# Shimel Run Mine Drainage Assessment and Restoration Plan

Prepared for the Moshannon Creek Watershed Coalition

by NMBS

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NEW MILES OF BLUE STREAM

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# Executive Summary

This project was undertaken to assess the water quality of the Shimel Run watershed, identify abandoned mine drainage (AMD) discharges, identify abandoned mine lands (AML), and to establish a plan to restore impaired sections of the stream so that native brook trout population can re-establish in the entire length of Shimel Run. This project was completed through a partnership between the Moshannon Creek Watershed Coalition Association (MCWC), Boy Scout Troop 48 of Osceola Mills, and NMBS. The project partners worked cooperatively to perform the necessary tasks to complete this project.

The Shimel Run watershed is located in Decatur Township Clearfield County, Pennsylvania and can be found on the Houtzdale, Wallaceton, and Sandy Ridge USGS 7.5-minute series topographic maps. The main stem of Shimel Run flows approximately 3.2 miles with approximately 0.8 miles of tributaries contributing to its flow. The stream originates northwest of the town of Drane and flows in a southeasterly direction until its confluence with Moshannon Creek northeast of Osceola Mills just off State Route 53. The Shimel Run watershed encompasses approximately 570 acres. Though the stream is adversely affected by AMD discharges, fish were seen at different sections throughout the main stem. With treatment occurring at priority areas within the watershed, fish will establish throughout the main stem and the reintroduction of trout will be made possible.

The MCWC, Boy Scouts, and NMBS worked together to assess the quality of Shimel Run. A stream walk was conducted along the entire course of Shimel Run and sampling location were established; ten discharge points were sampled on a monthly basis and four locations on the main stem were sampled on a quarterly basis. These sites were sampled for a period of one year for chemical parameters and flow rates. The discharges have only moderate to low levels of metal concentrations, but still degrade water quality in Shimel Run.

There were ten notable areas of pollution along Shimel Run that were sampled monthly, but only three of those were identified as needing treatment. Those discharges, SR-2, SR-5 and SR-7, can be treated passively using wetlands and limestone cells to improve water quality in Shimel Run to allow the existing fish populations to migrate throughout the watershed.

The primary goal of the project partners is to restore Shimel Run from the headwaters to the mouth where it enters Moshannon Creek. Restoration of this watershed will enhance the cold water fishery that already exists in some sections of the stream. Restoring the Shimel Run will, in turn, help improve the water quality to Moshannon Creek. Through remediation efforts of abandoned mine drainage within the Shimel Run watershed, the stream will be improved and a cold water fishery can be restored to an acceptable quality. A restored fishery would compliment the recreational activities, such as hiking, fishing, hunting, and ATV riding that already exist within the watershed. Restoration of the Shimel Run watershed will be accomplished through three priority treatment projects.

The recommended treatment systems for Shimel Run are all passive systems. These passive treatment systems will use the most appropriate of the technologies available at the time of design and construction. The systems will consist of a combination of aerobic wetlands, limestone cells, possibly an anoxic limestone drain, and aerating settling ponds.

If the three priority treatment projects are completed, Shimel Run is expected to be improved. Restoration efforts will allow for the aquatic ecosystem that exists in sections of the streams to re-establish throughout the entire length of Shimel Run. Eventually we look forward to re-establishing Shimel Run as a viable trout fishery.

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# Watershed Vision

It is the vision of the project partners to restore the Shimel Run watershed through remediation of abandoned mine drainage. These efforts will support the goal of improving water quality, and restoring a viable fishery throughout the length of Shimel Run. Restoration efforts will restore impaired sections of the stream and expand recreational opportunities. Restoration efforts will also focus on improving water quality in Moshannon Creek through the restoration of Shimel Run.

The restoration project also provides many hands-on learning opportunities for school students, youth groups, and the general public alike. Another vision of this project is to form a long-term stewardship in the watershed and to establish a relationship with the community that will work towards protecting and cleaning-up local watersheds.

# Introduction

Shimel Run has been moderately impacted by abandoned mine drainage throughout the study area mainly due to pre-act mining. Local residents have joined efforts of the MCWC to show ownership of their local stream and are committed to its restoration.

This stream was recommended for an assessment by the PADEP due to its ease of access and ability to be restored. Stream walks began in the Spring of 2006 to identify problem areas throughout the watershed. All discharges in the watershed were recorded to determine what discharges should receive monthly sampling. As the water quality of these discharges was assessed, it was determined only a few treatment systems were needed to completely restore Shimel Run. Throughout the development of the restoration plan, prioritization of problem areas was occurring. Thus far, we have not received any grants for design and permitting, construction or reclamation of problem areas outline in this restoration plan. Grants for the priority areas are expected to be submitted to insure the success and implementation of the restoration plan.

# Watershed Background

## Site Location:

The Shimel Run watershed is located in Clearfield County, Pennsylvania and can be found on the Houtzdale, Wallaceton, and (very minimally) Sandy Ridge USGS 7.5-minute series topographic maps (see page A2). The stream originates from a reclaimed surface mine near Drane and flows in a southeasterly direction until its confluence with Moshannon Creek along SR53. The nearest town is Osceola Mills. The watershed is comprised of approximately 570 acres The main stem is approximately 3.2 miles long and approximately 0.8 miles of tributaries contributes to its flow.

## Watershed History:

Generations of area residents have made their living and enjoyed recreation throughout the Shimel Run watershed. Recreation, including fishing, has been a favorite past time in this area, and despite degradation of the stream by AMD, sections of Shimel Run still contain an aquatic ecosystem. Mining occurred within this watershed in the early 1900s, but became prevalent in the 1940s through the present; this mining affected both water quality and the aesthetics of the surrounding landscape. Small deep mines accounted for most of the coal extracted prior to the 1940's, after which surface mining predominated. Most of the mining in the watershed was original done by one family: the Stein's. Local residents recall the Stein family having "punch" mines throughout the watershed. The large mine in the headwaters, where active treatment is still occurring, is the Miller-Stein operation. Active mining is once again occurring in the watershed near the mouth, where Junior Coal is remining an abandoned highwall area off of SR-53. All of these past and present activities have an effect on the water quality.

Historical water quality data was researched at the Moshannon DEP office. All permits in Decatur Township, both active and dead, were pulled off of the shelf and the topographic maps were reviewed to determine if mining occurred within the Shimel Run watershed. If mining took place and affected quality within the watershed, mining history was recorded and water quality was copied and entered into a database. This information is included on the project CD and on the newmilesofbluestream.com website. The historical data aids in completing the picture of mining activities and the subsequent affect on water quality. This historical data was used to develop the sampling plan and in the overall development of the restoration plan and treatment areas.

## Watershed Geology/Topography/Soils:

## Geology:

The description of the Geology of Clearfield County can be found at the Penn State University libraries and a map can be found on page A-12. Additionally, a (more current) geological map based upon data from DCNR (which originated with the Bureau of Topographic and Geologic Survey) appears on page A-11. Additional information can be found in the Geologic Surveys for the Houtzdale and Wallaceton Quadrangles. Clearfield County encompasses 1130 square miles. Based on geologic maps of the area surrounding Shimel Run, it lies almost entirely in the Allegheny High Plateaus of the Appalachian physiographic province west of the coastal plain physiographic province. This area is northwest of the Allegheny Front. The Houtzdale-Snowshoe syncline runs through this area. The stratigraphy in the study area consists predominantly of Mississippian and Pennsylvanian aged rock. In addition, thin local deposits of unconsolidated recent alluvium may be found along Shimel Run. Other than coals, the lithostratigraphy consists of heterogeneous succession of flat-lying beds of sandstones, siltstones, claystones, minor limestones, shales and other lithologies representing gradations between these various types. Some of the coals appear as major seams, while others appear as rider seams or as splits.

Within the watershed are both the Allegheny Formation which contains all of the mine-able coals and small segments of the Glenshaw Formation which rarely contains commercial coals. This allowed for extensive mining throughout the watershed. Removal of the Kittanning seams may account for the high alkalinity and pH found throughout the watershed, especially in the headwater reaches.

## Soils:

The 2005 NRCS data shows that there are approximately fourteen major soil units found along the main stem and tributaries of Shimel Run, with five making up approximately 50 to 60% of the watershed . The top five dominant soils along the main stem are Bethesda very channery silt loam(BeD or 92D), Gilpin channery silt loam (GlC and GlB), Wharton silt loam (WhB), and Brinkerton silt loam (BrB). Below are the descriptions for the fourteen major soil units found near the stream corridor within the watershed based on area starting with the largest. Approximately eighteen other soil units are found in the watershed. Information in this section was obtained from data provided by NRCS as well as a review of the Clearfield County Soil Survey. Several discrepancies were noted between the NRCS data and the older Soil Survey; the newer data was presumed to be more accurate for contemporary use.

**Bethesda very channery silt loam, 8 to 25 percent slopes (BeD or 92D)**

This soil is typically found on surface mine land on upland areas. It is deep and well drained. The permeability is moderately slow with a low available water capacity. Surface runoff is rapid or very rapid. Reaction in unlimed areas is strongly acid to extremely acid throughout. The dominant use is woodland, with hayland and pasture in some areas. The soil is generally suited to corn or small grain, and poorly suited to hay. The soil is poorly suited to pasture. It is generally unsuited to buildings and septic tanks due to the permeability and stability of the fill.

**Gilpin Channery Silt Loam , 8 to 15 percent slopes (GlC), –**

This soil is sloping, moderately deep, and well drained. It is on uplands. The slopes are generally smooth and convex. Reaction in unlimed areas is strongly acid to extremely acid throughout. Most areas of this soil are in woodland while some are in cultivated crops, hay or pasture. The soil, however, is suited to cultivated crops using techniques to reduce runoff and control erosion. The soil is also suited to pasture. The depth to bedrock is the main limitation of this soil.

**Wharton silt loam, 3 to 8 percent slopes (WhB) –**

This soil unit is gently sloping, deep, moderately well drained and found on uplands. It is listed as Prime Farmland of Clearfield County, and it contains hydric inclusions. Permeability is slow or moderately slow, and the available water capacity is high. Runoff is medium, and the reaction in unlimed areas is strongly acid or very strongly acid. The seasonal high water table is 18 to 36 inches, and the erosion hazard is moderate.

Most areas of this soil are in woodland, are cultivated, or are in permanent hay. Some areas are used for pasture, housing, or industry. The soil is also suited to cultivated crops, pasture, and trees. Non-farm uses are limited by the high water table and permeability.

**Gilpin Channery Silt Loam, 3 to 8 percent slopes (GlB), –**

This soil is gently sloping, moderately deep, and well drained. It is found on uplands with smooth and convex slopes. Reaction in unlimed areas is strongly acid to extremely acid throughout. Most areas of this soil are in native vegetation or woodland with few being cultivated crops, hay or pasture. The soil, however, is suited to cultivated crops using techniques to reduce runoff and control erosion. The soil is also suited to pasture. The depth to bedrock is the main limitation of this soil.

**Brinkerton silt loam, 3 to 8 percent slopes (BrB) –**

This soil unit is gently sloping, deep, and poorly drained. It is found on uplands. Permeability is moderate above the firm part of the subsoil and moderately slow to slow in the firm part, and runoff is slow. Reaction in unlimed areas is medium acid to very strongly acid. The seasonal high water table is from the surface to a depth of six inches, and the erosion hazard is moderate.

Most areas of this soil type are in woodland. The soil is also suited to some crops that tolerate seasonal wetness, pasture, and trees. Nonfarm uses of this soil are limited by the high water table and permeability.

**Ernest silt loam, 3 to 8 percent slopes (ErB) –**

This soil unit is described as gently sloping, deep, and moderately well drained. It is listed as a Statewide Important Farmland and contains hydric inclusions. The permeability is moderate above the firm part of the subsoil and moderately slow to slow in the firm part and substratum. The available water capacity is moderate, and the runoff is medium. The reaction in unlimed areas is strongly acid or very strongly acid. The high water table is at a depth of 18 to 36 inches, and the erosion hazard is moderate.

Most areas are in woodland. This soil unit is suited to cultivated crops, pasture, and trees. Non-farm uses are limited by the high water table and the permeability in the firm part of the subsoil. Within Shimel Run, this soil unit is found throughout the watershed close to the main stem.

**Cookport very stony loam, 0 to 8 percent slopes (CxB) –**

This soil unit is nearly level, gently sloping, deep, and moderately well drained. It is found on uplands. It has hydric inclusions. Stones of 3 to 10 inches in diameter are found on 3 to 15 percent of the surface. Permeability is moderate above the firm part of the subsoil, slow in the firm part, and moderately slow in the substratum. The available water capacity is moderate, and the runoff is medium. The reaction in unlimed areas is strongly acid to extremely acid, and the high water table is at a depth of 18 to 30 inches. The hazard of erosion is slight.

Most areas of this soil are in woodland. The stony surface make this soil unit unsuited to cultivated crops, hay, and pasture, but it is suited to trees. Non-farm uses are limited by the high water table and the slow permeability in the firm part of the subsoil.

**Clymer very stony loam, 0 to 8 percent slopes(CmB)**

This soil is very nearly level and gently sloping, deep and well drained. It is on uplands. Slopes are generally smooth and convex. Reaction in unlimed areas is strongly acid to extremely acid. The stones on the surface make this soil generally unsuitable for cultivated crops, hay or pasture. This soil is suited for trees, and potential productivity is high. Most areas are wooded. The depth to bedrock is the most limiting factor.

**Clymer very stony loam, 8 to 15 percent slopes (CmC)-**

This soil is sloping, deep and well drained. It is on uplands. Slopes are generally smooth and convex. Reaction in unlimed areas is strongly acid to extremely acid. The stones on the surface make this soil generally unsuitable for cultivated crops, hay or pasture. This soil is suited for trees, and potential productivity is high. Most areas are wooded. The depth to bedrock is the most limiting factor.

**Ernest silt loam, 8 to 15 percent slopes (ErC)**

This soil is sloping, deep and moderately well drained. Slopes are generally smooth and concave or convex. The permeability of this soil is moderate above the firm part of the subsoil and moderately slow or slow in the firm part and in the substratum. Available water capacity is moderate and runoff is medium. Reaction in unlimed areas is strongly acid or very strongly acid throughout. A seasonal high water table is at a depth of 18 to 36 inches. The hazard of erosion is severe. Most areas of this soil are in woodland. Some areas are in cultivated crops or hay or in native vegetation.

This soil is suited to cultivated crops. Subsurface drains are need in some areas that contain wet spots. This soil is suited to pasture. The soil is suited to trees and potential productivity is high. The seasonal high water table and the permeability in the firm part of the subsoil limit this soil for nonfarm use, especially for onsite waste disposal.

**Rayne-Gilpin complex, 15 to 25 percent slopes (RcD)**

This unit consists of moderately steep, well drained soils on uplands. Slopes generally are smooth and convex. They are approximately 60% deep Rayne soils, 30% moderately deep Gilpin soils and 10% other soils. The soils are so mixed that it is not practical to map them separately.

The permeability in these Rayne soil is moderate and available water capacity is high. Reaction in unlimed areas is very strongly acid or strongly acid. Runoff is rapid and the hazard of erosion is high. The permeability of these Gilpin soils is moderate and available water capacity is high. Runoff is rapid and the hazard of erosion is severe. Reaction in unlimed areas is strongly acid to extremely acid.

Most areas of this unit are in woodland. Some areas are in hazy, pasture or native vegetation. These soils are suited to some cultivated crops, but the hazard of erosion and slope are limitations. These soils are suited to pasture. This unit is suited to trees and potential productivity is high. Slope limits the use of equipment. Constructing roads on the contour helps to control erosion during timber harvesting. The depth to bedrock in the Gilpin soils and slope are the main limitations of the unit for nonfarm use.

**Ernest very stony silt loam, 0 to 8 percent slopes (ExB)**

This soil is nearly level and gently sloping, deep and moderately well drained. Slopes are generally smooth and concave or convex. The permeability of this soil is moderate above the firm part of the subsoil and moderately slow or slow in the firm part and in the substratum. Available water capacity is moderate and runoff is medium. Reaction in unlimed areas is strongly acid or very strongly acid throughout. A seasonal high water table is at a depth of 18 to 36 inches. The hazard of erosion is moderate. The stones on the surface make this soil generally unsuited to cultivated crops, hay or pasture. This soil is well suited to trees and most productivity is high. Most areas are woodland.

The seasonal high water table and the permeability in the firm part of the subsoil limit this soil for nonfarm use, especially for onsite waste disposal.

**Nolo very stony loam, 0 to 8 percent slopes (NxB)**

This soil is nearly level and gently sloping, deep, and poorly drained. It is on uplands. Slopes generally are smooth and concave. The permeability is moderate in the friable part of the subsoil and slow in the firm part. Available water capacity is moderate. Runoff is slow. Reaction in unlimed areas is very strongly acid or extremely acid. A high water table is between the surface and a depth of 6 inches. The hazard of erosion is slight. The stones on the surface and the seasonal high water table make this soil generally unsuitable for farming. The soil is suited to woodland and potential productivity is moderately high. Most areas are wooded.

The seasonal high water table and the permeability in the firm part of the subsoil limit this soil for nonfarm use, especially for onsite waste disposal.

## Wetlands:

The basin through which this stream drains was reviewed in regards to its location on the National Wetlands Inventory Map (NWI). The maps for the project area are the NWI 7.5 Minute Houtzdale, Wallaceton, and Sandy Ridge Quadrangles. Based on review of this mapping, sixteen wetland habitats were identified within the drainage basin of Shimel Run (see A-6).

All of the wetland habitats within the Shimel Run watershed can be placed into one of two systems, Palustrine or Riverine. The Riverine systems can be classified as Upper Perennial with an unconsolidated bottom. Hydrologically, they are permanently flooded. Four classes of Palustrine systems have been identified in this watershed. They are forested, scrub-shrub, emergent, and unconsolidated bottom habitats. The forested and scrub-shrub habitats are characterized as having broad-leaved deciduous, needle-leaved evergreen or dead vegetation. They range from temporarily to seasonally flooded and may result from impoundments. The emergent habitat type found within this watershed is characterized as persistent. Hydrologically, it is temporarily flooded. The unconsolidated bottom habitats range from semi-permanently to permanently flooded and result from impoundments or excavation.

## Land Use:

The Shimel Run watershed has been extensively mined for more than 80 years; mining has used both underground and surface mines. Remining activities are taking place within the watershed today. Local businesses such as John Glenn Sanitation and JJ Powel have offices near the mouth of Shimel Run. Logging has taken place in the watershed, though not extensively. Agriculture is also occurring in the watershed to a small extent. However, the majority of the watershed remains forested or reclaimed surface mine land, with the exception of a few homes and camps located within its bounds. It can be concluded, that land use impacts today are limited and do not significantly impact the water quality.

## Cultural:

The nearest community to the Shimel Run watershed is the village of Drane. Drane is a small, rural village that is home to several dozen families. Hunting and fishing is a favorite pastime of many of the residents there. Shimel Run supports small populations of fish at select locations throughout the watershed and through remediation efforts, it is believed the populations can spread throughout the main stem. Hunting, biking and hiking still occur at this time, and an abundance of wildlife is to be found there. Through restoration efforts in the watershed, the local community will benefit from restoring a significant cultural ingredient to the area.

# Mining

## Mining History:

Historically, both deep mining and surface mining have taken place within Shimel Run, dating back to the 1940s. Although Shimel Run still shows life, the water quality has been adversely affected.

Research completed during this assessment indicates that numerous permitted mining operations have occurred within Shimel Run At this time, one active operation is occurring by Junior Coal and another one ("Miller Stein"), which was operated by Al Hamilton Construction, is currently being actively treated under forfeiture.

The Department of the Interior, Office of Surface Mining Reclamation and Enforcement, was contacted to conduct a search of the ("Bureau of Mines") deep mine maps that have been catalogued within the watershed. This research indicates that there are several historic underground mining operations near the watershed and three (on two WPA maps – these are on accompanying CD) within the watershed. Through mine permit research, it also appears that a large underground mine existing in the headwaters, along with smaller deep mines throughout the watershed.

There are also a number of areas within Shimel Run on the BAMR AML inventory and priority areas. See maps A-8 and A-9 for more detail on these items. It appears that some of these areas have already been addressed through remining activities in the watershed.

See maps A-7 and A-8 for mapping of the mining activities. These historical mining permits were researched for water quality to include in the database and are discussed below. The historical water quality which was analyzed can be found on the project CD or on the newmilesofbluestream.com website.

## Historical Permits:

Historical water quality data was researched at the Moshannon District DEP office. All permits in Decatur Township, both active and dead, were pulled off of the shelf and the permit maps were reviewed to determine if mining occurred within the Shimel Run watershed. The following is a list of permits found in the Shimel Run watershed and information located in each permit. Additional information could be found by going to the Moshannon District DEP office and further investigating the coal permit.

- 17880109—This permit was a surface mine operation of King Coal Sales called Drane #4 Operation. It was permitted for 257 acres and 131 acres were affected. It mined the upper and middle Kittanning and the lower Freeport. It mined through existing surface and deep mines and had pre-existing discharges, D4-KJ5, D4-KJ56 and D4-77.
- 17940103—This permit was a surface mine operation of King Coal Sales called the Indigo Operation. It was permitted for 50 acres and 43.7 acres were affected. It mined the upper Kittanning and upper Kittanning rider. It had a variance to mine within 100 feet of Shimel Run. It received Stage III bond release in March 2007.
- 17970118—This permit was a surface mine operation of Junior Coal called the Decatur Operation. It was permitted for 71 acres and 39 acres were affected. It mined the upper and middle Kittanning and the lower Freeport. It remined 13 acres and eliminated 1500 feet of

highwall, along with improving 2000 feet of stream. Its reclaim value was $21,000. It placed 150 tons of baghouse lime on the middle Kittanning pit floor and spoil prior to backfilling and the upper Kittanning pits were to be ripped to expose the Johnstown limestone. They did alkaline addition to 15 acres at a rate of 630 tons/acre. They received a variance to within 100 feet of Shimel Run. The site has been backfilled since 2005.

- 17020101—This permit is an active surface mine operation of Junior Coal called Elliot South located near the mouth of Shimel Run. It mainly drains to Big Run, but has sample locations on Shimel Run. Sample point MP-1 is Shimel Run upstream and MP-6 is Shimel Run downstream. This mine is affecting 215 acres and removing 160 acres of coal. It is a remining 33 acres, daylighting 77 acres of deep mines, and eliminating 7600 linear feet of highwall. They are mining the upper Kittanning, and the upper and lower Freeport.
- 17910115—This permit was a surface mine permit of Forcey Coal called the Lynn Operation. It was permitted for 21.3 acres and 19.6 acres were affected. It mined the upper Kittanning and lower Freeport seams. They were to rip the upper Kittanning pit exposing the Johnstown limestone strata along with monitoring the pit quarterly. They were also responsible for a quarterly dilution ratio for Shimel Run.
- 17990102—This permit was a surface mine permit of River Hill called Six Mile Road Operation. It was a remine operation where 58 acres of surface was affected and 59 acres of deep mine were daylighted. They also eliminated 3900 feet of highwall. It mined the Clarion, upper and lower Freeport, upper, middle and lower Kittanning. They were responsible for special handling and alkaline addition to the site. The site had three pre-existing discharges, 7, 7A and 11. Some of the water from the permitted area drains to Little Laurel Run which has showed signs of degradation relative to background data. The site has been idle according to the May 2008 report.
- 17753159—This permit was a surface mine permit of Central PA Coal called the Miller Stein Operation. It was permitted for 475 acres with 209 acres affected. This permit mined the middle and upper Kittanning and the lower and upper Freeport. In 1993, the permit was transferred to Al Hamilton Contracting. It drains to Shimel Run and to two unnamed tributaries of Little Laurel Run. There was previous mining in the watershed on the Clarion and the lower Kittanning which produced poor quality drainage in the upper reaches; there was also mining on the upper Kittanning and lower and upper Freeport in the lower watershed which produced poor water quality. This was used to show precaution during mining activities. It turns out this permit produced a discharge that is still being actively treated. This permit is also on property or near and/or related to two additional permits not found. The "Stein" permit numbered 4475SM39 which mined seams MK, MK rider, UK and LF and the "Miller" permit on the Shoemaker property numbered 17800136 which mined the MK and MK rider. Both were mentioned in the Miller-Stein permit but were not found on the shelf.
- 17860144—This permit was a surface mine permit of Junior Coal which was a transfer for Power Operating called the Elliot Operation. It was 324 acres with 241 acres to be affected. This permit mined the upper and lower Freeport, lower Freeport rider and upper Kittanning. This site had previous mining of 17840151 by Forcey and 17820151 by T&T clay on the UF, LF and UK listed in the permit.
- 17050102—This permit was a surface mine permit of Whitetail Contracting called King#1 Operation. It was 18.5 acres with 12.8 acres affected on the upper Kittanning seam. It was a small remining operation where special handling techniques were used and 1800 to 3600 tons of limestone per acre were used in the backfill.

