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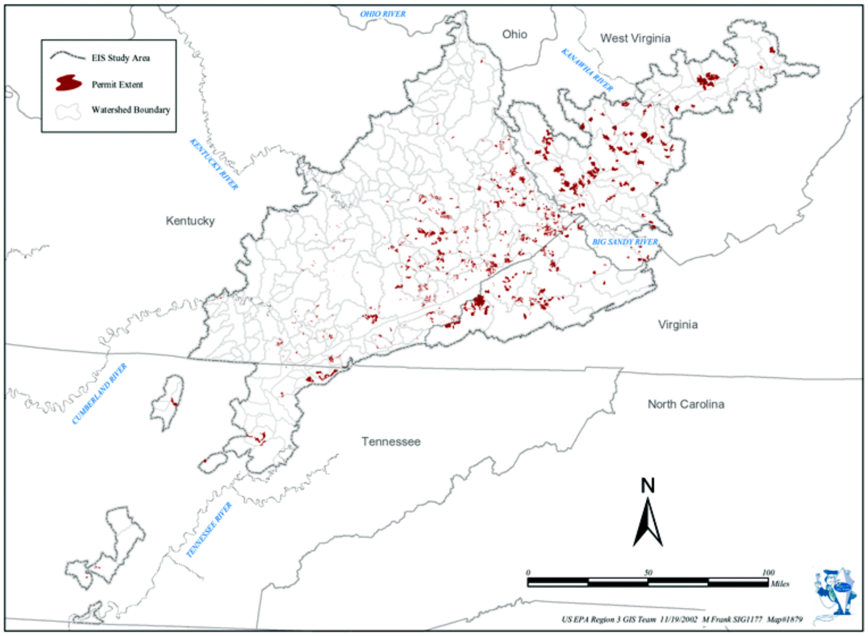
Mountaintop Mining/Valley Fills in Appalachia Draft Programmatic Environmental Impact Statement

APPENDIX I

CUMULATIVE IMPACT STUDY

Landscape Scale Cumulative Impact Study of Mountaintop Mining Operations



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Prepared By:

USEPA Region 3

With assistance from:

Gannett Fleming

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ACRONYM LIST

Acronym	Explanation
ac or Ac	Acre(s)
CEQ	Council on Environmental Quality
CPOM	Coarse Particulate Organic Matter
DEM	Digital Elevation Model
DOM	Dissolved Organic Matter
DOC	Dissolved Organic Carbon
FPOM	Fine Particulate Organic Matter
GIS	Geographic Information System
Mi	Miles
MMU	Minimum Mapping Unit
MTM/VF	Mountaintop Mining/Valley Fill
NEPA	National Environmental Policy Act
NLCD	National Land Cover Datasets
NDVI	Normalized Difference Vegetation Index
NRAC	Natural Resource Analysis Center
NRAV	Natural Resource Analysis Center (of WVU)
PEC	Potential Ecological Condition
WVGAP	West Virginia Gap Analysis Project

EXECUTIVE SUMMARY

This Landscape Scale Cumulative Impact Study evaluates the potentially adverse impacts of future mountaintop mining in a four-state study area in the Mid-Atlantic Region of the United States. The study area encompasses 12,200,888 acres within the Appalachian Coalfield Region in portions of West Virginia, Virginia, Tennessee, and Kentucky. The study area is characterized by steep mountainous slopes, confined river valleys, and narrow ridge tops. Forests dominate the land cover of the study area covering11,231,622 acres (92.1%). Ecological communities of the study area are unique in that they combine characteristically northern species with their southern counterparts, and thus boast great richness and diversity.

The potential adverse impacts of mountaintop mining in the study area are evaluated here at both a state-by-state level and the four-state study area level. Potential adverse impacts to aquatic, terrestrial, and riparian habitats are assessed. In addition, the West Virginia portion of the study area is evaluated in further detail as described below.

The study uses a Geographic Information System (GIS) approach to project future potentially adverse impacts on the natural environment within the study area by measuring specific landscape indicators. Aquatic, terrestrial, and riparian habitat data were acquired and entered into the GIS to determine pre-impact conditions of the study area. Then surface mine and valley fill spatial coverages from issued mine permits were imported into the GIS to calculate projected potentially adverse impacts. Within the West Virginia portion of the study area the GIS was used to calculate more detailed landscape indicators, some at the watershed level. The study methods build upon a Landscape Assessment Approach developed by Canaan Valley Institute and "landscape indicators" used to assess watershed conditions as described in the publication An Ecological Assessment of the United States Mid-Atlantic Region: A Landscape Atlas USEPA Office of Research and Development, Washington DC, November 1997.

Future ecological conditions in the study area are represented by the results of the landscape indicators. Landscape indicators are specific metrics (calculations) that provide an index to the health of an ecological region. Landscape indicators are direct or indirect measures of environmental parameters or combinations of parameters. By evaluating several indicators for a specific landscape unit (study area) it is possible to assess a level of ecological integrity or vulnerability to degradation.

Landscape indicator metrics calculated for each state and the four-state study area include:

- Mine permit surface area (ac)
- Direct impact to streams (mi and %)
- Direct impact to forests (ac and %)
- Grassland as indicator of past mining impact (ac and %)
- Non-forest land cover class area change (ac and %)

Landscape indicator metrics calculated in further detail for the West Virginia portion of the study area include:

- Mine data ratios (ac) - Valley fill area to mineral extraction area, Valley fill area to permit area, Mineral extraction area to permit area
- Direct impact to streams from valley fill area (mi and %)
- Direct impact to streams from mineral extraction area (mi and %)
- Direct impact to streams from permit area (mi and %)
- Forest loss from permit area (ac and %)
- Forest loss from valley fill area (ac and %)
- Forest loss from mineral extraction area (ac and %)
- Forest loss from auxiliary areas (ac and %)
- Impacts to riparian habitats (ac)
- Potential Ecological Condition (unit)
- Forest edge (%)
- Number of land cover patches (count)
- Percent landscape of patch type (%)
- Mean patch size (ac)

All metrics and the input data utilized are described in detail within the methodology section of the report. Individual metrics may not describe the complete ecological condition of a watershed. However, when considered collectively some conclusions regarding the ecological health of the watershed may be reached.

Mountaintop Mining Surface Area Metric Results

In the last ten years 403,810 acres were permitted for surface mining in the study area. Disturbance from surface mining has ecological implications in that the conversion of land use leads to a change in available habitat.

Aquatic Metric Results

The stream network used in the study is a synthetic network generated from a Digital Elevation Model (DEM). A DEM is a digital representation of the earth's surface based on a regular series of sample elevation points. The detail of a synthetic stream network generated in this fashion exceeds that of a USGS 1:24000 scale stream network. There are 58,998 miles of stream in the study area, as calculated by the synthetic network. The Kentucky portion of the study area contains more than one-half of the total stream lengths with 34,468 miles. Studies conducted in the West Virginia portion of the study area, which has over 12,000 miles of streams, indicate that first and second order streams comprise more than one-half of the total stream length in the study area.

Mountaintop mining has the potential to adversely impact 1,208 miles of stream in the study area (2.05%). The potential adverse impact to streams within the Kentucky portion of the study area is 730 miles, or 2.12%. While the greatest potential adverse impact in terms of percent of streams loss is in the West Virginia portion of the study area at 2.55%, or 307 miles.

Direct impacts to streams in the study area were calculated by mineral extraction area (0.42%) and valley fill (1.31%) that would result in actual destruction of existing streams. Indirect impacts to streams such as those that would occur downstream from filled or mined out stream areas were not evaluated in this analysis. As such, results of the direct impacts of stream metrics likely underestimates total impacts to streams.

Terrestrial Metric Results

Forests dominate the terrestrial habitats of the study area. Dominant among these forest types is the diverse mesophytic hardwood forest. This forest type is characterized by a diverse understory of trees that never attain canopy status and wildflowers are common. The cove hardwoods are a type of mixed mesophytic hardwood forest. Cove hardwoods are found in ravines, coves and along north-facing slopes. Due to the abundance and variety of fruits, seeds, and nuts the diverse mesophytic forest type provides excellent habitat for wildlife and game species alike. Grasslands and open habitats are naturally rare in the study area, therefore, species that require these types of habitats are also, generally rare in the study area.

Forest loss has the potential to impact the biodiversity of the study area in the form a floral and faunal shift with grassland species becoming more common. Likewise increases in edge habitat and forest fragmentation may lead to an increase in the number and abundance of edge dwelling species while inflicting a cost on forest interior species. Forest interior species, such as neotropical migrant birds, and terrestrial salamanders may be significantly impacted by such land use changes due largely to direct loss of critical habitat. The study area contains critical habitat for many forest interior bird species, likewise, forests in the eastern United States are among the most diverse in salamander richness and abundance in the world.

A decrease in forest cover, subsequently followed by conversion to grasslands, within the study area has the potential of shifting the fauna of the region from that which is dependent upon undisturbed intact forest to one dominated by grassland and edge dwelling species. This shift may take a considerably long amount of time to be recognized; however, some changes may be recognized immediately. This is a potentially adverse change in that many of the species that may be replaced have ranges that are restricted to the study area and nearby similar habitats. Thus, a change in these habitats could put a number of species in peril. The shift in terrestrial habitat would provide new refuge for some species that are considered rare in the study area, however, most of these species are well established in other parts of their range and are most likely rare in West Virginia because their habitat does not naturally occur there.

Results of this study support the thesis that fundamental changes to the terrestrial environment of the study area may occur from mountaintop mining. For example, it is estimated that the study area may have lost approximately 3.4% forest cover in the last ten years from surface mining. This equates to 380,547 acres. When adding past, present and future terrestrial disturbance, the study area estimated forest impact is 1,408,372 acres which equates to 11.5 % of the study area. This number is derived by adding grassland as an indicator of past mining, barren land classification, forest lost from the last ten years of surface mine permits and a projection of future forest loss that equates to the last ten years.

Much of this forest is the predominant diverse mesophytic hardwood forest, however, impacts to cove hardwood, oak, and other forest types are also expected. The predicted condition from the permit data suggests more than a 3X increase in the surface mining/quarries/gravel pits land class to 334,791 acres, and this is an underestimation because only fours years of permit data were used for the Kentucky evaluation of this metric . Not projected by the data but intuitively expected is a similar increase in the grassland cover types in the study area as mine sites move into reclamation. Furthermore, the permit data predict that edge habitat will increase by as much as 2.7% from the present condition in the West Virginia portion of the study area. Fragmentation of the terrestrial environment, predicted in the West Virginia portion of the study area, will be recognized by an increase in the number of land use patches from the present 100,392 to 139,689 and a decrease in average patch size under the permit condition.

All of these changes suggest that the biological integrity of the study area may be jeopardized. The potential ecological condition (PEC) is a measure of the biological integrity specific for eastern forests that takes into account forest cover, interior forest, and surrounding land use. PEC was calculated at the watershed level for the West Virginia portion of the study area and graphically extrapolated to predict PEC of the four-state study area. Results suggest that the predicted pre-impact PEC of study area is higher than that of the issued permits condition.

Riparian Habitat Metric Results

Riparian habitats are generally ecologically diverse and they often provide habitat for unique, or ecologically important species. For example, many neotropical migrant birds utilize this habitat type for breeding and the moist environment provides excellent habitat for salamanders. Furthermore, riparian habitats are the interface between the terrestrial and aquatic environment thus they contribute to the flow of energy between these environments. Due to the rugged topography of the study area, a large majority of the riparian habitats are associated with small, first and second order, streams.

Riparian habitats occupy 236,843 acres of the West Virginia portion of the study area. The projected potential adverse impacts in the West Virginia portion of the study area is 7,591 acres, or 3.2%. Approximately 55% of the projected riparian habitat impacts occur in first and second order streams which are important habitats to many species of salamanders and other wildlife.

I. INTRODUCTION

This Landscape Scale Cumulative Impact Study evaluates the cumulative impacts of past, present, and proposed mountaintop mining in a four-state study area of the Mid-Atlantic Region of the United States. The term mountaintop mining as used in this study refers to all surface mining in steep slope Appalachia. This study evaluates all surface mining operations in the study area that were permitted in or after 1992. Excluded from the study are permits that represent underground mining, preparation facilities, coal waste disposal areas, etc. so that only past, present, and projected surface mining activities are included. It is assumed that disturbances for permits approved before 1992 that were still operating after 1992 will be offset by digitized permits approved in recent years (2000-2002) that have not commenced.

A detailed description of the study methods is included in Section II - Methodology. In short the study evaluated impacts to both the aquatic and terrestrial environment in the four-state study area using digitized permit polygons and land cover data imported into a geographic information system (GIS).

In an attempt to relate the project impacts to cumulative impacts in the natural environment the study further evaluated a portion of the study area (West Virginia) in greater detail using methods built upon a Landscape Assessment Approach developed by Canaan Valley Institute and "landscape indicators" used to assess watershed conditions as described in the publication *An Ecological Assessment of the United States Mid-Atlantic Region: A Landscape Atlas* USEPA Office of Research and Development, Washington DC, November 1997. The detailed West Virginia-based study evaluated the future impacts based on permit data that was 60% complete.

Future ecological conditions in the study area are represented by the results of the landscape indicators. Landscape indicators are specific metrics that provide an index to the health of an ecological region. Landscape indicators are direct or indirect measures of environmental parameters or combinations of parameters. By evaluating several indicators it is possible to assess a level of ecological integrity or vulnerability to degradation relative to other watersheds.

All metrics and the input data utilized are described in detail within the methodology section of the report. Individual metrics may not describe the complete ecological condition of a watershed; however, when considered collectively some conclusions regarding the ecological health of the watershed may be reached.

The report begins with a brief description of aquatic and terrestrial habitats. Factors such as forest fragmentation are discussed as they relate to the study area habitats. Section II of the report details the study methodology including a description of the metrics and the geographic data sets. Section III presents the landscape indicator metric results including tables, figures and graphs. Section IV presents a discussion of the ecological significance of the landscape indicator metric results.

A. STUDY AREA

The study area includes eastern Kentucky, northwest Virginia, southwestern West Virginia and a small portion of Tennessee (Figure I.A-1). It covers an area of 12,200,888 acres. The study area is located within portions of nine ecological subregion sections (refer to Figure I.A-1).

Analysis at the ecological subregion level is of considerable value when the purpose is for strategic, multi-forest, statewide, and multi-agency assessment because several variables are considered when defining the boundaries of each ecological subregion (U.S. Forest Service, USDA, 2002). The ecological units of an ecological subregion analysis are termed *sections*. Within an ecological subregion section geomorphology, lithology, soils, vegetation, fauna, climate, surface water characteristics, disturbance regimes, land use, and cultural ecology are generally similar.

The percent of each ecological subregion section in the study area is outlined in Table I.A-1. Nearly 90% of the North Cumberland Mountains Ecological Subregion lies within the study area.

Characteristics of each ecological subregion section of the study area are summarized in Table I.A-2.

Table I.A-1

Ecological Subregion Section in the Study Area

Ecological Subregion	Percent in Study Area (%)
Allegheny Mountains	6.5
Central Ridge and Valley	0.4
Interior Low Plateau, Bluegrass	0.4
Interior Low Plateau, Highland Rim	0.7
Northern Cumberland Mountains	89.7
Northern Cumberland Plateau	57.9
Northern Ridge and Valley	0.9
Southern Cumberland Mountains	49.2
Southern Unglaciated Allegheny Plateau	11.0

Source: U.S. Forest Service, USDA, 2002

Table I.A-2

Ecological Subregion Section Characteristics

Ecological Subregion	Geomorphology (Province)	Natural Vegetation (Forest Type)	Climate (mean annual)
Allegheny Mountains	Appalachian Plateaus	Northeastern Spruce-Fir Northern Hardwoods Mixed Mesophytic Oak-Hickory-Pine	Prec: 46-60" Temp: 39-54˚F
Central Ridge and Valley	Ridge and Valley	Appalachian Oak	Prec: 36-55" Temp: 55-61 ˚F
Interior Low Plateau, Bluegrass	Interior Low Plateaus	Oak-Hickory	Prec: 44" Temp: 55 ˚F
Interior Low Plateau, Highland Rim	Interior Low Plateaus	Oak-Hickory	Prec: 44-54" Temp: 55-61 ˚F
Northern Cumberland Mountains	Appalachian Plateaus	Mixed Mesophytic Appalachian Oak Northern Hardwoods	Prec: 40-47" Temp: 45-50 ˚F
Northern Cumberland Plateau	Appalachian Plateaus	Mixed Mesophytic Appalachian Oak	Prec: 46" Temp: 55 ˚F
Northern Ridge and Valley	Ridge and Valley	Appalachian Oak Oak-Hickory-Pine Northern Hardwoods	Prec: 30-45" Temp: 39-57 ˚F
Southern Cumberland Mountains	Appalachian Plateaus	Appalachian Oak Mixed Mesophytic	Prec: 46" Temp: 55 ˚F
Southern Unglaciated Allegheny Plateau	Appalachian Plateaus	Mixed Mesophytic Appalachian Oak	Prec: 35-45" Temp: 5

Source: U.S. Forest Service, USDA, 2002

The study area is located within the Appalachian Coalfield Region of the Appalachian Plateau physiographic province and Bituminous Coal Basin. The rugged terrain of this region is generally characterized by steep mountain slopes, confined river valleys, and narrow ridge tops. The geologic processes and climatic conditions responsible for the formation of these land forms, have as a result, helped to determine the past and present land use and land cover of the region. The ecological communities of the study area are unique because they combine characteristically northern species with their southern counterparts, and thus boast enormous richness and diversity.

B. AQUATIC HABITATS

Lotic or flowing aquatic systems are important landscape features in the study area. Lotic systems may be considered to include rivers, streams, and creeks and springs. This section will discuss the types, features and functions of lotic systems in the study area.

1. Representative Streams

a. Physical Characteristics

Numerous physical parameters such as flow volume, substrate (i.e., the stream bottom made up of cobbles, gravel, sand, etc.), water chemistry, and bank cover influence the biota of the aquatic systems in the study area. These parameters are determined by the climate, lithology, relief and land use in the area of a particular stretch of stream.

b. Stream Classification

Streams are generally classified through a system called stream ordering (Strahler, 1957). This system classifies streams based on size and position within the drainage network. A first-order stream is defined as not having tributaries. The confluence of two streams of the same order produces the next highest order. For example, the joining of two first-order streams results in a second-order stream. The joining of two second-order streams produces a third-order stream, etc. Headwaters are usually classified as first- through third-order streams, mid-sized streams as fourth- through sixth-order streams, and larger rivers as seventh- through twelfth-order streams (Ward, 1992).

c. Habitats in Streams

Generally, headwater streams originate at high elevations in the study area. Substrate patterns in headwater streams channels are typically comprised of coarser material such as boulders, cobble rubble and bedrock. Large, woody debris often contribute to the substrate complexity in headwater streams. Small pools with finer sediments may also be found along headwater streams. Typical substrate patterns in larger rivers are comprised of finer material such as silt and sand. Mid-sized rivers typically contain a blend of cobble and gravel with some finer sediment interspersed in areas of slower flow.

The combination of substrate characteristics and varying flow rates and other flow characteristics (hydrologic cycles, flow patterns, load transport and storage) produce channel features such as riffles, runs, and pools. Riffles are erosional habitats where surface water flows over coarser substrate, creating turbulence, which causes disturbances in the surface of the water. This turbulence increases levels of dissolved oxygen by encouraging the mixing of oxygen in the air with the water. Pools are depositional areas where flow is slow or stagnant, allowing finer particulate matter to settle onto the stream bottom. Runs are moderately fast sections of streams where the water surface is not as disturbed. Headwater streams, typically consist of alternating riffles and runs though small depositional pools, may be present and represent an important microhabitat. Mid-sized rivers typically contain all three features because increased width and depth allow more variation in flow.

Stream features that are important in determining habitat for aquatic organisms include, overhanging vegetation, the presence and characteristics of leaf packs, in-stream vegetation, large woody debris, undercut banks, and exposed tree roots. Overhanging vegetation consists of riparian shrub and herbaceous vegetation on banks that grows over and sometimes into the surface water. In-stream vegetation occurs where proper substrate and flow conditions allow growth. Snags are pieces of wood that have accumulated in a stream area. Undercut banks and exposed tree roots are caused by a combination of unstable banks and fast streamflow. All of these features provide unique habitat for cover, habitat, and food for macroinvertebrates and fish.

Other in-stream features that provide additional habitat include littoral areas such as shorelines, sandbars, and islands. Typically these features exist most prominently in depositional systems such as larger rivers. These littoral areas are shallow habitats, which provide habitat for smaller fish and macroinvertebrates that are unable to live in the deeper sections of the river.

2. Energy Sources and Plant Communities

Aquatic ecosystem energy sources consist of allochthonous (material produced outside the stream such as leaves, wood, etc.) and autochthonous (instream primary production by plants, algae) sources. Allochthonous organic material includes leaves and woody material. These materials reach the stream either through directly falling into the stream or through indirectly being transported into the stream, commonly though wind movement or runoff. Allochthonous organic material has been found to be the predominant energy source in high-gradient streams of the southern Appalachians (e.g., Hornick et al., 1981, Webster et al., 1983, Wallace et al., 1992). Headwater energy sources are utilized, not only by invertebrates and vertebrates in upper reaches of the watershed, but, excess organic carbon is subsequently utilized by life forms in all stream orders down gradient. Since streams have a unidirectional flow, downstream areas are also dependent on upstream areas for portions of their energy (Vannote et al. 1980).

Plant communities of high-gradient streams live in what may be considered to be a physically challenging environment. Frequently these habitats are densely shaded and subject to high current velocities. As a result, the plant communities in high-gradient streams are reduced relative to lentic habitats and low-gradient streams (Wallace et al., 1992). However, the plant communities occurring in high-gradient streams contain flora uniquely adapted to survive in this type of environment. This habitat also supports an abundance of flora considered to be endemic (i.e., not found in other locations) to the region (Patrick, 1948). Possibly, the historic lack of direct anthropogenic (human-induced) disturbance to watersheds of high-gradient streams may have contributed to the survival of the unique and endemic flora of this region (Wilcove et al., 1998).

a. Primary Producers and Primary Production

Primary production is the input of energy into a system by the growth of flora living in the system. In streams, primary production is generally measured as mass of carbon or ash free dry mass, which is largely carbon, per unit area, per year. Primary production rates in Appalachian streams have been shown to vary with stream order, season, degree of shading, nutrients, and water hardness (Wallace et al., 1992). Although under some circumstances, gross primary production can be high (see Hill and Webster 1982b [in Wallace et al., 1992]), typical primary production inputs appear to range from approximately 9 to 446 pounds of carbon per acre of stream per year (Keithan and Lowe 1985, Rodgers et al., 1983, Wallace et al., 1992). Primary producers in Appalachian streams include vascular plants, bryophytes and algae.

b. Allochthonous Energy Sources and Processing

Allochthonous energy sources consist primarily of leaves and woody material. However, dissolved organic carbon (DOC) from a variety of sources is an additional allochthonous energy source. Sources of DOC external to the stream include groundwater or runoff. Sources internal to the stream relate largely to leaching of organic matter from detritus or other organic matter. Fisher and Likens, in Science Applications International Corporation (1998), explain that over 90 percent of the annual energy inputs to small forested streams can be attributed to leaf detritus and dissolved organic carbon from the terrestrial environment. Webster et al. (1995) further discusses sources for organic inputs to streams.

The estimate of almost 3600 pounds of carbon per acre of stream per year developed by Bray and Gorham (1964) as a measure of leaf and wood litterfall into a stream per year, is considered to be a good estimate for input into high-gradient Appalachian streams. The mass of material input as leaf fall is generally greater than that input as woody material. However, in some circumstances the mass of input as woody material may equal that of leaf input (Webster et al., 1990).

The headwater stream (first- through third-order) is the origin for energy processing within the river ecosystem. Headwater streams in the study area are located in forested areas and are characterized by a heavy leaf canopy and low photosynthetic production. Sources of energy for headwater streams are allochthonous in origin or derived from the terrestrial environment. The vast majority of this allochthonous material arrives in the streams in the form of Coarse Particulate Organic Matter or CPOM (> 1 mm in size). Smaller amounts of other allochthonous material that is transported to the stream includes Fine Particulate Organic Matter (FPOM, 50 um – 1 um in size) and Dissolved Organic Matter (DOM) traveling from surface and groundwater flow. Microbes and specialized macroinvertebrates living in headwater streams, called shredders, feed on the DOM and CPOM, converting it into FPOM and DOM. The FPOM and DOM are carried downstream to mid-sized streams.

Because mid-sized streams (fourth- through sixth-order) are wider than headwater streams, the canopy is usually more open and more light is able to penetrate to the stream bottom. As a result, a greater abundance of algae and aquatic plants are able to grow along the stream bottom. In general, the contribution of allochthonous material derived from terrestrial vegetation in midsized streams is less than in the headwater streams. Autochthonous material, meaning material that is derived from within the stream, becomes an important component of the energy budget in midsized streams.

3. Animal Communities

a. Invertebrates

Stream order typically dictates the community structure of the resident aquatic life. Headwater streams harbor primarily benthic macroinvertebrate communities who are specialized to feed on the CPOM deposited in the system. Examples of benthic macroinvertebrates include crayfish, worms, snails and flies. The majority of benthic macroinvertebrates in headwater streams are classified as shredders and collectors, who feed on the CPOM and FPOM, and predators who feed on the other macroinvertebrates. Typical benthic macroinvertebrates found in headwater streams in the study area include insects such as mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), dragonflies and damselflies (Odonata), beetles (Coleoptera), dobsonflies and alderflies (Megaloptera), true bugs (Hemiptera), springtails (Collembola), and true flies (Diptera). Other macroinvertebrates that have been collected include crayfish (Decapoda), isopods (Isopoda), worms (Oligochaeta and Annelida) and snails (Gastropoda) (FWS, 1998; Science Applications International Corporation, 1998).

In the southern Appalachian Mountains, macroinvertebrates of several orders including Ephemeroptera, Plecopter and Trichoptera have been found to be rich in species, including many endemic species and species considered to be rare. This diversity and unique assemblage of species has been attributed to the unique geological, climatological and hydrological features of this region (Morse et al., 1993, Morse et al., 1997). Many biologists agree that the presence of a biotic community with such unique and rare populations should be considered a critical resource.

b. Vertebrates

Two groups of vertebrates, fish and salamanders are the major stream-dwelling vertebrates in the study area. Typically, salamanders occupy small, high-gradient headwater streams while fish occur farther downstream. Predation by fish is believed to restricts salamanders to the smaller streams or the banks of large streams (Wallace et al., 1992).

Fish species present in headwater streams tend to be representative of cold water species, and primarily sustained by a diet of invertebrates (Vannote et al, 1980). As found with invertebrates and amphibians, the fish assemblages of the Appalachians tend to contain a relatively large number of endemic and unique species. Some fish species collected in the pristine headwaters of West Virginia include blacknose dace (*Rhinichthys atratulus*), creek chub (*Semotilus atromaculatus*), and slimy sculpin (*Cottus cognatus*) (FWS, 1998).

Many different kinds of amphibians and reptiles live in or near streams and wetlands. Many types of amphibians in particular are unique to the Appalachian regions. The West Virginia Division of Natural Resources has published a pamphlet, "Amphibians and Reptiles of West Virginia: A Field Checklist." This list mentions 46 amphibious species and 41 reptilian species, the vast majority of which are most likely located throughout the study area within suitable habitat of Kentucky, Tennessee, and Virginia. Many of these amphibious and reptilian species may be primarily terrestrial, but live in proximity to aquatic areas such as streams and wetlands. In addition, several species strictly rely on the presence of streams or wetlands for at least part of their life cycle (Conant and Collins, 1991).

It is difficult to predict what fish species will be found in a stream with a particular stream order designation. For example, one would expect a much higher diversity of fishes in a first-order stream that empties directly into a fourth-order stream than would be found in a first-order stream that joins with another first-order stream to form a second-order stream. It would be wrong to interpret the higher diversity in the first case as being indicative of a healthier or cleaner stream. In general, fish diversity is greater in higher-order streams, but certainly so-called “big river” fishes will enter first-order streams, when these streams drain directly into higher order lotic systems (Stauffer, 2000).

4. Ecosystem Function

The value of headwater streams in the study area was the subject of a symposium held in April 1999. The proceedings of this symposium are summarized below.

Small streams play a pivotal role in lotic ecosystems. Small streams:

- Have maximum interface with the terrestrial environment with large inputs of organic matter from the surrounding landscape
- Serve as storage and retention sites for nutrients, organic matter and sediments
- Are sites for transformation of nutrients and organic matter to fine particulate and dissolved organic matter

- Are the main conduit for export of water, nutrients, and organic matter to downstream areas (Wallace in Symposium on Aquatic Ecosystem Enhancement at Mountain Top Mining Sites, January 2000)

The major functions of headwater streams can be summarized into two categories, physical and biological (Wallace in Symposium on Aquatic Ecosystem Enhancement at Mountain Top Mining Sites, January 2000):

Physical

- Headwater streams tend to moderate the hydrograph, or flow rate, downstream
- They serve as a major area of nutrient transformation and retention
- They provide a moderate thermal regime compared to downstream waters- cooler in summer and warmer in winter
- They provide for physical retention of organic material as observed by the short "spiraling length"

Biological

- Biota in headwater streams influence the storage, transportation and export of organic matter
- Biota convert organic matter to fine particulate and dissolved organic matter
- They enhance downstream transport of organic matter
- They promote less accumulation of large and woody organic matter in headwater streams
- They enhance sediment transport downstream by breaking down the leaf material
- They also enhance nutrient uptake and transformation

In summary, light and the input of allochthonous material are the two limiting factors in the contribution of energy to a river ecosystem as a whole. When an energy source is altered or removed in the upstream reaches, downstream biological communities are also affected. The value of headwater streams to the river ecosystem is emphasized by Doppelt et al. (1993): "Even where inaccessible to fish, these small streams provide high levels of water quality and quantity, sediment control, nutrients and wood debris for downstream reaches of the watershed. Intermittent and ephemeral headwater streams are, therefore, often largely responsible for maintaining the quality of downstream riverine processes and habitat for considerable distances."

C. TERRESTRIAL HABITATS

Forests dominate the terrestrial habitats of the study area. Data provided by the West Virginia Gap Program indicates that at least nine forest types are located within the WV portion of study area. Dominant among these forest types is the diverse mesophytic hardwood forest. The diverse mesophytic forest is among the most diverse forest type in the southeastern United States (Hinkle et al.,1993). Yellow poplar (*Liriodendron tulipifera*) is the predominant species in the diverse mesophytic forest type in the Central Appalachians (Hicks, 1998); however, dominance is shared by a large number of species including various oaks (*Quercus* spp.), maples (*Acer* spp.), beech (*Fagus grandifolia*), hickories (*Carya* spp.), cherry (*Prunus* spp.), and black walnut (*Juglans nigra*), to name but a few (Strausbaugh and Core, 1997). This forest type is characterized by a diverse understory of trees that never attain canopy status and wildflowers are common.

The cove hardwoods are a type of mixed mesophytic hardwood forest. They are included here because species common to the cove hardwoods are likely common to the mixed mesophytic hardwood forest type as well due to their spatial relationship. Cove hardwoods are found in ravines, coves and along north-facing slopes. Often, pure stands of yellow poplar are the hallmark of the cove hardwood forests (Hicks, 1998). Species composition can be very diverse with red oak (*Quercus rubra)*, pin cherry (*P. pennsylvanica*), black cherry (*P. serotina*), paper birch (*Betula papyrifera*), yellow birch (*B. alleghaniensis*), aspen (*Populus* spp.), sugar maple (*A. sacchaum*), red maple (*A. rubra*), and Eastern hemlock (*Tsuga canadensis*) dominating (Strausbaugh and Core, 1997). Local species dominance patterns are often small scale with significant species changes over relatively short distances.

Due to the abundance and variety of fruits, seeds, and nuts the diverse mesophytic forest type provides excellent habitat for wildlife and game species alike. Wildlife species richness of the mixed mesophytic forests of the study area are considered one of the most diverse in the United States (Hinkle et al., 1993). Factors associated with the terrestrial habitats of the study area are described in detail below.

1. Defining Factors Associated with the Terrestrial Habitat

a. Forest Fragmentation

The phrase forest fragmentation describes a formerly continuous forest that has been broken into smaller pieces. Forest fragmentation occurs when an activity removes some forest and leaves remaining stands in smaller isolated blocks. The pattern of forest loss is as important as the amount of loss. A checkerboard pattern of remaining forest represents more forest fragmentation than clumps of forest of the same total acreage.

The degree of forest connectivity can affect the sustainability of forest species within and among a landscape. However, connectivity can sometimes be misleading. For example, a series of small woodlots may be connected and creating substantial area yet they make lack the interior forest needed to support certain species. Areas with large blocks of continuous forests support a variety of interior forest species, e.g., neotropical migrants, pileated woodpecker, etc., whereas areas with small fragmented forests tend to support fewer interior forest species with more edge dwelling species.

b. Edge Habitat

Edge habitat occurs at boundaries between different types of land cover. Many wildlife species require resources in two or more vegetation types and thus require edge habitat. Some species of birds forage in grasslands and nest in forests. Nest parasitic bird species such as brown-headed cowbirds (*Molothrus ater*) have their greatest impact on other native species in areas where edge habitat is common (Robinson et al., 1995 and citations within). For instance, the brown-headed cowbird is a native species of open prairies of the American mid-west but has spread to all of eastern North American due to the conversion of forests to agricultural lands. This species is essentially absent from interior forests but common along edge habitat ecotones. As forests are fragmented and edge habitat increases, interior species such as the ovenbird, hooded warbler, and wood thrush, are subject to nest parasitism by cowbirds, and thus decreased rates of reproductive success (Buckelew and Hall 1994, Robinson et al., 1995).

The outer boundary of a forest is not a line, but rather a zone that varies in width. Meffe and Carroll (1994) report of edge zones in Wisconsin that are as small as ten meters to those in Queensland that are as great as 500 m. The breadth of edge zones may well have to do with microclimatic differences associated with the edge. Edge zones are usually drier and receive more sunlight than interior forests and thus have a different floral composition, favoring shade-intolerant species. Microclimatic edge effects such as this may have a negative effect on interior species of the patch through altering of the physical environment and competition for resources. On the other hand, due to the different microclimate associated with the edge ecotone, these habitats are often more diverse than the interior habitat.

Edge effect is usually used to describe two phenomenon associated with edge habitats. Often, the phrase edge effect is used to describe the negative influence that edges have on the interior of a habitat and on the species that use the interior habitat, like the microclimatic differences described above. Furthermore, edge effect can be used to describe the increase in species richness often observed at the ecotone of forest edges.

c. Patches

Patch size refers to the area of a particular habitat or reserve within a landscape. The basic species-area relationship (MacArthur and Wilson, 1963) implies that larger patches sustain a greater number of species of a region than do smaller patches. This is due, in part, because large patches have an increased chance for immigration. Another reason that this relationship is due to an increase in habitat heterogeneity as patch size gets larger. Larger patches are also more likely to be able to accommodate disturbances than smaller patches. As patch size decreases forest perimeter-to-volume ratios increase, thereby increasing edge effects and reducing the amount of interior habitat.

