PLEASANT RUN WATERSHED IMPLEMENTATION PLAN

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

KENTUCKY DIVISION OF ABANDONED MINE LANDS

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SOURCES OF IMPAIRMENT

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 2004 303(d) list of waters for Kentucky (KDOW 2004) 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.

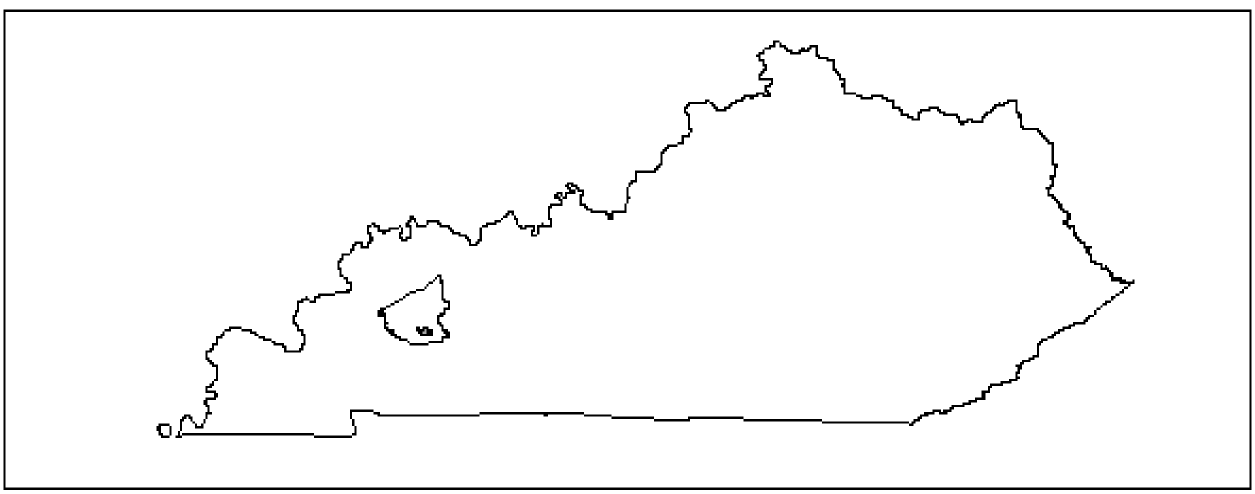

Figure 1. General location of Pleasant Run Watershed (shaded area) and Hopkins County, Kentucky.

