EXECUTIVE SUMMARY

The Pleasant Run/Nortonville area of Hopkins County includes the headwaters and main stem of the Pleasant Run watershed. The Headwaters of Pleasant Run area is a small portion of the Bunt Sisk Hills, a region that has been severely disturbed by over 60 years of coal mining and processing activities. The Nortonville Refuse site is the remnant of a coal tipple loadout facility that dumped acidic material for nearly 40 years. Acid mine drainage from barren, acidic refuse and slurry, underground mine seeps and portals, and mining pits with exposed highly acidic clays have rendered Pleasant Run lifeless.

In the winter of 2005 a biological and water monitoring program began in the Pleasant Run watershed. Some of the monitoring points were previously used during the Homestead Refuse Reclamation Project. In the summer of 2006 construction began on a reclamation project targeting Nortonville Refuse and acidic pits and spoil piles in the Pleasant Run watershed. Over 17 ha of severely eroded, barren refuse and acidic spoil were graded and covered with an agricultural limestone barrier and onsite spoil materials. Grass and calcareous rock diversion ditches and open limestone channels were installed to control erosion and add alkalinity directly into the headwaters of Pleasant Run.

All objectives of the Pleasant Run Acid Mine Drainage Abatement project have been met. Sediment load reduction at the Nortonville Refuse site has been reduced by an estimated 2,200 metric tonnes (2,400 tons) per year as calculated using the RUSLE formula. Acid load reduction, free hydrogen ion load reduction (Increase pH), dissolved iron load reduction, and dissolved aluminum load reduction objectives as measured at monitoring point #8 all show reductions also. The acid load was reduced by 2,900 metric tonnes (3,200 tons) annually while dissolved iron load reduction was around 25 metric tonnes (27 tons) per year. Dissolved

aluminum load and dissolved manganese loading showed similar reductions, (41 metric tonnes (46 tons) per year and 37 metric tonnes (40 tons) per year respectively. The reductions in acidity and dissolved metals are near the expected reductions. Free Hydrogen Ion Load Reduction is estimated to be two times less, in the Lower Pleasant Run Watershed, than the pre-project concentration for free hydrogen ions. This estimate is derived from the pre-project average mean pH of 3.7 and a post project average mean pH of 3.9. Despite the addition of alkalinity, Pleasant Run remains net acidic due to the numerous acidity sources outside the project area. Pleasant Run does not meet its designated uses of aquatic life and contact recreation (swimming). Future projects by conservation and reclamation organizations will continue to address the sediment and acidity loading into the watersheds improving the entire watersheds ability to support all levels of the aquatic communities.

INTRODUCTION

The exposure and oxidation of certain sulfide minerals in rocks as a consequence of coal mining activities has resulted in acid mine drainage (AMD), a serious water pollution problem in portions of the Illinois Basin coal field region. Acid mine drainage is a low pH, sulfate rich water with high acidity that is formed under natural conditions when rocks containing pyrite, and/or other sulfide minerals, are exposed to the atmosphere or oxidizing environments. In the Eastern US coalfields, iron, manganese, and aluminum tend to be the primary metals associated with the sulfide minerals in the coal fields. Natural weathering processes only expose small amounts of pyrite to be oxidized, and acid generation is minimal. When large volumes of pyritic material are exposed to oxidizing conditions through disturbances such as mining, the pyrite reacts more quickly. Water then moves the reaction products (dissolved metals, sulfate, and acidity) into groundwater and surface water sources.

Acid mine drainage is formed by the oxidation of pyrite to release dissolved ferrous iron, sulfate, and free hydrogen ions. Further oxidation of the ferrous iron results in the formation of ferric iron and, at a pH greater than 3.5, the precipitation of iron as a hydroxide commonly referred to as "yellow boy". The ferrous iron to ferric iron reaction results in an increase of free hydrogen ions and a lowering of pH. Acid mine drainage neutralized by limestone or other bases can form neutral mine drainage high in sulfate and possibly elevated concentrations of iron and manganese. These neutral solutions can become acidic on oxidation and precipitation of the metals.

Acidity is a measurement of the amount of base needed to neutralize a volume of water. Acidity in AMD is comprised of hydrogen ion concentration acidity (low pH) and mineral acidity which arises from the presence of dissolved metals in the water. In coal mine drainage the major contributors to acidity are ferrous and ferric iron, aluminum, and manganese as well as free hydrogen ions.

Many factors control the rate and extent of AMD formation. Acidity of the drainage tends to increase with an increase in the amount of pyrite in the overburden, coal, floor rock, or mine spoil and a decrease in the grain size of the pyrite. Iron oxidizing bacteria and low pH values speed up the acid forming reactions. Rates of acid formation tend to be slower in the presence of limestone or other neutralizing agents. Access to oxygen is commonly the limiting factor in rate of acid generation. Because of the complex interactions of these and other factors, prediction and remediation of AMD is site specific.

Study Area Description

The Pleasant Run Acid Mine Drainage Abatement project areas selected are located in the headwaters of Pleasant Run and within the city limits of Nortonville (Figure 1). The project sites were originally mined from the 1920's through 1958, prior to the advent of the Surface Mining Control and Reclamation Act of 1977 (SMCRA).

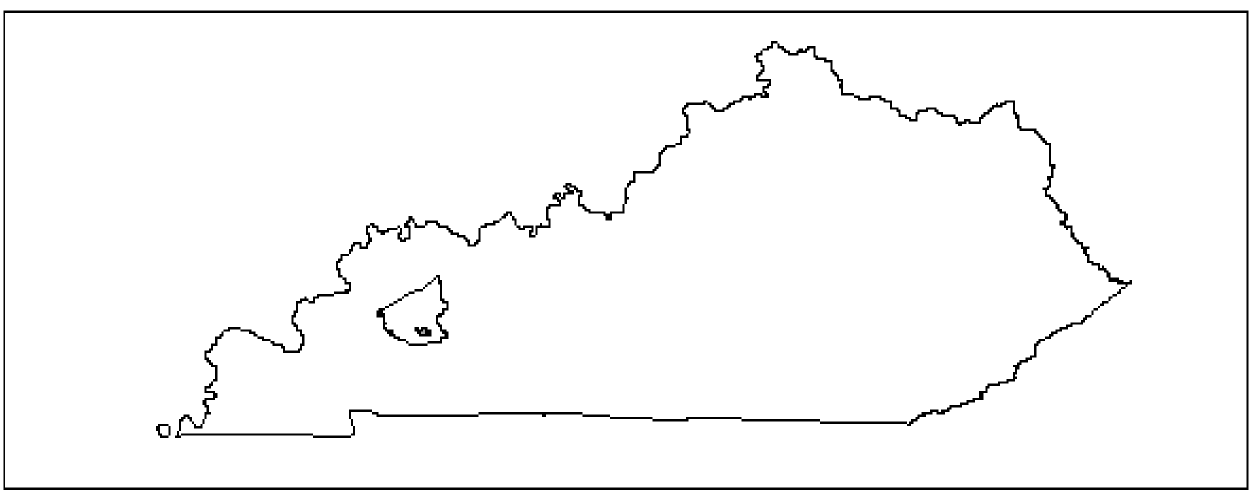

Figure 1: Location of Hopkins County, Kentucky.

Hydrologic Regime

Pleasant Run

Pleasant Run (HUC14 05110006040060), which is a first through third order stream within the study area, originates in south-central Hopkins County (Figure 2) and flows east to discharge into Drakes Creek 13.9 km (8.6 mi) upstream from its confluence with the Pond River (Figure 2). The Pond River discharges into the Green River, which flows northward into the Ohio River. Pleasant Run's main stem is approximately 12.7 km (7.9 mi) long and drains an area of 3,259.5 ha (8,054.5 acres (12.6 mi^2)). The average gradient is 6.8 m per km (35.5 ft per mi). Elevations for Pleasant Run range from 214 m (700 ft) above mean sea level (msl) in the headwaters to 122 m (400 ft) above msl at the mouth.

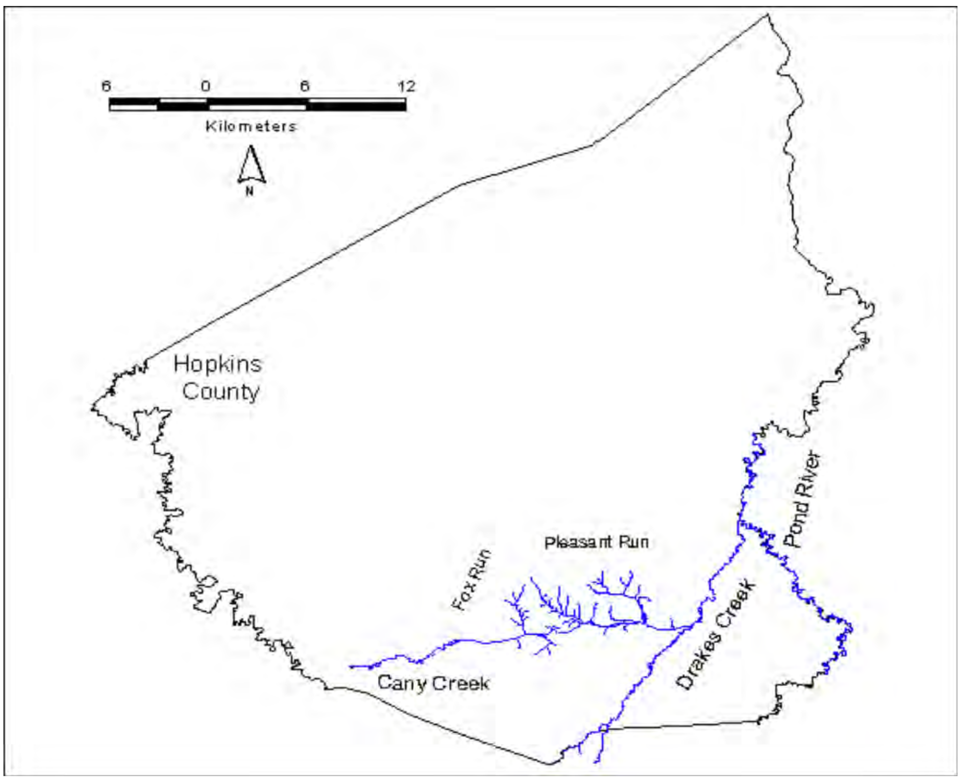

Figure 2: Location of Pleasant Run.

The 1998 303(d) list of waters for Kentucky (Wilson, 1998) indicates 12.7 km (7.9 mi) of Pleasant Run, from the headwaters to the confluence with the Pond River in Hopkins County, does not meet its designated use for contact recreation (swimming) and for aquatic life. The Pleasant Run watershed provides a classic example of impairment caused by AMD. Many sources of bituminous coal mine drainage, like that found in the Pleasant Run watershed, contain relatively high concentrations of sulfuric acid and may contain high concentrations of metals, especially iron, manganese, and aluminum.

Geologic Setting

The Pleasant Run watershed is in Kentucky's Western Coalfield physiographic region. The surface bedrock is of Pennsylvanian age. Formations of the Pennsylvanian age are mostly sandstone, siltstone, coal, and interbedded limestone and shale; alluvial deposits of siltstone and crossbedded sand or sandstone underlie the extensive lowland areas (USDA, 1977). The relief of the watersheds range from nearly level to steep. Gently sloping to steep soils are found in the uplands and nearly level soils are found on the floodplain (KYDOW, 2003).

Land-use Activities

The Pleasant Run watershed contains two main landuses: resource extraction (mining and disturbed land area) and agriculture (KYDOW, 2003). Coal, oil, and natural gas are among the natural resources of Hopkins County.

Soils Information

The Pleasant Run watershed consists of acidic silt loam. The soils near the mouths of these streams are materials washed from loess, sandstone, and shale, formed into an acidic alluvium. At the headwaters, the subsurface consists of weathered acidic sandstone and shale covered by a thin layer of loess (KYDOW, 2003).

Mining History

Mining activities have occurred in the Pleasant Run watershed during the pre-law, interim, and post-law eras. Mining permits in Kentucky are classified on the basis of whether the original permit was issued prior to August 3, 1977 (pre-law permit), after May 18, 1982 (post-Kentucky primacy) or in-between these dates (interim period). Only areas that were mined prior to May 18, 1982 were addressed under this project. A list of the various mining permits that have been issued for Pleasant Run is provided in the Total Maximum Daily Load (KYDOW, 2003).

Monitoring History

The waters of Pleasant Run were monitored as early as 1978 by the Division of Water (DOW) as reported in *The Effects of Coal Mining Activities on the Water Quality of Streams in the Western and Eastern Coalfields of Kentucky*, published in 1981 by the Kentucky Department for Natural Resources and Environmental Protection as part of an agreement with the Division of Abandoned Mine Lands (DAML). The DOW sampled the three unnamed tributaries to Pleasant Run on April 26, 1978. The three streams had pH values of 4.3, 3.5, and 3.2. The degradation of Pleasant Run is the consequence of acid mine drainage in the watershed as noted by the DOW. In 1997, the DOW conducted a survey of streams in the Western Kentucky Coal Fields, including Pleasant Run. The DOW reported a high level of pH impairment, citing acid mine drainage as the principal source. A pH of 2.9 was recorded on July 3, 1997. Based on these readings, the stream was listed as First Priority on the Kentucky 303(d) list of streams not meeting their designated uses. Pleasant Run does not support the designated uses of aquatic life and swimming (Wilson, 1998).

Project Description

The project (18 ha (34 acres)) reclaimed an expanse of abandoned strip and deep mine disturbance in southern Hopkins County, approximately 1.6 km (1.0 mi) northeast of the community of Saint Charles. The project encompassed two separate reclamation sites Nortonville Refuse, and acidic pits with spoil ridges in the headwaters of Pleasant Run. Borrow material was brought from another site to Nortonville Refuse for cover material. Nortonville Refuse was 13.9 acres of acid producing material with sparse vegetation. The Pleasant Run reclamation site had several pits and spoil piles along one ridgeline that produced very acidic water.

Sediment and erosion from all sites caused infertile deposition, channel filling, and increased swamping of the floodplain. Consequential water quality degradation has rendered much of the water within the Pleasant Run watershed basin unable to meet designated aquatic life uses, as well as, public, industrial, and domestic use.

Reclamation at site A (Nortonville Refuse) included light gradework to eliminate large and small gullies and to redirect drainage patterns. Reclamation at site B (Pleasant Run), acidic pits and spoil piles, included heavy gradework to eliminate pits and to provide a smooth surface for positive drainage. Prior to grading the acidic spoil at site B, water from wet-weather/seasonal water-holding areas was treated and released.

To minimize acid mine drainage and to present a medium capable of supporting vegetation, the graded coal refuse was capped with an agricultural limestone barrier covered by a minimum of two feet of suitable cover material. A designated borrow area was used to obtain the cover for Nortonville coal refuse. The cover material consisted of select material along mine spoil vegetated with volunteer trees and scrub. Grade work at site B to eliminate pits used adjacent spoil piles that were vegetated with volunteer trees and scrub.

Rock, temporarily placed in small drains at Pleasant Run and Nortonville, was used to substitute for bridges to allow heavy equipment to access the project site. Since these streams are severely impacted by acid mine drainage and sedimentation, the limestone stream crossings provided additional alkalinity and helped improve water quality within the immediate area of the rock.

Ditches were lined with class II/III stone or erosion control blanket to control drainage. Hay-bale silt checks and silt traps were used to minimize sedimentation. All areas disturbed by construction were covered with suitable cover material and were vegetated as soon as it was practical, using agricultural limestone, fertilizer, seed, mulch, crimping, and, erosion control blankets on steep slopes.

DATA COLLECTION AND METHODOLOGY

Data collection and methodology included a water monitoring program conducted by DAML personnel, a biological monitoring program conducted by DAML, and KDFWR personnel, and soil and refuse analysis including computer modeling utilizing the US Department of Agriculture's (USDA) Revised Universal Soil Loss Equation (RUSLE) conducted by DAML. Best management practices were chosen after analysis of water chemistry, soil and refuse testing, and site specific conditions.

Water Monitoring

Monitoring Objectives

The water monitoring objectives were to collect acid and metal concentrations and loading data for the Pleasant Run watershed where the water leaves the Homestead property near the WKY Parkway and US 62 and at the Nortonville Refuse in Nortonville and within the main stem of Pleasant Run at Nortonville.

Pleasant Run is being degraded by pyritic coal mine refuse and by seeps discharging acid mine drainage. Monitoring before and after the reclamation indicates the efficacy of the acid mine drainage abatement techniques used in the reclamation of the watersheds.

Monitoring Program

Existing water quality data within the study area indicated severe degradation of the water quality, but did not take into account all of the acid drainage sources or any natural buffering which may occur within the watershed. To address this, the main tributaries, including a tributary outside of the work area, were monitored (Figure. 3). The sites were monitored monthly, for a period of twelve months before construction activities began, to collect background data. The sites were monitored monthly during construction of the project and then monthly thereafter to demonstrate project success.

The following sites are part of a larger monthly monitoring program but are specific to this project:

Station Name	Site Number	Lat/Long
Upper Pleasant Run	PR – 2	37° 12’ 19.3” / 87° 31’ 33.1”
Homestead Trib. to Pleasant Run	PR – 3	37° 12’ 18.2” / 87° 31’ 29.1”
Mid Pleasant Run	PR – 4	37° 11’ 32.3” / 87° 29’ 54.9”
Northeast Trib. to Pleasant Run	PR – 5	37° 11’ 40.7” / 87° 27’ 19.1”
Nortonville Trib. to Pleasant Run	PR – 6	37° 11’ 41.6” / 87° 27’ 16.7”
Culvert Outlet in Refuse Fill	PR – 7	37° 11’ 55.7” / 87° 27’ 16.0”
Lower Pleasant Run at Nortonville	PR – 8	37° 11’ 31.3” / 87° 27’ 09.0”

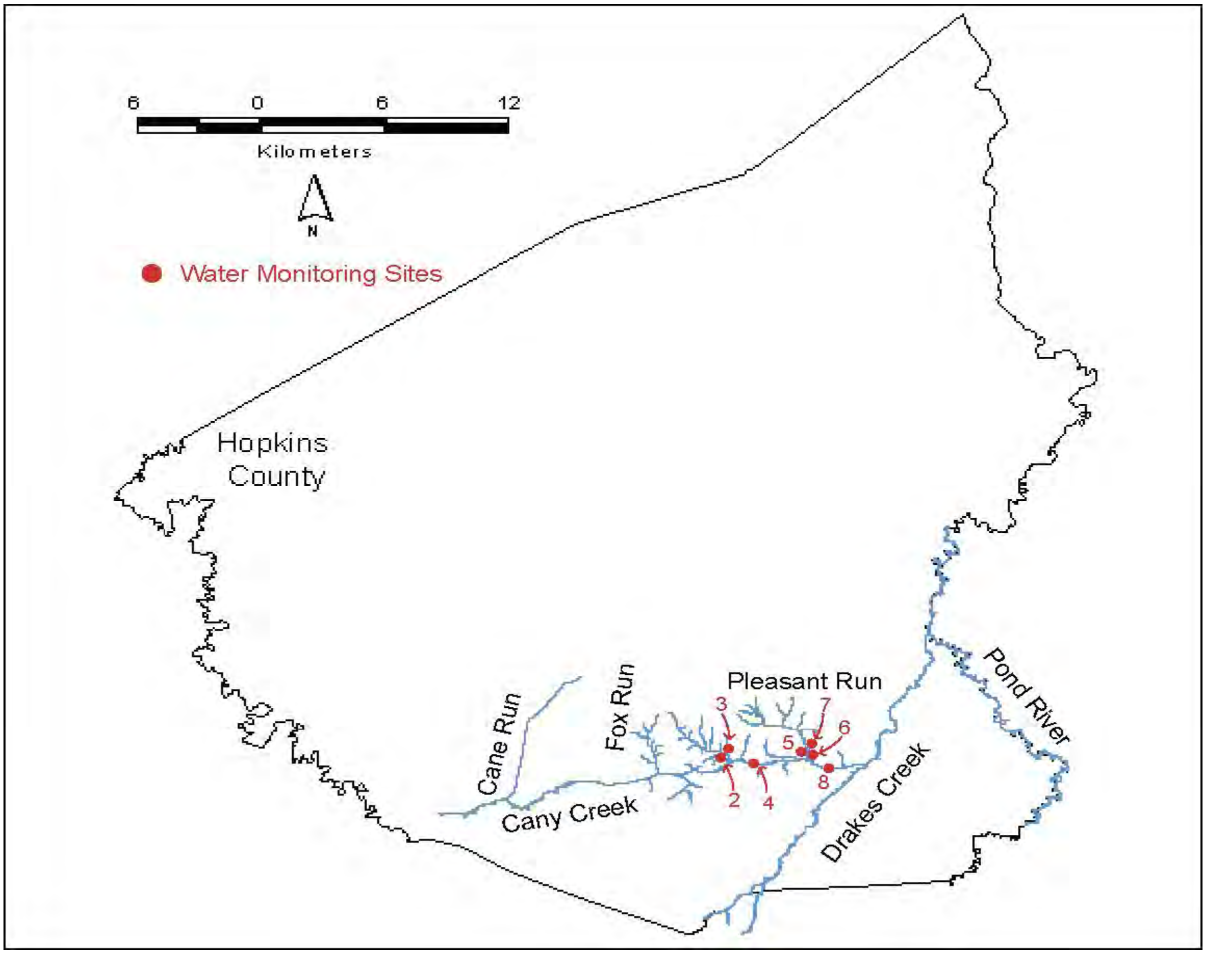

Figure 3: Location of water monitoring sites in the Pleasant Run watershed.

The following parameters were tested monthly:

Parameter	Analyzed By
Flow	Field
pH	Field/Lab
Conductivity	Field/Lab
Alkalinity	Lab
Acidity	Lab
Total Dissolved Solids	Lab
Calcium (total)	Lab
Aluminum (total)	Lab
Aluminum (Dissolved)	Lab
Iron (total)	Lab
Iron (dissolved)	Lab
Manganese (total)	Lab
Manganese (dissolved)	Lab
Sulfate	Lab

The following parameters were tested twice for background levels:

Parameter	Analyzed By
Chloride	Lab
Sodium	Lab
Potassium	Lab
Magnesium	Lab

All sample collection, preservation, and analysis were conducted in accordance with Standard Methods for the Examination of Water and Wastewater (APHA, 1992). Discharge was measured by current velocity meter or by the "bucket and stopwatch" method where possible. The bucket and stopwatch method involves measuring how much time it takes a given source to fill a container of known volume. This time is then interpolated to volume per minute. Three measurements were taken and the results averaged. Conductivity and pH were measured using calibrated pH and conductivity meters.

Monitoring site PR-2 was monitored during the previous Homestead Refuse Reclamation: Fox Run & Pleasant Run Watersheds project, so the site was used as a headwaters control station. Monitoring site PR-5 and PR-7 were established in drainages outside the current projects work area and served as control points in the Nortonville Refuse area of the watershed. For the purposes of this project the pre-construction dates were January 2005 to June 2006 and the post-construction dates were June 2007 to June 2008. These dates reflect the total disturbance time for both work sites within the watershed.

Chain of Custody Procedures

Division of Abandoned Mine Lands personnel conducted sampling for this project. Water monitoring samples were collected, labeled, preserved with a 1:1 nitric acid solution, placed on ice in a cooler and delivered to the laboratory within 24 hours with the following information:

- Date the sample was taken.
- Station at which the sample was taken.
- Name of the person conducting the sampling.
- Gear and/or method used to obtain the sample.
- General stream conditions at the time of sampling (high or low flow, turbid or clear, etc).
- pH.
- Conductivity.
- Stream Flow.

Quality Control Procedures

Quality control procedures for parameters analyzed by McCoy and McCoy followed the procedures outlined in *Quality Assurance Program Plan* – McCoy and McCoy Laboratories Inc., Madisonville, KY.

Biological Monitoring

While the adult forms of most species of aquatic insects are winged and highly mobile, their immature stages and other types of aquatic macroinvertebrates (crustaceans, mollusks, annelids, etcetera) have a relatively low degree of mobility. Thus, aquatic macroinvertebrates are continuously exposed to the full range of water quality conditions and are largely unable to flee poor conditions. If pollutants, such as acidity, dissolved metals, and sediments in the case of this study, are of sufficient concentration, many or all of the pollution-sensitive organisms may be eliminated, allowing the habitat to be overtaken by a few resistant species. These changes would be detectable even if the toxic levels of pollution occurred in short bursts at irregular intervals, and were not detected through water sampling. Recovery of macroinvertebrate populations following elimination of the pollution source would not be immediate. New generations of winged adult insects, from nearby unaffected waters, would be needed to lay eggs in the affected waters. Other macroinvertebrates would need to be transported by current from upstream, crawl from downstream areas, or rely upon other organisms for transport. As an example, many bivalve mollusks are dependent upon fish for transport of larvae (glochidia), which attach to the gills of host fish. As many bivalves appear to depend upon a limited number of fish species, their recovery must first await the return of those fishes from areas where the bivalves still exist. Therefore, recovery of the macroinvertebrate community following the elimination of a pollution source may take a significant amount of time.

Physical alteration of stream habitat, such as channelization, the clogging of interstitial spaces and the gills of organisms through sedimentation, and the alteration of temperature and flow as a result of the elimination of forest cover in headwater areas tend to result in a homogenization of habitats. These conditions eliminate specialized niche habitats, favoring a few generalist species over many specialist species.

Fish are more mobile than aquatic macroinvertebrates, and are capable of avoiding rising levels of pollution by taking refuge in unaffected tributaries or downstream reaches where the pollutant is diluted. They may then recolonize affected habitats from these refuges. So, given a sufficient food source, the diversity of a fish community may recover relatively quickly. However, the major portion of the base level of the fish community is composed of insectivores (chiefly of the family Cyprinidae – true minnows), which feed on macroinvertebrates. Thus, if the macroinvertebrate community is severely affected by a pollutant or stream alteration, the structure of the fish community will be affected. Also, while not a focus of this study, organic toxins tend to become more concentrated in fish, possibly causing fish communities to show the effects of low concentrations of those toxins through mutations and abnormalities. In very low concentrations, organic pollutants may cause these effects to occur before the toxins affect the macroinvertebrates. And, like the macroinvertebrates, alterations of the in-stream habitat can have significant impacts upon the makeup of the fish community, promoting hybridization of species and generalists such as green sunfish over other species, such as darters, that fill specialized niches.

Monitoring Objectives

The objective of biological monitoring for this project was to determine the overall effectiveness of the acid mine drainage mitigation project on water quality. As noted above, while regular monthly water sampling and testing can provide a series of discrete "snapshots" of the water quality within a system, the biological community will react to intermittent surges of pollution and/or transient changes in water chemistry. Also, the biological community will react to physical changes in the stream (sedimentation, altered flow and temperature regimes, and other habitat changes) that may not be detected through water sampling alone.

Monitoring Program

Biological monitoring stations are located on the main stem of Pleasant Run and at a control site on Cane Run (figure 4).

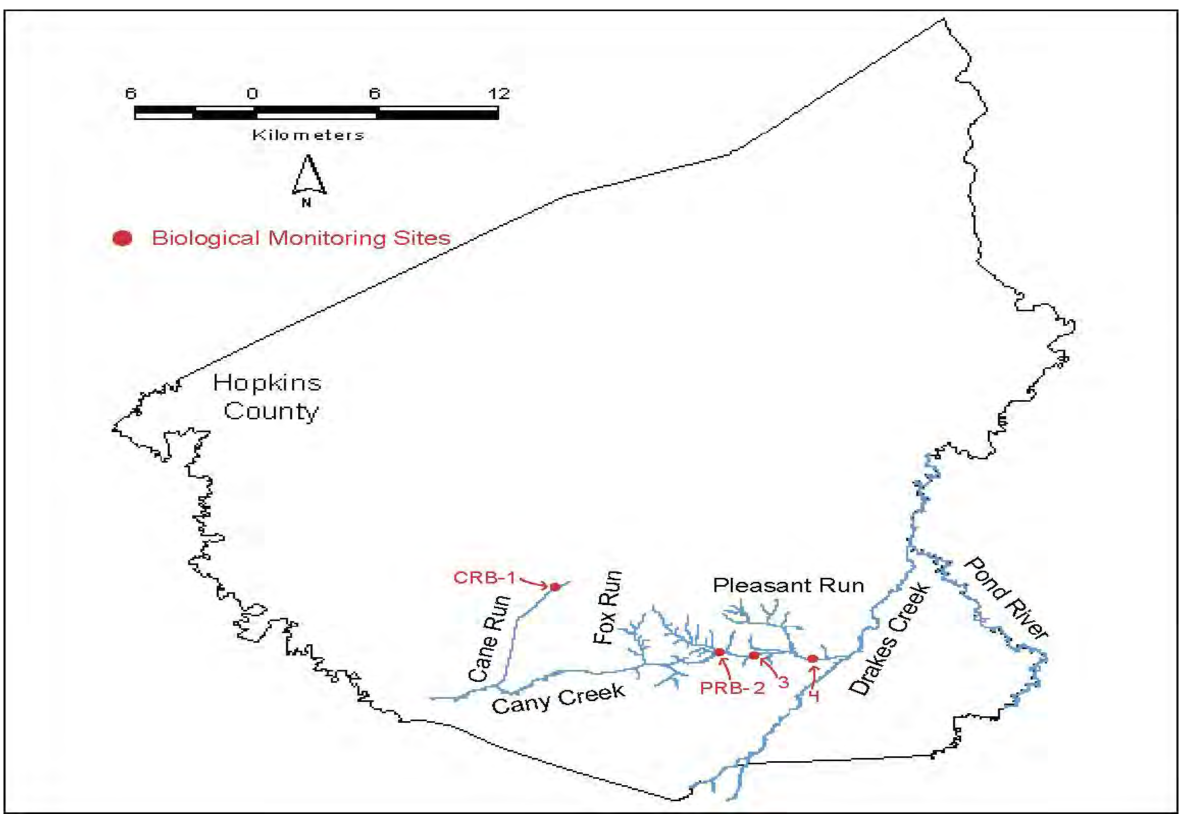

Figure 4: Biological monitoring sites.

Station Name	Site Number	Lat/Long
Upper Cane Run	CRB – 1	37° 12’ 23.9” / 87° 34’ 22.9”
Upper Pleasant Run	PRB – 2	37° 12’ 19.3” / 87° 31’ 33.1”
Mid Pleasant Run	PRB – 3	37° 12’ 18.2” / 87° 31’ 29.1”
Lower Pleasant Run at Nortonville	PRB – 4	37° 11’ 32.3” / 87° 29’ 54.9”

Site selection criteria included ease of repositioning and the ability to determine the effects of AMD treatments within the project area on the main stem of Pleasant Run. Therefore, each of these sites is located downstream from an area directly impacted by project related construction activities. The site on Cane Run (CR – 1) was selected as a control site due to its origin being in the same vicinity and geology as the project site. Therefore, the effects of any localized meteorological event upon the test sites should also occur at the control site, as should any effects produced by natural landform and geology. The control site, of course, was not impacted by project related construction activities.