Another aspect of patch size is isolation. Small, isolated patches are more prone to species extinctions than large patches and small groups of closely spaced patches because they are less likely to be colonized (MacArthur and Wilson, 1963). Isolation leads to a loss in genetic diversity and often to an increase in deleterious gene frequencies within the isolated populations. Isolation is a major cause of vicariant speciation but at the same time it is a major cause in species extinction (Brown and Lomolino, 1998). Vicariant event speciation describes the presence of two closely related yet disjunct species that are assumed to have been created when the range of their ancestor was split.

d. Biological Integrity and Potential Ecological Condition

Biological integrity refers to the ability of an environment to support and maintain a balanced and integrated adaptive assemblage of organisms having species composition, diversity, and functional organization comparable to that of an undisturbed habitat within the same region (Karr et al., 1986). Generally, the term biological integrity is limited to use of aquatic habitats where it has received much recent attention because of the terms use in the Clean Water Act (section 101(a)). However, the principal of biological integrity applies to all ecosystems. One measure of the biological integrity of the terrestrial environment is the potential ecological condition (PEC), also known as the bird community index (O'Connell et al., 1998). PEC and how it is calculated will be discussed in detail in Chapter II. Methodology, later in this report. Bird guilds are used as models in the PEC calculation, however, the results are applicable for all taxa that depend on interior forests (O'Connell et al. 1998; O'Connell et al., 2000). PEC is an effective measure of biologic integrity in that it takes into account measures of forest cover, interior forest habitat, and human use conditions to generate a value for a location (watershed or study area) that can be compared with values modeled from other locations or under different disturbance regimes. These modeled changes in PEC are equivalent to a change in biological condition, thus the link between biological integrity and PEC.

e. Interior Forest Habitat

A variety of wildlife species require large tracts of continuous forest cover for their survival. For example, the cerulean warbler, *Dendroica cerulea*, is a common bird of mixed mesophytic and Appalachian oak forests in West Virginia. This migratory species commonly occupies the heavily leafed canopy of mature forests during summer months and is rarely seen. Studies suggest that a minimum area of 700 hectares is required for sustaining a viable population of this species (Buckelew and Hall 1994). Robbins et al. (1989a) addressed habitat area requirements for a large number of forest-dwelling birds in the central Appalachians. Of the 75 forest and forest-edge species included in the study, none was restricted to small forests and many had minimum breeding habitat requirements greater than 3,000 hectares (Robbins et al., 1989b).

There are several reasons why interior forest habitat is required for the breeding success of many forest birds. One factor is the increased diversity of microclimates within larger forest patches. A second reason is the significantly higher rates of nest predation in small forest patches (Brittingham and Temple, 1983; Small and Hunter, 1988). Finally, Robbins et al. (1989) suggests that the short breeding period associated with neotropical migrants when compared to year-round residents leads to increased susceptibility to negative environmental influences like nest predation and brood parasitism. In short, many neotropical migrant species are forced to breed in large tracts of interior forest because they only have time for one breeding event per year.

2. Relating the Terrestrial Factors to Biodiversity

The term biodiversity is used to describe the variety of living organisms and can be applied to various levels of biological organization. For example, biodiversity may be implied at the genetic, species/population, or ecosystem levels. Often, biodiversity is used to describe the variety of a higher taxonomic order, birds for instance, in a region or study area. The terrestrial factors described above all have the potential to exert a considerable affect on biodiversity at one or numerous of the levels biological organization and scale. Below is some discussion that attempts to relate the terrestrial factors discussed above with biodiversity at both the watershed (local) and study area (regional) spatial levels.

a. Forest Fragmentation

Some of the effects of habitat fragmentation occur almost immediately while others develop over decades (Meffe and Carroll, 1994). The most notable effect of fragmentation is the loss of a particular species from the fragmented landscape. Data suggests that habitat destruction is responsible for more than one-half of the species lost. Endemic species, those with a very narrow distribution range limited to a specific habitat, may exhibit immediate loss or local extinction of populations. Meanwhile, species that are not rare or endemic may be affected at a much slower rate.

Take for example the reduced nesting/reproductive success of midwestern (United States) migratory birds in response to forest fragmentation (Robinson et al., 1995). Robinson et al. (1995) suggests that forest fragmentation leads to increase nest predation and ultimately to establishment of migratory bird populations that are unable to sustain themselves without immigration from non-fragmented habitats. Populations that exist this way are referred to as “sinks” depending solely on immigration from the “source” population for survival (Pulliam, 1988). By definition, a source habitat has reproductive success greater than local mortality, whereas, a sink habitat has mortality rates higher than reproductive rates. Thus, individuals living in sink habitats are on the brink of local extinction. However, so long as the source population is unaffected and immigration routes remain open, recolonization will likely take place following local extinction.

The reason that sink populations are unable to achieve reproductive success greater than mortality is generally a condition of the local environment. This condition may be associated with isolation, introduced species, loss of critical habitat, or any of a number of possible conditions. In any case, the effect likely exhibited on the species is the loss of a genetically effective population size. Genetic diversity is a key for the long-term survival of populations. Genetic variation is important to both fitness of the individual and adaptive change. Small populations generally are less genetically diverse than large populations and this decrease in genetic diversity tends to result in a reduced evolutionary adaptive fitness (ability to change with a changing environment) and ultimately to local extinction.

Thus, we can conclude that forest fragmentation exerts its effect on biodiversity at various levels of biological organization and spatial scales. A decrease in genetic diversity may lead to local extinction of a population while the local extinctions of many populations in a region may lead to a decrease in biodiversity at a broader landscape level.

b. Edge Habitat

Ecological processes that structure biological communities may change as a result of edge effects (Meffe and Carroll, 1995). These changes may be the result of an increase in those species that are attracted to edges and the decrease in those species that have characteristics that make them unsuitable for edge habitat. For example, Klein (1989) describes the decline of beetles from edge habitat compared to interior forest because beetle larvae were desiccating in the drier soils along the edge. It is unlikely that edge habitat itself would have considerable impact on genetic biodiversity. Obviously, habitat fragmentation associated with edge habitat does have a major impact on genetic variation as described above. The affect that edge habitat has on biodiversity is likely more at the species/community and ecosystem levels. Edge habitats tend to attract certain species of animals (Gates and Gysel, 1978) and this would lead to a shift in the composition of ecological communities.

At the broader landscape level, increased edge habitat would lead to an increase in edge favoring species and a decrease in numbers of those species associated with interior forests.

c. Patches

Patches and habitat fragmentation go hand-in-hand. Therefore, the affects that fragmentation has on genetic, species/population, and ecosystem diversity described above also apply to this topic. As fragmentation increases so do the number of patches in the landscape. Furthermore, an increase in fragmentation is generally associated with a decrease in the average size of patch types. One aspect of patches is associated with rare and endemic species. Some species have life history characteristics that limit their distribution to a small, defined patch or set of patch types. Thus, loss of a critical habitat across the region may lead to the complete extirpation of a species or group of species from the landscape.

d. Biological Integrity and Potential Ecological Condition

The measure of PEC is basically a measure of the biological condition of the terrestrial habitat. It is a tool that assigns a value to an area that can be interpreted as a measure of biodiversity. Since PEC takes into account ecosystems, not individuals, it is a tool that approximates the ecosystem biodiversity. Quite simply, PEC is a measure of the terrestrial ecosystem biodiversity at either the local (watershed) or regional (study area) level.

e. Interior Forest Habitat

Interior forest habitat is important to many species, in particular birds. Birds exhibit many traits that make them excellent indicators of ecological conditions at both a local and regional level (USEPA 2000). Ecological indicators describe the condition of an ecosystem or one of its critical components. Different bird species require different habitats for foraging, shelter, and breeding. Thus, bird populations are linked to an ecological condition and both are linked to a habitat or land cover type.

Many of the birds of the study area have minimum forest area requirements. These birds are considered forest interior species and their presence in the landscape is a good indication that excellent ecological conditions exist. Robbins et al. (1989) defined habitat area requirements for 75 species of birds in the Middle Atlantic States. Among the 75 birds included in the study, 19 were neotropical migrants. Declines in populations of neotropical migrants from eastern states have been well documented (Hutto, 1988; Robbins et at., 1989b; Penhollow and Stauffer, 2000). Causes for neotropical migrant population declines have been attributed to agriculture, urban and suburban sprawl, and deforestation (Askins et al., 1990). These declines are likely due to factors associated with forest fragmentation, as described above. Once habitats of contiguous interior forest become fragmented the factors described above (see Forest Fragmentation discussion) that effect biodiversity come into play.

D. RIPARIAN AND WETLAND HABITAT

Wetlands and riparian zones may occur along streams. Wetlands and riparian zones may influence the physical characteristics of streams, thereby affecting stream habitats. In addition, wetlands and riparian zones may be used by stream biota directly during periods of elevated flow. Wetlands are crucial transition zones between terrestrial and aquatic habitats. They are defined as areas "that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (COE, 1987). Wetlands can be found on floodplains along rivers and streams (riparian wetlands). Typical steep geomorphology of headwater streams usually prohibits the formation of a floodplain, so wetlands are usually restricted to small depressional areas. As the gradient of the land becomes more gradual, more wetlands are found on the floodplain of the stream. Wetlands associated with rivers can take the form of forested wetlands, emergent marshes, wet meadows or small ponds. The unique characteristics and vegetative composition of wetlands provide important habitat for many species of aquatic macroinvertebrates, amphibians, and reptiles.

II. METHODOLOGY

A. LANDSCAPE ECOLOGY

Landscapes are comprised of aggregations of various vegetation or land cover types (referred to as patches) that combine to create patterns or mosaics on the earth’s surface. Such patterns have developed as the result of climatic influences, site quality, natural disturbances, plant succession, and human activity. Landscape ecology is a discipline that focuses on understanding the causes and consequences of changes in landscape patterns. A fundamental tenet of landscape ecology is that humans and their activities are recognized as an integral part of the environment (USEPA, 1997). Numerous metrics have been developed to quantify changes in landscape patterns over time and space. Changes in patch diversity, size, proximity, edge, contagion, and connectivity have implications to floral and faunal communities as well as other natural features such as water ways.

Mountaintop mining and valley fill activities significantly affect the landscape mosaic. Landcover changes occur as forests are removed, the topography and hydrology is altered, and vegetation is eventually re-established. The result is an area drastically different from its pre-mining condition. Soil qualities are different, the vegetative community has a different structure and composition, and habitats are altered. Over time, if left unmanaged, forest succession will transform vegetative communities but the rate of this change is heavily dependent on the reclamation intent (i.e. post mining land use) and practice.

Scale plays an important role in landscape ecology. With changes in scale different patterns emerge or recede. The scale of analysis should be appropriate to the phenomenon under study. Furthermore, organisms perceive scale differently. The range of a salamander may be a single acre or less while a black bear may range over many square miles therefore they will be affected differently by the same landscape modification event. One species' entire range may be eliminated whereas another can shift its activities to another location. The study discussed here summarizes data on a watershed scale and is not intended to assess conditions for areas less than 5,000 to 10,000 acres in extent. Because of the limitations inherent to the input data, it is not appropriate to assess impacts at a finer scale. Indeed, any attempt to make a site specific evaluation would be a misuse of the data and any conclusions from such an evaluation would be highly suspect.

Landscape indicators are direct or indirect measures of environmental parameters or combinations of parameters. They have been likened to economic indicators such as housing starts, factory orders, and unemployment percentages. These indicators are used by economists to gauge national economic condition. No single indicator tells the entire story but by evaluating several one may perceive trends and make predictions. Likewise, by evaluating several indicators for a specific watershed or group of watersheds it is possible to assess a level of ecological integrity or vulnerability to degradation relative to other watersheds. Indicators also serve as monitoring tools to assess ecosystem condition as landcover modifications occur. To assess cumulative impact it is necessary to look a variety of indicators and make comprehensive analyses on the collective. It is also important to realize that some indicators are strongly correlated with one another.

B. DESCRIPTION OF GEOGRAPHIC DATA

1. Stream Network

The GIS stream network was generated from DEM data using standard ARC Info commands. The streams are "synthetic" in that they were not generated by conversion of existing maps, such as orthophotographs or USGS 7.5' quad sheets, into digital format. Rather, they were generated using a digital elevation model (DEM). A DEM is a digital representation of the earth's surface based on a regular series of sample elevation points organized in a 30x30 meter grid. DEM's can be used to model the direction of water flow and accumulation of flow.

For the data used in the cumulative impact study a contributing area of 30 acres was selected to generate a stream. There is some uncertainty is this selection given that permits in Kentucky have indicated perennial streams in watersheds smaller than 10 acres. Therefore; the synthetic stream network may underestimate stream length. This 30 acre threshold is supported by studies by the United States Geological Survey (USGS), West Virginia Water Resources Division District Office to field determine the ephemeral-intermittent and intermittent-perennial stream boundaries. The mean drainage area for 33 sampled ephemeral reaches in the West Virginia coal region was 30 acres (USGS unpublished data 2000); therefore, the synthetic streams are considered to represent ephermeral, intermittent, and perennial streams. The detail of these data exceeds that of USGS 1:24,000 scale stream networks (Figure II.C-1) which generally capture perennial and inconsistently ephemeral streams. The synthetic stream network was not ground truthed.

2. Land Cover Data

The forest loss was calculated using the National Land Cover Dataset (NLCD). The NLCD was produced as a cooperative effort among six programs within four U.S. Government agencies: the U.S. Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP); the U.S. Geological Survey's (USGS) National Water Quality Assessment Program (NAWQA); the Department of Interior National Biological Service's (NBS) Gap Analysis Program (GAP); the USGS's Earth Resources Observation Systems (EROS) Data Center; the National Oceanic and Atmospheric Administration's (NOAA) Coastal Change Analysis Program (C-CAP); and the EPA's North American Landscape Characterization (NALC) project. It provides a consistent, land cover data layer for the conterminous U.S. using early 1990s Landsat 5 thematic mapper (TM) data. The goal was to select TM scenes acquired in 1992, plus or minus one year, to allow for basic temporal consistency across the United States. Scenes were constrained to have a cloud coverage of no greater than 10 percent and to be of high digital quality.

These data can be used for landscape scale analysis in various disciplines such as wildlife ecology, forestry, or land use planning. The data scale is 1:50,000. The NLCD classification contains 21 different land cover categories. The National Land Cover Dataset has a spatial resolution of 30 meters and supplemented by various ancillary data. Map projection of original NLCD data set converted from Albers Conical Equal Area to the Universal Transverse Mercator, Zone 17 coordinate system.

The additional forest metrics that were calculated only for the West Virginia portion of the study area (ie. PEC, forest fragmentation and forest edge) were calculated using WV GAP Land Cover. This land Cover data set is a raster representation of vegetation/land cover for the state of West Virginia. This data can be used for landscape scale analysis in various disciplines such as wildlife ecology, forestry, or land use planning. The data have been developed for inclusion in the Gap Analysis Program. Data scale is 1:50,000. There are 26 land cover codes. Land cover data were collected as part of the West Virginia Gap Analysis Project, a collaborative effort between West Virginia University's Natural Resource Analysis Center, the West Virginia Cooperative Fish and Wildlife Research Unit, the West Virginia Division of Natural Resources, and the Biological Resources Division of the US Geological Survey. The source data were acquired from multiple 30-meter Landsat imagery obtained between 1992-1994 and field checked with videography. Preliminary results published 2000.

3. Riparian Habitat

While most habitats are mapped using land cover obtained from remotely sensed imagery, certain reptiles and amphibians rely on wetland or riparian habitat features that cannot be readily mapped from imagery therefore a separate model of riparian habitats is necessary to assess the relative sustain ability of these species within each future mountaintop mining scenario. The West Virginia Gap Analysis project (www.nrac.wvu.edu/gap/) created a model of these habitats using raster modeling techniques (with the aide of Geographic Information Systems) based on stream hydrology, elevation, slope and ancillary data including the USFWS National Wetlands Inventory (Strager et al., 2000.) This modeled habitat shows mapped stream, wetland, open water, and riparian habitats throughout the state at a much more detailed level than the WV-GAP land cover and allows for prediction of amphibian and reptile distribution. These data are used to estimate loss of these habitats. These data are intended to be used at a scale of 1:100,000 or smaller for the purpose of assessing the conservation status of vertebrate species and vegetation types over large geographic regions.

The model of potential wetland and riparian habitats is created from the combination of the riparian areas surrounding streams, existing wetlands data, and forested land cover data. This model is used as an input for species distribution modeling. Stream hydrology, percent slope, and digital elevation data were combined to produce relative cost path distance grids for headwater, small, and large streams. Path distance grids were derived from the "cost" incurred by movement from source cells (streams) to non-source cells. The cost of movement between cells is weighted by an impendent factor (slope) applied over surface distances (derived from digital elevation data). The resulting grids can be used to approximate riparian areas surrounding streams. Forested land cover and existing wetlands data were also input to the model of potential wetland and riparian habitats.

4. Mine Data

Mine permit GIS layers were obtained from the United States Office of Surface Mining (OSM). The goal was to compile GIS layers representing approved surface mining permits from the ten year time period of 1992-2002 within the four state EIS study area. Mine permit polygons are based on maps submitted to the SMCRA authority by mine operators seeking to obtain a permit. The mine data set was compiled in such a fashion as to be as consistent as practicable among the states in the study area; however, there were differences in the available digital data sets. Data for the prior ten years were available for Virginia, West Virginia, and Tennessee. Only four years of permit data were available for Kentucky.

OSM filtered the GIS data to exclude operations permitted prior to 1992, as well as permits which represent underground mining, preparation facilities, coal waste disposal areas, etc. The data were filtered so that only surface mining permits are included. The permit coverage was “clipped” to include permits located only within the EIS study area. The following are detailed descriptions of the mine data specific to each state within the study area. The list of permits included in the permit data set are presented in Appendix B.

Kentucky

Original Source Description

The Department for Surface Mining Reclamation and Enforcement (DSMRE) currently makes available scanned and georeferenced mining and reclamation plan maps and annual underground maps for permits issued by the Department. Mining and reclamation plan (MRP) maps are required to be submitted with an application for a permit to conduct surface coal mining and reclamation operations in the Commonwealth of Kentucky. MRP maps are generally drawn on an enlarged USGS seven and one-half (7 1/2) minute topographic map at a scale of between 400 and 600 feet to the inch. Permitted surface and underground mine boundaries and facilities associated with coal mining operations are shown along with names and locations of streams and other bodies of water, roads, buildings, cemeteries, oil and gas wells, public parks, public property, and utility lines.

The source of the GIS mine polygons for Kentucky used in this cumulative impact study are the surface mining overlay maps maintained by the Kentucky Department of Surface Mining Reclamation and Enforcement (DSMRE). These maps consist of frosted mylar sheets that overlay 7 ½ minute USGS topographic maps. DSMRE staff draw permitted surface and underground mine boundaries and selected other features in ink onto the mylar. DSMRE GIS specialist scanned and georeferenced these mylar overlays, which are now available to the pubic for downloading. Here is the site link where the scanned may be downloaded: http://kydsmre.nr.state.ky.us/gis/data.htm. MRP maps georeferenced beginning in July 2002, and all georeferenced underground maps are projected in the NAD83 Kentucky Single Zone Coordinate System. MRP maps processed prior to July 2002 were georeferenced in NAD83 Kentucky State Plane North or South zone coordinates.

Currently six series of overlays are available both in hardcopy and digitally. Each series represents a time period in the permitting of surface coal mining in Kentucky.

Series I: Areas permitted from 1977 to March 1, 1981, and which were active as of January 1, 1981.

Series II: Areas permitted from 1961 to 1977, and which were inactive as of January 1, 1981.

Series III: Areas permitted from March 1, 1981 through January 18, 1983.

Series IV: Areas permitted under the permanent program after January 18, 1983 and through April 1, 1986.

Series V: Areas permitted under the new permanent program after April 1, 1986 and through August 1, 1995.

Series VI: Areas permitted after August 1, 1995 and through August 31, 1999.

Series VII Areas permitted after September 1, 1999 and through April 30, 2000. (Series VII has been converted to GIS polygons by DSMRE.)

For the purposes of the cumulative impact analysis only the information from Series VI and VII were used. Series VI consists of three primary overlay sheets: (1) Polygon Layer - closed polygons - permit boundaries, etc… (2) Line Data Layer - lineal lines - roads, conveyors, utilities, etc… and (3) Point Data Layer - small ponds, sampling sites, mine adits, etc. Overlaying permits will be drawn on separate sheets of Mylar, thus there may be more than one polygon layer sheet (Sheet 1, Sheet 2, etc…). Hatched lines denote underground shadow areas. Areas of less than full recovery have a greater opening between hatch marks and recovery percentage is indicated.

Description of Map Symbols and Codes for KY data

The mining overlay maps are identified by the 7 ½ minute quadrangle name. Alpha characters are assigned to each permit number and appear as the first portion of the attribute code assigned to each map feature. The alpha codes are generally listed in alphabetic order and expand to multi-lettered codes (AA, BB etc.) to include all permits pertaining to a given quadrangle. Alpha codes and the specific permit number to which they correspond are listed at the bottom of the overlay. Adjacent maps that share the same permit boundary have, in most cases, the same alpha code on both maps. The number which follows the alpha code is a one-, two- or three-digit number defining the major category in which a mining feature falls (i.e. mining, fill areas, haul roads, etc.). Often a sub-category is used to describe a mining feature in greater detail. An example of a feature attribute code is 'A-610'. The code refers to a sediment structure (6), embankment type (10), within the permit number assigned 'A'. Areas common to more than one permit number are labeled with the alpha character and feature attribute codes of both permit numbers with a comma placed between them.

The permit features are drawn as dashed lines, solid lines, dash-dot-dot lines, or single dots. Haul roads and railroads are drawn as dashed lines unless they correspond to the permit boundary, in which case the permit boundary takes precedence. Features that appear as solid lines or polygons include mining areas, fill/storage areas, permit boundary areas, face-ups, and reference areas. Points are used to represent features of small acreage such as sediment structures, monitoring points and underground mine openings. Hatched lines indicate underground areas.

Due to the influx of new mining permits and the absence of some permits at the time of drafting, these overlays are not 100% comprehensive. The updating procedure (acreage additions and deletions) was initialized to keep the mining operations overlays as up-to-date as possible.

Description of Digital Data Base Queried for the Cumulative Impact Study for KY data

Staff from OSM's Pittsburgh Office downloaded the Series VII and VI digital information from KY DSMRE FTP server on October 7, 2002, and October XXX, respectively.

The Series VII GIS data was filtered to retain only those mining disturbances associated with surface mining activities. All polygons associated with the activities coded as "face up", "load out", "prep plant", "surface auger", "slide", "stockpile", or "underground" were deleted from consideration for the purpose of the cumulative impact analysis. Further, using the boundaries of the EIS study area in Kentucky, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. This filtered digital data for Series VII, which consisted of multiple polygons for surface mines, were forwarded to EPA's Wheeling Office.

The Series VI scanned and georeferenced mylars posed a more challenging task. Staff from OSM Pittsburgh Office used specialized software (Able Software R2V for Windows) to convert the digital picture images (rasters) to vectorized features (polygons, lines, and points). Once converted to GIS polygons, features representing surface mining disturbances were retained and other disturbances (such as underground mining, preparation plants, augering areas, face-up areas, stockpiles, ect) were eliminated. Further, using the boundaries of the EIS study area in Kentucky, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. This filtered digital data for Series VII, which consisted of multiple polygons for surface mines, were forwarded to EPA's Wheeling Office. Appendix B contains a list of digital mining polygons from Kentucky forwarded for inclusion in the cumulative impact study.

Tennessee

Original Source Description

The source of the GIS mine polygons for Tennessee used in this cumulative impact study is the a digital geographic database of coal mining permit boundaries in Tennessee produced by the U.S. Department of Interior, Office of Surface Mining Reclamation and Enforcement (OSM) in Knoxville, Tennessee. It consists of georeferenced digital map data and descriptive attribute data. OSM Knoxville Field Office Geographic Information System (KFO GIS) Team developed this information from public records. The source for most of these records is the permit application submitted by coal mining operators for review and approval by OSM to conduct surface coal mining operations at specific locations in the State of Tennessee. These materials are a working resource of OSM and are contained in its file rooms and archives in paper format. Data contained in these materials were converted to digital format generally through digitizing paper maps onto a planimetrically correct base.

Selected features from the last approved Mining Operation Plan maps and Environmental Resources maps contained within a permit application submitted by a coal mining operator to the Office of Surface Mining (OSM) were manually digitized into an individual coverage using the ArcEdit subsystem of ArcInfo Workstation. Each map was georeferenced using geographic features found in common on both the paper manuscript (map) and on Digital Raster Graphic (DRG) images of standard 7.5-minute series USGS topographic quadrangle maps as displayed on a computer monitor. These DRG's were acquired from the U.S. Tennessee Valley Authority and were transformed to Tennessee State Plane, NAD 27 coordinate system by OSM. After initial digitizing on a standard digitizing table, the digital data set was inspected on a computer monitor and visually compared against the paper manuscript. Coverage feature classes were edited to correct digitizing errors. Attribute data was added to describe features contained in the coverage. Individual coverages were then posted to the Knoxville Field Office Geographic Information System (KFO GIS). Each individual coverage was then incorporated into a master coverage of similar features. All compilation, digitizing, and quality control were performed by GIS specialists at the OSM in Knoxville, TN.

The accuracy of these digital data is based on features represented on source maps supplied by various coal mining operators. In general, these features were drawn by hand on paper reproductions of standard 7.5-minute series USGS topographic quadrangle maps enlarged to a scale of 1"=400' and were submitted as Mining Operation Plan maps or Environmental Resource maps in a permit application for approval by OSM to conduct surface coal mining operations at a specific location. It is not known whether these paper reproductions of the standard USGS topographic maps meet National Map Accuracy Standards. OSM digitized selected features from each paper source map using a minimum of four georeferenced control point locations (tics). Approximately 95 percent of the maps resulted in a Root Mean Square (RMS) error of less than 10 feet as reported by the software during calibration. None exceeded 25 feet. The difference in positional accuracy between the actual feature location on the ground and their digitized coordinates as shown in this data set are unknown

This data set is a work-in-progress and represents the current amount of digital data available for this theme at the time of its production. During production, selected paper maps from individual permit applications are digitized in reverse chronological order based on the permit and/or revision approval date. This method is used to ensure that data resulting from the most recently approved permitting action for any given mining operation is always available to KFO GIS users. As the general digitizing effort continues, maps are retrieved from successively older permit applications for digitizing and data entry. Current estimates of temporal coverage for this theme extend back to approximately 1984. As new information is made available to OSM, and as resources are available to capture this information into a digital format, this data set will be amended with updated features from newly approved mining operations and also be revised to include features from older mining operations.

Although these data have been processed successfully on a computer system at OSM, no warranty expressed or implied is made by OSM regarding the utility of the data on any other system, nor shall the act of distribution constitute any such warranty. For further information about the coal mining data sets held by OSM, contact Bill Card, Geographer, Office of Surface Mining, Knoxville Field Office, 530 Gay Street SW, Suite 500, Knoxville, TN 37902, telephone 865.545.4103, x. 134, fax 865.545.4111, e-mail bcard@osmre.gov.

Description of Digital Data Base Queried for the Cumulative Impact Study for TN data

Staff from OSM's Pittsburgh Office downloaded the most current digital database from Tennessee mining permits from OSM Knoxville Field Office FTP server on September 23, 2002. This database consisted of 816 mining polygons. Staff from the Knoxville Field Office telefaxed a list of new mining permits issued by OSM from January 1992 to date that were approved to use surface mining methods or a combination of surface and underground methods to extract coal. The permits on this list met the criteria established by the EIS Steering Committee for the cumulative impact study and was used to select a subset of mine permit digital data polygons from the source database. Further, using the boundaries of the EIS study area in Tennessee, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. This filtered digital data, which consisted of 39 new surface mines, were forwarded to EPA's Wheeling Office. Appendix B contains a list of digital mining polygons forwarded for inclusion in the cumulative impact study.

Virginia

Original Source Description

The source of the GIS mine polygons for Virginia used in this cumulative impact study is the a digital geographic database of coal mining permit boundaries in Virginia produced by the Virginia Department of Mines, Lands, and Minerals - Division of Mined Land Reclamation (DMLR) in Big Stone Gap, Virginia.

It consists of geo-referenced digital map data and descriptive attribute data. This data set is a work-in-progress and represents the current amount of digital data available for this theme at the time of its production.

Description of Digital Data Base Queried for the Cumulative Impact Study for VA data

Staff from OSM's Pittsburgh Office downloaded the most current digital database from Virginia DMLR FTP server on September 16, 2002. This database consisted of 2358 mining polygons. Staff from OSM Big Stone Gap Field Office identified the prefix in the permit identification number (GIS Data Field "PERMIT") representing mines approved to use surface mining methods or a combination of surface and underground methods to extract coal: "11", "15", "16", and "17".

Mining permits approved by Virginia DMLR beginning from January 1992 to the most current date were selected using information provided in the GIS database (GIS Data Field "PEISSUEDT"). The permits on this list met the criteria established by the EIS Steering Committee for the cumulative impact study and was used to select a subset of mine permit digital data polygons from the source database. Further, using the boundaries of the EIS study area in Virginia, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. This filtered digital data, which consisted of multiple polygons for 98 surface mines, were forwarded to EPA's Wheeling Office. Appendix B contains a list of digital mining polygons forwarded for inclusion in the cumulative impact study.

West Virginia

Original Source Description

The source of the GIS mine polygons for West Virginia used in this cumulative impact study is the a digital geographic database of coal mining permit boundaries, coal extraction polygons, and fill polygons produced by the West Virginia Division of Mining and Reclamation - Information Technology Office. These datasets are derived from hardcopy permit maps submitted to DMR. Hardcopy maps were scanned and georeferenced prior to extraction of features via on-screen digitizing by West Virginia University - Natural Resource Analysis Center. All datasets have been projected to UTM zone 17, NAD27.

Description of Digital Data Base Queried for the Cumulative Impact Study for WV data

Staff from OSM's Pittsburgh Office downloaded the most current digital database from West Virginia mining permits from West Virginia Department of Environmental Protection website: http://129.71.240.42/data/omr.html. Three GIS data layers -- permit boundaries, surface mine extraction areas, and valley fill areas - met the criteria established by the EIS Steering Committee for the cumulative impact study. This data set was filtered by using the last two digits of the permit identification number (the year the permit identification number was assigned) to include only those activities associated with new surface mining permitted after January 1, 1992. Further, using the boundaries of the EIS study area in West Virginia, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. Appendix B includes a list of 142 West Virginia mining permits forwarded for inclusion in the cumulative impact study.

<u>60% complete WV mine data set</u>

Due to project schedules the terrestrial forest metrics, except forest loss and percent forest, were calculated using a mine permit data set for WV that was only 60% complete at the time. The mine data set was provided by WVDEP. Mine permit polygons are based on maps submitted to the WVDEP by mine operators seeking to obtain a permit. The maps were digitized by WVU Natural Resource Analysis Center (NRAC.). These WV permit maps were queried by WVDEP to extract active and pending surface mines. Specifically, surface mine permits with an inspection status of: A1 (possibly moving coal), A4 (active but no coal removed), AM (active, moving coal), IA (approved inactive), and NS (not started) were used to approximate the present and near future active surface mining regions. These selections were made under the direction of the WVDEP. The scale of the mine permit data is reported as 1:24000 by the West Virginia GIS Technical Center. The mine permit data however was incomplete because it was still in the process of conversion from hard copy to digital format at the time of this investigation (60% complete as of August 2001). To further supplement identification of present/near future mountaintop mining “foot prints”, a third source of geographically referenced surface mining data was obtained from the Tennessee Valley Authority (TVA.) TVA compared satellite imagery obtained from the early 1990’s to imagery collected in 1999 from Landsat 7. Using a technique called Normalized Difference Vegetation Index (NDVI) they identified areas that experienced a dramatic drop in vegetative cover and compared these areas to the

WV DEP permit data and aerial photographs to derive and updated spatial dataset of mining regions in the Appalachian coal region. This effort was incomplete at the time of this study. These three sources were combined in a GIS and used as an approximation of present and near future mine disturbance area. These data are suitable for use at the HUC 11 watershed scale however it is not intended for localized studies (generally below 1:100,000.)

C. METRIC CALCULATION

1. Metric List

Landscape indicators are specific metrics. The word "metric" refers to a particular GIS calculation. Metrics calculated in this study are presented in Table II.C-1.

Table II.C-1
Metric List

Habitat Evaluated	Metric (unit)
Mine	Permit area per state and for entire study area (ac)
	Mine data ratios for West Virginia (ac) - Valley fill area to mineral extraction area, Valley fill area to permit area, Mineral extraction area to permit area
Aquatic	Direct impact to streams per state and for entire study area (mi and %)
	Direct impact to streams from valley fill area in West Virginia (mi and %)
	Direct impact to streams from mineral extraction area in West Virginia (mi and %)
	Direct impact to streams from permit area in West Virginia (mi and %)
Terrestrial	Direct impact to forests per state and for entire study area (ac and %)
	Forest loss from permit area in West Virginia (ac and %)
	Forest loss from valley fill area in West Virginia (ac and %)
	Forest loss from mineral extraction area in West Virginia (ac and %)
	Forest loss from auxiliary areas in West Virginia (ac and %)
	Grassland as indicator of past mining impact per state for entire study area (ac and %)
	Non-forest land cover class area change per state for entire study area (ac and %)
	*Impacts to riparian habitats in West Virginia (ac)
	*Potential Ecological Condition in West Virginia (unit)
	*Forest edge in West Virginia (%)
	*Number of land cover patches in West Virginia (count)
	*Percent landscape of patch type in West Virginia (%)
	*Mean patch size in West Virginia (ac)

* denotes results generated previously from 60% complete permit data.
ac = acres

2. Mine and Valley Fill Area

Mine areas were calculated based on permit boundaries obtained for each state. For West Virginia identification of valley fills and mineral extraction areas within the permit boundaries was possible however this was not the case for the other states where only permit boundaries were delineated. The permit boundaries represented the mine "footprint" that was used to determine areas of impact. The mine areas were represented digitally as a series of polygons. These were converted to raster (i.e. grid cells) format with a cell resolution of 30x30 meters to facilitate merging with the landcover data. The mine permit areas were "burned" into the landcover data to generate a post-impact scenario that could be compared to the original landcover data (i.e. pre-impact) for quantification of landcover changes.