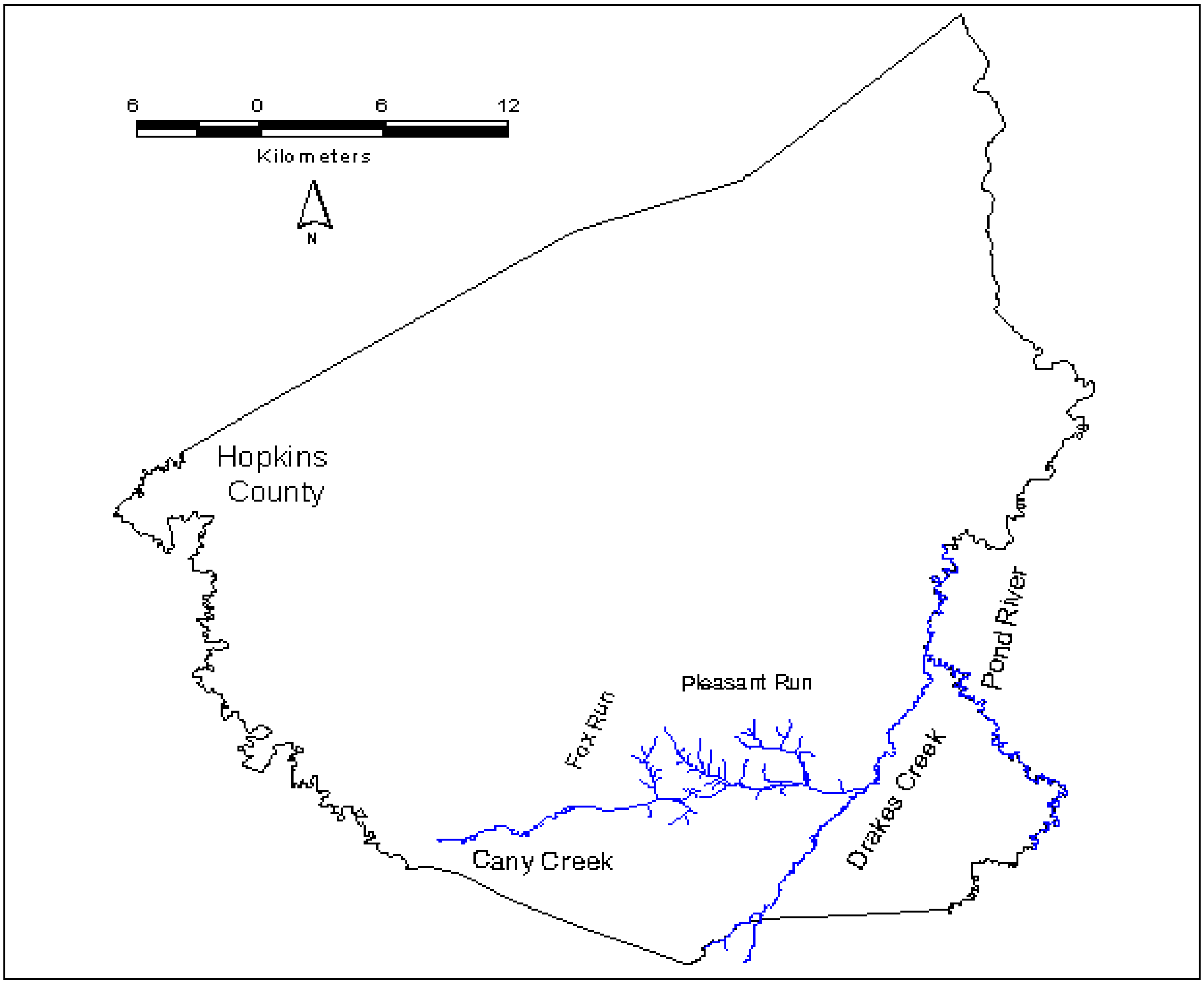

Figure 2. Location of Pleasant Run in Hopkins County, Kentucky.

Causes and Locations of the Watershed Impairments

Extensive surface and deep mining has occurred in the watershed with approximately 30 percent of the total acreage in the watershed disturbed by mining processes. Most of the mining was done from the 1920's through 1958, prior to the establishment of stringent regulations concerning reclamation and the environment. Conditions associated with the 970 hectares (2400 acres) of "pre-law" mine lands in the watershed include acid mine drainage, inadequate vegetation, abandoned highwalls, impoundments and pits, open shafts, and abandoned structures and machinery. Problems resulting from these conditions include the potential for personal injury, flooding, degraded fish and wildlife habitat due to sedimentation and pollution, poor aesthetics, and diminished land uses.

The headwaters area of the Pleasant Run watershed north of the Western Kentucky Parkway known as the Bunt Sisk Hills is a significant contributor of sediment and acid mine drainage into Pleasant Run. Mining has disturbed 360 hectares (900 acres) in the headwaters of Pleasant Run with an additional 340 hectares (850 acres) disturbed east of the headwaters in the Bunt Sisk Hills area. The original mining in the Bunt Sisk Hills area occurred from the 1940's through 1958 by the Peabody Coal Company and were a part of the Homestead Mine. The mining resulted in pits and spoil ridges with inadequate vegetative cover subject to widespread weathering. Drainage patterns have been significantly altered with numerous impoundments and pits located between spoil ridges. Most of the pits and impoundments are acidic with high concentrations of dissolved minerals leached from the spoil piles and underclays. Extensive areas of unvegetated coal refuse and coal processing tailings from tipple and coal processing operations have been deposited throughout the headwaters area of Pleasant Run. Erosion of these areas has resulted in large sediment loads of acid forming coal refuse washing into Pleasant Run killing vegetation and aquatic life.