In addition to the low pH and high mineralization of these streams caused by the sources of acid mine drainage to be addressed by this project, the physical properties of these streams present severe challenges to the establishment of healthy macroinvertebrate or fish communities. Pleasant Run at station PR – 2 exhibits characteristics of channelization, which is likely the result of a combination of impacts, such as the construction of an adjacent railroad corridor and efforts to improve drainage efficiency in order to reduce flooding. As a result, the stream is relatively wide and shallow during periods of normal flow. The channel substrate is predominantly composed of gravel and pebbles with some smaller cobbles. The substrate is heavily embedded with sediments that result from both disturbance of the erosive soils in the watershed and the presence of iron and aluminum oxide flocculants precipitating from the acidic drainage (Figure

5). These flocculants became more prevalent as pH levels rose following reclamation. Bars of accumulated sand and silt are also prevalent (Figure 6).

Figure 5: View of stream conditions at Biological monitoring station PR – 2, showing wide, shallow flow and embedded substrate.

Figure 6: View of stream conditions at Biological monitoring station PR – 2, demonstrating sediment bar formation.

Macroinvertebrate sampling was conducted during the spring sampling period through both qualitative and quantitative sampling methods. Qualitative sampling was accomplished through the 15 minute composite kick-net method, using D-frame kick-nets. All habitat types available within a sampling station were sampled as they are encountered during the 15 minute effort. Cobbles and leaves were screened from the sample, then washed and examined for macroinvertebrates prior to being returned to the stream. The samples were then picked in the field, and all macroinvertebrates encountered were preserved in 70% ethanol for subsequent identification. Crayfish were counted in the field and returned to the stream. All macroinvertebrates in the preserved samples were identified to the lowest possible taxon by a qualified biologist, utilizing accepted dichotomous keys.

Quantitative sampling was accomplished using ¼ square meter kick-net samples. A 1-meter square kick-net was utilized, with a ¼ square meter area (½ meter x ½ meter) of stream substrate being thoroughly disturbed immediately upstream from the net. At each station, a transect, consisting of four samples, was taken across a riffle. At the headwater stations where the streams are too narrow to permit a transect across a riffle, samples were taken from downstream to upstream along riffles. Of the four sample stations, only PR – 2 was sufficiently wide to permit sampling on a transect across the width of a riffle. Cobbles and leaves were screened from the sample, then thoroughly washed and examined for macroinvertebrates prior to being returned to the stream. The samples were then picked in the field, and all macroinvertebrates encountered were preserved in 70% ethanol for subsequent identification. Each sample was preserved separately. Crayfish were counted in the field and returned to the stream. All macroinvertebrates in the preserved samples were identified to the lowest possible taxon by a qualified biologist, utilizing accepted dichotomous keys.

After sorting and identification, the data was evaluated using the modified Hilsenhoff Biotic Index (mHBI) (Hilsenhoff, 1987; Lenat, 1993), which has been further customized for use in Kentucky by the Kentucky Division of Water Ecological Support Section (2002), to determine the overall pollution tolerance of the macroinvertebrate community and the degree to which the habitat is impaired. Other metrics used include the Total Number of Individuals, Ephemeroptera/Plecoptera/Trichoptera Richness (EPT), and Percent Dominant Taxon.

Fish sampling efforts were conducted in early summer by the use of a Smith-Root backpack electrofishing device. Both battery powered and generator powered models were utilized, depending upon availability of equipment. Regardless of the power source, the electrofishing gear utilized pulsed DC current. Such equipment is capable of maximizing capture potential while minimizing the potential for injury to any fish encountered. In order to minimize such injury, voltage and amperage of the unit were both set to the lowest settings which created an acceptable level of current that would provide for efficient sampling. During the early summer, the potential for interfering with nesting and/or spawning activities is low and flows should be stable and high enough to present stable populations, while still presenting optimal conditions for capturing fish. Any fish captured would be placed in a water-filled bucket while recovering from being stunned by the electrical field produced by the electrofishing unit. When possible, all fish would be identified in the field. If a species could not be identified in the field, a voucher specimen would be kept, preserved in a 10% formalin solution, and identified at a later time by a qualified biologist, utilizing accepted dichotomous keys. However, neither the pre-construction nor the post-construction sampling effort resulted in the capture of any fish. No fish were captured at any station during the pre-construction effort. During to post-construction effort, the high conductivity of the water at the time of sampling caused the equipment to malfunction due to insufficient electrical resistance between the anode and cathode of the unit. Also, no fish were noted as being present at any of the four biological monitoring stations utilized under this project. Following collection and positive identification, the data were to have been evaluated utilizing the Index of Biotic Integrity (IBI) (Karr, 1981). Also, Catch per Unit of Effort (CPUE) was to have been utilized.

Chain of Custody Procedures

Samples taken in the field were labeled with the following information:

- Date the sample was taken.
- Station at which the sample was taken.
- Name of the person conducting the sampling.
- Gear and/or method used to obtain the sample.

As noted above, macroinvertebrate samples were collected, picked in the field, and preserved for later identification. This identification was accomplished by qualified biologists – both AML staff and a hired consultant. The resulting data was analyzed by the AML staff biologist. Fish samples were to have been collected by a combination of personnel from the Kentucky Department of Fish and Wildlife Resources (KDFWR), DOW, and AML. However, as noted above, both sampling efforts resulted in the capture of no fish. Volunteers from AML staff, directed and supervised by qualified biologists, assisted in the collection of macroinvertebrates and the fish sampling efforts.

Quality Control Procedures

Equipment used in macroinvertebrate sampling was thoroughly rinsed in clear water between samples and inspected in order to prevent macroinvertebrates from one sample being transferred to another sample or site. Following the completion of sampling, all sampling equipment was thoroughly rinsed in clean water and dried. Organisms collected from each sample were preserved in a new, clean, empty container. Quality control for biological samples was provided by replicate samples at each station, and by ensuring that all habitat types at each station were sampled. Also, the preserved organisms from each sample are maintained in separate containers with labels identifying the date of sample and equipment used.

Soil and Refuse Analysis

Monitoring Objectives

The soil and refuse analysis objectives were to collect site specific data to populate the Revised Universal Soil Loss Equation (RUSLE) and to collect acidity data from representative samples of the pyritic coal processing refuse that was reclaimed by this project. RUSLE was used to calculate soil loss from the project area, both before and after the Best Management Practices (BMPs) were completed. This provided a means of estimating the reduction in sediment leaving the project area

Monitoring Program

McCoy and McCoy Laboratories in Madisonville, Kentucky analyzed the soil/refuse samples. The AML agronomist conducted all soil/refuse sampling for this project. The results were forwarded to the AML agronomist for interpretation. All holding times for laboratory analysis are greater than 24 hours. The methods of analysis are:

Parameter	Analyzed By
pH, Buffer	Lab
pH, Soil	Lab
Potential Acidity	Lab
Phosphorus, Available	Lab
Potassium, Available	Lab

The RUSLE Model

The Revised Universal Soil Loss Equation (RUSLE, Renard et al., 1997) is a set of mathematical equations for estimating average annual soil loss and sediment yield due to overland flow from undisturbed lands, lands undergoing disturbance, and from newly or established reclaimed lands. RUSLE estimates soil loss from a slope caused by raindrop impact and overland flow, plus rill erosion. It does not estimate gully or stream-channel erosion. Soil loss is defined here as that material actually removed from a particular slope or slope segment. The sediment yield from a surface is the sum of the soil losses minus deposition in macro-topographic depressions, at the toe of the slope, along field boundaries, or in terraces and channels sculpted into the slope.

RUSLE is derived from the theory of erosion processes, more than 10,000 plot years of data from natural rainfall plots, and from numerous rainfall simulation plots. RUSLE was developed by a group of nationally recognized scientists and soil conservationists who had considerable experience with erosion processes (SCS, 1993).

RUSLE retains the structure of its predecessor, the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978), namely:

$$A = R\ K\ LS\ C\ P$$

Where: A = Average annual soil loss in tons per acre per year
R = Rainfall/runoff erositivity
K = Soil erodibility
LS = Slope length and steepness
C = Cover management
P = Support practice

The R factor is an expression of the erosivity of rainfall and runoff at a particular location. The value of “R” increases as the amount and intensity of rainfall increases. The data for “R” for the project site was obtained from published maps (Renard et. al., 1997).

The K factor is an expression of the inherent erodibility of the soil surface material at a particular site under standard experimental conditions. The value of “K” is a function of the particle size distribution, organic matter content, structure, and permeability of the soil or surface material. For disturbed soils such as those encountered at the project site the nomograph equations embedded within the RUSLE program are used to compute appropriate erodibility values.

The LS factor is an expression of the effect of topography, specifically slope length and steepness, on rates of soil loss at a particular site. The value of “LS” increases as slope length and steepness increase, under the assumption that runoff accumulates and accelerates in the downslope direction. This assumption is usually valid for lands experiencing overland flow, as is found in our project area, but may not be valid for forest and other densely vegetated areas. The LS factor for our project site was determined by actual before and after reclamation surveys of the project area.

The C factor is an expression of the effects of surface covers and roughness, soil biomass, and soil disturbing activities on rates of soil loss at a particular site. The value of “C” decreases as surface cover and soil biomass increase, thus protecting the soil from rainsplash and runoff. The RUSLE program uses a sub-factor method to compute the value of “C”. The sub-factors that influence “C” change through time, resulting in concomitant changes in soil protection. A vegetation database is contained within the computer program that characterizes numerous plant types. RUSLE also contains an operations database file that characterizes the effects of various soil disturbing activities on soil loss rates. These operations alter the roughness, infiltration, distribution of biomass, and runoff properties of the surface. The operations include common tillage activities that may be used in the development of a seedbed at reclaimed sites. The “C” values were calculated using the RUSLE equations that consider local conditions.

The P factor is an expression of the effects of supporting conservation practices, such as contouring, buffer strips of close growing vegetation, and terracing, on soil loss at a particular site. The value of “P” decreases with the installation of these practices because they reduce runoff volume and velocity and encourage the deposition of sediment on the slope surface. The effectiveness of certain erosion control practices varies due to local conditions; therefore "P" values were calculated through the RUSLE equations based on site specific conditions.

Soil / Refuse Sampling

The coal processing refuse was sampled by the project agronomist at various locations in the project area. Any areas that had noticeably different soil properties were sampled and analyzed as separate samples.

Chain of Custody Procedures

KY DAML personnel conducted sampling for this project. Soil/refuse samples taken in the field were labeled with the following information:

- Date the sample was taken.
- Station at which the sample was taken.
- Name of the person conducting the sampling.
- Gear and/or method used to obtain the sample.

Quality Control Procedures

Quality control procedures for parameters analyzed by McCoy and McCoy followed the procedures outlined in *Quality Assurance Program Plan* **–** McCoy and McCoy Laboratories Inc., Madisonville, KY.

Best Management Practice Technologies Installed

Refuse Grading, Treatment, and Revegetation

The Pleasant Run Watershed Implementation Plan project involved the reclamation of 17.8 ha (43.9 acres) within the Pleasant Run watershed containing acidic mine spoil and refuse with sparse vegetation (Figures 7 and 8). The refuse and acidic mine spoil were significant sources of sedimentation and acid mine drainage (AMD) within the Pleasant Run watershed.

Figure 7: Nortonville Refuse Area.

Figure 8: Acidic impoundments in the headwaters of Pleasant Run.

Acidic impoundments and wet weather/seasonal water holding areas were treated, drained, graded to provide positive drainage and vegetated. The areas containing acidic mine refuse with sparse vegetation were graded to eliminate gullies and providing positive drainage.

The graded coal refuse was capped with an agricultural limestone barrier (Figure 9) and covered with a minimum of two feet of suitable cover material (Figure 10).

Revegetation efforts improved the vegetation of the site, reducing the sediment load to the stream. The refuse areas with sparse vegetation were seeded with a mix of acid tolerant warm and cool season grasses and legumes. While the use of native grasses and trees is preferred, it has been the experience of the DAML agronomist that a combination of native and non-native species is required for successful vegetation of acidic coal mine refuse (Figure 11).

Figure 9: Agriculture Limestone barrier application

Figure 10: Impoundment after backfilling, limestone barrier application, and suitable cover material placement.

Figure 11: Vegetation at the impoundment following additional seeding to improve vegetative cover.

Ditches

Grass Diversion Ditches

Grass diversion ditches were installed along the benches. The grass diversion ditches were lined with erosion control blanket. The erosion control blanket protects the diversion ditch from erosion while the grass is being established in the channel.

Open Limestone Channels

Over 4 km (2.5 miles) of varying sized open limestone channels (OLCs) were constructed with limestone rock and limestone sand (Figure 12). In addition to providing erosion control, they treat acid mine drainage before entering the streams. The OLCs intercept acidic water from the upper slopes of the refuse fill areas and from seeps providing treatment by increasing alkalinity to the water before discharging into the main tributaries. OLCs were also installed as side drains and terrace diversion channels on the graded refuse slopes.

Figure 12: Typical open limestone channel.

OLCs introduce alkalinity to acid water in open channels or ditches lined with limestone rock (Ziemkiewicz et al., 1994). Acid water is introduced to the channel and the acid mine drainage is treated by limestone dissolution. Past assumptions have held that armored limestone (limestone coated with Fe and/or Al hydroxides) ceased to dissolve, but experiments show that coated limestone continues to dissolve at about 20% the rates of unarmored limestone (Pearson and McDonnell, 1975). Another problem is that hydroxides tend to settle into and plug the voids in limestone beds forcing water to move around rather than through the limestone. While both armoring and plugging are caused by the precipitation of metal hydroxides they are two different problems. Maintaining a high flushing rate through the limestone bed can minimize plugging of the voids in limestone beds. Armoring, however, occurs regardless of the water velocity. Research by Ziemkiewicz and others (1997) has demonstrated that the rate of dissolution for armored limestone may be even higher than previous laboratory studies. Field experiments show considerable treatment by armored OLCs (Ziemkiewicz et al., 1994). The length of channel and the channel gradient are design factors that can be varied for optimum performance. Optimum performance is attained on slopes exceeding 20%, where flow velocities keep precipitates in suspension, and clean precipitates from limestone surfaces. Dissolved metals sorb onto the surfaces of the precipitates in suspension further reducing the amount of dissolved metals in the water.

Alternative Treatment Options

Active Treatment Technologies

Active treatment systems involve treating mine drainage with alkaline chemicals to neutralize acidity, raise water pH, and precipitate metals. Active treatment technologies are effective. However, when the cost of equipment, chemicals, and manpower are considered active treatment is expensive (Skousen et al., 1990). Chemical treatment is a long term never ending process. A variety of active treatment methods can be employed. Most active chemical treatment systems consist of an inflow pipe or ditch, a storage tank or bin to hold the chemical, a means of controlling the chemical application, a settling pond to capture precipitated metal oxyhydroxides, and a discharge point. Chemical compounds used in AMD treatment include:

Crushed limestone – rotating drum
Hydrated lime
Sodium carbonate (soda ash)
Sodium hydroxide (solid and liquid forms)
Ammonia
Pebble Quicklime (Calcium oxide).

The above treatment options could possibly have been used on the refuse sites. The flow at the toe of the refuse areas would have to be intercepted and directed to a central application site. The treated water would then flow into a settling pond before being discharged into the stream. The costs for construction of an active treatment site and the continuous operation and maintenance of an active treatment site are prohibitive at current funding levels. In addition, many of the active treatment options use chemicals that are harmful to biota in their concentrated state. The risk of release of these chemicals in concentrated form by vandalism or accident must be considered before deciding to use them.

Passive Treatment Options

Aerobic Wetland

An aerobic wetland consists of a large surface area pond with horizontal surface flow. The pond may be planted with cattails and other wetland species. Aerobic wetlands can only effectively treat water that is net alkaline. In aerobic wetland systems, metals are precipitated through oxidation reactions to form oxides and hydroxides.

Aerobic wetlands are not suitable for the refuse sites. The water discharging from the sites is net acidic.

Compost / Anaerobic Wetland

Compost wetlands, sometimes called anaerobic wetlands, consist of a large pond with a lower layer of organic substrate. The flow is horizontal through the substrate layer of the pond. The compost layer usually contains calcium carbonate either naturally as in spent mushroom compost, or added during construction of the wetland. A typical compost wetland will have 12 to 24 inches of organic substrate and be planted with cattails or other wetland vegetation. The vegetation helps stabilize the substrate and provides additional organic matter to perpetuate the sulfate-reduction reactions. Compost wetlands can treat discharges that contain dissolved oxygen, ferric iron, aluminum, or acidity in the 500 ppm range.

The compost wetland acts as a reducing environment. The compost removes oxygen from the system. Microbial organisms within the organic substrate reduce sulfates to water and hydrogen sulfide and increase the partial pressure of carbon dioxide. The elevated carbon dioxide levels increase the dissolution rates of limestone. Chemical and microbial processes generate alkalinity and increase the pH.

The refuse sites may be suitable for compost wetlands. The flow from the refuse would need to be intercepted and directed to the wetlands at the toe of the slopes. Compost wetlands are relatively expensive to construct and this project concentrated on grading and vegetating barren areas of refuse. Revegetation of the refuse slopes was necessary before the installation of compost wetlands could be considered. Budget constraints do not allow the installation of compost wetlands on the project area at this time.

Anoxic Limestone Drains

An anoxic limestone drain (ALD) is a buried bed of limestone constructed to intercept subsurface mine water and prevent contact with atmospheric oxygen. Keeping the water anoxic prevents oxidation of metals and prevents armoring of the limestone. The closed environment traps carbon dioxide, increasing the partial pressure and resulting in a greater dissolution rate than a system open to the atmosphere. The purpose of an ALD is to provide alkalinity thereby changing net acidic water to net alkaline water. ALDs are limited to the amount of alkalinity they can generate based on solubility equilibrium reactions. An ALD is a pretreatment step to increase alkalinity and raise pH before the water is oxidized and the metals precipitated in an aerobic wetland. The water leaving the site has already been oxidized so the use of an ALD on the refuse sites was not possible.

Vertical Flow Reactors

Vertical flow reactors were conceived as a way to overcome the alkalinity generation limitations of an anoxic limestone drain and the large area requirements for compost wetlands. The vertical flow reactor consists of a treatment cell with a limestone underdrain topped with an organic substrate and standing water. The water flows vertically through the organic substrate that strips the oxygen from the water making it anoxic. The water then passes through the limestone, which dissolves increasing alkalinity. The water is discharged through a pipe with an air trap to prevent oxygen from entering the treatment cell. Highly acidic water can be treated by passing the water through a series of treatment cells. A settling pond and an aerobic wetland where metals are oxidized and precipitated typically precede and follow the treatment cells.

Problems associated with vertical flow reactors include plugging of the pipes and precipitation of metals on the organic substrate surface, preventing flow into the limestone underdrain.

The refuse sites may be suitable for vertical flow reactors. However, it would be difficult to intercept all of the acidic water flowing through the refuse and direct it to the treatment cells.

Other Options

Other options included removal of the pyrite-rich refuse, mixing the refuse with agricultural limestone and placing it in a compacted fill. This option is expensive and current funding levels are not adequate for consideration of this option. The estimated cost for this option is in excess of ten million dollars for the refuse sites.

Other options also include doing nothing. The acid mine drainage and silt will continue to erode unabated into the streams impacting fish and other aquatic life downstream from the site.

Maintenance Agreement

The Division of Abandoned Mine Lands continues to monitor all project sites annually for a period of 5 years after the final inspection of the project. All project sites are inspected annually by DAML's staff agronomist or his representative. In addition, DAML responds to any complaints received for maintenance on its project sites. Any maintenance required will be performed under a separate maintenance contract. The DAML, as part of its annual grants from the Office of Surface Mining (OSM), budgets a portion of the annual grant for maintenance of reclamation projects completed by AML. Funds for any maintenance work required will be made available through DAML's annual grant from OSM. This is standard operating procedure for all DAML projects. After the 5 year monitoring period by DAML maintenance of the project sites will be performed by mutual agreement with the landowner.

RESULTS

Pleasant Run below the Reclamation Area

The field pH values for the headwaters of Pleasant Run, below the reclamation of Site B, ranged from 2.8 to 3.8 with an average of 3.1 prior to reclamation and ranged from 2.9 to 5.3 with an average of 3.4 at station PR-3 after reclamation began (Figure 13). The field pH values of the Nortonville tributary ranged from 2.5 to 4.2 with an average of 3.0 prior to reclamation and ranged from 2.5 to 4.2 with an average of 3.1 at station PR-6 (Figure 14). The field pH values of lower Pleasant Run, station PR-8 ranged from 3.4 to 5.4 with an average of 3.7 prior to reclamation and ranged from 3.3 to 7.1 with an average of 3.9 after reclamation began (Figure 15). Samples taken at site 8 prior to construction exceeded pH of 4 on seven occasions out of seventeen visits; samples taken at site 8 post construction exceeded pH of 4 on nine occasions out of twelve visits.

Total calcium concentrations below the reclamation increased slightly from an average of 221 mg/l to 243 mg/l after grading and agricultural limestone applications and construction of the open limestone channels.

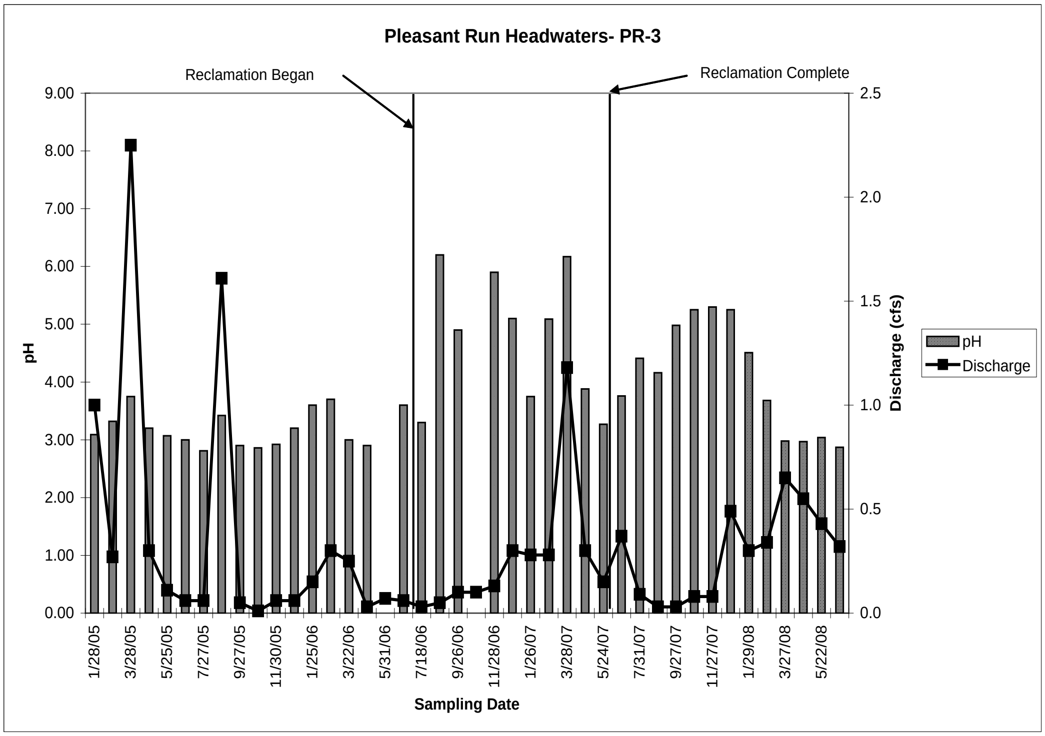

Figure 13: Discharge and pH values below the headwaters reclamation work area.

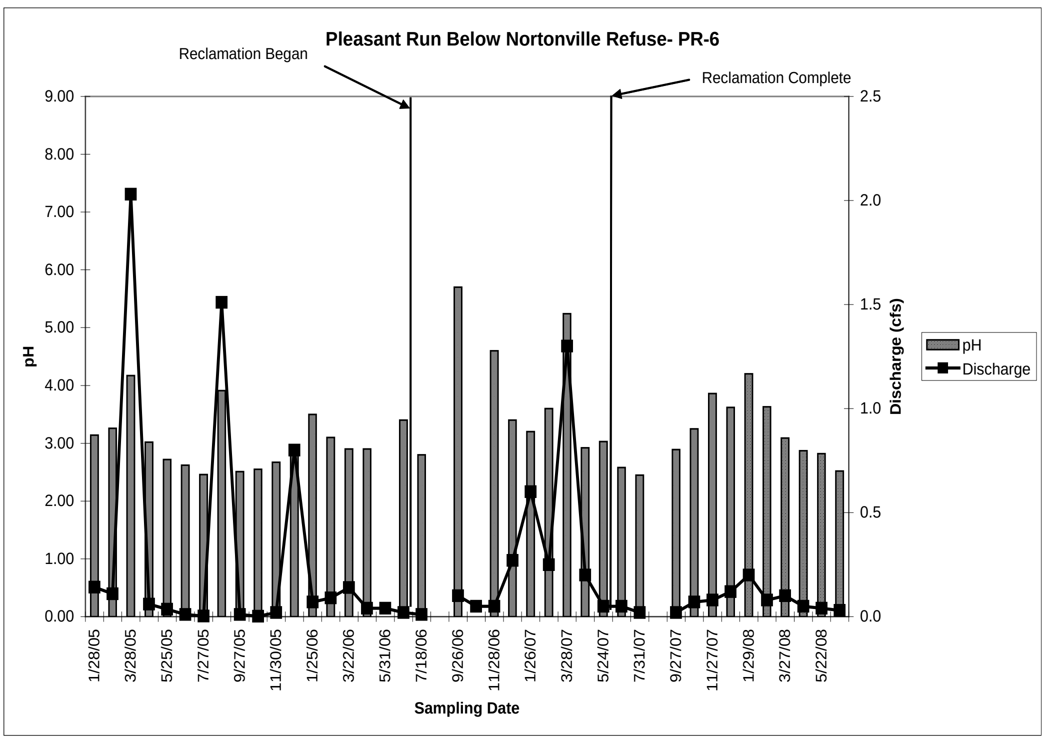

Figure 14: Discharge and pH values below the Nortonville Refuse reclamation work area.

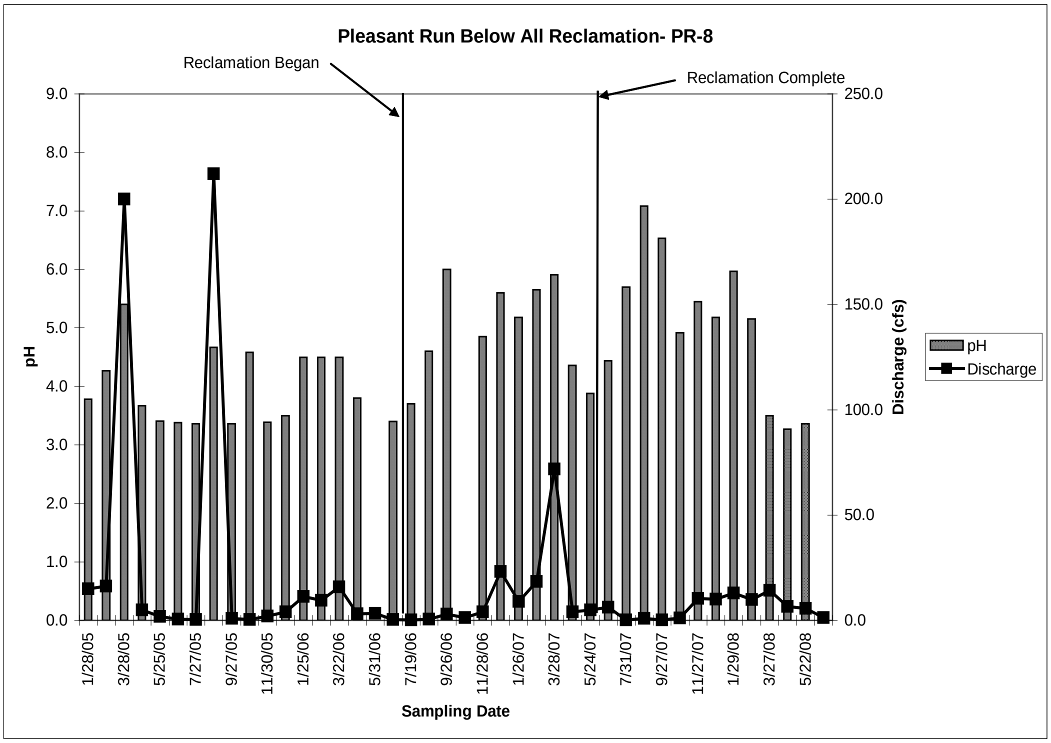

Figure 15: Discharge and pH values below all the reclamation work in the Pleasant Run watershed.

Acidity concentrations at sampling station PR-8 Lower Pleasant Run were used to determine the efficacy of the BMP's. Acidity leaving the work area decreased from an average of 459 mg/l $CaCO_3$ prior to reclamation to an average of 107 mg/l $CaCO_3$ after reclamation began (Figure 17). The sampling site remained net acidic. Acid loading rates were significantly decreased. But, a true comparison of pre-construction to post construction efficacy will not be known with this short time span of monitoring.

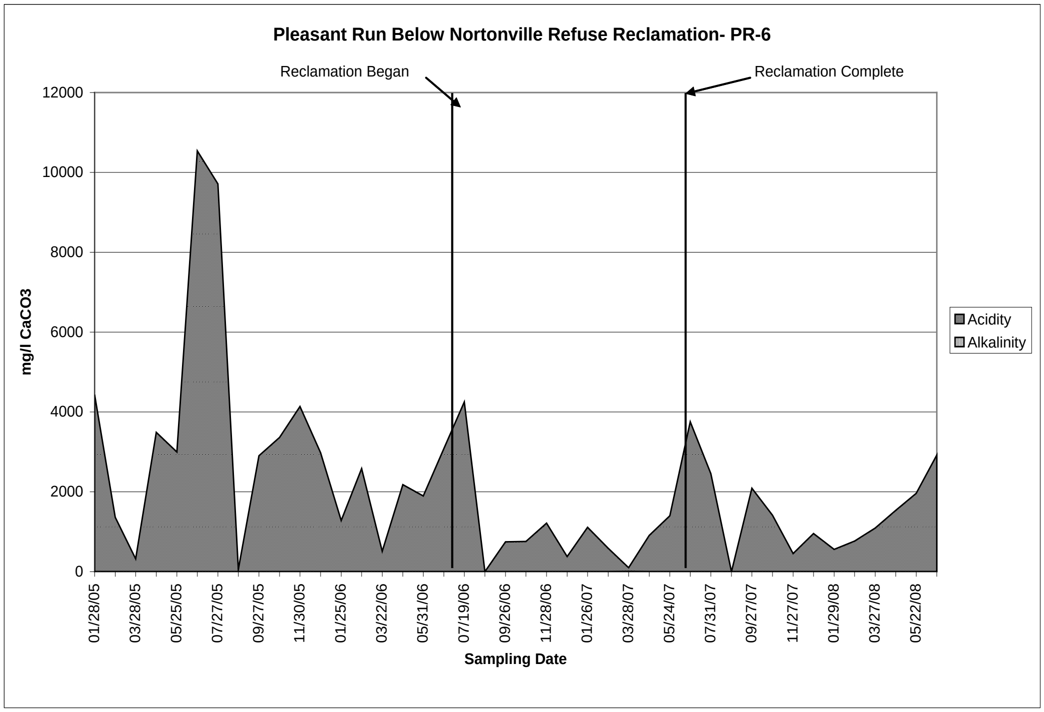

Figure 16: Acidity and Alkalinity concentrations below the Nortonville Refuse work area.