This procedure involved reclassifying any area on the original landcover grid that intersected the permit boundaries to the Surface Mine category. Calculation of mine areas was done by totaling the number of pixels of each mine class (i.e. permit area, valley fills, and mineral extraction areas) and multiplying by the pixel area (900 square meters). The result was then divided by 4047 to convert to acres.

3. Mine Data Ratios

For West Virginia, three ratios were calculated: Valley Fill : Mineral Extraction Area, Valley Fill : Permit Area, and Mineral Extraction Area : Permit Area. This was done by dividing areas which were computed as described above.

4. Direct Impact to Streams

Direct impact of mine/fill areas to streams was calculated by converting all mine regions to polygons and overlaying them with the stream line data in a GIS. This operation essentially "clips out" the portion of the stream coverage that falls within the mine/fill polygons. Length of impacted streams was calculated and percent of streams directly impacted was determined by dividing the impacted length by the total length of streams. Total stream impact was calculated by using the permit area as the disturbance area. Impact from mineral extraction area and impact from valley fill were calculated for West Virginia permits.

5. Direct Impact to Forests

Forest loss was calculated by first converting both the pre- and post-impact landcover grid to a simple forest/non-forest layer. Grid cells with the following classification were lumped into the forest class:

- ❑ Deciduous Forest
- ❑ Evergreen Forest
- ❑ Mixed Forest
- ❑ Woody Wetlands

All other categories were non-forest. Next, forested pixels were totaled and divided by the total number of pixels in the study area to determine percent forest cover. This procedure was also done for each watershed in the study area. To determine forest area, the forested pixels were totaled and multiplied by 900 square meters. The result in square meters was then converted to acres by dividing by 4047. Changes in forest cover due to mining activity was determined by comparing the results of this procedure for the pre- and post-impact landcover scenarios.

6. Percent Forest Cover

Using the forest/non-forest layer described in the previous metric the percent forest cover with each study watershed was calculated by dividing the number of forested pixels by the total number of pixels in the watershed. Possible values range from 0 to 1, with 1 indicating 100% forest cover.

7. Grassland as Indicator of Past Mining Impact

Grassland as Indicator of Past Mining Impact was calculated by summing the transitional and pasture/hay land cover class acreage. This metric was developed in an attempt to quantify terrestrial impacts from mining before 1992. Because grasslands are not common natural habitats in the West Virginia portion of the study area (Straughsbaugh and Core, 1997), it can be assumed that natural grasslands are uncommon habitat throughout the four-state study area. Therefore, the transitional and pasture/hay land cover classes can generally be attributed to reclaimed mine areas. This metric gives a general indication of past mining terrestrial impact.

8. Non-forest Land Cover Class Area Change & Percent Change

Losses to non-forest landcover classes were computed by taking the difference in the number of pixels of each landcover category between the pre- and post-impact landcover grids. This difference was then divided by the original number of pixels of each landcover type to obtain percent change. Computation of areas was done by simply multiplying the pixel totals for a category by the pixel area (900 square meters) and converting to acres. Differences in landcover arose solely from the reclassification of the original (circa 1992 NLCD) landcover to surface mines (surface mining/quarries/gravel pits) in areas that intersected mine permit boundaries as described above.

9. Impacts to Riparian Habitat

This metric calculated using prior permit data set. Having obtained the wetland/riparian habitat (described above), determining the amount of loss due to mine/fill areas was accomplished through an overlay operation. Much like the method used in the Streams Through Mines metric a clipping operation was performed to identify and quantify wetland/riparian habitats that were spatially coincident with mine/fill polygons. Once these impacted regions were identified the area of each habitat type was totaled for each watershed.

10. Potential Ecological Condition

Potential Ecological Condition (PEC) is an index intended to assess the ecological integrity of each watershed based primarily on the extent of large scale human disturbance and “local” tabulations of forest cover. This is a raster based metric. Calculation of the PEC is a multi-step process.

First, the land use/cover map for each scenario is reclassified to produce a forest/non-forest map and a human use map. The human use map is simply all the land use area associated with human activity including shrubland (which captures transitional areas such as recent clearcuts and mine sites in early reclamation stages), major highways, powerlines, populated areas, agricultural landcover, and mine/fill regions. The human use map was queried to identify areas of human use that were greater than or equal to five (5) acres in extent. These areas were then buffered by three (3) pixels (each pixel is 30x30 meters) to approximate an "edge effect." Human use areas smaller than five (5) acres did not receive a buffer and were assumed to not affect the integrity of the surrounding forest.

The next step was to calculate a local forest cover percentage for every pixel in the watershed. This is termed a "floating window" procedure and involves centering a 200 acre circle on every pixel in the watershed and determining the percent forest cover within the circle. 200 acres was determined by O'Connell et al. (1998) to be the landscape unit size within which bird communities respond to alterations in land-cover and was part of a more detailed index of biotic integrity developed for the Mid-Atlantic Highlands.

The local forest cover map was then combined with the buffered human disturbance map to arrive at a PEC value for each pixel. The possible PEC values were zero, one, and two, with zero representing the lowest ecological condition and 2 the highest. Table II.D-2 shows how the final PEC number for a pixel was determined. As shown, the highest PEC rating could be attained only when the pixel in question had a local forest cover greater than or equal to 87% and it was forested and not within the buffer around a large human use area. Furthermore, a pixel received the lowest PEC rating when it was either classified as a human use or was less than 28% forested within the 200 acre local evaluation window. Interpretations of this data should not be made for areas less than 5000 acres (CVI unpublished.)

The PEC metric is modeled on the Bird Community Index (BCI) through collaboration between the Canaan Valley Institute and developers of the BCI (O'Connell et al. 1998.) The BCI is a type of IBI

(Index of Biotic Integrity) developed to assess ecological condition on a landscape scale. The index, developed by Penn State University researchers, is based on data for breeding songbird communities under the premise that songbird community composition reflects ecosystem properties of concern such as structural complexity, interspecific dynamics, and landscape configuration (O'Connell et al. 1998.) The BCI was tested on 126 sites in the Mid-Atlantic Highlands, an area which extends in a northeast to southwest direction through Pennsylvania, southeastern Ohio, West Virginia, Maryland, and Virginia. This is a mountainous area comprising the Blue Ridge, Ridge and Valley, Allegheny Plateau, and Ohio Hills physiographic provinces (O'Connell et al. 1998). Study sites were selected to represent the entire region. BCI was found to be highly correlated with a human disturbance gradient used to rank sites and defined thresholds of land-cover change where significant shifts in BCI categories were observed. The BCI may serve as a substitute for more numerous and intensive measurements of condition and disturbance (O'Connell et al., 1998).

The PEC metric is a simplified version of the BCI based primarily on factors such as forest cover with a 200 acre vicinity of a location and a buffer around large areas of human disturbance.

Locations with high PEC values are considered to have high ecological integrity. Such areas closely resemble native conditions, largely unmodified by recent human activity. They have extensive, unfragmented forests with mature vegetation, and a closed canopy. Although most of the forests in this region have been cutover, enough time has passed to allow re-establishment of mature forests on previously logged areas or abandoned agricultural land. Mid-range PEC values represent medium integrity sites. Attributes of these sites include higher landscape diversity (i.e. a greater variety of cover types), greater contagion (i.e. interspersion of different cover types), more edge, more agricultural and mine land, less forest cover, and lower canopy height and closure when compared to high integrity areas

Low-range PEC values indicate a landscape dominated by mountaintop mining, agricultural or other human related activities. Forest cover is less than 28% at the 200 acre scale and trees are generally smaller with a more open canopy and interior conditions are non-existent.

11. Forest Edge

The forest edge metric was calculated for each scenario using the forest/non-forest map. Every forested pixel in a watershed was evaluated in the four cardinal directions to determine the presence of an adjacent non-forest pixel. If a non-forest pixel was found bordering a forested pixel that pixel was considered to be a forest edge. The number of forest edge pixels were totaled for each watershed and divided by the total number of forested pixels to obtain the forest edge metric. Values fall within the zero to one range where zero represents no forest edge and one represents the maximum possible if every forest cell were adjacent to a non-forest cell.

The significance of this metric is as follows. Fragmented forests have more edge habitat (areas along the boundaries between different types of land cover) than non-fragmented forests. Irregularly shaped forest patches have more edge habitat than simple shaped forest patches due to the amount of perimeter per unit area. Small amounts of forest edge positioned naturally within the landscape can be beneficial to both the forest itself and some wildlife. The edges provide ecotones where food sources, habitat, and energy sources are enhanced. The creation of more forest edge habitat often corresponds to an increase in local species diversity as "edge" species are attracted to the region. However, the creation of edge habitat can also lead to the elimination of forest interior species and the encroachment of diseases and invasive exotic species (Jones, 1997). In addition, trees along the forest edge are subjected to greater variations in microclimate and greater storm damages. What determines "too much" edge cannot be answered without ascertaining impact on a particular species since species differ in their edge requirements and/or tolerance.

12. FRAGSTATS Metrics

Three metrics were calculated using FRAGSTATS, a program developed to quantify landscape pattern based on land cover data where regions of the same cover type are considered patches and groups of patches of a land cover type comprise classes.

The Number of Landcover Patches is the number of different land cover class areas. Land cover class area is the area of a land cover type.

The Percent Landscape of Patch Type is the percentage the landscape comprised of the corresponding patch type. It is the class area (describe above) divided by the total landscape area (i.e. watershed.)

The Mean Patch Size was calculated by dividing the class area for each land cover type by the number of patches of that cover type. This metric provides information on the average size of cover type patches within the watersheds. If larger patches are being fragmented into smaller patches this will be manifest in a general decrease in mean patch size.

The FRAGSTATS output generated patch specific data for each land use type in a watershed over the 36 long-term scenarios. Thus, a watershed with 20 land use classes (from WV Gap data) would have 720 results for each scenario (36 X 20 = 720). Patch analysis using FRAGSTATS was time consuming and generated 14 patch specific metrics for each watershed. Therefore, patch analysis was only run on those watersheds that exhibited major changes in the other metrics and the metric output was truncated to the three metrics that appeared to yield the most important data. Eight of the 63 watersheds were included in the FRAGSTATS analysis of land use patches. Three metric results, the number of patches, percent of the landscape, and mean patch size were used.

The number of patches within a watershed was calculated for each of the 36 long-term scenarios by summing the total number of patches of all of the land class types within the watershed under each scenario. FRAGSTATS calculates the total number of patches of each particular land class in each watershed. Percent of the landscape is also calculated by FRAGSTATS for each land class type in the watershed. This analysis was merely the graphing of the FRAGSTATS results. Mean patch size was calculated by dividing the land class area in a watershed by the number of patches of that class in the watershed.

III. RESULTS

A. MINING SURFACE AREA METRIC RESULTS

1. Permit Area

The permit area from mountaintop mining in the study area from the last ten years is 403,810 acres. If mining trends are consistent, an additional permit area of 403,810 acres will occur in the next ten years. Of the four states in the study area, Kentucky has the greatest permit area with 271,972 acres of mining projected for a ten year period. This permit area is derived by multiplying the acreage based on four years of permit data by a multiplier to generate a ten year number comparable with the other states (108,789 x 2.5). West Virginia, Virginia, and Tennessee permit areas are 90,104 acres, 32,325 acres, and 9,409 acres, respectively. Figure III.A-1 presents the locations of the permits in the study area.

2. Mine Data Ratios

A typical mountaintop mine site is divided into development areas, production areas, support areas, reclamation areas, and valley fills. The mineral extraction area consists of the development and production areas. In West Virginia, the potentially adverse impact of mountaintop mining is 90,104 acres. Of this, the total mineral extraction area equals 51,382 acres while the total valley fill area equals 19,486 acres. The remaining 19,236 acres constitutes auxiliary areas such as office buildings, infrastructure, etc. Figure III.A-2 presents a typical mountaintop mine layout depicting the permit area, production areas and valley fills. The mine data ratios indicate that the permit area is twice as large as the mine extraction area and the mine extraction area is almost twice the acreage of the valley fills.

Mine data ratios from the West Virginia portion of the study area are:

Valley fill : Mine extraction area = 0.4

Valley fill : Mine permit area = 0.2

Mine extraction area : Mine permit area = 0.5

B. AQUATIC METRIC RESULTS

1. Calculated Stream Length

The stream lengths for the Kentucky, Virginia, Tennessee and West Virginia portion of the study area based on the synthetic stream network described in section II. B are as follows. These stream lengths characterize the study area prior to overlaying the mine permits.

Table III.B-1 Miles of Stream in the Synthetic Stream Network

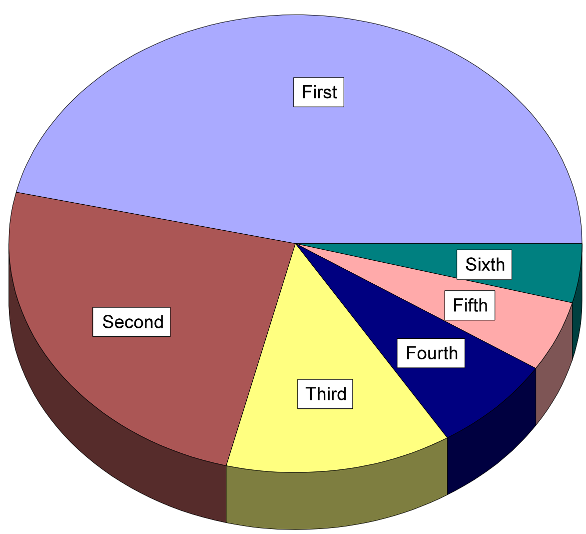
State	Miles of Stream within Study Area Portion of State
Kentucky	34,468
Tennessee	5,505
Virginia	7,015
West Virginia	12,010
Entire Study Area	58,998

Total stream length for the approximate 12 million acre study area is 58,998 miles. The order of streams found in the study area include first to sixth order streams. Identification and calculation of stream length by order was not performed in this study. However; a previous analysis (Gannett Fleming 2002) calculated the percent of first through sixth order streams in the West Virginia portion of the study area. This prior identification and calculation of stream orders provides an indication that over half of the stream length in the study area is comprised of first and second order streams. The percent of streams classified by order for the West Virginia portion of the study area are summarized below.

Table III.B-2 Percent of Streams within Different Stream Orders

Stream Order	Percent of Total Stream Length In the WV portion of study area
First	47%
Second	25%
Third	13%
Fourth	7%
Fifth	5%
Sixth	4%

Figure III.B-1 Percent of Streams within Different Stream Orders



2. Aquatic Direct Impacts

Based on permits issued in the last ten years and an assumption of similar permits in the next ten years, aquatic direct impacts to 1, 208 miles of study area stream is estimated. The aquatic metrics include the miles of direct stream impact per state portion of the study area and for the entire study area. Because the calculation of miles of direct stream impact is based on the stream network used, percent of direct stream impact is also a metric. The percent of direct stream impact per state portion of the study area and for the entire study area is calculated. Additional metrices were calculated for the West Virginia portion of the study area because the digital permit data included consistent attribution of the mineral extraction and valley fill areas within the permit area.

Potential impacts to aquatic habitats were evaluated using the metric for direct impacts to stream length and percent of stream directly impacted. Direct impacts are defined as the areas where the permit polygons overlapped the synthetic stream network. The direct impacts reflect surface mining impacts including valley filling, backfilling, and other surface mining impacts that would directly destroy the stream.

Table III.B-3 Miles of Direct Stream Impact

State	Miles of Direct Stream Impact within Study Area Portion of State Based on Permit Area	Percent Impact
Kentucky	730	2.12%
Tennessee	20	0.36 %
Virginia	151	2.10 %
West Virginia	307	2.55 %
Entire Study	1,208	2.05 % of study area streams

Additional results are available for the West Virginia portion of the study area. The digital permit data for West Virginia allowed calculation of the direct stream impacts from mineral extraction area and from valley fill area. These results are as follows.

Table III.B-4 Miles of Direct Stream Impact Per Mineral Extraction and Valley Fill Areas

	Miles of Direct Stream Impact within West Virginia Portion of Study Area	**Percent Impact**
Mineral Extraction Area	50.43	0.42 %
Valley Fill	156.82	1.31 %
Permit Area	307	2.55 %

As can be seen from the table above, an additional 100 miles of direct stream impact is calculated when the entire permit boundary is used as the disturbance area, as opposed to discrete valley fill and mineral extraction polygons. Although direct stream impact could occur from road crossing and ancillary operations outside of the mineral extraction and valley fill areas, calculation of direct stream impacts using the permit area may be an overestimate.

C. TERRESTRIAL METRIC RESULTS

1. Study Area and State Results

a. Forest Loss

The potentially adverse impact of forest loss from mountaintop mining in the study area from the last ten years of permitting is 380,547 acres. The study area contains 11,231,622 acres of forest. This terrestrial impact equates to a 3.4% forest loss in the study area. Of the four states included in the study area, Kentucky is projected to have the greatest potentially adverse impact of forest loss from mountaintop mining with 255,582 acres (4.0%) of forest loss; however, Kentucky also has the greatest acreage within the study area. The Kentucky forest loss is based on four years of permit data multiplied by 2.5 to yield a ten year estimate(102,233 acres x 2.5). Projected forest loss from the other three states in order of potential adverse impact are: West Virginia, 86,587 acres (3.2%); Virginia, 29,224 acres (2.5%); and Tennessee, 9,154 acres (1.0%).

When adding past, present and future terrestrial disturbance, the study area estimated forest impact is 1,408,372 acres which equates to 11.5 % of the study area. This number is derived by adding grassland as an indicator of past mining, barren land classification, forest lost from the last ten years of surface mine permits and a projection of future forest loss that equates to the last ten years.

b. Non-forest Land Cover Class Change

Forests occupy 92.1% of the study area. Therefore, the greatest potential adverse impact from mountaintop mining is to the forest cover classes. Table III.C-1 summarizes the impacts to all non-forest land cover classes for each state and for the entire study area. In general, the potential adverse impacts for non-forest land cover classes are consistent among each state.

High intensity residential is the only land cover class with no projected impact in the four-state study area. Urban/recreational grasses and emergent herbaceous wetlands are projected to have negligible potential adverse impacts in the study area. Transitional lands and the pasture/hay cover class exhibit the greatest potential adverse impact of the non-forest land cover classes with projected losses of 1,986 acres and 999 acres, respectively. The greatest net change is an increase of 231,177 acres in the surface mining/quarries/gravel pits cover class. This net change takes into account the acres of remining (surface mining/quarries/gravel pits landcover acres in permit polygons). The acres of remining are 4,922 in Kentucky; 16 in Tennessee; 1,849 in Virginia; and 2,664 in West Virginia.

Grasslands (pasture/hay and transitional) are expected to increase as mine sites move to the reclamation phase. This trend is not depicted in the table.

Table III.C-1
Non-Forest Land Cover Class Impacts (acres)

Kentucky Portion of the Study Area	Pre-Impact (NLCD)	Condition from 4 yrs of Issued Permits	Difference
Open Water (ac)	43,914	43,731	-182
Low Intensity Residential (ac)	23,674	23,628	-46
High Intensity Residential (ac)	5,459	5,459	0
Commercial/Industrial/Transportation (ac)	24,673	24,526	-147
Surface Mining/Quarries/Gravel Pits (ac)	37,710	141,577	103,867
Transitional (ac)	17,133	16,363	-770
Pasture / Hay (ac)	251,470	251,051	-419
Row Crops (ac)	65,866	65,798	-68
Urban/Recreational Grasses (ac)	9,410	9,408	-2
Emergent Herbaceous Wetlands (ac)	1,210	1,210	0

Table III.C-1 continued

Tennessee Portion of the Study Area	Pre-Impact (NLCD)	Condition from 10 yrs of Issued Permits	Difference
Open Water (ac)	12,472	12,454	-18
Low Intensity Residential (ac)	10,771	10,769	-2
High Intensity Residential (ac)	1,471	1,471	0
Commercial/Industrial/Transportation (ac)	6,185	6,166	-19
Surface Mining/Quarries/Gravel Pits (ac)	1,208	10,601	9,393
Transitional (ac)	3,059	2,897	-162
Pasture / Hay (ac)	56,114	56,083	-31
Row Crops (ac)	15,358	15,350	-8
Urban/Recreational Grasses (ac)	6,297	6,297	0
Emergent Herbaceous Wetlands (ac)	146	146	0
Virginia Portion of the Study Area	Pre-Impact (NLCD)	Condition from 10 yrs of Issued Permits	Difference
Open Water (ac)	4,790	4,672	-118
Low Intensity Residential (ac)	10,484	10,473	-11
High Intensity Residential (ac)	133	133	0
Commercial/Industrial/Transportation (ac)	4,749	4,729	-20
Surface Mining/Quarries/Gravel Pits (ac)	18,981	49,458	30,477
Transitional (ac)	11,592	10,896	-696
Pasture / Hay (ac)	117,519	117,224	-295
Row Crops (ac)	13,738	13,629	-109
Urban/Recreational Grasses (ac)	182	182	0
Emergent Herbaceous Wetlands (ac)	316	311	5

Table III.C-1 continued

West Virginia Portion of the Study Area	Pre-Impact (NLCD)	Condition from 10 yrs of Issued Permits	Difference
Open Water (ac)	16,622	16,607	-15
Low Intensity Residential (ac)	16,110	16,079	-31
High Intensity Residential (ac)	86	86	0
Commercial/Industrial/Transportation (ac)	9,310	9,275	-35
Surface Mining/Quarries/Gravel Pits (ac)	45,715	133,155	87,440
Transitional (ac)	19,441	19,083	-358
Pasture / Hay (ac)	67,335	67,081	-254
Row Crops (ac)	17,048	16,914	-134
Urban/Recreational Grasses (ac)	128	128	0
Emergent Herbaceous Wetlands (ac)	1,383	1,383	0
Entire Study Area	Pre-Impact (NLCD)	Condition from Issued Permits	Difference
Open Water (ac)	77,798	77,464	-334
Low Intensity Residential (ac)	61,039	60,949	-90
High Intensity Residential (ac)	7,149	7,149	0
Commercial/Industrial/Transportation (ac)	44,917	44,696	-221
Surface Mining/Quarries/Gravel Pits (ac)	103,614	334,791	231,177
Transitional (ac)	51,225	49,239	-1,986
Pasture / Hay (ac)	492,438	491,439	-999
Row Crops (ac)	112,010	111,691	-319
Urban/Recreational Grasses (ac)	16,017	16,015	-2
Emergent Herbaceous Wetlands (ac)	3,055	3,050	-5

c. Grasslands as Indicators of Past Mining Impacts

Grasslands are not common natural habitats in the West Virginia portion of the study area (Straughsbaugh and Core, 1997). It can be assumed that natural grasslands are uncommon habitat throughout the four-state study area, in particular in the steep mountainous portions of the study area like West Virginia and Kentucky. The NLCD indicates that there are 543,663 acres of grasslands (transitional and pasture/hay land cover classes) in the four-state study area. Much of the present grasslands in the study area could be attributed to past mining impacts.

The NLCD indicate that Kentucky has historically undergone the greatest potential adverse impact from mining with 268,603 acres of grasslands. Grasslands equal 129,110 acres in Virginia, 86,777 acres West Virginia, and 59,173 acres in Tennessee. There is a low likelihood that all of the grasslands of the study area can be attributed to mining. However, this acreage for West Virginia is supported by a separate study which estimated 244,000 acres of West Virginia has been disturbed by past or current mining (Yuill, 2002). For further extrapolation on this subject please refer to IV. Uncertainty Section of this report.

2. West Virginia Specific Results

a. Forest Loss

Total forest area of the West Virginia portion of the study area is 2,703,677 acres. The potentially adverse impact of mountaintop mining in West Virginia is summarized below based on specific mining disturbance activities:

Forest loss from mine permit areas = 86,587 ac (3.2%)

Forest loss from mineral extraction areas = 45,544 ac (1.7%)

Forest loss from valley fill areas = 18,338 ac (0.7%)

Forest loss from auxiliary areas = 22,705 ac (0.8%)

b. Impacts to Riparian Habitats

The projected riparian habitat potential adverse impact in the West Virginia portion of the study area total 7,591 acres of an existing 236,843 acres (WV GAP Dataset). This equates to a 3.2% loss in this habitat type in the West Virginia portion of the study area. Approximately 55% of the potentially adverse impacts occur in forested headwater (1^{st} and 2^{nd} order Strahler streams) riparian areas (3,233 ac) and forested small stream (3^{rd} and 4^{th} order Strahler streams) riparian areas (913 ac). There is a high likelihood that these impacts will occur because they are inherently associated with valley fill activities due to this type habitat's position on the landscape. This analysis used the 60% complete permit dataset, therefore, potentially adverse impacts may be underestimations.

c. Potential Ecological Condition

Potential ecological condition (PEC) is a metric designed to determine the ecological condition of a particular landscape unit. Generally, PEC is evaluated at the watershed level. Figure III.C-1 shows the positive relationship between PEC and forest cover using data from the 63 watersheds in the West Virginia portion of the study area.

Using the relationship represented in Figure III.C-1 the PEC of the study area can be calculated for the existing condition (pre-impact), the issued permit condition, and the future projected condition. These conditions are represented on the figure with dashed lines. PEC of the study area under the pre-impact condition is near 1.7 units. Under the permit issued condition PEC scores have the potential adverse impact of dropping to near 1.65 units. The projected future condition could yield a potential adverse impact of a drop in PEC score for the study area to about 1.59 units.

It should be noted that although forest cover is a large determinant in the calculation of PEC, other land use variables also go into the variable (refer to II. Methodology for description of PEC calculation). The values represented in Figure III.C-1 are approximations; however, due to the strong relationship between forest cover and PEC there is a high likelihood that these approximations are accurate.

d. Forest Edge

Forest loss from mountaintop mining in the West Virginia portion of the study area has the potential of creating 2.7% more edge habitat. A total of 17,477 more edge pixels are in the West Virginia portion of the study area after the 60% complete permit dataset is applied to the pre-impact WV GAP dataset. This potentially adverse impact has a high likelihood of occurrence. This increase in edge habitat is an underestimation since the value was calculated using the 60% complete permit dataset.

e. Number of Patches

There area 100,392 pre-impact land class patches in the West Virginia portion of the study area (WV GAP Dataset). When the 60% complete permit data is applied to the WV GAP land cover dataset the number of land class patches increases to 139,689. This is equates to an approximately 40% increase in the number of land class patches which implies an increase in fragmentation of the natural environment. This potentially adverse impact has a high likelihood of occurrence and is an underestimation especially since the result was generated from 60% of the permit data set.

f. Mean Patch Size

Mean patch size in the West Virginia portion of the study area is 24.64 acres (WV GAP Dataset) before the mine permit dataset is applied. Application of the 60% complete permit dataset to the WV GAP land cover dataset yields a mean patch size of 14.33 acres. This reduction in the average size of land class patches implies fragmentation of the natural environmental. The potentially adverse impact of fragmenting the natural environment has a high likelihood of occurrence especially since this decreased is biased high because the permit dataset used was only 60% complete.

g. Percent of the Landscape

The percent of the landscape in the West Virginia portion of the study area that each land class patch type occupies is presented in Table III.C-2. Table III.C-2 includes the percent of the landscape of each land class patch type using the WV GAP Dataset prior to application of the 60% complete permit dataset. The greatest change is in the mining - barren class patch type which shows a 1.9% increase in area following application of the permit dataset. The greatest potential adverse impact is experienced by the diverse mesophytic forest type with a reduction in area of 1.3%.

Table III.C-2
Land Class Patch Type Percent of Landscape, WV

Land Class Patch Type	Percent of the Landscape	
	Pre-Impact (WV GAP Dataset)	Condition from 10 yrs of Issued Permits
Shrubland	1.0	0.9
Woodland	0.2	0.2
Water	1.0	1.0
Highway	<0.1	<0.1
Powerlines	0.3	0.3
Populated	0.2	0.2
Urban (all 3 types)	1.2	1.2
Rowcrop - Ag.	<0.1	<0.1
Pasture - Grassland	3.2	3.5
Mining - Barren	2.6	4.5
Planted Grass	<0.1	<0.1
Conifer Plantation	<0.1	<0.1
Floodplain Forest	0.6	0.6
Forested Wetlands	<0.1	<0.1
Shrub Wetlands	<0.1	<0.1
Herbaceous Wetlands	<0.1	<0.1
Cove Hardwoods	11.7	11.3
Diverse Mesophytic Forest	61.6	60.3
Hardwood - Conifer Forest	1.0	1.0
Oak Forest	6.4	6.3
Mtn. Hardwood Forest	8.6	8.4
Mtn. Hardwood - Conifer Forest	<0.1	<0.1
Mt. Conifer Forest	<0.1	<0.1

IV. UNCERTAINTY SECTION

A. AQUATIC IMPACTS

1. Direct Stream Loss

a. Permit Boundaries

Calculation of direct stream loss based on the entire permit area may overestimate actual direct impact. As can be seen from the West Virginia specific analysis, an additional 100 miles of direct stream impact is calculated when the permit area is used as opposed to a sum of the direct impact based on valley fill area and extraction area. This auxiliary area is occupied by support areas, erosion and sedimentation control facilities haul roads and areas included within the permit because of geometry but not disturbed by mining activities. Direct impacts to streams could occur from activity within the auxiliary area such as sediment ponds and haul roads. The sum of these auxiliary areas is generally small relative to the entire permit area; however, this could overestimate the direct stream loss.

b. Stream Network

The miles of stream is calculated based on a given stream network. Different stream lengths result when different measuring sticks are used. The calculated miles of stream differ between a synthetic stream network and if one were to calculate the miles of stream based on USGS topographic maps. Also, there can be length differences between synthetic stream networks generated in slightly different ways or quantified in slightly different ways because the stream length is greater when greater stream sinuosity. Therefore, there is uncertainty in the miles of direct stream impacts. There is less uncertainty in the percent of direct stream impacts.

The GIS stream network was generated from DEM data using standard ARC Info commands. The streams are "synthetic" in that they were not generated by conversion of existing maps, such as orthophotographs or USGS 7.5' quad sheets, into digital format. Rather, they were generated using a digital elevation model (DEM). A DEM is a digital representation of the earth's surface based on a regular series of sample elevation points organized in a 30x30 meter grid. DEM's can be used to model the direction of water flow and accumulation of flow.

For the data used in the cumulative impact study a contributing area of 30 acres was selected to generate a stream. There is some uncertainty is this selection given that permits in Kentucky have indicated perennial streams in watersheds smaller than 10 acres. Therefore; the synthetic stream network may underestimate stream length.

B. TERRESTRIAL IMPACTS

1. Forest Loss

a. Permit Boundaries

The forest loss was calculated based on permit boundaries. As can be seen from the West Virginia specific analysis, 0.8% of the forest loss was due to auxiliary areas (outside of the mineral extraction and valley fill areas). It is an overestimate to assume that the entire area within the permit boundary will be disturbed. Also, mine areas and fills on permit application maps are often altered during the life of a mine; therefore, the extent of mine extraction area or valley fill used in this study has uncertainty.

b. Kentucky Permit Data

Mine permit polygons in Kentucky were based upon four years of mining permits. Since the other three states had permit data for a ten year time period the Kentucky Permit area and forest loss were multiplied by 2.5 to approximate mine disturbances in a ten year time frame. This adjustment for Kentucky has no spatial placement. There is uncertainty in what land cover type will be disturbed by the actual mines. Kentucky presently is 92.8% forested (NLCD). This suggests that there is a high likelihood that the forest land cover will incur the projected potential adverse impact.

Multiplying the four year permit data by 2.5 to approximate ten years of mining Permit also assumes that mining in Kentucky will continue at the same rate for the last six years of the projection. This also leads to some uncertainty in the data.

c. Timber Harvesting

Mountaintop mining is not the only activity affecting the landscape in the watersheds studied. Forest harvesting is widespread. The wood products industry plays an important role in West Virginia's economy accounting for 11.2% of the state's manufacturing employment (this figure excludes furniture and paper.) The economic importance of this industry is growing . Greenstreet and Cardwell (1997) reported a 40% increase in payroll employment between 1980 and 1995. Much of West Virginia's forests are single cohort stands of merchantable size containing high value species such as oaks, black cherry, yellow-poplar, sugar maple, and white ash. 66% of the state's forests are owned by non-industrial forest land owners, 24% are owned by corporations, and just 6% are publicly owned (Birch, 1996.) Between 1975 and 1989 the percentage of private forest land owners planning to harvests timber rose from 8% to 35% (Birch and Kingsley, 1978; DiGiovanni, 1990 as reported by Fajvan et al., 1998)

In West Virginia the most prominent harvest technique is diameter limit cutting (WV Asst. State Forester, personal communication.) This method selects trees based on stem diameter. For instance all merchantable trees greater than 12" diameter are removed. As large, high value species are disproportionately removed from the stand, species composition shifts to less desirable species such as red maple. Decreases in average stand diameter occur as well as changes in stand density and structure (Fajvan et al., 1998.) Oaks and hickories are highly valued commercially however they also provide an important habitat component to many species of wildlife. With fewer mast producing trees in the residual stands some wildlife populations may experience declines. From an economic standpoint potential future stand value may be decreased. According to Dwyer and Kurtz (1991) "…all too often [diameter limit harvesting] is used as an expedient means to liquidate the future stock of potentially high quality timber supply to improve short-term returns to the purchaser." In sum, diameter limit harvesting is widespread and it has ecological and economic impacts that may combine with impacts from mountaintop mining to exacerbate cumulative effects on the environment and local communities.

d. Temporal Misrepresentations

Forests are the post-mining land use on many of the mined sites used in this analysis. Forest regeneration on mined sites was not considered in the analysis of forest loss from the issued permits or for the projected future condition. Thus, future conditions may have forests on some of the current mine permit areas and this is not accounted for in the analysis. This suggests that forest loss has been overestimated to some extent. Handel (2001) showed that forest regeneration on mined sites is slow; therefore, the likelihood that the projected potential adverse impact to forests will occur is still relatively high.

2. Non-forest Land Cover Class Change

a. Underestimations Due to Scale

The potential adverse impacts to non-forested land cover classes could be grossly underestimated for land cover classes that are common at a small scale. For example, there are probably many home sites that would classify as low intensity residential that are undetectable and therefore unmapped in the National Land Cover Dataset because they are located within a broader land cover type like the deciduous forest. Urban/recreational grasses and emergent herbaceous wetlands are two other land cover that may be under-represented due to this matter of scale.

b. Temporal Misrepresentations

The potential adverse impacts to the transitional and pasture/hay land cover classes may be underestimated due to difficulties projecting these land cover classes on a temporal scale. Many of the mine sites that appear in the pre-impact condition will be reclaimed to grasslands in the near future. This reclamation is not accounted for when projecting potential adverse impacts from the permit data or when projecting the future condition. In the same respect, the surface mining/quarries/gravel pits may be overestimated in the permit condition and projected future condition.

c. Other Land Use Changes

Other land use changes like timber harvesting, commercial development, residential development, etc. are not projected in this analysis. The lack of these other land use changes should be considered when evaluating the projected potential adverse impact from mining under the permit condition and the projected future condition. Any where in this report where a percent land cover is change is noted in this report the reader should consider there is potential for other land use changes to alter the recorded percent. For this reason, in this report potential adverse impacts were recorded as an area (ac) impact when possible.