Areas to the east of U.S. 41-A were part of the White City Mine mined by Peabody Coal Company. Mining has disturbed approximately 120 hectares (300 acres) in this area of the watershed. Numerous smaller permits remined various sites within this larger disturbance. Most of this activity was by the Russell Badgett Coal Company under its Sextet and Chip #1 mines, with mining ceasing by 1975.

South of U.S. 62 along the southern boundary of the Pleasant Run watershed both strip and deep mining has occurred. Mining has disturbed approximately 40 hectares (100 acres) south of U.S. 62 and approximately 80 hectares (200 acres) immediately north of U.S. 62 in the central portion of the watershed. Several companies from the 1930's through 1976 performed mining in the area south of U.S. 62. Inadequate reclamation in this area has resulted in unvegetated spoil ridges, coal refuse piles, highwalls, pits and impoundments, open shafts, and abandoned structures and machinery, contributing large sediment and acid loads to Pleasant Run.

The coal refuse pile located within the Nortonville city limits was started by the Norton Coal Company in the early 1920's with the last date of operation being in the mid 1950's. Refuse on this site averages approximately 40 feet thick and is devoid of vegetation with approximately 20 hectares (50 acres) disturbed. The site suffers severe erosion with large amounts of acidic coal refuse and fines being deposited into Pleasant Run.

Previous Reclamation Projects

Impacts to Pleasant Run from abandoned mine lands is severe. Stream work and reclamation has been performed on various portions of the stream over the years in an attempt to alleviate localized flooding and pollution due to excessive sediment and acid loads from the un-reclaimed mine lands. To date approximately 400 acres of pre-law mining in the watershed has been reclaimed at a total cost of $4.1 Million. Previous projects include the Pleasant Run and Pleasant Run II projects that reclaimed 274 acres at a cost of $2.6 Million, and the Wice/Blue Flame Tipple Project that reclaimed 10 acres at a cost of $137,000. The Homestead Reclamation Project reclaimed 92 acres in the headwaters of the watershed at a cost of $1.4 Million. The Homestead Reclamation Project included 319 funding in the amount of $756,286.

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).

LOAD REDUCTION ESTIMATE

Sediment Load Reduction

The FFY 2005 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. Using the Revised Universal Soil Loss Equation (RUSLE) the estimated sediment load reduction from reclamation of the 13-acre Nortonville refuse site is 2073 tonnes (2285 tons) per year. As future funding allows for additional reclamation in the watershed, similar results will be obtained on the remaining impacted sites.

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).

Water monitoring was conducted in the Pleasant Run watershed from January 2005 to November 2005. Stream flow was measured and water samples were collected for analysis. Water analysis parameters included acidity determinations. Monthly acid loading was calculated for each stream segment monitored using the flow measurements and the acidity analysis results. The monthly acid loading was averaged and annual acid loading was calculated for each stream segment. The calculated acid load for monitoring site 8 at river mile 1.7, the closest monitoring point to Pleasant Run's confluence with Drakes Creek is 2000 tonnes (2204 tons) per year. The Pleasant Run project proposes to dose the Pleasant Run watershed with sand-sized limestone particles based on the acid load calculations determined by water monitoring prior to dosing. As reclamation is completed in the watershed and passive treatment systems are installed, reducing acid loading from AMD sites into the stream, dosing with limestone sand will be reduced. If dosing is 100% effective the acid load reduction in the Pleasant Run watershed will be 2000 tonnes (2204 tons) per year.

Free Hydrogen Ion Load Reduction (Increase pH)

As alkalinity in the watershed increases due to limestone dosing, reclamation activities, and the installation of passive treatment systems acidity will decrease. As acidity decreases the free hydrogen ion concentration will decrease resulting in a rise in pH. During the sampling period from January 2005 to November 2005 the pH at the monitoring point located farthest downstream in the Pleasant Run watershed ranged from 3.4 to 5.4. If the proposed project results in net alkaline conditions the minimum pH would be approximately 6.4. Due to pH's logarithmic scale an increase in pH to 6.4 would result in a reduction of free hydrogen ion concentrations ranging from 10 to 1000 times the pre-project concentrations.