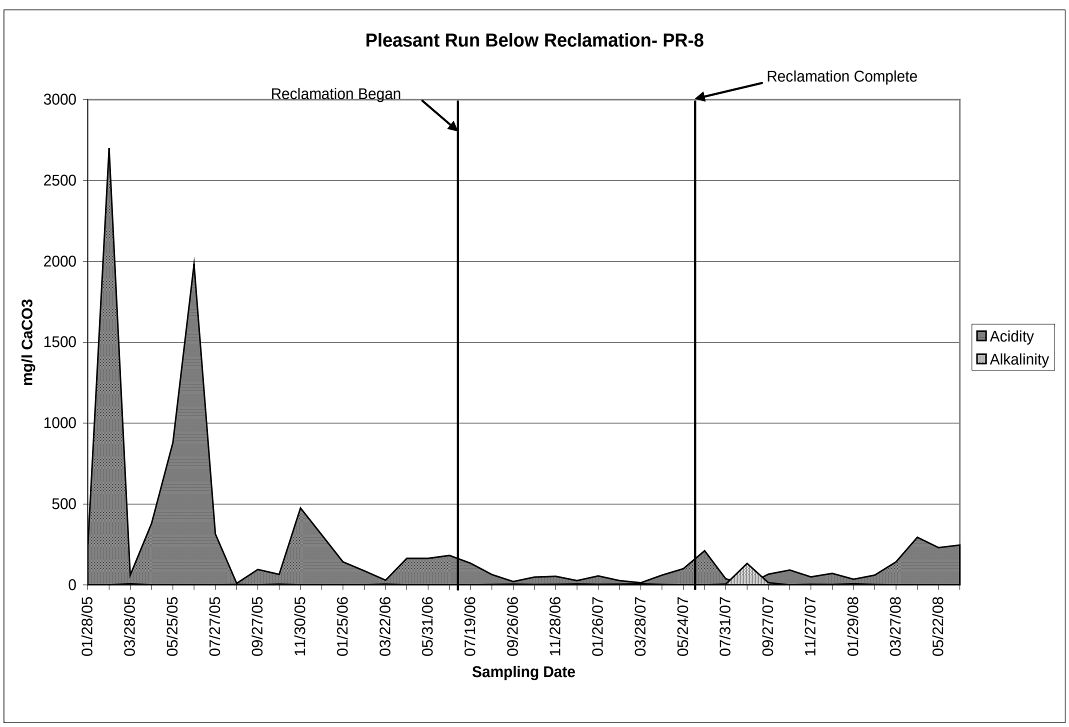

Figure 17: Acidity and Alkalinity concentrations below all reclamation work in the Pleasant Run watershed.

Iron concentrations (Figure 19) at station PR-8 decreased after reclamation started. However, lower discharge rates may give a lower reading in iron loading than reclamation will truly provide. Dissolved iron concentrations were reduced from an average of 8.4 mg/l prior to reclamation to 3.9 mg/l after reclamation began. Dissolved iron concentrations were reduced by 53% after reclamation began indicating the iron was precipitating rapidly, and is very visible in the Pleasant Run bed load.

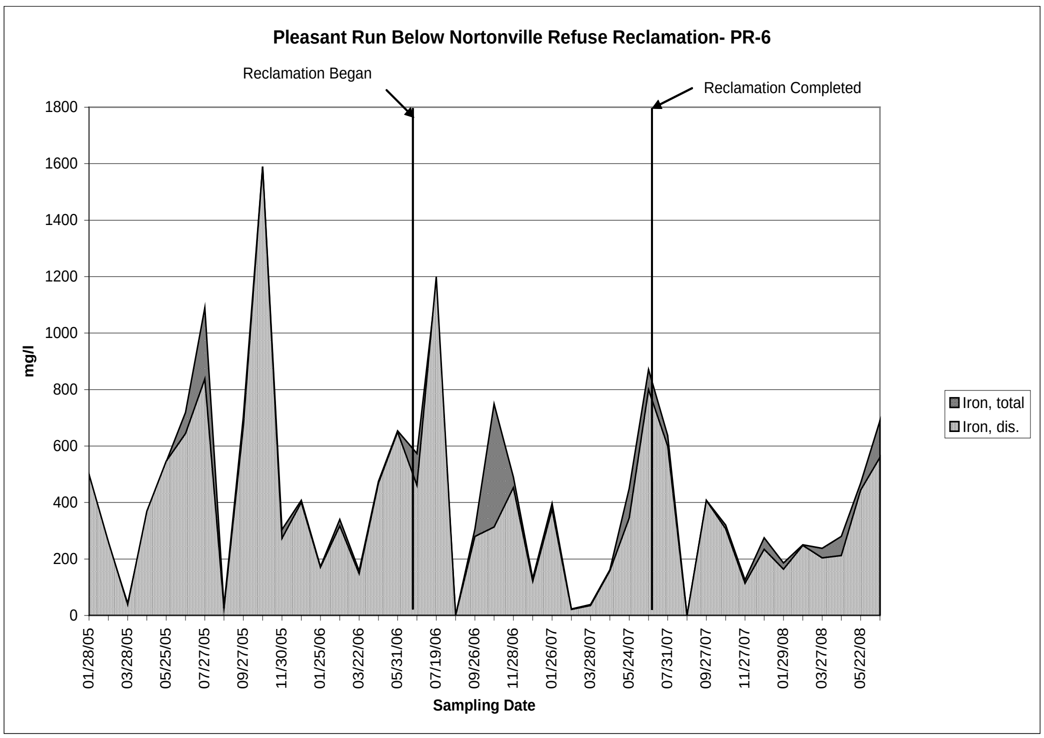

Figure 18: Iron concentrations below the Nortonville Refuse reclamation work area.

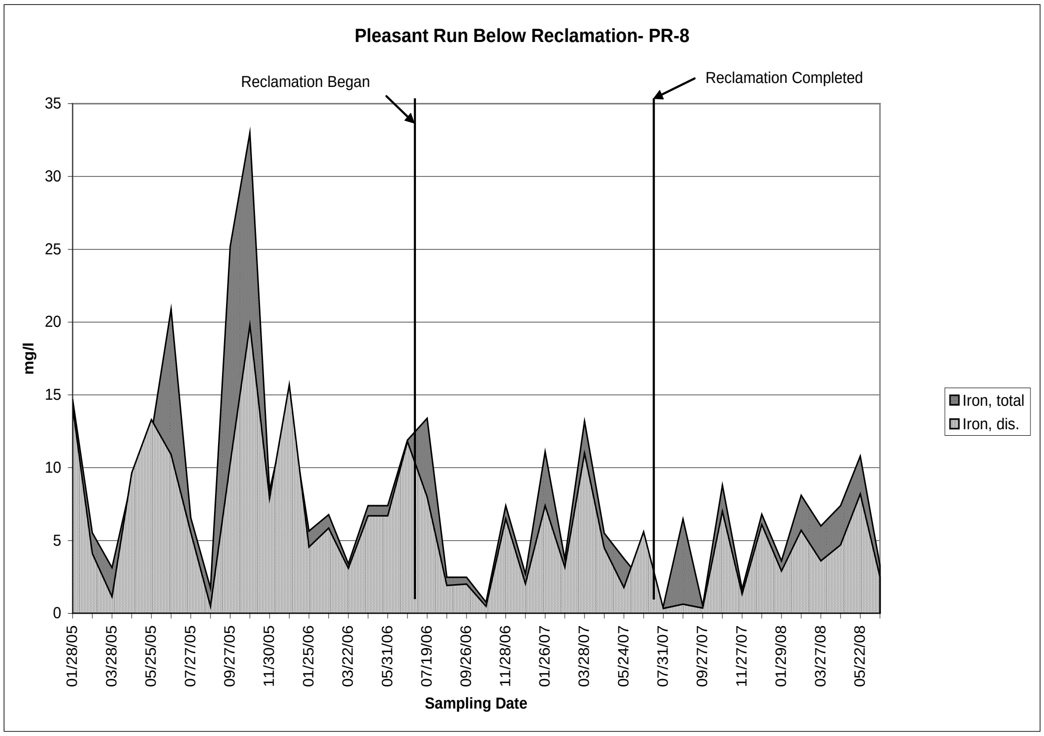

Figure 19: Iron concentrations below all reclamation work in the Pleasant Run watershed.

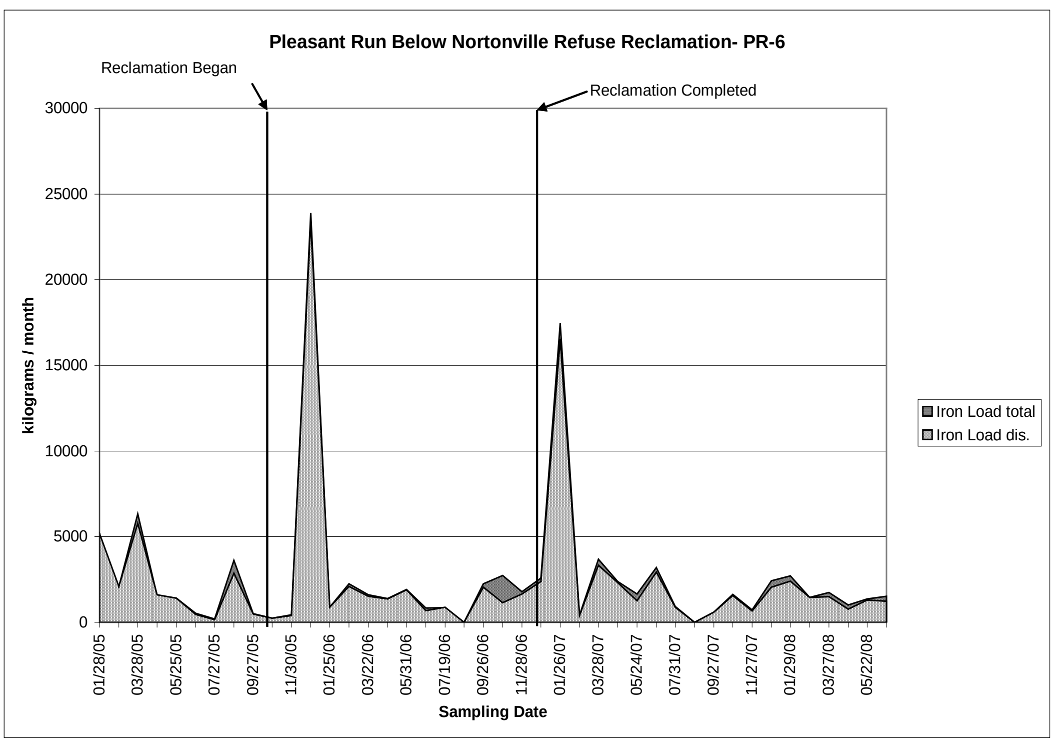

Figure 20: Iron loading below the Nortonville Refuse reclamation work area.

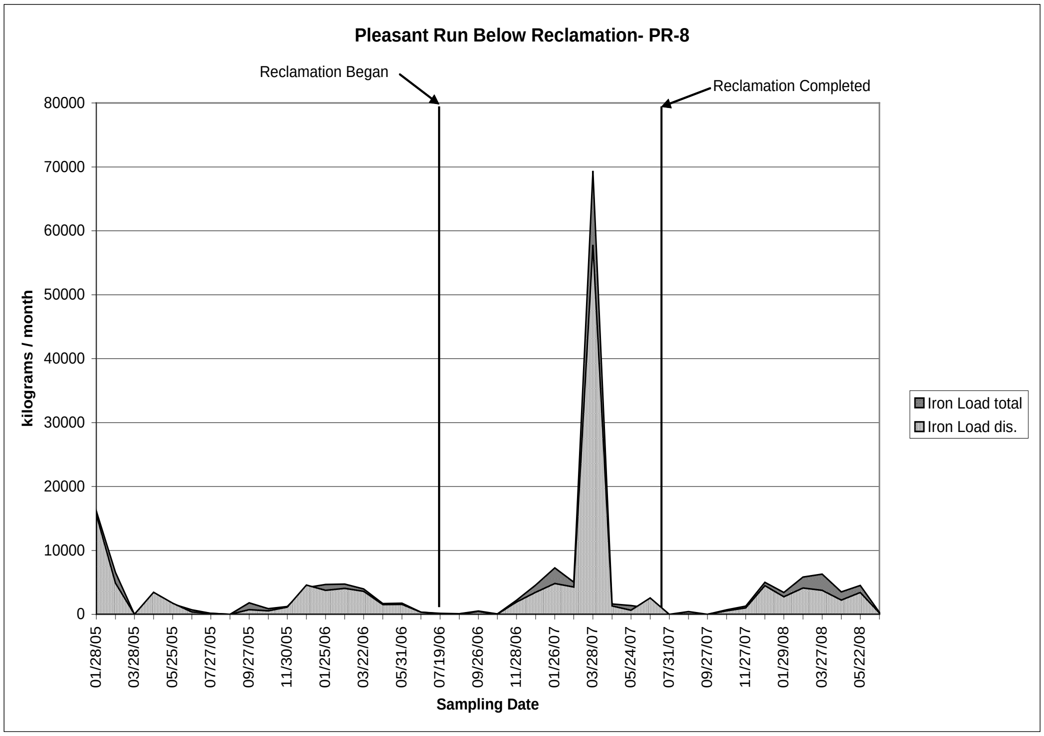

Figure 21: Iron loading below all the reclamation work in the Pleasant Run watershed.

Dissolved aluminum concentrations were reduced by 29% from an average of 7.6 mg/l before reclamation to an average of 5.4 mg/l after reclamation (Figure 23). Dissolved aluminum concentrations increased March through June of 2008 accompanying a decrease in pH. Additions of calcium to the Pleasant Run streambed load through limestone sand dosing and future reclamation projects in the drainage are needed to stabilize the pH and maintain lower dissolved metals concentrations.

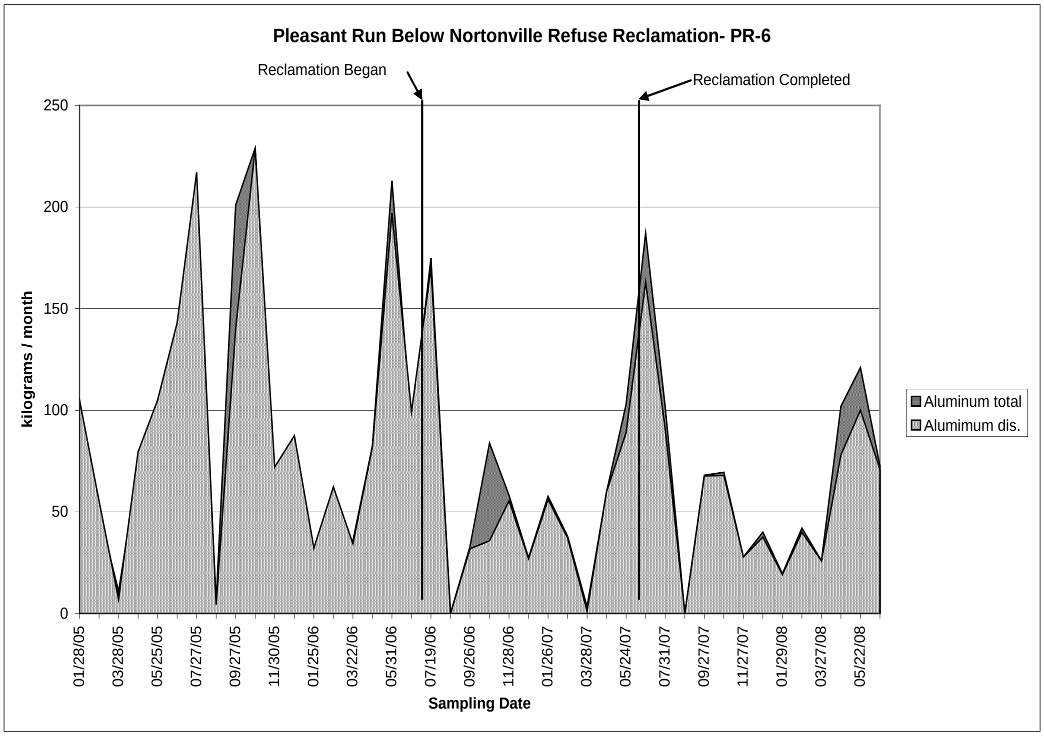

Figure 22: Aluminum concentrations below the Nortonville Refuse reclamation work area.

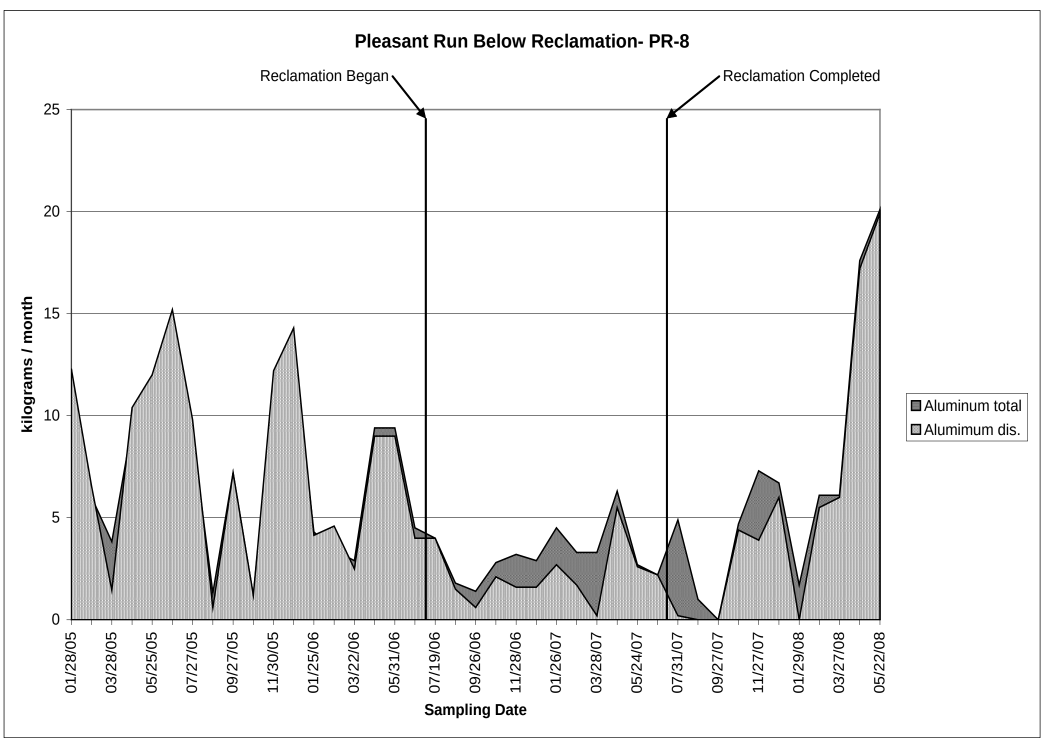

Figure 23: Aluminum concentrations below all reclamation work in the Pleasant Run watershed.

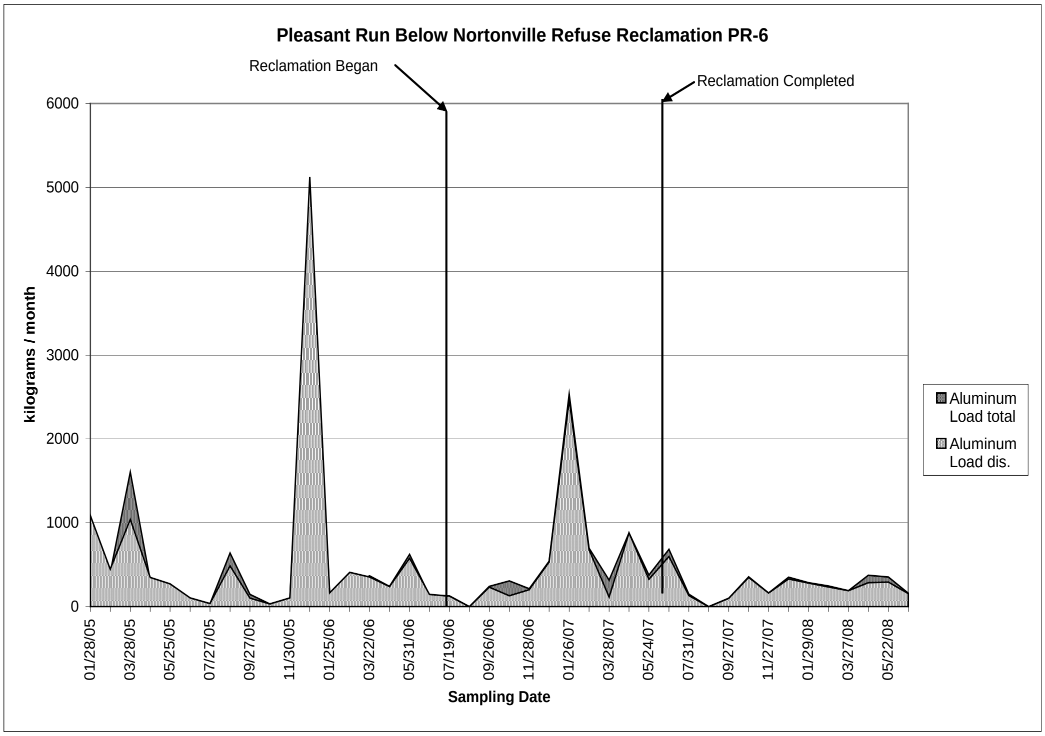

Figure 24: Aluminum loading below the Nortonville Refuse reclamation work area.

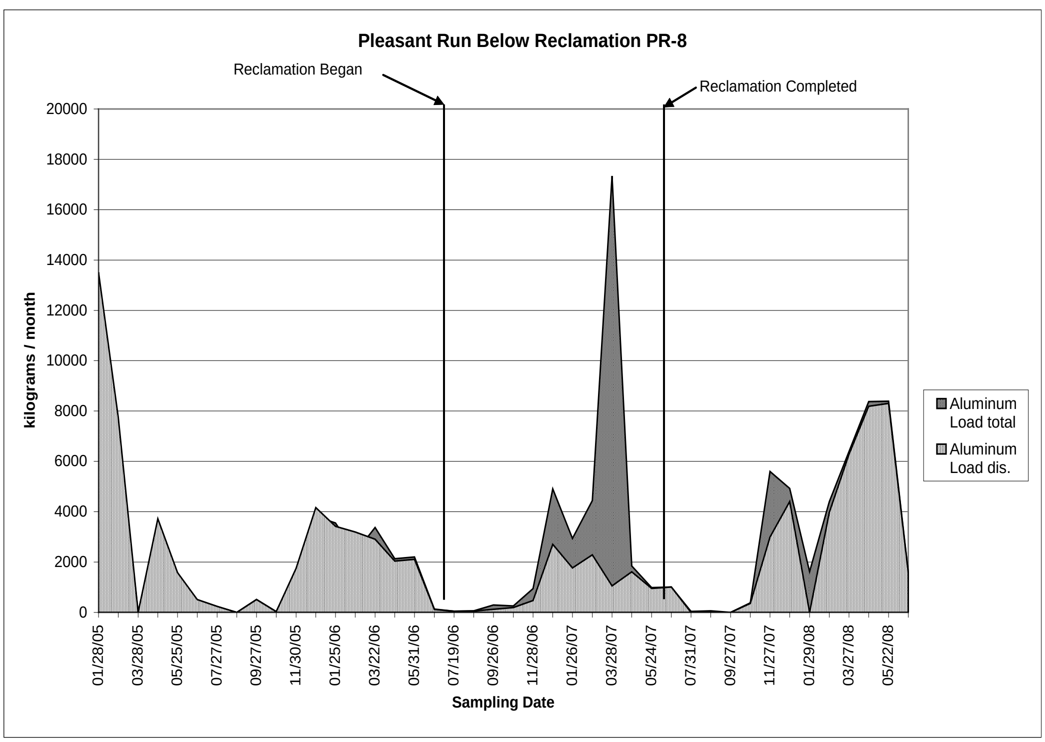

Figure 25: Aluminum loading below all reclamation work in the Pleasant Run watershed.

The water monitoring of Pleasant Run near Nortonville shows that covering the barren refuse areas and installation of limestone channels decreased the concentrations of metals, however, the complete precipitation of metals will require a greater increase in alkalinity within the watershed.

The USDA's RUSLE was used for the calculation of potential annual sheet and rill erosion losses of soil/refuse from the worksites each year. It was calculated that the annual soil loss was 2,177 metric tonnes (2,400 tons/year). The refuse samples had an average potential acidity of 77 metric tons $CaCO_3$/1,000 metric tonnes soil. The highly weathered surface layer had acidity as low as 27 Mg/1,000 Mg; however the underlying materials have an average potential acidity ranging from 53-127 metric tonnes/1,000 Mg. The actual acid loading is higher due to the formation of sulfur salts in the refuse and subsequent dissolution and runoff of acid into the stream during precipitation events. The RUSLE equation does not account for direct soil loss through gullies. The refuse materials have poor permeability resulting in higher runoff potentials which can convert the surface flows into gullies that act as erodible ditches. The erodible ditches cut into the refuse material and expose new materials for weathering with each precipitation event.

Post-reclamation RUSLE calculations estimate erosion losses of 105 metric tonnes/year (116 tons/year), a 95% reduction. Grading the refuse material and construction of erosion control ditches will significantly reduce the erosion losses for the reclaimed areas, and the direct loading of acidity into the streams. Unfortunately, enough alkaline materials could not be added to the spoil materials to eliminate the potential acidity. Instead, acid tolerant plants were chosen for the reclamation areas, and the DAML program has provided maintenance levels of limestone to areas demonstrating the worst plant stress due to acidic soil conditions. In the future the landowner will be responsible for such improvements.

Biological Monitoring Results

While the project resulted in a considerable improvement in water quality through reductions in turbidity levels and acidity, these improvements do not appear to have been sufficient enough to allow for a significant recovery of the aquatic biotic community. As noted above, fish have not been noted as being present within the system either prior to or following reclamation. Also, the post-construction macroinvertebrate sampling effort (Figures 27 and 29) saw a significant reduction in the number of macroinvertebrates in the system as compared with the pre-construction sampling effort (Figures 26 and 28). In the post-construction quantitative samples (Figure 27), no organisms being captured at either PRB-2 or PRB-3, and only a single isopod (*Asellus sp*.) being captured at site PRB-4. However, this may well be due to a significant environmental impact (most likely the serious drought of late 2007), as the control site CRB-1 also saw a notable reduction in both total numbers captured and the species richness of the macroinvertebrate community. Most macroinvertebrates and fish also require pH levels between 5.5 and 8.0. Consistent levels of pH 4.5 and lower, along with sedimentation and the production of flocculants, have and continue to severely limit the opportunities for aquatic life in this system. It must be stressed that there are many areas within the Pleasant Run watershed that have been affected by mining, which have not yet been reclaimed in any way. These areas continue to produce low pH drainage, along with sediments through erosion and production of metal hydroxide flocculants.

Order	Family	FinalID	TolVal	Site #1 CR-01	n x ά	Site #4 PR-02	n x ά	Site #5 PR-03	n x ά	Site #6 PR-04	n x ά
Diptera	Chironomidae	Cricotopus sp	7	9	63		0		0		0
Megaloptera	Sialidae	Sialis sp	7.17	8	57.36		0		0		0
Diptera	Chironomidae	Eukiefferiella sp	3.4	8	27.2		0		0		0
Plecoptera	Perlodidae	Isoperla bilineata	5.44	5	27.2		0		0		0
Trichoptera	Polycentropodidae	Polycentropus sp	3.53	3	10.59		0		0		0
Diptera	Chironomidae	Polypedilum sp	6.8	2	13.6	1	6.8		0		0
Isopoda	Asellidae	Lirceus fontinalis	7.85	3	23.55		0		0		0
Plecoptera	Taeniopterygidae	Taeniopteryx sp	5.37	1	5.37		0	1	5.37		0
Trichoptera	Phryganeidae	Agrypnia vestita	6	2	12		0		0		0
Diptera	Chironomidae	Polypedilum convictum	5.3	2	10.6		0		0		0
Lumbriculida	Lumbriculidae	Unid. Lumbriculid sp	7.3		0	1	7.3		0		0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia sp	0.94		0		0	1	0.94		0
Odonata	Aeshnidae	Boyeria vinosa	5.89	1	5.89		0		0		0
Hemiptera	Corixidae	Sigara modesta	9		0		0		0	1	9
Diptera	Ceratopogonidae	Bezzia sp	6.9		0	1	6.9		0		0
Decapoda	Cambaridae	Cambarus sp	4.9	1	4.9		0		0		0
		Total number of species:	n x ά	12	261.26	3	21	2	6.31	1	9
		Total number:	mHBI value	45	5.80578	3	7	2	3.155	1	9

Figure 26: Pre-construction quantitative macroinvertebrate sampling data (March 27, 2007).

Order	Family	FinalID	TolVal	Site #1 CR-01	n x ά	Site #4 PR-02	n x ά	Site #5 PR-03	n x ά	Site #6 PR-04	n x ά
Plecoptera	Taeniopterygidae	Taeniopteryx sp	5.37	3	16.11		0		0		0
Trichoptera	Rhyacophilidae	Rhyacophila ledra/fenestra	3.86	2	7.72		0		0		0
Diptera	Chironomidae	Chironomus sp	9.63	2	19.26		0		0		0
Ephemeroptera	Leptophlebiidae	Leptophlebia sp	6.23	1	6.23		0		0		0
Plecoptera	Perlodidae	Isoperla bilineata	5.44	1	5.44		0		0		0
Plecoptera	Nemouridae	Amphinemura sp	3.33	1	3.33		0		0		0
Megaloptera	Sialidae	Sialis sp	7.17	1	7.17		0		0		0
Isopoda	Asellidae	Asellus sp	9.4		0		0		0	1	9.4
		Total number of species:	n x ά	7	65.26	0	0	0	0	1	9.4
		Total number:	mHBI value	11	5.93273	0	#DIV/0!	0	#DIV/0!	1	9.4

Figure 27: Post-construction quantitative macroinvertebrate sampling data (April 17, 2008).