3. Grasslands as Indicators of Past Mining Impacts

The assumption that all grasslands (pasture/hay and transitional cover classes) in the study area are indicators of historic mining results in an overestimation of past mining impacts. Literature review does indicate that natural grasslands are uncommon in the study area; however, there is no way to be certain that all grasslands in the study area are historic mining sites. A more accurate representation may have been to designate all grasslands above a certain coal seem elevation and of a minimum size as grasslands indicating past mining impacts. This exercise was not done due to project schedule constraints.

The reader should be aware that this number is an overestimation of past mining impacts. Abandoned farm sites and herbaceous floodplains are two examples of the grasslands cover that would result in an overestimation with this metric. Yuill (2002), reporting on the West Virginia portion of the study area only, indicated that agriculture decreased from almost a million acres in 1950 to about 246,000 acres presently. These abandoned agricultural lands may now be another land use (i.e. residential, commercial) but some may be transitional lands that are part of the calculation to approximate past mining impacts. However, Yuill (2002) also estimated 244,000 acres of West Virginia has been disturbed by past or current mining by compiling various data sources including land cover categories such as grassland/pasture. The Yuill (2002) study seems to support the use of transitional and pasture/hay land cover classes as indicators of past mining.

4. Impacts to Riparian Habitats

a. Uncertainty in the Data

This metric was calculated from the 60% complete permit dataset. Therefore, the potentially adverse impact that was calculated is an underestimation of the expected. Riparian habitats used in this analysis were those identified in the WV GAP Dataset (refer to Section II. Methodology for specifics). This dataset differs from the WV GAP land use dataset that was used for modeling other impacts and it includes many of the land use classes used in the other analyses. Thus, impacts to riparian habitats presented herein may be expressed as impacts to other patch types (i.e. Diverse mesophytic forest, Floodplain forest) in other places in this document.

b. Problems in Defining Riparian Habitat

Riparian habitats are defined as those habitats located on the banks of a natural watercourse (Stiling, 1996). Larger watercourses have broader, more defined riparian areas. For example, a river flowing through a valley may have a riparian corridor that is hundreds of feet broad on either side. On the other hand, a small headwater stream flowing down a steep-sided valley may have a riparian area of only a few feet broad. Because of this, many of the riparian areas of the study area may be under-represented in the data.

To help appreciate the extent of potential adverse impacts to riparian habitats of the study area the reader should refer to the stream impact results. The direct impacts to first and second order streams also have impacts to riparian habitats that likely are lacking from the data. These potentially adverse impacts probably constitute a very small area and if included would not change the results substantially.

5. Potential Ecological Condition

a. Factors Associated with Calculation and Application

Potential Ecological Condition (PEC) is a value calculated to determine the ecological health of a defined landscape scale, usually the watershed level. This cumulative impact study evaluated potentially adverse impacts on a broader scale (state by state and four-state study area). The detailed West Virginia analysis did provide watershed level PEC results. From these the relationship between PEC and percent forest cover was used to approximate PEC scores at a study area level. These results are by no means an accurate account of PEC of the study area but are presented here to represent the general trend in PEC decline as forest cover declines.

Other factors associated with PEC calculation (refer to II. Methodology) are omitted from the approximation of PEC at the study area level. Since percent forest cover explains most of the variation in PEC value (refer to Figure III.C-1) it is assumed that the approximated PEC values are accurate representations and worthwhile to be used to show a declining trend in PEC value with declining percent forest cover.

b. Lack of Pre-Impact Value

PEC of the study area was not calculated using the pre-impact data. The best approximation of pre-impact PEC of the study area was obtained through a scatter plot of PEC values vs. percent forest cover for the 63 watersheds in the West Virginia portion of the study area (Figure III.C-1). The results do not allow for a true comparison of pre- and post-potential adverse impact of PEC values. As stated above, however, since PEC and percent forest cover are strongly positively related the approximation presented here is worthwhile to be used to show a declining trend in PEC value with declining percent forest cover.

6. Forest Edge

Forest edge was calculated from the 60% complete permit dataset for the West Virginia portion of the study area. For this reason, the forest edge results are likely an underestimation of the potential adverse impact. Another consideration of forest edge is that beyond a certain threshold as forest is loss the ability for forests to have an edge is loss. That is, at some point, the amount of forest edge in a forest that is being continually fragmented, will eventually begin to decrease because there isn't enough forest to sustain an edge. Graphically it would appear as a bell-shaped curve.

7. Number of Patches, Mean Patch Size, and Percent of the Landscape

Patch metrics (Number of Patches, Mean Patch Size, and Percent of the Landscape) were run on the 60% complete permit dataset resulting in an underestimation of the potentially adverse impacts. The FRAGSTATS software quantified patch metrics within each of the 63 watersheds of the in the West Virginia portion of the study area. This watershed approach differs from most of the metrics presented in this report which are at the state or four-state study area level. To convert the watershed-based results to a result for the West Virginia portion of the study area each of the 63 watersheds results were tallied for each metric.

V. DISCUSSION

A. ECOLOGICAL SIGNIFICANCE OF METRICES ASSOCIATED WITH THE AQUATIC ENVIRONMENT

1. Summary and Discussion of Results of Aquatic Metrices

Direct impacts to 1,208 miles of streams is estimated based on the last 10 years of digital permit data. If mining, permitting and mitigation trends stay the same, an additional thousand miles of direct impacts could occur in the next ten years. The watersheds with the greatest miles of streams impacted and percent of stream length impacted are presented on Figure V.A-1. The majority of the streams directly impacted are headwater streams. Figure V.A-2 presents ranges of miles of direct stream impacts.

2. Consequences of Altering Ecological Processes in Aquatic Systems

a. Considerations in the Cumulative Impact Assessment of Ecological Process Effects

The array of effects that mountaintop mining and valley fill activities may pose can be incredibly complex. Inherent to this complexity is a tendency for these effects to combine with and/or compound one another. In aquatic systems, the adverse effects of mountaintop mining and valley fill activities may combine to create a larger net negative effect than if considered singularly. This is an additive process referred to as a cumulative effect.

Cumulative effects are broadly defined by the Council on Environmental Quality (CEQ) guidelines for implementing the National Environmental Policy Act (NEPA) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions" (40 CFR 1508.7). Within the context of this cumulative impact study, cumulative impacts were assessed for a 63 watershed area, representing a subset of the entire MTM/VF study area.

An additional component of cumulative effect, are the underlying adverse effects that may compound one another, creating net negative effects of a different, and potentially more intense, nature. This is a multiplicative process referred to as synergism. Cumulative effects within or among watersheds can cause unacceptable changes to downstream aquatic, terrestrial, and human resources. Cumulative impacts from changes in topography and land cover may result in the elimination of large tracts of habitat necessary for native forest-interior species and may result in micro-climatic changes.

The cumulative effects in aquatic ecosystems may not only affect aquatic resources. By their nature, the cumulative effects of mountaintop mining and valley fill activities upon aquatic systems can extend to affect the environmental health of ecosystems outside the aquatic realm. This is due primarily to the extensive and complex interconnectedness between terrestrial and aquatic ecosystems. Physical, chemical, and biological changes to aquatic systems can affect water quality, water quantity, and aquatic life. This in turn may lead to changes in the natural environment such as forest communities (floral and faunal), microhabitats; and rare, threatened and endangered species. These effects may compound further and ultimately affect the human environment.

The cumulative effects analysis of aquatic systems performed in this study focused on direct impact to stream systems through actual loss of stream length. No attempt was made to assess stream length that may become impaired as a result of indirect effects from filling or mining.

It is also necessary to consider the secondary effects of activities associated with mountaintop mining and valley fill activities. Secondary effects are actions which, in this case, are conducted in support of establishing or operating a mine, and are defined by CEQ as those that are "caused by an action and are later in time or farther removed in distance but are still reasonably foreseeable" (40 CFR 1508.80). These activities such as clearing sites, building access or haul roads, and drainage or sediment control systems, can cause alterations in the topography and drainage patterns of mined areas. There are also changes in vegetation and ground cover that are associated with mountaintop mining. The possible cumulative effect from similar or multiple projects has been raised as a concern for analysis in these watersheds. No quantitative evaluation of secondary effects was performed in this cumulative impact study.

b. Ecological Process Effects in Aquatic Systems

This section focuses specifically in the cumulative impacts to headwater streams and their associated watersheds from mining and associated activities. One useful approach to evaluating cumulative impacts focuses on an evaluation of ecological processes. USEPA (1999) lists a total of 10 ecological processes that effectively capture ecosystem functioning and should be evaluated for adverse effects. These processes include:

1. Habitats Critical to Ecological Processes
2. Pattern and Connectivity of Habitat Patches
3. Natural Disturbance Regime
4. Structural Complexity
5. Hydrologic Patterns
6. Nutrient Cycling
7. Purification Services
8. Biotic Interactions
9. Population Dynamics
10. Genetic Diversity

Two of these processes are associated largely with terrestrial systems in the MTM/VF study area. These include pattern and connectivity of habitat patches and natural disturbance regimes. Impacts to these ecological processes have been discussed in terrestrial-related sections of this document. Impacts from MTM/VF activities to the remaining eight ecological processes will be summarized in this section as part of the evaluation of cumulative impacts.

Impacts to ecological processes may result from direct activities or indirectly from alterations resulting from direct activities. This is true both for primary impacts from mining and from secondary impacts which include items such as road building, changes in residential patterns etc. that may occur as a result of the mining activity. The most significant direct impact to headwater stream systems is the direct filling of the steam and watershed during mining activities. Other direct impacts would result from secondary activities such as logging or road building but in terms of total impacts to this ecosystem, impacts from filling would be far more extensive and long lasting. Indirect impacts from filling include impacts that affect the ecological process in the stream system downstream from the filled area. These impacts largely result from direct changes in the stream system's flow regime, thermal regime, water chemistry or sediment load from mining. A cascading series of indirect effects may result from changes to any one ecological process.

Habitats Critical to Ecological Processes

At the level of a landscape or region, certain natural habitat types are especially important for the ecological functioning or species diversity of the ecosystem. Unusual climatic or edaphic (soil-based) conditions may create local biodiversity hotspots or disproportionally support ecological processes such as hydrologic patterns, nutrient cycling, and structural complexity. For these reasons, preservation of specific habitats (usually the remaining natural areas within the landscape) should be a priority (USEPA, 1999).

Within the landscape, certain habitats disproportionately contribute to ecosystem functioning. In general, these are the remaining natural areas, especially those that integrate the flows of water, nutrients, energy, and biota through the watershed or region (Polunin and Worthington, 1990). Headwater stream systems naturally provide these listed functions. (USFWS, 1999).

Headwater streams are destroyed by filling. The fisheries and streams technical studies in support of the MTM/VF EIS support that the functions of these systems may be impacted for considerable downstream distances by upstream fills. Cumulatively, many activities, in addition to filling, resulting from mine construction may result in destruction or degradation of the headwater stream systems. Although data are lacking on the magnitude of mining impacts compared to other major alterations in land use such as forestry, the permanent nature of filling would suggest that MTM/VF impacts of critical headwater stream systems constitute one of the most major threats to this system in the study area.

Structural Complexity

At the local scale, ecosystems possess a natural complexity of physical features that provides for a greater variety of niches and more intricate interactions among species. Local structural complexity increases with more snags in the forest, and more woody debris in the stream. At other scales, spatial heterogeneity is equally important, affecting a wide range of ecological processes from predator-prey interactions to energy transfer among ecosystems (USEPA, 1999). Considerable experimental evidence supports the concept that physical structure may prevent generalist foragers from fully exploiting resources and thus promote the coexistence of more species (e.g., Werner, 1984). Simply put, complex habitats accommodate more species because they create more ways for species to survive (Norse, 1990).

Headwater stream systems are known to be structurally complex. The structural complexity of headwater streams may be negatively impacted by several indirect effects from MTM/VF. Stream sections downstream from fills may be subjected to increased sedimentation from improper placement of sedimentation ponds, sedimentation pond failure or from post mining run off. Sedimentation may also result from runoff from areas being logged prior to mining. Sedimentation may fill pool areas and smother riffles and snags, decreasing the structural complexity of the stream.

Technical studies performed for the MTM/VF EIS indicate that both stream flow and stream temperature may become more constant in streams sections downstream from fill. Although these changes may not impact the physical complexity of streams, there may be subtle decreases in availability of niches that occur from decreasing the normal flow and thermal fluctuations inherent in headwater stream systems.

Timber harvesting or tree removal is generally performed prior to mining. Timber harvesting may be limited to the area of coal extraction, or may extend down the watershed from the anticipated toe of fill. This activity would impact the leaves and woody material available for deposition into a stream. A decrease in these materials would impact the stream's structural complexity by reducing the material available for forming leaf packs, snags, or other woody-material related stream structures. Woody material in these systems is also responsible for retaining small volumes of water into micro-pools which represent an additional source of structural complexity (Wallace, 1992).

Several of the impact factors mentioned including sedimentation and reductions in the inputs of leaves and woody material would not be limited to mining impacts only. These types of impacts would also occur from other activities such as forestry.

Hydrologic Patterns

Ecosystems possess natural hydrologic patterns that provide water for organisms and physical structure for habitats. This cycle of water is also the vehicle for the transfer of abiotic and biotic materials through the ecosystem. The natural hydrologic patterns of an ecosystem include the magnitude, frequency, duration, timing, and rate of change (flashiness) of water flow.

The range of hydrologic variability in streamflow quantity and timing can be thought of as a "master variable" affecting biodiversity and ecological integrity in riverine systems (USEPA, 1999). The natural flow of a river varies on a time scale of days, seasons, years and longer (Poff et al. 1997).

There are five critical components of the flow regime (Poff and Ward, 1989, Richter et al., 1996):

- Magnitude
- Frequency
- Duration
- Timing
- Rate of change (flashiness) of hydrologic conditions

These components interact to maintain the dynamics of in-channel and floodplain habitats that are essential to aquatic and riparian species (Poff et al., 1997).

Hydrologic modeling studies performed for the MTM/VF EIS found that peak storm water flows are slightly higher during and after mining. Hydrologic results from a separate field study indicate that fills tend to increase the base flow of the stream and decrease the peak flow during a storm event. Water temperature in streams in filled watersheds was less variable than in unfilled watersheds.

These types of impacts appear to be unique to MTM/VF activity in the study area. Other activities which might affect hydrologic patterns, such as agricultural practices or water withdrawals, are not major activities in the study area. Alterations in hydrologic patterns may have further impacts on other ecological processes and are discussed under those processes. For both direct and indirect impacts to ecological processes resulting from alterations in hydrologic patterns, MTM/VF would appear to be the major impact producing activity in the study area.

Nutrient Cycling

Ecosystems have evolved efficient mechanisms for cycling nutrients, which combined with sunlight and water determine the productivity of the systems. The natural flow or organisms, energy, and nutrients is essential for maintaining the trophic structure and resiliency of the ecosystem. Reduction or augmentation of nutrient inputs to ecosystems can drastically alter these trophic interactions and ultimately the quality of the environment. The input and assimilation of nitrogen is the most common measure of nutrient cycling, but the dynamics of other essential compounds are also important.

Nutrient cycles are the processes by which elements such as nitrogen, phosphorus, and carbon move through an ecosystem. This cycling is critical to the functioning of ecosystems; otherwise essential elements and nutrients would continue on a relentless flow downhill, depleting ecosystems uphill (Noss and Cooperrider, 1994). But terrestrial and aquatic systems have developed mechanisms that slow the movement of water, nutrients, and energy to the sea. Vegetation of all types intercepts nutrient-rich waters and bind materials in place. Anadromous fishes and other migrating species move major amounts of biomass and minerals upstream, but the role of animals in moving nutrients uphill has received relatively little study.

Trophic interactions within ecosystems (e.g., the food chain of plant-herbivore-carnivore) are the most visible part of the cycling of energy and nutrient within ecosystems. Changes in the input or export of nutrients within ecosystems can affect the status of these trophic levels and can have ramifications for biotic interactions as well as ecosystem functioning. Less obviously, decomposers (such as invertebrates and microorganisms) serve the critical role of recycling dead material at each stage of the nutrient cycle and ultimately supply the soil nutrients that feed the plants that capture the sun's energy. Many small streams have a nutrient base of leaves and downed wood that feeds insects shredders and collectors. When this nutrient base is diminished by the removal of downed wood or logging of forests, production rapidly declines.

Impacts from MTM/VF activities to the ability of headwater streams to maintain their nutrient cycling function are of great concern. The loss of the nutrient cycling function of the portion of headwater streams from direct filling may represent a substantial loss of energy to the entire aquatic system within and beyond the watershed containing the fill. This direct loss may be compounded by the further impairment of the aquatic community downstream from fills. Studies seem to suggest that the impacts to the aquatic community downstream from fills may result from water quality impacts due to filling which may be extremely difficult or impossible to correct.

The combination of the direct fill impacts which decrease nutrient cycling and indirect impacts through impairment of the aquatic community downstream from fills may result in a substantial impact to the nutrient cycling function in headwater streams. This impact has proven difficult to study directly. There is ongoing debate among regulators and scientists on the best way to collect quantitative evidence for the possible occurrence and the severity of the potential impact to nutrient cycling functions of headwater streams. Although this impact is difficult to demonstrate empirically, substantial evidence exists in the primary literature demonstrating that shifts in the aquatic community structure impact the ability of streams to process leaves and woody material, thereby decreasing the input of energy to downstream areas. This evidence supports ongoing concerns over impacts from MTM/VF to the nutrient cycling process.

Other activities, such as logging, also pose potential threats to the nutrient cycling function of headwater streams in the study area. However, the permanent nature of filling compared to the more temporary and possibly more manageable impacts from forestry, would suggest that MTM/VF impacts of to the nutrient cycling function of headwater stream systems constitute one of the most major threats to this system in the study area.

Purification Services

Ecosystems naturally purify the air and water. They also detoxify and decompose both natural and manmade wastes. Purification processes are necessary for the normal functioning of ecosystems; they break down harmful concentrations of toxic materials and refertilize soils and sediments through the action of microbes and other organisms. The capacity of ecosystems to assimilate and recycle waste material depends on physical, chemical, and biological mechanisms; this capacity may be exceeded by anthropogenic inputs depending on system-specific conditions.

Headwater stream systems do not have a tremendous capacity to provide purification services. However, although this ecological process is not one which requires protection for headwater streams, the absence of streams to provide this service reflects the sensitivity of this system to inputs of a variety of toxic materials. Surface mining releases a variety of potentially toxic materials into the environment including metals and mineral constituents such as sulfates which may act by altering physical characteristics of water (e.g. pH or specific conductance). Headwater streams, with their innately limited buffering capacity and lack of ability to sequester and precipitate out contaminants, tend to be at risk from any input of toxic materials.

In contrast, wetlands are among the most effective ecosystems for removing pollutants and purifying wastes. Wetlands operate through a series of interdependent physical, chemical and biological mechanisms that include sedimentation, adsorption, precipitation and dissolution, filtration, biochemical interactions, volatilization and aerosol formation and infiltration (USEPA, 1999). Constructing wetlands has been suggested as a possible mitigation measure for impacts to headwater streams. While this issue is complex, there may be promise in constructing wetlands in stream channels of streams impacted by MTM/VF or at the toe of fill where groundwater emerges into stream channels to improve the water quality of streams downstream from fill areas. The success of these wetland systems to improve water quality would be highly dependent on the toxicity of the water initially.

Biotic Interactions

The interactions, including the antagonistic and symbiotic interactions, among organisms are some of the most important, but least understood, factors influencing the structure of natural ecosystems. Because these interactions have evolved over long periods of time, the deletion of species from or the addition of species to an ecosystem can dramatically alter its composition, structure, and function.

Biotic interactions that are particularly important in maintaining community structure or ecosystem function are described as “keystone” interactions (USEPA, 1999).

Section I.A. describes biotic interactions common in headwater streams. Other Sections in Chapter I discuss various vertebrate species including birds, salamanders and newts and mammals which require interactions with the aquatic environment in order to maintain their lifecycle. Biotic communities have been demonstrated to occur in the uppermost reaches of watersheds, even in “ephemeral” stream zones which flow only as a result of rain or snow melt. Filling eliminatesl aquatic and aquatic-dependant interactions that would formerly have occurred in the filled area. In areas downstream from fills, changes in the macroinvertebrate and fish communities have been observed. (USEPA, 2000 and Stauffer, 2000). Any change in community composition may potentially have impacts to biotic interactions beyond that measured in the community composition study, but these interactions are often difficult to demonstrate.

Many other impact producing factors in the study area may cause environmental changes that would result in alterations or simplifications in biotic communities and associated biotic interactions. Although data are lacking on the magnitude of mining impacts compared to other major alterations in land use such as forestry, the permanent nature of filling would suggest that MTM/VF impacts to biotic interactions in headwater stream systems, including interactions linking terrestrial biota to the aquatic environment, constitute one of the most major threats to this system in the study area.

Population Dynamics

The population is a critical unit, not only for evolutionary change, but for the functioning of ecosystems. Population numbers alone do not adequately reflect the prospects for species or the continued performance of their ecological role. Information about life history and population dynamics, such as dispersion, fertility, recruitment, and mortality rates, is critical to identifying potential effects on population persistence and ecological processes. Key factor analysis can determine which links in these dynamics primarily affect population success, while population viability analysis can predict the amount and distribution of habitat needed to maintain healthy populations (USEPA, 1999).

When populations are lost, the local adaptations of these populations are lost, the ecosystem functions performed by these populations cease, and ultimately species may go extinct. In general, the risk of losing populations (and with them ecological integrity) is greatest when populations are small, but even large populations may have critical components of their life histories of population cycles that make them especially vulnerable (USEPA, 1999).

Direct and indirect impacts affecting population dynamics are of great concern for the headwater stream systems in the study area. As discussed in Section I.A., these biotic systems are characteristically locations with high numbers of endemic, unique and rare populations of macroinvertebrates, amphibians and fish. These populations tend to be small and highly specialized for life in the headwaters environment. Species with these traits tend to be sensitive to relatively small changes in their environment (Stein et al., 2000). Some species in headwater streams may have distributions limited to only one or several watersheds. With such a small geographic range, fill activities from one mine may impact the entire population.

MTM/VF activities may impact population dynamics through indirect as well as direct impacts. Examples of changes that might occur include the following. Changes in contaminants or in thermal regime may affect survivorship and reproduction. The number of individuals available for recruitment may also decrease. The increase in base flow may eliminate intermittent flow areas which serve as refugia for amphibians from fish. The loss of autochthonous input from concurrent timber harvesting may decrease the habitat types available which may impact reproductive success for some species. Finally, egg mortality may increase from increased sedimentation.

Many other impact producing factors in the study area may cause environmental changes that would result in altered population dynamics and the extirpation of populations of some species. Although data are lacking on the magnitude of mining impacts compared to other major alterations in land use such as forestry, the permanent nature of filling would suggest that MTM/VF impacts to population dynamics in headwater stream systems constitute one of the most potentially adverse threats to this system in the study area.

Genetic Diversity

Diversity at the genetic level underlies the more visible diversity of life that we see expressed in individuals, populations, and species. Over evolutionary time, the genetic diversity of individuals within and among populations of species contributes to the complex interplay of biological and nonbiological components of ecosystems. The preservation of genetic diversity is critical to maintaining a reservoir of evolutionary potential for adaptation to future stresses.

Genetic diversity originates at the molecular level and is the result of the accumulation of mutations, many of which have been molded by natural selection. The genetic variants found in nature are integrated not only into the physiological and biochemical functions of the organism, but also into the ecological framework of the species. The genetic diversity of a species is a resource that cannot be replaced (Solbrig, 1991). Genetic diversity enables a population to respond to natural selection, helping it adapt to changes in selective regimes. Evidence indicates that a reduction of genetic diversity may increase the probability of extinction in populations.

Many of the factors that would affect genetic diversity have been discussed for population dynamics. Extirpating populations as well as species would result in decreases in genetic diversity in the study area. Direct filling of streams reduces the numbers of individuals of rare and endemic species thereby reducing its genetic diversity or even causing it to become extinct. Indirect impacts from mining through alterations in water chemistry, stream flow or the aquatic thermal regime may also negatively impact populations reducing genetic diversity.

The southern Appalachians have been identified by the Nature Conservancy as one of the hot spot areas in the United States for rarity and richness (Stein et al., 2000). This region is known to have the highest regional concentration of aquatic biodiversity in the nation. For this reason, it is hypothesized that impacts which result in decreases in genetic diversity, as measured by loss of species, loss of populations or loss of genetic variants, would have a disproportionately large impact on the total aquatic genetic diversity of the nation.

B. ECOLOGICAL SIGNIFICANCE OF METRICS ASSOCIATED WITH THE TERRESTRIAL ENVIRONMENT

1. Ecological Significance of Forest Loss

Based on permits issued in the last ten years and an assumption of similar permits in the next ten years, mountaintop mining has the potential to adversely impact 380,547 acres of forest in the four-state study area. Table V.B-1 outlines the projected terrestrial impacts in the four-state study area. Table V.B-1 projects the future terrestrial condition using the issued permit data and a long-term future projection which is 2X the permit data projection. The data show that forest loss is associated with an increase in the quarry/strip mines/gravel pits land cover type. When adding past, present, and future forest impact; the study area estimated forest impact is 1,408,372 acres. This impact acreage errs toward overestimation as described in the uncertainty section.

Table V.B-1
Predicted Terrestrial Impacts

Kentucky Portion of the Study Area	Baseline Condition (NLCD)	Condition from Issued Permits	Projected Future Condition
Forest Cover (ac) [4 yr permit data x 2.5]	6,400,838	6,145,256	5,889,674
Forest Cover (%) [4 yr permit data x 2.5]	92.8	89.3	85.6
Forest Loss (ac) [4 yr permit data x 2.5]	---	255,582	511,164
Grassland as indicator of past mining impact (ac)	268,603	267,414	---
Quarry/strip mines/gravel pits (ac) [4 yr permit data x 2.5]	37,710	271,972	---
Tennessee Portion of the Study Area	Baseline Condition (NLCD)	Condition from Issued Permits	Projected Future Condition
Forest Cover (ac)	960,455	951,301	942,147
Forest Cover (%)	89.5	88.6	87.8
Forest Loss (ac)	---	9,154	18,308
Grassland as indicator of past mining impact (ac)	59,173	58,980	---
Quarry/strip mines/gravel pits (ac)	1,208	10,601	---
Virginia Portion of the Study Area	Baseline Condition (NLCD)	Condition from Issued Permits	Projected Future Condition
Forest Cover (ac)	1,166,652	1,137,428	1,108,204
Forest Cover (%)	86.5	84.3	82.1
Forest Loss (ac)	---	29,224	58,448
Grassland as indicator of past mining impact (ac)	129,110	128,120	---
Quarry/strip mines/gravel pits (ac)	18,982	49,458	---

Table V.B-1 continued
Predicted Terrestrial Impacts

West Virginia Portion of the Study Area	Baseline Condition (NLCD)	Condition from Issued Permits	Projected Future Condition
Forest Cover (ac)	2,703,677	2,617,065	2,530,478
Forest Cover (%)	93.8	90.6	87.5
Forest Loss (ac)	---	86,587	173,174
Forest Loss from Valley Fills (ac)	---	*18,338*	---
Forest Loss from Mineral Extraction Area (ac)	---	*45,544*	---
Forest Loss from Auxiliary Areas (ac)	---	*22,705*	---
Grassland as indication of past mining impact (ac)	86,777	86,164	---
Quarry/strip mines/gravel pits (ac)	45,715	133,155	---
Entire Study Area	Baseline Condition (NLCD)	Condition from Issued Permits	Projected Future Condition
Forest Cover (ac)	11,231,622	10,844,519	10,457,416
Forest Cover (%)	92.1	88.9	85.7
Forest Loss (ac)	---	380,547	774,206
Grassland as indicator of past mining impact (ac)	543,663	540,678	---
Quarry/strip mines/gravel pits (ac)	103,615	403,810	---

NLCD = National Land Cover Data Set

Figure V.B-1 depicts the 20 watersheds with the most potential adverse impact in terms of forest loss. When this figure is compared to Figure II.A-1 one can see that the Northern Cumberland Mountains Ecological Subregion has the greatest potential adverse impact in terms of forest loss (%). In contrast, Figure V.B-2 depicts watersheds in the four-state study area with less than 87% forest cover. The Northern Cumberland Plateau Ecological Subregion has the most watersheds with less than 87% forest cover under the condition from the issued permits.

a. Uniqueness of Habitats Within the Study Area

The study area is unique in that it contains a diverse flora and fauna with a mixture of northern and southern species. The steep mountain slopes and deep valleys create a unique topography which lends itself to the development of numerous microclimates. These microclimates are in part responsible for the great variety of vegetative communities found within the study area. Each of these vegetative communities provides forage, shelter, and nesting places for reproduction to characteristic wildlife species.

The data suggests that five of the land use / habitat types of the West Virginia portion of the study area undergo considerable changes under the long-term mountaintop mining scenarios. These five habitat types and the species that they support are discussed below.

Diverse Mesophytic Hardwood Forests and Cove Hardwood Forests

Dominant among the land use types in the West Virginia portion of the study area is the diverse mesophytic hardwood forest (61.6%). This forest type is among the most diverse forest type in the southeastern United States, containing more than 30 canopy species (Hinkle et al.,1993). The predominant species in the diverse mesophytic forest type are various maples (*Acer* spp.), yellow poplar (*Liriodendron tulipifera*) and beech (*Fagus grandifolia*); however, dominance is shared by a large number of species including various oaks, hickories (*Carya* spp.), cherry (*Prunus* spp.), and black walnut (*Juglans nigra*), to name but a few. This forest type is characterized by a diverse understory of trees that never attain canopy position such as dogwoods (*Cornus* spp.), magnolias (*Magnolia* spp.), sourwood (*Oxydendrum arboreum*), striped maple (*Acer pennsylvanicum*), and redbud (*Cercis canadensis*). Wildflowers are commonly found in this forest type because of the open canopy in the spring.

The cove hardwoods are a type of mixed mesophytic hardwood forest. They are included here because species common to the cove hardwoods are likely common to the mixed mesophytic hardwood forest type as well due to their spatial relationship. Cove hardwoods are found in ravines, coves and along north-facing slopes. Species composition is generally very diverse with yellow poplar, red oak (*Quercus rubra)*, pin cherry (*P. pennsylvanica*), black cherry (*P. serotina*), paper birch (*Betula papyrifera*), yellow birch (*B. alleghaniensis*), aspen (*Populus* spp.), sugar maple (*A. saccharum*), red maple (*A. rubrum*), and Eastern hemlock (*Tsuga canadensis*). Local species dominance patterns are often small scale with significant species changes over relatively short distances.

Due to the abundance and variety of fruits, seeds, and nuts the diverse mesophytic forest type provides excellent habitat for wildlife and game species alike. Species of birds typically present include the wood thrush (*Hylocichla mustelina*), Acadian flycatcher (*Empidonax virescens*), and blue-gray gnat-catcher (*Polioptila caerulea*). Wildlife species richness of the mixed mesophytic forests of the study area are considered one of the most diverse in the United States (Hinkle et al., 1993).

Mining-Barren Lands

The mining-barren lands patch type includes those areas where mining activities have significant surface expression. Generally, vegetative cover and overburden have been removed to expose deposits of coal, iron-ore, limestone, and other rocks and minerals. Included in this category are inactive coal mines, quarries, gravel pits, etc. that lack sufficient vegetative cover for reclassification in another patch type. Also included are those areas that for one reason or another, human induced or not, are unable to support vegetation. These may be areas with thin soils, or sand or rock covered. For the sake of this report, the increase in mining-barren lands recognized under many of the long-term scenarios is associated entirely with coal mining. Other mining activities in the study area may also lead to an increase in this patch type.

Pasture-Grasslands

The pasture-grasslands land cover type includes pastureland, hay fields, old fields, abandoned farms, and other herbaceous land cover areas (excluding wetlands). This is an important patch type in the study area because many of the mine sites are converted to grasslands post-mining. Grasslands are unique to the study area and historically were sporadic in distribution across West Virginia (Strausbaugh and Core, 1997).

Grasslands provide food and shelter to a variety of wildlife, including game animals such as whitetail deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*). This patch type also provides habitat for a variety of songbirds that are rare in the study area. Included among these are the grasshopper sparrow (*Ammodramus savannarum*), Henslow's sparrow (*A. henslowi*), and the bobolink (*Dolichonyx oryzivorus*), each of which is listed as rare in West Virginia (Wood and Edwards, 2001). These species may be listed as rare because historically their habitat is rare in the state. As this patch type increases in abundance these species may well be removed from the list.

Oak Forests

The oak forest land cover patch occurs throughout much of West Virginia. These areas generally occur on poorer/well-drained soils, ridges, or south and west facing slopes. Dominant species include white oak (*Q. alba*), black oak (*Q. velutina*), chestnut oak (*Q. montana*), and red oak mixed with red maple, yellow poplar, beech, and sugar maple.

Oak forests are important to wildlife because of their production of hard mast. Hard mast includes acorns, walnuts, and other seeds from trees. Many wildlife species feed on acorns throughout the year. Deer and squirrels are well known acorn feeders but even the lesser seen mice and many birds depend on acorns for food throughout the year.

b. Discussion of Wildlife Dependent on Forested Habitats

The WV Gap Dataset indicates that there are 26 distinct land use types in the West Virginia portion of the study area and 16 of these are associated with the terrestrial habitat. The WV Gap data also includes a list of species that are dependent upon each land use type / habitat. Table V.B-2 summarizes the WV Gap data for the terrestrial habitats of the study area.

Table V.B-2
Summary of West Virginia Gap Terrestrial Land Use Data and the Number of Wildlife Species Associated with Each Land Use Class

Land Use Class	Size (ac)	No. of Species Associated with the Land Use Class		
		Birds	Mammals	Herptiles
Diverse Mesophytic Hardwood Forests	1,852,790	131	56	57
Oak Forests	193,833	106	54	43
Pasture-Grasslands	97,620	72	44	29
Mountain Hardwood Forests	31,633	114	53	45
Hardwood-Coniferous Forests	864	124	56	46
Cove Hardwoods	350,861	93	45	39
Urban and Populated Lands	44,163	17	6	6
Mining-Barren Lands	78,377	24	6	12
Shrublands	30,196	102	54	33
Woodlands	5,170	54	21	12
Floodplain Forests	17,384	110	53	55
Mountain Coniferous Forests	864	81	49	31
Mountain Hardwood-Coniferous Forests	793	107	52	33
Row Crops-Agriculture	1,638	49	27	15
Conifer Plantations	168	95	53	33
Planted Grass	390	11	5	3

The diverse mesophytic hardwood forest is the dominant habitat type in the West Virginia portion of the study area. Table V.B-2 indicates that as many as 244 vertebrate species occupy the diverse mesophytic hardwood forests of the West Virginia portion of the study area. In general, species found within the diverse mesophytic hardwood forest are found in the other forest types. This is supported by the data presented in Table V.B-3 which lists the number of bird species that each habitat type (patch) shares with the mixed mesophytic hardwood forest patch type. Thus in a broad sense, forest loss in the West Virginia portion of the study area has the potential of directly impacting as many as 244 vertebrate wildlife species.