- 267M006—This permit was a surface mine operation of Associated Drilling opened in 1967 in the headwaters of Shimel Run on the C coal. It affected 1073 and was a precursor to all later mining in this area. They added an additional 1388 acres in 1974. As part of the permit they mention sealing the Reading #2 mine, along with sealing the Kephart Mine and Monarch Shaft, along with having the following history of mining:
    - Twist deep mine on UF and LF, abandoned 1936 to Moshannon Creek
    - Thomas Walker, UF, operating 1936 to Moshannon Creek
    - Baltic slope, UF, abandoned 1936 to Gearheart Run
    - Reading #2-3, deep mine, UF and LF, operating 1936 to Shimel Run
    - Dunlap-Leader, deep mine, UF and Kittanning seam, abandoned 1936 to Shimel Run
    - J. Rider, deep mine, MK, LF and UF, to Shimel Run
    - Superna and Palinpesky, deep mine, #9713, LF, A-type, issued 5/18/48, to Shimel Run
    - C.E. Powell Coal Company, strip mine, #14060, A-type, issued 7/18/54, to Shimel Run
    - Dale Taylor and Son Coal Company, strip mine, #18710, A type, issued 7/19/59, for LF, MK and LK seams, to Moshannon Creek
    - Risinsky and Stevens Coal Company, deep mine, #19254, A type, issued 3/25/60, for the MK seams
    - George Bowers strip, #261M134, issued 1/4/62, UF seam to Shimel Run
    - Elliot Coal mine company, deep mine, #264M4, A type for the MK seam, tributary to Moshannon Creek
    - See above, #266M011
    - Hasley Cont. Company, #3268BSM009, C-C' (strip)
    - Hasley Cont. Company, #1769302, deep C seem
    - K&J Coal Company, #4473SM4, C'-D-E seams
    - K&J Coal Company, #4474SM4, A B rider, C-C'-D
    - Earl M. Brown Company, #4470SM16, A-A rider
    - Avery Coal Company, strip, #4472SM11, C-C'-D-E
    - Power Construction Company, strip, #4471BSM9, C-C'-D-E
    - Fran Contracting Company, strip, #4472BSM11, C-C'-D-E
    - K&J Coal Company, strip, #4474SM4, A, B – rider, C-C'-D
- 17800136T—This permit was a surface mine operation of Central PA Coal called the Miller Operation and was given a new number of 17803158. It was previously T&T Clay Company. It affected 255 acres and mined the middle and lower Kittanning, along with the lower Kittanning rider.
- 17900112—This permit was a surface mine operation of King Coal Sales called Wally #4 Operation. It was permitted for 112 acres and affected 69 acres. It mined the lower Freeport only.
- 17880120—This permit was a surface mine operation of King Coal Sales called Wally #3 Operation. It was permitted for only 25 acres and affected 8 acres. It mined both the upper and

lower Freeport. It was transferred from Wally Coal to King Coal in 1991. It discharges to both Shimel and Crowell Run.

- 17840151—This was a reclamation permit only with no extraction of coal by Forcey Coal called the Roberts Mine.
- 17870127—This was a reclamation permit only with no extraction of coal by Forcey Coal called the Drane #3 Operation.
- 17860901—This was an incidental strip permit of Forcey Coal called Drane #2 Operation where they were to seal a deep mine with clay and eliminate subsidence and while doing this were given permission to remove the stumps from an abandoned deep mine.

## Current Mining:

At this time, one active operation is occurring by Junior Coal along SR-53 and another one ("Miller Stein"), which was operated by Al Hamilton Construction, is currently being actively treated under bond forfeiture and managed by the PADEP.

## Remining Potential:

As evidenced by remining within the watershed in the past five years, there is great remining potential in the watershed. Various coal companies, Junior Coal, King Coal, and River Hill have all performed remining in the watershed. Due to the presence of the Johnstown limestone and the success of past mining producing "good" quality water, future remining will be encouraged in the watershed to restore any abandoned highwalls or spoil areas.

# Data Collection

## Field Reconnaissance:

NMBS representatives initially walked the stream in the spring of 2006 in preparation of the assessment. Discharges were located, flagged and inspected for flow devices. Field measurements such as pH, conductivity, and temperature were also collected at each reconnaissance point. Fifteen areas were flagged during field reconnaissance. Ten of these sites were chosen for monthly sampling, while four sites were chosen to be monitored on a quarterly basis. The remaining reconnaissance points were considered non-significant, thus, they were not included in the monitoring plan on either a monthly or quarterly sampling schedule. Weirs were built by MCWC volunteers and installed by the Osceola Mills Boy Scouts and MCWC. The weirs were installed in the summer of 2006 and sampling began in August 2006. Representatives from the MCWC collected the monthly samples after being trained by NMBS.

## Historical Data:

Data from the Moshannon Creek Watershed Data clearinghouse (most of which originated in permit review at PADEP offices) was reviewed and is included. Additional review of historical mining permits was completed, and those of significance were noted and included in the data collected for this assessment.

The historical data which was gathered is available electronically on the accompanying CD and on newmilesofbluestream.com.

## Documentation of Problem Areas:

Table 1 represents the sampling locations within the Shimel Run watershed. The table contains the monitoring point and latitude and longitude. Pages A-4 and A-5 show sample locations.

**Table 1: Sampling Plan**

### Monthly samples

| NAME | Lat | Long |
|---|---|---|
| SR-HW | 40.885429 | -78.29131 |
| SR-2 | 40.883961 | -78.29344 |
| SR-4a | 40.886532 | -78.29049 |
| SR-4b | 40.886532 | -78.29049 |
| SR-5 | 40.885521 | -78.28496 |
| SR-6 | 40.876171 | -78.28275 |
| SR-7 | 40.870369 | -78.2636 |
| SR-9 | 40.87059 | -78.25084 |
| SR-10 | 40.871849 | -78.24936 |
| SR-11 | 40.885391 | -78.29131 |

### Quarterly samples

| NAME | Lat | Long |
|---|---|---|
| Q-SR CHURCH | 40.882271 | -78.28716 |
| Q-SR MOUTH | 40.871941 | -78.24925 |
| Q-SR-7 ABOVE | 40.87088 | -78.26437 |
| Q-SR-7 BELOW | 40.870892 | -78.26328 |

## Permission:

Access was granted by various property owners to conduct the water quality sampling. Each landowner was contacted by mail, and permission was obtained for the installation of the weirs and for the monthly sampling. For projects that have been submitted for grants, landowner permission has been granted for additional water sampling and property access for surveying and other project development. Signed agreements will be obtained for all construction projects.

## Property Ownership:

The following is a table containing all potentially relevant landowners in the watershed. Specific landowners will be investigated prior to grant submittal for the design and permitting phase.

**Table 2: Landowners:**

| Landowner | Address | City | Zip |
|---|---|---|---|
| Douglas and Will Burge | 676 Centre Rd | Osceola Mills | 16666 |
| Edgar and Brenda English | RR1 Box 196C | Philipsburg | 16866 |
| Gregory and Debra Kay | 818 Centre Rd. | Osceola Mills | 16666 |
| John and Anna Demchek | 312 Sarah St | Osceola Mills | 16666 |
| John Glenn Sanitation | 3452 Voyzey Rd. | Philipsburg | 16866 |
| Kovalchick Corp. | 1060 Wayne Ave. | Indiana | 15701 |

| Landowner | Address | City | Zip |
|---|---|---|---|
| L.P. Mitchell Gas Inc. | P.O. Box 104 | Osceola Mills | 16666 |
| Mary Ana Simler | 1589 Black Moshannon Rd. | Philipsburg | 16866 |
| Melvia and Peggy Ann Woodring | 91 Hollis Lane | Osceola Mills | 16666 |
| Steinman Development Company | P.O. Box 128 | Lancaster | 17603 |
| William and Garnett Kay | 121 Petes Road | Osceola Mills | 16666 |
| Anthony and Margaret Caprio | 6665 Stumptown Rd. | Osceola Mills | 16666 |
| Austin John Jr. | 564 Centre Rd. | Osceola Mills | 16666 |
| Centre M.E. Church | RR | Osceola Mills | 16666 |
| Edward and Theon Hughes | 1112 Centre Rd | Osceola Mills | 16666 |
| Hazel Heney | 250 Sixmile Rd | Osceola Mills | 16666 |
| JR Land Company Inc. | 2330 Six Mile Rd. | Philipsburg | 16866 |
| King Coal Sales Inc. | P.O. Box 712 | Philipsburg | 16866 |
| Larry and Catherine Hollis | 177 Hollis Lane | Osceola Mills | 16666 |
| Lynn Forcey | 310 S. Front St. | Philipsburg | 16866 |
| Raymond and Martha Hughes | 392 Centre Rd. | Osceola Mills | 16666 |
| Robert Williamson | 2766 Drane HW | Osceola Mills | 16666 |
| Ronald and Judy Yarger | 115 Six Mile Rd | Osceola Mills | 16666 |
| Ronald and Lily May Petrowski | 2524 Drane HW | Osceola Mills | 16666 |
| William Wigfield | 14101 Clifford Av. | Cleveland | 44135 |

## Development of Monitoring Plan:

A monitoring plan was developed after the initial reconnaissance. The sampling plan focused on the mine drainage discharges that were affecting the stream, therefore considered significant. Significant discharges were based on flow, chemistry, impacts to Shimel Run, the impact area and accessibility to treat, and many other factors. Stream sample locations were established and monitored on a quarterly basis to monitor impacts of significant discharges on the main stem of Shimel Run. See Table 1 for the list of sampling points and the number of times the samples were collected. Other sources of hydrology were not monitored due to them having minimal impacts to overall water quality.

## Sampling Methods:

NMBS trained members of the MCWC to conduct the monthly sampling. They were trained to properly conduct field chemistry tests, collect water samples, and measure flow rates.

Samplers were trained to collect pH, conductivity, and temperature measurements in the field. A NMBS representative reviewed proper use and care of each of the pieces of equipment required for these measurements.

A NMBS representative took samplers into the field and identified the points that were selected for monitoring and reviewed proper sampling methods with samplers at each of these sites.

The sampling methods used require that samples be taken as close to the source as possible. Samplers were directed to take samples in a section of the stream or discharge where flow is concentrated to provide the best representation of the chemical properties and to avoid sampling in pooled backwater areas or areas that are littered with decaying organic matter. Samplers were also directed to avoid areas that contain heavy concentrations of aquatic vegetation.

Samplers were taught to collect water samples in a manner that would prevent contamination. These steps included the exclusive use of bottles supplied by the lab and the technique of field rinsing equipment. Field rinsing was used to equilibrate the equipment to the sample environment; this was also done to ensure that all cleaning solution residues had been removed before sampling began.

Samplers were taught to rinse and then fill bottles in a manner that minimizes contact with the air. The exposure of the sample to the atmosphere can increase the dissolved oxygen concentration, causing reduced metal ions to oxidize and precipitate as hydroxides. The precipitation of iron and other metal hydroxides can result in lower concentrations of iron and co-precipitating metals in the analyzed sample.

Samplers were instructed to keep bottles cool as soon as possible. Provisions were made as part of the sampling plan to ensure prompt delivery of samples to the lab. Each sampler had a cooler in their vehicle for temporary storage of the samples.

Samplers were taught to use a water resistant field book to record sampling information in the field. The sampling information includes date, sample name, field pH, field conductivity, flow, temperature, and weather conditions. Samplers were also directed to always be aware of and record potential sources of contamination at any field site.

Samplers were instructed to properly label bottles. These labels were the same as those recorded on the chain of custody that was sent with the bottles to the lab. A NMBS representative maintained responsibility for filling out the chain of custody and any additional lab paperwork that was required.

## Water Quality Measurements:

Water samples were analyzed for mine drainage parameters. The pH, conductivity, and temperature were measured in the field. The pH and conductivity were measured using hand held Testr's by Oakton and temperature was measured with a standard thermometer. The meters were calibrated with buffer solutions prior to each use.

Iron, aluminum, manganese, acidity, alkalinity, lab pH, lab conductivity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and sulfates were measured in the laboratory. Mahaffey Laboratory, Ltd. performed the analyses using standard methods. Samples for metals were preserved in the field by adding five drops of nitric acid. None of the samples were filtered, so they represent total metal concentrations.

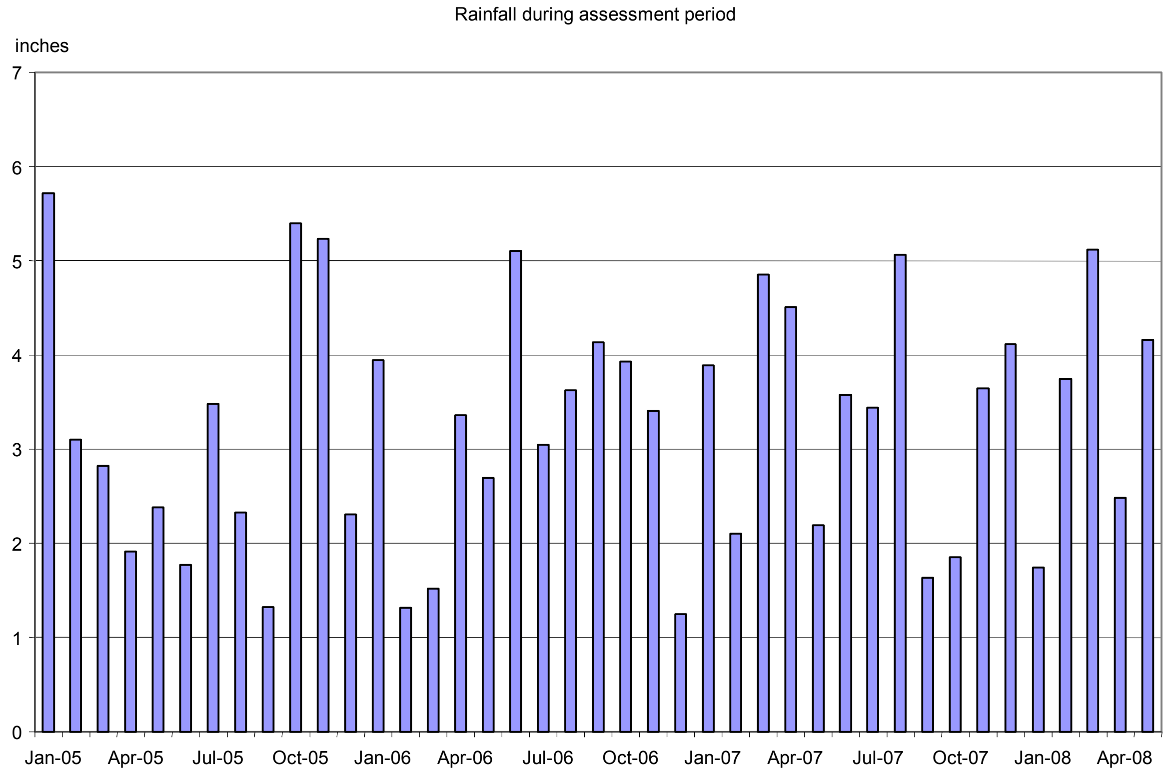
## Flow Rate:

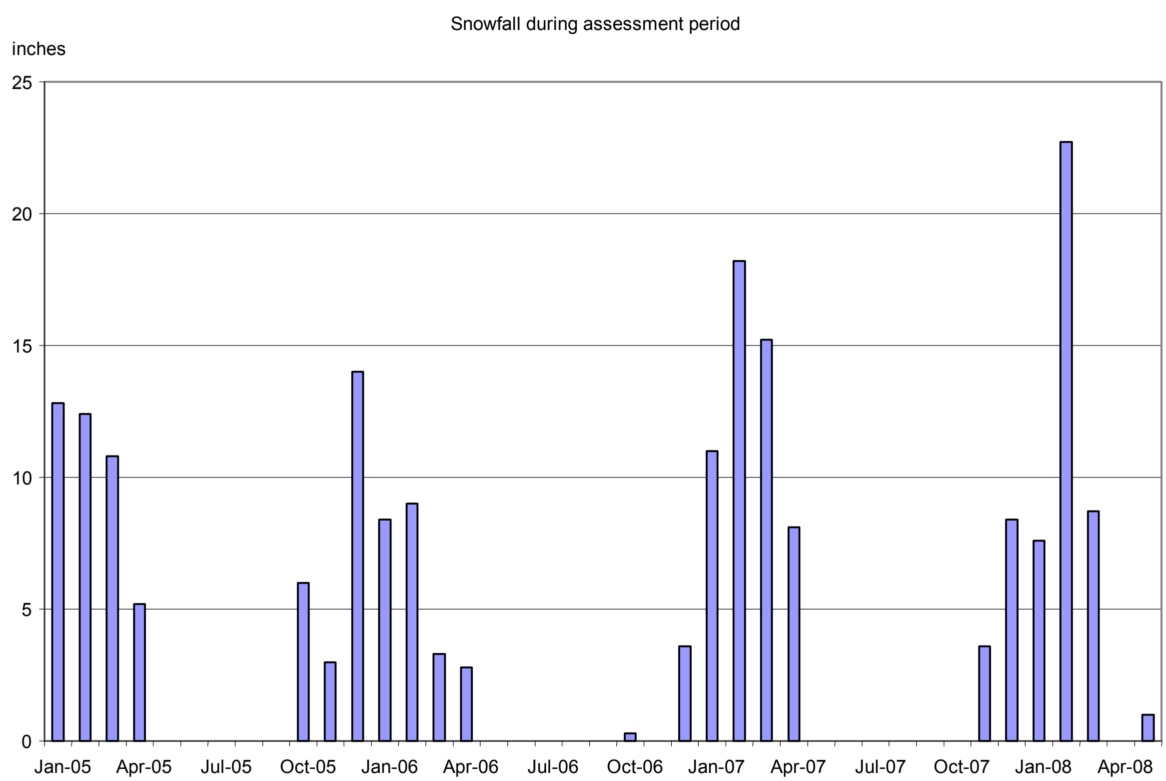
Several types of flow devices and methods were used to collect flow data during the Shimel Run assessment. V-notch weirs were installed at most sampling locations. The water flow height over the weir was measured and gallons per minute (gpm) were calculated. Pipes were also installed at numerous locations, and a bucket and stopwatch were used for the "timed volume" method. In-Stream flow measurements were taken using a flow meter.

## Precipitation during Sampling Period:

Precipitation data, both rainfall and snowfall, was obtained from the climate.met.psu.edu website from the "PLBP1-Philipsburg" station. Sampling took place for the assessment from August 2006 through August 2007 through which approximately 46 inches of rain fell that year, with an average of 38 inches typical in Clearfield County. Approximately 56 inches of snow fell in our sample year with a typical average of 49 inches. It can be concluded that our "sample year" was a relative wet year. The year prior to our starting sampling, the area received 41 inches of rain and 41 inches of snow from January through May, so it was a typical year. This should have had the water table at a normal level and allow for the measurement of normal discharge and stream flows throughout the watershed.

The figures below represent rainfall and snowfall from January 2005 through the sampling period and ending in May 2008. By reviewing the precipitation data, it allows us to determine if “normal” conditions exist during the assessment period.



# Mapping

Maps were created to show the location of the watershed, the stream quality, the sampling that has been done for this assessment, historical mining activities within the watershed through research in Moshannon District office, the location of wetlands, the location of mining activity and reclamation priority from online BAMR files, the soils in the watershed, the geology of the watershed, and the proposed treatment locations. A description of each of these maps appears on page A-1.

# Data Analysis

The sampling data for each sample location can be found in the following sections. Flow values at each point were collected and samples were analyzed for pH, conductivity, acidity, aluminum, iron, manganese, and sulfate. The loadings for acidity, aluminum, and iron are calculated and included as columns in each table. Each table contains not only the raw water data, but also an average value for each parameter, the maximum value, the minimum value, and the 75% and 90% confidence intervals for each parameter, and the upper bound for 75% and 90% of the standard data as defined by the standard deviation and median values.

There are two values with the text “90” and two with the text “75.” The values with the text “CI” appended represent the upper bound for the respective confidence interval for qualifying the data. The values without “CI” represent the highest value for that percentage (e.g., 90% -- this means that 90% of the data is expected to be at or below this value). More accurately, it represents the value on the right tail of the curve which will allow the area under a normal curve to represent that amount of data. For example, the value for “90” represents the z value which is the appropriate number of standard deviations (1.645) to the right of the mean to indicate that 90% of the resulting data will be at or below this value.

# Discharge Areas/Descriptions of Sample Locations

## SR-2

This monitoring point receives flow from an overflowing pond. Drainage also contributes from a reclaimed hillside from the Miller-Stein mining site. A source of sewage from a local household also contributes pollution to this monitoring point.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | 0.00 | 6.30 | 724.00 | 18.00 | 0.00 | -7.00 | 0.00 | 1.88 | 0.00 | 1.29 | 0.05 | 28.00 |
| 09/12/2006 | 15.00 | 6.50 | 424.00 | 17.00 | 3.06 | -5.00 | -0.90 | 0.79 | 0.14 | 0.31 | 0.10 | 41.00 |
| 10/09/2006 | 3.00 | 6.70 | 488.00 | 18.00 | 0.65 | -8.00 | -0.29 | 0.53 | 0.02 | 0.56 | 0.05 | 33.00 |
| 11/13/2006 | 60.00 | 6.50 | 353.00 | 15.00 | 10.79 | 2.00 | 1.44 | 0.42 | 0.30 | 0.09 | 0.13 | 41.00 |
| 12/18/2006 | 10.00 | 6.60 | 350.00 | 18.00 | 2.16 | 3.00 | 0.36 | 7.43 | 0.89 | 0.58 | 2.01 | 40.00 |
| 01/15/2007 | 75.00 | 6.50 | 300.00 | 13.00 | 11.69 | 5.00 | 4.50 | 1.54 | 1.38 | 0.13 | 0.55 | 36.00 |
| 02/12/2007 | 0.00 | | | | | | | | | | | |
| 03/10/2007 | 12.00 | 6.40 | 427.00 | 11.00 | 1.58 | 5.00 | 0.72 | 1.99 | 0.29 | 0.15 | 0.71 | 35.00 |
| 04/14/2007 | 2.50 | 6.00 | 2110.00 | 14.00 | 0.42 | 3.00 | 0.09 | 0.29 | 0.01 | 0.15 | 0.05 | 1272.00 |
| 05/13/2007 | 15.00 | 6.60 | 449.00 | 19.00 | 3.42 | -1.00 | -0.18 | 0.53 | 0.10 | 0.20 | 0.16 | 39.00 |
| 06/10/2007 | 3.00 | 6.90 | 458.00 | 23.00 | 0.83 | -9.00 | -0.32 | 10.70 | 0.38 | 0.40 | 0.46 | 26.00 |
| 07/15/2007 | 0.00 | | | | | | | | | | | |
| 08/11/2007 | 0.00 | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Average** | 15.04 | 6.50 | 608.30 | 16.60 | 3.46 | -1.20 | 0.54 | 2.61 | 0.35 | 0.39 | 0.43 | 159.10 |
| **Min** | 0.00 | 6.00 | 300.00 | 11.00 | 0.00 | -9.00 | -0.90 | 0.29 | 0.00 | 0.09 | 0.05 | 26.00 |
| **Max** | 75.00 | 6.90 | 2110.00 | 23.00 | 11.69 | 5.00 | 4.50 | 10.70 | 1.38 | 1.29 | 2.01 | 1272.00 |
| **90%** | 54.78 | 6.90 | 1496.65 | 22.26 | 10.46 | 7.94 | 3.06 | 8.44 | 1.09 | 0.98 | 1.42 | 802.41 |
| **75%** | 42.82 | 6.78 | 1229.34 | 20.55 | 8.35 | 5.19 | 2.30 | 6.68 | 0.87 | 0.80 | 1.12 | 608.83 |
| **90% CI** | 26.06 | 6.63 | 889.22 | 18.39 | 5.67 | 1.69 | 1.34 | 4.45 | 0.59 | 0.58 | 0.74 | 362.53 |
| **75% CI** | 22.74 | 6.59 | 804.69 | 17.85 | 5.01 | 0.82 | 1.10 | 3.90 | 0.52 | 0.52 | 0.65 | 301.32 |
| **StdDev** | 24.16 | 0.24 | 540.03 | 3.44 | 4.26 | 5.55 | 1.53 | 3.54 | 0.45 | 0.36 | 0.61 | 391.07 |