Order	Family	FinalID	TolVal	CR-01	n x ά	PR-02	n x ά4	PR-03	n x ά5	PR-04	n x ά6
Megaloptera	Sialidae	Sialis sp	7.17	10	71.7	1	7.17		0		0
Diptera	Chironomidae	Cricotopus sp	7	9	63		0		0		0
Diptera	Chironomidae	Eukiefferiella sp	3.4	8	27.2		0		0		0
Plecoptera	Perlodidae	Isoperla bilineata	5.44	5	27.2		0	2	10.88		0
Amphipoda	Gammaridae	Gammarus lacustris	6.9		0	1	6.9	3	20.7		0
Coleoptera	Dytiscidae	Hydroporus undalatus	8.9	3	26.7		0		0		0
Diptera	Chironomidae	Polypedilum sp	6.8	2	13.6	1	6.8		0		0
Isopoda	Asellidae	Lirceus fontinalis	7.85	3	23.55		0		0		0
Trichoptera	Polycentropodidae	Polycentropus sp	3.53	3	10.59		0		0		0
Decapoda	Cambaridae	Cambarus sp	4.9	1	4.9	1	4.9		0		0
Diptera	Chironomidae	Polypedilum convictum	5.3	2	10.6		0		0		0
Plecoptera	Capniidae	Allocapnia sp	2.52	2	5.04		0		0		0
Plecoptera	Taeniopterygidae	Taeniopteryx sp	5.37	1	5.37		0	1	5.37		0
Trichoptera	Phryganeidae	Agrypnia vestita	6	2	12		0		0		0
Coleoptera	Haliplidae	Peltodytes sexmaculatus	8.7		0	1	8.7		0		0
Diptera	Ceratopogonidae	Bezzia sp	6.9		0	1	6.9		0		0
Diptera	Chironomidae	Chironomus sp	9.63		0	1	9.63		0		0
Ephemeroptera	Isonychiidae	Isonychia sp	3.45		0		0	1	3.45		0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia sp	0.94		0		0	1	0.94		0
Hemiptera	Corixidae	Sigara modesta	9		0		0		0	1	9
Hemiptera	Corixidae	Sigara signata	9		0		0		0	1	9
Lumbriculida	Lumbriculidae	Lumbriculus sp	7.3		0		0		0	1	7.3
Lumbriculida	Lumbriculidae	Unid. Lumbriculid sp	7.3		0	1	7.3		0		0
Odonata	Aeshnidae	Boyeria vinosa	5.89	1	5.89		0		0		0
		Taxa Richness	EPT	14	0	8	0	5	0	3	0
		Total Number of Individuals:	% Ephem	52	0	8	0	8	0	3	0
		EPT/Chironomidae	Dominant Taxon(%)	#DIV/0!	0.19231	#DIV/0!	0.125	#DIV/0!	0.375	#DIV/0!	0.33333
		Dominant Taxon		Sialis sp		None		Gammarus lacustris		None	

Figure 28: Pre-construction qualitative macroinvertibrate sampling results (March 27, 2007)

Order	Family	FinalID	TolVal	Site #1 CR-01	n x ά	Site #4 PR-02	n x ά4	Site #5 PR-03	n x ά5	Site #6 PR-04	n x ά6
Amphipoda	Gammaridae	Gammarus lacustris	6.9		0		0		0	6	41.4
Diptera	Chironomidae	Chironomus sp	9.63	2	19.26	1	9.63		0	2	19.26
Decapoda	Cambaridae	Orconectes sp	5.49	3	16.47		0		0		0
Megaloptera	Sialidae	Sialis sp	7.17	2	14.34	1	7.17		0		0
Plecoptera	Taeniopterygidae	Taeniopteryx sp	5.37	3	16.11		0		0		0
Plecoptera	Perlodidae	Hydroperla crosbyi	2	2	4		0		0		0
Trichoptera	Rhyacophilidae	Rhyacophila ledra/fenestra	3.86	2	7.72		0		0		0
Amphipoda	Gammaridae	Gammarus fasciatus	9.09	1	9.09		0		0		0
Decapoda	Cambaridae	Cambarus sp	4.9		0		0		0	1	4.9
Ephemeroptera	Leptophlebiidae	Leptophlebia sp	6.23	1	6.23		0		0		0
Isopoda	Asellidae	Asellus sp	9.4		0		0		0	1	9.4
Lumbriculida	Lumbriculidae	Lumbriculus sp	7.3		0		0		0	1	7.3
Plecoptera	Nemouridae	Amphinemura sp	3.33	1	3.33		0		0		0
Plecoptera	Perlodidae	Isoperla bilineata	5.44	1	5.44		0		0		0
Trichoptera	Hydropsychidae	Cheumatopsyche sp	6.22		0		0		0	1	6.22
Trichoptera	Phryganeidae	Ptilostomis sp	6.37	1	6.37		0		0		0
		Taxa Richness	EPT	11	0	2	0	0	0	5	0
		Total Number of Individuals:	% Ephem	19	0	2	0	0	#DIV/0!	6	0
		EPT/Chironomidae	Dominant Taxon (%)	#DIV/0!	0.27273	#DIV/0!	0.5	#DIV/0!		#DIV/0!	0.5
		Dominant Taxon		Taeniopteryx sp./ Orconectes sp.		None				Gammarus lacustris	

Figure 29: Post-construction qualitative macroinvertebrate sampling data (April 17, 2008).

Current and Future Reclamation Projects

In 2008 the KYDAML began design for the Bunt Sisk Hills Project to reclaim areas in the headwaters of Pleasant Run and Fox Run. Maintenance and repair work for Homestead and Pleasant Run projects are planned for the fall of 2008.

CONCLUSIONS

The reclamation of 17 ha of barren, acidic refuse and spoil in the Pleasant Run watershed reduced the overall pollution loads into the watersheds. The grading, liming, covering, and vegetating of the barren refuse resulted in over 80% reductions in erosion losses at Nortonville Refuse. Before reclamation, water and wind erosion would continually remove materials to expose new layers of the refuse for weathering in addition to eroded acidic materials deposited downstream from the mining disturbed areas. The weathering and oxidation processes resulted in fresh acid salts that readily dissolve and degrade the water quality. Reclamation covered the acidic materials, greatly reducing, but not stopping, the weathering processes. The elimination of gullies and the installation of water control structures such as diversion ditches and open limestone channels have greatly reduced the sediment loads that may be washed from the reclamation areas. The construction of open limestone channels and use of agriculture limestone barriers added an alkalinity source to help lower acidity loads in the headwaters of Pleasant Run. However, the overall acidity load within the watershed was immensely greater than the alkalinity produced from limestone placed as a part of this project. Despite the total consumption of all alkalinity added to the two sites reclaimed in the watershed acidity loads are far less after construction in the sub-watersheds. Total acidity concentrations within Pleasant Run were reduced by 75% after construction.

Biological monitoring has not shown that there has been any effect upon the aquatic biological community. While conditions may have incrementally improved, as revealed through water quality data, overall environmental conditions (drought) have prohibited the biological community from taking any advantage of any improvement. Establishing or maintaining a healthy macroinvertebrate community within these heavily mined watersheds will be a great challenge, at best.

The technologies used in this project were successful in the reductions of sediments lost from the sites. The open limestone channels have been shown at other sites to greatly improve water quality. Most of the channels installed within this project serve as erosion protection and do not receive continual flows. The vegetation efforts were moderately successful. Some portions of the project will require subsequent revegetation due to adverse weather conditions (drought) and burn-out from acidic hotspots within the cover material. Overall, the revegetation has been greatly improved when compared to the original barren conditions. In future projects, the timing of vegetation efforts should be reviewed. In unsuitable seasons a cover crop may be an alternative, temporary, vegetation method. The cover crop may also provide a green manure layer to further aid the establishment of the final vegetative cover.

Overall, the reclamation activities have decreased the acid and sediment generation from 17 ha, however, far more acidic and barren spoils and coal processing waste deposits exist within these watersheds outside this project's area. The many other sources of acid mine drainage such as from underground mine works, exposed acidic clays, and refuse piles still continue to degrade the watershed. Future work is still merited to continue to improve the water quality.

REFERENCES CITED

APHA. 1992. *Standard Methods for the Examination of Water and Wastewater*. 18th Ed. American Public Health Association, Washington, DC.

Hilsenhoff, W.L. 1987. "An Improved Biotic Index of Organic Stream Pollution." *Great Lakes Entomology*. 20: 31-39.

Karr, J. R. 1981. "Assessment of Biotic Integrity Using Fish Communities." *Fisheries (Bethesda)*. 6: 21-27.

KYDOW. 2003. *Total Maximum Daily Load (TMDL) Development pH (H^+ mass) for Pleasant Run Watershed (Hopkins County, Kentucky).* KY Division of Water, Department for Environmental Protection, Frankfort, KY.

KYDOW Ecological Support Section. 2002. *Methods for Assessing Biological Integrity of Surface Waters in Kentucky.* KY Division of Water, Department for Environmental Protection, Frankfort, KY.

KYDOW. 1981. *The Effects of Coal Mining Activities on the Water Quality of Streams in the Western and Eastern Coalfields of Kentucky.* KY Division of Water, Department for Environmental Protection, Frankfort, KY.

Lenat, D. R. 1993. "A Biotic Index for the Southeastern United States: Derivation and List of Tolerance Values, With Criteria for Assigning Water Quality Ratings." *Journal of the North American Benthological Society*. 12: 279-290.

Pearson, F.H., and McDonnell. 1975. "Use of Crushed Limestone to Neutralize Acid Wastes." *Journal of the Environmental Engineering Division*. 101: 139-158.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder. 1997. *Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE).* US Department of Agriculture Publication AH-703, Washington, D.C.

Skousen, J.G., K. Politan, T. Hilton, and A. Meek. 1990. "Acid Mine Drainage Treatment Systems: Chemicals and Costs." *Green Lands*. 20: 31-37.

SCS. 1993. *RUSLE User's Guide.* Soil and Water Conservation Society, Ankeny, IA.

USDA. 1977. *Soil Survey of Hopkins County Kentucky*. United States Department of Agriculture, Washington, DC.

Wilson, J. 1998. *303(d) List of Waters for Kentucky.* KY Division of Water, Department for Environmental Protection, Frankfort, KY.

Wischmeier, W.H., and D.D. Smith. 1978. *Predicting Rainfall-Erosion Losses – A Guide to Conservation Planning.* US Department of Agriculture Publication AH-537, Washington, D.C.

Ziemkiewicz, P.F., J.G. Skousen, D.L. Brant, P.L. Sterner, and R.J. Lovett. 1997. "Acid Mine Drainage Treatment with Armored Limestone in Open Limestone Channels." *Journal of Environmental Quality*. 26: 560-569.

Ziemkiewicz, P.F., J.G. Skousen, and R. Lovett. 1994. "Open Limestone Channels for the Treating Acid Mine Drainage: A New Look at an Old Idea." *Green Lands*. 24: 36-41.

APPENDIX A. FINANCIAL AND ADMINISTRATIVE CLOSEOUT

Budget Summary

Budget Categories	Section 319(h)	Non-Federal Match	Grant Contract Total	Over-match	Final Expenditures
Personnel					
Supplies					
Equipment					
Travel					
Contractual	$ 720,440.00	$491,810.00	$1,212,250.00		**$ 991,532.90**
Operating Costs					
Other					
Total	**59.43%**	**40.57%**	**100%**		

The final reimbursement to the Kentucky Division of Abandoned Mine Lands listed above includes $53,569.80 that was invoiced and paid upon acceptance of the final report by the KY Division of Water. All dollars were not spent; there were $220,717.15 excess project funds to reallocate. This project did generate overmatch provided by the Kentucky Division of Abandoned Mine Lands. This overmatch was not posted to the Grant.

Equipment Summary

There was no equipment purchased for this project.

Special Grant Conditions

There were no special grant conditions.

APPENDIX B. QA/QC FOR WATER MONITORING

QUALITY ASSURANCE PROJECT PLAN

PLEASANT RUN AMD ABATEMENT PROJECT

Nonpoint Source Acid Runoff Pollution at the Nortonville and Homestead Refuse Disposal Sites

KENTUCKY DIVISION OF ABANDONED MINE LANDS

December 2005

Revision

Approving Officials	Title	Signature	Date
Steve Hohmann	Division Director	___________________	_______
Mark Carew	Project Manager	___________________	_______
Rosetta Fackler	EPA Project Manager	___________________	_______
Rodney Pierce	EPA QA Manager	___________________	_______

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PROJECT MANAGEMENT

Distribution List

Steve Hohmann	Director - Kentucky Division of Abandoned Mine Lands (KYDAML)
Mark Carew	Registered Geologist – KYDAML
Edwin Boone	Environmental Tech III – KYDAML
Mark Meade	Environmental Tech III – KYDAML
Bob Scott	Design Branch Manager – KYDAML
Corrine Wells	Nonpoint Source Section Supervisor – KY Division of Water
Michele Koziol	EPA Project Manager – KY Division of Water
Rodney Pierce	EPA QA Manager – KY Division of Water

Project Organization

The Kentucky Division of Abandoned Mine Lands (AML) will conduct monitoring for this project. The following personnel will be in charge of the monitoring activities:

AML Project Geologist -	Mark Carew 2521 Lawrenceburg Road Frankfort, KY 40601 (502) 564-2141
AML Project Biologist -	Ed Boone Kentucky Division of Abandoned Mine Lands 2521 Lawrenceburg Road Frankfort, KY 40601 (502) 564-2141
AML Project Agronomist -	Mark Meade Kentucky Division of Abandoned Mine Lands 2521 Lawrenceburg Road Frankfort, KY 40601 (502) 564-2141
AML Project Engineer -	Bob Scott Kentucky Division of Abandoned Mine Lands 2521 Lawrenceburg Road Frankfort, KY 40601 (502) 564-2141

Mark Carew is the project QA manager. Water monitoring will be conducted under the supervision of Mark Carew – Project Geologist/Manager. Biological monitoring will be conducted under the supervision of Edwin Boone – Project Biologist. Refuse sampling will be conducted under the supervision of Mark Meade – Project Agronomist. Sediment load calculations using the Revised Universal Soil Loss Equation (RUSLE) will be conducted under the supervision of Bob Scott – Project Engineer.

The KY DAML will contract with a laboratory for water and soil/refuse analysis. The laboratory being used for water and soil/refuse analysis will be either McCoy and McCoy Laboratories in Madisonville KY and/or Delta Testing in Hyden, KY.

Problem Definition/ Background

Watershed Information

Pleasant Run (HUC14 05110006040060), a third order stream, originates in southern Hopkins County (figure 1) and flows east to discharge into Drakes Creek 13.9 km (8.6 mi) upstream from its confluence with the Pond River (figure 2). The Pond River discharges into the Green River, which flows northward into the Ohio River. Pleasant Run's main stem is approximately 12.7 km (7.9 mi) long and drains an area of 3,259.5 ha (8,054.5 acres (12.6 mi^2)). The average gradient is 6.8 m per km (35.5 ft per mi). Elevations for Pleasant Run range from 214 m (700 ft) above mean sea level (msl) in the headwaters to 122 m (400 ft) above msl at the mouth.

The 2002 303(d) list of waters for Kentucky (KDOW 2002) indicates 12.7 km (7.9 mi) of Pleasant Run, from the headwaters to the confluence with the Drakes Creek in Hopkins County, does not meet its designated use for contact recreation (swimming) and for aquatic life.

The Pleasant Run AMD Abatement Project areas selected for BMP implementation were originally mined from the 1920's through 1958 and are pre-law mining sites. The proposed

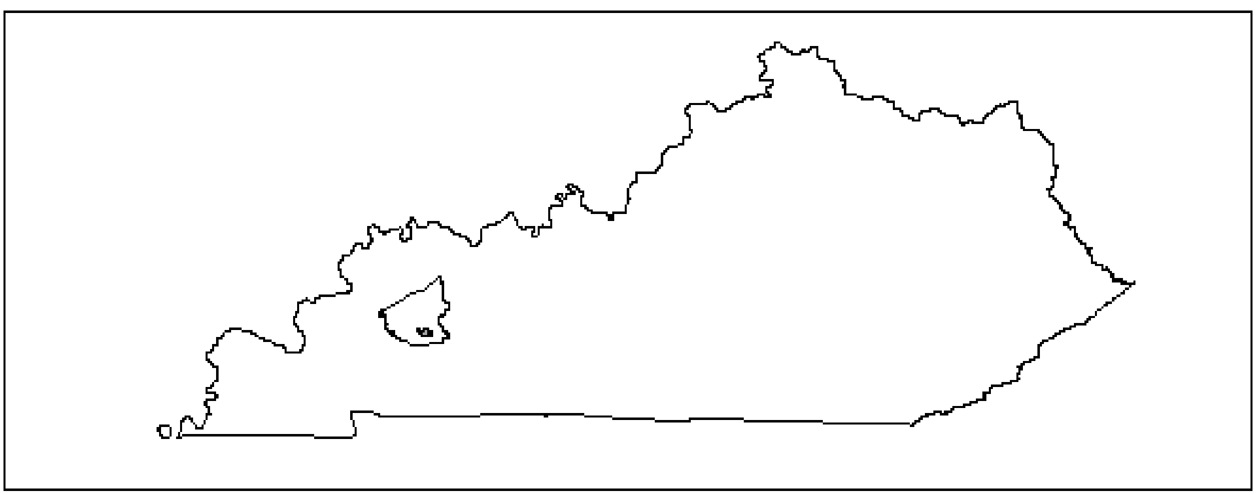

Figure 1. General location of Pleasant Run Watershed (shaded area) and Hopkins County, Kentucky.

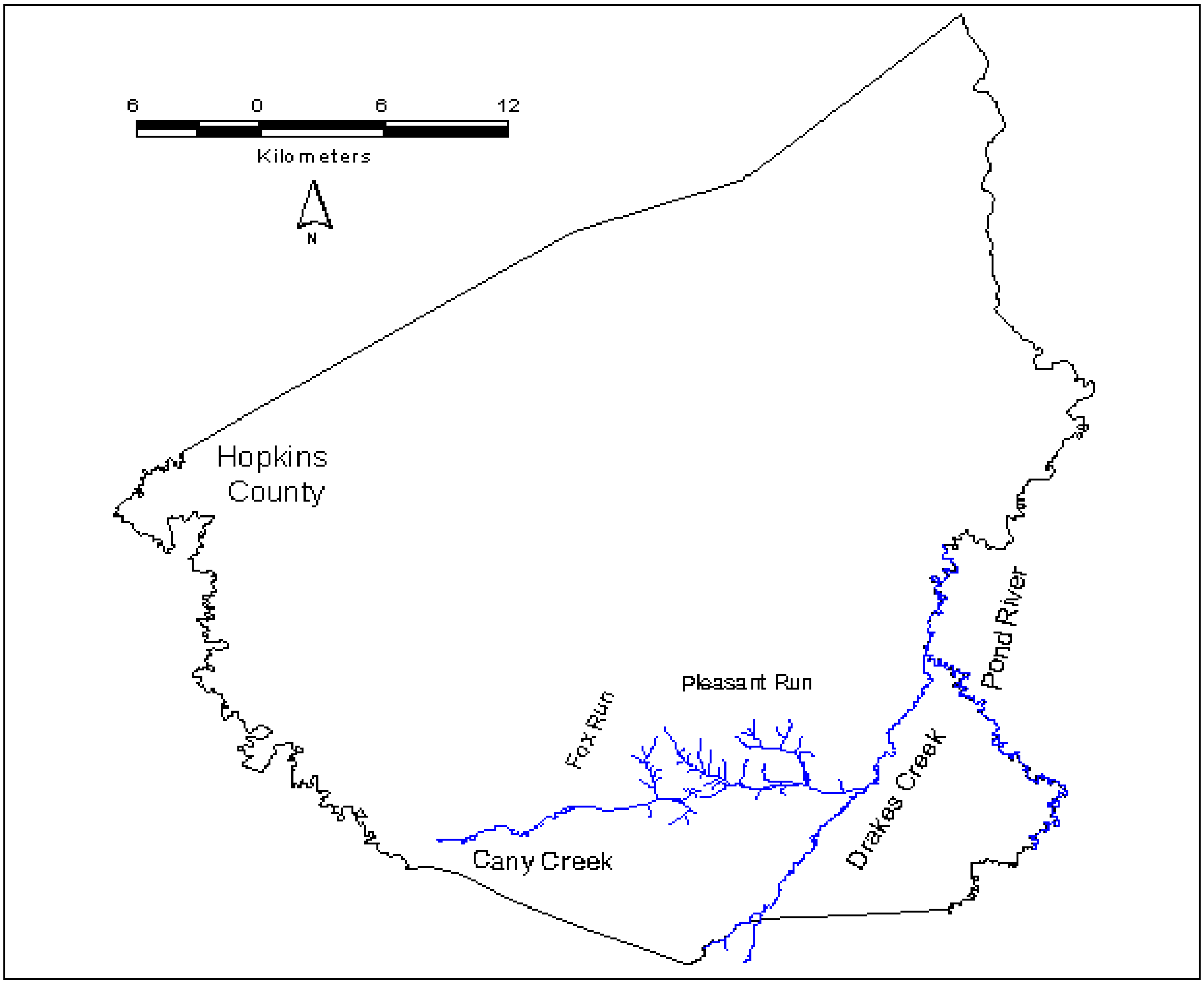

Figure 2. Location of Pleasant Run in Hopkins County, Kentucky.

project will reclaim an expanse of abandoned strip and deep mine disturbance in southern Hopkins County, northeast of the community of Saint Charles in the headwaters of Pleasant Run, and a site north of and adjoining the community of Nortonville. The sites in the headwaters of Pleasant Run contain pit and ridge formations of severely eroded acidic spoil piles mixed with coal refuse. The Nortonville site consists of several acres of highly acidic coal refuse and spoil from a coal tipple loadout.

The Pleasant Run AMD Project will reclaim and revegetate areas with inadequate vegetative cover and passively treat AMD with site-specific techniques. Reclamation of the project sites will result in a reduction in the sediment load entering Pleasant Run. A reduction in the sediment load being derived from acidic spoil and refuse will also result in a reduction in the acid load and dissolved metal loads from direct erosion of acid forming materials into the stream. The Revised Universal Soil Loss Equation (RUSLE) will be used to calculate sediment load reductions on the reclaimed sites. Spoil testing along with RUSLE will allow calculations of the reduction in acid loading from the direct erosion of acid forming materials into the stream. Passive treatment of AMD in the watershed will improve water quality in the receiving stream, reducing acidity, increasing pH, and reducing dissolved metal concentrations. Water monitoring and biological monitoring will document improvements to the main stem of Pleasant Run.

Monitoring History

The waters of Pleasant Run were monitored as early as 1978 by the Division of Water (DOW) as reported in *The Effects of Coal Mining Activities on the Water Quality of Streams in the Western and Eastern Coalfields of Kentucky*, published in 1981 by the Kentucky Department for Natural Resources and Environmental Protection as part of an agreement with the Division of Abandoned Lands. The DOW sampled the three unnamed tributaries to Pleasant Run on April 26, 1978. The three streams had pH values of 4.3, 3.5, and 3.2. The degradation of Pleasant Run is the consequence of acid mine drainage in the watershed as noted by the DOW.

In 1997, the DOW conducted a survey of streams in the Western Kentucky Coalfields, including Pleasant Run. The DOW reported a high level of pH impairment, citing acid mine drainage as the principal source. A pH of 2.9 was recorded on July 3, 1997. Based on these readings, the stream was listed as First Priority on the Kentucky 303(d) list of streams not meeting their designated uses. Pleasant Run does not support the designated uses of aquatic life and swimming (KDOW 2002).

A TMDL for Pleasant Run has been developed and submitted to the Environmental Protection Agency. The pH near the mouth of Pleasant Run ranged from 2.8 during low flow to 5.6 during high flow during the TMDL study period from November 14, 1999 thru May 5, 2000. The pH ranged from 2.5 to 4.0 at river mile 4.4 during the same study period, and ranged from 2.5 to 3.6 at river mile 6.6 (Ormsbee, 2004).

Problem Definition

Pleasant Run

The 2002 303(d) list of waters for Kentucky (KDOW 2002) indicates 7.9 mi of Pleasant Run, from the headwaters to the confluence with the Pond River in Hopkins County, does not meet its designated use for contact recreation (swimming) and for aquatic life. The Pleasant Run watershed provides a classic example of impairment caused by AMD. Bituminous coal mine drainage, like that found in the Pleasant Run watershed, generally contains very concentrated sulfuric acid and may contain high concentrations of metals, especially iron, manganese, and aluminum.

Project Description

The Pleasant Run AMD Abatement Project areas selected for BMP implementation were originally mined from the 1920's through 1958 and are pre-law mining sites. The proposed project will reclaim an expanse of abandoned strip and deep mine disturbance in southern Hopkins County, northeast of the community of Saint Charles in the headwaters of Pleasant Run, and a site north of and adjoining the community of Nortonville. The sites in the headwaters of Pleasant Run contain pit and ridge formations of severely eroded acidic spoil piles mixed with coal refuse. The Nortonville site consists of several acres of highly acidic coal refuse and spoil from a coal tipple loadout.

The Pleasant Run AMD Project will reclaim and revegetate areas with inadequate vegetative cover and passively treat AMD with site-specific techniques. Reclamation and revegetation of the project sites will result in a reduction in the sediment load entering Pleasant Run. A reduction in the sediment load being derived from acidic spoil and refuse will also result in a reduction in the acid load and metal loads from direct erosion of acid forming materials into the stream. Increases in alkalinity as a result of passive treatment of AMD at the project sites will reduce the acid load and free hydrogen ion load entering Pleasant Run. As pH increases, as a result of passive treatment, dissolved iron and aluminum will precipitate out of solution reducing dissolved metal loads.

Objective

- Sediment Load Reduction
- Acid Load Reduction
- Free Hydrogen Ion Load Reduction (Increase pH)
- Dissolved Iron Load Reduction
- Dissolved Aluminum Load Reduction

Methods

Sediment Load Reduction

Construction includes heavy gradework to eliminate large and small gullies and to redirect drainage patterns. To minimize acid mine drainage and to present a medium capable of supporting vegetation, the graded coal refuse will be capped with an agricultural limestone barrier covered by a minimum of two feet of topsoil. The cover material consists of ridges of mine spoil vegetated with volunteer trees and scrub. Sufficient soil will remain within the borrow areas to provide adequate cover for these areas once topsoil excavation is complete.

Ditches lined with class II/III stone will control drainage. Installation and maintenance of hay-bale silt checks and silt traps will minimize sedimentation. All areas disturbed by construction will be covered with topsoil and vegetated, as soon as practical, using agricultural limestone, fertilizer, seed, mulch, crimping, and netting.

Acid Load Reduction

Acidity is a measure of the amount of base needed to neutralize a volume of water. For AMD, acidity includes hydrogen ion concentration (low pH) and mineral acidity, which, when dealing with AMD from coalmines in the eastern U.S., arises predominately from the presence of dissolved iron, aluminum, and manganese in the water (Hedin et al., 1991).

Regrading and revegetation have the potential to reduce acid loads and improve water quality. Covering acid producing materials on a site with good soil material and establishing vegetation has a major impact on reducing acid concentrations in water and often decreases the flow of water from these sites by encouraging infiltration into the soil and evapotranspiration by plants.

Passive treatment technologies can greatly improve water quality discharge into the receiving streams. Selection and design of an appropriate passive system is based on water chemistry, flow rate, local topography, and site characteristics (Hyman and Watzlaf, 1995). Water sampling, soil sampling and detailed site investigations will be conducted on the project sites to determine which passive treatment technologies are most appropriate for the sites selected.

The passive treatment technologies that may be used on the Pleasant Run AMD Project include constructed wetlands, anoxic limestone drains (ALD), vertical flow systems, alkaline recharge basins, open limestone channels (OLC) and limestone sand treatment.

Constructed Wetlands

Constructed wetlands are man-made ecosystems that mimic their natural counterparts. Often they consist of shallow excavations filled with flooded gravel, soil, and organic matter to support wetland plants. Aerobic wetlands promote oxidation and hydrolysis in the surface water of the wetland. Net alkaline water is required for aerobic wetlands to function as designed. In anaerobic wetlands the metabolic products of sulfate reducing bacteria, usually accompanied by limestone, are major reactants in raising pH and precipitating metals. The bacteria use organic substrates and sulfate as nutrients.

Anoxic Limestone Drains

ALDs are buried limestone cells that generate bicarbonate alkalinity as anoxic water flows through. ALDs are limited to the amount of alkalinity they can generate based on solubility equilibrium reactions. An ALD is a pretreatment step to increase alkalinity and raise pH before the water is oxidized and the metals precipitated in an aerobic wetland. The AMD must have low dissolved oxygen levels, low ferric iron concentrations, and low aluminum concentrations for long-term successful treatment.

Vertical Flow Systems

Vertical flow systems were conceived as a way to overcome the alkalinity generation limitations of an anoxic limestone drain and the large area requirements for compost wetlands. The vertical flow reactor consists of a treatment cell with a limestone underdrain topped with an organic substrate and standing water. The water flows vertically through the organic substrate that strips the oxygen from the water making it anoxic. The water then passes through the limestone, which dissolves increasing alkalinity. The water is discharged through a pipe with an air trap to prevent oxygen from entering the treatment cell. Passing the water through a series of treatment cells can treat highly acidic water. A settling pond and an aerobic wetland where metals are oxidized and precipitated typically follow the treatment cells. Problems associated with vertical flow reactors include plugging of the pipes with aluminum which must be periodically flushed when aluminum loading is high, and precipitation of metals in the organic substrate which may clog, preventing flow into the limestone underdrain.

Alkaline Recharge Basins

Alkaline recharge basins are basins filled with limestone rock that are designed to provide contact of the water entering the basin with the limestone rock for a 12 hour time period (ideally) which, through dissolution, will saturate the water with alkalinity.

Open Limestone Channels

Open limestone channels (OLCs) introduce alkalinity to acid water in open channels or ditches lined with limestone rock (Ziemkiewicz et al., 1994). Armoring of the limestone with iron hydroxides reduces limestone dissolution, so longer channels and more limestone is required to account for the reduced efficiency. Another problem is that hydroxides tend to settle into and plug the voids in limestone beds forcing water to move around rather than through the limestone. Maintaining a high flushing rate through the limestone bed can minimize plugging of the voids in limestone beds. Optimum performance is attained on slopes exceeding 20%, where flow velocities keep precipitates in suspension, and clean precipitates from limestone surfaces. Utilizing OLCs with other passive systems can maximize treatment and metal removal.

