples collected here and continuing at the remaining five downstream sites, nutrient concentrations were notably and consistently higher during base flow than anywhere upstream. The influence of Leggetts Creek is seen strongly in the water quality data at this site during baseline conditions. During base flow, the upstream concentration of nitrogen is 0.3 mg/l; at this site, it is 2.4 mg/l. The largest contributor of flow between these two points is Leggetts Creek. During stormflow, these same increasing trends are evident for nitrogen and phosphorus levels in addition to the metals. The cumulative water quality impacts of the densely populated and heavily urbanized city of Scranton, along with the influence of many discharging CSOs, make the influence of Leggetts Creek less obvious during stormflows. During storms, aluminum, iron, nitrogen, phosphorus, and TSS exceeded water quality standards and limits. In addition, the suspended sediment concentration was one of the highest on the mainstem Lackawanna River, and Leggetts Creek had the highest concentration of suspended sediment in the whole watershed.

LAWR 11.1 (Olive Street, Scranton)

The Lackawanna River sampling site at Olive Street in the middle of Scranton was located three miles further downstream. Nitrogen and phosphorus both exceeded naturally occurring background levels at 2.07 mg/l and 0.25 mg/l, respectively, during base flow sampling. The macroinvertebrate community was noticeably degraded from the two upstream sites but still was considered only slightly impaired. The increased urbanization was reflected in fewer total taxa (10), fewer EPT taxa, and a higher Hilsenhoff score, meaning the genera found were more tolerant of organic pollution. However, the sample consisted of more than 18 percent Ephemeroptera (mayflies), which boosted the overall metric score. In the high flow events, total aluminum and iron were above water quality standards, including an iron concentration ten times greater than during base flow conditions. Total aluminum concentrations increased from undetected during base flow conditions to exceeding water quality standards during storms.

LAWR 9.3 (Elm Street Bridge)

This site was downstream of Scranton at the Elm Street bridge. Base flow nutrient concentrations were very similar to the site upstream, with both nitrogen (2.1 mg/l) and phosphorus (0.23 mg/l) above water quality background levels of concern. The remaining parameters were all within acceptable ranges. Storm sample results showed similar trends to the upstream site as well. Iron concentrations increased more than ten times from base flow to stormflow situations. However, neither nitrogen nor phosphorus concentrations exceeded background levels during high flows.

LAWR 7.0 (Taylor)

Due to a limited number of river access points in the city of Scranton, an additional location was sampled during base flow for water quality and macroinvertebrates. This site could not be sampled during storms because there was no bridge crossing, but staff collected biological and water quality data during baseline conditions directly downstream of Scranton in Taylor. During base flow, nitrogen was higher at this site than any site along the mainstem Lackawanna River at 4.7 mg/l, and total phosphorus also was elevated at 0.6 mg/l. All other water quality parameters were within acceptable ranges. The biological community at LAWR 7.0 was ranked as moderately impaired. The dominant taxon was Chironomidae, which encompassed more than 30 percent of the sample; only ten taxa were found, including only five EPT taxa. This biological condition was expected as the site was downstream of a majority of the greater Scranton area and all the perturbations that come from urban areas. A YSI datalogger was also deployed during two rain events at this site to take continuous field chemistry data readings.

LAWR 4.2 (3rd Street, Old Forge)

This was the last downstream site (located at 3rd Street in Old Forge, Pa.) on the mainstem Lackawanna River that is not impacted by discharge from the Old Forge borehole. Baseline conditions were similar to the four upstream stations, with nitrogen and phosphorus concentrations exceeding background levels and all other parameters within acceptable ranges. In high flow events, aluminum, iron, nitrogen, phosphorus, and TSS all exceeded water quality standards or levels of concern. Similarly to LAWR 11.1, aluminum increased from undetected at low flows to being over the water quality standard, and iron concentration increased ten times from base flow to stormflow.