## SR-4a

These monitoring points receive flow from the same reclaimed field as SRHW. A pipe was placed at the edge of the field by the company that did the reclamation of the site. Another pipe was place in the woods to capture flow seeping from the edge of the field.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10/09/2006 | 0.95 | 7.70 | 1440.00 | 198.00 | 2.26 | -185.00 | -2.11 | 0.56 | 0.01 | 2.95 | 0.05 | 619.00 |
| 11/13/2006 | 1.71 | 7.20 | 1290.00 | 152.00 | 3.12 | -132.00 | -2.71 | 0.61 | 0.01 | 0.66 | 0.05 | 561.00 |
| 12/18/2006 | 1.36 | 7.30 | 1430.00 | 176.00 | 2.87 | -156.00 | -2.54 | 0.60 | 0.01 | 0.42 | 0.05 | 636.00 |
| 01/15/2007 | 12.00 | 7.40 | 1190.00 | 119.00 | 17.12 | -98.00 | -14.10 | 0.41 | 0.06 | 0.24 | 0.05 | 515.00 |
| 02/12/2007 | 1.25 | 7.20 | 1380.00 | 169.00 | 2.53 | -149.00 | -2.23 | 0.27 | 0.00 | 0.14 | 0.05 | 611.00 |
| 03/10/2007 | 1.33 | 7.30 | 1260.00 | 128.00 | 2.04 | -108.00 | -1.72 | 0.14 | 0.00 | 0.10 | 0.05 | 605.00 |
| 04/14/2007 | 1.67 | 7.30 | 1300.00 | 133.00 | 2.66 | -119.00 | -2.38 | 0.09 | 0.00 | 0.05 | 0.05 | 530.00 |
| 05/13/2007 | 2.00 | 7.20 | 1430.00 | 152.00 | 3.65 | -129.00 | -3.09 | 0.82 | 0.02 | 0.59 | 0.05 | 619.00 |
| 06/10/2007 | 1.05 | 7.20 | 1440.00 | 180.00 | 2.27 | -161.00 | -2.03 | 1.00 | 0.01 | 0.82 | 0.05 | 632.00 |
| 07/15/2007 | 0.75 | 7.20 | 1500.00 | 204.00 | 1.83 | -185.00 | -1.66 | 1.08 | 0.01 | 1.01 | 0.55 | 630.00 |
| 08/11/2007 | 0.75 | 7.40 | 1420.00 | 192.00 | 1.73 | -173.00 | -1.56 | 1.29 | 0.01 | 1.06 | 0.05 | 566.00 |
| | | | | | | | | | | | | |
| **Average** | 2.26 | 7.31 | 1370.91 | 163.91 | 3.83 | -145.00 | -3.29 | 0.62 | 0.01 | 0.73 | 0.10 | 593.09 |
| **Min** | 0.75 | 7.20 | 1190.00 | 119.00 | 1.73 | -185.00 | -14.10 | 0.09 | 0.00 | 0.05 | 0.05 | 515.00 |
| **Max** | 12.00 | 7.70 | 1500.00 | 204.00 | 17.12 | -98.00 | -1.56 | 1.29 | 0.06 | 2.95 | 0.55 | 636.00 |
| **90%** | 7.61 | 7.56 | 1528.94 | 211.97 | 11.14 | -95.50 | 2.67 | 1.27 | 0.04 | 2.08 | 0.34 | 663.59 |
| **75%** | 6.00 | 7.48 | 1481.39 | 197.51 | 8.94 | -110.39 | 0.87 | 1.07 | 0.03 | 1.67 | 0.27 | 642.37 |
| **90% CI** | 3.87 | 7.38 | 1418.56 | 178.40 | 6.03 | -130.07 | -1.49 | 0.82 | 0.02 | 1.14 | 0.17 | 614.35 |
| **75% CI** | 3.39 | 7.36 | 1404.22 | 174.04 | 5.37 | -134.57 | -2.03 | 0.76 | 0.02 | 1.01 | 0.15 | 607.95 |
| **StdDev** | 3.26 | 0.15 | 96.07 | 29.21 | 4.45 | 30.09 | 3.62 | 0.39 | 0.02 | 0.82 | 0.15 | 42.85 |

## SR-4b

These monitoring points receive flow from the same reclaimed field as SRHW. A pipe was placed at the edge of the field by the company that did the reclamation of the site. Another pipe was place in the woods to capture flow seeping from the edge of the field.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | 0.00 | | | | | | | | | | | |
| 09/12/2006 | 1.50 | 6.40 | 803.00 | 43.00 | 0.77 | -31.00 | -0.56 | 1.53 | 0.03 | 1.30 | 0.32 | 345.00 |
| 10/09/2006 | 0.40 | 6.60 | 1010.00 | 63.00 | 0.30 | -48.00 | -0.23 | 1.90 | 0.01 | 3.27 | 0.05 | 446.00 |
| 11/13/2006 | 4.00 | 6.40 | 635.00 | 4.00 | 0.19 | 0.16 | 0.01 | 0.37 | 0.02 | 0.09 | 285.00 | 6.20 |
| 12/18/2006 | 1.00 | 6.40 | 756.00 | 18.00 | 0.22 | 2.00 | 0.02 | 0.18 | 0.00 | 0.23 | 0.09 | 358.00 |
| 01/15/2007 | 15.00 | 5.40 | 402.00 | 6.00 | 1.08 | 15.00 | 2.70 | 2.51 | 0.45 | 0.55 | 2.66 | 181.00 |
| 02/12/2007 | 0.00 | | | | | | | | | | | |
| 03/10/2007 | 0.00 | | | | | | | | | | | |
| 04/14/2007 | 2.73 | 6.00 | 544.00 | 10.00 | 0.33 | 4.00 | 0.13 | 0.13 | 0.00 | 0.25 | 0.25 | 248.00 |
| 05/13/2007 | 3.33 | 5.40 | 586.00 | 7.00 | 0.28 | 15.00 | 0.60 | 0.22 | 0.01 | 0.74 | 0.88 | 275.00 |
| 06/10/2007 | 0.00 | | | | | | | | | | | |
| 07/15/2007 | 0.00 | | | | | | | | | | | |
| 08/11/2007 | 0.00 | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Average** | 2.15 | 6.09 | 676.57 | 21.57 | 0.45 | -6.12 | 0.38 | 0.98 | 0.07 | 0.92 | 41.32 | 265.60 |
| **Min** | 0.00 | 5.40 | 402.00 | 4.00 | 0.19 | -48.00 | -0.56 | 0.13 | 0.00 | 0.09 | 0.05 | 6.20 |
| **Max** | 15.00 | 6.60 | 1010.00 | 63.00 | 1.08 | 15.00 | 2.70 | 2.51 | 0.45 | 3.27 | 285.00 | 446.00 |
| **90%** | 8.91 | 6.91 | 1003.07 | 58.88 | 1.01 | 33.46 | 2.16 | 2.59 | 0.35 | 2.75 | 218.09 | 500.39 |
| **75%** | 6.88 | 6.66 | 904.82 | 47.65 | 0.84 | 21.55 | 1.62 | 2.11 | 0.27 | 2.20 | 164.90 | 429.74 |
| **90% CI** | 4.03 | 6.40 | 799.98 | 35.67 | 0.66 | 8.84 | 1.05 | 1.59 | 0.18 | 1.61 | 108.13 | 354.34 |
| **75% CI** | 3.46 | 6.30 | 762.84 | 31.43 | 0.60 | 4.34 | 0.85 | 1.40 | 0.15 | 1.40 | 88.03 | 327.64 |
| **StdDev** | 4.11 | 0.50 | 198.48 | 22.68 | 0.34 | 24.06 | 1.08 | 0.98 | 0.17 | 1.11 | 107.46 | 142.73 |

## SR-5

This monitoring point receives flow from a channelized, wetland area. The area upslope from the sampling point is a reclaimed strip mine area. It is possible that this location was related to past deep mining, but no clear evidence could be found.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | 0.00 | | | | | | | | | | | |
| 09/12/2006 | 1.10 | 3.70 | 474.00 | 0.00 | 0.00 | 30.00 | 0.40 | 0.21 | 0.00 | 1.04 | 2.47 | 190.00 |
| 10/09/2006 | 0.00 | | | | | | | | | | | |
| 11/13/2006 | 9.10 | 4.00 | 472.00 | 0.00 | 0.00 | 30.00 | 3.27 | 0.86 | 0.09 | 1.57 | 2.39 | 186.00 |
| 12/18/2006 | 5.20 | 3.70 | 689.00 | 0.00 | 0.00 | 56.00 | 3.49 | 0.47 | 0.03 | 1.70 | 6.08 | 308.00 |
| 01/15/2007 | 91.00 | 3.60 | 499.00 | 0.00 | 0.00 | 42.00 | 45.83 | 0.76 | 0.83 | 0.92 | 4.28 | 207.00 |
| 02/12/2007 | 0.00 | | | | | | | | | | | |
| 03/10/2007 | 0.00 | | | | | | | | | | | |
| 04/14/2007 | 28.62 | 3.60 | 579.00 | 0.00 | 0.00 | 50.00 | 17.16 | 0.34 | 0.12 | 1.03 | 5.31 | 260.00 |
| 05/13/2007 | 36.22 | 3.50 | 645.00 | 0.00 | 0.00 | 60.00 | 26.06 | 0.48 | 0.21 | 0.94 | 5.40 | 270.00 |
| 06/10/2007 | 0.00 | | | | | | | | | | | |
| 07/15/2007 | 0.00 | | | | | | | | | | | |
| 08/11/2007 | 0.00 | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Average** | 13.17 | 3.68 | 559.67 | 0.00 | 0.00 | 44.67 | 16.03 | 0.52 | 0.21 | 1.20 | 4.32 | 236.83 |
| **Min** | 0.00 | 3.50 | 472.00 | 0.00 | 0.00 | 30.00 | 0.40 | 0.21 | 0.00 | 0.92 | 2.39 | 186.00 |
| **Max** | 91.00 | 4.00 | 689.00 | 0.00 | 0.00 | 60.00 | 45.83 | 0.86 | 0.83 | 1.70 | 6.08 | 308.00 |
| **90%** | 56.35 | 3.97 | 712.37 | 0.00 | 0.00 | 65.85 | 45.04 | 0.93 | 0.72 | 1.76 | 6.91 | 318.65 |
| **75%** | 43.36 | 3.88 | 666.42 | 0.00 | 0.00 | 59.48 | 36.31 | 0.80 | 0.57 | 1.59 | 6.13 | 294.03 |
| **90% CI** | 25.15 | 3.80 | 622.01 | 0.00 | 0.00 | 53.32 | 27.88 | 0.69 | 0.42 | 1.43 | 5.38 | 270.24 |
| **75% CI** | 21.54 | 3.76 | 603.25 | 0.00 | 0.00 | 50.71 | 24.31 | 0.64 | 0.36 | 1.36 | 5.06 | 260.18 |
| **StdDev** | 26.25 | 0.17 | 92.83 | 0.00 | 0.00 | 12.88 | 17.63 | 0.25 | 0.31 | 0.34 | 1.57 | 49.74 |

## SR-6

This discharge is located moving downstream in a reclaimed surface mine site. It “pops” up on the lowest point of what would have been the mine floor.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | 0.00 | | | | | | | | | | | |
| 09/12/2006 | 1.00 | 5.70 | 237.00 | 12.00 | 0.14 | 1.00 | 0.01 | 0.69 | 0.01 | 0.54 | 0.12 | 77.00 |
| 11/13/2006 | 30.00 | 6.20 | 150.00 | 12.00 | 4.32 | 5.00 | 1.80 | 1.98 | 0.71 | 0.14 | 0.40 | 34.00 |
| 12/18/2006 | 2.14 | 6.00 | 179.00 | 12.00 | 0.31 | 6.00 | 0.15 | 1.63 | 0.04 | 0.31 | 0.27 | 50.00 |
| 01/15/2007 | 60.00 | 6.40 | 210.00 | 18.00 | 12.95 | 2.00 | 1.44 | 0.87 | 0.63 | 0.10 | 0.41 | 66.00 |
| 02/12/2007 | 0.00 | | | | | | | | | | | |
| 02/12/2007 | 0.00 | | | | | | | | | | | |
| 03/10/2007 | 0.00 | | | | | | | | | | | |
| 04/14/2007 | 10.00 | 6.20 | 133.00 | 11.00 | 1.32 | 3.00 | 0.36 | 0.75 | 0.09 | 0.05 | 0.20 | 34.00 |
| 05/13/2007 | 0.00 | | | | | | | | | | | |
| 06/10/2007 | 0.00 | | | | | | | | | | | |
| 07/15/2007 | 0.00 | | | | | | | | | | | |
| 08/11/2007 | 0.00 | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Average** | 7.93 | 6.10 | 181.80 | 13.00 | 3.81 | 3.40 | 0.75 | 1.18 | 0.30 | 0.23 | 0.28 | 52.20 |
| **Min** | 0.00 | 5.70 | 133.00 | 11.00 | 0.14 | 1.00 | 0.01 | 0.69 | 0.01 | 0.05 | 0.12 | 34.00 |
| **Max** | 60.00 | 6.40 | 237.00 | 18.00 | 12.95 | 6.00 | 1.80 | 1.98 | 0.71 | 0.54 | 0.41 | 77.00 |
| **90%** | 37.16 | 6.54 | 251.80 | 17.65 | 12.66 | 6.81 | 2.09 | 2.14 | 0.86 | 0.56 | 0.49 | 83.77 |
| **75%** | 28.36 | 6.40 | 230.74 | 16.25 | 9.99 | 5.78 | 1.68 | 1.86 | 0.69 | 0.46 | 0.42 | 74.27 |
| **90% CI** | 16.04 | 6.29 | 213.10 | 15.08 | 7.76 | 4.93 | 1.35 | 1.61 | 0.55 | 0.38 | 0.37 | 66.32 |
| **75% CI** | 13.60 | 6.24 | 203.68 | 14.45 | 6.57 | 4.47 | 1.17 | 1.48 | 0.47 | 0.33 | 0.34 | 62.07 |
| **StdDev** | 17.77 | 0.26 | 42.55 | 2.83 | 5.38 | 2.07 | 0.81 | 0.58 | 0.34 | 0.20 | 0.13 | 19.19 |

## SR-7

This monitoring point is a deep mine discharge that is contributing a substantial amount of flow to Shimel Run. The discharge flows approximately 200 yards to where it enters Shimel Run along Logan Road.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | | 4.70 | 681.00 | 3.00 | | 14.00 | | 0.06 | | 0.35 | 0.76 | 260.00 |
| 09/12/2006 | 51.60 | 4.90 | 592.00 | 5.00 | 3.09 | 12.00 | 7.42 | 0.05 | 0.03 | 0.48 | 1.00 | 256.00 |
| 10/09/2006 | 28.20 | 4.90 | 626.00 | 5.00 | 1.69 | 10.00 | 3.38 | 0.05 | 0.02 | 0.49 | 1.06 | 260.00 |
| 11/13/2006 | 96.60 | 5.10 | 547.00 | 6.00 | 6.95 | 17.00 | 19.69 | 0.05 | 0.06 | 0.57 | 1.00 | 223.00 |
| 12/18/2006 | 77.80 | 5.00 | 574.00 | 6.00 | 5.60 | 594.00 | 554.14 | 0.05 | 0.05 | 0.39 | 0.86 | 240.00 |
| 01/15/2007 | 302.01 | 5.00 | 481.00 | 6.00 | 21.73 | 17.00 | 61.56 | 0.06 | 0.22 | 0.54 | 1.08 | 200.00 |
| 02/12/2007 | 91.21 | 5.00 | 536.00 | 6.00 | 6.56 | 17.00 | 18.59 | 0.05 | 0.05 | 0.40 | 0.97 | 215.00 |
| 03/10/2007 | 218.46 | 5.00 | 522.00 | 5.00 | 13.10 | 18.00 | 47.15 | 0.05 | 0.13 | 0.36 | 0.84 | 223.00 |
| 04/14/2007 | 178.35 | 4.90 | 463.00 | 5.00 | 10.69 | 14.00 | 29.94 | 0.05 | 0.11 | 0.35 | 0.75 | 186.00 |
| 05/13/2007 | 182.57 | 5.40 | 460.00 | 6.00 | 13.14 | 15.00 | 32.84 | 0.05 | 0.11 | 0.33 | 0.56 | 169.00 |
| 06/10/2007 | 70.34 | 5.20 | 516.00 | 5.00 | 4.22 | 14.00 | 11.81 | 0.05 | 0.04 | 0.34 | 0.59 | 211.00 |
| 07/15/2007 | 56.76 | 5.10 | 570.00 | 6.00 | 4.08 | 15.00 | 10.21 | 0.05 | 0.03 | 0.40 | 0.72 | 244.00 |
| 08/11/2007 | 15.00 | 5.00 | 596.00 | 5.00 | 0.90 | 15.00 | 2.70 | 0.05 | 0.01 | 0.42 | 0.82 | 239.00 |
| | | | | | | | | | | | | |
| **Average** | 114.08 | 5.02 | 551.08 | 5.31 | 7.65 | 59.38 | 66.62 | 0.05 | 0.07 | 0.42 | 0.85 | 225.08 |
| **Min** | 15.00 | 4.70 | 460.00 | 3.00 | 0.90 | 10.00 | 2.70 | 0.05 | 0.01 | 0.33 | 0.56 | 169.00 |
| **Max** | 302.01 | 5.40 | 681.00 | 6.00 | 21.73 | 594.00 | 554.14 | 0.06 | 0.22 | 0.57 | 1.08 | 260.00 |
| **90%** | 257.37 | 5.29 | 657.64 | 6.71 | 17.56 | 323.65 | 320.91 | 0.06 | 0.17 | 0.55 | 1.13 | 272.04 |
| **75%** | 214.25 | 5.21 | 625.57 | 6.29 | 14.58 | 244.13 | 244.39 | 0.06 | 0.14 | 0.51 | 1.04 | 257.91 |
| **90% CI** | 155.44 | 5.09 | 580.63 | 5.70 | 10.51 | 132.68 | 140.03 | 0.05 | 0.10 | 0.45 | 0.92 | 238.10 |
| **75% CI** | 142.99 | 5.07 | 571.74 | 5.58 | 9.65 | 110.62 | 117.94 | 0.05 | 0.09 | 0.44 | 0.90 | 234.18 |
| **StdDev** | 87.11 | 0.17 | 64.78 | 0.85 | 6.03 | 160.65 | 154.58 | 0.00 | 0.06 | 0.08 | 0.17 | 28.55 |

## SR-9

This discharge is an alkaline discharge that borders SR-53 and receives flow from a wetland area seeping from an area near J.J. Powell's.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | | 7.30 | 513.00 | 50.00 | | -38.00 | | 0.52 | | 0.05 | 0.34 | 134.00 |
| 09/12/2006 | 4.29 | 7.40 | 463.00 | 46.00 | 2.37 | -35.00 | -1.80 | 0.77 | 0.04 | 0.08 | 0.47 | 137.00 |
| 10/09/2006 | 3.75 | 7.70 | 454.00 | 44.00 | 1.98 | -32.00 | -1.44 | 1.90 | 0.09 | 0.07 | 0.75 | 149.00 |
| 11/13/2006 | 15.00 | 7.00 | 339.00 | 34.00 | 6.12 | -16.00 | -2.88 | 0.39 | 0.07 | 0.06 | 0.23 | 98.00 |
| 12/18/2006 | 7.50 | 7.00 | 570.00 | 32.00 | 2.88 | -18.00 | -1.62 | 0.15 | 0.01 | 0.05 | 0.12 | 122.00 |
| 01/15/2007 | 60.00 | 7.10 | 381.00 | 30.00 | 21.58 | -12.00 | -8.63 | 0.70 | 0.50 | 0.07 | 0.78 | 64.00 |
| 02/12/2007 | 10.00 | 6.90 | 444.00 | 20.00 | 2.40 | -3.00 | -0.36 | 0.36 | 0.04 | 0.06 | 0.26 | 104.00 |
| 03/10/2007 | 12.00 | 6.90 | 781.00 | 25.00 | 3.60 | -11.00 | -1.58 | 1.99 | 0.29 | 0.12 | 0.63 | 108.00 |
| 04/14/2007 | 12.00 | 7.30 | 400.00 | 24.00 | 3.45 | -12.00 | -1.73 | 0.20 | 0.03 | 0.05 | 0.20 | 78.00 |
| 05/13/2007 | 15.00 | 6.90 | 331.00 | 29.00 | 5.22 | -9.00 | -1.62 | 0.17 | 0.03 | 0.05 | 0.17 | 80.00 |
| 06/10/2007 | 12.00 | 7.20 | 336.00 | 34.00 | 4.89 | -16.00 | -2.30 | 0.18 | 0.03 | 0.07 | 0.19 | 91.00 |
| 07/15/2007 | 6.00 | 7.10 | 412.00 | 44.00 | 3.17 | -26.00 | -1.87 | 0.25 | 0.02 | 0.04 | 0.27 | 117.00 |
| 08/11/2007 | 5.00 | 7.50 | 444.00 | 54.00 | 3.24 | -37.00 | -2.22 | 0.32 | 0.02 | 0.04 | 0.25 | 109.00 |
| | | | | | | | | | | | | |
| **Average** | 13.55 | 7.18 | 451.38 | 35.85 | 5.07 | -20.38 | -2.34 | 0.61 | 0.10 | 0.06 | 0.36 | 107.00 |
| **Min** | 3.75 | 6.90 | 331.00 | 20.00 | 1.98 | -38.00 | -8.63 | 0.15 | 0.01 | 0.04 | 0.12 | 64.00 |
| **Max** | 60.00 | 7.70 | 781.00 | 54.00 | 21.58 | -3.00 | -0.36 | 1.99 | 0.50 | 0.12 | 0.78 | 149.00 |
| **90%** | 38.49 | 7.59 | 650.80 | 53.47 | 13.87 | -0.97 | 1.07 | 1.64 | 0.34 | 0.10 | 0.73 | 148.09 |
| **75%** | 30.99 | 7.47 | 590.79 | 48.17 | 11.22 | -6.81 | 0.04 | 1.33 | 0.27 | 0.09 | 0.62 | 135.73 |
| **90% CI** | 20.75 | 7.29 | 506.69 | 40.73 | 7.61 | -15.00 | -1.35 | 0.89 | 0.17 | 0.07 | 0.46 | 118.40 |
| **75% CI** | 18.58 | 7.26 | 490.05 | 39.26 | 6.85 | -16.62 | -1.65 | 0.81 | 0.15 | 0.07 | 0.43 | 114.97 |
| **StdDev** | 15.17 | 0.25 | 121.22 | 10.71 | 5.35 | 11.80 | 2.07 | 0.63 | 0.15 | 0.02 | 0.23 | 24.98 |

## SR-10

This monitoring point consists of seeps coming from a wetland that borders SR-53 and a pond that overflows during high flow events.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | 0.00 | | | | | | | | | | | |
| 09/12/2006 | 0.00 | | | | | | | | | | | |
| 10/09/2006 | 0.00 | | | | | | | | | | | |
| 11/13/2006 | 10.80 | 6.80 | 287.00 | 42.00 | 5.44 | -28.00 | -3.63 | 0.22 | 0.03 | 0.02 | 0.16 | 40.00 |
| 12/18/2006 | 0.00 | | | | | | | | | | | |
| 01/15/2007 | 31.53 | 6.80 | 200.00 | 28.00 | 10.59 | -11.00 | -4.16 | 0.39 | 0.15 | 0.02 | 0.30 | 30.00 |
| 02/12/2007 | 0.00 | | | | | | | | | | | |
| 03/10/2007 | 0.00 | | | | | | | | | | | |
| 04/14/2007 | 0.00 | | | | | | | | | | | |
| 05/13/2007 | 0.00 | | | | | | | | | | | |
| 06/10/2007 | 0.00 | | | | | | | | | | | |
| 07/15/2007 | 0.00 | | | | | | | | | | | |
| 08/11/2007 | 0.00 | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Average** | 3.26 | 6.80 | 243.50 | 35.00 | 8.01 | -19.50 | -3.89 | 0.31 | 0.09 | 0.02 | 0.23 | 35.00 |
| **Min** | 0.00 | 6.80 | 200.00 | 28.00 | 5.44 | -28.00 | -4.16 | 0.22 | 0.03 | 0.02 | 0.16 | 30.00 |
| **Max** | 31.53 | 6.80 | 287.00 | 42.00 | 10.59 | -11.00 | -3.63 | 0.39 | 0.15 | 0.02 | 0.30 | 40.00 |
| **90%** | 18.07 | 6.80 | 344.70 | 51.28 | 14.00 | 0.27 | -3.27 | 0.50 | 0.23 | 0.02 | 0.39 | 46.63 |
| **75%** | 13.61 | 6.80 | 314.25 | 46.38 | 12.20 | -5.68 | -3.46 | 0.44 | 0.18 | 0.02 | 0.34 | 43.13 |
| **90% CI** | 7.36 | 6.80 | 315.06 | 46.52 | 12.25 | -5.52 | -3.45 | 0.44 | 0.19 | 0.02 | 0.35 | 43.23 |
| **75% CI** | 6.13 | 6.80 | 293.53 | 43.05 | 10.97 | -9.73 | -3.59 | 0.40 | 0.16 | 0.02 | 0.31 | 40.75 |
| **StdDev** | 9.00 | 0.00 | 61.52 | 9.90 | 3.64 | 12.02 | 0.38 | 0.12 | 0.08 | 0.00 | 0.10 | 7.07 |