Dissolved Iron Load Reduction

As pH increases above 3.5, as a result of passive treatment, dissolved iron will begin to precipitate out of solution reducing dissolved metal loads. Between January 2005 and November 2005 dissolved iron loading at the farthest downstream monitoring point in Pleasant Run located at Nortonville averaged 4.8 tonnes (5.3 tons) per month for a total of 57.6 tonnes (63.5 tons) per year. If dosing with limestone sand is successful in raising and maintaining the pH above 4.0 there will be a significant reduction in the dissolved iron load. If the pH can be maintained above 6.0 the dissolved iron load will be near zero.

Dissolved Aluminum Load Reduction

As pH increases above 4.5, as a result of passive treatment, dissolved aluminum will begin to precipitate out of solution reducing dissolved metal loads. Dissolved aluminum is particularly harmful to aquatic life. Between January 2005 and November 2005 dissolved aluminum loading at the farthest downstream monitoring point in Pleasant Run located at Nortonville averaged 5.4 tonnes (5.9 tons) per month for a total of 64.8 tonnes (71.4 tons) per year. If dosing with limestone sand is successful in raising and maintaining the pH above 5.0 there will be a significant reduction in the dissolved aluminum load. If the pH can be maintained above 6.0 the dissolved aluminum load will be near zero.

BMP IMPLEMENTATION

The FFY 2005 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.

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.

Similar reclamation techniques may be used on future projects in the watershed reclaiming the remaining abandoned mine sites to reduce sediment loads entering Pleasant Run.

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 and future projects in the watershed to reduce acid and metal loads include constructed wetlands, anoxic limestone drains (ALDs), vertical flow systems, alkaline recharge basins, open limestone channels (OLCs), 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. New designs for this treatment method include self-flushing siphon systems that retain the water for a set time period and then flush the water out of the basin through a siphon system, flushing the metal precipitates from the limestone. Flushing the metal precipitates from the crushed limestone retains the efficiency of the limestone dissolution. It should be noted that the first water into the system is retained the longest, maximizing contact time with the limestone for dissolution, and the water in the inlet pipes when the system flushes has no contact time with the limestone. To optimize treatment a second self-flushing system could be installed in series so the first water into the second system is the untreated water from the inlet pipes of the first treatment cell allowing it maximum contact time in the second cell.

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. As funding allows other reclamation techniques and passive treatment systems to be installed in the watershed dosing with limestone sand is reduced with the ultimate goal of eliminating dosing completely when reclamation in the watershed is completed.

COST ESTIMATE AND SOURCE OF FUNDING

Reduction of the acid load in Pleasant Run by dosing with limestone sand is estimated to cost $75,000 the first year of dosing, when the dosing rate is doubled to allow one year of the required alkaline material to be incorporated in the bedload of the stream, and $37,500 each year thereafter at the dosing rate calculated from the annual acid load in Pleasant Run. As reclamation is accomplished in the watershed and passive treatment systems are installed dosing will be reduced.

Pre-law mining has disturbed approximately 970 hectares (2400 acres) in the Pleasant Run watershed. Approximately 160 hectares (400 acres) have been reclaimed to date. At a cost of $25,000 per hectare ($10,000 dollars per acre) approximately $20 Million of pre-law mine reclamation remains in the watershed. Using the annual acid load of 2000 tons calculated for Pleasant Run the cost for passive treatment of the AMD in the Pleasant Run watershed over a 50-year period would equal approximately $2 Million. The total cost for the reclamation and AMD treatment of the remaining 970 hectares (2400 acres) in the Pleasant Run watershed is $22 Million.

To date the Kentucky Division of Abandoned Mine Lands (AML) has spent approximately $3.4 Million on reclamation in the Pleasant Run watershed. EPA 319 grants have totaled $765,000 for past reclamation in the watershed. For FFY 2005 AML has committed $490,000 in AML funds and the Kentucky Division of Water (DOW) has committed $720,000 in federal 319 funds for a total of $1.21 Million for reclamation in the Pleasant Run watershed. Reclamation will include reclaiming a 13 acre coal processing refuse site in the city of Nortonville, reclaiming a 47 acre sub-watershed in the headwaters of Pleasant Run, and dosing the Pleasant Run watershed with sand-sized limestone particles based on the acid loading calculations for Pleasant Run.