Table V.B-3
Summary of the Avian Richness
of the West Virginia Portion of the Study Area

WV Gap Habitat Class	Total No. of Avian Species	No. of Avian Species Shared With the Mixed Mesophytic Hardwood Forest
Barren-Mining Lands	24	16
Commercial	17	10
Conifer-Oak Forests	124	117
Conifer Plantations	95	84
Cove Hardwoods	93	93
Floodplain Forests	110	108
Planted Grass	11	6
Grasslands	72	44
Mixed Mesophytic Hardwoods	131	---
Mountain Coniferous	81	71
Mountain Hardwoods	114	114
Mtn. Hardwoods-Coniferous	107	98
Oak Forests	106	105
Orchards	23	21
Pasture	49	30
Palustrine Emergent Wetlands	55	26
Palustrine Forested Wetlands	84	77
Palustrine Open Water	100	70
Palustrine Scrub-Shrub WLs	66	52
Row Crops	49	30
Rural Lands	100	73
Shrublands	102	79
Urban Lands	17	10
Woodlots	54	51

Source: WV Gap Dataset

Wildlife impacts in the West Virginia portion of the study area can be semi-quantified as done above through the application of data available from the WV Gap Dataset. There is a high likelihood that wildlife assemblages in Virginia, Tennessee, and Kentucky run a similar risk of potential adverse impacts on wildlife assemblages as those in West Virginia since the ecological subregions, described previously, do not follow political borders.

c. Important Wildlife That May Serve as Models or Ecological Indicators of Disturbance

Impacts on Forest Interior and Neotropical Migrant Bird Populations

West Virginia has a rich avian fauna with 183 known species of birds (WV Gap data). There are 131 species of birds known to inhabit the mixed mesophytic hardwood forests of the study area (WV Gap data). Table V.B-3 summarizes the avian richness of the study area based on WV Gap habitat and bird occurrence data. The data show that forested habitats of the study area are the most diverse in terms of avian species richness and that shrublands, open water wetlands, and grasslands contain a rich avian assemblage that differs considerably from that of the forests.

Table V.B-4 lists area requirements for the 19 neotropical migrant bird species included in Robbins et al. (1989) study. This table lists the area where the maximum number of individuals is observed and the area where 50% of the maximum number of individuals is observed for each species. Based on these data, 14 of the 19 species require unbroken tracts of forest in excess of 7,413 ac (3,000 ha) for a maximum probability of observation. The black-throated blue warbler (*Dendroica caerulescens*) has the largest area requirement of the birds included in the study. This statement is supported by the 2,471 ac (1,000 ha) area requirement for probability of observation 50% that of the maximum.

Table V.B-4
Forest Area Requirements for 19 Neotropical Migrant Bird Species of the Study Area

Common Name	**Area where probability of observance is maximum (ac)**	**Area where probability of observance is 50% max. (ac)**
Acadian flycatcher	7,413+	37
Great crested flycatcher	178	1
Blue-gray gnatcatcher	7,413+	37
Veery	618	49
Wood thrush	1,235	2
Red-eyed vireo	7,413+	6
Northern parula	7,413+	1,285
Black-throated blue warbler	7,413+	2,471
Cerulean warbler	7,413+	1,730
Black-and-white warbler	7,413+	544
Worm-eating warbler	7,413+	371
Ovenbird	1,112	15
Northern waterthrush	7,413+	494
Louisiana waterthrush	7,413+	865
Kentucky warbler	741	42
Canada warbler	7,413+	988
Summer tanager	7,413+	99
Scarlet tanager	7,413+	30
Rose-breasted Grossbeak	7,413+	2

Adapted from: Robbins et al. (2000)

In general, watershed PEC values throughout the West Virginia portion of the study area, under the issued permit condition, are good or excellent. PEC values range from 0.86 units to 1.93 units with a mean value of 1.57 units (standard deviation 0.20 units). Forty-six of the 63 watersheds have PEC values of 1.62 or greater. This suggests that mountaintop mining alone may not have an adverse impact on the biologic integrity of the West Virginia portion of the study area.

Although the data suggests that ample forest will remain in the West Virginia portion of the study area to maintain relatively high PEC scores, impacts to many forest interior bird species are still likely to occur. Take for example those species with breeding ranges that are restricted to or confined mostly within the study area. Figure V.B-3 illustrates the breeding ranges of three forest interior bird species (Louisiana Waterthrush, Worm-eating Warbler, and Cerulean Warbler) that may be affected by mountaintop mining. The core of each of these species breeding ranges is within the study area. Disturbances associated with mountaintop mining have the potential to adversely impact each of these species breeding ranges. The above mentioned warblers inhabit upland forests while the Louisiana waterthrush inhabits forested riparian habitats. The potential adverse impact of loss of habitat for these species has extreme ecological significance in that habitats required by these species for successful breeding are limited in the eastern United States.

Wood and Edwards (2001) provide evidence that mine sites that were converted to grasslands after mountaintop mining provide habitat for a number of grassland bird species that are listed as "rare" in West Virginia. These species are rare in West Virginia because historically grasslands are rare in the state (Strausbaugh and Core, 1997). Some may argue that providing habitat for species listed as rare is ecologically significant. However, these grassland species have substantial breeding habitat in other parts of the United States. To illustrate this the breeding habitat of four grassland species known to occupy the grasslands of post-mining sites (Dicksissel, Horned Lark, Eastern Meadow Lark, Grasshopper Sparrow) is depicted on Figure V.B-4. The core breeding area for each of these species is well outside of the study area.

In conclusion, the avian fauna of the study area is rich and contains a number of species with interior forest requirements for successful breeding. Large tracts of intact forest are rare in the eastern United States due to a number of land use change associated reasons. Mountaintop mining in the study area has the potential to impact as much as 380,547 ac of forest. These impacts would result in fragmentation of the environment into areas of forests and grasslands. The remaining forest patches may provide proper habitat to maintain the population of most of the states avian fauna; however, a few species may be put into peril because their core breeding area is within the heart of the future mountaintop mining area. Loss of these species has more ecological importance than providing habitat for grassland species considered rare in the state because it suggests possible future endangerment of some forest interior species as opposed to the potential gain of some disjunct grassland species populations.

Impacts on Terrestrial Salamander Populations

Salamanders are an important ecological component in the mesic forests of the study area and are often the most abundant group of vertebrates in both biomass and number (Burton and Lykens, 1975; Hairston, 1987). Ecologically, salamanders are intimately associated with forest ecosystems acting as predators of small invertebrates and serving as prey to larger predators (Pough et al., 1987). Studies conducted in Eastern forests suggest that timber harvesting is detrimental to salamander populations (Bennett et al., 1980; Pough et al, 1987; Ash, 1988; Petranka et al., 1999). Specifically, Ash (1988) reported on the local extinction of Jordan's salamander (*Plethodon jordani*) from clearcut plots in North Carolina. Similarly, Petranka et al. (1993) found that forest floor salamanders were more than twice as abundant in mature forests as in clearcut plots.

Clearcutting occurs prior to surface coal mining; therefore, studies described above suggesting that timber harvesting is detrimental to salamander populations would seem to be applicable to the impact from mountaintop mining. No studies could be found that specifically address the impact of mountaintop mining on salamander populations. There are, however, many studies that present the negative impact that acidification of the terrestrial environment, a phenomenon associated with surface mining (Thomas et al., 2001 and references within), has on salamander populations (Dunson et al., 1992, Wyman and Jancola, 1992; Horne and Dunson, 1994; Frisbie and Wyman, 1995). One of the greatest impacts that mountaintop mining operations have on the terrestrial salamanders of the study area is the placement of fill in the valleys. This leads to the direct loss of salamanders under the fill and to a change in habitat on top of the fill. Removal of forests and the establishment of grasslands in once forested areas also leads to a decline in salamander populations. It has been suggested that forest clearing (clearcutting) degrades the forest floor microhabitat by increasing exposure to solar radiation and thus decreasing surface soil moisture thereby rendering it inhospitable to salamanders (Ash, 1988). This thesis has been supported within the study area. Handel (2001) reports that soil moisture within remnant forests was significantly higher than that of nearby reclaimed mine sites. Furthermore, Wood and Edwards (2001) observed a shift in the herpetofauna community from amphibian dominated in the forests to reptile dominated in grasslands of mine sites.

Petranka et al. (1993) estimates that between 75% and 80% of terrestrial salamanders are lost following clearcutting of mature timber stands. Furthermore, reestablishment of salamander populations to pre-harvest conditions has been estimated to range between 20 and 70 years (Petranka et al., 1993; deMaynadier and Hunter, 1995; Ash, 1997). Although these numbers differ and there is debate in the scientific community over which is correct (Petranka, 1999), it can be concluded that salamander populations suffer major setbacks in the years following forest removal. There is evidence that terrestrial salamander populations do not become successfully established in nearby forests as forest clearing is taking place (Hairston, 1987). Therefore, it can be concluded that salamander populations become reestablished once forests become reestablished.

Handel (personal communication) suggested, based on the findings of his study of reforestation on mined sites, that mined sites may take as long as 120 years or more to attain mature forest conditions. From this, we can conclude that salamander populations in the study will be reduced in number and biomass for a long period of time. This reduction in salamander populations may have negative impacts on the species that depend upon them in the food web.

Thirty-one (31) species of salamanders are known from the West Virginia portion of the study area (WV Gap data). Of these 25 species are known to inhabit the mixed mesophytic hardwood forest while 21 species are known to occupy cove hardwood forests. Petranka (1993) presented a conservative estimate that there are about 4,050 salamanders per acre of mature forest floor in Eastern forests (10,000/ha). Applying this number to the 11,231,622 acre of forest in the study area yields a conservative estimate of 36,390,455,280 salamanders in the study area. Assuming that 80% (Petranka, 1993) of the salamanders are lost in the projected forest impact areas, approximately 1,232,972,280 have the potential of being adversely impacted. This equates to 3.4% of the entire salamander population of the four-state study area. Species that are most likely to be affected are those that are most abundant on the forest floor and along the riparian areas of the small headwater streams. These are predominantly the *Plethodon* and *Desmognathus* species.

2. Discussion of Habitat Changes and Interpretation of Significance

Habitat changes will occur in the study area and these changes will involve a shift from a forest dominated landscape to a fragmented landscape with considerably more mining lands and eventually grassland habitat (Figure V.B-5). This shift should lead to a shift in the floral and faunal components of the ecosystem. For example, dry grassland species will dominate the once post-mined and forest harvested sites. This will result in an overall reduction in the native woody flora as well as a reduction in the spring herbs and other vegetative components characteristic to the study area (Handel, 2001).

Wildlife shifts will include a shift from forest to grassland species. The abundance of grassland birds will likely increase while many forest interior, neotropical migrant species will suffer losses in terms of number (Wood and Edwards, 2001). There will likely be an increase in game species such as whitetail deer and turkey due to an increase in grasslands and the diversification of the habitats. The herpetofauna will likely undergo a shift from mesic favoring salamander dominated communities along the riparian corridors of the small headwater streams and in the litter of the forest floor to a snake dominated grassland fauna (Wood and Edwards, 2001).

3. Potentially Adverse Impact on Biodiversity

Biodiversity is the variety of organisms in an area. In this case, the area is defined as the four-state study area; however, a better ecological boundary would be the Ecological Subregions described in Table II.A-1. Biodiversity can be applied to various levels of biological organization but in the case of assessing potential adverse impacts to biodiversity within the Ecological Subregions of the study area only two levels of biological organization apply. Impacts to the terrestrial environment may affect biodiversity of the at the (1) genetic and/or (2) species/population level. Species affected by fragmentation within the Ecological Subregions would include those with specific requirements for habitats that are lost and those with poor dispersal abilities.

The direct loss of habitat and fragmentation of a once contiguous environment is considered by some to be the most serious threat to biological diversity (Wilcox and Murphy, 1985). Unfortunately, the result of anthropogenic changes on the natural environment takes time, which makes impacts difficult to measure. The effects of habitat losses are likely to take generations, even centuries, before fully realized (Tilman et al., 1994; Brown and Lomolino, 1998).

Wilcove (1987), recognizing this time lag affect on natural environments, presented a series of sequential stages that are expected to occur following anthropogenic change to the natural environment. These stages lead finally to biological collapse and begin immediately following fragmentation of the natural environment.

1. Initial exclusion of some species when fragmented patches do not, by chance, include any individuals of the species.
2. Extirpation due to a loss of resources. Many species require multiple habitats for forage, shelter, and breeding purposes and some of the isolated patches in the fragmented environment may not include all the needs of each species.
3. Small population problems such as a reduced gene pool, unbalanced population demographics, and susceptibility to stochastic events (fire, severe weather, etc.).
4. Isolation effects like reduced gene flow and the increased frequency of deleterious genes in the population.
5. Ecological imbalances associated with predator-prey relationships, host-parasite relationships, and mutualisms. Furthermore, the fragmentation may lead to an increase in invasive species, which could further help trigger local extinctions. This stage may also include changes in the composition of the ecological communities, where populations once low number become dominant and visa-versa.

Thus, we can conclude that fragmentation of the study area has the potential to impose considerable impact on the terrestrial environment. Some of these impacts may be recognized immediately while others may take tens or hundreds of years to surface.

4. Carbon sequestration and the Forest Carbon Cycle

Energy flows and materials circulate through the global ecosystem. Essential nutrients and other chemicals, including man-made materials, flow from the non living to the living parts of the global ecosystem in a path know as the biogeochemical cycle.

The energy flow in terrestrial ecosystems depends on interactions between a number of biogeochemical cycles such as the carbon cycle and hydrological cycles. Terrestrial ecosystems play a role in the global carbon cycle. Carbon is exchanged between trees and the atmosphere through photosynthesis and respiration. The cycling of carbon as carbon dioxide involves assimilation and respiration by plants. Human activities affect the global carbon cycle. According to the Intergovernmental Panel on Climate Change, from 1850 to 1998, approximately 270 GtC has been emitted as carbon dioxide into the atmosphere from fossil fuel burning and cement production (IPCC, 2001).

Carbon dioxide is what is known as a greenhouse gas which means that it contributes to global warming. According to the World Resource Institute (1997), drawing carbon dioxide out of the atmosphere (sequestration) and into biomass is the only known practical way to remove large volumes of this greenhouse gas from the atmosphere (June 2001). Reforestation could potentially achieve significant carbon sequestration. It has been estimated that temperate forests sequester 1.5 to 4.5 tons of carbon per hectare per year as reported by the Intergovernmental Panel on Climate Change (2000).

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Figure II.A-1
Study Area

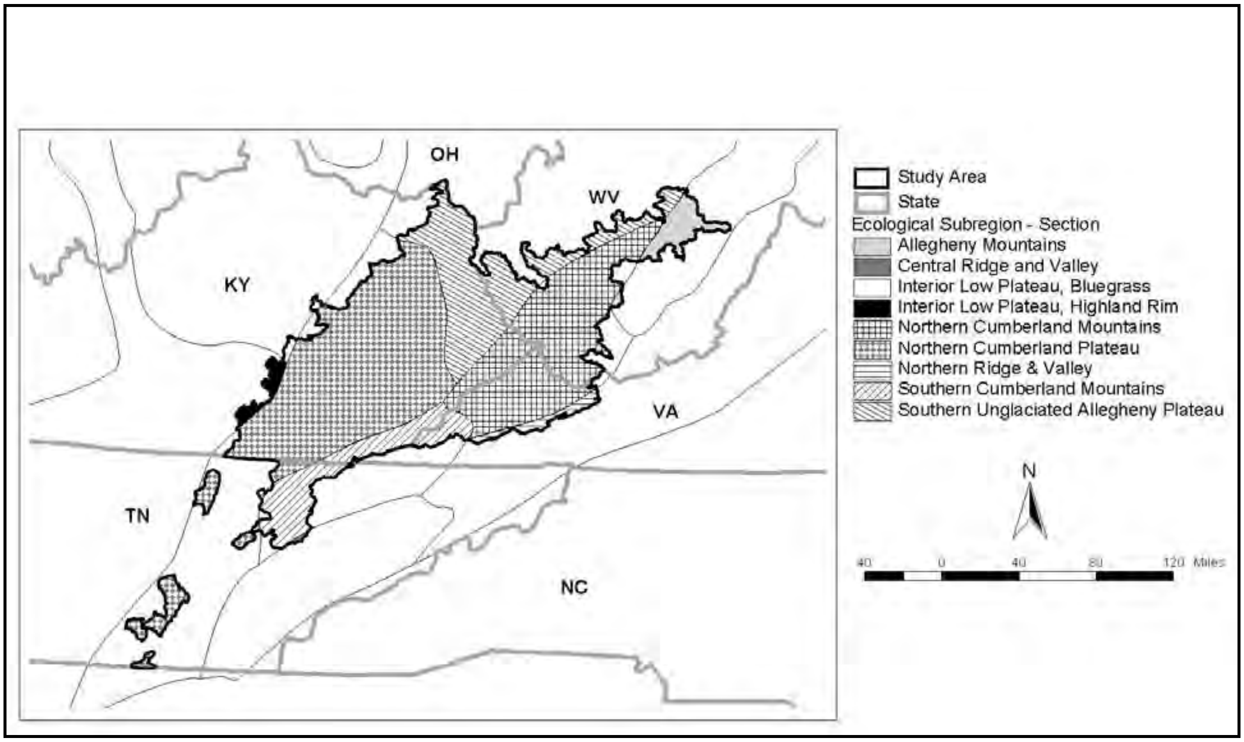


Figure III.A-1
Permit Locations

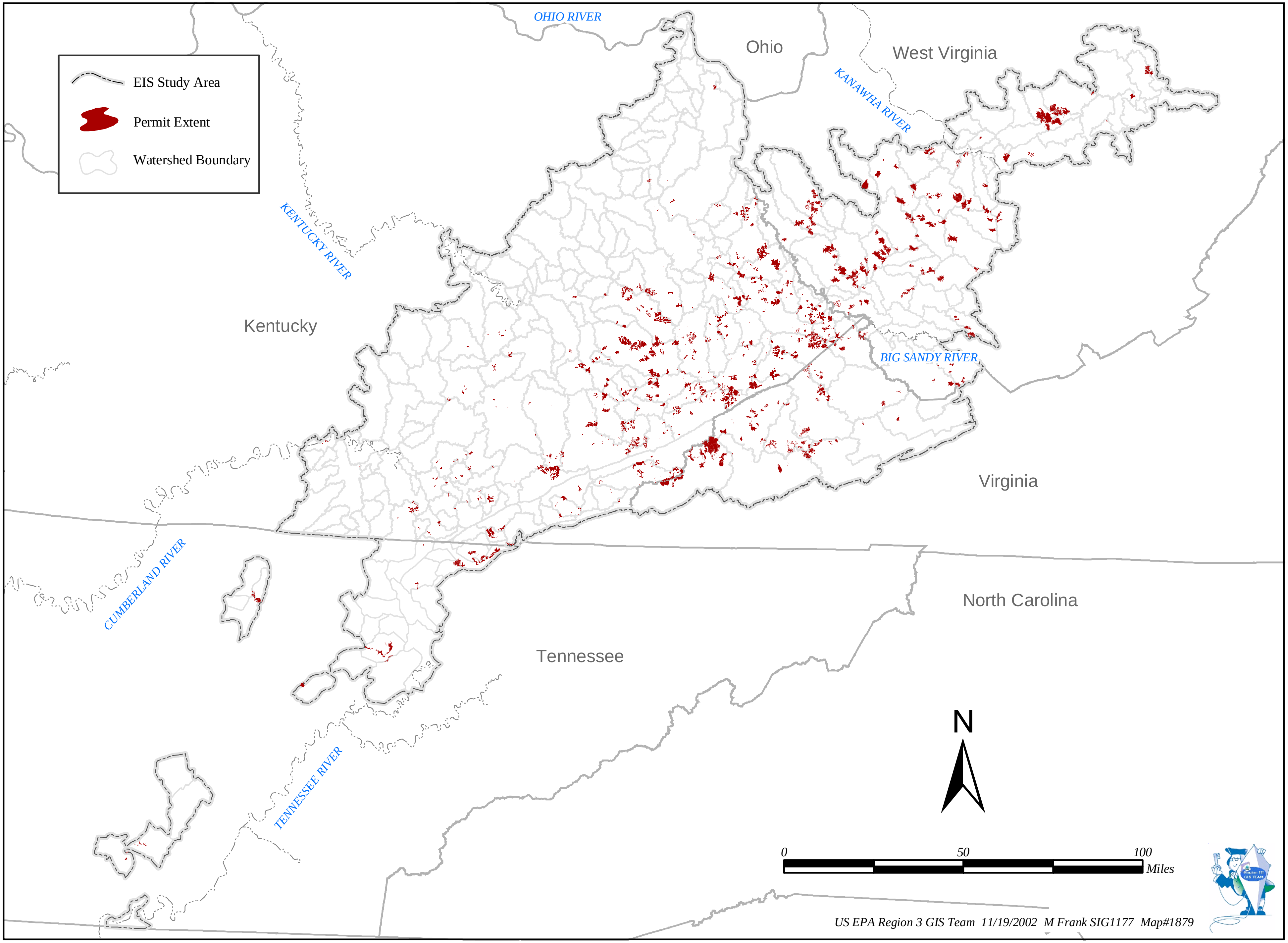


Figure III.A-2 Typical MTM/VF Mine Site Layout

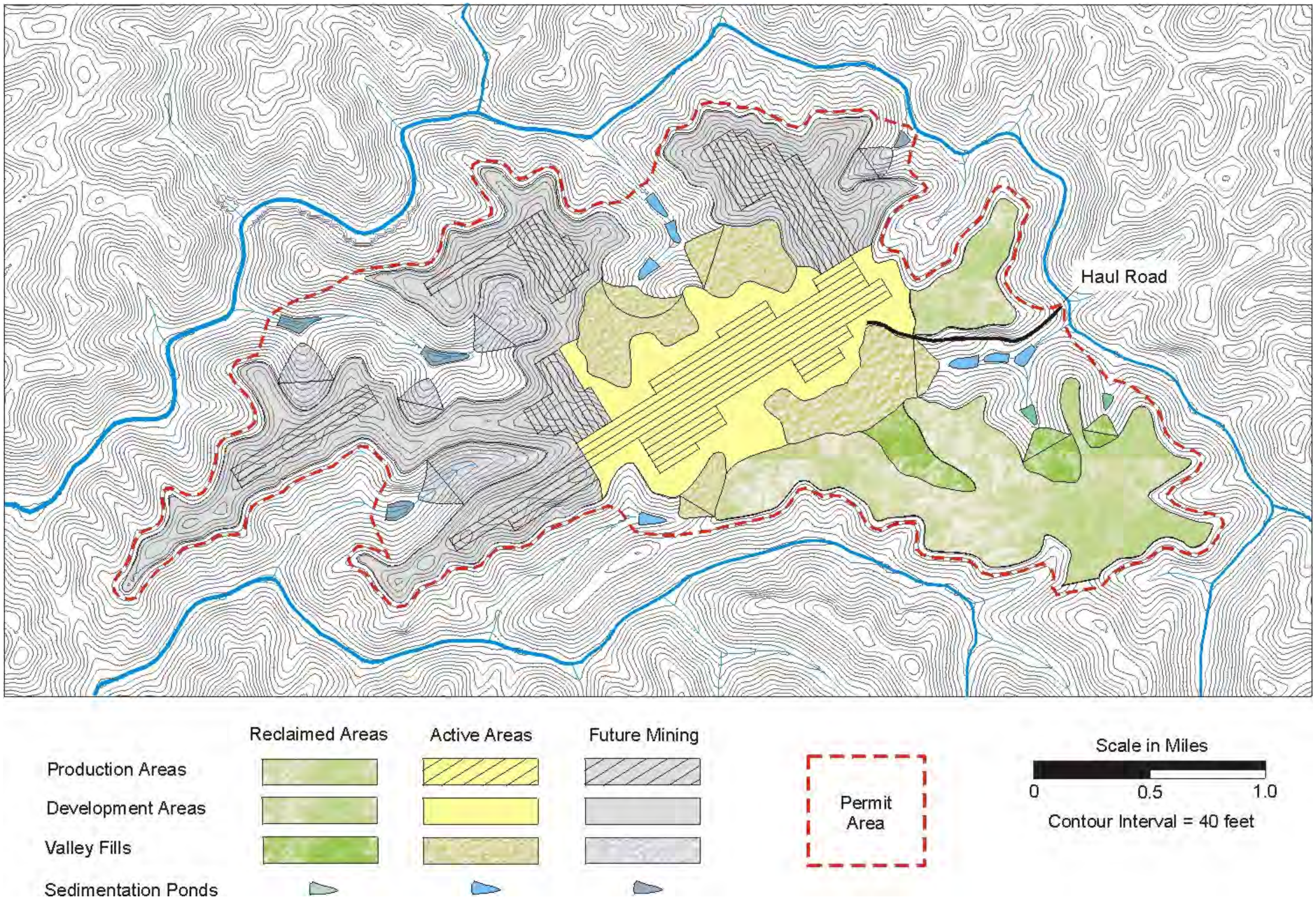


Figure III.C-1.
Relationship Between Forest Cover and Potential Ecological Condition

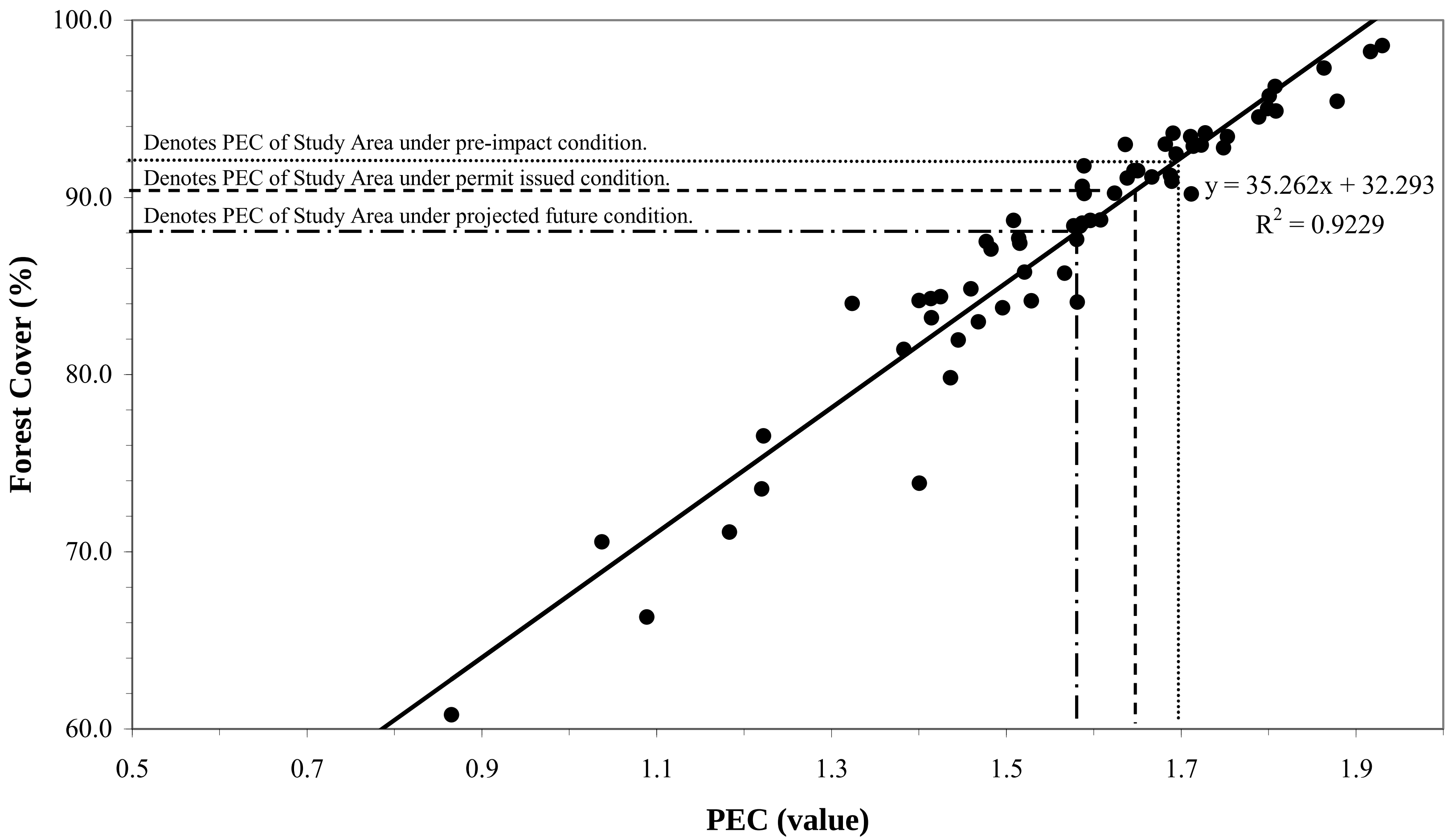


Figure V.A-1
Most Impacted Watersheds Based on Miles of
Direct Stream Impact or Percent of Direct Stream Impact

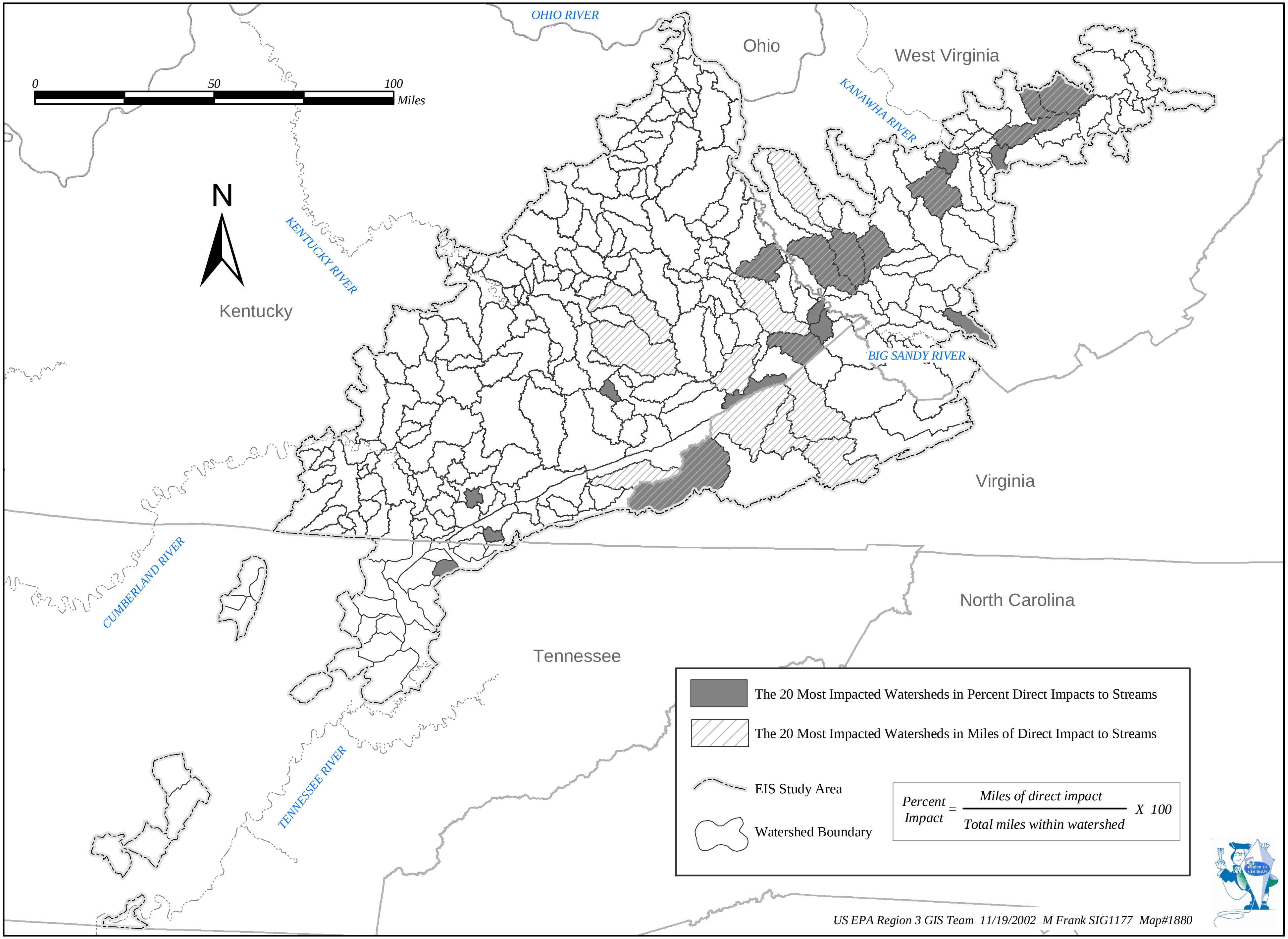


Figure V.A-2
Miles of Stream Length Directly Impacted (By Watershed)