Limestone Sand Treatment

Sand-sized limestone may be directly dumped into acid mine drainage impacted streams at various locations in watersheds. The sand is picked up by the stream flow and redistributed downstream, neutralizing the acid as the stream moves the limestone through the streambed. The limestone in the streambed reacts with acid in the stream, causing neutralization. The use of the direct application of limestone sand to treat acidified streams is the least expensive method available based on the cost per ton of acid neutralized (Zurbuch, 1996; Zurbuch et al., 1996). This method does not require the large capital investment or the costs associated with the operation and maintenance of mechanical stream dosing systems. Acid producing mine spoil has been eroding into Pleasant Run for over 50 years from denuded mine sites resulting in a significant quantity of acidic refuse in the bed load of the stream. Acid loading will be calculated from baseline water monitoring to determine the amount of limestone sand required. Limestone sand will be added at four locations in the watershed to treat the acid producing refuse in the streambed.

Free Hydrogen Ion Load Reduction (Increase pH)

The passive treatment methods described in the above acid load reduction section will increase alkalinity and reduce acidity in the receiving stream resulting in a reduction of hydrogen ion concentration and a resultant rise in pH.

Dissolved Iron Load Reduction

The passive treatment methods described in the above acid load reduction section will reduce acidity concentrations in the AMD impacted water. Enough alkalinity must be added to raise the water pH to the level that dissolved metals in the water will form insoluble metal hydroxides and settle out of the water. Iron in its oxidized state (ferric iron) will begin precipitating out of solution at a pH of 3.5. The combination of raising the pH of the impacted water above 3.5 and oxygenating the impacted water, converting iron from its reduced state (ferrous iron) to ferric iron, will precipitate the iron out of solution.

Dissolved Aluminum Load Reduction

The passive treatment methods described in the above acid load reduction section will reduce acidity concentrations in the AMD impacted water. Enough alkalinity must be added to raise the water pH to the level that dissolved metals in the water will form insoluble metal hydroxides and settle out of the water. Aluminum hydroxide precipitates out of solution at a pH of 4.5. Raising the pH of the impacted water above 4.5 will precipitate the aluminum out of solution. Dissolved aluminum is particularly harmful to aquatic life.

Other Options

The Nortonville site may provide the opportunity for AML to explore another unique treatment option. There is a constant source of highly acidic water flowing from the Nortonville site. The close proximity of the AMD source to the receiving stream and the location of the site adjoining the city limits of Nortonville restrict the on-site treatment options available. If water quality data and flow measurements make it feasible, and the local public utilities are agreeable, AML may pursue the option of piping the AMD into the South Hopkins Sewer Districts sewage treatment plant. Sewage treatment plants naturally generate highly alkaline wastewater ideally suited for neutralizing AMD. Similar AMD treatment projects have been successfully completed in towns in West Virginia.

All applicable environmental permits will be obtained.

Quality Objectives and Criteria

A. To collect acid and metal loading data for the Pleasant Run tributary of Drakes Creek. Pleasant Run is being degraded by pyritic coal mine refuse and by seeps discharging acid mine drainage in the Pleasant Run Watershed. Monitoring before and after the reclamation will indicate the efficacy of the acid mine drainage abatement techniques used in the reclamation of the site.

B. To obtain data regarding short term impacts of acid mine drainage mitigation efforts upon the water quality as measured by the aquatic communities of Pleasant Run by means of sampling the macroinvertebrate population. Monitoring macroinvertebrates before, and after reclamation efforts will indicate the short-term effectiveness of this acid mine drainage mitigation project.

C. To obtain site-specific data to populate the Revised Universal Soil Loss Equation (RUSLE). RUSLE will be used to calculate soil loss from the project area before, and after, the Best Management Practices (BMPs) are completed. This will provide a means of estimating the reduction in sediment entering Pleasant Run after completion of the project. Pleasant Run is being degraded by uncontrolled erosion of non-vegetated pyritic coal processing refuse into the creek.

D. To collect soil/refuse analysis data. The refuse analysis will be used in conjunction with the soil loss analysis to calculate the acid load entering the stream before and after reclamation of the refuse from the direct washing of refuse into the stream.

Special Training/Certification

All personnel involved in the reclamation and monitoring activities on this project are professionals in their fields. No additional training or certification is necessary for the successful completion of the project.

Documents and Records

The KYDAML project manager will be responsible for disseminating the most current approved version of the QA Project Plan to the individuals responsible for each aspect of the monitoring plan.

Water monitoring data will be reported by the selected laboratory to the Division of Abandoned Lands on the laboratories standard report form. The data will then be entered into a Microsoft Excel spreadsheet.

Biological monitoring data will be reported to the project manager by the project biologist in Microsoft Excel spreadsheet format.

Soil/refuse analysis will be reported to the project manager by the project agronomist on the standard laboratory report form. The project manager will then calculate acid loading due to sediment loss based on the RUSLE calculations.

Soil/refuse loss before and after implementation of the BMPs will be calculated using the RUSLE under the direction of the project engineer. The project engineer will report the results to the project manager in a Microsoft Word document.

The final report will be submitted in both electronic and print format to the Division of Water using Microsoft Word and Excel formats. All records including but not limited to laboratory analysis, inspection reports, invoices, correspondence, rock weigh tickets, seed tickets, and interim and final reports will be retained by the Kentucky Division of Abandoned Mine Lands at the central office location, 2521 Lawrenceburg Road, Frankfort, KY for a minimum period of five years after acceptance of the final report by the Kentucky Division of Water.

DATA GENERATION AND ACQUISITON

Sampling Process Design

Water Monitoring

Water quality data will be collected at the mouths of selected tributaries and in the main stem of Pleasant Run (figure 3).

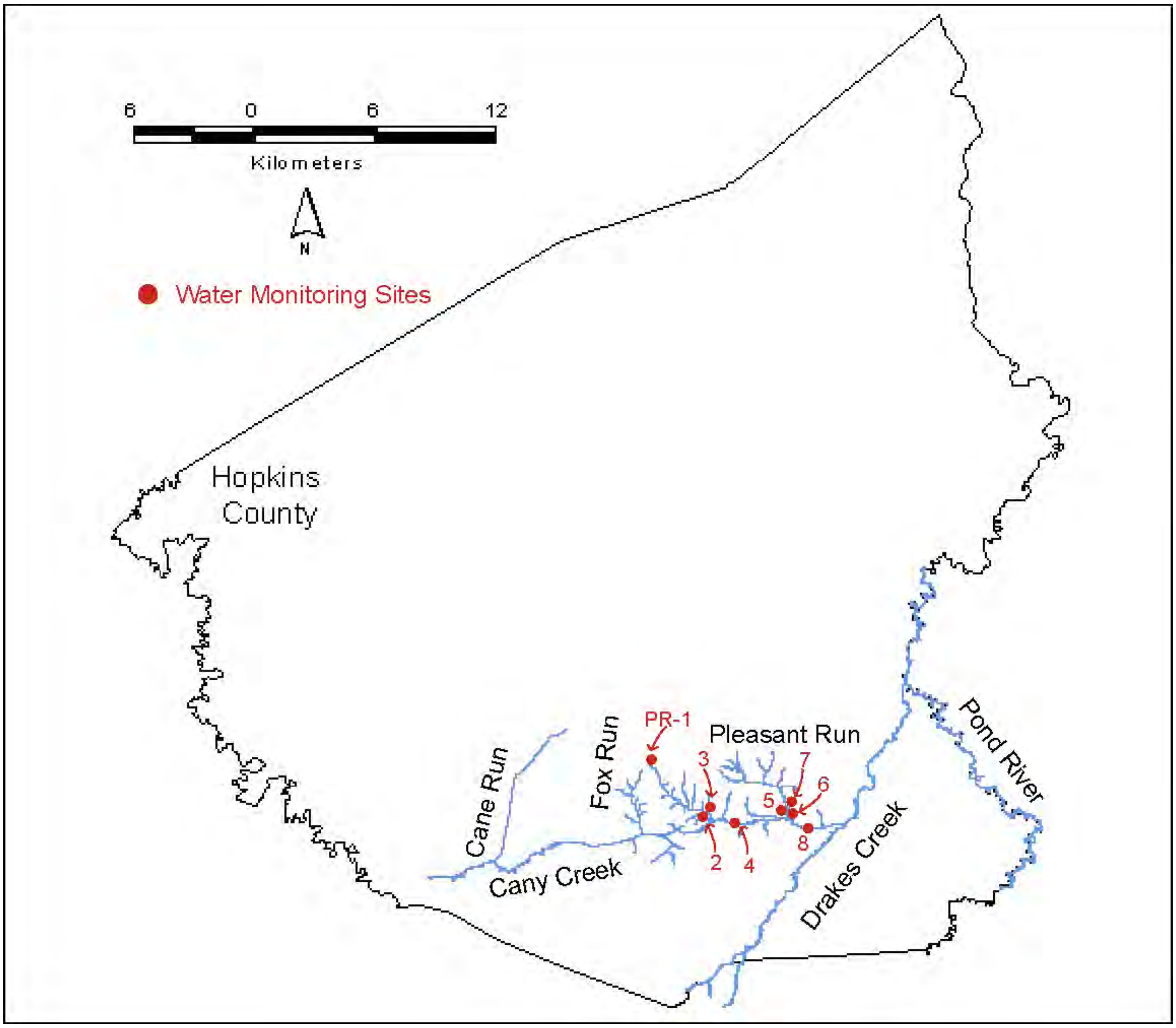

Figure 3. Location of water monitoring sites in the Pleasant Run watershed.

Monitoring Site

Station Name	Site Number	Lat/Long
Upper Trib. of Pleasant Run	PR – 1	37° 13’ 18.2” / 87° 32’ 00.6”
Upper Pleasant Run	PR – 2	37° 12’ 19.3” / 87° 31’ 33.1”
Homestead Trib. to Pleasant Run	PR – 3	37° 12’ 18.2” / 87° 31’ 29.1”
Mid Pleasant Run	PR – 4	37° 11’ 32.3” / 87° 29’ 54.9”
Northeast Trib. to Pleasant Run	PR – 5	37° 11’ 40.7” / 87° 27’ 19.1”
Nortonville Trib. to Pleasant Run	PR – 6	37° 11’ 41.6” / 87° 27’ 16.7”
Culvert Outlet in Refuse Fill	PR – 7	37° 11’ 55.7” / 87° 27’ 16.0”
Lower Pleasant Run at Nortonville	PR – 8	37° 11’ 31.3” / 87° 27’ 09.0”

Water monitoring sites PR-1, PR-2 and PR-3 are located in the Homestead mine impacted area. Water monitoring sites PR-2 and PR-3 are located at the mouths of the main tributaries contributing the acid and sediment load from the Homestead project area. Monitoring at the mouths of the main tributaries accounts for all of the acid drainage sources and any natural buffering that may occur in the watershed. Water monitoring site PR-1 is located near the headwaters of Pleasant Run adjacent to the project area. Monitoring this site will demonstrate the immediate effect of the BMPs implemented on the project. Water monitoring site PR-5 is located near the mouth of a main tributary draining the northeast section of the watershed. Monitoring this site will demonstrate the effectiveness of treatment methods in this portion of the watershed. Water monitoring site PR-6 is located at the mouth of the small tributary draining the Nortonville portion of the project. Monitoring this site will demonstrate the effectiveness of the reclamation at the Nortonville site. Water monitoring site PR-7 is located at the outlet of a concrete culvert that passes under the refuse fill reclaimed on a previous project. The culvert drains a small watershed that is not impacted by acidic refuse. Acidic groundwater is seeping into the culvert as it passes under the reclaimed refuse fill. Monitoring this site will demonstrate the effectiveness of the treatment proposed upstream of the culvert inlet. Water monitoring sites PR-4 and PR-8 are located on the main stem of Pleasant Run at about the mid-point and near the mouth respectively. Monitoring these two sites will demonstrate improvements in water quality to the main stem of Pleasant Run.

The following parameters will be tested monthly:

Parameter	**Analyzed By**	**Method**
Flow	Field	Flow meter/Volumetric
pH	Field/Lab	SM 4500-A
Specific Conductance	Field/Lab	SM 2510
Alkalinity	Lab	SM 2320 B
Acidity	Lab	EPA 305.1
Total Dissolved Solids	Lab	SM 2540
Calcium (total)	Lab	EPA 200.7
Aluminum (total)	Lab	EPA 200.8
Aluminum (dissolved)	Lab	EPA 200.8
Iron (total)	Lab	EPA 200.8
Iron (dissolved)	Lab	EPA 200.8
Manganese (total)	Lab	EPA 200.8
Manganese (dissolved)	Lab	EPA 200.8
Sulfate	Lab	EPA 300.1

Flow - Flow measurements provide information on the proportional effects that pollution sources have on receiving streams. Flow is being measured so loading calculations can be performed on the parameters being analyzed.

pH - The pH of the water is a measurement of the hydrogen-ion activity and gives an indication of the general chemical status of the water, whether the water is acidic or basic.

Specific Conductance - Conductivity is a measure of the water's ability to conduct an electrical current. Conductivity is measured to give an approximation of the amount of solids dissolved in the water. AMD pollution produces elevated conductivity readings since the dissolved metals, sulfate, and hydrogen ions can all conduct a charge.

Alkalinity and Acidity - Acidity is a measure of the amount of base needed to neutralize acid in a solution. Acidity differs from pH in that pH is a measure of the intensity and acidity is a measure of the amount. Water samples can have the same pH but very different acidity values.

The acidity concentration affects the type of treatment system that may be designed to neutralize the acid. Alkalinity is a measurement of the capacity of the water to neutralize acid. Below a pH of 4.5 no measurable alkalinity will be present in the water.

Total Dissolved Solids - Dissolved solids values are used in evaluating water quality and are useful for comparing waters with one another. The residue left after evaporation can be used as an approximate check on the general accuracy of an analysis when compared with the computed dissolved solids value.

Aluminum, Iron, Manganese - In coal mine drainage, major contributors to acidity are from ferrous and ferric iron, aluminum, and manganese, as well as free hydrogen ions. Aluminum rarely occurs in solution in natural waters in concentrations greater than a few tenths of a milligram per liter. The exceptions are mostly waters of very low pH such as acid mine drainage impacted waters. Dissolved aluminum in waters having a low pH has a deleterious effect on fish and other forms of aquatic life. Iron concentrations in natural waters are also generally small. The chemical behavior of iron and its solubility in water is dependent on the oxidation intensity and the pH of the system in which it occurs. Water in a flowing surface stream that is fully aerated should not contain more than a few micrograms per liter of dissolved iron at equilibrium in the pH range of about 6.5 to 8.5. Waters that are depleted in oxygen can retain ferrous iron in solution and water with a low pH can retain both ferrous and ferric iron in solution. Manganese is an undesirable impurity in water supplies due to a tendency to deposit black oxide stains. Manganese is often present at concentrations greater than one milligram per liter in acid mine drainage. Manganese usually persists in the water for greater distances downstream from the pollution source than the iron contained in the acid mine drainage. As the acidity is neutralized, ferric hydroxide precipitates first. Aluminum and iron concentrations in acid mine drainage affects the type of treatment systems that can be used for neutralizing the acidity.

Sulfate - Sulfur that occurs in reduced form in the sulfide minerals is relatively immobile. When sulfide minerals such as pyrite undergo weathering in contact with aerated water, the sulfur is oxidized to yield sulfate ions that go into solution in the water. Hydrogen ions are produced in considerable quantities in this oxidation process (Hem, 1992).

Calcium - Generally calcium is the predominant cation in river water. The tolerance of many aquatic species to low pH and high dissolved aluminum concentrations is hardness dependent.

The higher the calcium concentration the more tolerant some fish are to low pH and high aluminum concentrations.

Biological Monitoring

Aquatic macroinvertebrates are always in the stream and are continuously exposed to the full range of water quality conditions. Aquatic macroinvertebrates serve as a reflection of stream quality over a period of time. If a pollutant were strong enough it might eliminate many or all of the pollution-sensitive organisms, even though the toxic levels of pollution occurred at irregular intervals. The absence of the sensitive organisms would be a clue that something had upset the stream ecology even though the water might have acceptable chemical quality at the time of sampling.

Biological monitoring stations will be located on the main stem of Pleasant Run and at a control site on Cane Run (figure 4).

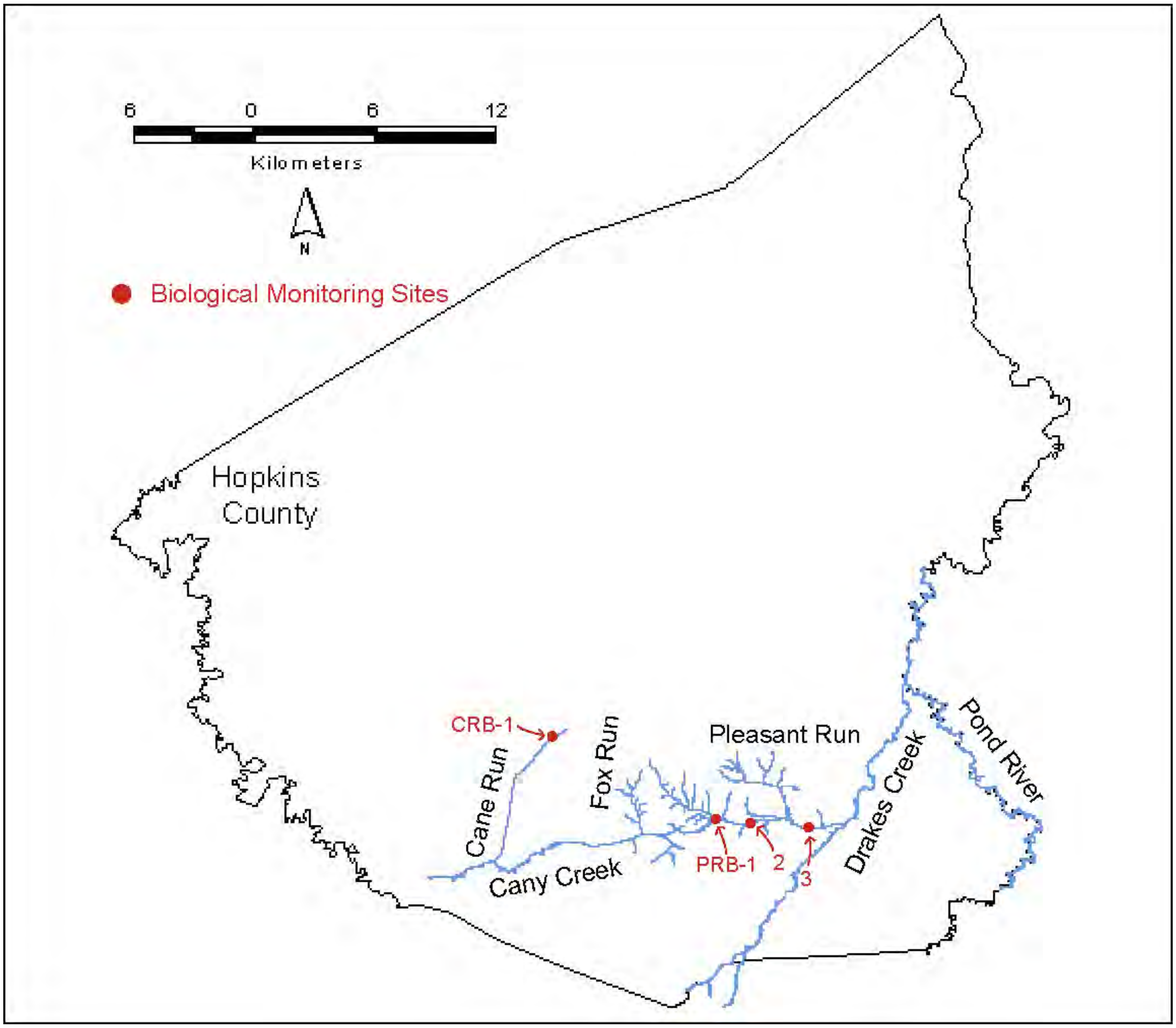

Figure 4. Biological monitoring sites in the Pleasant Run watershed.

Monitoring Site

Station Name	Site Number	Lat/Long
Upper Pleasant Run	PRB – 1	37° 12' 14.8" / 87° 31' 26.6"
Mid Pleasant Run	PRB – 2	37° 11' 32.3" / 87° 29' 54.9"
Lower Pleasant Run	PRB – 3	37° 11' 31.3" / 87° 27' 09.0"
Cane Run	CRB – 1	37° 12' 33.2" / 87° 34' 14.6"

Site selection criteria included ease of repositioning and the ability to determine the effects of AMD treatments within the project area on the main stem of Pleasant Run. All sites are downstream from the AMD impacted tributaries. Data reporting for all collections will be conducted as per Kentucky Division of Water (DOW) accepted methods (See later discussion for details).

Aquatic macroinvertebrates are to be collected in spring by a series of four one-quarter meter kick net samples per station, along with one triangular kick-net sweep to cover all habitat types in the sample area. All whole samples are to be picked in the field, stored in 70% ethanol, and returned to the DAML Frankfort office for sorting and identification to the lowest possible taxon. After sorting and identification, the data will be evaluated using the modified Hilsenhoff Biotic Index (HBI) (Hilsenhoff, 1987, 1988, Lenat, 1993) to determine the overall pollution tolerance of the macroinvertebrate community and the degree to which the habitat is impaired. Other metrics to be used includes the Total Number of Individuals, Ephemeroptera/Plecoptera/Trichoptera Richness (EPT), and Percent Dominant Taxon.

Soil Loss Monitoring Program

The RUSLE Model

The Revised Universal Soil Loss Equation (RUSLE), (Renard et al., 1997) is a set of mathematical equations for estimating average annual soil loss and sediment yield due to overland flow from undisturbed lands, lands undergoing disturbance, and from newly or established reclaimed lands. RUSLE estimates soil loss from a slope caused by raindrop impact and overland flow, plus rill erosion. It does not estimate gully or stream-channel erosion. Soil loss is defined here as that material actually removed from a particular slope or slope segment. The sediment yield from a surface is the sum of the soil losses minus deposition in macro-topographic depressions, at the toe of the slope, along field boundaries, or in terraces and channels sculpted into the slope.

RUSLE is derived from the theory of erosion processes, more than 10,000 plot years of data from natural rainfall plots, and from numerous rainfall simulation plots. RUSLE was developed by a group of nationally recognized scientists and soil conservationists who had considerable experience with erosion processes (Soil and Water Conservation Society, 1993).

RUSLE retains the structure of its predecessor, the Universal Soil Loss Equation (USLE), (Wischmeier and Smith, 1978), namely:

$$A = R\ K\ LS\ C\ P$$

Where: A = Average annual soil loss in tons per acre per year

R = Rainfall/runoff erosivity

K = Soil erodibility

LS = Slope length and steepness

C = Cover management

P = Support practice

The R factor is an expression of the erosivity of rainfall and runoff at a particular location. The value of “R” increases as the amount and intensity of rainfall increases. The data for “R” for the project site will be obtained from the Division of Water, Engineering Memorandum Number 2, (4-30-71) revised (6-1-79) for Hopkins County, Kentucky.

The K factor is an expression of the inherent erodibility of the soil surface material at a particular site under standard experimental conditions. The value of “K” is a function of the particle size distribution, organic matter content, structure, and permeability of the soil or surface material. For disturbed soils such as those encountered at the project site the nomograph equations embedded within the RUSLE program are used to compute appropriate erodibility values.

The LS factor is an expression of the effect of topography; specifically slope length and steepness, on rates of soil loss at a particular site. The value of "LS" increases as slope length and steepness increase, under the assumption that runoff accumulates and accelerates in the downslope direction. This assumption is usually valid for lands experiencing overland flow, as is found in our project area, but may not be valid for forest and other densely vegetated areas. The LS factor for our project site will be determined by actual before and after reclamation surveys of the project area.

The C factor is an expression of the effects of surface covers and roughness, soil biomass, and soil disturbing activities on rates of soil loss at a particular site. The value of “C” decreases as surface cover and soil biomass increase, thus protecting the soil from rainsplash and runoff. The RUSLE program uses a sub-factor method to compute the value of “C”. The sub-factors that influence “C” change through time, resulting in concomitant changes in soil protection. A vegetation database is contained within the computer program that characterizes numerous plant types. RUSLE also contains an operations database file that characterizes the effects of various soil disturbing activities on soil loss rates. These operations alter the roughness, infiltration, distribution of biomass, and runoff properties of the surface. The operations include common tillage activities that may be used in the development of a seedbed at reclaimed sites. C values will be calculated using the RUSLE equations, which consider local conditions.

The P factor is an expression of the effects of supporting conservation practices, such as contouring, buffer strips of close growing vegetation, and terracing, on soil loss at a particular site. The value of "P" decreases with the installation of these practices because they reduce runoff volume and velocity and encourage the deposition of sediment on the slope surface. The effectiveness of certain erosion control practices varies due to local conditions, therefore P values will be calculated through the RUSLE equations based on site specific conditions.

The *Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites, and Reclaimed Lands* (Toy and Foster, 1998) will be used for analyzing the RUSLE data.

Soil Sampling

The coal processing refuse will be sampled at various locations in the project area as determined by the project agronomist. Any areas that have noticeably different soil properties will be sampled and analyzed as separate samples. The soil/refuse samples will be analyzed for Soil Water pH, Buffer pH, Extractable Phosphorus, Extractable Potassium, and Potential Acidity.

The following methods will be used for soil analysis:

Parameter	**Analyzed By**	**Method**
pH, Soil	Lab	9045
Potential Acidity	Lab	EPA 60027805
Phosphorus, Available	Lab	Mehlich 3
Potassium, Available	Lab	Mehlich 3
pH, Buffer	Lab	SMP

pH, Soil - Soil pH is analyzed to determine the acidity of the spoil material on-site. pH is an important factor in determining spoil quality for plant growth.

Potential Acidity - Potential acidity is used to test for sulfur that may come into solution as weathering occurs. Using this parameter helps to determine the quantity of agricultural limestone needed for maintaining pH at a suitable level for plant growth. Potential acidity is used with the Universal Soil Loss Equation for calculating the acid loading into a stream from the direct washing due to erosion of pyritic coal refuse into the stream.

Phosphorous, Available - Phosphorous is an essential element in plant growth and reproduction. It is typically the most limiting factor on mine spoils for plant growth.

Potassium, Available - Potassium is a macronutrient as well as phosphorous and nitrogen, essential for plant metabolism. Potassium may be abundant in shaley mine spoils.

pH, Buffer - Buffer pH measures the acidity that is available on exchange sites in the soil or spoil matrix. It is useful in determining the proper amount of agricultural limestone to apply when potential acidity is not a limiting or major factor.

Sampling Methods

Water Monitoring

All sample collection, preservation, and analysis will be conducted in accordance with *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 1998). Discharge will be measured by current velocity meter or by the volumetric bucket and stopwatch method where possible. Three measurements will be taken and the results averaged. Conductivity and pH will be measured on-site using calibrated pH and conductivity meters. The conductivity and pH probes will be triple rinsed with the final rinse using the water to be analyzed to prevent contamination by the previous sample.

Water samples will be collected in new, clean sample bottles, labeled for identification. Three sample bottles will be used for each sample. One sample bottle will contain the untreated or raw sample. This sample will be used for analysis of acidity, alkalinity, and sulfate. A second sample bottle will be treated with nitric acid to keep metals that might otherwise precipitate in solution. This sample will be used for analysis of total - iron, manganese, aluminum, and calcium. The third sample bottle will be filtered with a 45-micron filter and treated with nitric acid. This sample will be used to analyze for total dissolved solids, and dissolved - iron, manganese, and aluminum. The samples will be placed on ice and transported to the laboratory on the same day they are collected for analysis.

Biological Monitoring

Aquatic macroinvertebrates are to be collected in spring by a series of four one-quarter meter kick net samples per station, along with one triangular kick-net sweep to cover all habitat types in the sample area. All whole samples are to be picked in the field, stored in 70% ethanol, in new, clean, glass bottles, and returned to the DAML Frankfort office for sorting and identification to the lowest possible taxon. After sorting and identification, the data will be evaluated using the modified Hilsenhoff Biotic Index (HBI) (Lenat, 1993) to determine the overall pollution tolerance of the macroinvertebrate community and the degree to which the habitat is impaired. Other metrics to be used include the Total Number of Individuals, Ephemeroptera/Plecoptera/Trichoptera Richness (EPT), and Percent Dominant Taxon. Personnel from KY DAML will process macroinvertebrate samples, with aid and advice from cooperating outside sources as necessary. As such, no contracted services will be utilized for sample identification and data analysis.

Soil/Refuse Monitoring

The coal processing refuse will be sampled at various locations in the project area as determined by the project agronomist. Any areas that have noticeably different soil properties will be sampled and analyzed as separate samples. The soil/refuse samples will be collected in new, clean, labeled plastic bags. The samples will be delivered to the laboratory on the same day they are collected.

Sample Handling and Custody

Water Monitoring

Water monitoring samples will be collected, labeled, preserved with a 1:1 nitric acid solution, placed on ice in a cooler and delivered to the laboratory on the same day collected with the following information:

- Date the sample was taken.
- Station at which the sample was taken.
- Name of the person conducting the sampling.
- Gear and/or method used to obtain the sample.
- General stream conditions at the time of sampling (high or low flow, turbid or clear, etc).

- pH.
- Conductivity.
- Stream Flow.

Chain of Custody Procedures

KY DAML personnel will conduct sampling for this project. Chain of custody will be maintained using the KY DAML Water Analysis Worksheet / Chain of Custody form, which is attached.

Biological Monitoring

Samples taken in the field shall be labeled with the following information:

- Date the sample was taken.
- Station at which the sample was taken.
- Name of the person conducting the sampling.
- Gear and/or method used to obtain the sample.
- General stream conditions at the time of sampling (high or low flow, turbid or clear, etc).
- Water temperature.
- pH
- Conductivity.
- Weather.

Macroinvertebrate samples will be collected, processed, and preserved using a 70% ethanol solution. The samples will be transported by the project biologist to the central office and analyzed by qualified AML personnel.

Chain of Custody Procedures

KY DAML personnel will conduct biological sampling and analysis for this project. The project Biologist shall maintain custody of the biological samples. If it becomes necessary to remand custody of the samples the chain of custody will be maintained using the KY DAML Water Analysis Worksheet / Chain of Custody form, which is attached.

Soil/Refuse Monitoring

Soil/refuse samples taken in the field will be labeled with the following information:

- Date the sample was taken.
- Station at which the sample was taken.
- Name of the person conducting the sampling.
- Gear and/or method used to obtain the sample.
- Soil/refuse samples will be collected by AML personnel and taken to and analyzed by a qualified independent laboratory.

Chain of Custody Procedures

KY DAML personnel will conduct sampling for this project. Chain of custody will be maintained using the KY DAML Water Analysis Worksheet / Chain of Custody form, which is attached.

Analytical Methods

Water Monitoring

McCoy and McCoy Laboratories in Madisonville, Kentucky and/or Delta Testing in Hyden, Kentucky will analyze the water monitoring samples. Water samples taken in the field will be labeled, preserved with a 1:1 nitric acid solution, placed on ice in a cooler and delivered to the laboratory on the same day they are collected. All holding times for lab analysis are greater than 24 hours.