## SR-11

This monitoring point receives flow from a failing settling pond. Flow from the second pond at the Miller-Stein Active Treatment System is seeping through the berm and entering into the headwaters.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | 0.00 | | | | | | | | | | | |
| 09/12/2006 | 0.28 | 5.80 | 1850.00 | 16.00 | 0.05 | 8.00 | 0.03 | 12.20 | 0.04 | 2.30 | 0.07 | 1085.00 |
| 10/09/2006 | 0.00 | | | | | | | | | | | |
| 11/13/2006 | 1.50 | 6.20 | 1850.00 | 15.00 | 0.27 | 8.00 | 0.14 | 2.63 | 0.05 | 0.59 | 0.05 | 1043.00 |
| 12/18/2006 | 0.00 | | | | | | | | | | | |
| 01/15/2007 | 6.00 | 6.40 | 1400.00 | 16.00 | 1.15 | 3.00 | 0.22 | 0.48 | 0.03 | 0.11 | 0.07 | 735.00 |
| 02/12/2007 | 0.00 | | | | | | | | | | | |
| 03/10/2007 | 0.00 | | | | | | | | | | | |
| 04/14/2007 | 1.50 | 6.00 | 2110.00 | 14.00 | 0.25 | 3.00 | 0.05 | 0.29 | 0.01 | 0.15 | 0.05 | 1272.00 |
| 05/13/2007 | 0.50 | 6.10 | 2260.00 | 16.00 | 0.10 | 6.00 | 0.04 | 1.36 | 0.01 | 0.35 | 0.05 | 1354.00 |
| 06/10/2007 | 0.00 | | | | | | | | | | | |
| 07/15/2007 | 0.00 | | | | | | | | | | | |
| 08/11/2007 | 0.50 | 6.00 | 2210.00 | 16.00 | 0.10 | 3.00 | 0.02 | 1.63 | 0.01 | 1.17 | 0.05 | 1290.00 |
| | | | | | | | | | | | | |
| **Average** | 0.79 | 6.08 | 1946.67 | 15.50 | 0.32 | 5.17 | 0.08 | 3.10 | 0.02 | 0.78 | 0.06 | 1129.83 |
| **Min** | 0.00 | 5.80 | 1400.00 | 14.00 | 0.05 | 3.00 | 0.02 | 0.29 | 0.01 | 0.11 | 0.05 | 735.00 |
| **Max** | 6.00 | 6.40 | 2260.00 | 16.00 | 1.15 | 8.00 | 0.22 | 12.20 | 0.05 | 2.30 | 0.07 | 1354.00 |
| **90%** | 3.52 | 6.42 | 2472.93 | 16.88 | 1.01 | 9.25 | 0.21 | 10.56 | 0.06 | 2.16 | 0.07 | 1506.07 |
| **75%** | 2.70 | 6.32 | 2314.57 | 16.46 | 0.80 | 8.02 | 0.17 | 8.32 | 0.05 | 1.74 | 0.07 | 1392.86 |
| **90% CI** | 1.55 | 6.22 | 2161.51 | 16.06 | 0.60 | 6.83 | 0.14 | 6.15 | 0.04 | 1.34 | 0.06 | 1283.43 |
| **75% CI** | 1.32 | 6.18 | 2096.86 | 15.89 | 0.52 | 6.33 | 0.12 | 5.23 | 0.03 | 1.17 | 0.06 | 1237.21 |
| **StdDev** | 1.66 | 0.20 | 319.92 | 0.84 | 0.42 | 2.48 | 0.08 | 4.54 | 0.02 | 0.84 | 0.01 | 228.72 |

## SR-HW

This monitoring point is receiving flow from a reclaimed strip mine site. Flow is coming from three different sources at the toe of the reclaimed field. The three source of flow all had similar chemistry so the monitoring point was place where the discharges combine.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | | 7.60 | 1450.00 | 133.00 | | -119.00 | | 0.07 | | 0.08 | 0.05 | 624.00 |
| 09/12/2006 | 51.60 | 7.70 | 1040.00 | 121.00 | 74.87 | -108.00 | -66.82 | 0.12 | 0.07 | 0.08 | 0.05 | 443.00 |
| 10/09/2006 | 19.60 | 8.00 | 1150.00 | 122.00 | 28.67 | -111.00 | -26.09 | 0.58 | 0.14 | 0.22 | 0.11 | 489.00 |
| 11/13/2006 | 51.60 | 7.80 | 1040.00 | 117.00 | 72.39 | -95.00 | -58.78 | 0.20 | 0.12 | 0.06 | 0.05 | 437.00 |
| 12/18/2006 | 54.70 | 7.80 | 1080.00 | 121.00 | 79.36 | -101.00 | -66.25 | 0.14 | 0.09 | 0.06 | 0.05 | 473.00 |
| 01/15/2007 | 139.40 | 7.70 | 908.00 | 95.00 | 158.80 | -77.00 | -128.71 | 0.31 | 0.52 | 0.07 | 0.07 | 361.00 |
| 02/12/2007 | 36.23 | 7.80 | 1120.00 | 110.00 | 47.79 | -92.00 | -39.97 | 0.05 | 0.02 | 0.04 | 0.05 | 484.00 |
| 03/10/2007 | 54.70 | 7.70 | 1110.00 | 109.00 | 71.49 | -86.00 | -56.41 | 0.10 | 0.07 | 0.03 | 0.05 | 518.00 |
| 04/14/2007 | 54.68 | 7.80 | 1080.00 | 105.00 | 68.85 | -90.00 | -59.01 | 0.12 | 0.08 | 0.05 | 0.05 | 418.00 |
| 05/13/2007 | 54.70 | 7.70 | 1100.00 | 117.00 | 76.74 | -97.00 | -63.62 | 0.13 | 0.09 | 0.06 | 0.05 | 439.00 |
| 06/10/2007 | 20.88 | 8.00 | 1160.00 | 122.00 | 30.55 | -104.00 | -26.04 | 0.13 | 0.03 | 0.12 | 0.05 | 515.00 |
| 07/15/2007 | 8.12 | 7.80 | 1260.00 | 129.00 | 12.56 | -107.00 | -10.42 | 0.19 | 0.02 | 0.14 | 0.05 | 562.00 |
| 08/11/2007 | 8.12 | 7.90 | 1250.00 | 119.00 | 11.59 | -99.00 | -9.64 | 0.13 | 0.01 | 0.21 | 0.05 | 533.00 |
| | | | | | | | | | | | | |
| **Average** | 46.19 | 7.79 | 1134.46 | 116.92 | 61.14 | -98.92 | -50.98 | 0.17 | 0.10 | 0.09 | 0.06 | 484.31 |
| **Min** | 8.12 | 7.60 | 908.00 | 95.00 | 11.59 | -119.00 | -128.71 | 0.05 | 0.01 | 0.03 | 0.05 | 361.00 |
| **Max** | 139.40 | 8.00 | 1450.00 | 133.00 | 158.80 | -77.00 | -9.64 | 0.58 | 0.52 | 0.22 | 0.11 | 624.00 |
| **90%** | 103.57 | 7.99 | 1350.32 | 133.56 | 126.90 | -80.40 | 2.34 | 0.40 | 0.33 | 0.20 | 0.08 | 596.43 |
| **75%** | 86.30 | 7.93 | 1285.36 | 128.55 | 107.11 | -85.98 | -13.70 | 0.33 | 0.26 | 0.16 | 0.08 | 562.69 |
| **90% CI** | 62.76 | 7.85 | 1194.33 | 121.54 | 80.12 | -93.79 | -35.59 | 0.24 | 0.17 | 0.12 | 0.06 | 515.40 |
| **75% CI** | 57.77 | 7.83 | 1176.31 | 120.15 | 74.41 | -95.33 | -40.22 | 0.22 | 0.15 | 0.11 | 0.06 | 506.05 |
| **StdDev** | 34.88 | 0.12 | 131.22 | 10.11 | 39.97 | 11.26 | 32.41 | 0.14 | 0.14 | 0.06 | 0.02 | 68.16 |

## Q-SR-7 ABOVE

This monitoring point is an in-stream sample located just upstream from the point at which water from SR-7 enters Shimel Run.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/07/2006 | 0.00 | | | | | | | | | | | |
| 11/02/2006 | 564.14 | 6.80 | 849.00 | 20.00 | 135.29 | -7.00 | -47.35 | 0.21 | 1.42 | 0.07 | 0.11 | 244.00 |
| 04/03/2007 | 363.53 | 6.90 | 1076.00 | 24.00 | 104.62 | -8.00 | -34.87 | 0.30 | 1.31 | 0.08 | 0.15 | 468.00 |
| 06/13/2007 | 0.00 | 6.70 | 375.00 | 20.00 | 0.00 | -6.00 | 0.00 | 0.61 | 0.00 | 0.15 | 0.27 | 145.00 |
| | | | | | | | | | | | | |
| **Average** | 231.92 | 6.80 | 766.67 | 21.33 | 79.97 | -7.00 | -27.41 | 0.37 | 0.91 | 0.10 | 0.18 | 285.67 |
| **Min** | 0.00 | 6.70 | 375.00 | 20.00 | 0.00 | -8.00 | -47.35 | 0.21 | 0.00 | 0.07 | 0.11 | 145.00 |
| **Max** | 564.14 | 6.90 | 1076.00 | 24.00 | 135.29 | -6.00 | 0.00 | 0.61 | 1.42 | 0.15 | 0.27 | 468.00 |
| **90%** | 692.58 | 6.96 | 1355.05 | 25.13 | 196.66 | -5.36 | 12.96 | 0.72 | 2.21 | 0.17 | 0.31 | 557.88 |
| **75%** | 553.96 | 6.92 | 1178.00 | 23.99 | 161.54 | -5.85 | 0.82 | 0.61 | 1.82 | 0.15 | 0.27 | 475.97 |
| **90% CI** | 462.25 | 6.89 | 1106.37 | 23.53 | 147.34 | -6.05 | -4.10 | 0.57 | 1.66 | 0.14 | 0.26 | 442.83 |
| **75% CI** | 392.94 | 6.87 | 1004.15 | 22.87 | 127.07 | -6.34 | -11.11 | 0.51 | 1.43 | 0.13 | 0.23 | 395.54 |
| **StdDev** | 280.04 | 0.10 | 357.68 | 2.31 | 70.93 | 1.00 | 24.54 | 0.21 | 0.79 | 0.04 | 0.08 | 165.48 |

## Q-SR-7 BELOW

This monitoring point is an in-stream sample located just downstream from the point at which water from SR-7 enters Shimel Run.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/07/2006 | 23.34 | 4.80 | 680.00 | 4.00 | 1.12 | 12.00 | 3.36 | 0.64 | 0.18 | 0.45 | 1.45 | 261.00 |
| 11/02/2006 | 632.49 | 6.70 | 779.00 | 16.00 | 121.35 | -3.00 | -22.75 | 0.13 | 0.99 | 0.17 | 0.25 | 332.00 |
| 04/03/2007 | 659.74 | 6.70 | 881.00 | 18.00 | 142.40 | -3.00 | -23.73 | 0.19 | 1.50 | 0.18 | 0.40 | 358.00 |
| 06/13/2007 | 90.23 | 5.60 | 548.00 | 6.00 | 6.49 | 12.00 | 12.98 | 0.16 | 0.17 | 0.48 | 0.50 | 219.00 |
| | | | | | | | | | | | | |
| **Average** | 351.45 | 5.95 | 722.00 | 11.00 | 67.84 | 4.50 | -7.54 | 0.28 | 0.71 | 0.32 | 0.65 | 292.50 |
| **Min** | 23.34 | 4.80 | 548.00 | 4.00 | 1.12 | -3.00 | -23.73 | 0.13 | 0.17 | 0.17 | 0.25 | 219.00 |
| **Max** | 659.74 | 6.70 | 881.00 | 18.00 | 142.40 | 12.00 | 12.98 | 0.64 | 1.50 | 0.48 | 1.45 | 358.00 |
| **90%** | 913.26 | 7.47 | 955.74 | 22.55 | 190.34 | 18.75 | 23.00 | 0.68 | 1.78 | 0.60 | 1.54 | 397.60 |
| **75%** | 744.20 | 7.01 | 885.41 | 19.08 | 153.48 | 14.46 | 13.81 | 0.56 | 1.46 | 0.51 | 1.27 | 365.97 |
| **90% CI** | 632.35 | 6.71 | 838.87 | 16.78 | 129.09 | 11.62 | 7.73 | 0.48 | 1.25 | 0.46 | 1.10 | 345.05 |
| **75% CI** | 547.83 | 6.48 | 803.70 | 15.04 | 110.66 | 9.48 | 3.14 | 0.42 | 1.09 | 0.42 | 0.96 | 329.24 |
| **StdDev** | 341.53 | 0.93 | 142.09 | 7.02 | 74.47 | 8.66 | 18.56 | 0.24 | 0.65 | 0.17 | 0.54 | 63.89 |

## Q-SR CHURCH

This monitoring point is an in-stream sample located on the main stem of Shimel Run near Centre Church. It is also located just downstream of the confluence of the tributary containing SR-5.

| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/07/2006 | 16.61 | 7.30 | 2210.00 | 70.00 | 13.94 | -51.00 | -10.16 | 0.21 | 0.04 | 0.46 | 0.07 | 1165.00 |
| 11/02/2006 | 209.99 | 7.40 | 1300.00 | 59.00 | 148.56 | -45.00 | -113.31 | 0.26 | 0.65 | 0.77 | 0.16 | 586.00 |
| 04/03/2007 | 268.72 | 7.10 | 1590.00 | 42.00 | 135.33 | -24.00 | -77.33 | 0.59 | 1.90 | 1.24 | 0.57 | 798.00 |
| 06/13/2007 | 98.42 | 7.70 | 2260.00 | 67.00 | 79.07 | -44.00 | -51.93 | 0.63 | 0.74 | 0.59 | 0.17 | 1322.00 |
| | | | | | | | | | | | | |
| **Average** | 148.44 | 7.38 | 1840.00 | 59.50 | 94.23 | -41.00 | -63.18 | 0.42 | 0.84 | 0.77 | 0.24 | 967.75 |
| **Min** | 16.61 | 7.10 | 1300.00 | 42.00 | 13.94 | -51.00 | -113.31 | 0.21 | 0.04 | 0.46 | 0.07 | 586.00 |
| **Max** | 268.72 | 7.70 | 2260.00 | 70.00 | 148.56 | -24.00 | -10.16 | 0.63 | 1.90 | 1.24 | 0.57 | 1322.00 |
| **90%** | 333.91 | 7.79 | 2615.89 | 80.16 | 195.26 | -21.68 | 8.22 | 0.78 | 2.11 | 1.33 | 0.61 | 1520.68 |
| **75%** | 278.10 | 7.66 | 2382.41 | 73.94 | 164.86 | -27.49 | -13.27 | 0.67 | 1.73 | 1.16 | 0.50 | 1354.30 |
| **90% CI** | 241.17 | 7.58 | 2227.94 | 69.83 | 144.74 | -31.34 | -27.48 | 0.60 | 1.47 | 1.05 | 0.43 | 1244.22 |
| **75% CI** | 213.27 | 7.52 | 2111.21 | 66.72 | 129.54 | -34.25 | -38.23 | 0.55 | 1.28 | 0.96 | 0.37 | 1161.02 |
| **StdDev** | 112.75 | 0.25 | 471.66 | 12.56 | 61.42 | 11.75 | 43.40 | 0.22 | 0.78 | 0.34 | 0.22 | 336.13 |

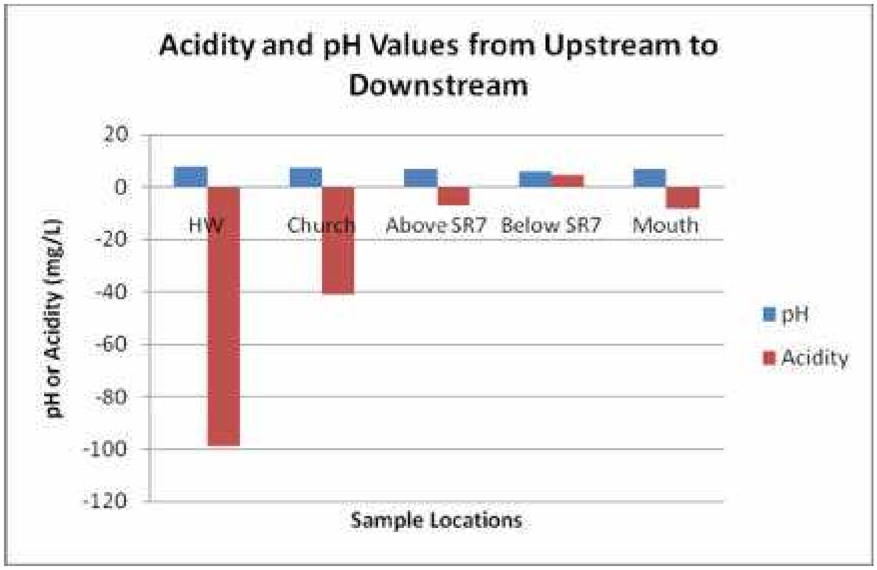
## Q-SR MOUTH

This monitoring point is an in-stream sample located at the mouth of Shimel Run just before it enters Moshannon Creek.

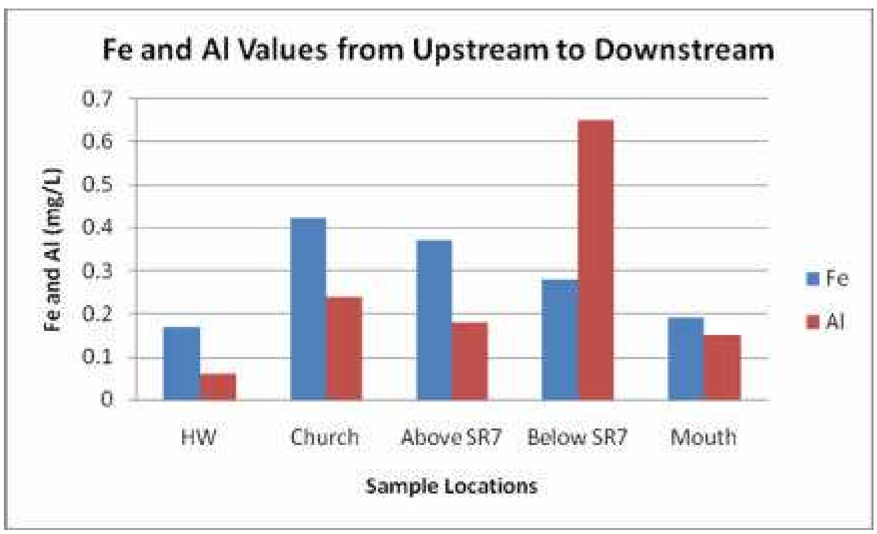
| Date | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/02/2006 | 80.78 | 6.80 | 693.00 | 23.00 | 22.28 | -12.00 | -11.62 | 0.17 | 0.16 | 0.15 | 0.10 | 238.00 |
| 11/02/2006 | 696.54 | 7.00 | 680.00 | 18.00 | 150.34 | -4.00 | -33.41 | 0.06 | 0.50 | 0.12 | 0.10 | 2852.00 |
| 04/03/2007 | 1109.88 | 6.90 | 746.00 | 19.00 | 252.86 | -6.00 | -79.85 | 0.29 | 3.86 | 0.18 | 0.28 | 307.00 |
| 06/13/2007 | 223.17 | 7.20 | 444.00 | 27.00 | 72.25 | -11.00 | -29.44 | 0.24 | 0.64 | 0.09 | 0.12 | 161.00 |
| | | | | | | | | | | | | |
| **Average** | 527.59 | 6.98 | 640.75 | 21.75 | 124.43 | -8.25 | -38.58 | 0.19 | 1.29 | 0.14 | 0.15 | 889.50 |
| **Min** | 80.78 | 6.80 | 444.00 | 18.00 | 22.28 | -12.00 | -79.85 | 0.06 | 0.16 | 0.09 | 0.10 | 161.00 |
| **Max** | 1109.88 | 7.20 | 746.00 | 27.00 | 252.86 | -4.00 | -11.62 | 0.29 | 3.86 | 0.18 | 0.28 | 2852.00 |
| **90%** | 1299.12 | 7.26 | 861.57 | 28.52 | 289.82 | -1.90 | 9.29 | 0.35 | 4.13 | 0.20 | 0.29 | 3043.94 |
| **75%** | 1066.96 | 7.17 | 795.12 | 26.48 | 240.05 | -3.81 | -5.12 | 0.30 | 3.27 | 0.18 | 0.25 | 2395.65 |
| **90% CI** | 913.35 | 7.12 | 751.16 | 25.13 | 207.13 | -5.07 | -14.65 | 0.27 | 2.71 | 0.17 | 0.22 | 1966.72 |
| **75% CI** | 797.27 | 7.07 | 717.94 | 24.11 | 182.24 | -6.03 | -21.85 | 0.25 | 2.28 | 0.16 | 0.20 | 1642.57 |
| **StdDev** | 469.01 | 0.17 | 134.24 | 4.11 | 100.54 | 3.86 | 29.10 | 0.10 | 1.72 | 0.04 | 0.09 | 1309.69 |

## Comparison of Stream Water Quality Throughout the Watershed

The following graphs represent the change in water quality from the upstream to the downstream sample locations on Shimel Run.




This graph represents the trend of acidity and pH from the headwaters to the mouth of Shimel Run. Alkalinity and acidity trends throughout are affected by mine discharges, while pH remains fairly consistent in the stream channel. In the headwaters of Shimel Run, the pH averages above 7.0 while alkalinity is almost 100 mg/L. The impacts of the Miller-Stein operation can be seen at the "church" sampling location, but still alkalinity is greater than acidity. The largest adverse impact to the stream is from the deep mine discharge, SR-7, and can be seen at the below SR-7 stream sampling location, where pH decreases and acidity of 5 mg/L, though still not severe, does adversely affect the fish population in the spring when the mine flushes higher levels of acidity. By the time Shimel Run reaches the mouth, it recovers and is alkaline again.




This graph represents the changing quality of iron and aluminum from the headwaters to the mouth of Shimel Run. The metal concentrations maintain extremely low levels, below 1.0 mg/L on average throughout the watershed. Similar to the acidity concentrations, an increase in aluminum is seen in the sample collected below the SR-7 deep mine discharge.

## AMD Treatment Methods:

Through the years, many treatments have been developed for AMD remediation and currently there are a number of organized efforts in Pennsylvania using both active and passive treatment methods on a watershed scale. Active treatment methods incorporate the use of mechanized procedures for the addition of alkaline materials and require constant monitoring and maintenance. Basic chemicals are used as additives to increase the pH and cause the precipitation of metals, such as Fe, Mn, and Al. The chemicals commonly used are Ca(OH)2 (hydrated lime), NaOH (caustic soda), $NH_3$ (ammonia), CaO (pebble quicklime) and $Na_2CO_3$ (soda ash) (Robb and Robinson, 1995). The chemicals used on a particular site depend on mine drainage characteristics and site accessibility. Hydrated lime is commonly used, but is hydrophobic and requires mixing. Pebble quicklime (CaO) is utilized at sites where it is usually dissolved by a water wheel arrangement. Soda ash, in the form of briquettes, is used in remote areas with low flows and low acidity. Caustic soda is also used in remote areas with low flows. Liquid caustic soda is capable of treating high acidity and high Mn because it raises the pH quickly, but it is expensive and dangerous to handle. Another potentially dangerous chemical used less frequently is ammonia. It must be handled carefully and is stored as a liquid. Ammonia can raise the pH above 9.2, but may have direct negative impacts on the biota of the receiving streams (Skousen and Ziemkiewicz, 1995).