Future funding in the watershed will depend on the amount of federal 319 dollars available and the ability for the KY AML program to match the federal dollars. AML funds are expended on a priority basis with public safety and health being the top priority. Only a small portion of annual AML grant funds is expended on strictly environmental issues.

The only other known sources of funding are small watershed grants available through the federal Office of Surface Mining, and the EPA. These funds are awarded to watershed groups on a competitive basis.

EDUCATIONAL COMPONENT

The pollution in the Pleasant Run watershed has been a topic of concern in the local newspapers particularly the toxic refuse located in the city of Nortonville. The local newspapers will be informed of the upcoming project proposed for FFY 2005 and the status and progress of the project. The newspaper exposure should inform the local citizens of the extent of the problems in the Pleasant Run watershed and the proposed solutions. In addition the project will be featured in an article in the National Abandoned Mine Lands newsletter bringing national awareness to the problem and the solutions used to help mitigate the pollution.

SCHEDULE FOR IMPLEMENTATION

From 1980 to 2005 approximately 160 hectares (400 acres) of pre-law mine sites have been reclaimed at a cost of $4.1 Million. In 2006 an additional 24 hectares (60 acres) will be reclaimed at a cost of $1.21 Million. Approximately 80% or 785 hectares (1940 acres) will remain to be reclaimed in the watershed after the current proposed project is completed. The estimated cost to reclaim the remaining acreage and treat the AMD discharges is $20.8 Million. With only 20% of the acreage reclaimed in the past 25 years, the rate of reclamation will need to be increased significantly to accomplish the remaining reclamation in an expeditious manner. This will require a major increase in the availability of federal funds earmarked for the Pleasant Run watershed.

MILESTONES FOR IMPLEMENTATION

Several milestones have already been accomplished in the watershed including:

- Preparation of an NPS TMDL for low pH
- Establishment of a monitoring program to document current pollution loads
- Reclamation of 160 hectares (400 acres) or 20% of the disturbed acreage

Milestones that will be accomplished after the FFY 2005 Pleasant Run Project include:

- Reclamation of 24 hectares (60 acres) including a sub-watershed in the headwaters
- Limestone sand dosing of the watershed based on acid loading calculations
- Macroinvertebrate and fish sampling to document efficacy of the limestone dosing

Milestones that need to be implemented after the FFY 2005 project include:

- Securing additional funding for continued reclamation in the watershed
- Securing funding for the construction of passive treatment systems in the watershed
- Continued dosing with limestone sand at the calculated acid loading rate
- Continued water monitoring to document chemical changes in water quality

- Continued biological monitoring to document aquatic life response to dosing and reclamation
- Reclamation of the remaining mine sites. Sites should be reclaimed on a sub-watershed basis, completing reclamation in the sub-watershed as funds become available, allowing aquatic life to become re-established in the sub-watershed and the elimination of limestone sand dosing in the watershed.

CRITERIA FOR DOCUMENTATION OF LOAD REDUCTION

Water monitoring including flow, net acidity, dissolved aluminum, dissolved iron, and dissolved manganese will allow the calculation of acid loading and metal loading in the Pleasant Run watershed and any reductions in loading as dosing and/or reclamation improve water quality in the watershed.

Sediment loading reductions as a result of mine reclamation will be documented with the use of the Revised Universal Soil Loss Equation. The parameters needed to populate the soil loss equation model will be collected prior to and after construction activities on the sites proposed for reclamation.

MONITORING

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 coalmine 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.