Methods of analysis are:

Parameter	Analyzed By	Method
Flow	Field	Flow meter/Volumetric
pH	Field/Lab	SM 4500-A
Specific Conductance	Field/Lab	SM 2510
Alkalinity	Lab	SM 2320 B
Acidity	Lab	EPA 305.1
Total Dissolved Solids	Lab	SM 2540
Calcium (total)	Lab	EPA 200.7
Aluminum (total)	Lab	EPA 200.8
Aluminum (dissolved)	Lab	EPA 200.8

Iron (total)	Lab	EPA 200.8
Iron (dissolved)	Lab	EPA 200.8
Manganese (total)	Lab	EPA 200.8
Manganese (dissolved)	Lab	EPA 200.8
Sulfate	Lab	EPA 300.1

Laboratory Analytical Methods are covered in *McCoy & McCoy Laboratories, Inc. - Quality Assurance Program Plan*, attached. Water analysis will conform to *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 1998).

Biological Monitoring

All whole samples are to be picked in the field, stored in 70% ethanol, and returned to the DAML Frankfort office for sorting and identification to the lowest possible taxon. After sorting and identification, the data will be evaluated using the modified Hilsenhoff Biotic Index (HBI) (Lenat, 1993) to determine the overall pollution tolerance of the macroinvertebrate community and the degree to which the habitat is impaired. Other metrics to be used includes the Total Number of Individuals, Ephemeroptera/Plecoptera/Trichoptera Richness (EPT), and Percent Dominant Taxon.

Soil/Refuse Monitoring

McCoy and McCoy Laboratories in Madisonville, Kentucky will analyze the soil/refuse samples. The AML agronomist will conduct all soil/refuse sampling for this project. The results will be forwarded to the AML agronomist for interpretation. All holding times for laboratory analysis are greater than 24 hours. The methods of analysis are:

Parameter	**Analyzed By**	**Method**
pH, Soil	Lab	9045
Potential Acidity	Lab	EPA 60027805
Phosphorus, Available	Lab	Mehlich 3
Potassium, Available	Lab	Mehlich 3
pH, Buffer	Lab	SMP

Laboratory Analytical Methods are covered in *McCoy & McCoy Laboratories, Inc. - Quality Assurance Program Plan*, attached.

Quality Control Procedures

Water Monitoring

Quality control procedures for parameters analyzed by McCoy and McCoy will follow the procedures outlined in *Quality Assurance Program Plan* – McCoy and McCoy Laboratories Inc., Madisonville, KY (attached).

Biological Monitoring

Equipment used in biological monitoring will be decontaminated by rinsing in clean water or, in the case of pH and conductivity meters, rinsed with distilled water with a final rinse using the water being sampled. Conductivity meters and pH meters will be calibrated with known calibration solutions prior to each sampling session, and be re-calibrated periodically. Organisms collected from each sample at each sampling station will be collected in a new container. Quality control for biological samples will be provided by replicate samples at each station, and by ensuring that all habitat types at each station are sampled. Variance in organisms and numbers of organisms between sampling stations and trips will reflect improvement or degradation of water quality. In order to explain such variance, factors such as variations in flow from portals and coal waste, weather, and life cycles of aquatic insects will be considered and investigated. Species identification of collected organisms will be crosschecked and verified by outside experts such as DOW and/or Kentucky State Nature Preserves Commission, as necessary.

Soil/Refuse Monitoring

The RUSLE model will rely on before and after site surveys conducted by a licensed surveyor. The resulting cross sections will be used by an AML engineer for inclusion into the RUSLE model for the project area.

Quality control procedures for parameters analyzed by McCoy and McCoy will follow the procedures outlined in *Quality Assurance Program Plan* – McCoy and McCoy Laboratories Inc., Madisonville, KY (attached).

Instrument/Equipment Testing, Inspection, and Maintenance

Instrument/Equipment Testing, Inspection, and Maintenance procedures for the laboratory analysis is included in the *Quality Assurance Program Plan* - McCoy and McCoy Laboratories Inc., Madisonville, KY (attached).

Instrument/Equipment Calibration and Frequency

Instrument/Equipment Calibration and Frequency procedures for the laboratory analysis is included in the *Quality Assurance Program Plan* - McCoy and McCoy Laboratories Inc., Madisonville, KY (attached).

Inspection/Acceptance of Supplies and Consumables

Inspection/Acceptance of Supplies and Consumables procedures for the laboratory analysis is included in the *Quality Assurance Program Plan* - McCoy and McCoy Laboratories Inc., Madisonville, KY (attached).

Non-direct Measurements

No non-direct measurement techniques will be used on this project.

Data Management

Water Monitoring

Forms used for reporting the results of data analysis for water samples will contain the following information:

- The site of the sampling station, including:

  Name of County.

  Name of stream.
- A unique sample identifier, which will include:

  Sampling station ID number.

  Date the sample was taken.
- Name and agency of the individual who took the sample.
- The results of the analysis.

AML will report the results of data analysis to DOW for entry into their database. The data will be compiled and recorded in Microsoft Excel, and will be reported to DOW in both software and hardcopy. Each sampling date at each site will be reported on a separate page. The DOW database will be the primary repository for this information. Data analysis including graphs and/or statistical analysis will be reported to DOW in the project's final report.

Biological Monitoring

Forms used for reporting the results of data analysis for biological samples will contain the following information:

- The site of the sampling station, including:

  Name of County.

  Name of stream.
- A unique sample identifier, which will include:

  Sampling station ID number.

  Date the sample was taken.

- Name and agency of the individual who took the sample.
- The results of the analysis, including:

  Taxonomy and number of individuals of each organism identified

  Summary of HBI or IBI calculation

  Results of HBI or IBI calculation

For macroinvertebrate samples, the HBI tolerance value of each organism identified. AML will report the results of data analysis to DOW for entry into their database, including the raw data as well as the conclusions of all indices used. The data will be compiled and recorded in Microsoft Excel, and will be reported to DOW in both software and hardcopy. Each sampling date at each site will be reported on a separate page. Each organism will be reported on a separate line, including order, family, genus, species and number encountered. The DOW database will be the primary repository for this information.

Soil/Refuse Monitoring

Forms used for reporting the results of data analysis for soil/refuse samples will contain the following information:

- The site of the sampling station, including:

  Name of County.

  Name of stream.

- A unique sample identifier, which will include:

  Sampling station ID number.

  Date the sample was taken.

- Name and agency of the individual who took the sample.
- The results of the analysis.

AML will report the results of data analysis to DOW for entry into their database. The data will be compiled and recorded in Microsoft Excel, and will be reported to DOW in both software and hardcopy. Each sampling date at each site will be reported on a separate page. The DOW database will be the primary repository for this information. Data analysis including loading calculations, graphs, RUSLE analysis and results and/or statistical analysis will be reported to DOW in the project's final report.

ASSESSMENT AND OVERSIGHT

Assessments and Response Actions

Water Monitoring

Water monitoring will be conducted monthly. The project manager will review the results of the water monitoring analysis as they are received from the laboratory. Any errors or deficiencies noted during review of the data will be discussed and corrected by the project manager and the laboratory manager.

Laboratory Assessments and Response Actions are covered in *McCoy & McCoy Laboratories, Inc. - Quality Assurance Program Plan*, attached.

Biological Monitoring

Biological monitoring will be conducted each spring. The project manager will review the results of the biological monitoring as they are received from AML's biologist. Any errors or deficiencies noted during review of the data will be discussed and corrected by the project manager and the biologist.

Soil/Refuse Monitoring

Soil/refuse monitoring will be conducted prior to construction activities. The project agronomist will review the results of the soil/refuse monitoring analysis as they are received from the laboratory. Any errors or deficiencies noted during review of the data will be discussed and corrected by the project agronomist and the laboratory manager.

Laboratory Assessments and Response Actions are covered in *McCoy & McCoy Laboratories, Inc. - Quality Assurance Program Plan*, attached.

Construction Activities

Construction activities will be monitored daily by an AML inspector. The AML Construction Branch Manager, the AML Project Manager, and the AML Regional Office Supervisor will make periodic visits to the site during construction. The inspector will handle problems or deficiencies during construction. The Construction Branch Manager will make any changes or deviations from the original plans that are necessary due to site conditions. Monthly meetings will be conducted with the contractor to discuss the progress to date and invoicing.

Reports to Management

The Resident Inspector will submit daily inspection reports for construction activities to the Regional Office Supervisor. The Regional Office Supervisor, upon approval, will forward the daily inspection reports to the Construction Branch Manager at the Frankfort central office for review. Monthly invoices will be reviewed and approved by the inspector, Regional Office Supervisor, Construction Branch Manager, and the Division Director before submittal for payment. Monthly status reports will be prepared by the Construction Branch Manager and submitted to the Division Director.

DATA VALIDATION AND USABILITY

Data Review, Verification, and Validation

The project manager will check the water monitoring data. Total dissolved solids will be compared to specific conductance to check that it falls within the calculated range. Duplicates will be compared. If the data falls within the acceptable range the data will be accepted. If the data falls out of the acceptable range the data will be rejected.

Laboratory Data Review, Verification, and Validation are covered in *McCoy & McCoy Laboratories, Inc. - Quality Assurance Program Plan*, attached.

Verification and Validation Methods

The project manager will receive the laboratory analysis data sheets from the laboratory. The project manager will check the analysis. Total dissolved solids will be compared to the calculated range using the specific conductance values obtained in the field. Duplicates will be compared. If the data falls within the acceptable range the data will be entered into an Excel spreadsheet.

Laboratory Verification and Validation Methods are covered in *McCoy & McCoy Laboratories, Inc. - Quality Assurance Program Plan*, attached.

Reconciliation with User Requirements

Once the project manager accepts the data the data will be analyzed by graphical and/or statistical methods to document any improvements in water quality post construction. Pre-construction biological monitoring will be compared to post-construction biological monitoring to document changes in the aquatic organisms due to improvements in stream quality. Final results will be compiled and documented in the project final report to be submitted to the Division of Water.

Literature Cited

APHA. American Public Health Association, American Water Works Association, and Water Environment Federation. 1998. Standard Methods for the examination of water and wastewater. 20th Edition. American Public Health Association, American Water Works Association and Water Environment Federation, Washington D.C.

Hedin, R.S., D.H. Dvorak, S.L. Gustafson, D.M. Hyman, P.E. McIntire, R.W. Nairn, R.C. Neupert, A.C. Woods, and H.M. Edenborn. 1991. Final Report: Use of a constructed wetland for the treatment of acid mine drainage at the Friendship Hill National Historic Site, Fayette County, Pennsylvania. U.S. Bureau of Mines, Pittsburgh, PA.

Hem, J.D. 1992. Study and interpretation of the chemical characteristics of natural water. U.S. Geological Survey Water-Supply Paper 2254. 264 pp.

Hilsenhoff, W. L. 1987. An improved biotic index for organic stream pollution. Great Lakes Entomologist 20: 31-39.

Hilsenhoff, W. L. 1988. Seasonal correction factors for the biotic index. Great Lakes Entomologist 21: 9-13.

Hyman, D.M. and G.R. Watzlaf. 1996. Metals and other components of coal mine drainage. In: Proceedings, Eighteenth Annual Conference of the Association of Abandoned Mine Lands, September 15-18, Kalispell, MT.

Kentucky Division of Water (KDOW). 1981. The effect of coal mining activities on the water quality of streams in the western and eastern coalfields of Kentucky. Department for Environmental Protection, Natural Resource and Environmental Protection Cabinet, Frankfort, KY.

KDOW. 2002. 2002 303(d) list of impaired waters for Kentucky. Department for Environmental Protection, Natural Resource and Environmental Protection Cabinet, Frankfort, KY.

Lenat, D.R. 1993. A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water quality ratings. Journal of the North American Benthological Society 12(3): 279-290.

Ormsbee, L. 2004. Total maximum daily load (TMDL) development – pH (H+ ion mass) – for Pleasant Run Watershed (Hopkins County, Kentucky). Kentucky Department for Environmental Protection, Division of Water.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder coordinators. 1997. Predicting soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). U.S. Department of Agriculture, Agricultural Handbook 703, 404 pp.

Soil and Water Conservation Society. 1993. RUSLE user's guide. Soil and Water Cons. Soc. Ankeny, IA. 164 pp.

Toy, T. J., and G. R. Foster. 1998. Guidelines for the use of the Revised Universal Soil Loss Equation (RUSLE) version 1.06 on mined lands, construction sites, and reclaimed lands. Office of Surface Mining. Denver, CO., 142 pp.

Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall-erosion losses – a guide to conservation planning. AH-537. U.S. Dept. Ag. Washington, D.C., 58 pp.

Ziemkiewicz, P.F., J.G. Skousen, and R. Lovett, 1994. Open limestone channels for the treating acid mine drainage: a new look at an old idea. Green Lands 24(4): 36-41.

Zurbuch, P.E., 1996. Early results from calcium carbonate neutralization of two West Virginia Rivers acidified by mine drainage. Proceedings of the Annual West Virginia Surface Mine Drainage Task Force Symposium 17:L1-L9, Morgantown.

Zurbuch, P.E., R. Menendez, and J.L. Clayton, 1996. Limestone neutralization of Dogway Fork, West Virginia, by means of a rotary-drum system. Restoration Ecology 4:206-219.

APPENDIX C. BMP IMPLEMENTATION PLAN

BEST MANAGEMENT PRACTICES IMPLEMENTATION PLAN for the

PLEASANT RUN ACID MINE DRAINAGE ABATEMENT PROJECT

Nonpoint Source Acid Runoff Pollution in the Pleasant Run Watershed – Hopkins County, Kentucky

KENTUCKY DIVISION OF ABANDONED MINE LANDS

July 2005

Approving Officials	Title	Signature	Date
Steve Hohmann	Division Director	___________________	_______
Mark Carew	Project Manager	___________________	_______
Joe Ferguson	EPA Project Manager	___________________	_______
Rodney Pierce	EPA QA Manager	___________________	_______

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Attachments

Detailed plans with BMP locations.

SOURCE OF IMPAIRMENT

Problem Definition/ Background

Watershed Information

Pleasant Run (HUC14 05110006040060), a third order stream, originates in southern Hopkins County (figure 1) and flows east to discharge into Drakes Creek 8.6 miles upstream from its confluence with the Pond River (figure 2). The Pond River discharges into the Green River, which flows northward into the Ohio River. Pleasant Run's main stem is approximately 7.9 miles long and drains an area of 8,054.5 acres (12.6 mi^2)). The average gradient is 35.5 ft per mile. Elevations for Pleasant Run range from 700 ft above mean sea level (msl) in the headwaters to 400 ft above msl at the mouth.

The 2002 303(d) list of waters for Kentucky (KDOW 2002) indicates 7.9 miles of Pleasant Run, from the headwaters to the confluence with the Drakes Creek in Hopkins County, does not meet its designated use for contact recreation (swimming) and for aquatic life.

The Pleasant Run AMD Abatement Project areas selected for BMP implementation were originally mined from the 1920's through 1958 and are pre-law mining sites. The proposed project will reclaim an expanse of abandoned strip and deep mine disturbance in southern Hopkins County, northeast of the community of Saint Charles in the headwaters of Pleasant Run,

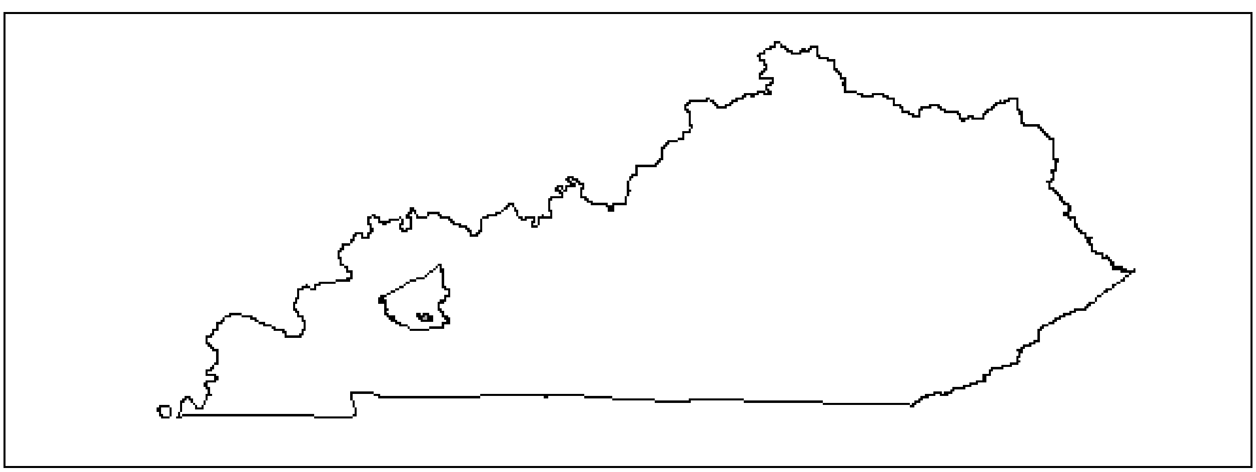

Figure 1. General location of Pleasant Run Watershed (shaded area) and Hopkins County, Kentucky.

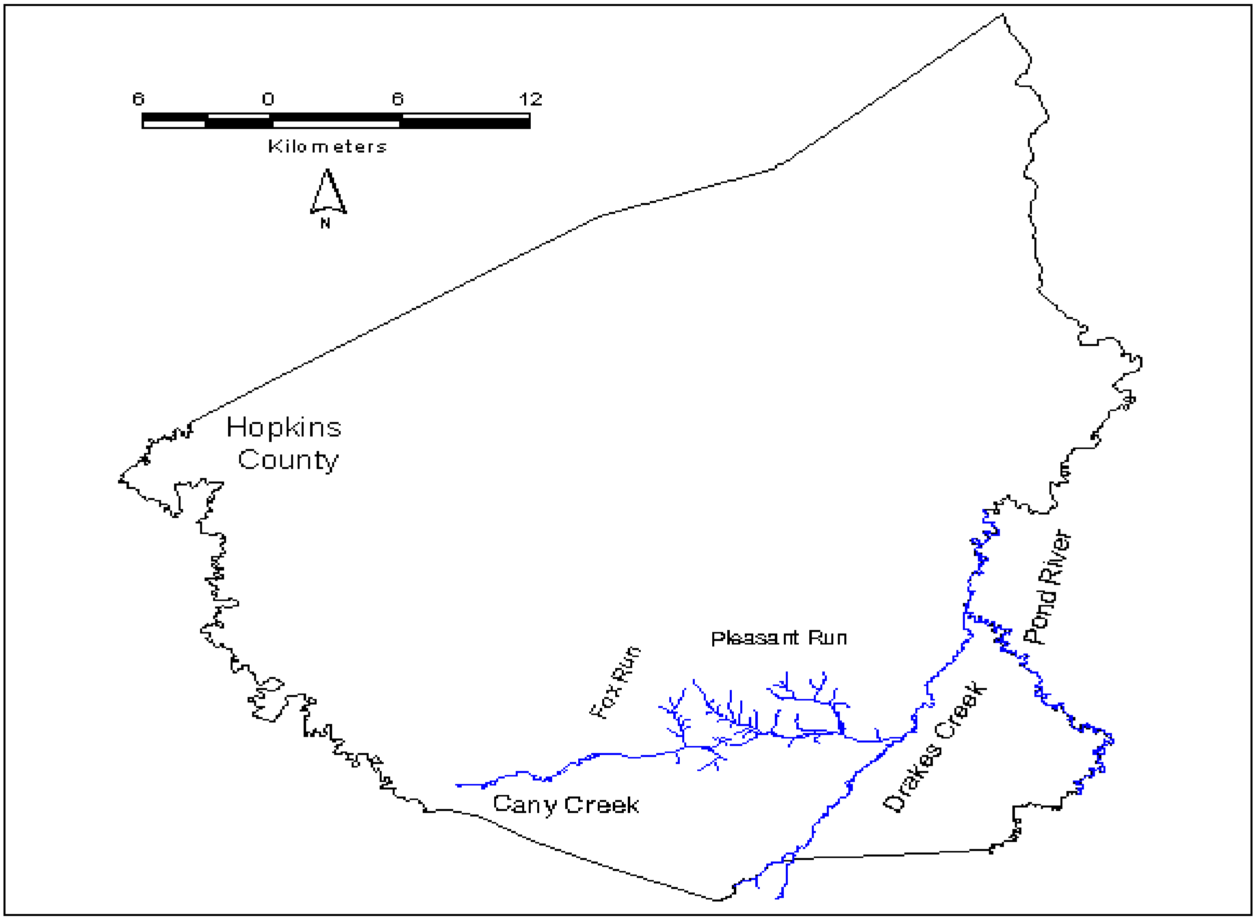

Figure 2. Location of Pleasant Run in Hopkins County, Kentucky.

and a site north of and adjoining the community of Nortonville. The sites in the headwaters of Pleasant Run contain pit and ridge formations of severely eroded acidic spoil piles with acidic impoundments. The Nortonville site consists of several acres of highly acidic coal refuse and spoil from a coal tipple loadout.

Monitoring History

The waters of Pleasant Run were monitored as early as 1978 by the Division of Water (DOW) as reported in *The Effects of Coal Mining Activities on the Water Quality of Streams in the Western and Eastern Coalfields of Kentucky*, published in 1981 by the Kentucky Department for Natural Resources and Environmental Protection as part of an agreement with the Division of

Abandoned Lands. The DOW sampled the three unnamed tributaries to Pleasant Run on April 26, 1978. The three streams had pH values of 4.3, 3.5, and 3.2. The degradation of Pleasant Run is the consequence of acid mine drainage in the watershed as noted by the DOW.

In 1997, the DOW conducted a survey of streams in the Western Kentucky Coalfields, including Pleasant Run. The DOW reported a high level of pH impairment, citing acid mine drainage as the principal source. A pH of 2.9 was recorded on July 3, 1997. Based on these readings, the stream was listed as First Priority on the Kentucky 303(d) list of streams not meeting their designated uses. Pleasant Run does not support the designated uses of aquatic life and swimming (KDOW 2002).

TMDL Development/Results

A TMDL for Pleasant Run has been developed and submitted to the Environmental Protection Agency. The pH near the mouth of Pleasant Run ranged from 2.8 during low flow to 5.6 during high flow during the TMDL study period from November 14, 1999 thru May 5, 2000. The pH ranged from 2.5 to 4.0 at river mile 4.4 during the same study period, and ranged from 2.5 to 3.6 at river mile 6.6 (Ormsbee, 2004).

BMP IMPLEMENTATION

The Pleasant Run AMD Project will reclaim and revegetate areas with inadequate vegetative cover and passively treat AMD with site-specific techniques. Reclamation of the project sites will result in a reduction in the sediment load entering Pleasant Run. A reduction in the sediment load being derived from acidic spoil and refuse will also result in a reduction in the acid load and dissolved metal loads from direct erosion of acid forming materials into the stream. The Revised Universal Soil Loss Equation (RUSLE) will be used to calculate sediment load reductions on the reclaimed sites. Spoil testing along with RUSLE will allow calculations of the reduction in acid loading from the direct erosion of acid forming materials into the stream.

Passive treatment of AMD in the watershed will improve water quality in the receiving stream, reducing acidity, increasing pH, and reducing dissolved metal concentrations. Increases in alkalinity as a result of passive treatment of AMD at the project sites will increase pH and reduce the acid load entering Pleasant Run. As pH increases, as a result of passive treatment, dissolved iron and aluminum will precipitate out of solution reducing dissolved metal loads. Water monitoring and biological monitoring will document improvements to the main stem of Pleasant Run.

Project Objectives

- Sediment Load Reduction
- Acid Load Reduction
- Increase pH
- Dissolved Iron Load Reduction
- Dissolved Aluminum Load Reduction

Sediment and erosion from all sites causes infertile deposition, channel filling, and increased swamping of the floodplain. Consequential water quality degradation renders much of the water within the Pleasant Run watershed to not meet designated aquatic life uses, as well as, public, industrial, and domestic use.

Construction at the Nortonville site (site A) consists of 12.5 acres of barren eroding refuse and slurry located at the northern edge of the city of Nortonville between U.S. route 41 and the railroad. To minimize acid mine drainage and to provide a medium capable of supporting vegetation, the graded coal refuse will be capped with an agricultural limestone barrier covered by a minimum of two feet of suitable cover material. The graded refuse area outslope will be vegetated. The level portion of the refuse area will be graveled at the request of the landowner for industrial use.

There is approximately 4 additional acres proposed for reclamation. Included is a proposed open limestone channel just east of U.S. 41 designed to boost alkalinity in the watershed. A one-acre poorly vegetated area from the previously constructed 2AG Pleasant Run

Project will be limed and vegetated. A limestone channel from the 2AG project will be reworked with additional limestone installed in the channel to treat the acidity of the water draining from the site. There is approximately 3 acres downstream of the main refuse pile that is being adversely affected by coal refuse washing from the refuse pile that is poorly vegetated. Refuse will be removed from the channel and the site will be limed and vegetated or covered with borrow material and limed and vegetated.

There is an off-site borrow area associated with the proposed reclamation of site "A". It is approximately 7 acres in size and is comprised of a Pre-Law surface strip mine that is located about 2000 feet west of site "A". It is mostly tree covered with maple and ash predominating. Plans for the borrow area include harvesting about 50,000 cubic yards of cover material and placement of the cover material on the graded refuse/slurry area to provide a growth medium for revegetation. The borrow area will be graded for positive drainage and will be revegetated. Sufficient cover material will remain within the borrow area to provide adequate cover for revegetation of the area once cover material excavation is complete. Erosion control will be via silt traps and/or staked straw bales.

Site "B" includes approximately 36 acres of pits and spoil on the number 11 and/or 12 seams in the headwaters of Pleasant Run. It consists of two large pits that are partially water filled. The pits have a layer of pyrite-rich clay exposed in the bottom of the pits that adversely affects the water quality discharging from the pits. The spoil ridges surrounding the pits are vegetated with loblolly pine and volunteer species such as red maple. There are about 4 acres of poorly vegetated pits and spoil ridges on the number 9 seam below the 11 and 12 seams. The pits in the 11 and 12 seams drain into and further degrade the water quality discharging from the number 9 seam pits. Proposed reclamation at site "B" includes clearing and grubbing the spoil piles and grading the spoil into the pits covering the exposed acid forming underclay. The sites will be limed and vegetated. This should greatly reduce the acid load in the sub-watershed. An open limestone channel will be established for about 1,400 linear feet from the 11/12 pits on the ridge above the number 9 seam to the pit on the number 9 seam and down slope to the confluence with Pleasant Run. The limestone channel will increase alkalinity, reducing acidity entering Pleasant Run from the site. Erosion control will be via silt traps and/or staked straw bales. No off site borrow or fill is anticipated for site "B".

Site “C” includes the upper reaches of Pleasant Run upstream of the old coal silo. It includes installation of open limestone channels and limestone dosing to improve the water chemistry in the upper reaches of the watershed. Work will be limited to the drainage channels and access disturbance will be kept to a minimum. All disturbances will be vegetated.

Dosing with sand sized limestone particles is proposed at four locations within the Pleasant Run watershed. The dosing sites are located on existing roadways and no additional construction funds are anticipated for development of dosing sites. Dosing rates will be calculated based on acid loading calculations determined by water monitoring in the watershed. Dosing with limestone sand in the watershed should result in immediate improvements to the water quality of Pleasant Run. Acidity should be neutralized, pH should increase, and dissolved metals should precipitate out of solution with the increase in pH.

Rock may be temporarily placed in the upper reach of Pleasant Run to allow heavy equipment to access the project site. Since these streams are severely impacted by acid mine drainage and sedimentation, the limestone stream crossings should help improve water quality.

Ditches lined with class II/III stone or erosion control blanket will control drainage. Installation and maintenance of hay-bale silt checks and silt traps will minimize sedimentation. All areas disturbed by construction will be covered with suitable cover material and vegetated, as soon as practical, using agricultural limestone, fertilizer, seed, mulch, crimping, and, on steep slopes, netting. All applicable environmental permits will be obtained.

The total estimated construction cost to reclaim the sites including federal funds and non-federal funds is $1,031,970.

BMP Technologies Proposed

Refuse Grading, Treatment, and Revegetation

The Pleasant Run Clean Water Action Plan project will involve the reclamation of areas containing acidic mine refuse with sparse vegetation at the Nortonville site (site A), and the elimination of acidic impoundments and subsequent burial and sequestration of acid forming material in the pit floors at Site B.

The acidic impoundments and wet weather/seasonal water holding areas will be eliminated. The water will be treated before discharging. The impoundments will be graded to provide positive drainage and will be revegetated. The areas containing acidic mine refuse with sparse vegetation will be graded eliminating gullies and providing positive drainage. The graded coal refuse will be capped with an agricultural limestone barrier and covered with a minimum of two feet of suitable cover material.

Revegetation efforts will improve the vegetation of the site reducing the sediment load to the stream. The refuse area with sparse vegetation will be seeded with a mix of acid tolerant warm and cool season grasses and legumes. Bare root stock trees, with the landowner's consent, will be planted on the upland reclamation area at Site B. A combination of native grasses and trees and non-native grasses and legumes will be used in the revegetation efforts on the project. While the use of native grasses and trees is preferred, it has been the experience of the Division of Abandoned Mine Lands that a combination of native and non-native species is required for successful revegetation of acidic coal mine refuse. The proposed seed mixture is:

Seed Mixture	Seeding Rate (Lb./ac. PLS*)
SPRING SEED MIX	
Application Period: February 15 to June 15	
Orchardgrass	20
Switchgrass	10
Redtop	5
Timothy	10
Birdsfoot Trefoil	10
Korean Lespedeza (Hulled)	10
Medium Red Clover	10
Ladino Clover	5
	(80 LBS.) *Pure Live Seed
FALL SEED MIX	
Application Period: August 15 to February 14	
Perennial Ryegrass	20
Switchgrass	10
Orchardgrass	10
Timothy	10
Redtop	5
Ladino Clover	5
Medium Red Clover	10
Birdsfoot Trefoil	5
Korean Lespedeza	5
	(80 LBS.) *Pure Live Seed

The Revised Universal Soil Loss Equation and refuse sample analysis will be used to calculate the reduction in silt loading and acid loading by direct washing of the acidic refuse into the streams after completion of the reclamation.

The construction cost of grading the refuse and elimination of the pits, water treatment, installation of the agricultural limestone barrier, trash/debris disposal, placing soil cover material, liming, and revegetation at the sites is estimated to be $622,538.

Grass Diversion Ditches

Grass diversion ditches will be installed along the benches. The grass diversion ditches will be lined with erosion control blanket. The erosion control blanket protects the diversion ditch from erosion while the grass is being established in the channel. The estimated construction cost to install the grass diversion ditches on the project is $34,987.

Open Limestone Channels

Open limestone channels will be constructed with limestone rock and limestone sand and in addition to providing erosion control will treat acid mine drainage before entering the streams. The limestone channels will intercept acidic water from the upper slopes of the refuse fill areas and from seeps providing treatment by increasing alkalinity to the water before discharging into the main tributaries. Open limestone channels will be installed as side drains and terrace diversion channels on the re-graded refuse slopes.