Other active treatment methods include dissolved air flotation and ion exchange devices, flocculants, coagulants, and oxidants (Skousen and Ziemkiewicz, 1995). Active methods are successful, but expensive. It is not uncommon for water treatment costs to exceed $200,000 per year at AMD sites using active treatment. Another concern is the large volume of sludge produced from the precipitation of metals. Disposal costs for the sludge add to the cost of chemical treatment. Active methods may also cause environmental damage because potentially harmful chemicals are used. The high cost and possible side effects of active treatment can be avoided by the use of passive treatment systems.

Passive treatment systems, which require only limited maintenance, are the alternative approach to active treatment methods. They require no input of manufactured chemicals and have a lower operation and maintenance cost. A downside is that they do require longer retention times and larger treatment areas (Hedin et al., 1994). Page D-1 shows the evolution of passive treatment technology since the early 1980s. Passive treatment systems were first designed after it was observed that natural wetland systems in the path of AMD had some positive effects. The first passive systems described were natural *Sphagnum* wetlands that were improving AMD as discharges flowed through them. The first constructed wetlands were small and planted with cattails (*Typha latifolia)*. They were designed to encourage oxidation processes to precipitate unwanted metals and in turn increase the pH (Robb and Robinson, 1995). Constructed wetlands function by precipitating metal hydroxides, forming metal sulfides, and adsorbing small amounts of metals to the plant community (Skousen and Ziemkiewicz, 1995).

Two types of wetlands are constructed, aerobic and anaerobic. Aerobic wetland systems are designed to encourage metal precipitation through oxidation processes and are therefore normally shallow, vegetated, and have surface flow predominating (Robb and Robinson, 1995). Anaerobic wetland systems require that the mine water flow through an organic layer under anaerobic conditions. The organic material most commonly used is spent mushroom compost. This organic material must contain sulfate-reducing bacteria for metal sulfide precipitates to form (Robb and Robinson, 1995).

Both vegetation and bacteria are vital to wetland treatment success. Wetland plant species have many roles in mine drainage treatment. They include substrate consolidation, metal accumulation, stimulation of microbial activity and improve the aesthetics of the site. Constructed wetlands can also provide valuable wildlife habitat, for animals such as reptiles and amphibians. Plants may also serve as a food source. Sulfate reducing bacteria, such as *Desulfovibrio* and *Desulfotomaculum,* play a major role by increasing the pH and encouraging metal precipitation. It has been shown that *Desulfovibrio* are most effective at a pH > 4.5 so an important aspect of anaerobic wetland treatment is maintaining the pH within the organic layer (Nawrot and Klimstra, 1990). Sulfate reducers exist in the absence of oxygen and are only found in the deeper parts of the organic layer where they are able to perform their function of sulfate reduction and alkalinity production. Treatment efficiencies of these microbial dependent wetlands show trends of seasonal variation. The decrease in treatment efficiency may be due to biological functions slowing with decreasing temperatures (Kepler, 1990).

These bacteria utilize the organic substrate as a carbon source and use sulfate as an electron acceptor in the following reactions:

$$SO_4^{2-} + 2\ CH_2CHOHCOO^- + 4\ H^+ \dashrightarrow H_2S + 2\ CH_3COOH + 2\ H_2CO_3\ (1)$$

$$SO_4^{2-} + CH_3OO^- + 3\ H^+ \dashrightarrow H_2S + 2\ H_2CO_3\ (2)$$

$$SO_4^{2-} + 2\ CH_3CHOHCOO^- +3\ H^+ \dashrightarrow 3H_2S + 6\ H_2CO_3\ (3)$$

Sulfate reducing bacteria cannot break down complex organic substrates so they rely mainly on fermenting bacteria to provide substrates like acetate and lactate from larger organic molecules (Cork and Cusanovich, 1979). Plants aid in maintaining these bacterial communities by providing attachment sites and a continual supply of organic matter (Skousen and Ziemkiewicz, 1995).

Another type of passive treatment technology is an anoxic limestone drain (ALD). The Tennessee Division of Water Pollution Control in 1988 first built prototype ALDs. At the same time, the Tennessee Valley Authority (TVA) personnel found that AMD from a coal refuse dam was being neutralized by calcium carbonate limestone in an old road buried beneath the dam (Brodie et al., 1993). In an ALD, alkalinity is produced when AMD contacts limestone in an anoxic environment producing bicarbonate alkalinity. ALDs consist of a shallow limestone filled trench, sealed from the atmosphere, through which the AMD is channeled. Limestone with greater than 90% $CaCO_3$ is used to produce the greatest amount of alkalinity (Brodie et al., 1993). The limestone layer is often covered with plastic or geotextile fabric. Clay soil is then placed over the plastic or fabric followed by a covering of a heavy soil, then vegetated. The amount of limestone used is determined by the flow and loading of the AMD and desired longevity for the system. Usually, extra limestone is employed to ensure a comfortable safety factor for longevity. The use of an oxidation basin immediately after the ALD allows for precipitation of the metals (Brodie et al., 1993).

Three other criteria are followed when constructing ALDs. The first is to keep out any organic matter that may allow microorganisms to grow and coat the limestone. The second is that larger limestone (1"-6") should be used to maintain flow in case plugging occurs due to metal precipitation. Finally, oxygen should be kept out of the drain to deter metal precipitates from forming (Skousen and Ziemkiewicz, 1995). ALDs have been found to raise pH and introduce as much as 300 mg/l of bicarbonate alkalinity as shown by the following equations:

$$CaCO_3\ (s) + 2\ H^+ \leftarrow\!\!\!\dashrightarrow Ca^{2+} + H_2CO_3^-\ (1)$$

$$CaCO_3\ (s) + H_2CO_3^- \leftarrow\!\!\!\dashrightarrow Ca^{2+} + 2\ HCO_3^-\ (2)$$

$$CaCO_3\ (s) + H_2O \leftarrow\!\!\!\dashrightarrow Ca^{2+} + HCO_3^- + OH^-\ (3)$$

The rate of calcium dissolution is dependent on carbon dioxide partial pressure. Generally, the rate of calcium dissolution will increase as the partial pressure increases (Plummer et al., 1979).

As the water leaves the ALD and is exposed to oxygen, the increased pH promotes metal precipitation and the bicarbonate alkalinity neutralizes the acidity produced by metal hydrolysis (Hedin and Watzlaf, 1994). Dissolved oxygen (DO) concentration is a limiting factor in the utility of ALDs. A DO level of less than 1.0 mg/l is recommended to ensure that $Fe^{3+}$ will not precipitate, coating the limestone or clogging the system (Kepler and McCleary, 1994). $Al^{3+}$, however, can precipitate at a pH > 4.5 in the absence of oxygen, therefore clogging the system even in the absence of oxygen (Kepler and McCleary, 1994). ALDs are often used in combination with anaerobic constructed wetlands and vertical flow wetlands, which are also called successive alkalinity producing systems (SAPS) in the literature.

Vertical flow wetlands are being used on mine sites for the treatment of AMD (page D-2 and D-3). It is a newer technology that has shown great success. Vertical flow wetlands combine ALDs and anaerobic wetlands into one integrated system. Vertical flow is promoted through rich organic wetland substrates followed by a limestone bed (Kepler and McCleary, 1994). Most systems are constructed as ponds lined with 65-85 cm of limestone on which approximately 65 cm of spent mushroom compost is spread. To maintain reducing conditions within the organic layer, at least 85 cm of compost is recommended (Demchak, et al. 2001). On top of the compost layer is freestanding water with a depth of 40-255 cm (Skousen and Ziemkiewicz, 1995). Perforated pipes under the limestone layer collect the flow. Various piping patterns are used from a minimal approach where only 2-3 pipes are placed lengthwise through the system, to a maximal approach where piping is placed in a grid-like pattern on 5' or 10' centers. Demchak et al. recommends the use of increased piping to insure preferential flow does not occur.

Vertical flow wetlands add alkalinity both through bacterial sulfate reduction and limestone dissolution. Bacterial-mediated sulfate reduction occurs in the organic layer. Bacteria oxidize organic compounds using sulfate and release hydrogen sulfide and bicarbonate. The sulfate reduction directly affects concentrations of dissolved metals by raising alkalinity and providing the conditions necessary for precipitating them as metal sulfides (Skousen and Ziemkiewicz, 1995). Metals precipitating in the system may decrease the lifespan. Flushing the wetlands may be a solution to increasing the treatment success and may aid in the prevention of clogging. Acidic conditions may also be created from reactions involving $H_2S$, including $H_2S \rightarrow H^+ + HS^-$ and $Fe^{2+} + HS^- \rightarrow FeS + H^+$. When the mine water enters the organic layer containing dissolved $Fe^{3+}$, dissolved $O_2$, or precipitated Fe and Mn oxides, the $H_2S$ is oxidized and mineral acidity is affected (Hedin et al., 1994). As the $H_2S$ levels increase, the acidity decreases raising pH levels. The amount of $H_2S$ produced can be qualitatively detected by both the odor of the gas and the rich black color of the organic layer which can be an indicator of successful treatment within the wetland (Nawrot and Klimstra, 1990).

Another source of bicarbonate in vertical flow wetlands is attributed to dissolution of the limestone, $CaCO_3 + H^+ \rightarrow Ca^{2+} + HCO_3^-$. The dissolution rate and concomitant alkalinity generation are greatly affected by the partial pressure of $CO_2$. Anaerobic mine water increases $CO_2$ partial pressures due to decomposing organic matter and precipitation of metal sulfides. The dissolved $CO_2$ is a weak diprotic acid and continues to react with limestone, producing more $Ca^{2+}$ and $HCO_3^-$. When highly acidic water contacts limestone, the first reaction is neutralization of proton acidity. The reaction increases pH and decreases metal solubility. As pH rises above 4.5, bicarbonate accumulates, decreasing the solubility of metals (Hedin et al., 1994a). It has been stated that limestone dissolution requires a 12-hour contact time for maximum alkalinity production (Kepler and McCleary, 1994). In vertical flow wetlands, through a combination of bacterial mediated sulfate reduction and limestone dissolution, alkalinity is produced. The increased pH results in the precipitation of metals when the discharged water is exposed to oxygen.

Passive treatment technology is undergoing rapid development because of the importance of developing remediation methods for AMD at a low cost. Other systems are being studied to determine if they can be successfully used as cost-efficient systems, either alone or in combination with other systems. One such system is a limestone pond. The pond is constructed on an upwelling of an AMD seep or underground discharge point. Limestone is placed on the bottom of the pond and water flows up through it. They are normally constructed with 1-3 m of water, 0.3-1.0 m of limestone, and have a retention time of 1-2 days. The drainage requires a low DO, and should contain minimal $Fe^{3+}$ and $Al^{3+}$, so clogging does not occur (Skousen and Ziemkiewicz, 1995). If higher concentrations of metals are present, a flushing system can be added.

Another technique involves the use of open limestone channels. They add alkalinity to acidic water in open channels or ditches lined with limestone. The channel should contain a slope greater than 20% to maintain flow velocities that keep precipitates in suspension (Skousen and Ziemkiewicz, 1995). Direct addition of limestone sand to streams is another technique being used. The sand is placed in the headwaters of a stream and during high flows the sand moves downstream and mixes with natural sediments. No harmful effects have been seen. An increase in pH and calcium levels have been observed along with a decrease in toxic aluminum species. A careful selection of particle size, purity and mass of the limestone is important for treatment success (Downey et al., 1994).

Diversion wells have been used in Scandinavia to treat small acidic streams since the late 1970's (Sverdrup, 1983). The first full-sized wells were implemented in Sweden in 1980 and were first used in Lebanon County, Pennsylvania in 1986. Diversion wells are constructed from a cylinder or vertical tank made of either concrete or metal. They are 1.5-1.8 m in diameter, 2.0-2.5 m deep and filled with limestone. They contain a large pipe that extends vertically down the center of the well. Water is fed from the stream into the pipe that exits near the bottom through a nozzle. Water then flows up through the limestone, fluidizing it. Grinding and dissolution of the limestone occurs creating alkalinity. Due to the high pressure created within the wells, floc is removed at a consistent rate, so limestone coating is not a concern. Diversion wells are not entirely passive in that limestone must be added on a monthly basis and sometimes even daily. They work best where metal concentrations are low since there are no settling ponds employed.

Bioremediation is another passive treatment technique being used. Seeded microbes are used to convert metals to their less harmful species. Metal oxidation and precipitation are promoted through hydroxide formation, as is metal reduction and precipitation through sulfide formation. One example is the use of metal oxidizing beds for the treatment of both Mn and Fe (Skousen and Ziemkiewicz, 1995). Mn is difficult to remove because of the high pH required to precipitate it (> 9.0) and competition with Fe precipitation when Fe is present in high concentration. Researchers in Maryland have established a combination of microbes that have been shown to precipitate Mn to effluent standards. These beds have been in use for approximately 10 years, with the first being constructed in Pennsylvania in 1994.

### Maintenance

Through discussions with the various project partners, it was determined that long term maintenance of the constructed treatment systems will be conducted through a coordinated effort. The partners are willing to do the field work associated with maintenance of the treatment cells. An operation and maintenance plan will be developed for each treatment project as it enters final design. Potential problems are as follows:

- Wetlands require minimal maintenance.
- Visual inspections are necessary to insure muskrats and beavers are not impacting inlet/outlet structures or destroying vegetation.
- Vertical flow wetlands require regular flushing to insure plugging does not occur. This flushing frequency will vary depending on the size of the system and metal loading entering the system.
- The primary maintenance issue is with solids removal in the settling ponds. The purpose of the settling pond is to collect precipitated metals. These solids accumulate over time and will eventually need to be removed. Ponds are typically designed to operate for 10 years or more before needing to be cleaned out.

## Prioritization of Treatment Areas

The prioritization of treatment areas were based on a variety of criteria. Criteria outlined by the EPA for the development and prioritization of treatment projects were used. Priorities were based on loadings or significant impact in the watershed, availability of space for construction, cost feasibility, landowner permission, access, and overall impact towards reaching the outlined watershed goals. Three treatment systems are being recommended for construction to improve water quality in the watershed and allow for repopulation of trout throughout Shimel Run. We will, however, address quality of each sample location and give a brief justification for our decision to treat or not treatment each location.

Each priority area and its conceptual treatment design are presented below. All are conceptual designs and will most likely change during the design and permitting phase of each individual project as more information is gathered. Cost estimates are also given for each project. The cost estimates were obtained using AMDtreat.

## Priority #1: SR-2

### Site Description:

This monitoring point was a collection of water from both the overflow from an old sediment pond on the Miller Stein surface mine site and additional seepage from the toe of slope from the reclaimed hillside area.

**Table 17: Summary of Chemistry for SR-2**

| | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average** | 15.04 | 6.50 | 608.30 | 16.60 | 3.46 | -1.20 | 0.54 | 2.61 | 0.35 | 0.39 | 0.43 | 159.10 |
| **Min** | 0.00 | 6.00 | 300.00 | 11.00 | 0.00 | -9.00 | -0.90 | 0.29 | 0.00 | 0.09 | 0.05 | 26.00 |
| **Max** | 75.00 | 6.90 | 2110.00 | 23.00 | 11.69 | 5.00 | 4.50 | 10.70 | 1.38 | 1.29 | 2.01 | 1272.00 |
| **90%** | 54.78 | 6.90 | 1496.65 | 22.26 | 10.46 | 7.94 | 3.06 | 8.44 | 1.09 | 0.98 | 1.42 | 802.41 |
| **75%** | 42.82 | 6.78 | 1229.34 | 20.55 | 8.35 | 5.19 | 2.30 | 6.68 | 0.87 | 0.80 | 1.12 | 608.83 |
| **90% CI** | 26.06 | 6.63 | 889.22 | 18.39 | 5.67 | 1.69 | 1.34 | 4.45 | 0.59 | 0.58 | 0.74 | 362.53 |
| **75% CI** | 22.74 | 6.59 | 804.69 | 17.85 | 5.01 | 0.82 | 1.10 | 3.90 | 0.52 | 0.52 | 0.65 | 301.32 |
| **StdDev** | 24.16 | 0.24 | 540.03 | 3.44 | 4.26 | 5.55 | 1.53 | 3.54 | 0.45 | 0.36 | 0.61 | 391.07 |

### Recommendations:

The SR-2 discharge was dry four of the sampling months and was less than 3 gpm an additional three months, but when the discharge flowed, iron levels were moderate at 7 and 10 mg/L. It is an alkaline discharge with pH averaging 6.5. A small aerobic wetland is recommended to allow for metal precipitation during the high flow months to protect the stream quality in the headwater reaches. The design flow is based on 20 gpm, Fe concentration of 5 mg/L and Al concentration of 2 mg/L.

It is recommended that a series of two small aerobic wetlands be constructed using the iron removal rate of 5 $g/m^2$/day to allow for metal precipitation and the increase of pH. The wetlands will be constructed with a substrate of a 1:1 ratio of organic matter and limestone to maintain the pH as the iron precipitates. The size of the cells will be 90 ft x 50 ft and will cost approximately $55,000 to construct. Additional monies will be needed for design and permitting of the project.

### Predicted Effect of System on Receiving Stream:

The water discharging from the aerobic wetlands should be alkaline in nature with minimal iron and aluminum concentrations. The treatment should remove 1 lb/day of acidity, 1 lb/day of iron, and 1 lb/day of aluminum. The metals should all be retained in the wetland. The treated water should be able to support an aquatic community.

### Other:

A final O&M plan will be developed with the construction phase of the project once final design specs are complete. Visual checks of the system will be made quarterly to insure that wildlife is not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the treatment system on water quality. The Moshannon Creek Watershed Coalition has agreed to assume the long term O&M of the treatment system. They will be conducting the quarterly checks and reporting to NMBS if any corrections need to be made.

## Priority #2: SR-5

### Site Description:

This monitoring point receives flow from a channelized, wetland area. The area upslope from the sampling point is a reclaimed strip mine area. It is possible that this location was related to past deep mining, but not clear evidence could be found.

**Table 18: Summary of Chemistry for MR SR-5**

| | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average** | 13.17 | 3.68 | 559.67 | 0.00 | 0.00 | 44.67 | 16.03 | 0.52 | 0.21 | 1.20 | 4.32 | 236.83 |
| **Min** | 0.00 | 3.50 | 472.00 | 0.00 | 0.00 | 30.00 | 0.40 | 0.21 | 0.00 | 0.92 | 2.39 | 186.00 |
| **Max** | 91.00 | 4.00 | 689.00 | 0.00 | 0.00 | 60.00 | 45.83 | 0.86 | 0.83 | 1.70 | 6.08 | 308.00 |
| **90%** | 56.35 | 3.97 | 712.37 | 0.00 | 0.00 | 65.85 | 45.04 | 0.93 | 0.72 | 1.76 | 6.91 | 318.65 |
| **75%** | 43.36 | 3.88 | 666.42 | 0.00 | 0.00 | 59.48 | 36.31 | 0.80 | 0.57 | 1.59 | 6.13 | 294.03 |
| **90% CI** | 25.15 | 3.80 | 622.01 | 0.00 | 0.00 | 53.32 | 27.88 | 0.69 | 0.42 | 1.43 | 5.38 | 270.24 |
| **75% CI** | 21.54 | 3.76 | 603.25 | 0.00 | 0.00 | 50.71 | 24.31 | 0.64 | 0.36 | 1.36 | 5.06 | 260.18 |
| **StdDev** | 26.25 | 0.17 | 92.83 | 0.00 | 0.00 | 12.88 | 17.63 | 0.25 | 0.31 | 0.34 | 1.57 | 49.74 |

### Recommendations:

The SR-5 discharge shows a flashy flow and is affected by either surface runoff or mine pool elevation changes. It was dry for seven of the sampling months, but flowed as high as 90 gpm in January 2007. In the Spring of 2007, it flowed for three months at 30 to 35 gpm and adversely impacted the headwaters of Shimel Run and therefore it is recommended that treatment should occur on this discharge. Fish can be seen downstream at the Q-SR Church sample location and it is believed that in the spring, when this discharge flows at its highest and flushes aluminum levels at 5-10 mg/L, a possible fish kill may occur, discouraging breeding populations in the headwaters region or forcing the populations downstream. By treating the discharge, it would allow the fish populations to move upstream and use all of Shimel Run. Fish currently seem to be staying between the confluence of Shimel Run and the tributary below SR-5 and in Shimel Run **above** SR-7.

Based on the flow rates and chemistry, a limestone cell and settling basin is recommended at this site. A design flow of 35 gpm with an acidity of 50 mg/L, Fe of less than 1 mg/L, and aluminum of 5 mg/L were used to size the cell. It was determined that 650 tons of limestone would be needed to treat the discharge based on the alkalinity generation rate. An estimated cost of $75,000 would build the system and pond and additional costs would be needed for design/permitting.

### Predicted Effect of System on Receiving Stream:

The water discharging from the settling basin should be alkaline in nature with minimal iron and aluminum concentrations. The treatment should remove 16 lbs/day of acidity, 1 lb/day of iron, and 2 lbs/day of aluminum. The metals should be retained in the basin. The treated water should be able to support an aquatic community.

### Other:

A final O&M plan will be developed with the construction phase of the project once final design specs are complete. Visual checks of the system will be made quarterly to insure that wildlife is not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the treatment system on water quality. The Moshannon Creek Watershed Coalition has agreed to assume the long term O&M of the treatment system. They will be conducting the quarterly checks and reporting to NMBS if any corrections need to be made.

## Priority #3: SR-7

### Site Description:

This monitoring point is a deep mine discharge that is contributing a substantial amount of flow to Shimel Run. The discharge flows approximately 200 yards to where it enters Shimel Run along Logan Road.

**Table 19: Summary of Chemistry for SR-7**

| | Flow (gpm) | pH (SU) | Cond | Alk | Alk load (lbs/day) | Acidity (mg/l) | Acid load (lbs/day) | Iron | Iron load (lbs/day) | Mn | Al | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average** | 114.08 | 5.02 | 551.08 | 5.31 | 7.65 | 59.38 | 66.62 | 0.05 | 0.07 | 0.42 | 0.85 | 225.08 |
| **Min** | 15.00 | 4.70 | 460.00 | 3.00 | 0.90 | 10.00 | 2.70 | 0.05 | 0.01 | 0.33 | 0.56 | 169.00 |
| **Max** | 302.01 | 5.40 | 681.00 | 6.00 | 21.73 | 594.00 | 554.14 | 0.06 | 0.22 | 0.57 | 1.08 | 260.00 |
| **90%** | 257.37 | 5.29 | 657.64 | 6.71 | 17.56 | 323.65 | 320.91 | 0.06 | 0.17 | 0.55 | 1.13 | 272.04 |
| **75%** | 214.25 | 5.21 | 625.57 | 6.29 | 14.58 | 244.13 | 244.39 | 0.06 | 0.14 | 0.51 | 1.04 | 257.91 |
| **90% CI** | 155.44 | 5.09 | 580.63 | 5.70 | 10.51 | 132.68 | 140.03 | 0.05 | 0.10 | 0.45 | 0.92 | 238.10 |
| **75% CI** | 142.99 | 5.07 | 571.74 | 5.58 | 9.65 | 110.62 | 117.94 | 0.05 | 0.09 | 0.44 | 0.90 | 234.18 |
| **StdDev** | 87.11 | 0.17 | 64.78 | 0.85 | 6.03 | 160.65 | 154.58 | 0.00 | 0.06 | 0.08 | 0.17 | 28.55 |

### Recommendations:

The SR-7 discharge is a high flow deep mine discharge with a maximum flow of 300 gpm. It is slightly acidic with an average pH of 5.0, but low metals with Fe, Al, and Mn: all being less than 1.0 mg/L; however, acidity is greater than alkalinity. This discharge is adversely affecting Shimel Run as evidenced by the quarterly monitoring points above and below this discharge. Stream quality above shows a pH averaging 6.8, while stream quality below the discharge is 4.8 to 5.6. In order to allow the fish population to move from the headwaters to the mouth, it is important to improve water quality through this stream reach. It is recommended that a limestone cell be placed on this discharge to increase pH flowing into the main stem of Shimel Run.

The design flow for the system is a flow rate of 125 gpm, acidity of 15 mg/L and Fe and Al less than 1 mg/L. Due to the higher pH (5.0) and low acidity, the kinetics of the reaction will be very slow. It will be important to incorporate baffles and other devices to increase contact time with the limestone. It is recommended that 1800 tons of limestone be placed in a series of two to three treatment cells to allow for maximum contact time and neutralization potential. Settling basins are not necessary as there are not metals to precipitate. Another alternative is an anoxic limestone drain if the discharge has a low dissolved oxygen. Readings will be taken before a final design is made. An estimated cost of $75,000 would build the system and additional costs would be needed for design/permitting.