LAWR 0.8 (Mouth of Lackawanna River)

The influence of CSOs and urban development on the site at the mouth are difficult to distinguish because of the considerable influence of AMD from the Old Forge borehole. Iron is the primary pollutant, and under normal circumstances, the river here is discolored by iron precipitate (yellow boy) and devoid of almost all aquatic life (Buda, 2009). Water quality during base flow includes an iron concentration of 6.1 mg/l; the water quality standard is 1.5 mg/l. In addition, nitrogen and phosphorus were both slightly above natural background levels at 1.8 mg/l and 0.13 mg/l, respectively. During stormflows, aluminum once again increases from below the detection limit to exceeding water quality standards. With the higher flows during storm events to dilute the influence of the borehole AMD discharge, iron concentrations are lower in storms (2.3 mg/l) but are still above the standard. TSS also exceeds water quality level of concern during stormflows at LAWR 0.8.

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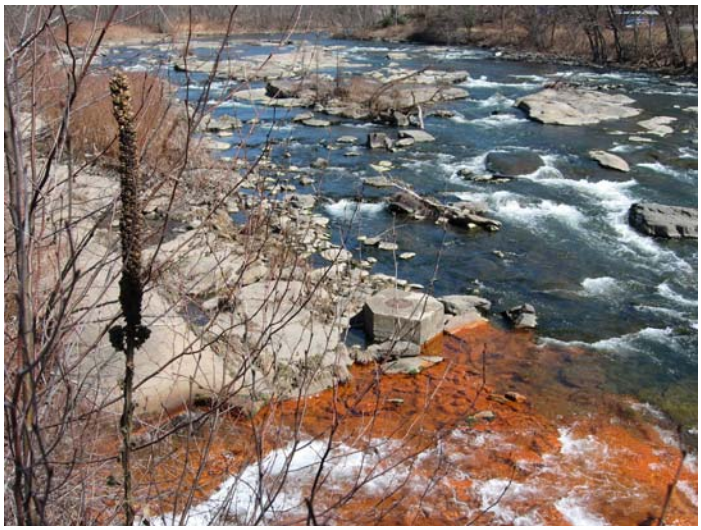

Influence of abandoned mine drainage from Old Forge borehole.

Review of reported CSO Data

Sewer authorities within the Lackawanna River Watershed are responsible for the operation, maintenance, and monitoring of CSO outfalls. Each sewer authority is required to submit monthly reports to PADEP documenting the operation of each outfall for which they are responsible. All reports include information about which days had overflows at which outfalls and how much rain was recorded for that day. In addition, some also include data on overflow duration and volume from specific locations. After reviewing these reports for all three sewer authorities from April 2009–April 2010, there are some interesting trends that emerge for the year as a whole, as well as for the two storms that were sampled. Reported overflow durations ranged from less than one hour to 40 hours. During very large storms, generally greater than one and one half inches, it was not uncommon to have CSOs flowing into the next day or even the second day after the rain stopped. Surprisingly, even during these large storms, not all CSOs actually discharge any water. In fact, there were numerous individual outfalls that did not overflow at all during the entire year.

However, there are also numerous outfalls that begin discharging with very little rain. During the study year, CSOs started discharging with less than a quarter of an inch of rain 40 percent of the time, and discharged with less than one half inch of rain 60 percent of the time.

During the December 2009 storm that was sampled, more than one million gallons of water was documented as being discharged from CSOs over a four-hour time period. During the March 2010 storm, more than seven million gallons of water were reported as discharged through CSOs over a 12-hour time period. These volumes do not include discharges from all CSOs, as those data are not available for all outfalls, so the cumulative volume from all CSOs is likely to be much higher.

Stormwater and CSOs are intricate issues that can be complicated to manage and difficult to correct. From this one-year study, it is easy to see the impacts of stormwater on the water quality of a watershed. Stormflows greatly increase pollutant loading, sometimes by more than 100 times the rate of base flow. The elevated nutrient and metal loadings during storms are a detriment to water quality and aquatic life. Although high flow events typically have short durations, they can cause considerable and ongoing damage to aquatic habitats. In the Lackawanna River Watershed, high storm flows, exacerbated by urban runoff and CSOs, have caused severe erosion of banks, scoured streambeds, and increased sedimentation.