Open limestone channels (OLCs) introduce alkalinity to acid water in open channels or ditches lined with limestone rock (Ziemkiewicz et al., 1994). Acid water is introduced to the channel and the acid mine drainage is treated by limestone dissolution. Past assumptions have held that armored limestone (limestone coated with Fe and/or Al hydroxides) ceased to dissolve, but experiments show that coated limestone continues to dissolve at about 20% the rates of unarmored limestone (Pearson and McDonnell 1975). Another problem is that hydroxides tend to settle into and plug the voids in limestone beds forcing water to move around rather than through the limestone. While both armoring and plugging are caused by the precipitation of metal hydroxides they are two different problems. Maintaining a high flushing rate through the limestone bed can minimize plugging of the voids in limestone beds. Armoring, however, occurs regardless of the water velocity. Recent work has demonstrated that the rate of dissolution for armored limestone may be even higher than previous laboratory studies (Ziemkiewicz et al., 1997). Field experiments show considerable treatment by OLCs (Ziemkiewicz et al., 1994). The length of channel and the channel gradient are design factors that can be varied for optimum performance. Optimum performance is attained on slopes exceeding 20%, where flow velocities keep precipitates in suspension, and clean precipitates from limestone surfaces. Dissolved metals sorb onto the surfaces of the precipitates in suspension further reducing the amount of dissolved metals in the water. Open limestone channels may be designed and constructed for long-term treatment. Utilizing OLCs with other passive systems can maximize treatment and metal removal. The estimated construction cost to install the open limestone channels is $231,176.

Limestone Sand Treatment

During testing of a self-feeding rotary drum system that ground limestone aggregate into a slurry, Zurbuch (1989) found that undissolved sand-sized particles continued to be reactive in stream sediments and significantly reduced acidity. Further research into the use of quarry produced limestone fines as a method to treat streams acidified by acid deposition corroborated the rotary drum results (Ivahnenko et al., 1988).

Sand-sized limestone may be directly dumped into acid mine drainage impacted streams at various locations in watersheds. The sand is picked up by the stream flow and redistributed downstream, neutralizing the acid as the stream moves the limestone through the streambed. The limestone in the streambed reacts with acid in the stream, causing neutralization. Coating of limestone particles with Fe oxides can occur, but the agitation and scouring of the limestone in the streambed keep fresh surfaces available for reaction.

Water monitoring is being conducted to determine the acid load in the Pleasant Run watershed. Limestone sand dosing is proposed at rates determined by the acid loading calculations. Limestone sand will be introduced into the watershed at double the calculated rate for the first year and, if the desired results are achieved, will be added at the calculated rate for every year after resulting in one year worth of neutralization potential in the streambed. Limestone dosing will be conducted from existing roadways with no additional expense for dosing site construction.

The use of the direct application of limestone sand to treat acidified streams is the least expensive method available based on the cost per ton of acid neutralized (Zurbuch, 1996;

Zurbuch et al., 1996). This method does not require the large capital investment or the costs associated with the operation and maintenance of mechanical stream dosing systems.

The cost to treat the acid load in the Pleasant Run watershed with limestone sand the first year of dosing when rates are doubled is calculated to be $90,000. As funding permits, additional acid mine drainage projects in the watershed will reduce the need for limestone dosing in the Pleasant Run watershed.

Silt Control

BMPs for silt control during construction activities include staking of silt control bales at the toe of the slopes and above diversions and temporary and/or permanent water diversions. Dug out silt control structures will be used during all construction activities. The estimated cost to install silt control bales and dug out silt control structures is $12,540.

Access Roads

Access roads in the project area will be graded and ditched. Water bars may be installed as needed on long steep grades. Culverts will be installed as needed to direct water from road ditch-lines into diversion ditches and/or natural drains. Temporary low water crossings will be installed using limestone riprap at two locations. Roadstone will be applied to access road surfaces to protect the roadbed from erosion. The estimated cost to improve and maintain access roads in the project area is $40,729.

Alternative Treatment Options

Active Treatment Technologies

Active treatment systems involve treating mine drainage with alkaline chemicals to neutralize acidity, raise water pH, and precipitate metals. Active treatment technologies are effective, however, when the cost of equipment, chemicals, and manpower are considered active treatment is expensive (Skousen et al. 1990). Chemical treatment is a long term never ending process. A variety of active treatment methods can be employed. Most active chemical treatment systems consist of an inflow pipe or ditch, a storage tank or bin to hold the chemical, a means of controlling the chemical application, a settling pond to capture precipitated metal oxyhydroxides, and a discharge point. Chemical compounds used in AMD treatment include:

Crushed limestone – rotating drum

Hydrated lime

Sodium carbonate (soda ash)

Sodium hydroxide (solid and liquid forms)

Ammonia

Pebble Quicklime (Calcium oxide).

The above treatment options could possibly be used on the refuse and acidic impoundment sites. The flow at the toe of the refuse areas would have to be intercepted and directed to a central application site. The treated water would then flow into a settling pond before being discharged into the stream. The costs for construction of an active treatment site and the continuous operation and maintenance of an active treatment site are prohibitive at current funding levels. In addition many of the active treatment options use chemicals that are harmful to biota in their concentrated state. The risk of release of these chemicals in concentrated form by vandalism or accident must be considered before deciding to use them.

Passive Treatment Options

Aerobic Wetland

An aerobic wetland consists of a large surface area pond with horizontal surface flow. The pond may be planted with cattails and other wetland species. Aerobic wetlands can only effectively treat water that is net alkaline. In aerobic wetland systems, metals are precipitated through oxidation reactions to form oxides and hydroxides.

Aerobic wetlands are not suitable for the refuse site or the acidic impoundment sites. The water discharging from the sites is net acidic.

Compost / Anaerobic Wetland

Compost wetlands, sometimes called anaerobic wetlands, consist of a large pond with a lower layer of organic substrate. The flow is horizontal through the substrate layer of the pond. The compost layer usually contains calcium carbonate either naturally as in spent mushroom compost, or added during construction of the wetland. A typical compost wetland will have 12 to 24 inches of organic substrate and be planted with cattails or other wetland vegetation. The vegetation helps stabilize the substrate and provides additional organic matter to perpetuate the sulfate reduction reactions. Compost wetlands can treat discharges that contain dissolved oxygen, ferric iron, aluminum, or acidity in the 500 ppm range.

The compost wetland acts as a reducing environment. The compost removes oxygen from the system. Microbial processes within the organic substrate reduce sulfates to water and hydrogen sulfide. The anoxic environment within the substrate increases the dissolution of limestone. Chemical and microbial processes generate alkalinity and increase the pH.

The refuse site and the acidic impoundment sites may be suitable for compost wetlands. The flow from the refuse would need to be intercepted and directed to the wetlands at the toe of the slopes. Compost wetlands are relatively expensive to construct. This project is concentrating on grading and revegetating barren areas of refuse and elimination of acidic impoundments. Revegetation of the refuse slopes and elimination of the acidic impoundments need to occur before the installation of compost wetlands is considered. Budget constraints do not allow the installation of compost wetlands on the project area at this time.

Anoxic Limestone Drains

An anoxic limestone drain (ALD) is a buried bed of limestone constructed to intercept subsurface mine water and prevent contact with atmospheric oxygen. Keeping the water anoxic prevents oxidation of metals and prevents armoring of the limestone. The process of limestone dissolution generates alkalinity. The purpose of an ALD is to provide alkalinity thereby changing net acidic water to net alkaline water. ALDs are limited to the amount of alkalinity they can generate based on solubility equilibrium reactions. An ALD is a pretreatment step to increase alkalinity and raise pH before the water is oxidized and the metals precipitated in an aerobic wetland.

This project involves acidic refuse material placed on a slope and acidic impoundments. The water leaving the sites has already been oxidized so the use of an ALD on the refuse site and at the acidic impoundment sites is not possible.

Vertical Flow Reactors

Vertical flow reactors were conceived as a way to overcome the alkalinity generation limitations of an anoxic limestone drain and the large area requirements for compost wetlands. The vertical flow reactor consists of a treatment cell with a limestone underdrain topped with an organic substrate and standing water. The water flows vertically through the organic substrate that strips the oxygen from the water making it anoxic. The water then passes through the limestone, which dissolves increasing alkalinity. The water is discharged through a pipe with an air trap to prevent oxygen from entering the treatment cell. Passing the water through a series of treatment cells can treat highly acidic water. A settling pond and an aerobic wetland where metals are oxidized and precipitated typically follow the treatment cells.

Problems associated with vertical flow reactors include plugging of the pipes with aluminum which must be periodically flushed when aluminum loading is high, and precipitation of metals in the organic substrate which may clog, preventing flow into the limestone underdrain.

The refuse site and the acidic impoundment sites may be suitable for vertical flow reactors. Aluminum levels would need to be measured at all sites being considered for the installation of vertical flow wetlands due to clogging concerns with the pipes and limestone underdrains.

This project is concentrating on grading and revegetating barren areas of refuse and elimination of acidic impoundments. Revegetation of the refuse slopes and elimination of the acidic impoundments need to occur before the installation of vertical flow reactors is considered. Future maintenance concerns including removal of precipitates from the wetland cells dictates that vertical flow systems only be installed when no other option is applicable.

Other Options

Other options include removal of the pyrite-rich refuse, mixing the refuse with agricultural limestone and placing it in a compacted fill. This option is expensive and current funding levels are not adequate for consideration of this option. The estimated cost for this option is in excess of three million dollars for the refuse site.

Other options also include doing nothing. The acid mine drainage and silt will continue to erode unabated into the streams impacting fish and other aquatic life downstream from the sites.

DOW – NPS Notification

The Division of Water Non-Point Source Section will be contacted and kept informed of the BMP implementation by e-mail. DOW personnel will be invited to attend the pre-bid meeting and pre-construction conference. Anticipated start dates will be discussed at the pre-construction conference.

Technology Demonstration Financial Plan of Action

Educational Activities

The Pleasant Run Acid Mine Drainage Abatement Project will provide an opportunity for education and outreach. By presenting the project at professional meetings issues such as the importance of clean water, acid mine drainage abatement techniques, and the availability of programs involved with environmental restoration will be highlighted.

The Division of Abandoned Mine Lands will present the Pleasant Run Acid Mine Drainage Abatement Project and results at the Non-Point Source conference; disseminating the information and techniques to other environmental restoration professionals. In addition the Division of Abandoned Mine Lands will present the Pleasant Run Acid Mine Drainage Abatement Project and results at various other water and reclamation conferences and events.

All final draft educational materials produced by this project will be submitted to the Division of Water for review and approval before production and distribution.

Budget Synopsis

The total budget for the Pleasant Run Acid Mine Drainage Abatement Project is $1,212,250. This includes $720,440 in Section 319(h) funds and $491,810 in funds from non-federal matching sources. This equates to a 60/40 cost share between federal and non-federal matching funds for the project. The total construction budget for BMP implementation on the project is $1,031,970. This includes $720,440 in Section 319(h) funds and $311,530 in funds from non-federal matching sources. Section 319(h) funds will be used for BMP implementation in the Pleasant Run watershed. The non-federal match funds provided by the Kentucky Division of Abandoned Mine Lands will be used for BMP implementation in the Pleasant Run watershed as well as project management, project monitoring, and project planning.

Maintenance Agreement

The Division of Abandoned Mine Lands continues to monitor all project sites annually for a period of 5 years after the final inspection of the project. AML's staff agronomist or his representative inspects all project sites annually. In addition AML responds to any complaints received for maintenance on its project sites. Any maintenance required will be performed under a separate maintenance contract. The Division of Abandoned Mine Lands as part of its annual grants from the Office of Surface Mining budgets a portion of the annual grant for maintenance of reclamation projects completed by AML. Funds for any maintenance work required will be made available through AML's annual grant from OSM. This is standard operating procedure for all AML projects. After the 5-year monitoring period by AML maintenance of the project sites will be performed based on AML's project priority policies.

References Cited

Ivahnenko, T.I., D.J. Renton, and H.W. Rauch, 1988. Effects of liming on water quality of two streams in West Virginia. Water, Air and Soil Pollution 41:311-357.

Kentucky Division of Water (KDOW). 1981. The effect of coal mining activities on the water quality of streams in the western and eastern coalfields of Kentucky. Department for Environmental Protection, Natural Resource and Environmental Protection Cabinet, Frankfort, KY.

KDOW. 2002. 2002 303(d) list of impaired waters for Kentucky. Department for Environmental Protection, Natural Resource and Environmental Protection Cabinet, Frankfort, KY.

Ormsbee, L. 2004. Total maximum daily load (TMDL) development – pH (H+ ion mass) – for Pleasant Run Watershed (Hopkins County, Kentucky). Kentucky Department for Environmental Protection, Division of Water.

Pearson, F.H., and McDonnell, 1975. Use of crushed limestone to neutralize acid wastes. Journal of the Environmental Engineering Division, American Society of Civil Engineers, Vol. 101, No. EE1, Proc. Paper 11131, pp. 139-158.

Skousen, J., K. Politan, T. Hilton, and A. Meek, 1990. Acid mine drainage treatment systems: chemicals and costs. Green Lands 20(4): 31-37.

Ziemkiewicz, P.F., J.G. Skousen, and R. Lovett, 1994. Open limestone channels for the treating acid mine drainage: a new look at an old idea. Green Lands 24(4): 36-41.

Ziemkiewicz, P.F., J.G. Skousen, D.L. Brant, P.L. Sterner, and R.J. Lovett, 1997. Acid mine drainage treatment with armored limestone in open limestone channels. J. Environ. Qual. 26:560-569.

Zurbuch, P.E., 1989. The self-feeding rotary drum stream neutralization system. Federal aid D-J project F-24-R, job I-2, final report. West Virginia Department of Natural Resources, Elkins.

Zurbuch, P.E., 1996. Early results from calcium carbonate neutralization of two West Virginia rivers acidified by mine drainage. Proceedings of the Annual West Virginia Surface Mine Drainage Task Force Symposium 17:L1-L9, Morgantown.

Zurbuch, P.E., R. Menendez, and J.L. Clayton, 1996. Limestone neutralization of Dogway Fork, West Virginia, by means of a rotary-drum system. Restoration Ecology 4:206-219.

APPENDIX D. LABORATORY DATA

PR-2 Pleasant Run's headwaters above all reclamation work

Date	Discharge	pH		Conductivity		Acidity	Alkalinity	TDS
	total, mg/l	Field	Lab	Field, uS	Lab, uS	mg/l CaCO3	mg/L CaCO3	mg/l
1/28/2005	2.00	3.44		2690		480	0	2617
2/22/2005	0.60	3.48		2550		440	0	2467
3/28/2005	7.17	4.17		1379		140	0	1214
4/28/2005	0.41	3.30		2890		700	0	2800
5/25/2005	0.15	3.11		3090		1700	0	3140
6/21/2005	0.09	3.01		3260		318	0	3252
7/27/2005	0.08	2.85		3300		1443	0	3242
8/30/2005	6.63	3.67		1334		47	0	850
9/27/2005	0.09	3.02		3030		160	0	2672
10/27/2005	0.06	2.92		2390		82	0	2731
11/30/2005	0.25	3.04		2930		741	0	2888
12/20/2005	1.35	3.30		2880		676	0	2908
1/25/2006	11.47	3.60		4200		580	0	2078
3/27/2008	0.60	3.60		1174		487	0	2358
3/22/2006	0.84	2.94	3.54	2050	1684	196	0	1270
4/20/2006	0.60	3.10	3.21	1415	2320	222	0	2022
5/31/2006	0.37		3.14	1470	2311	334	0	2111
6/22/2006	0.06	3.70	3.10	1570	2480	430	0	1969
7/18/2006	0.03	2.80	3.04	1537	2000	375	0	1887
8/22/2006	0.12	3.30	3.01	1505	2820	333	0	2527
9/26/2006	0.29	3.40	3.44	1145	2070	213	0	1388
10/18/2006	0.25		3.10	2850	2750	251	0	1852
11/28/2006	3.00	3.20	3.28	1270	2390	387	0	2059
12/27/2006	1.21	2.90	3.35	2210	2210	238	0	1547
1/26/2007	0.65	3.30	3.45	2650	2300	303	0	1836
2/27/2007	1.00	3.74	3.76	2210	2010	176	0	1902
3/28/2007	3.31	3.33	3.30	2200	2060	198	0	1853
4/24/2007	0.60	3.11	3.35	2500	2520	270	0	2440
5/24/2007	0.30	2.95	3.11	2870	3050	381	0	1489
6/21/2007	0.12	3.20	3.54	2850	3090	186	0	2002
7/31/2007	0.06	3.10	3.28	1710	2680	184	0	1704
8/28/2007					No Water for Sampling			
9/27/2007	0.03	3.46	3.24	3190	2840	202	0	2321
10/31/2007	0.17	3.60	3.38	2710	2520	204	0	2176
11/27/2007	0.44	3.81	3.51	2330	2286	189	0	2049
12/20/2007	0.90	3.88	3.55	2240	2180	308	0	1658
1/30/2008	2.00	3.98	3.89	2480	2240	216	0	2087
2/28/2008	1.55	3.75	3.30	2360	2170	162	0	1853
3/27/2008	1.16	3.30	3.46	2500	2150	202	0	2093
4/25/2008	0.23	3.13	3.19	2819	2470	261	0	2380
5/22/2008	0.39	3.14	3.34	2950	2620	275	0	2312
6/18/2008	0.16	2.83	3.00	3290	2910	336	0	2585

PR-2 Pleasant Run's headwaters above all reclamation work

Date	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Sulfate, dis. mg/l
1/28/2005	377	15.4	17.0	41.0	41.5	9.0	9.4	1800
2/22/2005	353	14.0	15.6	31.0	31.5	9.1	9.8	1600
3/28/2005	195	8.5	6.9	12.2	8.0	3.7	4.0	860
4/28/2005	404	16.0	18.0	35.7	38.4	10.7	12.0	1950
5/25/2005	395	15.7	17.9	39.0	42.9	10.3	12.7	2110
6/21/2005	430	18.2	18.1	36.1	36.4	18.1	17.5	2450
7/27/2005	427	20.2	21.6	29.8	34.7	17.6	21.0	2200
8/30/2005	150	4.6	4.5	4.8	3.8	3.1	3.1	700
9/27/2005	300	11.2	10.7	19.2	18.0	16.2	15.5	1450
10/27/2005	431	24.4	20.6	23.2	24.0	19.1	20.0	2300
11/30/2005	384	30.8	20.7	33.4	33.7	20.0	20.5	2020
12/20/2005	423	18.2	19.9	43.7	45.0	22.2	20.7	376
1/25/2006	303	14.6	14.6	43.4	40.9	12.6	12.4	1410
3/27/2008	351	12.0	16.0	18.7	38.0	11.5	13.8	1560
3/22/2006	262	14.5	13.3	11.9	11.5	10.3	9.3	1000
4/20/2006	306	17.4	17.0	26.4	25.5	14.0	13.6	1700
5/31/2006	283	10.9	10.6	29.8	26.8	13.8	12.5	1820
6/22/2006	277	9.2	4.9	24.3	14.0	16.0	8.6	1700
7/18/2006	270	17.9	17.0	22.3	22.0	17.0	17.0	1600
8/22/2006	443	0.6	0.6	24.2	21.8	12.0	12.0	2100
9/26/2006	222	7.9	7.8	25.2	24.7	10.9	10.0	1160
10/18/2006	249	12.2	9.2	16.5	16.5	14.0	14.0	1600
11/28/2006	296	18.9	17.2	53.0	43.0	11.0	10.9	1760
12/27/2006	254	14.4	13.5	35.4	34.0	10.9	10.0	1500
1/26/2007	245	20.0	19.0	64.0	59.0	12.0	11.3	1600
2/27/2007	322	12.4	11.2	29.4	27.7	9.0	9.5	1640
3/28/2007	268	11.4	7.7	37.0	3.6	7.9	4.9	1760
4/24/2007	500	16.0	15.2	27.1	27.0	11.5	10.0	1940
5/24/2007	412	13.3	13.3	12.0	12.0	24.0	18.0	1100
6/21/2007	471	10.9	8.7	6.0	4.3	12.7	12.4	1600
7/31/2007	327	5.4	4.7	1.8	1.7	11.7	11.2	1400
8/28/2007					No Water for Sampling			
9/27/2007	323	3.9	3.5	7.0	3.2	1.5	1.5	2000
10/31/2007	290	13.9	10.9	16.1	13.1	12.9	11.5	1900
11/27/2007	398	13.2	13.0	14.5	14.0	9.8	9.4	1720
12/20/2007	298	20.2	18.2	44.0	40.0	7.9	7.2	1380
1/30/2008	342	9.2	9.0	18.2	18.0	7.2	7.2	1720
2/28/2008	312	17.4	16.8	28.0	22.0	6.4	6.0	1520
3/27/2008	456	6.1	5.8	12.0	9.5	6.5	5.9	1620
4/25/2008	356	18.9	17.9	10.2	8.5	9.1	8.4	2000
5/22/2008	453	20.5	18	38	33	11.2	10.7	1800
6/18/2008	478	12.4	12.0	15.0	14.0	17.0	15.0	2100

PR-3 Headwater tributary of Pleasant Run below the headwaters reclamation area.

Date	Discharge	pH		Conductivity		Alkalinity	Acidity	TDS
	total, mg/l	Field	Lab	Field, uS	Lab, uS	mg/l CaCO3	mg/L CaCO3	mg/l
1/28/2005	1.00	3.09		2860		0	690	2698
2/22/2005	0.27	3.32		2510		0	570	2382
3/28/2005	2.25	3.75		1447		0	190	1252
4/28/2005	0.30	3.20		2840		0	970	2962
5/25/2005	0.11	3.07		3030		0	500	3084
6/21/2005	0.06	3.00		3150		0	1643	3276
7/27/2005	0.06	2.81		3280		0	1973	3284
8/30/2005	1.61	3.42		1361		0	59	935
9/27/2005	0.05	2.90		3140		0	189	2470
10/27/2005	0.01	2.86		3280		0	83	2422
11/30/2005	0.06	2.92		3090		0	949	3004
12/20/2005	0.06	3.20		3170		0	731	3414
1/25/2006	0.15	3.60		4300		0	426	2070
3/27/2008	0.30	3.70		1224		0	436	2352
3/22/2006	0.25	3.00	3.60	2120	1932	0	202	1461
4/20/2006	0.03	2.90	3.14	1530	2040	0	228	1677
5/31/2006	0.07		3.18	1427	2170	0	320	2052
6/22/2006	0.06	3.60	3.60	1670	2720	0	390	1629
7/18/2006	0.03	3.30	3.00	1686	2650	0	338	2020
8/22/2006	0.05	6.20	6.70	1494	2760	29	67	1564
9/26/2006	0.10	4.90	6.33	1150	2350	35	21	1660
10/18/2006	0.10		6.28	3470	2960	42	15	2190
11/28/2006	0.13	5.90	5.96	1401	2800	16	83	2160
12/27/2006	0.30	5.10	4.71	2370	2210	2	88	1659
1/26/2007	0.28	3.75	3.71	3200	2760	0	211	2682
2/27/2007	0.28	5.09	4.80	2470	2320	3.3	137	2166
3/28/2007	1.18	6.17	5.80	1810	1775	11	39	1637
4/24/2007	0.30	3.88	3.60	2690	2910	0	242	2550
5/24/2007	0.15	3.27	3.46	2880	3080	0	266	2560
6/21/2007	0.37	3.76	4.00	2720	3000	0	184	2278
7/31/2007	0.09	4.41	4.38	2910	2650	0	101	2389
8/28/2007	0.03	4.16	4.16	3120	2840	0	113	3097
9/27/2007	0.03	4.98	4.33	2910	2650	0	105	2330
10/31/2007	0.08	5.25	4.59	2850	2660	0	117	2347
11/27/2007	0.08	5.30	5.02	2300	2130	4	102	1902
12/20/2007	0.49	5.25	4.81	2410	2280	2.5	146	2010
1/30/2008	0.30	4.51	4.24	2590	2320	0	174	2243
2/28/2008	0.34	3.68	3.54	2920	2710	0	352	2435
3/27/2008	0.65	2.98	3.16	3960	3260	0	1328	3058
4/25/2008	0.55	2.97	3.04	4439	3490	0	1600	3107
5/22/2008	0.43	3.04	3.19	3820	3640	0	1010	3404
6/18/2008	0.32	2.87	3.06	3720	3210	0	798	3343

PR-3 Headwater tributary of Pleasant Run below the headwaters reclamation area.

Date	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Sulfate, dis. mg/l
1/28/2005	395	29.1	32.4	28.6	30.8	11.7	12.2	1900
2/22/2005	340	22.0	24.3	18.5	19.1	10.2	10.8	1400
3/28/2005	192	9.8	8.9	5.5	4.6	4.9	5.5	890
4/28/2005	420	25.2	27.9	23.4	25.3	11.5	12.6	1930
5/25/2005	406	22.0	23.4	24.8	25.1	9.7	10.8	2130
6/21/2005	450	22.2	22.6	26.5	26.0	15.3	15.0	2410
7/27/2005	466	21.3	21.4	27.2	31.0	12.9	15.4	2170
8/30/2005	135	5.4	4.9	3.9	3.7	3.9	3.8	800
9/27/2005	360	12.1	11.8	27.0	23.3	14.3	12.0	1700
10/27/2005	472	24.4	13.6	26.1	25.7	14.0	14.0	1950
11/30/2005	436	24.1	26.8	29.8	29.1	15.9	15.9	2160
12/20/2005	528	27.2	29.4	34.3	35.5	17.4	18.7	2530
1/25/2006	298	15.9	15.1	17.9	40.5	10.9	12.4	1460
3/27/2008	354	13.4	20.3	32.8	18.3	13.1	11.5	1530
3/22/2006	291	15.0	14.8	40.0	34.0	11.4	11.0	1160
4/20/2006	400	19.1	19.0	15.9	16.0	14.1	14.0	1300
5/31/2006	340	11.8	11.8	15.6	14.3	10.7	10.7	1700
6/22/2006	329	9.8	9.3	17.2	15.4	13.4	13.1	1300
7/18/2006	309	19.7	19.7	17.0	17.0	13.0	13.0	1700
8/22/2006	314	6.1	4.2	24.7	24.7	16.0	16.0	1260
9/26/2006	360	2.2	0.0	19.6	15.2	9.3	9.0	1300
10/18/2006	360	1.3	0.0	15.3	11.8	10.0	9.6	1840
11/28/2006	460	3.8	0.4	33.0	25.0	8.3	8.1	1700
12/27/2006	340	9.7	6.8	19.3	16.9	9.2	8.9	1360
1/26/2007	382	17.2	16.9	25.3	21.3	13.1	13.0	2300
2/27/2007	339	9.6	9.0	21.6	15.1	11.3	11.0	1860
3/28/2007	290	5.9	2.8	22.2	10.3	5.6	4.5	1340
4/24/2007	1200	20.9	20.0	20.9	16.7	13.2	13.2	1350
5/24/2007	482	16.2	16.0	8.5	7.1	19.0	15.0	2100
6/21/2007	578	12.8	10.8	9.9	7.1	11.2	11.2	1700
7/31/2007	402	4.2	3.8	3.0	1.8	8.5	8.2	2000
8/28/2007	297	2.4	2.2	1.5	0.8	8.1	7.7	2800
9/27/2007	350	2.5	2.2	1.0	0.9	8.7	8.7	2000
10/31/2007	405	9.4	6.5	13.6	10.5	9.4	9.1	1960
11/27/2007	388	7.3	7.0	11.8	9.9	6.5	6.0	1500
12/20/2007	429	9.7	8.0	19.6	15.0	9.1	8.4	1620
1/30/2008	418	8.4	8.3	20.5	14.5	8.2	8	1800
2/28/2008	420	44.9	41.5	51.0	39.0	12.2	10.9	2000
3/27/2008	348	35.3	35.2	140.0	110.0	15.1	15.0	2600
4/25/2008	199	144	121	125	83	19.6	19.2	2700
5/22/2008	409	67.4	67.1	150.0	130.0	18.2	17.8	2800
6/18/2008	393	40.9	40.0	112.0	109.0	22.0	21.0	2800

PR-4 Pleasant Run below the Bunt Sisk Hills area.

Date	Discharge	pH		Conductivity		Alkalinity	Acidity	TDS
	total, mg/l	Field	Lab	Field, uS	Lab, uS	mg/l CaCO3	mg/L CaCO3	mg/l
1/28/2005	10.00	3.22		2250		0	430	2017
2/22/2005	2.82	3.53		1694		0	310	1452
3/28/2005	45.23	4.23		825		0	150	699
4/28/2005	1.56	3.29		2280		0	800	2180
5/25/2005	0.75	3.05		2630		0	1750	2618
6/21/2005	0.15	2.98		2960		0	1226	2758
7/27/2005	0.09	2.84		2910		0	1231	2880
8/30/2005	23.78	3.52		1055		0	41	811
9/27/2005	0.30	2.93		2800		0	162	1990
10/27/2005	0.12	2.91		3100		0	84	1650
11/30/2005	0.74	2.89		2780		0	1145	2628
12/20/2005	2.50	3.00		2670		0	688	2642
1/25/2006	3.60	3.80		1460		0	324	1232
3/27/2008	3.30	3.60				0	219	1246
3/22/2006	7.01	3.30	3.74	1145	1076	0	91	600
4/20/2006	1.40	4.60	3.20	1130	1840	0	169	1431
5/31/2006	0.70		3.48	1054	1766	0	301	1597
6/22/2006	0.16	5.70	5.76	1309	2225	6	40	1582
7/18/2006	0.10	3.70	4.61	1223	2130	5	69	1963
8/22/2006	0.07	4.30	4.13	1175	2370	2	114	2044
9/26/2006	1.12	4.30	4.38	1070	2170	0	86	1204
10/18/2006	0.40		3.99	2880	2560	0	111	1457
11/28/2006	0.87	4.00	3.74	890	1959	0	116	1415
12/27/2006	5.30	4.90	4.32		1200	0	81	840
1/26/2007	2.50	3.70	3.76	1820	1516	0	132	900
2/27/2007	4.25	4.52	4.30	1340	1289	0	96	1120
3/28/2007	21.5	4.66	4.70	1000	918	2	51	525
4/24/2007	0.8	3.47	3.72	1720	2110	0	139	1340
5/24/2007	0.1	3.35	3.55	2540	2730	0	186	1960
6/21/2007	0.1	6.03	5.99	2640	2920	10	34	1975
7/31/2007					No Water for Sampling			
8/28/2007					No Water for Sampling			
9/27/2007					No Water for Sampling			
10/31/2007	0.58	4.47	4.28	2480	2440	0	124	2286
11/27/2007	1.4	4.50	4.08	1700	1748	0	123	1200
12/20/2007	3.49	4.18	3.86	1600	1612	0	172	1087
1/30/2008	3	4.40	4.24	1620	1510	0	116	1112
2/28/2008	5.66	3.84	3.71	1730	1754	0	165	1388
3/27/2008	4.48	3.10	3.26	2220	2090	0	364	1841
4/25/2008	2.52	2.88	3.01	2840	2560	0	574	2481
5/22/2008	1.76	2.93	3.17	2940	2690	0	957	2232
6/18/2008	0.55	2.82	2.97	3440	3080	0	522	2672

PR-4 Pleasant Run below the Bunt Sisk Hills area.