### Predicted Effect of System on Receiving Stream:

The water discharging from the treatment system should be alkaline in nature with minimal iron and aluminum concentrations. The treatment should remove 60 lbs/day of acidity, and 1 lb/day of iron, and 1 lbs/day of aluminum. The treated water should be able to support an aquatic community.

### Other:

A final O&M plan will be developed with the construction phase of the project once final design specs are complete. Visual checks of the system will be made quarterly to insure that wildlife is not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the treatment system on water quality. The Moshannon Creek Watershed Coalition has agreed to assume the long term O&M of the treatment system. They will be conducting the quarterly checks and reporting to NMBS if any corrections need to be made.

## Additional Sampling Locations

1. SR-HW: The headwaters of Shimel Run are extremely alkaline with a pH ranging from 7.6 to 8.0 and alkalinity from 95 to 130 mg/L. It is believed that this quality is due to high quantities of alkaline backfill in the Miller Stein surface mine operation. Regardless of the reason, the stream quality is excellent in the headwaters of Shimel Run.
2. SR-11: This discharge is found near the headwaters of Shimel Run and was used to monitored seepage from a settling pond associated with active treatment from the Miller Stein operation. This site had minimal flow, was alkaline in nature, and the metals were less than 1 mg/L. The site was chosen as an oversite to monitor treatment at Miller Stein.
3. SR-4a: This discharge was on the backside of Miller Stein and for nine months it had less than 1 gpm on flow. In January 2007 it did flow at 12 gpm. It was an alkaline discharge with a pH greater than 7.0. It had alkalinity ranging from 150 to 200 mg/L with iron and aluminum less than 1 mg/L. Again, it is thought that alkaline addition was added to the backfill on this part of the site. No treatment is recommended.
4. SR-4b: This discharge was closely related to SR-4a, but did have slightly different chemistry. It also had flow of less than 1 gpm for 9 months and a high value of 15 gpm in January 2007. It had a pH of around 6.0, with slightly lower alkalinities of 7 to 60 mg/L. Its metals concentrations were slightly higher at 2.5 mg/L for Fe and 2.7 mg/L for Al, both in January 2007 due to the flushing event. Treatment is not recommended at this sited based on one high flow event. The cost of a treatment system cannot be justified at this time, but the site s could continue to be monitored as other treatment systems are put on line.
5. SR-6: This discharge is located moving downstream in a reclaimed surface mine site. It "pops" up on the lowest point of what would have been the mine floor. For nine months of the sampling it was dry or less than 1 gpm. It was slightly acidic with a pH of 5.7 to 6.2, with alkalinities ranging from 12-18 mg/L. Metal concentrations were less than 1 mg/L. The chemistry does not warrant a treatment system.
6. SR-9: This discharge is an alkaline discharge that borders SR-53 and receives flow from a wetland area seeping from an area near J.J. Powell's. The pH was consistently greater than 7.0 with alkalinity between 25 and 50 mg/L. The metals were all less than 1 mg/L. No treatment is recommended at this site.

7. SR-10: This monitoring point consists of seeps coming from a wetland that borders SR-53 and a pond that overflows during high flow events. It was dry ten of the sampling times. It was alkaline with a pH of 6.8 and alkalinity between 30-40 mg/L. The metals were less than 1 mg/L. No treatment is recommended.

### Summary Treatment Areas

The following table summarizes the treatment necessary for the restoration of Shimel Run. The total cost includes expected costs of construction, design, and permitting. These are estimated costs based upon current dollars, current costs, and current designs.

| Priority | Sites | Treatment | Cost |
|---|---|---|---|
| #1 | SR-2 | Aerobic Wetland | $90,000 |
| #2 | SR-5 | Limestone cell, settling basin | $125,000 |
| #3 | SR-7 | Limestone cell or ALD | $125,000 |

# Potential Funding Sources

PADEP's Growing Greener Program is considered the largest source of funding for watershed projects. This program provides funding for design/permitting and construction phases for remediation of mine drainage in a watershed. The grant period normally opens in early winter and closes in early spring, with announcements made in late summer. The grant length is normally two to three years to allow for completion of construction. Non-profit groups, educational institutions and municipalities may apply for grants. Through submission to the Growing Greener Grant program, projects are eligible for EPA 319 Watershed grants. To be eligible for EPA 319 monies, a TMDL needs to be completed on the watershed.

The Bureau of Abandoned Mine Reclamation (BAMR) can also provide funds for surface reclamation projects. BAMR can also design and construct passive treatment systems. It is the landowner's responsibility to contact BAMR to get them involved with projects.

The Office of Surface Mining Appalachian Clean Streams Initiative. These grants can be used for construction phases only, not for engineering or design costs. This program also requires a significant match. These grants are within the $100,000 range, but can be successfully matched with other funding to complete a project. OSM has an open grant application, so no deadlines exist.

There are many small grant programs that exist that can be used for match monies or for small projects. Western PA Small Watershed Grant Program, PA American Water, Heinz Foundation and many others exist. It is up to the group and their consultant to find the right grant program to fit the project.

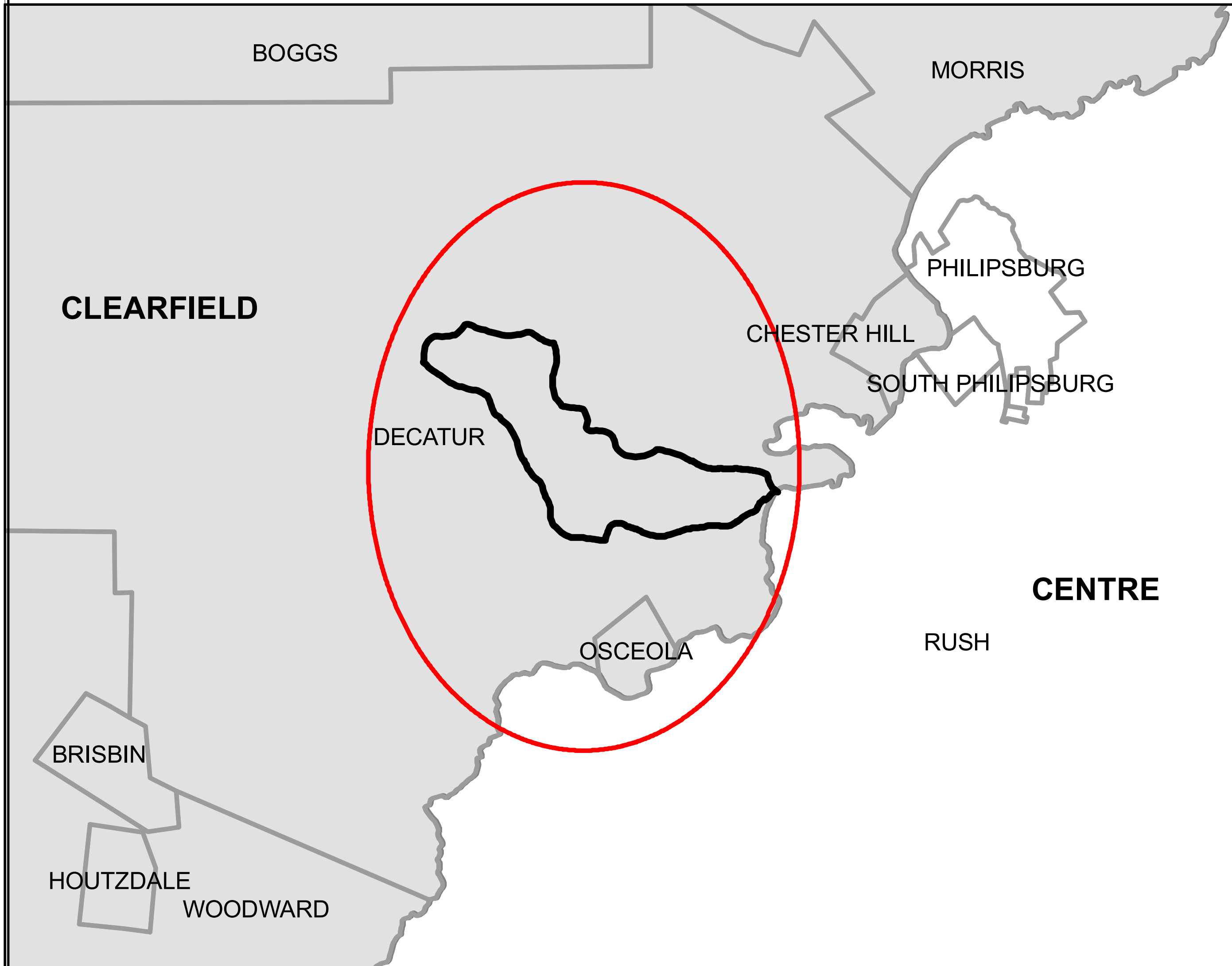
As stated above, all grant programs rely on match money for success and funding. This match comes through community involvement, volunteers, equipment donation, or material donation.

# Appendix A: Maps

| | | |
|---|---|---|
| A-2 | Watershed in PA | This displays the location of the watershed in Pennsylvania as well as the nearby civil boundaries. |
| A-3 | Stream Quality | This displays a color coded version of the watershed. The variation in color describes the quality of the stream as it runs from headwaters to mouth based upon the sampling performed. |
| A-4 | Sampling | This displays the points at which sampling was performed in the watershed as part of this assessment. |
| A-5 | Sampling on Topo | This displays the same data as is seen in A-4, but relevant portions of USGS quad maps are also displayed to provide context and area topography. |
| A-6 | Wetlands/NWI | This displays the NWI wetland areas within the watershed (as identified by US Fish & Wildlife). |
| A-7 | Historical Permitting | This displays the approximate center point of areas permitted in or partially in or otherwise impacting the watershed. Historical permits were discussed in the text. |
| A-8 | Mined areas | This displays the position of permitted and other historical mining operations in and near the watershed. AML List items in and near the watershed are also displayed by type on this map. |
| A-9 | AML priorities | This displays AML priorities in and near the watershed as determined and reported by the Bureau of Abandoned Mine Reclamation in 2008. |
| A-10 | Soil survey | This displays the soils of the area as reported by NRCS in 2005. Some differences will appear on this map as compared to the last published soil survey report. The data used to create this map was considered more recent, and thereby more appropriate to report. |
| A-11 | Geology | This displays the regional bedrock within and near the watershed. Data was provided by DCNR (see http://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspx) which digitized data from the 1980 map published by the Bureau of Topographic and Geologic Survey. |
| A-12 | Clearfield County Geology | This displays a map made in 1884 which displays the geology determined at the time. |
| A-13 | Treatment Areas | This displays the location of recommended treatment areas. |

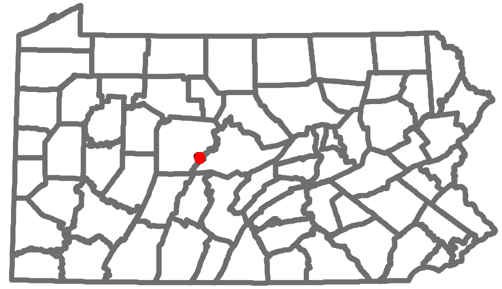
Maps should be used as reference only. Exact precision is neither implied nor guaranteed.

# Shimel Run Watershed in PA




Watershed closeup

1:88000



Watershed in PA

Topographic Map:
watershed, and county boundaries
Provided by PASDA

0 1,000 2,000 4,000 6,000 8,000 Meters

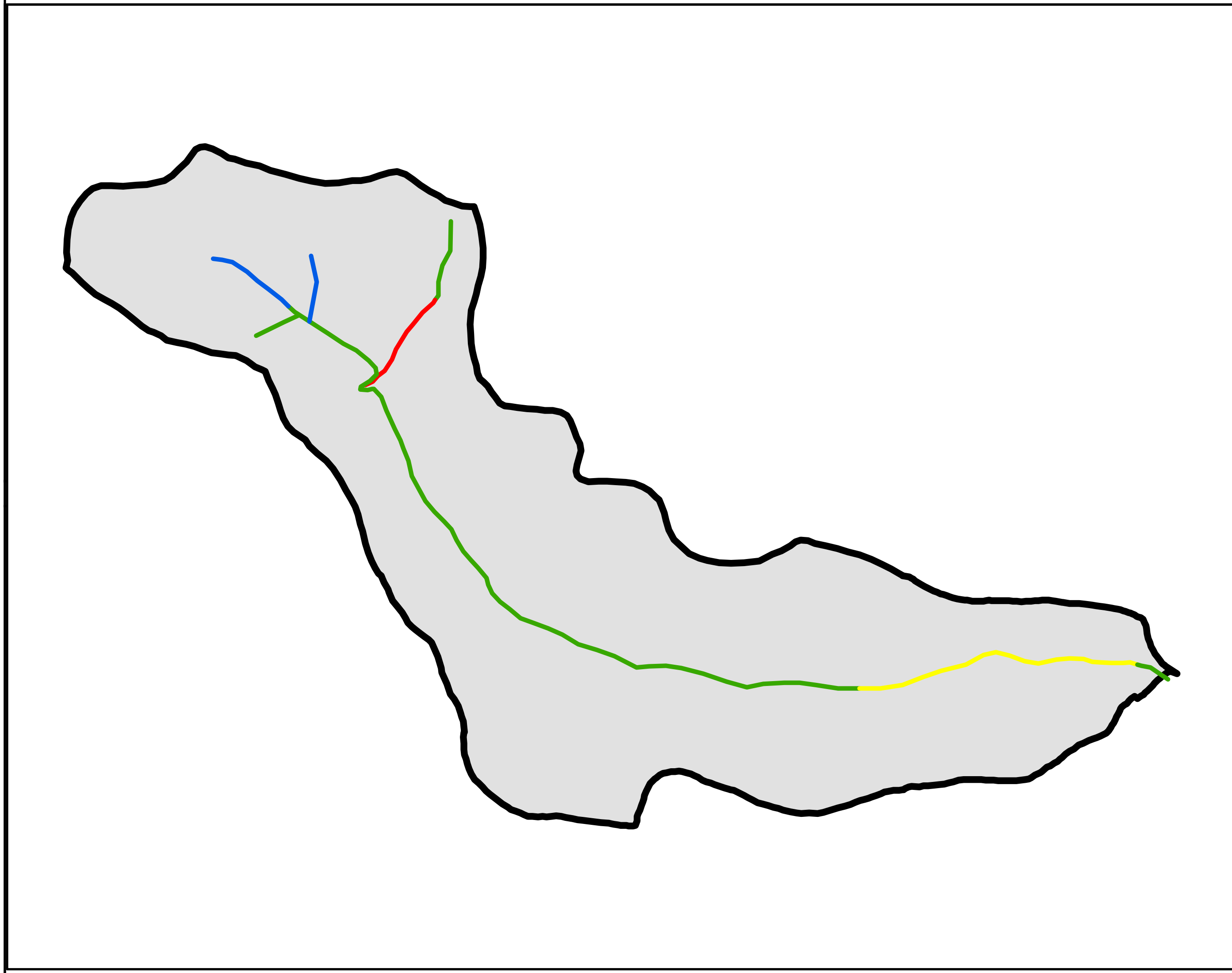
A-2

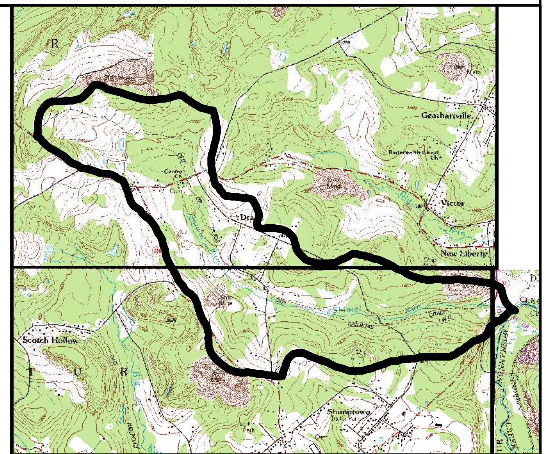
Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NEW MILES OF BLUE STREAM

# Shimel Run - Stream Quality

N





Watershed on Topo

Topographic Map:
7.5 minute Raster graphics,
watershed, and civil bounds
Provided by PASDA

**Legend**

*Highly degraded*

*Moderately degraded*

*Slightly degraded*

*High Quality*

Watershed and Stream segment quality

1:28000

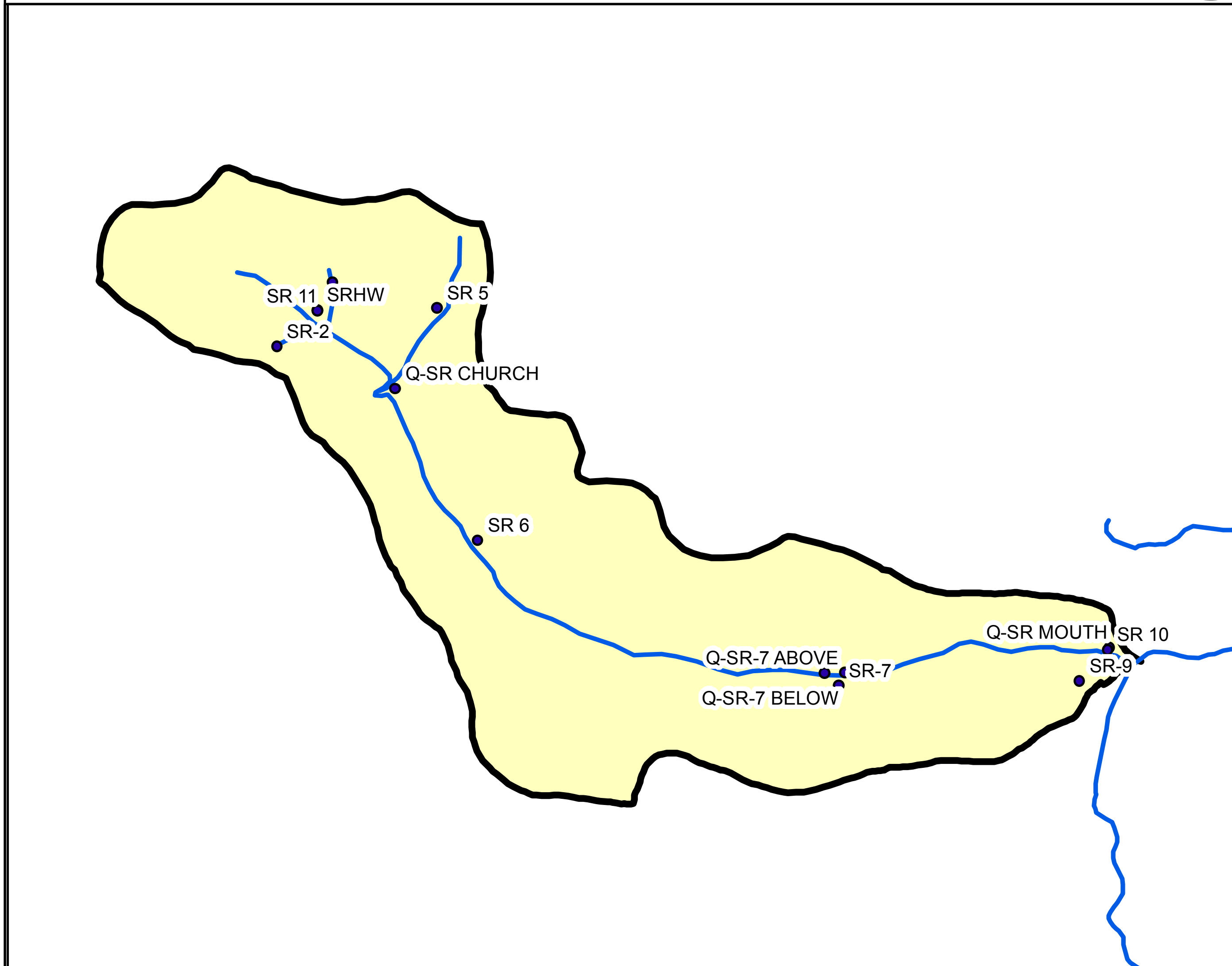
0 300 600 1,200 1,800 2,400 Meters



Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

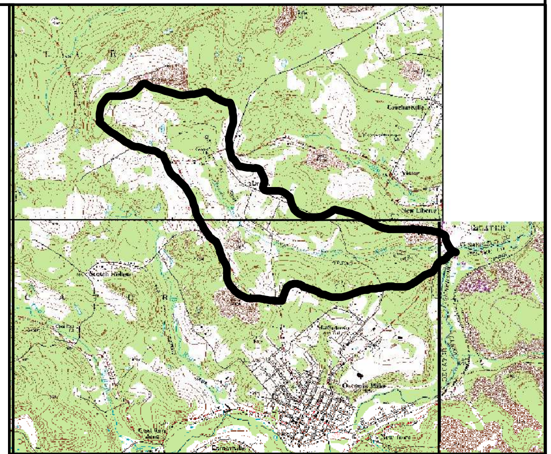
NEW MILES OF BLUE STREAM

# Shimel Run - Sampling




Location of sampling points in watershed

1:28000



Watershed on Topo(s)

7.5 minute Topo Quads, watershed bounds, and stream digitizing provided by PASDA

0 320 640 1,280 1,920 2,560 Meters

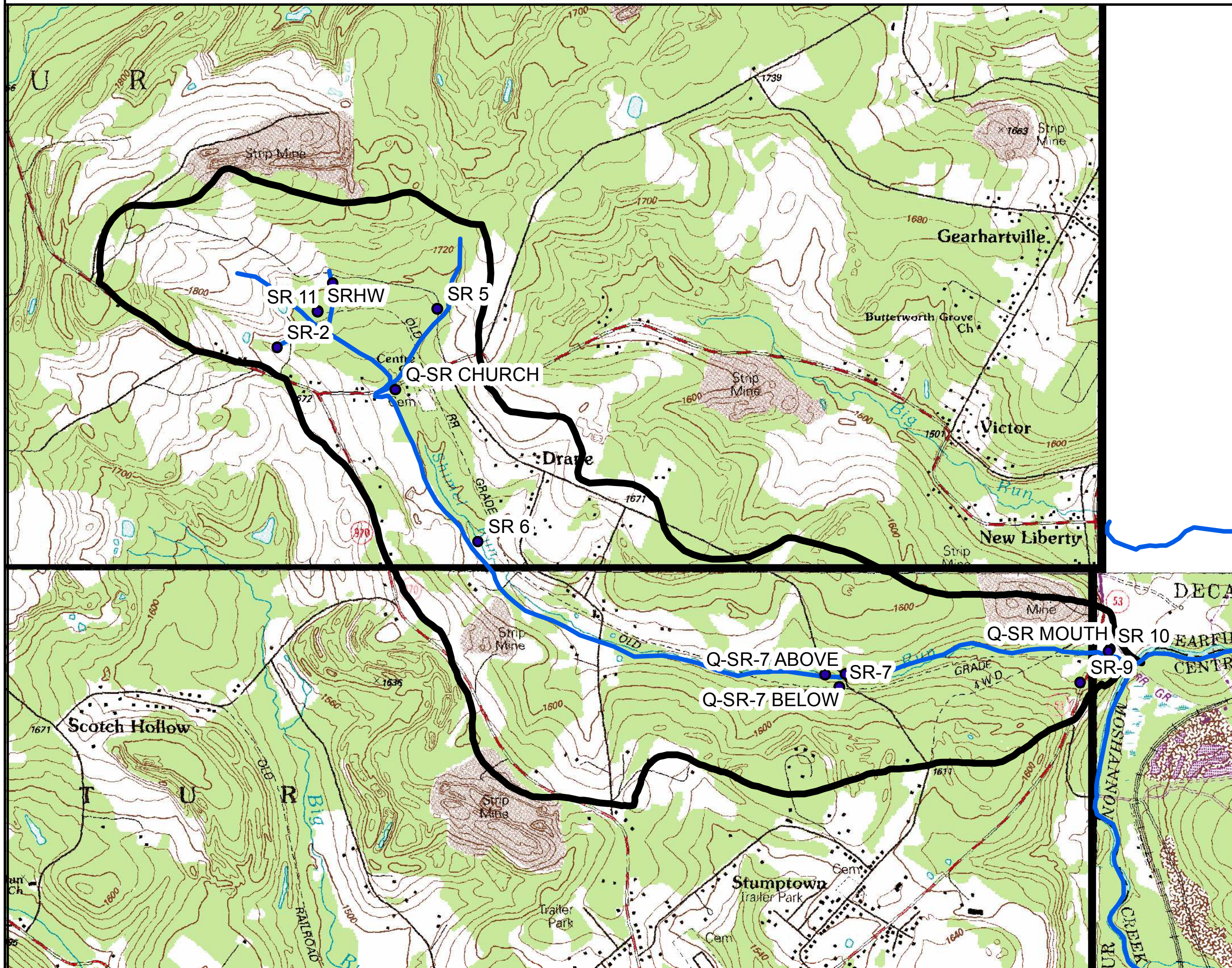
A-4

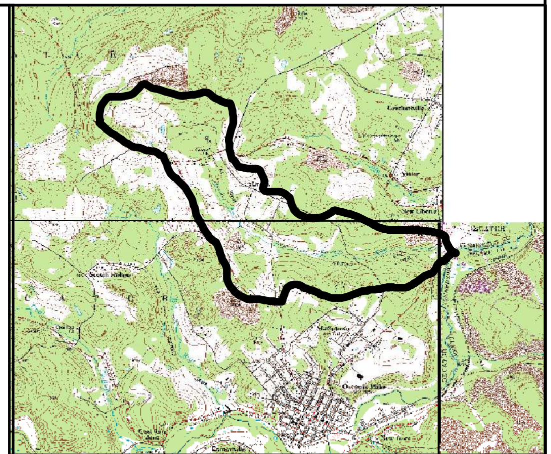
Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NEW MILES OF BLUE STREAM