Water Monitoring

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

Monitoring Site

Station Name	Site Number	Lat/Long
Upper Trib. of Pleasant Run	PR – 1	37° 13’ 18.2” / 87° 32’ 0.6”
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”
Lower Pleasant Run	PR – 7	37° 11’ 29.1” / 87° 25’ 40.9”

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

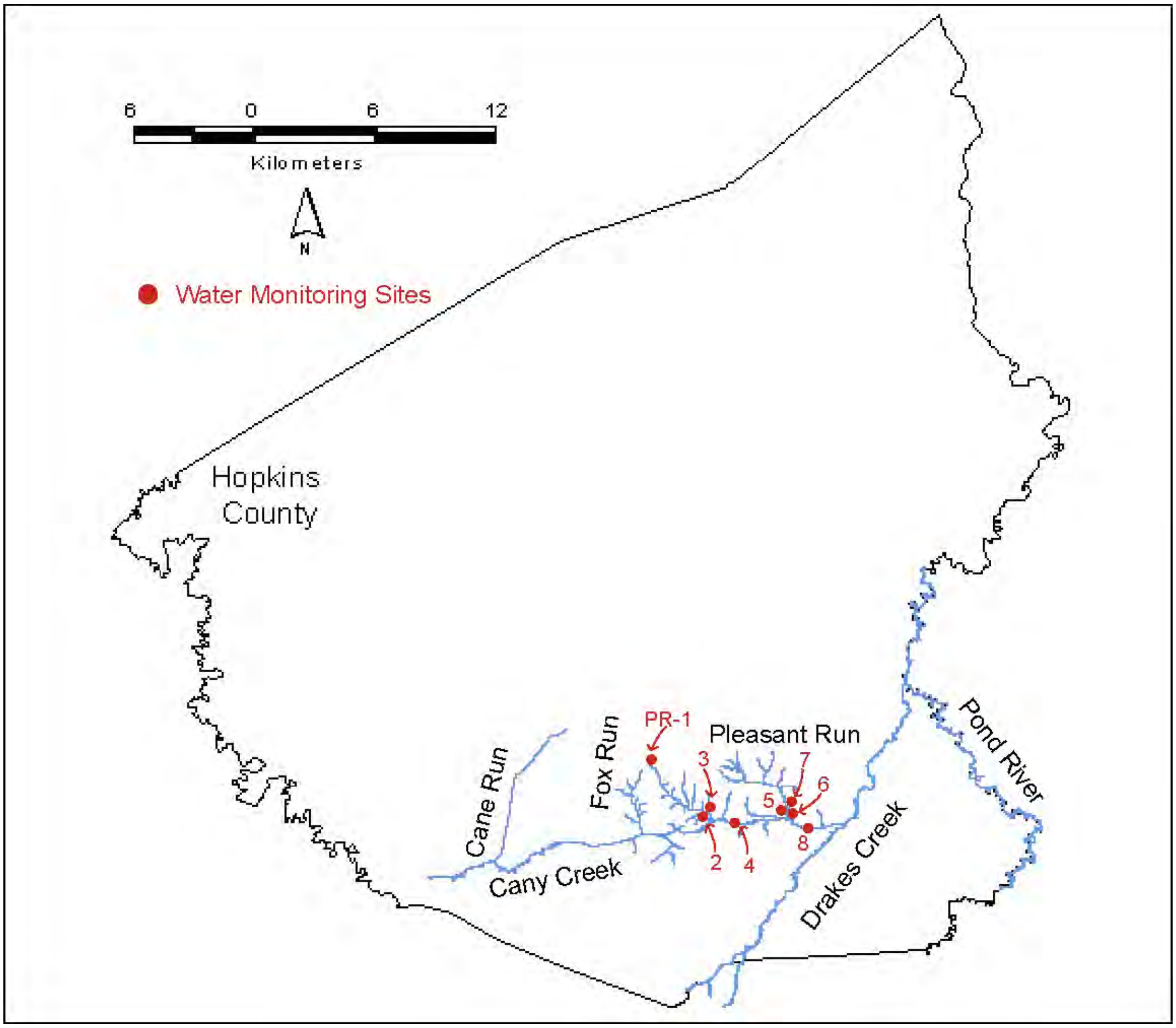

Figure 3. Location of water monitoring sites in the Pleasant Run watershed.

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 sites PR-4 and PR-7 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:

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).