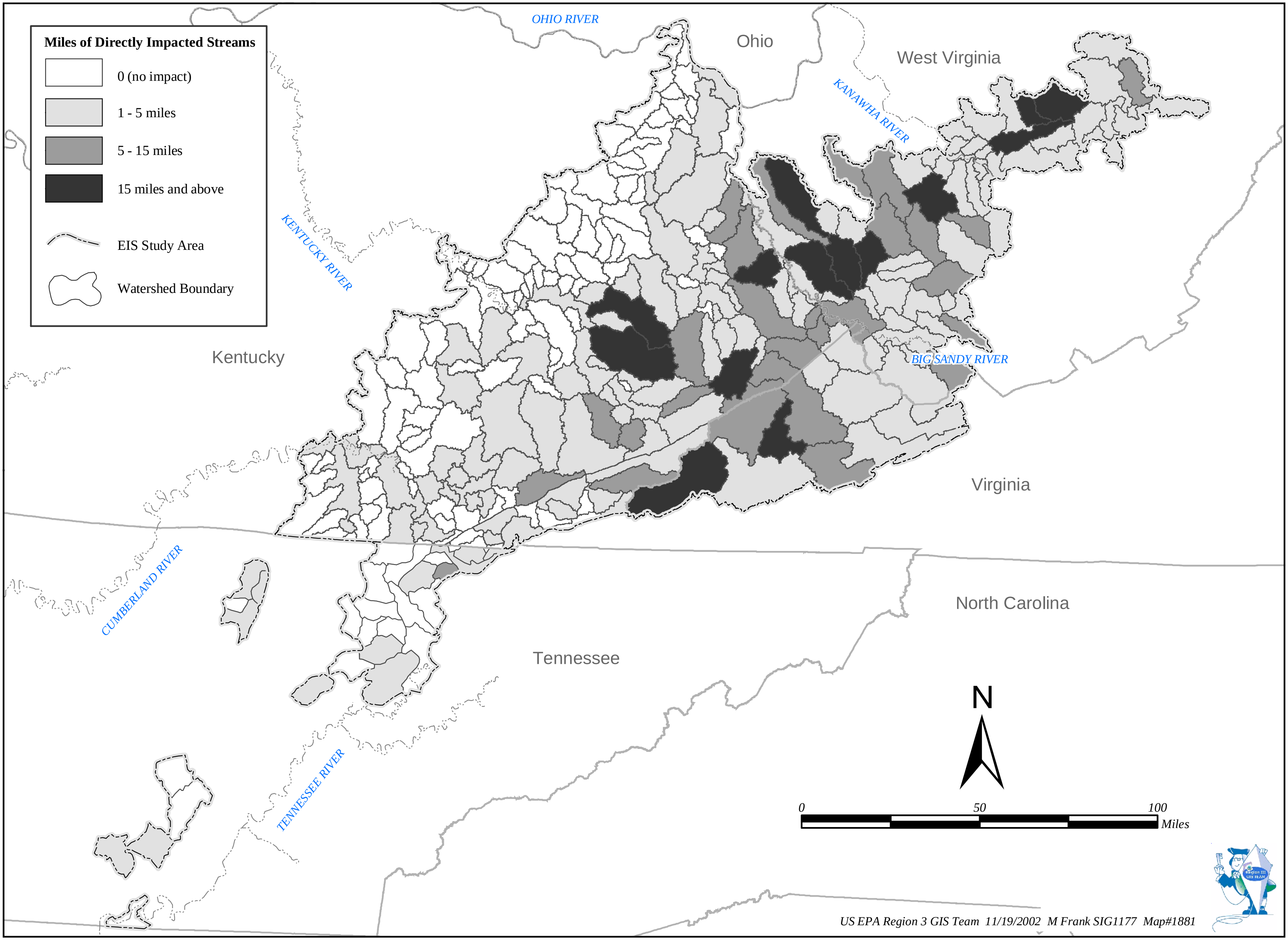


Figure V.B-1
Most Impacted Watersheds Based on Percent Forest Loss

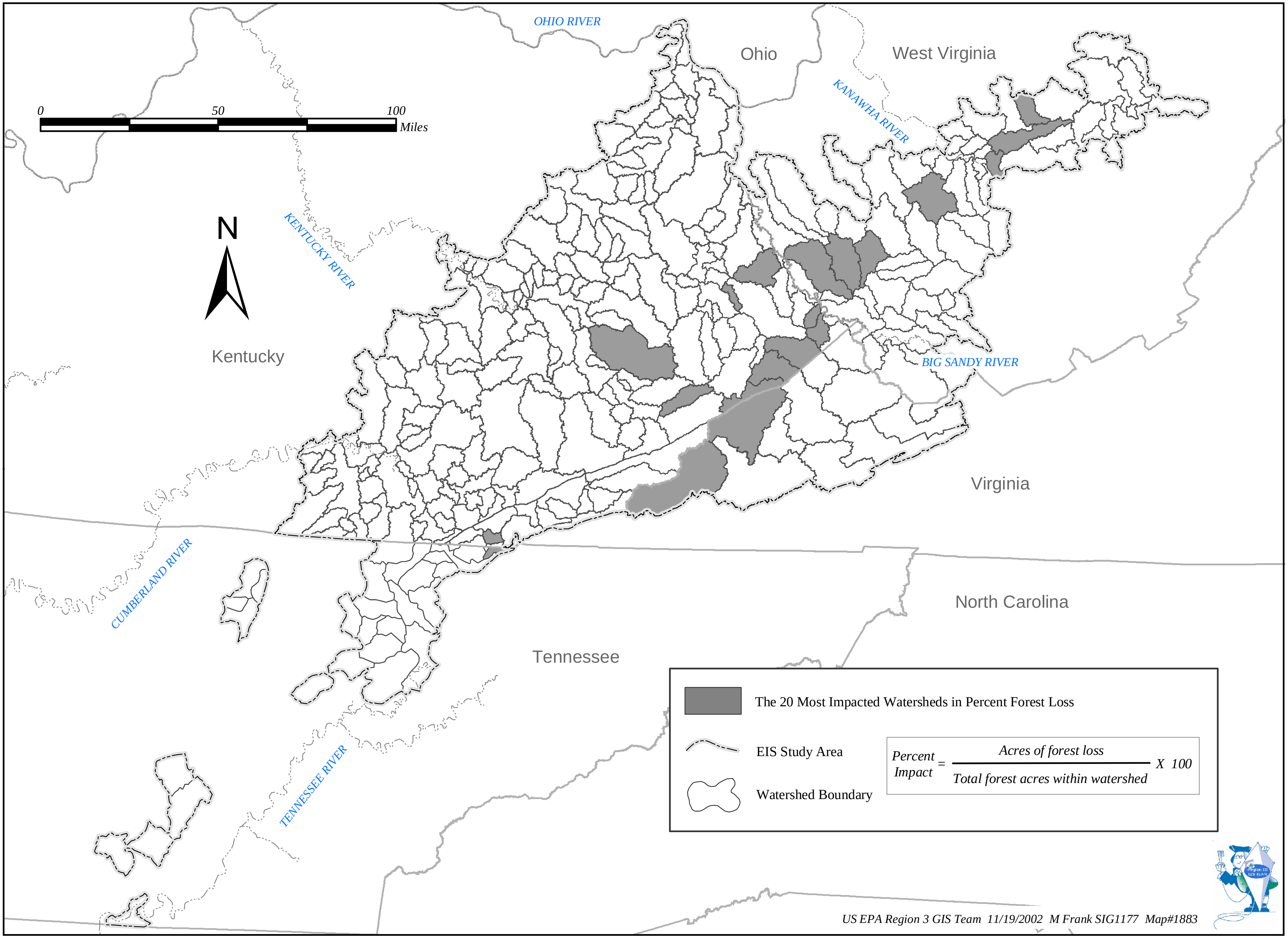


Figure V.B-2
Watersheds With Less Than 87% Total Forest Cover

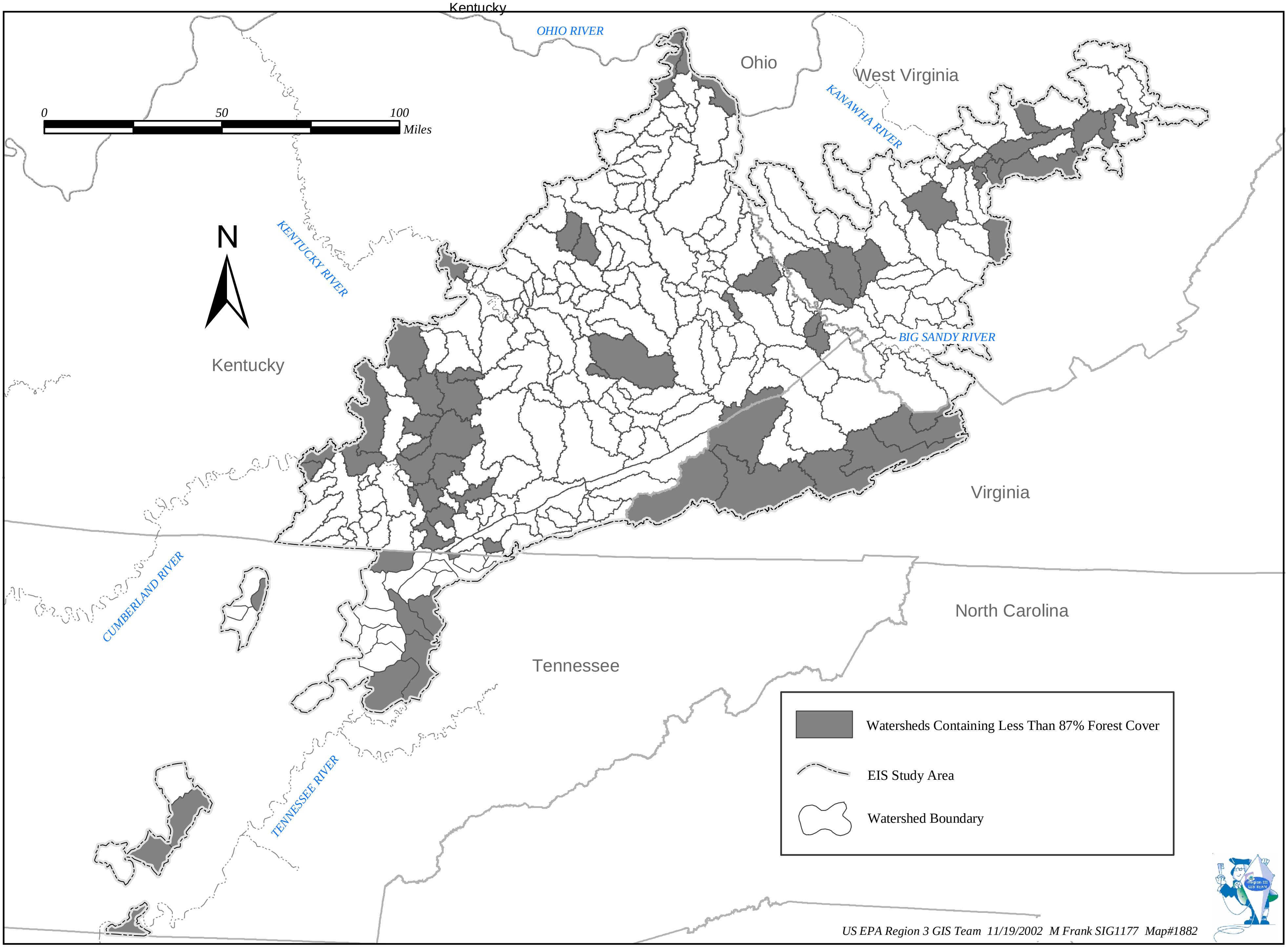


Figure V.B-3
Breeding Range Distribution of Forest Interior Bird Species Known to Occupy the Study Area

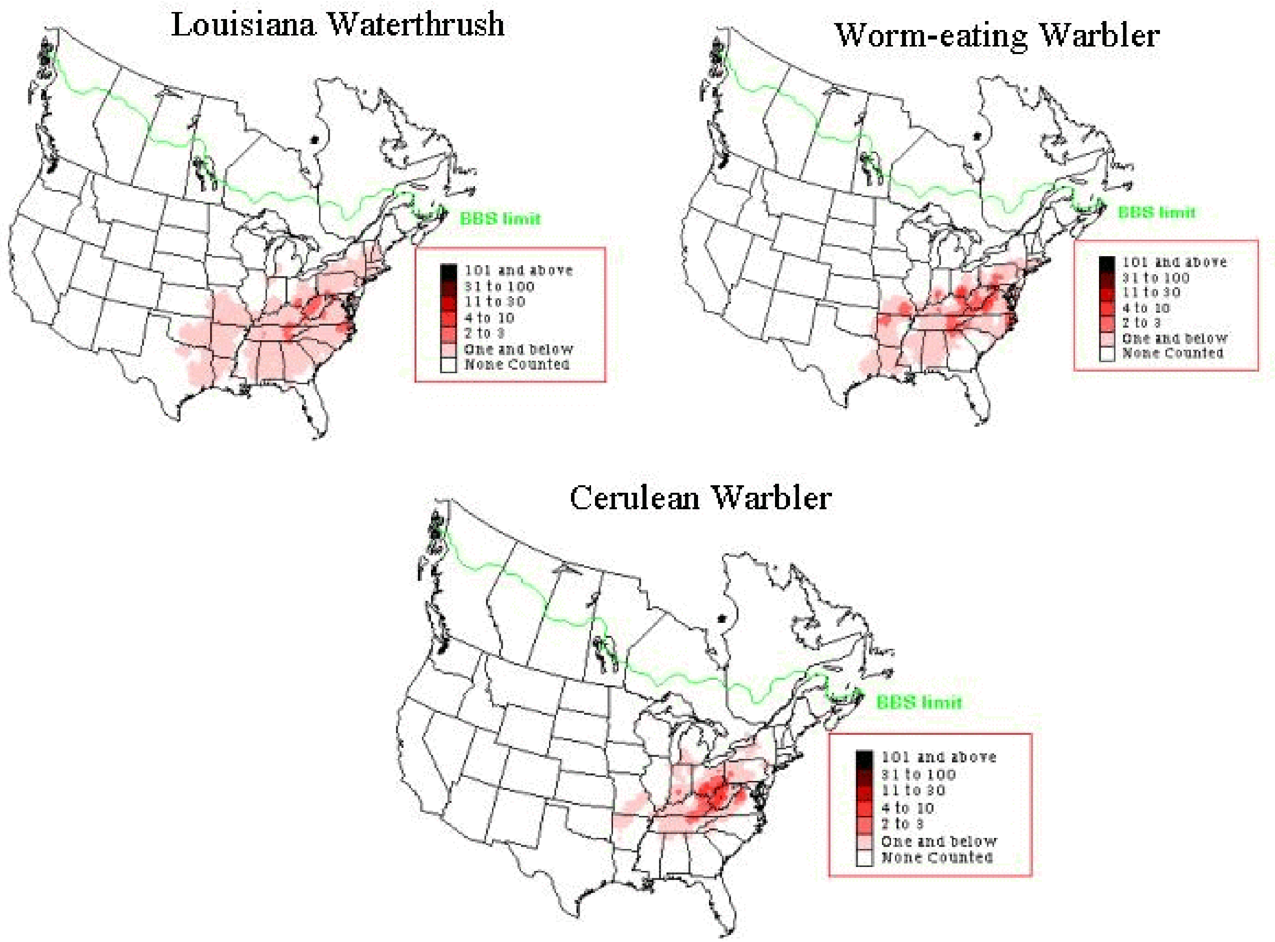
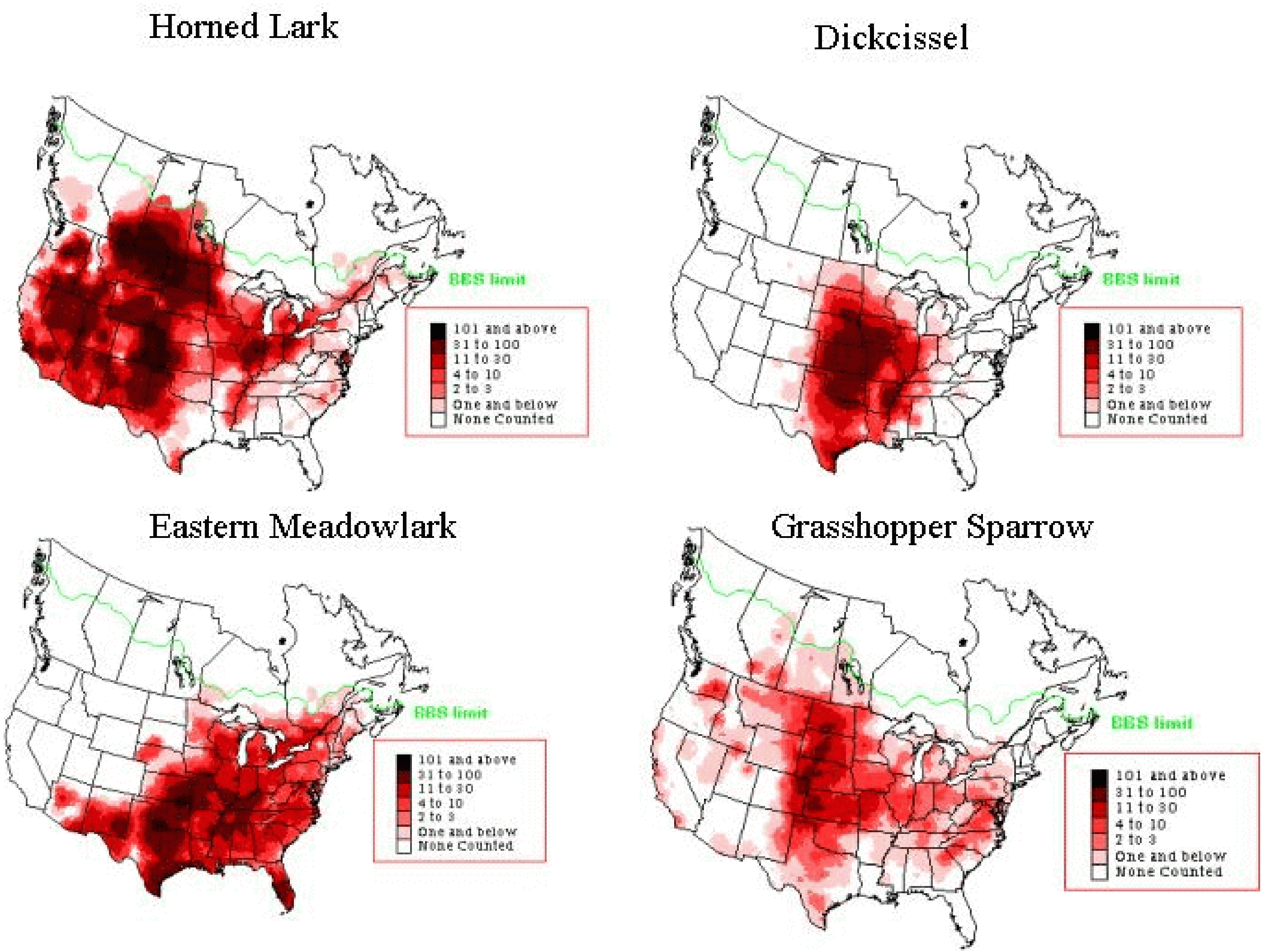


Figure V.B-4
Breeding Range Distribution of Grassland Bird Species Known to Occupy the Study Area



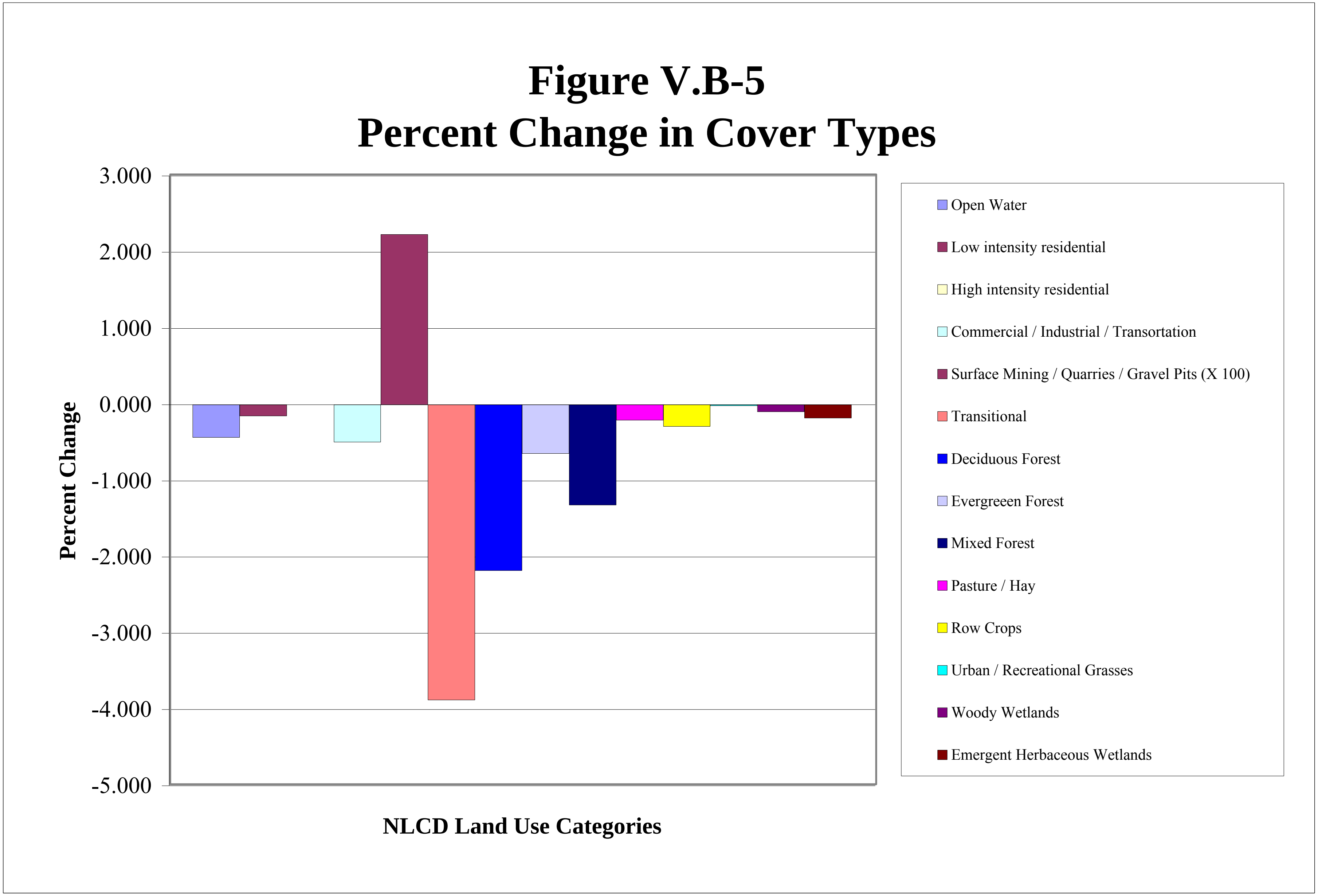


Figure V.B-5
Percent Change in Cover Types
3.000
2.000
1.000
0.000
-1.000
-2.000
-3.000
-4.000
-5.000
Percent Change
NLCD Land Use Categories
Open Water
Low intensity residential
High intensity residential
Commercial / Industrial / Transortation
Surface Mining / Quarries / Gravel Pits (X 100)
Transitional
Deciduous Forest
Evergreeen Forest
Mixed Forest
Pasture / Hay
Row Crops
Urban / Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands

Study Area - West Virginia

Land Use / Land Cover (value)	(description)	Pre-Impact (ac)	Pre-Impact (%)	Post-Impact (ac)	Change (%)	Change (ac)
11	Open Water	16,622	0.6	16,607	-0.1	15
21	Low intensity residential	16,110	0.6	16,079	-0.2	31
22	High intensity residential	86	0.0	86	0.0	0
23	Commercial / Industrial / Transortation	9,310	0.3	9,275	-0.4	35
32	Surface Mining / Quarries / Gravel Pits	45,715	1.6	133,155	191.3	-87,440
33	Transitional	19,441	0.7	19,083	-1.8	358
41	Deciduous Forest	2,396,893	82.7	2,318,251	-3.3	78,642
42	Evergreeen Forest	52,910	1.8	52,206	-1.3	705
43	Mixed Forest	252,519	8.7	245,257	-2.9	7,263
81	Pasture / Hay	67,335	2.3	67,081	-0.4	254
82	Row Crops	17,048	0.6	16,914	-0.8	134
85	Urban / Recreational Grasses	128	0.0	128	0.0	0
91	Woody Wetlands	1,354	0.0	1,352	-0.1	2
92	Emergent Herbaceous Wetlands	1,383	0.0	1,383	0.0	0
	TOTAL	**2,896,857**	**100**	**2,896,857**	**180**	**0**

Total acres for study area: 2,896,857
Total acres for permit areas: 90,104 (3.1% of total area)

Total forested acres (41,42,43,91): 2,703,677
Total forested acres in permit areas: 86,587 (3.2% of total forest)

Descriptions of GIS Mine Polygons Used in the Cumulative Impact Study

Kentucky

Original Source Description

The Department for Surface Mining Reclamation and Enforcement (DSMRE) currently makes available scanned and georeferenced mining and reclamation plan maps and annual underground maps for permits issued by the Department. Mining and reclamation plan (MRP) maps are required to be submitted with an application for a permit to conduct surface coal mining and reclamation operations in the Commonwealth of Kentucky. MRP maps are generally drawn on an enlarged USGS seven and one-half (7 1/2) minute topographic map at a scale of between 400 and 600 feet to the inch. Permitted surface and underground mine boundaries and facilities associated with coal mining operations are shown along with names and locations of streams and other bodies of water, roads, buildings, cemeteries, oil and gas wells, public parks, public property, and utility lines.

The source of the GIS mine polygons for Kentucky used in this cumulative impact study are the surface mining overlay maps maintained by the Kentucky Department of Surface Mining Reclamation and Enforcement (DSMRE). These maps consist of frosted mylar sheets that overlay 7 ½ minute USGS topographic maps. DSMRE staff draw permitted surface and underground mine boundaries and selected other features in ink onto the mylar. DSMRE GIS specialist scanned and georeferenced these mylar overlays, which are now available to the pubic for downloading. Here is the site link where the scanned may be downloaded: http://kydsmre.nr.state.ky.us/gis/data.htm. MRP maps georeferenced beginning in July 2002, and all georeferenced underground maps are projected in the NAD83 Kentucky Single Zone Coordinate System. MRP maps processed prior to July 2002 were georeferenced in NAD83 Kentucky State Plane North or South zone coordinates.

Currently six series of overlays are available both in hardcopy and digitally. Each series represents a time period in the permitting of surface coal mining in Kentucky.

◊ Series I: Areas permitted from 1977 to March 1, 1981, and which were active as of January 1, 1981.

◊ Series II: Areas permitted from 1961 to 1977, and which were inactive as of January 1, 1981.

◊ Series III: Areas permitted from March 1, 1981 through January 18, 1983.

◊ Series IV: Areas permitted under the permanent program after January 18, 1983 and through April 1, 1986.

- ◊ Series V: Areas permitted under the new permanent program after April 1, 1986 and through August 1, 1995.

- ◊ Series VI: Areas permitted after August 1, 1995 and through August 31, 1999.

- ◊ Series VII Areas permitted after September 1, 1999 and through April 30, 2000. (Series VII has been converted to GIS polygons by DSMRE.)

For the purposes of the cumulative impact analysis only the information from Series VI and VII were used. Series VI consists of three primary overlay sheets: (1) Polygon Layer - closed polygons - permit boundaries, etc… (2) Line Data Layer - lineal lines - roads, conveyors, utilities, etc… and (3) Point Data Layer - small ponds, sampling sites, mine adits, etc. Overlaying permits will be drawn on separate sheets of Mylar, thus there may be more than one polygon layer sheet (Sheet 1, Sheet 2, etc…). Hatched lines denote underground shadow areas. Areas of less than full recovery have a greater opening between hatch marks and recovery percentage is indicated.

DESCRIPTION OF MAP SYMBOLS AND CODES

The mining overlay maps are identified by the 7 ½ minute quadrangle name. Alpha characters are assigned to each permit number and appear as the first portion of the attribute code assigned to each map feature. The alpha codes are generally listed in alphabetic order and expand to multi-lettered codes (AA, BB etc.) to include all permits pertaining to a given quadrangle. Alpha codes and the specific permit number to which they correspond are listed at the bottom of the overlay. Adjacent maps that share the same permit boundary have, in most cases, the same alpha code on both maps. The number which follows the alpha code is a one-, two- or three-digit number defining the major category in which a mining feature falls (i.e. mining, fill areas, haul roads, etc.). Often a sub-category is used to describe a mining feature in greater detail. An example of a feature attribute code is ‘A-610’. The code refers to a sediment structure (6), embankment type (10), within the permit number assigned ‘A’. Areas common to more than one permit number are labeled with the alpha character and feature attribute codes of both permit numbers with a comma placed between them.

The permit features are drawn as dashed lines, solid lines, dash-dot-dot lines, or single dots. Haul roads and railroads are drawn as dashed lines unless they correspond to the permit boundary, in which case the permit boundary takes precedence. Features that appear as solid lines or polygons include mining areas, fill/storage areas, permit boundary areas, face-ups, and reference areas. Points are used to represent features of small acreage such as sediment structures, monitoring points and underground mine openings. Hatched lines indicate underground areas.

Due to the influx of new mining permits and the absence of some permits at the time of drafting, these overlays are not 100% comprehensive. The updating procedure (acreage additions and deletions) was initialized to keep the mining operations overlays as up-to-date as possible.

PERMIT MAPPING CODES

1—Contour Mining Area
2—Area Mining Area
3—Mountaintop Removal Area
4—Augering Area
5—Fill area
57 – General Fill/Spoil Storage Area/Refuse Area
58 –Hollow fill
59—Topsoil Storage
510—General/Temporary/Equipment Storage Area
6—Sediment Structure
69—Sediment Type
610—Embankment Type
611—Dugout
612—Rock Check Dam
613—Diversion Ditch
616—Combination Diversion Ditch
618—Pole Structure
620—Earth Dam
7—Access/Haul Road
8—Monitoring Point
81—Surface Water Monitoring Point
82—Biology Monitoring Point
83—Groundwater Monitoring Point
84—Geologic Sampling Point
85—Surface/Biology Monitoring Point
9—Permit Boundary Area
0—Other Features
06—Underground Mine Opening
Adits [Y] - leg of Y in direction of mine opening
Air shafts [V]
014—Reference Area
015—Face-Up Area / Re-grade Area
017—Wildlife Habitat
019—Railroad
021—Coal Stockpile
030—Underground Mine Area
040—Mine Management Area
050—Prep Plant

As previously mentioned, Kentucky DSMRE converted the Series 7 digital and geo-referenced mylars to GIS polygons. Series 7 GIS data is described below:

The GIS data consists of the boundaries of permitted surface and underground mines and other selected features for permits issued between September 1, 1999 and April 30, 2000. Kentucky DSMRE used ArcView 3.1 software to create the Series 7 GIS data. Information describing each permit is contained in the dBASE file include the following:

SHAPE	- layer type
CODE	- mine feature*
FACILITY_ID	- mine feature id
PERMIT	- permit number

* mine feature codes

FU	Face Up
LO	Load Out
MM	Mine Management Area
PP	Prep Plant
SA	Surface Area
SBK	Spoil Bank Fill
SC	Surface Contour
SG	Surface Auger
SM	Surface Mountaintop
Slide	Slide
Spoil	Spoil
Stockpile	Stockpile
UG	Underground

Kentucky DSMRE forewarns the users of the digital information that the maps available for download do not comprise a complete set of maps that may be available. Additional hardcopies of these or other MRP or annual underground maps may be obtained by contacting: Daryl Hines, Christina Rice, or Amy Covert at (502) 564-2320 in the Kentucky Department for Surface Mining Reclamation and Enforcement.

<u>Description of Digital Data Base Queried for the Cumulative Impact Study</u>

Staff from OSM's Pittsburgh Office downloaded the Series VII and VI digital information from KY DSMRE FTP server on October 7, 2002, and October XXX, respectively.

The Series VII GIS data was filtered to retain only those mining disturbances associated with surface mining activities. All polygons associated with the activities coded as "face up", "load out", "prep plant", "surface auger", "slide", "stockpile", or "underground" were deleted from consideration for the purpose of the cumulative impact analysis. Further, using the boundaries of the EIS study area in Kentucky, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. This filtered digital data for Series VII, which consisted of multiple polygons for surface mines, were forwarded to EPA's Wheeling Office.

The Series VI scanned and georeferenced mylars posed a more challenging task. Staff from OSM Pittsburgh Office used specialized software (Able Software R2V for Windows) to convert the digital picture images (rasters) to vectorized features (polygons, lines, and points). Once converted to GIS polygons, features representing surface mining disturbances were retained and other disturbances (such as underground mining, preparation plants, augering areas, face-up areas, stockpiles, ect) were eliminated. Further, using the boundaries of the EIS study area in Kentucky, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. This filtered digital data for Series VII, which consisted of multiple polygons for surface mines, were forwarded to EPA's Wheeling Office.

Below is a list of digital mining polygons from Kentucky forwarded for inclusion in the cumulative impact study.

SERIES 7 PERMITS

Permit ID	Permit ID	Permit ID	Permit ID
9180346	8670390	8980507	8970358
8885022	8980446	8600034	8130010
8970369	8665025	8985167	8360265
8988106	8070265	8675172	8660240
8970390	8670383	8930093	8955002
8980450	8670402	8950141	8070236
8640096	8980467	8800103	8980446
8600359	8480151	8800130	8670394
8600349	8610454	8605201	8360249
8130220	8970388	8980488	8980481
8605198	8985694	8605223	8800117
8950139	8480200	8985908	8600377
8980516	8360261	8678021	8260530
8980469	8670399	8985913	8670377
8600374	8970376	8480191	8600369
8130246	8970396	8615297	8130249
8130246	8980444	8980565	8670257
8600316	8980450	8660229	8615273
8070097	8800132	9180375	8130240
8980492	8980490	8630277	8160109
8675225	8580135	8605154	8920100
8485327	8980479	8130257	8360231
8600034	8970357	8480140	8130226
8365197	8585056	8980545	8480179

SERIES 6 PERMITS

Permit ID	Permit ID
864012	8649000
845005	8800014
1111111	8800023
4800093	8800034
4805070	8800043
4805074	8800103
6805009	8800108
6805012	8800109
6807001	8800130
8320043	8805058
8320144	8805059
8450050	8805126
8580151	8805137
8580152	8805138
8589999	8805139
8640096	8805144
8640107	8805148
8640115	8805150
8640117	8807000
8640124	8880078
8640132	
8640135	
8640142	
8648016	

Descriptions of GIS Mine Polygons Used in the Cumulative Impact Study

Tennessee

Original Source Description

The source of the GIS mine polygons for Tennessee used in this cumulative impact study is the a digital geographic database of coal mining permit boundaries in Tennessee produced by the U.S. Department of Interior, Office of Surface Mining Reclamation and Enforcement (OSM) in Knoxville, Tennessee. It consists of georeferenced digital map data and descriptive attribute data. OSM Knoxville Field Office Geographic Information System (KFO GIS) Team developed this information from public records. The source for most of these records is the permit application submitted by coal mining operators for review and approval by OSM to conduct surface coal mining operations at specific locations in the State of Tennessee. These materials are a working resource of OSM and are contained in its file rooms and archives in paper format. Data contained in these materials were converted to digital format generally through digitizing paper maps onto a planimetrically correct base.