# Shimel Run - Sampling on Topo

N



Watershed on Topo(s)

Location of sampling points in watershed

1:28000

7.5 minute Topo Quads, watershed bounds, and stream digitizing provided by PASDA

0 320 640 1,280 1,920 2,560 Meters

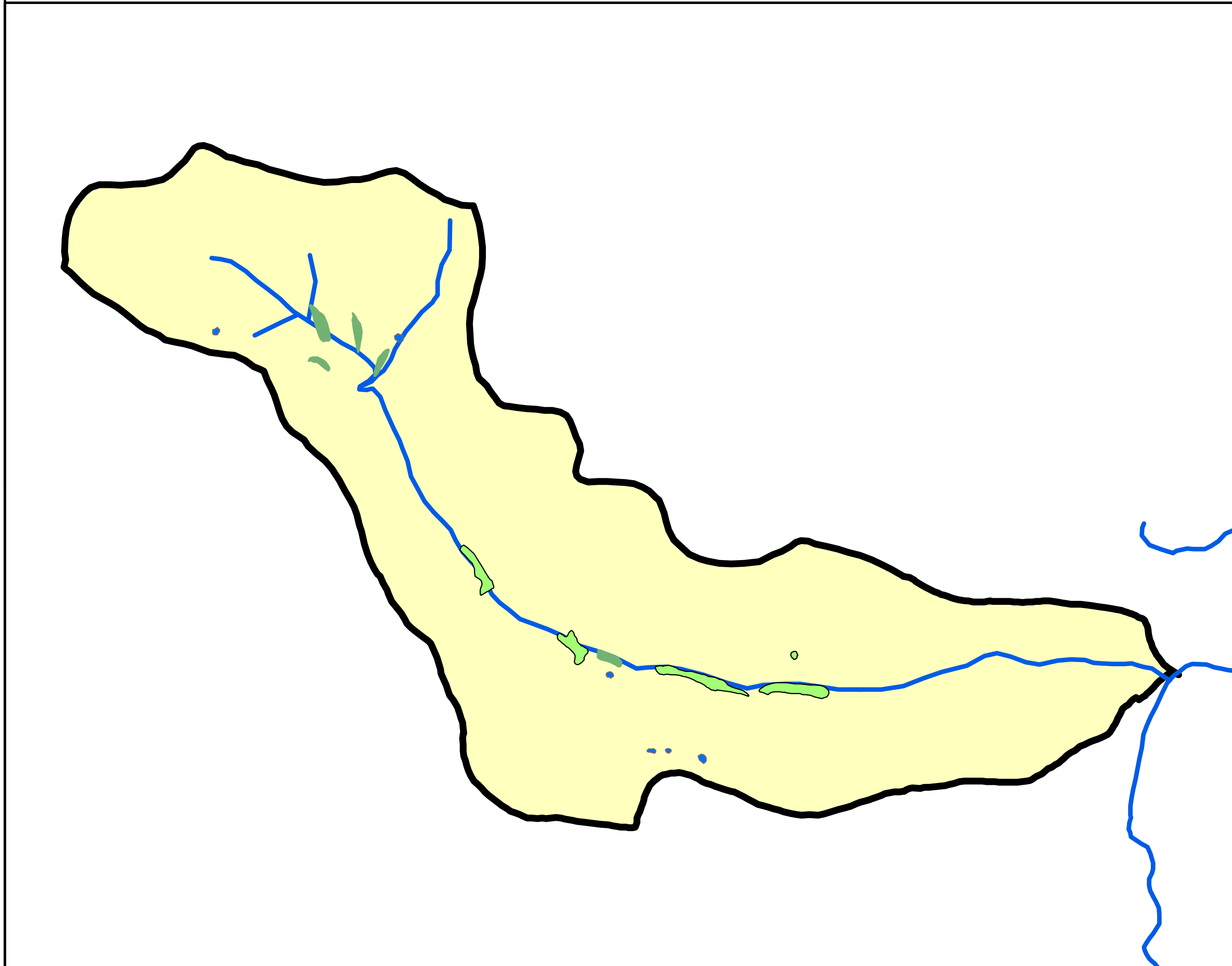


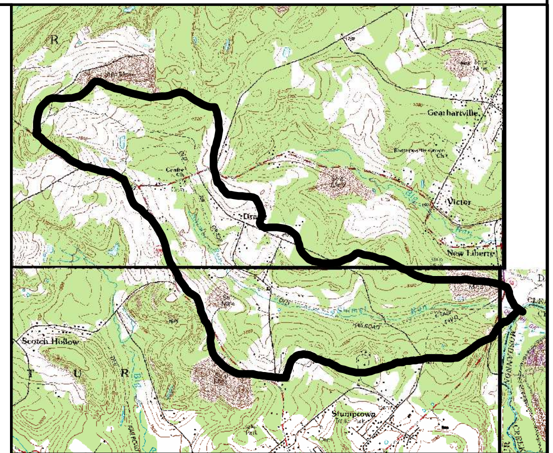
Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NMBS NEW MILES OF BLUE STREAM

# Shimel Run - NWI Wetlands

N





Watershed on Topo

Topographic Map:
7.5 minute Raster graphics,
watershed, and civil bounds
Provided by PASDA

NWI Mapping provided by US
Fish & Wildlife via
http://wetlandsfws.er.usgs.gov

## Legend

### NWI

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

Watershed and NWI Wetlands

1:28000

0 300 600 1,200 1,800 2,400
Meters

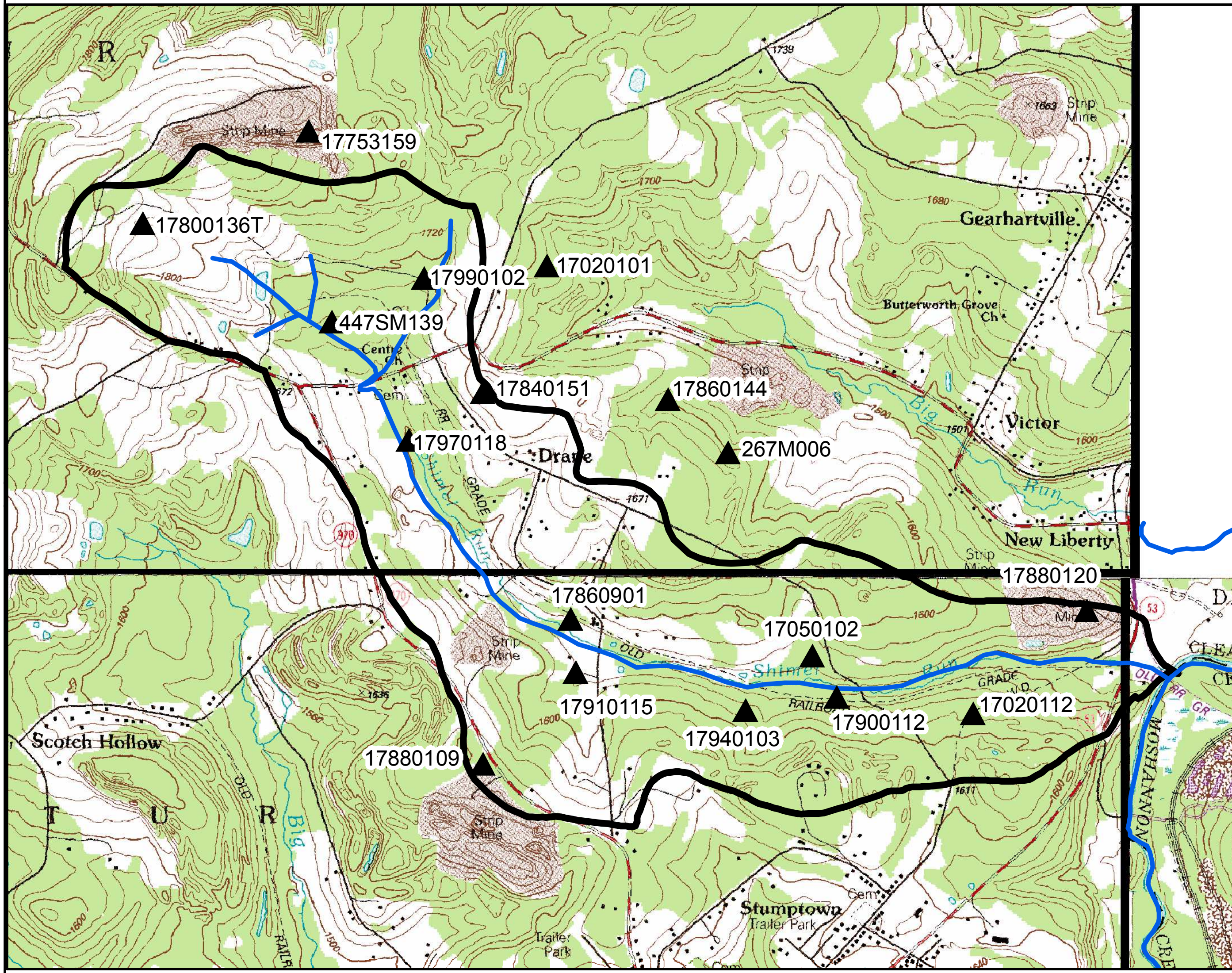


Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

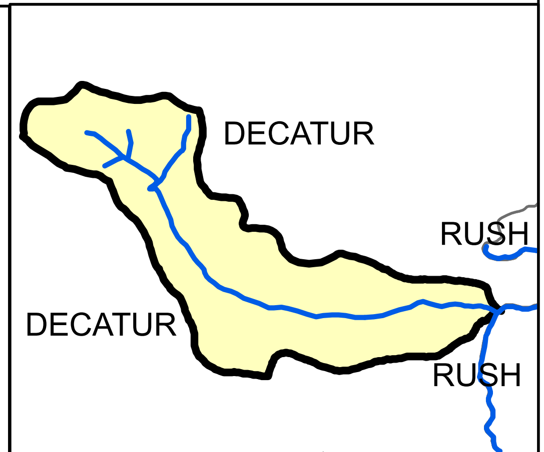
# Shimel Run - Historical Permits

N




Location of historical sampling points in watershed

1:28000




Watershed and Townships

Size of permits not represented -- see text for permit sizes. Points represent approximate center of permit area.

7.5 minute Topo Quads, watershed bounds, and stream digitizing provided by PASDA

0 300 600 1,200 1,800 2,400 Meters

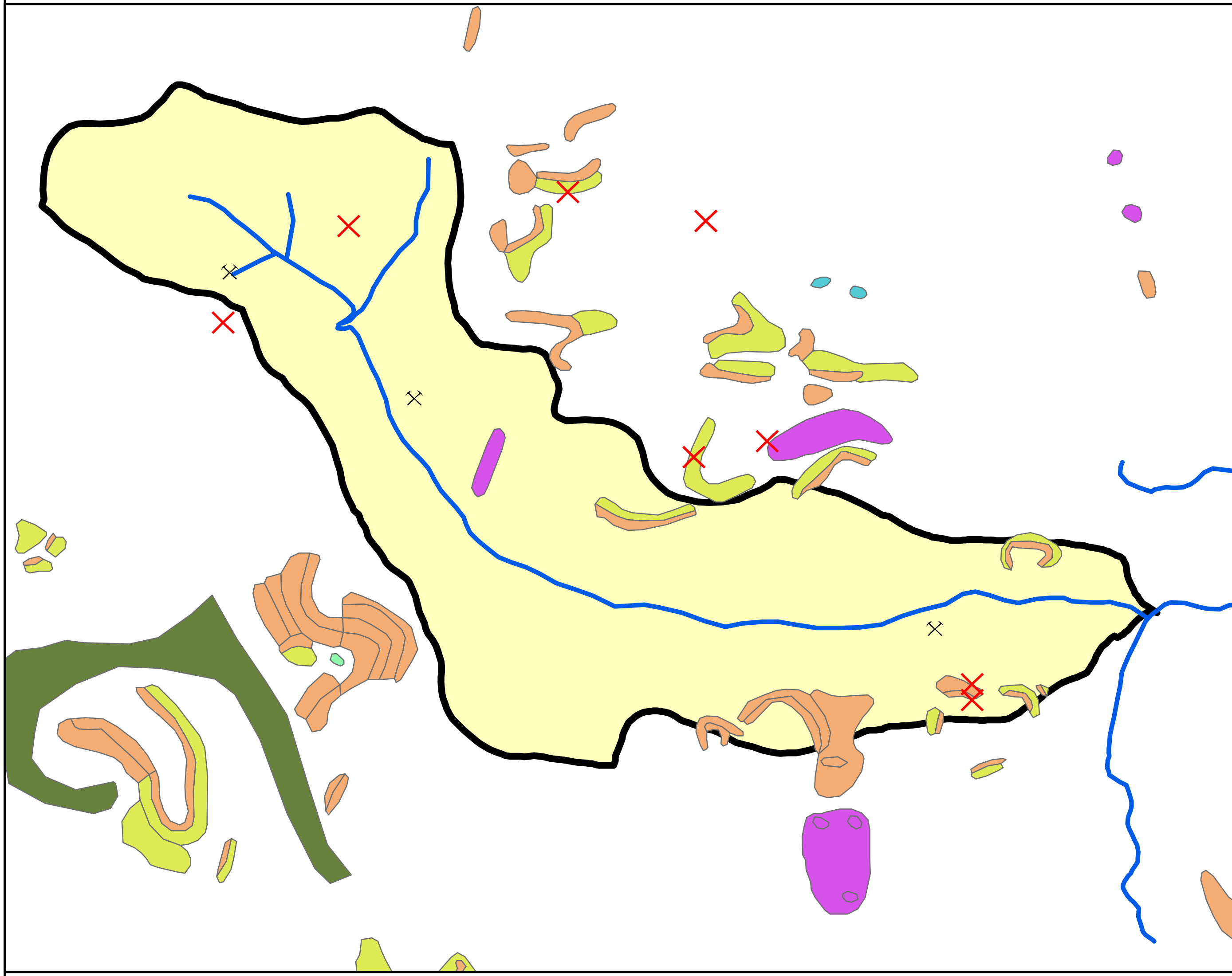


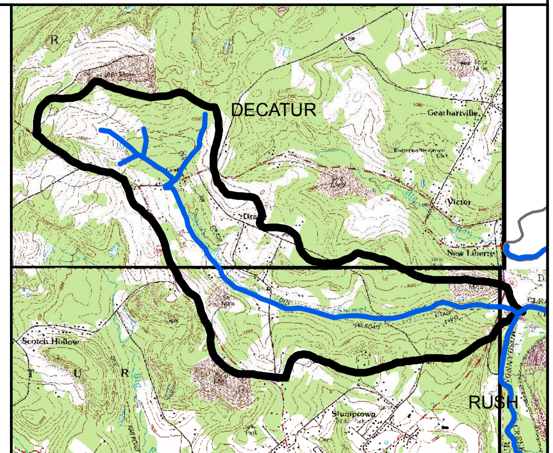
Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NMBS NEW MILES OF BLUE STREAM

# Shimel Run - Mining Activity

N






## Watershed on Topo

Topographic Map:
7.5 minute Raster graphics, watershed, and civil bounds provided by PASDA

AML data from BAMR AML list

**Legend**

Mining permits

**AML Items**

**SF_TYPE**

- AMD Ground Saturation
- Coal Deep Mine
- Coal Surface Mine
- Entry Point/Opening
- Equipment
- Impacted Water Source
- Refuse Pile
- Settling Basin
- Spoil Area
- Structure
- Subsidence Area
- Waters Affected by Impacted Water Source
- Mine Maps

Watershed, Mining Actiivity, and AML Items

1:28000

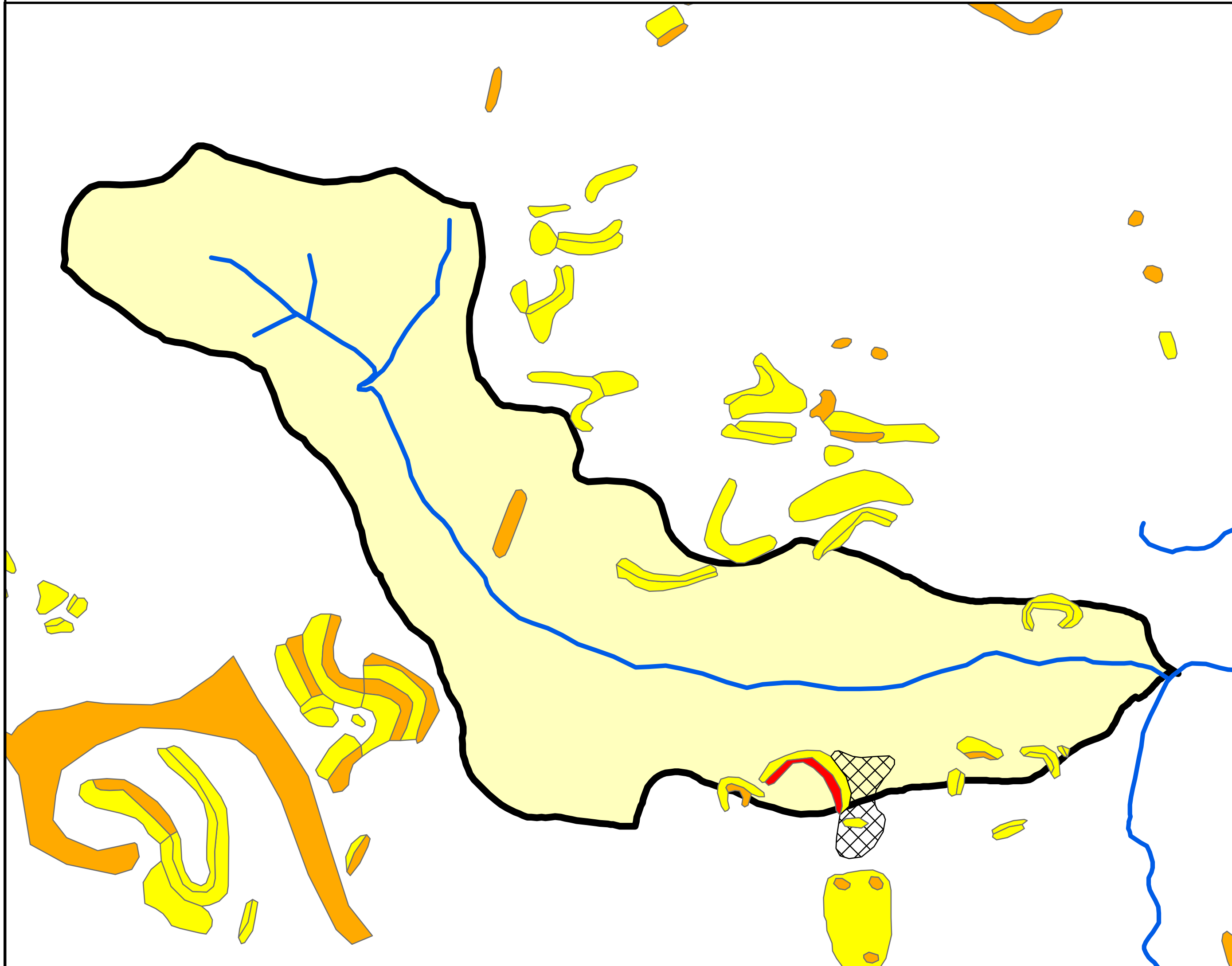
0 300 600 1,200 1,800 2,400 Meters

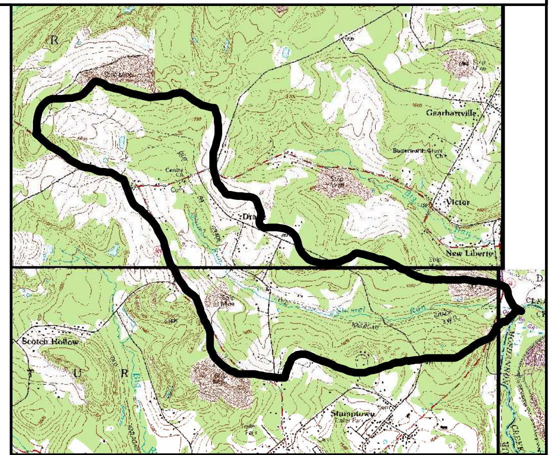


Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

# Shimel Run - AML Priorities

N





Watershed on Topo

Topographic Map:
7.5 minute Raster graphics, watershed, and civil bounds provided by PASDA

AML data from BAMR AML list

**Legend**

**AML Items**

**SF_PRIORIT**

- 1
- 2
- 3
- NONE
- UNDET

Watershed and AML Priorities

1:28000

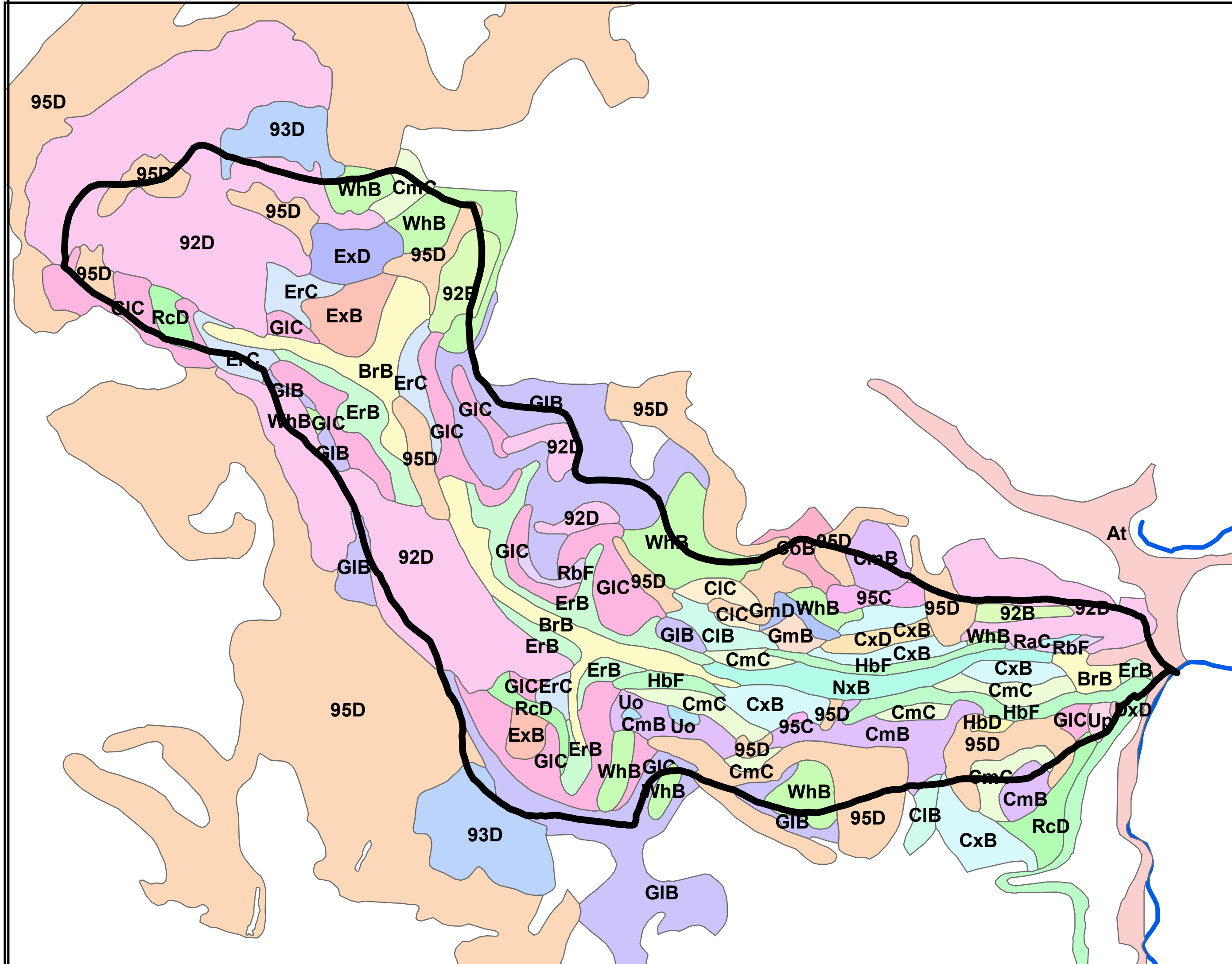
0 295 590 1,180 1,770 2,360 Meters



Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

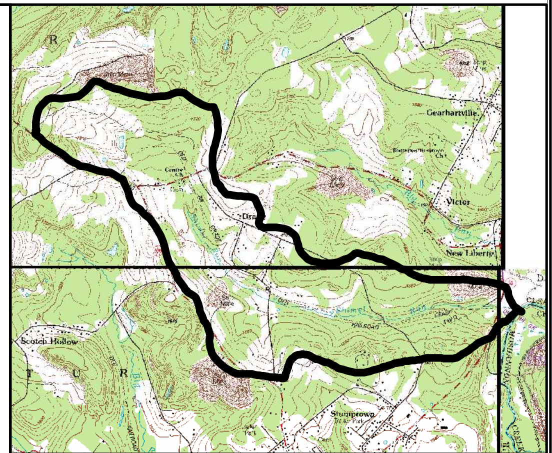
# Shimel Run - Soils

N




Watershed and Soils

1:28000



Watershed on Topo

Topographic Map:
7.5 minute Raster graphics,
watershed, and civil bounds
Provided by PASDA