Date	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Sulfate, dis. mg/l
1/28/2005	292	21.3	23.8	20.2	22.2	9.9	10.3	1370
2/22/2005	210	13.8	15.4	11.5	12.0	7.8	8.5	1000
3/28/2005	97	8.0	6.0	8.0	3.2	3.2	3.4	460
4/28/2005	279	18.8	21.1	14.5	15.7	10.2	11.2	1420
5/25/2005	312	18.3	20.8	10.2	10.9	9.7	11.0	1800
6/21/2005	383	23.5	24.5	8.6	8.5	17.0	17.0	2150
7/27/2005	380	26.8	26.4	9.2	10.3	15.5	17.3	1860
8/30/2005	91	4.5	4.5	3.2	1.7	3.2	3.1	720
9/27/2005	320	14.3	14.2	3.6	3.5	8.0	8.0	1250
10/27/2005	400	34.0	21.7	3.4	3.4	18.5	17.7	1250
11/30/2005	327	27.9	29.3	12.3	10.9	18.7	18.9	1830
12/20/2005	373	26.6	29.3	15.9	16.1	19.9	20.7	1940
1/25/2006	167	12.2	12.2	10.8	10.1	9.1	9.0	820
3/27/2008	166	10.6	11.5	10.4	10.2	8.0	8.4	705
3/22/2006	117	7.1	7.0	7.2	7.0	6.5	6.5	500
4/20/2006	240	16.7	11.4	10.3	10.2	12.9	12.7	1180
5/31/2006	285	17.0	10.9	11.3	9.4	10.3	10.1	1320
6/22/2006	350	1.4	0.7	0.7	0.6	12.0	12.0	1300
7/18/2006	310	3.7	3.4	0.3	0.2	9.9	9.9	1660
8/22/2006	355	4.0	3.8	0.6	0.4	11.2	8.9	1700
9/26/2006	300	4.4	4.2	1.3	0.6	10.0	9.7	900
10/18/2006	290	7.1	6.9	0.7	0.7	11.6	11.4	1160
11/28/2006	258	8.0	8.0	6.4	5.3	7.8	7.8	1160
12/27/2006	137	11.9	10.6	8.0	6.1	6.6	6.6	650
1/26/2007	160	12.0	12.0	14.6	14.0	9.0	9.0	740
2/27/2007	141	6.4	5.2	9.2	7.5	7.4	6.6	980
3/28/2007	113	6.4	4.3	16.4	0.5	4.5	4.5	470
4/24/2007	307	12.7	12.3	6.4	6.3	9.4	9.2	1040
5/24/2007	411	15.5	15.5	1.5	1.5	14.0	14.0	1600
6/21/2007	544	1.4	0.0	0.2	0.2	5.8	5.8	1400
7/31/2007					No Water for Sampling			
8/28/2007					No Water for Sampling			
9/27/2007					No Water for Sampling			
10/31/2007	370	10.8	10.2	2.67	0.91	10.2	10	1960
11/27/2007	280	12.4	11.3	1.94	1.57	6.8	6.8	940
12/20/2007	229	12.9	12.6	11.5	10.8	6.8	6.8	860
1/30/2008	224	7	6.7	5.9	4.1	5.1	4.9	900
2/28/2008	210	20	17.7	14.1	13.9	6.6	6.6	1140
3/27/2008	264	15.1	14.3	16.1	15.1	8	7.8	1620
4/25/2008	219	39.9	39.1	23	22	12	12	2200
5/22/2008	371	38.5	38	34	30	13.2	13	1800
6/18/2008	442	30.1	29.7	16.5	15.8	21	19	2200

PR-5 Tributary entering Pleasant Run above ditchline from Nortonville Refuse area.

Date	Discharge	pH		Conductivity		Alkalinity	Acidity	TDS
	total, mg/l	Field	Lab	Field, uS	Lab, uS	mg/l CaCO3	mg/L CaCO3	mg/l
1/28/2005	4.00	5.5		1632		15	80	1481
2/22/2005	4.27	5.7		1195		10	40	1041
3/28/2005	32.86	6.4		656		13	40	498
4/28/2005	1.30	5.6		1770		22	384	1950
5/25/2005	0.58	5.9		2180		59	200	2324
6/21/2005	0.14	5.2		2330		29	343	2414
7/27/2005	0.16	4.9		2320		23	95	2602
8/30/2005	6.35	6.4		607		15	0	358
9/27/2005	0.10	6.1		1887		10	9	1528
10/27/2005	0.16	4.8		2520		5	3	1840
11/30/2005	0.59	5.9		1735		27	75	1668
12/20/2005	0.56	4.8		1717		15	56	1674
1/25/2006	3.89	6.2		1047		30	37	852
3/27/2008	2.40	5.5		502		25	45	1012
3/22/2006	5.10	5.1	5.4	570.0	911.0	5	29	404
4/20/2006	0.75	5.4	4.63	851	1476	1	76	902
5/31/2006	0.52		5.8	969	1679	10	50	1269
6/22/2006	0.07	6.5	6.4	1928	1827	29	7	900
7/18/2006	0.10	6.5	6.4	1038	2060	23	27	1152
8/22/2006	0.10	5.9	6.5	802	1660	23	6	1179
9/26/2006	0.77	5.7	6.6	657	1488	32	0	780
10/18/2006	0.45		6.4	1680	1514	28	4	598
11/28/2006	1.33	6.1	5.9	693	1466	9	11	1155
12/27/2006	6.00	5.4	5.8		959	11	9	671
1/26/2007	2.74	5.9	5.7	1340	1146	5	15	817
2/27/2007	4.40	6.15	6.06	1040	995	11	6	635
3/28/2007	18.53	6.63	6.42	930	927	22	9	583
4/24/2007	1.5	5.46	5.66	1370	1460	6	17	892
5/24/2007	0.5	5.95	6.43	1980	2170	19	32	1313
6/21/2007	0.07	6.09	6.45	2310	2430	14	28	1943
7/31/2007	0.02	5.9	6.03	2490	2410	14	3	2029
8/28/2007					No Water for Sampling			
9/27/2007	0.11	6.6	5.93	2600	2430	15	21	2479
10/31/2007	0.58	6.68	5.9	1680	1700	18	15	1108
11/27/2007	2.91	7.3	6.03	1040	1110	14	29	644
12/20/2007	3.6	5.91	5.51	1110	1111	5	25	796
1/30/2008	5	6.34	6.09	1200	1183	16	35	897
2/28/2008	4.5	5.98	5.68	1220	1224	4	14	869
3/27/2008	10.64	4.91	5.04	1360	1401	3	24	1182
4/25/2008	1.7	4.78	4.85	1749	1786	3	51	1334
5/22/2008	1.19	5.13	5.05	1870	1946	5	43	1330
6/18/2008	0.17	5.52	5.44	2390	2226	5	31	1610

PR-5 Tributary entering Pleasant Run above ditchline from Nortonville Refuse area.

Date	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Sulfate, dis. mg/l
1/28/2005	245	4.4	2.3	1.1	0.9	5.0	5.0	947
2/22/2005	167	2.8	1.5	0.6	1.5	3.7	4.2	700
3/28/2005	82	2.7	0.1	1.9	0.1	1.6	1.7	320
4/28/2005	265	4.4	1.5	6.0	0.8	5.8	6.1	1130
5/25/2005	335	0.9	0.3	2.0	0.7	5.2	6.3	1730
6/21/2005	384	1.9	1.7	5.5	5.1	9.7	0.0	1880
7/27/2005	400	1.7	2.1	0.3	0.2	10.1	10.6	1610
8/30/2005	63	1.3	0.0	0.8	0.1	1.4	1.4	280
9/27/2005	31	0.4	0.3	0.2	0.0	4.0	3.9	1280
10/27/2005	435	3.2	3.0	0.2	0.4	10.0	9.7	1400
11/30/2005	247	0.8	1.0	0.7	0.5	6.4	6.6	1100
12/20/2005	276	1.8	2.4	1.8	3.2	8.2	8.0	1140
1/25/2006	148	1.3	0.7	0.9	2.7	3.3	3.5	550
3/27/2008	157	1.0	0.9	0.8	1.8	4.1	4.2	590
3/22/2006	102	1.7	1.1	1.8	0.4	3.4	3.3	310
4/20/2006	220	1.6	1.6	2.5	0.7	7.3	6.9	680
5/31/2006	255	0.9	0.8	8.0	8.0	6.8	6.4	1040
6/22/2006	230	0.0	0.0	5.1	0.3	4.5	4.5	880
7/18/2006	255	0.0	0.0	0.6	0.1	5.2	5.0	900
8/22/2006	207	0.2	0.0	0.2	0.0	2.5	2.5	987
9/26/2006	165	0.0	0.0	2.5	0.5	2.6	2.6	620
10/18/2006	192	0.0	0.0	1.6	1.4	3.0	3.0	480
11/28/2006	298	1.2	0.4	8.3	0.7	4.3	4.0	880
12/27/2006	120	6.9	6.8	1.2	0.8	4.2	3.3	460
1/26/2007	122	2.1	1.0	1.8	0.7	4.2	4.0	690
2/27/2007	122	1.2	0.4	0.5	1.3	3.7	3.5	510
3/28/2007	60	2.1	0.0	1.3	0.6	0.3	0.3	510
4/24/2007	190	1.6	0.6	1.7	0.7	5.0	5.0	700
5/24/2007	343	0.8	0.2	3.1	0.2	11.0	8.0	1000
6/21/2007	437	0.0	0.0	0.2	0.1	6.7	6.6	1500
7/31/2007	327	0.0	0.0	2.1	2.1	4.1	3.8	1720
8/28/2007					No Water for Sampling			
9/27/2007	275	0.4	0.3	0.1	0.1	4.9	4.9	2200
10/31/2007	221	0.0	0.0	0.7	0.6	5.0	4.9	880
11/27/2007	179	0.5	0.3	0.8	0.5	2.3	2.3	460
12/20/2007	155	2.7	1.1	0.8	0.8	2.5	2.5	640
1/30/2008	161	1.5	0.4	1.1	0.4	2.7	2.6	730
2/28/2008	175	2.6	1.2	0.5	0.3	3.0	3.0	700
3/27/2008	258	3.0	3.0	2.8	1.8	3.7	3.5	930
4/25/2008	229	2.5	1.7	1.0	0.3	4.7	4.7	1100
5/22/2008	326	2.5	1.5	1.5	0.56	5.7	5.6	1000
6/18/2008	418	1	0.6	0.24	0.19	9.2	8.9	1200

PR-6 Ditchline below the Nortonville Refuse reclamation work.

Date	Discharge	pH		Conductivity		Alkalinity	Acidity	TDS
	total, mg/l	Field	Lab	Field, uS	Lab, uS	mg/l CaCO3	mg/L CaCO3	mg/l
1/28/2005	0.14	3.14		3000		0	4430	3244
2/22/2005	0.11	3.26		1980		0	1360	1746
3/28/2005	2.03	4.17		580		0	320	440
4/28/2005	0.06	3.02		2730		0	3490	2946
5/25/2005	0.04	2.72		3610		0	3000	4400
6/21/2005	0.01	2.62		4030		0	10540	5298
7/27/2005	0.00	2.46		5260		0	9710	17766
8/30/2005	1.51	3.91		601		0	56	343
9/27/2005	0.01	2.51		5100		0	2905	4829
10/27/2005	0.00	2.55		6240		0	3360	8064
11/30/2005	0.02	2.67		2470		0	4136	2298
12/20/2005	0.80	2.90		2760		0	2981	2950
1/25/2006	0.07	3.50		1650		0	1279	1396
3/27/2008	0.09	3.10		1096		0	2581	2290
3/22/2006	0.14	2.90	3.40	1607	1407	0	509	803
4/20/2006	0.04	2.90	2.93	1682	2400	0	2181	1328
5/31/2006	0.04		2.87	1940	2750	0	1896	2393
6/22/2006	0.02	3.40	2.89	4450	3360		3084	3080
7/18/2006	0.01	2.80	2.88	3100	4250	0	4252	4120
8/22/2006					No Water for Sampling			
9/26/2006	0.10	5.70	3.50	1260	2690	0	747	1632
10/18/2006	0.05		3.22	3030	2870	0	756	1770
11/28/2006	0.05	4.60	3.18	1444	2740	0	1214	2476
12/27/2006	0.27	3.40	3.48		1251	0	378	876
1/26/2007	0.60	3.20	3.26	2620	2510	0	1112	1834
2/27/2007	0.25	3.60	3.75	1560	1429	0	585	1092
3/28/2007	1.30	5.24	5.12	560	558	5	98	392
4/24/2007	0.2	2.92	3.19	2340	2550	0	907	1638
5/24/2007	0.05	3.03	3.24	2570	2720	0	1400	1915
6/21/2007	0.05	2.58	2.70	5110	5460	0	3752	3930
7/31/2007	0.02	2.45	2.55	5510	4920	0	2455	2044
8/28/2007					No Water for Sampling			
9/27/2007	0.02	2.89	2.68	4480	4320	0	2088	4238
10/31/2007	0.07	3.25	3.00	3100	3010	0	1414	1970
11/27/2007	0.08	3.86	3.53	1240	1244	0	456	820
12/20/2007	0.12	3.62	3.38	2040	2030	0	955	1349
1/30/2008	0.2	4.20	4.02	1390	1340	0	556	1203
2/28/2008	0.08	3.63	3.46	1880	1856	0	764	1890
3/27/2008	0.1	3.09	3.25	2179	2280	0	1091	2078
4/25/2008	0.05	2.87	2.97	2867	2680	0	1536	3282
5/22/2008	0.04	2.82	3.00	3070	2840	0	1964	2738
6/18/2008	0.03	2.52	2.76	4740	4112	0	2924	4386

PR-6 Ditchline below the Nortonville Refuse reclamation work.

Date	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Sulfate, dis. mg/l
1/28/2005	199	92.1	105.0	480.0	500.0	5.1	5.0	2134
2/22/2005	131	50.3	55.4	257.0	261.0	4.0	4.3	1100
3/28/2005	55.9	10.8	7.0	42.6	38.9	0.7	0.7	290
4/28/2005	165	72.4	79.6	356.0	369.0	5.3	5.7	1850
5/25/2005	223	96.7	105.0	544.0	546.0	5.8	6.3	3360
6/21/2005	288	127.0	143.0	719.0	644.0	12.1	11.9	3860
7/27/2005	371	204.0	217.0	1090.0	838.0	18.8	19.3	4430
8/30/2005	53	5.8	4.4	32.8	25.9	0.5	0.5	290
9/27/2005	150	201.0	140.0	704.0	670.0	12.0	12.0	4100
10/27/2005	261	229.0	229.0	1590.0	1590.0	22.0	22.0	8100
11/30/2005	129	66.6	72.1	304.0	273.0	4.6	4.9	1580.0
12/20/2005	185	78.4	87.5	408.0	400.0	7.2	6.6	357.0
1/25/2006	144	30.0	32.2	173.0	171.0	3.3	3.4	1279.0
3/27/2008	167	41.2	62.3	340.0	317.0	4.9	4.8	1360.0
3/22/2006	59.6	35.8	34.4	158.0	148.0	3.5	3.3	740
4/20/2006	132	82.5	82.0	475.0	469.0	6.9	6.9	1120
5/31/2006	1120	213.0	197.0	654.0	650.0	6.8	6.8	2100
6/22/2006	186	91.7	99.3	574.0	461.0	9.1	8.5	2800
7/18/2006	158	175.0	170.0	1170.0	1200.0	8.8	8.9	3800
8/22/2006					No Water for Sampling			
9/26/2006	269	33.0	31.9	306.0	280.0	3.2	3.2	1340
10/18/2006	493	83.9	35.8	749.0	313.0	2.9	2.8	1540
11/28/2006	120	58.2	55.5	490.0	453.0	3.2	3.2	2300
12/27/2006	96	27.4	27.0	131.0	121.0	1.7	1.7	740
1/26/2007	89	57.7	56.1	397.0	376.0	3.4	3.4	2300
2/27/2007	61.6	38.1	37.1	22.6	21.5	2.4	2.3	920
3/28/2007	61.8	3.3	1.2	38.6	35.0	0.7	0.7	230
4/24/2007	71	60.0	60.0	162.0	158.0	3.4	3.4	1700
5/24/2007	17.5	103.0	89.0	450.0	345.0	4.5	4.5	1900
6/21/2007	350	187.0	163.0	871.0	800.0	11.2	11.2	3600
7/31/2007	348	102.0	91.0	637.0	600.0	10.7	10.4	1700
8/28/2007					No Water for Sampling			
9/27/2007	272	68	67.8	408	407	8.3	7.9	4000
10/31/2007	177	69.5	67.9	320	307	4.3	4.3	1800
11/27/2007	140	27.8	27.8	126	114	1.15	1.11	700
12/20/2007	15	40	37.6	275	234	1.85	1.85	1200
1/30/2008	99	19.6	19.2	186	164	1.14	1.2	920
2/28/2008	126	42	40	250	248	19	19	1460
3/27/2008	90	26	25.9	238	204	2	2	1760
4/25/2008	109	102	78	280	212	2.2	2.2	2900
5/22/2008	195	121	100	469	444	4	4.2	2000
6/18/2008	267	72.6	70.9	690	560	10	10	3500

PR-7 Side drain running under a reclaimed mine area.

Date	Discharge	pH		Conductivity		Alkalinity	Acidity	TDS
	total, mg/l	Field	Lab	Field, uS	Lab, uS	mg/l CaCO3	mg/L CaCO3	mg/l
1/28/2005	0.07	3.5		2980		0	2500	1956
2/22/2005	0.05	4.9		848		10	120	725
3/28/2005								
4/28/2005	0.40	3.6		1702		0	1920	1432
5/25/2005	0.01	3.1		2750		0	8000	3332
6/21/2005	0.01	3.1		5130		0	5589	7552
7/27/2005	0.00	2.7		8110		0	12914	11486
8/30/2005	0.88	5.8		362		9	21	209
9/27/2005	0.01	2.7		7350		0	5860	6348
10/27/2005	0.00	3.0		9570		0	8070	7660
11/30/2005	0.01	3.3		1440		0	2287	1414
12/20/2005	0.75	3.1		1828		0	2156	1708
1/25/2006	0.09	3.8		986		0	602	840
3/27/2008	0.04	4.2		997		0	895	948
3/22/2006	0.16	3.7	4.7	814	887	2	270	431
4/20/2006	0.03	3.4	3.3	1108	2420	0	780	2210
5/31/2006	0.02		3.3	1151	1836	0	1430	1412
6/22/2006	0.01	3.6	3.1	3400	4500	0	4906	4454
7/18/2006	0.01	3.5	3.1	4490	5530	0	6960	4379
8/22/2006					No Water for Sampling			
9/26/2006	0.05	4.8	3.5	927	2130	0	822	938
10/18/2006	0.02		3.5	1884	1764	0	686	816
11/28/2006	0.20	3.8	3.4	696	1526	0	596	990
12/27/2006	0.09	4.3	4.6		687	2	176	481
1/26/2007	0.04	4.0	4.0	1230	1043	0	426	861
2/27/2007	0.08	4.5	4.82	830	773	3.6	277	581
3/28/2007	0.63	6.6	6.1	220	228	22	17	154
4/24/2007	0.03	3.5	3.7	1310	1391	0	617	917
5/24/2007	0.02	2.6	2.66	3550	4060	0	1367	1660
6/21/2007	0.08	2.9	3	7600	8220	0	8300	6655
7/31/2007	0.03	2.8	2.98	9850	7290	0	2470	3200
8/28/2007	0.02	3.0	2.73	10420	8380	0	993	5084
9/27/2007	0.02	3.3	3.03	9550	8050	0	9120	6060
10/31/2007	0.02	3.4	3.16	2300	3200	0	2228	2190
11/27/2007	0.11	4.9	4.71	690	700	2	220	387
12/20/2007	0.12	4.5	4.46	1020	1021	0	386	646
1/30/2008	0.15	4.7	4.78	930	882	4	369	641
2/28/2008	0.12	4.5	4.7	1010	984	3	340	631
3/27/2008	0.08	3.8	4.3	1255	1185	0	578	912
4/25/2008	0.04	3.4	3.31	1651	1656	0	881	
5/22/2008	0.02	3.3	3.52	1910	1814	0	994	1631
6/18/2008	0.02	2.8	3.1	7350	18670	0	6516	12447

PR-7 Side drain running under a reclaimed mine area.

Date	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Sulfate, dis. mg/l
1/28/2005	113	107.0	110.0	540.0	520.0	4.0	3.6	1305
2/22/2005	49	15.4	13.7	115.0	120.0	1.8	1.9	400
3/28/2005								
4/28/2005	80	44.7	48.9	260.0	272.0	3.0	3.2	1110
5/25/2005	111	69.9	77.3	489.0	500.0	3.6	4.0	2320
6/21/2005	240	154.0	190.0	1250.0	1140.0	10.2	11.4	4690
7/27/2005	348	330.0	354.0	2810.0	1630.0	18.1	17.3	7990
8/30/2005	28	0.0	0.0	26.0	19.0	0.3	0.3	172
9/27/2005	115	359.0	329.0	130.0	180.0	15.3	13.5	5900
10/27/2005	160	304.0	272.0	1260.0	1015.0	21.6	20.9	7500
11/30/2005	58	31.4	29.9	218.0	208.0	1.9	2.2	770
12/20/2005	93	41.4	43.8	297.0	286.0	2.9	3.2	1180
1/25/2006	81	14.6	15.2	107.0	97.6	1.4	1.4	520
3/27/2008	73	16.2	23.7	154.0	148.0	1.9	2.0	544
3/22/2006	35	16.1	15.9	91.0	90.0	1.6	1.6	380
4/20/2006	50	60.0	60.0	385.0	377.0	4.2	4.0	2100
5/31/2006	52	67.0	66.0	559.0	420.0	3.0	3.0	1300
6/22/2006	105	300.0	255.0	980.0	898.0	9.6	9.6	4100
7/18/2006	40	350.0	339.0	1560.0	1550.0	14.0	14.0	4000
8/22/2006					No Water for Sampling			
9/26/2006	65	36.0	36.0	306.0	280.0	3.2	3.2	840
10/18/2006	72	131.0	68.0	1093.0	329.0	2.2	1.7	720
11/28/2006	24	26.0	26.0	230.0	213.0	1.7	1.7	940
12/27/2006	35.7	18.1	16.8	7.3	7.1	1.2	1.2	290
1/26/2007	33.3	25.9	22.7	174.0	164.0	2.1	2.1	550
2/27/2007	32.3	17.2	16.1	166.0	117.0	1.5	1.4	360
3/28/2007	10	2.1	0.4	13.2	11.0	0.4	0.4	124
4/24/2007	22.8	38.6	36.0	134.0	143.0	2.7	2.7	980
5/24/2007	180	116	99	429	408	5.84	5.81	1500
6/21/2007	56	420	436	134	106	15.6	15.5	6600
7/31/2007	300	340	299	107	105	16.2	16	2900
8/28/2007	87	289.5	288.8	3070	2900	18.2	17.7	5000
9/27/2007	62	320	320	860	856	16.6	16.6	6000
10/31/2007	90	105	51	392	238	4.1	3.4	2100
11/27/2007	100	12	6.9	69	68	0.73	0.7	310
12/20/2007	155	19.5	17.5	76.7	67.1	1.18	1.16	560
1/30/2008	48	16	12.6	120	117	0.96	0.95	460
2/28/2008	86	20.2	18	135	100	1.2	1.2	460
3/27/2008	36	16.3	16.1	128	124	1.2	1.2	740
4/25/2008	19.6	36.8	35	145	142	1.68	1.65	1220
5/22/2008	62	43.6	42.7	336	332	2.6	2.6	1200
6/18/2008	106	132	128	3040	2710	19	17	9500

PR-8 Pleasant Run below all the reclamation work

Date	Discharge total, mg/l	pH Field	pH Lab	Conductivity Field, uS	Conductivity Lab, uS	Alkalinity mg/l CaCO3	Acidity mg/L CaCO3	TDS mg/l
1/28/2005	15.00	3.8		1704		0	230	1509
2/22/2005	16.20	4.3		1190		0	2700	1000
3/28/2005		5.4		555		7	60	440
4/28/2005	4.89	3.7		1758		0	380	1680
5/25/2005	1.80	3.4		2190		0	880	2158
6/21/2005	0.46	3.4		2420		0	1983	2618
7/27/2005	0.34	3.4		2420		0	315	2774
8/30/2005		4.7		751		3	10	465
9/27/2005	0.97	3.4		2090		0	95	1912
10/27/2005	0.37	4.6		1823		5	65	1636
11/30/2005	1.96	3.4		2020		0	476	1924
12/20/2005	3.98	3.5		1974		0	309	1786
1/25/2006	11.29	4.5		1715		0	142	744
3/27/2008	9.51	4.5		977		0	87	908
3/22/2006	15.89	4.5	5.10	855	792	5	29	401
4/20/2006	3.1	3.8	3.67	845	1473	0	164	1254
5/31/2006	3.2		3.67	1746	1473	0	164	1254
6/22/2006	0.4	3.4	3.57	1085	2090	0	182	1142
7/18/2006	0.15	3.7	3.60	1074	2120	0	134	1264
8/22/2006	0.49	4.6	4.21	804	1862	3	64	1372
9/26/2006	2.9	6.0	5.39	668	1520	5	21	756
10/18/2006	1.26		4.92	2130	1974	2	48	710
11/28/2006	4.04	4.85	4.98	732	1611	4	53	1102
12/27/2006	23.1	5.6	5.33		821	6	26	575
1/26/2007	8.93	5.18	4.92	1310	1246	4	56	917
2/27/2007	18.4	5.65	5.41	970	930	5	26	679
3/28/2007	71.77	5.91	5.76	880	830	7	13	616
4/24/2007	4	4.36	4.77	1410	1594	2	60	987
5/24/2007	5	3.88	3.7	2250	2450	0	100	1100
6/21/2007	6.24	4.44	4.25	2470	2650	0	211	2808
7/31/2007	0.1	5.7	5.44	2480	2350	5	37	1881
8/28/2007	0.9	7.08	6.5	900	688	133	0	266
9/27/2007	0.14	6.53	5.67	2450	2390	13	66	2196
10/31/2007	1.1	4.92	4.42	1770	1773	0	92	1208
11/27/2007	10.47	5.45	5.1	1110	1094	4	49	726
12/20/2007	10.03	5.18	4.81	1090	1097	3	71	744
1/30/2008	13	5.97	5.51	1230	1200	7	35	826
2/28/2008	9.85	5.15	4.85	1330	1293	2	60	815
3/27/2008	14.3	3.5	3.66	1700	1670	0	142	1121
4/25/2008	6.5	3.27	3.27	2248	2130	0	294	2136
5/22/2008	5.7	3.36	3.58	2310	2180	0	230	1965
6/18/2008	1.21		3.61		2620	0	246	2188

PR-8 Pleasant Run below all the reclamation work

Date	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Sulfate, dis. mg/l
1/28/2005	230	11.3	12.3	14.7	14.2	6.6	6.1	977
2/22/2005	154	6.0	6.5	5.5	4.1	4.7	5.2	600
3/28/2005	67	3.8	1.4	3.1	1.1	1.8	1.8	320
4/28/2005	236	9.5	10.4	9.1	9.7	7.4	8.3	1080
5/25/2005	289	10.7	12.0	12.3	13.3	8.0	9.2	1490
6/21/2005	349	13.7	15.2	20.9	10.9	13.1	13.8	1740
7/27/2005	367	9.1	9.8	6.6	5.6	13.2	13.8	1680
8/30/2005	82	1.3	0.6	1.7	0.5	2.4	2.4	380
9/27/2005	299	7.2	7.2	25.2	10.3	10.5	10.5	1440
10/27/2005	311	1.2	1.2	33.0	19.8	7.5	7.5	1320
11/30/2005	261	11.4	12.2	8.4	7.9	12.5	13.8	1180
12/20/2005	289	13.1	14.3	14.4	15.7	12.5	13.3	1390
1/25/2006	120	4.3	4.1	5.7	4.6	4.4	4.5	480
3/27/2008	132	3.4	4.6	6.8	5.9	4.6	4.8	527
3/22/2006	88	2.9	2.5	3.4	3.1	3.8	3.8	310
4/20/2006	230	9.4	9.0	7.4	6.7	9.2	9.1	1020
5/31/2006	230	9.4	9.0	7.4	6.7	9.2	9.1	1020
6/22/2006	249	4.5	4.0	11.9	11.8	10.0	10.0	900
7/18/2006	260	4.0	4.0	13.4	8.0	8.3	8.3	1000
8/22/2006	250	1.8	1.5	2.5	1.9	9.0	9.0	1120
9/26/2006	166	1.4	0.6	2.5	2.0	3.9	3.9	600
10/18/2006	197	2.8	2.1	0.8	0.5	8.1	7.8	520
11/28/2006	160	3.2	1.6	7.4	6.5	5.4	4.9	940
12/27/2006	118	2.9	1.6	2.7	2.0	4.1	3.7	380
1/26/2007	143	4.5	2.7	11.1	7.4	5.8	5.5	680
2/27/2007	148	3.3	1.7	3.7	3.2	3.9	3.8	460
3/28/2007	55	3.3	0.2	13.2	11	6.7	2.79	390
4/24/2007	219	6.3	5.5	5.5	4.5	6	6	800
5/24/2007	320	2.7	2.6	3.77	1.77	10	10	800
6/21/2007	446	2.2	2.2	2.1	5.6	9.4	9.3	2400
7/31/2007	294	4.9	0.2	0.49	0.33	5.2	5	1600
8/28/2007	37.2	1	0	6.47	0.63	0.51	0.51	170
9/27/2007	209	0	0	0.52	0.36	6.4	6.1	1980
10/31/2007	200	4.7	4.4	8.8	7	7	7	1020
11/27/2007	155	7.3	3.9	1.66	1.33	3.4	3.4	580
12/20/2007	161	6.7	6	6.8	6.1	4	3.6	590
1/30/2008	188	1.7	0	3.6	2.9	3.3	2.9	630
2/28/2008	175	6.1	5.5	8.1	5.7	4	4	630
3/27/2008	210	6.1	6	6	3.6	5.6	5.5	900
4/25/2008	251	17.6	17.2	7.4	4.7	8.1	7.9	1860
5/22/2008	358	20.1	19.9	10.8	8.2	9.4	9.2	1600
6/18/2008	479	18	17.7	3.3	2.5	15	14	1700