Selected features from the last approved Mining Operation Plan maps and Environmental Resources maps contained within a permit application submitted by a coal mining operator to the Office of Surface Mining (OSM) were manually digitized into an individual coverage using the ArcEdit subsystem of ArcInfo Workstation. Each map was georeferenced using geographic features found in common on both the paper manuscript (map) and on Digital Raster Graphic (DRG) images of standard 7.5-minute series USGS topographic quadrangle maps as displayed on a computer monitor. These DRG's were acquired from the U.S. Tennessee Valley Authority and were transformed to Tennessee State Plane, NAD 27 coordinate system by OSM. After initial digitizing on a standard digitizing table, the digital data set was inspected on a computer monitor and visually compared against the paper manuscript. Coverage feature classes were edited to correct digitizing errors. Attribute data was added to describe features contained in the coverage. Individual coverages were then posted to the Knoxville Field Office Geographic Information System (KFO GIS). Each individual coverage was then incorporated into a master coverage of similar features. All compilation, digitizing, and quality control were performed by GIS specialists at the OSM in Knoxville, TN.

The accuracy of these digital data is based on features represented on source maps supplied by various coal mining operators. In general, these features were drawn by hand on paper reproductions of standard 7.5-minute series USGS topographic quadrangle maps enlarged to a scale of 1"=400' and were submitted as Mining Operation Plan maps or Environmental Resource maps in a permit application for approval by OSM to conduct surface coal mining operations at a specific location. It is not known whether these paper reproductions of the standard USGS topographic maps meet National Map Accuracy Standards. OSM digitized selected features from each paper source map using a minimum of four georeferenced control point locations (tics). Approximately 95 percent of the maps resulted in a Root Mean Square (RMS) error of less than 10 feet as reported by the software during calibration. None exceeded 25 feet. The difference in positional accuracy between the actual feature location on the ground and their digitized coordinates as shown in this data set are unknown

This data set is a work-in-progress and represents the current amount of digital data available for this theme at the time of its production. During production, selected paper maps from individual permit applications are digitized in reverse chronological order based on the permit and/or revision approval date. This method is used to ensure that data resulting from the most recently approved permitting action for any given mining operation is always available to KFO GIS users. As the general digitizing effort continues, maps are retrieved from successively older permit applications for digitizing and data entry. Current estimates of temporal coverage for this theme extend back to approximately 1984. As new information is made available to OSM, and as resources are available to capture this information into a digital format, this data set will be amended with updated features from newly approved mining operations and also be revised to include features from older mining operations.

Although these data have been processed successfully on a computer system at OSM, no warranty expressed or implied is made by OSM regarding the utility of the data on any other system, nor shall the act of distribution constitute any such warranty.
For further information about the coal mining data sets held by OSM, contact Bill Card, Geographer, Office of Surface Mining, Knoxville Field Office, 530 Gay Street SW, Suite 500, Knoxville, TN 37902, telephone 865.545.4103, x. 134, fax 865.545.4111, e-mail bcard@osmre.gov.

Description of Digital Data Base Queried for the Cumulative Impact Study

Staff from OSM's Pittsburgh Office downloaded the most current digital database from Tennessee mining permits from OSM Knoxville Field Office FTP server on September 23, 2002. This database consisted of 816 mining polygons. Staff from the Knoxville Field Office telefaxed a list of new mining permits issued by OSM from January 1992 to date that were approved to use surface mining methods or a combination of surface and underground methods to extract coal. The permits on this list met the criteria established by the EIS Steering Committee for the cumulative impact study and was used to select a subset of mine permit digital data polygons from the source database. Further, using the boundaries of the EIS study area in Tennessee, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. This filtered digital data, which consisted of 39 new surface mines, were forwarded to EPA's Wheeling Office.

Below is a list of digital mining polygons forwarded for inclusion in the cumulative impact study.

Area	Perimeter	Permit	Acres	Issued	Type	Permittee
30465400	41338.5	2846	699.39	19930629	S	Skyline Coal Co.
1035160	6072.51	2853	23.7639	19980319	S	East Fork
1746640	13837.1	2863	40.0974	19940902	S	Hood Coal Corp.
15103300	18107.5	2876	346.724	19920214	S	Skyline Coal Co.
2192200	12866.7	2892	50.3259	19920803	C	Rich Resources I
6163980	24088.8	2904	141.507	19920904	C	Tennesse Consoli
5232260	27300	2905	120.114	19920810	C	Robert Clear Coa
3127850	54218.6	2923	71.8056	19960109	S	Round Mountain M
5937830	13173.5	2927	136.314	19931002	S	Tennessee Consol
5590310	26912.8	2929	128.34	19930507	C	Robert Clear Coa
9672760	25563.8	2931	222.056	19940914	C	Gatliff Coal Co.
3474050	20565.2	2938	79.7532	19950331	S	Tennessee Consol
5795880	28318.9	2944	133.059	19940520	C	Robert Clear Coa
21139800	143268	2947	485.303	19951023	C	Gatliff Coal Co.
14015400	99090	2951	321.75	19960911	S	Premium Coal Co.
7915880	42381.8	2952	181.724	19950804	S	Hood Coal Corp.
4861450	16927.3	2953	111.604	19961025	S	Gatliff Coal Co.
12050700	63882.9	2955	276.645	19971110	S	Gatliff Coal Co.
49239200	160020	2956	1130.38	19951016	S	Tennessee Mining
4482470	26429.7	2957	102.903	19960126	C	Tennessee Consol
41457200	31645.1	2959	951.727	19970403	S	Skyline Coal Co.
25640600	23207.6	2981	588.627	19970911	S	Cumberland Coal
6050420	16749.5	2982	138.899	19970507	S	Tennessee Consol
3565400	30569.4	2983	81.8494	19960423	S	Robert Clear Coa
16370900	49242.5	2990	375.825	19970102	S	Addington Enterp
26786700	65574.6	2994	614.939	19960912	S	Addington Enterp
17007500	97312.6	3005	390.439	19970326	S	Robert Clear Coa
31883600	111662	3008	731.947	19970728	C	Additngton Enter
24616600	139962	3010	565.12	19980127	A	Tennessee Mining
2648310	13755.2	3013	60.7968	19980304	A	Tennessee Consol
12745900	43582.5	3015	292.605	19980509	A	Appolo Fuels Inc
6018640	51569.3	3045	138.169	19980811	A	Appolo Fuels Inc
9653380	46303.8	3048	221.609	19990401	A	Robert Clear Coa
36521400	113165	3054	838.414	20000815	A	Appolo Fuels Inc
15718800	83907.7	TN-005	360.854	19930107	C	Gatliff Coal Co.
23922900	112234	3058	549.194	20001114	A	Mountainside Coa
15811500	102234	3059	362.983	20010801	A	Mountainside Coa
10227800	33875.4	3052	234.798	20010607	A	Mountainside Coa
12017900	73438.7	2865	275.892	19920124	C	Gatliff Coal Co.

Descriptions of GIS Mine Polygons Used in the Cumulative Impact Study

Virginia

Original Source Description

The source of the GIS mine polygons for Virginia used in this cumulative impact study is the a digital geographic database of coal mining permit boundaries in Virginia produced by the Virginia Department of Mines, Lands, and Minerals – Division of Mined Land Reclamation (DMLR) in Big Stone Gap, Virginia.

It consists of geo-referenced digital map data and descriptive attribute data. …

This data set is a work-in-progress and represents the current amount of digital data available for this theme at the time of its production. …

Description of Digital Data Base Queried for the Cumulative Impact Study

Staff from OSM's Pittsburgh Office downloaded the most current digital database from Virginia DMLR FTP server on September 16, 2002. This database consisted of 2358 mining polygons. Staff from OSM Big Stone Gap Field Office identified the prefix in the permit identification number (GIS Data Field "PERMIT") representing mines approved to use surface mining methods or a combination of surface and underground methods to extract coal: "11", "15", "16", and "17".

Mining permits approved by Virginia DMLR beginning from January 1992 to the most current date were selected using information provided in the GIS database (GIS Data Field "PEISSUEDT"). The permits on this list met the criteria established by the EIS Steering Committee for the cumulative impact study and was used to select a subset of mine permit digital data polygons from the source database. Further, using the boundaries of the EIS study area in Virginia, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area. This filtered digital data, which consisted of multiple polygons for 98 surface mines, were forwarded to EPA's Wheeling Office.

Below is a list of digital mining polygons forwarded for inclusion in the cumulative impact study.

Permit	Issue Date	Surface Mine Description
1101530	6/21/1995	Mine #1
1101556	5/3/1996	JIM BELCHER FORK STRIP
1101736	1/26/2000	Burnt Poplar surface mine #1

Permit	Issue Date	Surface Mine Description
1101474	8/16/1993	Dwale #7 job
1101434	10/5/1992	MINE #5
1101599	5/9/1997	NEECE CREEK SURFACE MINE
1101654	8/25/1998	Mine #1
1101700	10/22/1999	Lower Elk Creek reserve
1101633	4/23/1998	SYCAMORE STRIP
1101785	10/1/2001	PHELPS NO. 1 MINE
1101550	12/21/1995	LAUREL FORK STRIP
1101707	11/9/1999	CLINTWOOD R-38
1101784	9/28/2001	Bee Branch Surface
1101400	1/13/1992	Guess Fork strip
1101762	11/9/2000	PAW PAW STRIP
1101795	2/1/2002	BEARWALLOW SURFACE MINE
1601787	11/16/2001	Buckeye Branch - Caney Fork remining permit
1101720	11/15/1999	Tilley Branch mine
1101781	8/28/2001	Glamorgan Auger Mine #1
1101621	11/12/1997	BULL GAP MINE
1101701	11/5/1999	STARR BRANCH STRIP
1601788	11/20/2001	CONVICT HOLLOW REMINING PERMIT
1101481	9/21/1993	GREENBRIER CREEK MINE
1101685	4/13/1999	LOVERS GAP #3 SURFACE MINE
1101759	9/28/2000	LOVERS GAP #4 SURFACE OPERATION
1101792	1/16/2002	Surface Mine No. 1
1101548	11/29/1995	Lovers Gap surface mine
1101553	3/19/1996	SHORTRIDGE BRANCH SURFACE MINE
1101606	7/7/1997	Toms Fork North surface mine
1101417	5/14/1992	HACKNEY HOLLOW SURFACE MINE
1101737	1/28/2000	TARPON SURFACE MINE
1101555	5/1/1996	STRIP #1
1101752	7/26/2000	HURRICANE BRANCH STRIP #1
1101416	5/13/1992	Rock Branch surface operation
1101494	3/2/1994	CANE BRANCH MINE
1101669	12/10/1998	STRIP #6
1101600	5/21/1997	MINE #1
1101622	11/17/1997	Georges Fork Surface Mine
1101518	11/30/1994	RED ONION MINE
1101782	9/7/2001	BIG CREEK SURFACE MINE
1501660	10/15/1998	GEORGE'S FORK #2 MINE
1101783	9/25/2001	ALLIED COAL MINE #2
1101447	12/1/1992	STALLARD BRANCH SURFACE MINE
1101675	2/10/1999	HIBBITTS GAP SURFACE MINE
1701547	11/9/1995	HESS CREEK KENNEDY SEAM COMPLEX
1101401	1/16/1992	NORTH FOX GAP SURFACE MINE
1101537	9/14/1995	BOLD CAMP SURFACE MINE
1101776	5/9/2001	Long Branch surface mine
1101538	9/22/1995	Wampler Ridge surface mine
1501778	6/4/2001	Straight Fork Surface Mine
1101445	11/23/1992	COBRA PIT #1
1101743	3/17/2000	BIRCHFIELD NO. 5
1101760	10/20/2000	Backbone Ridge surface mine
1101463	5/12/1993	TRACE FORK SURFACE OPERATION
1101623	12/1/1997	TRACE FORK STRIP
1601486	11/10/1993	Pardee No. 1 Strip
1101661	10/19/1998	ROGERS RIDGE SURFACE MINE
1101691	8/10/1999	TRACE FORK #3 MINE

Permit	Issue Date	Surface Mine Description
1101549	12/20/1995	HART CREEK SURFACE MINE
1101673	1/12/1999	DARK HOLLOW STRIP #1
1101516	11/10/1994	Rabbit Ridge
1101779	6/11/2001	HONEY BRANCH REMINING PERMIT
1101740	2/22/2000	STRIP #9
1101460	2/25/1993	Mine #2
1101468	7/21/1993	Raging Bull adjacent areas
1101627	1/13/1998	TRACE FORK #2
1101763	11/13/2000	COON BRANCH SURFACE/AUGER MINE
1101607	7/9/1997	BLACK BEAR SURFACE MINE
1101694	9/17/1999	Sawmill Hollow mine
1101800	4/26/2002	AMOS RIDGE SURFACE MINE
1101521	1/23/1995	SCREAMING EAGLE #2 SURFACE MINE
1101699	10/18/1999	FORK RIDGE MINE
1601656	9/14/1998	Jr.
1501702	11/5/1999	BANNER #2 STRIP
1601738	2/1/2000	Stonega #1 Strip (Bluff Spur mine)
1601505	9/8/1994	MINE #49
1101774	4/26/2001	SAWMILL HOLLOW #2
1501773	4/10/2001	JR.
1101681	3/16/1999	BLACK BEAR #2 SURFACE MINE
1101602	5/23/1997	Silver Fox surface mine
1101671	12/30/1998	BANNER #1 STRIP
1601503	7/29/1994	SARGENT HOLLOW
1701766	11/21/2000	Jr.
1601876	10/4/2001	Stonega No. 2 Strip
1601576	9/27/1996	Black Creek surface mine
1101758	9/26/2000	Black Bear #3 surface operation
1101536	9/13/1995	DANTE REFUSE RECOVERY OPERATION
1101794	1/16/2002	Roda #2 Strip
1101620	11/6/1997	POSSUM TROT HOLLOW MINE
1601491	1/14/1994	AUSTIN POWDER HOLLOW SURFACE & DEEP MINE
1101492	2/15/1994	White Stallion
1101750	6/19/2000	KELLY BRANCH SURFACE MINE
1101580	10/29/1996	C & M #3
1601777	5/21/2001	BULL RUN SURFACE MINE
1601744	3/20/2000	STATE LINE STRIP
1601423	8/3/1992	EASTERN STRIP
1601466	5/26/1993	Western strip
1601519	12/14/1994	SOUTHERN STRIP

Descriptions of GIS Mine Polygons Used in the Cumulative Impact Study

West Virginia

Original Source Description

The source of the GIS mine polygons for West Virginia used in this cumulative impact study is the a digital geographic database of coal mining permit boundaries, coal extraction polygons, and fill polygons produced by the West Virginia Division of Mining and Reclamation – Information Technology Office. These datasets are derived from hardcopy permit maps submitted to DMR. Hardcopy maps were scanned and georeferenced prior to extraction of features via on-screen digitizing by West Virginia University - Natural Resource Analysis Center. All datasets have been projected to UTM zone 17, NAD27.

Description of Digital Data Base Queried for the Cumulative Impact Study

Staff from OSM's Pittsburgh Office downloaded the most current digital database from West Virginia mining permits from West Virginia Department of Environmental Protection website: http://129.71.240.42/data/omr.html. Three GIS data layers -- permit boundaries, surface mine extraction areas, and valley fill areas – met the criteria established by the EIS Steering Committee for the cumulative impact study. This data set was filtered by using the last two digits of the permit identification number (the year the permit identification number was assigned) to include only those activities associated with new surface mining permitted after January 1, 1992. Further, using the boundaries of the EIS study area in West Virginia, a GIS specialist at OSM Pittsburgh Office used readily available querying tools in ESRI ARCVIEW software to select only those surface mining permits that were located wholly or partly within the EIS study area.

Below is a list of 142 West Virginia mining permits forwarded for inclusion in the cumulative impact study.

PERMIT_ID	PERMIT_ID	PERMIT_ID
s051799	s302693	s501592
s500997	s502197	s501400
s500999	s302193	s501494
s200995	s502097	s301496
s500593	s502095	s301492
s400597	s402095	s201496
s200599	s502393	s501796
s300599	s502399	s501798
s400401	s502297	s301794
s400497	s302299	s501694
s300495	s503595	s501194

s200499	s303593	s501092
s300499	s303793	s401096
s100495	s503195	s201092
s300795	s503097	s501300
s400699	s503095	s501396
s200697	s503395	s401396
s400199	s503295	s301396
s300195	s357600	s201398
s200197	s500900	s401298
s300199	s400998	s201298
s500395	s200896	s402596
s400399	s100896	s502598
s400397	s500596	s502496
s300295	s400596	s302794
s501895	s300598	s502698
s501899	s300400	s102192
s501597	s200494	s402096
s401595	s500700	s302300
s201593	s300796	s402396
s301599	s200798	s502296
s401499	s400600	s503996
s301693	s400698	s503792
s401197	s300696	s403192
s501095	s400198	s503096
s501395	s400300	s503392
s401395	s500396	s504692
s301393	s500394	s505592
s501297	s500398	s505792
s501299	s200396	s506692
s201293	s100394	s507492
s301299	s400200	s501594
s502997	s100200	
s502995	s300296	
s502597	s200294	
s502495	s501900	
s502493	s501998	
s502797	s401500	
s502799	s501596	

APPENDIX J

AOC DOCUMENTS

DEPARTMENT OF MINES, MINERALS AND ENERGY
DIVISION OF MINED LAND RECLAMATION

GUIDANCE MEMORANDUM[1] No. 4-02
Issue Date: March 22, 2002
Subject: Approximate Original Contour Guidelines

The Department of Mines, Minerals and Energy (DMME), Division of Mined Land Reclamation (DMLR) through this guidance memorandum is implementing the following guidelines concerning approximate original contour on steep-slope surface mine operations while providing a means for determining excess spoil quantities.

It is intended to improve consistency in the final configuration of areas restored to a usable and productive post mining land use.

The basis of AOC lies in the federal **Surface Mining Control and Reclamation Act of 1977**. The federal Act requires that a mine site be regraded to AOC. The federal Office of Surface Mining (OSM) recognizes that, in primacy states, the state regulatory authority is primarily responsible for interpreting what constitutes AOC at a given mine site. Virginia's requirements are set out in the **Virginia Coal Surface Mining Control and Reclamation Act of 1979** (Act), as amended, and the **Coal Surface Mining Reclamation Regulations** (4 VAC 25-130).

Virginia Requirements for Approximate Original Contour

Approximate original contour (AOC) is defined under Section 4 VAC 25-130-700.5 of the regulations as –

> "that surface reconfiguration achieved by backfilling and grading of the mined areas so that the reclaimed areas including any terracing or access roads closely resembles the general surface configuration of the land prior to mining and blends into and complements the drainage pattern of the surrounding terrain, with all highwalls, spoil piles, and coal refuse piles eliminated."

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[1] This Memorandum is to be considered a guideline issued under the authority of § 45.1-230.A1 of the Code of Virginia which reads:

"In addition to the adoption of regulations under this chapter, the Director may at his discretion issue or distribute to the public interpretative, advisory or procedural bulletins or guidelines pertaining to permit applications or to matters reasonably related thereto without following any of the procedures set forth in the Administrative Process Act (§ 2.2-4000 et seq.). The materials shall be clearly designated as to their nature, shall be solely for purposes of public information and education, and shall not have the force of regulations under this chapter or under any other provision of this Code."

{tc \l1 "Virginia Requirements for Approximate Original Contour**}**

Sections 4 VAC 25-130-816.102(a) and 4 VAC 25-130-817.102(a) of the regulations provide backfilling and regrading standards for all disturbed areas of a permit. The AOC standards must be achieved for all disturbed areas, except as allowed by subsection (k) of the aforementioned regulations, when:

(1) the standards for thin overburden are met in 4VAC 25-130-816.104,
(2) the standards for thick overburden are met in 4VAC 25-130-816.105, or
(3) Approval is obtained from the Division for:
  (a) Mountaintop removal operations in accordance with 4 VAC 25-130-785.14
  (b) A variance from AOC in accordance with 4 VAC 25-130-785.16: or
  (c) Incomplete elimination of highwalls in previously mined areas per 4 VAC 25-130-816.106

AOC is to be met whenever there is no variance clearly defined in the approved permit package.

To help decide if AOC is achieved in the permit proposal, DMLR considers, at a minimum, the following three criteria:

(1) Surface configuration
(2) Drainage patterns
(3) Highwalls and spoil pile elimination

The Act requires that post mining areas have all highwalls and spoil piles eliminated. Static safety factors of 1.3 or greater are required.

In reviewing a permit application, this static safety factor requirement can be considered achieved by post mining slopes that are 2h:1v. The post mining slopes may also match pre-mining slopes that are steeper or flatter than 2h:1v, as long as the minimum 1.3 static safety factor is met. Access roads for the post mining land use should be limited to a 20 feet width. The Division may approve greater access road width if it can be demonstrated that it supports the post mining land use. Drainage controls and berms should be included and approved in the plans. In order to determine if a proposed grading plan achieves AOC, both the pre-mining and post mining cross sections should be submitted. These pre-mining and post mining cross sections should match and be provided for all critical slope areas (i.e. finger ridges, significant slope changes, etc.).

The following figures are provided to demonstrate some applications of these guidelines. Three typical mining examples are presented. In each situation, the reclaimed configuration is established by initiating backfilling operations at the location of the outcrop at the lowest seam to be mined. A flat area may be left for an access road and drainage control. After these allowances, the slope is then started upward on a 2h:lv slope (or equivalent premining slope), as long as the 1.3 static safety factor is met.

- **Figure 1** demonstrates a steep slope/mountaintop mining operation that has been returned to AOC.

- **Figure 2** demonstrates a typical steep slope contour mine returned to AOC. In all cases the highwalls must be eliminated. This may require slopes steeper than 2h:lv.

- **Figures 3** and **4** demonstrate a finger ridge removal operation that has been returned to AOC. For long finger ridge removal, cross sections should be provided transversely through the length of the finger ridge showing a profile of the ridge and perpendicular to the profile (i.e. parallel to the proposed highwall from outcrop to outcrop). In all cases, highwalls have to be eliminated. Generally for long finger ridges, the cross sections from crop to crop are used to establish the post-reclamation profiles.

The boundary of the mined area is determined by vertically projecting a line from the outcrop of the lowest coal seam mined. The mined area is shown on the following figures. Individual mining areas within each permit area should be established. For contiguous mining operations the mining should be considered one operation (**Figure 5**).

Again, although the two mined areas are combined for reclamation purposes, in order to meet AOC, the Act requires each individual highwall be eliminated.

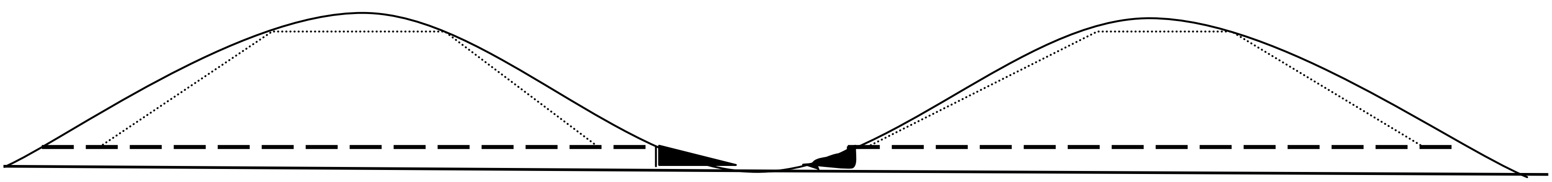
Final elevations are not controlling factors in determining whether an area has been restored to AOC. The area need not be restored to the original elevations. The reclaimed area may be somewhat lower or even higher than the original elevations. The key component in determining AOC is the proposed configuration of the backfill. This configuration needs to comply with the provisions detailed above.

Once the final proposed configuration is determined, the applicant should include detailed spoil volume calculations based on site-specific materials, so that swell shrinkage and bulking can be accurately predicted. The total spoil volume is calculated for the site. Next the volume of material required to backfill the site to the approved AOC configuration is determined. By definition, any excess material not required to return the site to AOC is excess spoil and may be placed in approved excess spoil disposal sites.

An additional option for AOC includes **landform grading**. In this situation, the permittee may use variations in slope to create contours that reflect more natural slopes. For example, a permittee may place additional material on the bench area and reduce the slope of the contour as long as he can show stability in that area. The operator may use excess spoil to produce irregular shapes of natural stable slopes. These slopes would be characterized by a continuous series of concave and convex forms, interspersed with swales and berms that blend with natural slopes. Landform grading may be employed as long as the volume of excess spoil initially determined is not exceeded.

Slope drainage devices would follow natural slope drop lines to re-create natural original drainage patterns. All spoil piles should be used in the grading. The surface configuration criterion for meeting AOC will be met if the landforms constructed closely match undisturbed areas, with curvilinear contours. Again, documentation of the mine area prior to disturbance is essential for the support of the rationale for the post-mining configuration of landform grading. As long as these landform-graded areas meet the criteria for AOC and the determined excess spoil volumes are not exceeded, they would be accepted as AOC.

Typical Mountaintop Operation



Premining Section

Postmining Section

Lowest seam to be mined

Typical postmining slopes are 2h: 1v
Drainage structure may be left
Terraces are acceptable

Figure 1

Fill Area

Typical Contour

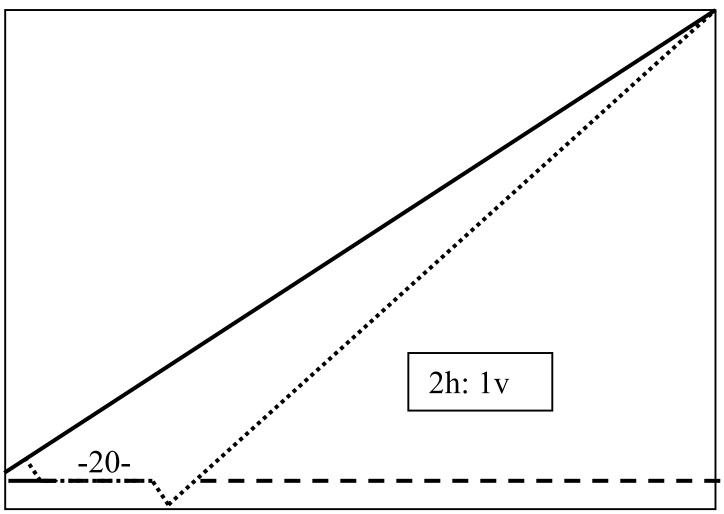
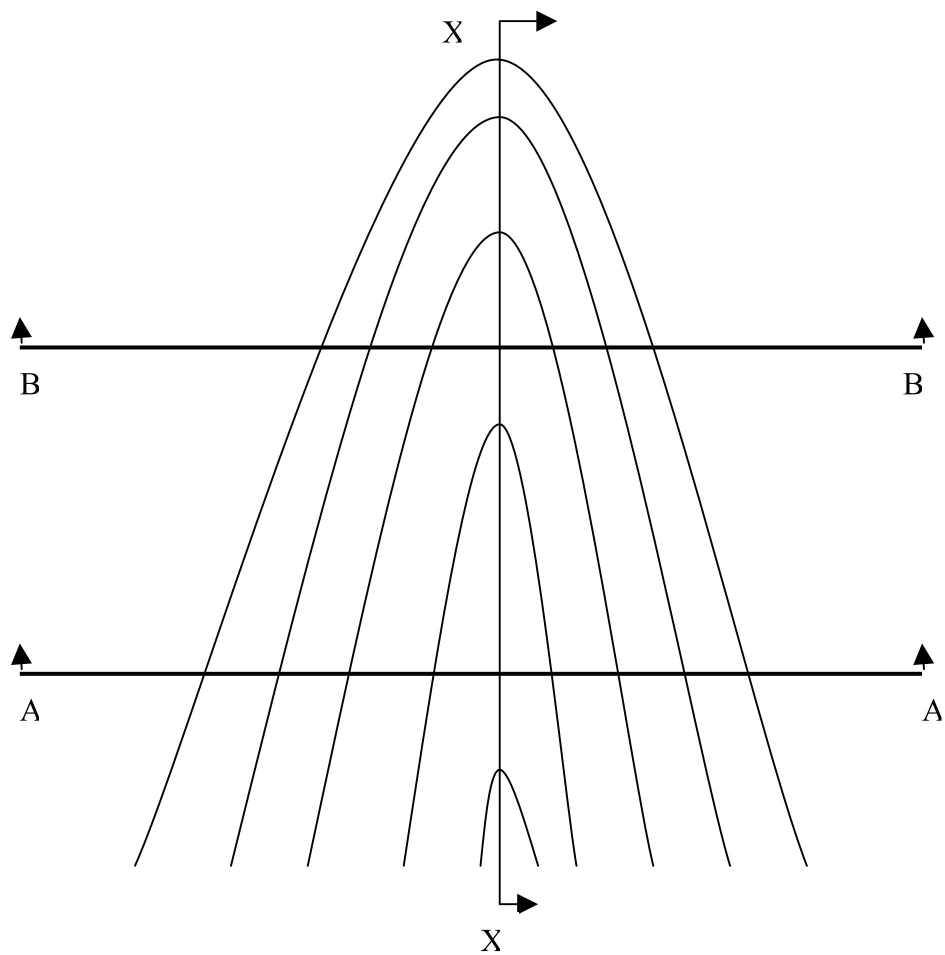


Figure 2

Premining Cross Section

Postmining Cross Section

Lowest coal seam to be mined



Plan View

1"=50'

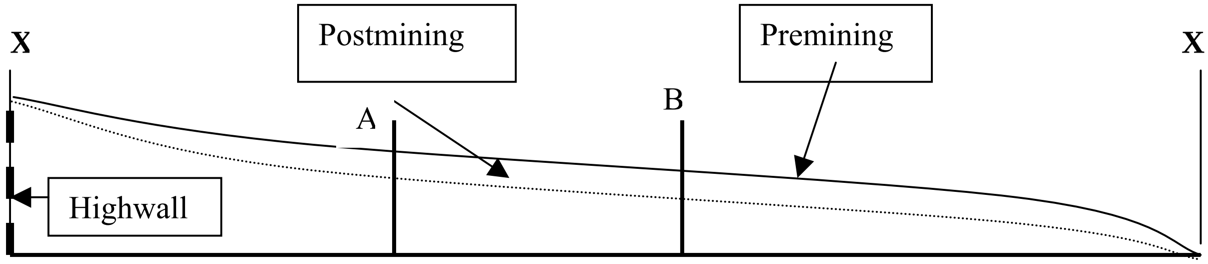
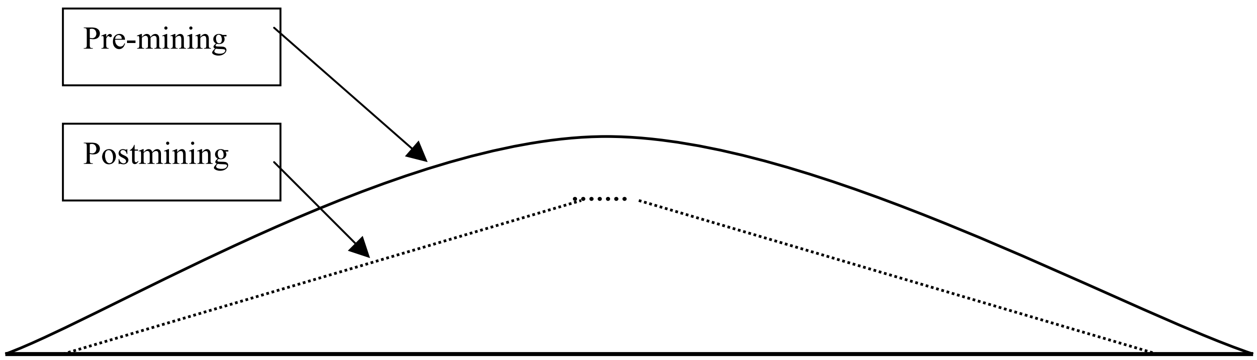
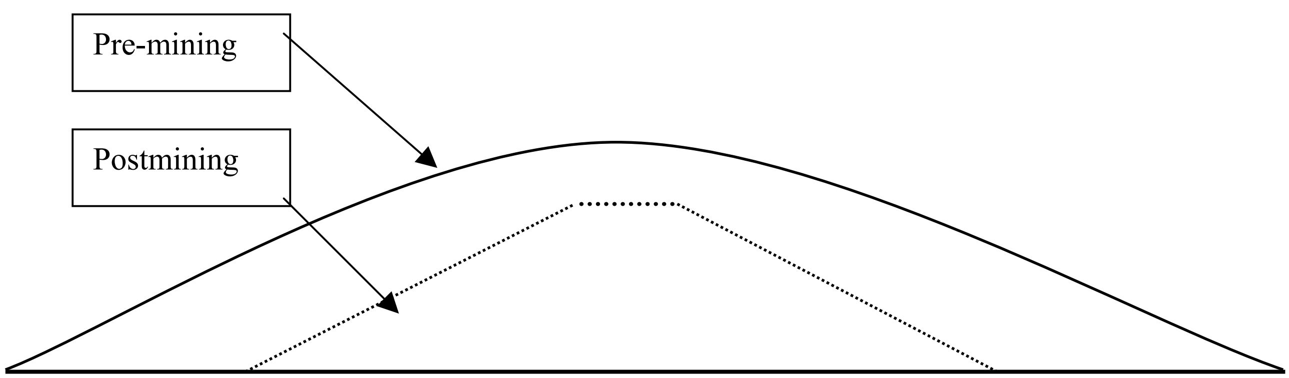


Figure 3

Typical Cross Sections

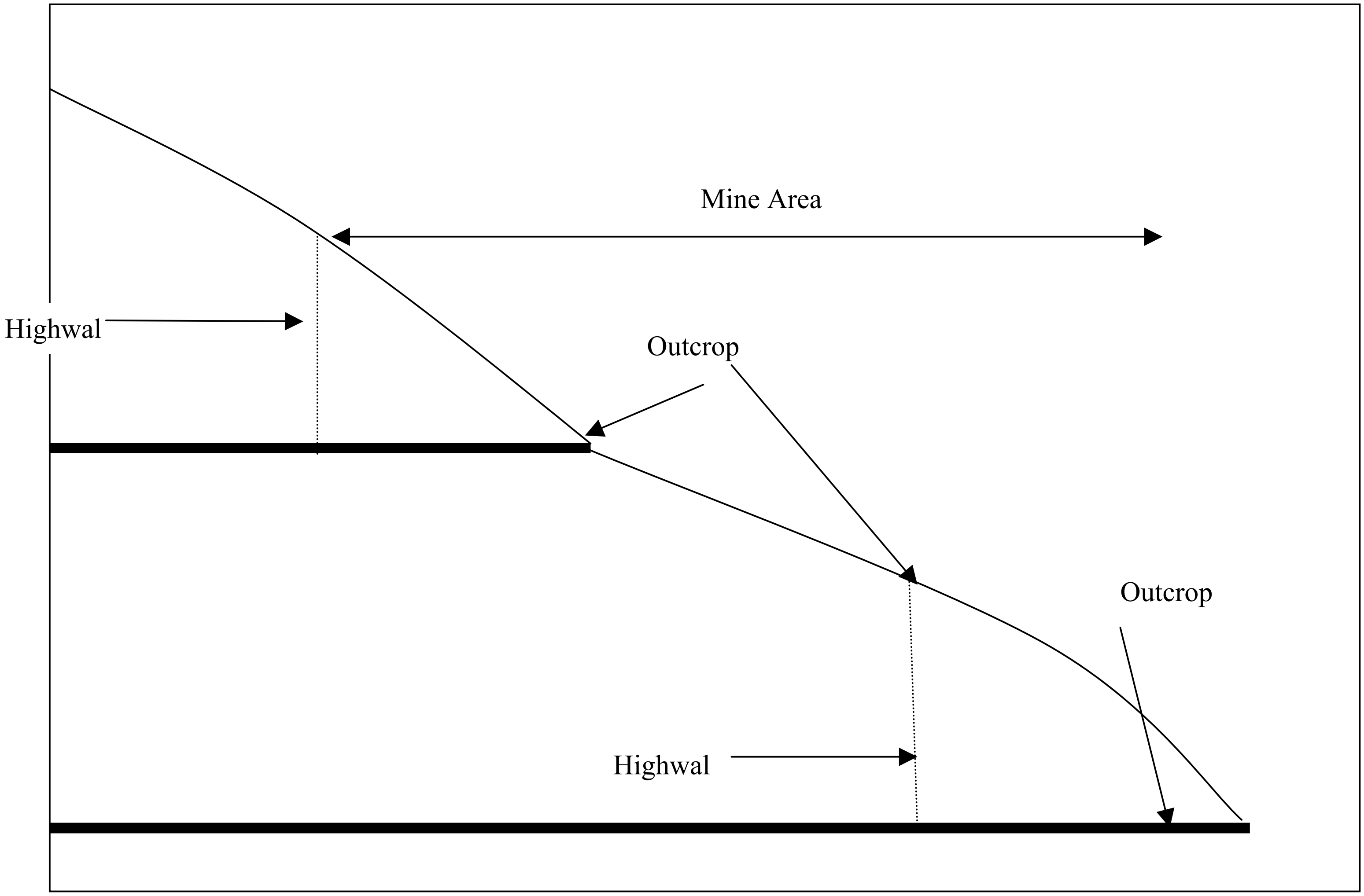


A-A 1”=50’)



B-B (1”=50’)

Figure 4



For contiguous operations the mined area will be combined for multiple seams when the horizontal distances between the highwall of the lower operations and the outcrop of the higher operation is less then 25 feet.