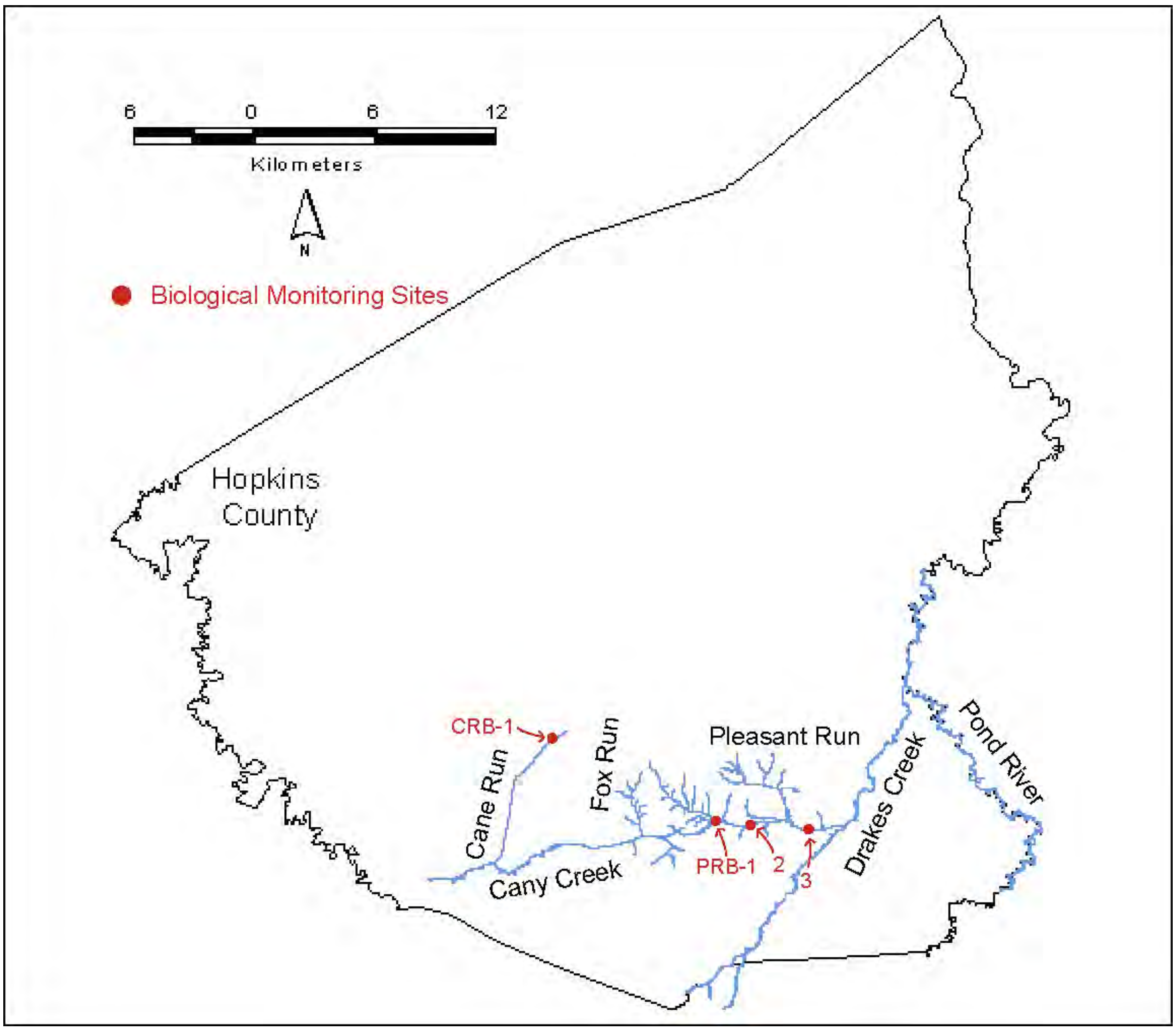

Figure 4. Biological monitoring sites in the Pleasant Run watershed.

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’ 29.1” / 87° 25’ 40.9”
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 macrotopographic 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.

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