Soil data acquired from USDA NRCS
via http://SoilDataMart.nrcs.usda.gov

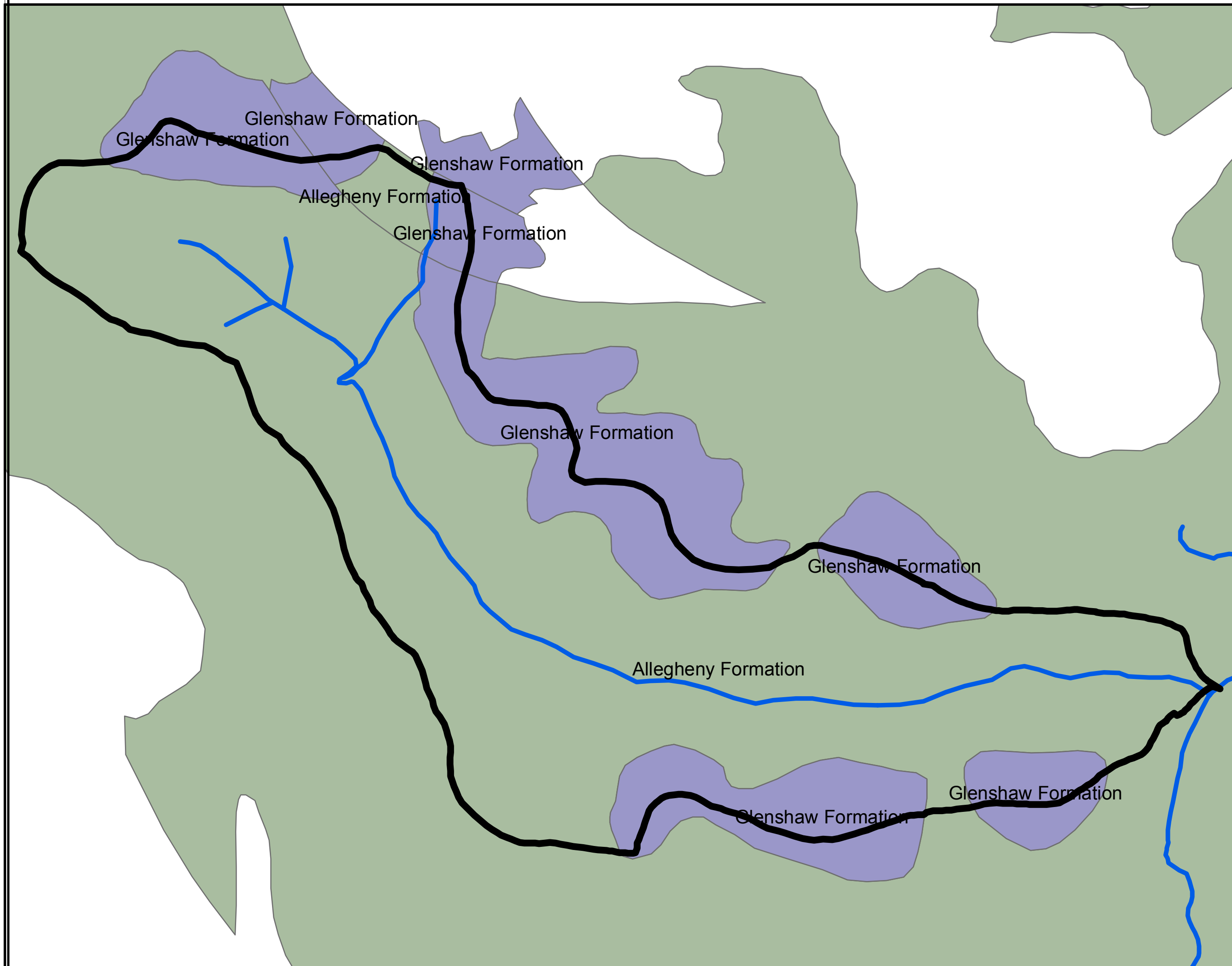
0 300 600 1,200 1,800 2,400 Meters



Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

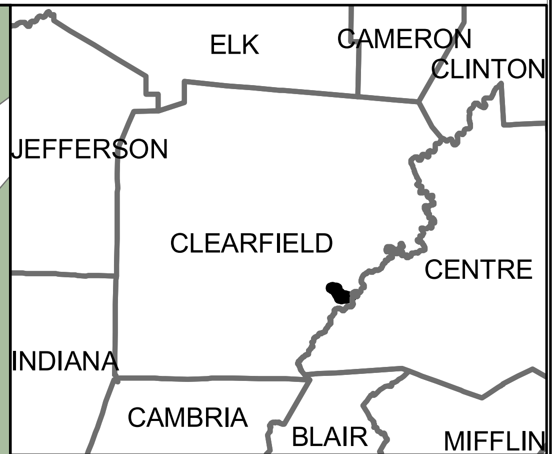
NMBS
NEW MILES OF BLUE STREAM

# Shimel Run - Geology




Watershed and Geology

1:14600




Watershed in County

Topographic Map:
7.5 minute Raster graphics,
watershed, and civil bounds
Provided by PASDA

Geologic formation data provided by DCNR
it represents data from 1980 published by the
Bureau of Topographic and Geologic Survey

## Legend

### Geology

**NAME**

Allegheny Formation

Glenshaw Formation

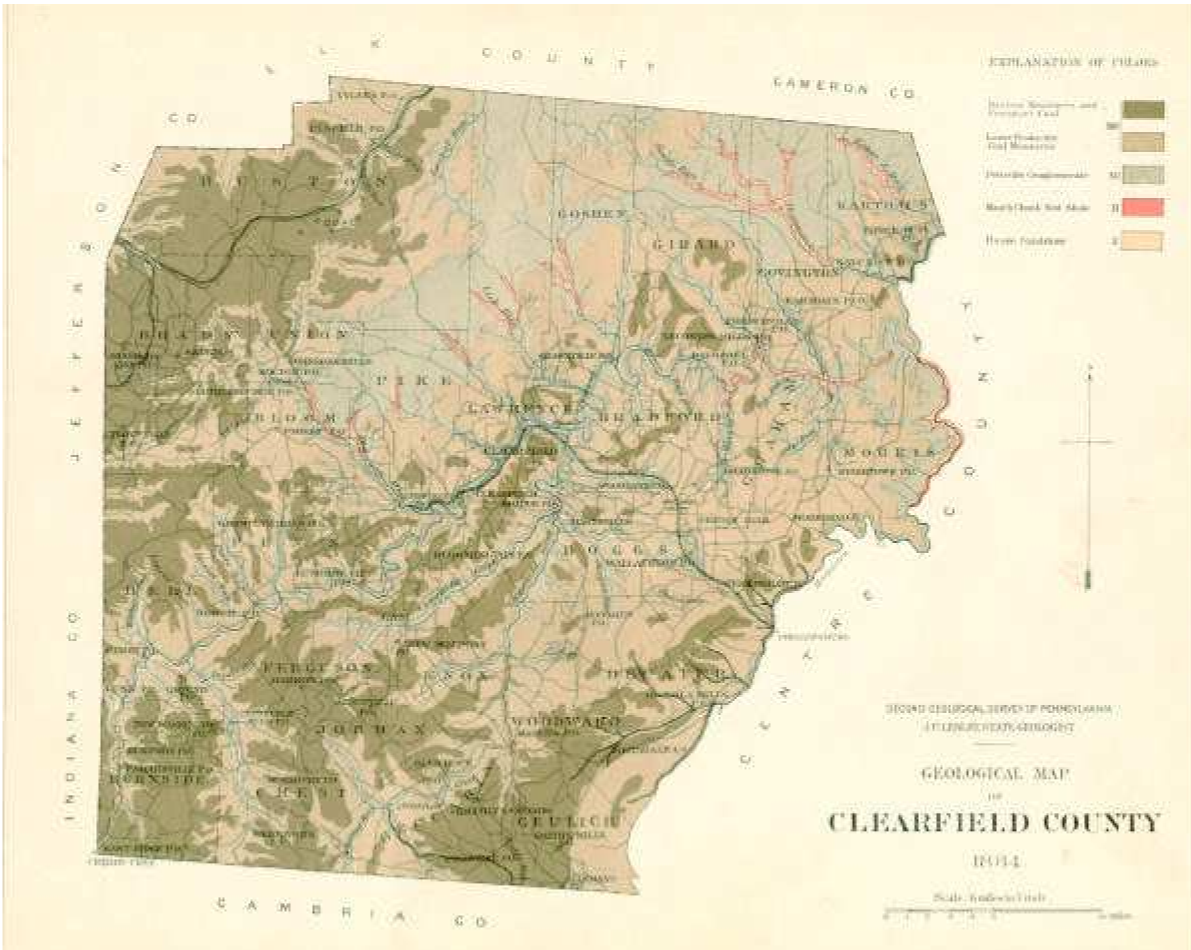
0 280 560 1,120 1,680 2,240 Meters



Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

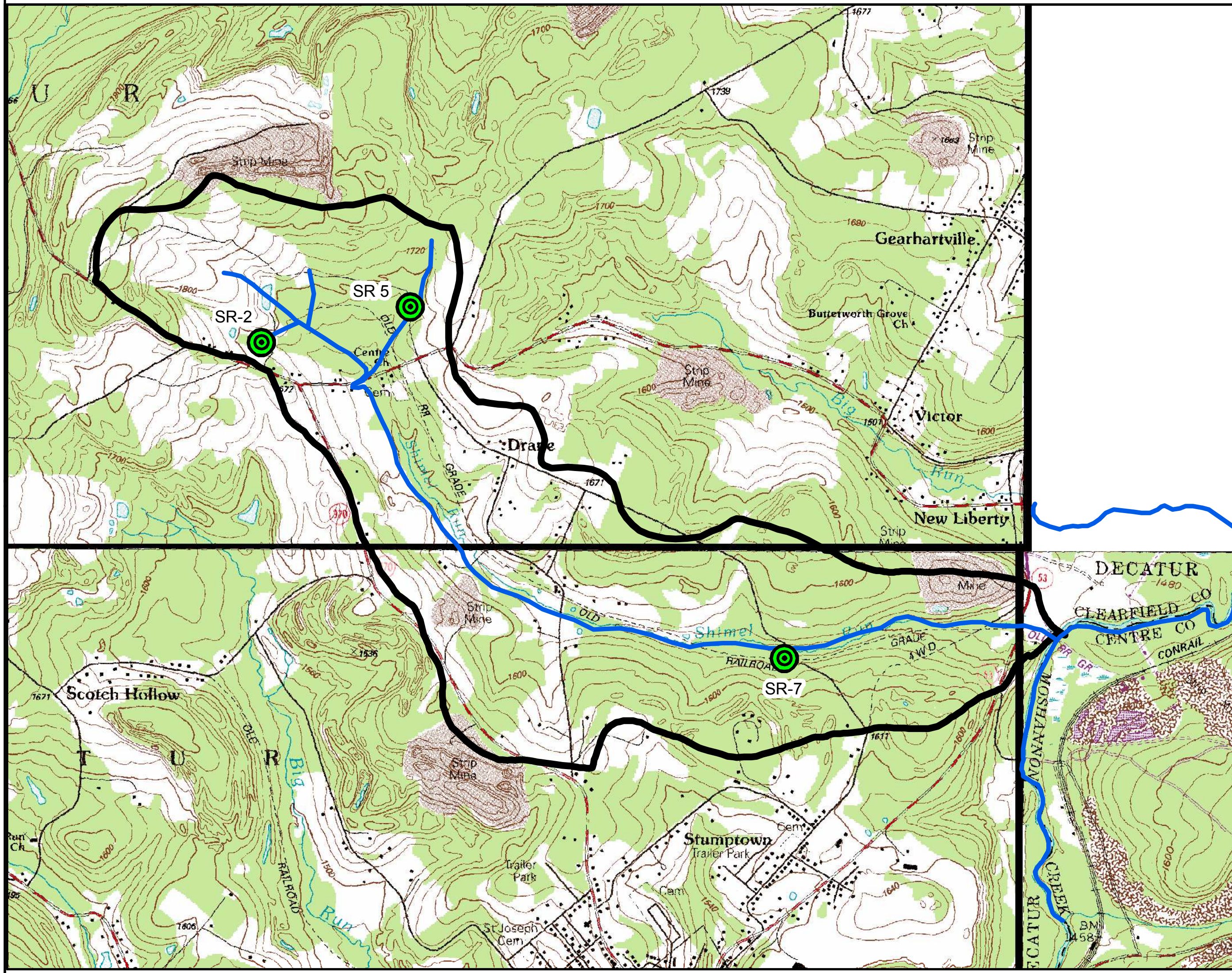
NEW MILES OF BLUE STREAM

## Clearfield County Geology



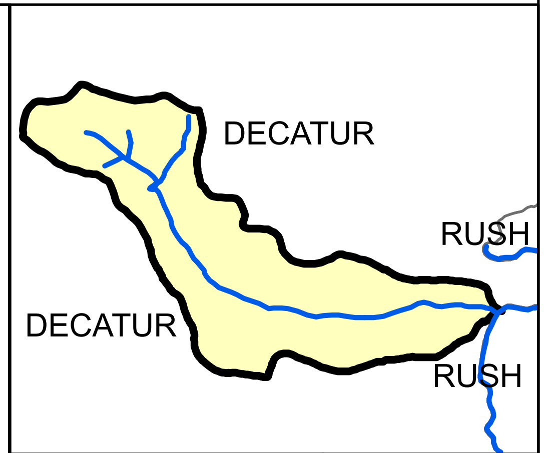
# Shimel Run - Treatment Sites

N




Watershed and Proposed Treatment Locations

1:28000




Watershed and Townships

Topographic Map:
7.5 minute Raster graphics,
watershed, and civil bounds
Provided by PASDA

0 345 690 1,380 2,070 2,760 Meters

A-13

NMBS
NEW MILES OF BLUE STREAM

Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

# Bibliography

Brodie, G.A., C.R. Britt, and T.M. Tomasczewski, H.N. Taylor. 1993. Anoxic limestone drains to enhance performance of aerobic acid drainage treatment wetlands-experiences of the Tennessee Valley Authority.

Cork, D.J. and Cusanovich, M.A. 1979. Continuous disposal of sulfate by bacterial mutualism. Microbiology. 20: 591-602.

Demchak, J., T. Morrow, and J. Skousen. 2001. Treatment of Acid Mine Drainage by Four Vertical Flow Wetlands In Pennsylvania. Geochemistry: Exploration, Environment, Analysis. 1: 71-80.

EPA. 1997. A Citizen's Handbook to Address Contaminated Coal Mine Drainage. #EPA-903-K-97-003.

Hedin, Robert S., Robert W. Nairn, and Robert L.P. Kleinmann. 1994. Passive treatment of coal mine drainage. Bureau of Mine Information Circular, US Dept. of the Interior.

Hedin, Robert. S., and George R. Watzlaf. 1994. The effects of anoxic limestone drains on mine water chemistry. Proceedings of International Land Reclamation and Mine Drainage Conference and the Third International Conference on Abatement of Acidic Drainage, Pittsburgh, PA. pp. 185-194.

Kepler, Douglas A. and Eric C. McCleary. 1994. Successive alkalinity producing systems(SAPS) for the treatment of acidic mine drainage. Proceedings of International Land Reclamation and Mine Drainage Conference and the Third International Conference on Abatement of Acidic Drainage, Pittsburgh, PA.

Nawrot, Jack R. and Willliam B. Klimstra. 1990. Biochemical treatment of mine drainage through a reedgrass wetland. Proceedings of Mining and Reclamation Conference and Exhibition, Charleston, WV.

Plummer, L.N., Parkhurst, D.L., and Wigley, M.L. 1979. Critical review of the kinetics of calcite dissolution and precipitation. In chemical modeling in aqueous systems-speciation, sorption, solubility, and kinetics (ed. E. A. Jenne). American Chemical Society Symposium, Series 93.

Robb, Gordon A. and James D.F. Robinson. 1995. Acid drainage from mines. The Geographical Journal. 161: 47-54.

Skousen, Jeffrey G. and Paul F. Ziemkiewicz. 1995. Acid Mine Drainage: Control and Treatment. National Mine Land Reclamation Center, West Virginia University.

Sverdrup, H.U. 1983. "The Limestone Wells at Piggeboda." Translation from the Symposium Proceeding "Kalkining av rinnende vatten." Alvesta, Sweden. pp. 11.

# Glossary

Acidic: a condition where the concentration of positively charged hydrogen ions is high, and the pH is less than 7.0.

Aerobic: a condition existing or process conducted in the presence of oxygen

Alkalinity: a measure of the ability of a solution to absorb positively charged hydrogen ions without a significant change in pH. Also referred to as buffering capacity. Alkaline solutions have a pH greater than 7.0.

Aluminum: a common metal element found in mine drainage that oxidizes as a whitish precipitate at pH levels greater than 4.5.

Anaerobic: a condition existing or process conducted in the absence of oxygen.

Appalachian Clean Streams Initiative: a program sponsored by OSM to coordinate and focus mine drainage clean up projects in the United States.

BAMR: Bureau of Abandoned Mine Reclamation. Part of the Pennsylvania DEP.

Basic: a condition where the concentration of negatively charged hydroxide ions is high, and the pH is greater than 7.0 (alkaline)

DCNR: (Pennsylvania) Department of Conservation and Natural Resources

DEP: (Pennsylvania) Department of Environmental Protection

Dissolved Oxygen (D.O.): the amount of oxygen that is dissolved in a solution. DO can cause armoring on limestone by oxidizing iron compounds in mine drainage to form iron hydroxide.

Dissolved Solids: compounds in a solution that can be precipitated through chemical processes into solids.

Effluent: the solution that flows out of a basin, pond, tank, wetland, ditch, pipe, or other containment.

Environmental Protection Agency (EPA): the federal agency created by executive order in 1970 to coordinate efforts to protect human health and biological communities form environmental pollutants.

Ferric hydroxide: an iron compound that forms when dissolved iron in mine drainage is oxidized, and appears as a rusty, reddish-orange residue. It is often called yellowboy.

Flow Rate: the rate a solution moves through a ditch, wetland, pond, or stream defined in terms of quantity of mine drainage per unit time (i.e., 150 gallons per minute)

gpm: gallons per minute. See "Flow Rate"

Hydroxide: a compound containing the OH- molecule

Iron: a common metal contained in mine rocks in the form of iron sulfide that oxidizes as a reddish colored hydroxide solid.

Manganese: a metal found in mine drainage that oxidizes as a blackish stain.

Metal: elements that are solids, have few electrons in the outer shell, and lose electrons easily to form cations. Metals of concern in mine drainage are iron, aluminum, manganese, and sometimes lead, mecury, copper and zinc.

Neutral: a condition where the concentration of hydrogen ions equals the concentration of hydroxide ions, resulting in a solution that is neither acidic or basic and has a pH of 7.0.

Neutralize: to cause a solution to move toward a pH reading of 7.0 through chemical or biological processes.

NMBS: The name of the company that prepared this document. See www.newmilesofbluestream.com for more information.

O & M: Operations and Maintenance

Office of Surface Mining (OSM): the federal agency charged with enforcing SMCRA and dealing with health, safety and resource protection isues related to active mining and abandoned mine problems.

OSM: Office of Surface Mining

Overburden: the layers of rock and soil found above coal bed deposits. Overburden rocks often contain acid forming materials in the form of iron sulfide and other compounds that can form dissolved metals and sulfates.

Oxidation: a reaction in which a substance losses electrons. In the case of mine drainage metals oxidation, the oxidizing agent is gaseous oxygen. Metal oxides are formed in the process.

PADEP: Pennsylvania Department of Environmental Protection

Permeability: a measure of the rate of water movement through soil or other substance.

PFBC: Pennsylvania Fish & Boat Commission

PGC : Pennsylvania Game Commission

pH: a value, expressed as standard units on a scale of 0-14, that uses a logarithmic measure to express concentrations of hydrogen ions. pH readings below 7.0 are said to be acidic, and readings above 7.0 are basic or alkaline.

Porosity: the ration of volume of voids to the total volume of material. Used to describe the ability of a fluid to move through crushed rocks or other material.

Pre Act mining: mining that occurred prior to the passing of SMCRA in 1977.

Pyrite: the iron sulfide mineral, often called “fools gold” that is found in earthen and rock layers near coal seams. Pyrite is the usual source of the sulfur that binds with hydrogen and oxygen in rain water to form the sulfuric acid component of mine drainage.

Reduction: a reaction in which a substance gains electrons. In mine drainge treatment, reduction usually involves stripping away of oxygen atoms from sulfate or metal compounds.

Residence Time: the length of time that mine drainage remains in a treatment pond, wetland, or other structure. Designed residence times depend on incoming flow rate, the rate of treatment process in the structure, the contaminants in the mine drainage to be treated, the size of the structure, and the settling rates of solids in the discharge.

RMEF: Rocky Mountain Elk Foundation

Sedimentation: the process whereby particles settle out of solutions. Sedimentation produces a sludge or other layer of solids at the bottom of a sedimentation or settling pond.

SGL: State Game Lands

Sludge: the laer of solids that settle from a solution, including suspended silt and soil particles and precipitates formed by chemical processes.

Solubility: the amount of material that can dissolve in a given amount of water or other solvent at a given temperature to produce a stable solution. Highly soluble substances dissolve quickly. Soluble products will not settle out of a solution unless they are precipitated.

Substrate: the rich, organic layer of compost or other material found at the bottom of wetlands.

Sulfates: compounds containing sulfur and oxygen. Elevated sulfate levels are common in mine drainage. Sulfates can bond with hydrogen ions to form sulfuric acid or bind to calcium atoms to form a gypsum solid.

Surface Mining Control Act of 1977 (SMCRA): the federal law that requires mining operations to prevent water pollution, reclaim mine lands and protect other sources.

Suspended Solids: solid particles that are suspended in solution. Suspended solids in mine drainage can include oxidized metals, silt or soil and other tiny debris particles.

TDS: Total Dissolved Solids

TMDL : Total Maximum Daily Load

Topographical Map: a map that shows land elevations by use of lines that connect points of equal elevation, water bodies, streams, buildings, mine sites, roads, and other land features.

TSS: Total Suspended Solids

UT: Unnamed Tributary

Vertical Flow Wetland (VFW): specialized mine drainage treatment ponds that make sue of chemical and biological processes to treat the acid, metals, and sulfate found in mine drainage.

VFW: See Vertical Flow Wetland

Watershed: an area of land from which water drains toward a single channel.

WPA: Works Progress Administration