Figure 5

GUIDELINES FOR DETERMINING

APPROXIMATE ORIGINAL CONTOUR IN KENTUCKY

1. SURFACE CONFIGURATION

The reclaimed area shall closely resemble the general configuration of the land prior to mining. This does not mean that the post-mining contours must exactly match the pre-mining contours, or that post-mining slopes must be long and uninterrupted, if pre-mining slopes were. The general terrain, post-mining, will, however, be comparable to the pre-mining terrain. If the area was level or gently rolling prior to mining, it shall retain those features after mining. Rolls, dips, crests, and slopes need not be restored in their original locations. Level areas may be increased or terraces created, in accordance with existing regulations, through formation of shorter, steeper slopes, if the slopes are capable of supporting the post-mining land use and blend in with the surrounding terrain. During the permitting process, the permit applicant shall provide detailed cross-sections and contour maps clearly depicting the pre-mining and post-mining surface configurations.

In accordance with 405 KAR 16:190, Section 2(4)(a), the width of the individual terrace bench shall not exceed 20 feet, unless specifically approved as necessary for stability, erosion control, or roads included in the approved post-mining land use plan.

The spoil balance calculations in the permit application will also be used in determining the post-mining surface configuration.

2. SPOIL VOLUME

The permit application shall provide a justification for the balance of backfill and excess spoil material by describing the site-specific reasons for and means by which the proposed backfilling and grading plan will achieve the surface configuration. Approximately 80% of the bank volume of spoil must be returned to the mined area. Some flexibility in this percentage will be recognized for site-specific and engineering considerations, and for feasibility of the mining plan.

The proposed design location and size of the fills shall be justified in the permit application.

3. STABILITY

The spoil will be placed in the backfill area so that the outslopes of the backfill do not exceed a 2h:1v slope unless established in the permit application that the steeper slope backfill is necessary to reach the desired configuration, and that slope stability can be maintained. The final backfill configuration shall be designed and constructed so that the in-place spoil will be stable. The final configuration must include allowances for the approved design locations of post-mining features such as permanent water impoundments, roads, and drainage control facilities, including but not limited to diversions and terraces.

Fills shall have a stable final configuration, with outslopes not to exceed 2h:1v, and drainage control structures placed and sized as appropriate.

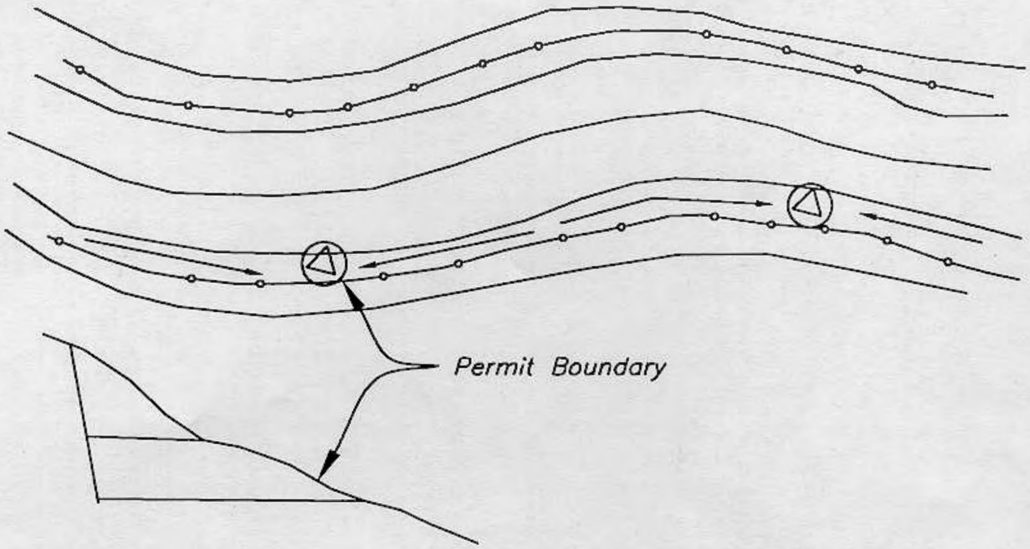
4. DRAINAGE CONTROLS

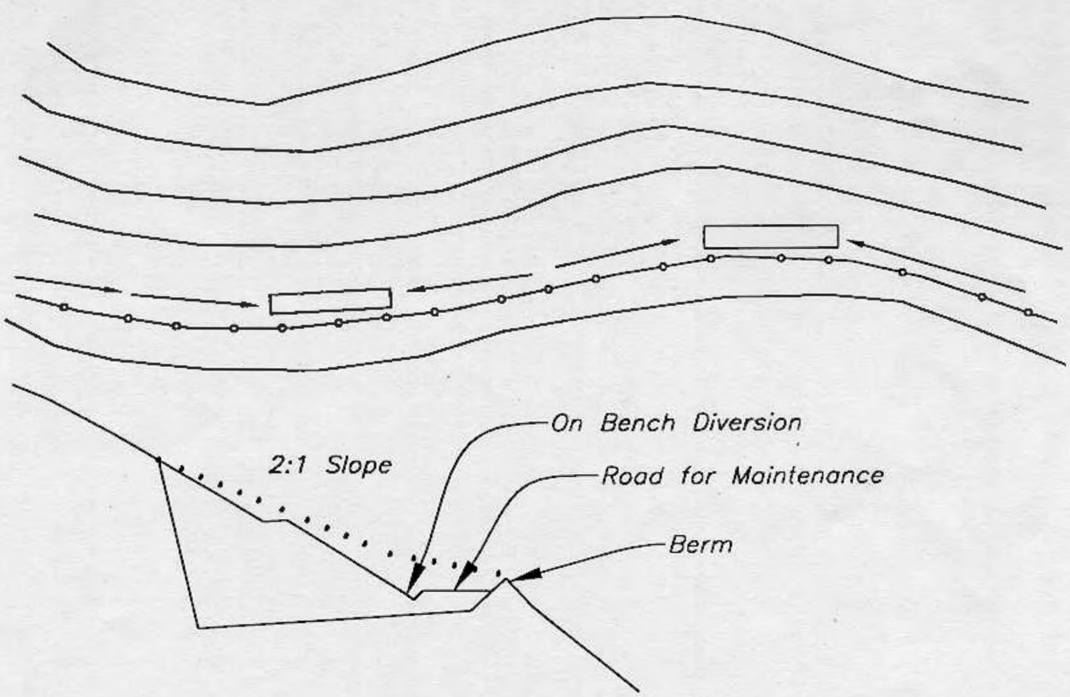
Establishing controlled drainage patterns is a major factor in the determination and construction of the final design configuration. Hollows and ridges below or above the mine areas have to be recognized and accounted for in the design and reestablishment of drainage for the backfill. The final drainage plan shall be incorporated into the final configuration so that the reclaimed area blends into and compliments the drainage pattern of the surrounding area. Water intercepted within or from the surrounding terrain shall flow through and from the reclaimed area in an unobstructed and controlled manner. The permit application review will consider the reestablishment of the approximate watershed acreages within the mine area, in order to reduce impacts to the hydrologic performance of the watershed.

5. HIGHWALLS and SPOIL PILES

All highwalls, spoil piles, and depressions, except small depressions approved in accordance with 405 KAR 16:190, Section 2(5) or 18:190, Section 2(4), shall be eliminated in a manner which blends in with the surrounding terrain.

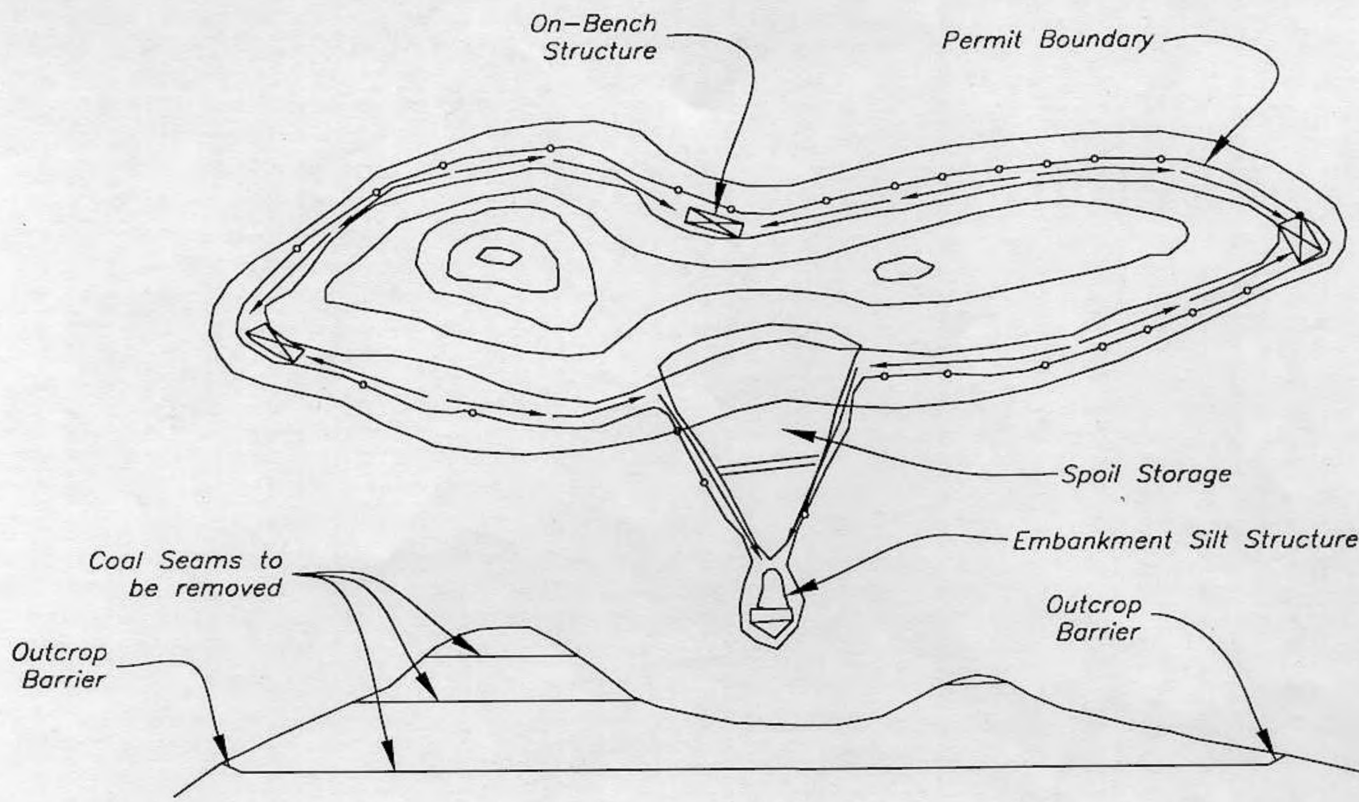
AOC Reclamation – Contour Strip

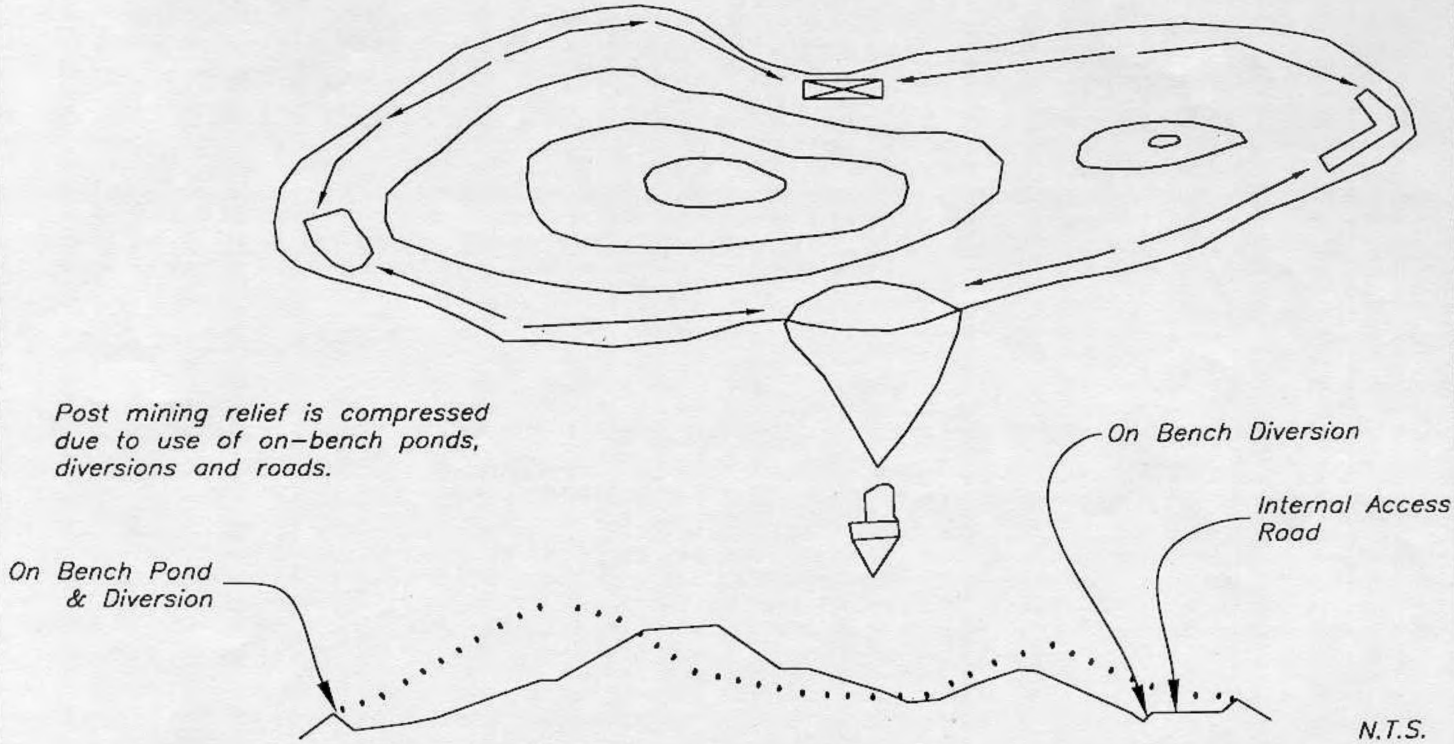




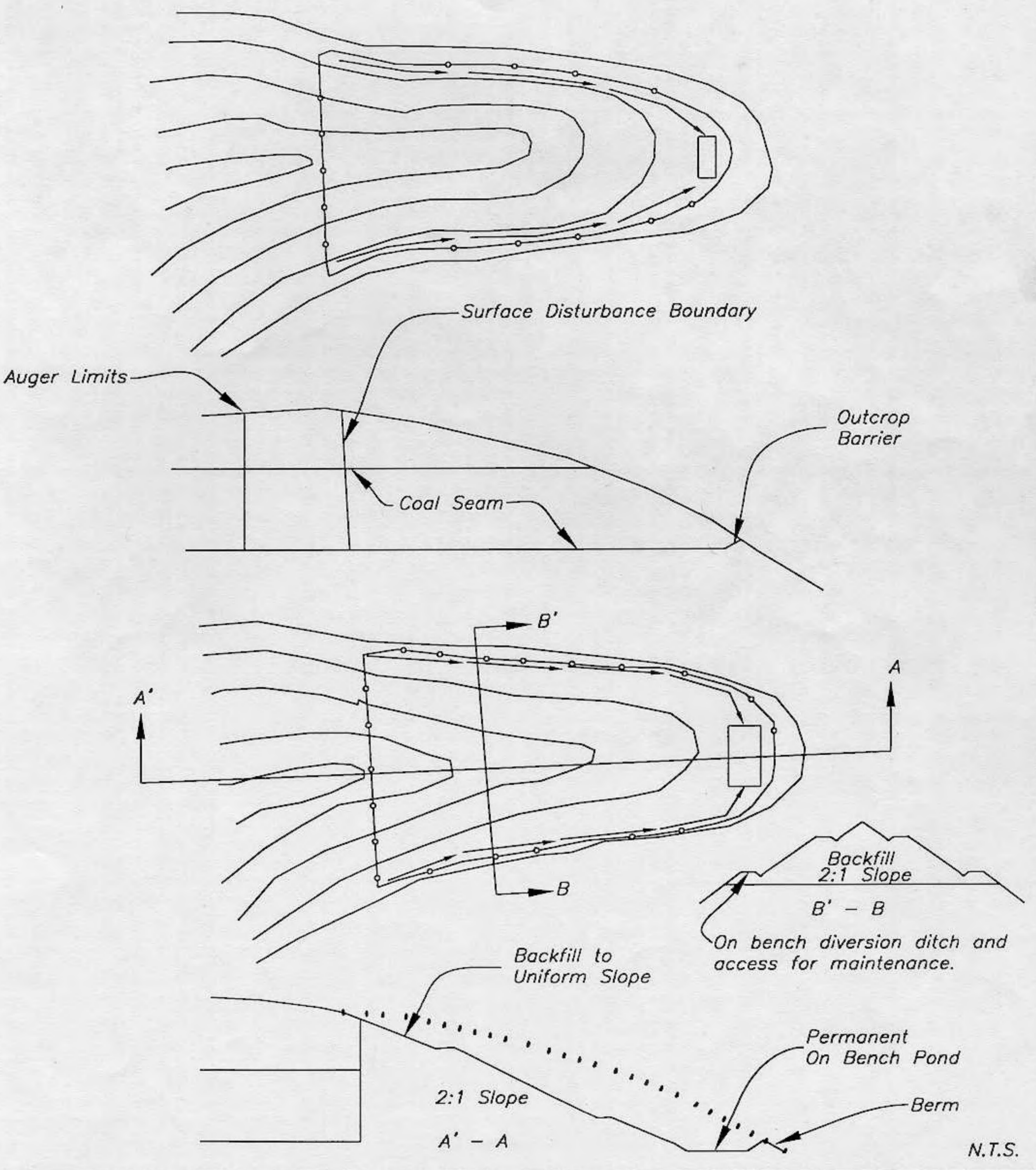
N.T.S.

A.O.C. Reclamation – Area Mines





A.O.C. Reclamation – Point Removal



29 *AOC and Excess Spoil Disposal*

C O N T E N T S

SUBJECT: **Durable Rock Fills**

DATE: **November 13, 1992**

The West Virginia Surface Mining Reclamation Regulations at 38-2-14.14(g)(7), for durable rock fills, state in part that “the underdrain system may be constructed simultaneously with excess spoil placement by the natural segregation of dumped materials”. This construction method results in the larger dumped rocks settling on the bottom of the valley floor to form an adequate underdrain.

It has been observed during recent field visits, that a few durable rock fills were being constructed using multiple side dumping points, which were located well ahead of the developing toe. However, this construction method, also known as “wing dumping, can create several types of problems.

Excessive side dumping of spoil creates increased disturbed area within the limits of the fill that results in an increased sediment load upon the sediment control structure. Additionally, when conditions arise which dictate that a durable rock fill cannot be constructed to meet its original design capacity, any spoil which had been previously side dumped ahead of the developing toe would than have to be rehandled and placed within the confines of the fill. Thus, this practice can result in environmental problems and unnecessary additional disturbance.

Therefore, for durable rock fills, it shall be the policy of this agency to limit side dumping or “wing dumping” of spoil to a distance not to exceed 300 feet downstream from the developing toe, as measured horizontally. The developing toe shall be defined as that area which is clearly being formed by the dumping of materials from points located near the center of the hollow.

NOTE: This is also in the I & E Handbook, Series 14

SUBJECT:	**AOC/Excess Spoil Guidelines**
DATE:	**June 24, 1999**

In order to establish a common beginning point for the AOC analysis, the applicant is to be requested to supply calculations, maps and cross-sections which are based upon the AOC/Excess Spoil Guidance of March 18, 1999. This will be in addition to the demonstration of AOC calculations contained in the mine designs and proposal maps submitted as part of the application. Other justification may be used; however, they must yield same or similar results as this agency will use this document for comparison as to whether AOC is achieved.

The foregoing information, together with information contained in the No Practical Alternatives document, will be used to evaluate valley fill size, location, and whether the backfilled area has been returned to AOC.

As always, the regulatory requirements of slope stability, drainage, etc., will apply to the review of the application. This applies to all applications which have not been approved.

SUBJECT:	**Final AOC Guidance Document Policy**
DATE:	**June 5, 2000**
Approval:	**Michael C. Castle, Director**

Effective immediately, all surface mine applications submitted after March 24, 2000, must have the Final AOC Guidance Document policy used to determine the adequacy of the AOC design and fill placement.

It is important to note that the Final AOC Guidance Document does not apply to contour mines. Contour mining application (regardless of date of receipt) will be reviewed using the existing AOC/Excess Spoil Guidance document which does apply to contour operations.

1. Introduction and Background

1.1 Applicable Provisions of State Law

Surface Mining Control and Reclamation Act of 1977 (SMCRA)

30 USC 1291 Section 701(2)

West Virginia Surface Coal Mining and Reclamation Act (WVSCMRA)

22-3-3(e)
22-3-13(d)(3)
22-3-13(b)(4)
22-3-13(b)(10)(B), (C), (F), (G)

West Virginia Surface Mining Reclamation Regulations (WVSMRR)

38 CSR 2-2.47
38 CSR 2-2.63
38 CSR 2-5.2, 5.3, 5.4
38 CSR 2-8, 8.a
38 CSR 2-14.5
38 CSR 2-14.8.a
38 CSR 2-14.14
38 CSR 2-14.15.a

1.2 Purpose, Objectives and Applicability

An objective and well-defined method for determining post-mining land configuration is necessary to assure compliance with applicable laws, provide an opportunity for early coordinated regulatory review, and allow for meaningful and timely public input and transparent decision-making.

This method is referred to as the "AOC Process" throughout this document.

The AOC Process outlined in this document shall be undertaken for all proposed steep slope surface coal mining applications. Steep slope operations are all operations where the natural slope of the land within the permit area exceeds an average of twenty (20) degrees, as measured from the horizontal. The AOC Process shall be completed before the issuance of a Surface Mining Application (SMA) number by WVDEP.

Nothing in this AOC Process shall be construed to regulate the surface activity solely associated with underground mining or coal refuse facilities.
This guidance document has been developed to accomplish the following objectives:

- Provide an objective process for achieving AOC while ensuring stability of backfill material and minimization of sedimentation to streams.
- Provide an objective process for determining the quantity of excess spoil that may be placed in excess spoil disposal sites such as valley fills.

- Optimize the placement of spoil to reduce watershed impacts.
- Provide an objective process for use in permit reviews as well as field inspections during mining and reclamation phases.
- Maintain the flexibility necessary for the operator to address site-specific mining and reclamation conditions.

2. AOC and Excess Spoil Quantity Relationship

2.1 Elements of AOC Definition

The following terms are necessary for development of the AOC Process:

A. Configuration: **-** Configuration relates to the shape of the regraded or reclaimed area. In addition to complying with the definition of AOC the reclaimed configuration must comply with performance standards found in WVSCMRA, such as ensuring stability, controlling drainage, and preventing stream sedimentation.

B. Stability: **-** Stability relates to the placement of material in the regraded or reclaimed area. State regulations (see 38 CSR-2-14.8.a. and 14.15.a) require material to be placed in a manner that achieves a minimum long-term static safety factor, prevents slides, and minimizes erosion.

C. Drainage: **-** Drainage relates to moving water from and within the regraded or reclaimed area. Reclaimed drainage configurations must comply with performance standards found in WVSCMRA, such as minimizing sedimentation, and restoring water quality and quantity.

2.2 Introduction of AOC Model Concept

The AOC Process includes the development a volumetric model referred to as the AOC Model. This volumetric model provides a definitive and reproducible means to calculate the volumes of material that can be backfilled or placed in excess spoil disposal areas. The volumes obtained from the AOC Model are used as a volumetric basis for the actual mine configuration. The actual configuration of the final mine plan may vary from the AOC Model except as described below.

Portraying these performance standards as variables in a model or formula provides an objective process for determining what post-mining surface configuration meets the AOC definition, while complying with the other performance standards in WVSCMRA. The following terms were developed and defined for use in the AOC Model:

Configuration

OC Volume of material required to replicate the original contours of the undisturbed area proposed to be mined. **OC** includes overburden (**OB**), interburden (**IB**), and coal in their undisturbed pre-mining state.

TSM Total spoil material to be handled or available. This material will be classified as either backfill material (**BKF**), excess spoil material (**ES**), or off site disposal material (**OSDV**)

Performance Standards

SR Backfill volume displaced due to compliance with **S**tability **R**equirements.

DR Backfill volume displaced due to compliance with **D**rainage control **R**equirements.

SCR Backfill volume displaced due to compliance with **S**ediment **C**ontrol **R**equirements.

AR Backfill volume displaced due to compliance with **A**ccess / maintenance **R**equirements.

MBR Backfill volume displaced due to compliance with the reduction of peak backfill elevation to meet **M**aximum **B**ackfill **R**equirements.

AOC Volume of backfilled spoil and configuration required to satisfy the definition of **A**pproximate **O**riginal **C**ontour.

This document uses the above acronyms for illustrative purposes only and they are not intended to represent standard engineering terminology. Instead, they illustrate the AOC Model process, rather than quantifying each term in the formula. While the terms can be quantified individually, this is not required by the AOC Model process. Use of the AOC Model results in a theoretical reclamation configuration that can be quantified.

INSERT GRAPHIC 1

Figure 1: Details Of Backfill Volume Displaced When Complying With Performance Standards

The following formula determines the amount of backfill that must be returned to the mined area to satisfy AOC.

$$\mathbf{OC - (SR + DR + SCR + AR + MBR) = AOC}$$

2.3 Definition of Configuration

2.3.1 Introduction

The following terms are used consistently in the AOC Model to define the condition of the mined area:

2.3.2 Total Spoil Material (**TSM**)

Total spoil material is all of the overburden and interburden that must be handled as a result of the proposed mining operation. **TSM** will either be placed in the mined area, in excess spoil disposal sites (valley fills), on pre-existing benches or in off-site disposal areas.

TSM volumes are determined by using standard engineering practice, such as average-end area, stage-volume calculations, or 3-dimensional (3-D) grid subtraction methods. The Secretary must have adequate information submitted by the applicant to properly evaluate **TSM** calculations. If the applicant uses an average-end area method, cross-sections must be supplied for a base line or lines at an interval no less than every 500 feet or more frequently if the shape of the pre-mined area is highly variable between the 500-foot intervals. If the applicant uses a stage-storage method, planimetered areas should also be determined on a contour interval (CI) that is representative and reflects any significant changes in slope (20' CI or less recommended). If a 3-D model is used, the pre-mining contour map and, if possible, a 3-D model graphic should be provided. The grid node spacings used in generating volumetrics should be identified. If digital data is used by the applicant, it should be in a format and on a media acceptable to the Secretary.

TSM is determined by combining the overburden (**OB**) volume over the uppermost coal seam to be excavated with the interburden (**IB**) volumes between the remaining lower coal seams, and then multiplying this sum by a “bulking” factor (**BF**). Bulking factors are calculated by a two-step process: 1) “swell” volume is determined from the amount of expected expansion of previously undisturbed natural material through the incorporation of air-filled void spaces; 2) “shrink” volume can be calculated from the amount the swelled material compacts during placement (reducing the void spaces and, consequently, the volume). Thus, the bulking factor is the swell factor minus the shrink factor, which varies based on the overburden lithology (e.g., sandstone swells more and shrinks less than shale). The applicant shall clearly identify the value of **BF** used. Permit applications that propose a **BF** greater than 30% shall contain a justification of the weighted bulking factor utilized-based not only on the weighting of individual swell factors calculated for each major rock type to be excavated that will be placed in the backfill, but also on the shrinkage or compaction factor due to spoil placement methods. In equation form:

(OB + IB) x (1 + BF)= TSM

Spoil Placement Areas - There are only three areas that **TSM** may be placed:

- backfill (**BFA**)
- excess spoil disposal areas (**ESDA**), i.e. valley fills.
- off-site disposal areas (**OSDA**)

BFA Backfill Area (mined area) is the area inside the outcrop of the lowest coal seam mined. (See Figure 2)

ESDA Excess Spoil Disposal Area. The area outside of the mined area used for placement of excess spoil. (See Figure 2)

OSDA Off-Site Disposal Areas include but are not limited to:

- unreclaimed mine sites not subject to SMCRA and State mining reclamation laws that are permitted and bonded by the applicant for spoil disposal
- approved AML or bond forfeiture projects that require such additional spoil to achieve final reclamation
- existing benches in accordance with 38 CSR-2.14.14.
- previously mined post SMCRA mined areas and excess spoil disposal areas that can accommodate additional spoil disposal that do not change the toe location. These areas shall be permitted and bonded by the applicant for spoil disposal.

The volume of spoil placed off-site shall be deducted from the spoil volumes in accordance with Section 4.3.

INSERT GRAPHIC 2

Figure 2

2.3.3 Original Contour (**OC**)

The original configuration of the mine area is determined from topographic maps of the proposed permit area. This configuration is developed through the use of appropriate cross-sections, slope measurements, and standard engineering procedures. Sufficiently detailed topographic maps, adequate numbers of cross-sections, or labeled 3-D model grids/graphics should be submitted that illustrate the representative pre-mine topography and slopes. Digital data should be submitted with the application in a format and on a media acceptable to the regulatory authority.

2.4 Effect of Performance Standards on Backfill Volume

2.4.1 Introduction

The spoil material displaced due to the performance standards is deducted from configuration volumes. Each component occupies space in the mined area that could otherwise contain spoil material. The Secretary shall assure that the AOC Model design includes only necessary and justifiable deductions based on the following criteria.

2.4.2 Stability Requirements (**SR**)

The slopes of the spoil material placed in the backfill areas or excess spoil disposal sites must be stable. Accordingly, the spoil material shall be placed in such a manner as to prevent slides or slope failures and achieve a minimum, long-term static safety factor of 1.3 for the backfill.

For the purpose of determining the backfill volume for the AOC Model the backfill slopes shall consist of a 2 horizontal to a 1 vertical (2H:1V) slope between the terraces plus a terrace of twenty feet width constructed at each one hundred feet vertical rise above the toe of the backfill.

This shall constitute the standard template for defining the backfill volume. If the applicant demonstrates that the overburden and interburden cannot attain a 1.3 factor of safety at 2:1 slopes, more gentle slopes may only be justified by the submission of geotechnical test data and stability analyses to the Secretary.

The template only applies to the determination of backfill volumes for the AOC Process. The actual configuration need not conform to the template or the "AOC Model".

INSERT GRAPHIC 3

Figure 3

2.4.3 Drainage Control Requirements (**DR**)

Drainage structures are used to divert or convey surface runoff. For the determination of backfill volumes for the AOC model, it is assumed that all drainage structures, except for clean water diversion ditches, are integrated with the sediment control structures.

The integration of the drainage structure with the sediment control structures only apply for the determination of backfill volumes for the AOC Model and the final design and configuration need not conform to the AOC Model.

If the applicant proposes a diversion ditch to transport discharge from undisturbed areas, or from drainage control structures, these structures must be properly designed to provide the required capacity and designed using standard engineering practices and theory. When reviewing the size and placement of these structures, the Secretary shall assess the design plans to assure the structures are no larger/wider than necessary for proper design and comply with standard engineering practices.

The design of the drainage structures only apply for the determination of backfill volumes for the AOC Model and the final design and configuration need not conform to the AOC Model.

2.4.4 Sediment Control Requirements (**SCR**)

For the determination of backfill volumes for the AOC Model, the design of the sediment control structures shall include the drainage structures (except for diversion ditches). It is also assumed that the sediment control structures are located at the toe of the backfill slopes on the pavement of the primary mountaintop seam and on the seam mined for contour mining.

For the purpose of the AOC Model the design of the sediment control shall consist of a continuous ditch around the perimeter of both the primary mountaintop seam and on the lowest seam mined for contour mining. These structures must have a total design depth (including freeboard) of no less than 3 feet. These structures must be properly designed to provide the required sediment storage capacity and designed using standard engineering practices and theory.

When reviewing the size and placement of these structures used in the AOC Model, the Secretary shall assess the design plans to assure the structures are no larger/wider than necessary for proper design and comply with standard engineering practices.

The design of the sediment control structures only applies to the determination of backfill volumes for the AOC Model. The final design and configuration need not conform to the AOC Model.

2.4.5 Access/Maintenance Roads (**AR**)

For purposes of this AOC Model, the applicant must justify, based on operation specific details, all access and maintenance road and safety berm widths. Under no circumstances may the road width exceed 25 feet plus a maximum allowance of 10 feet (horizontal) for a safety berm. An allowance for roads shall be provided for roads located on the primary mountaintop seam outcrop and along the outcrop of the lowest seam mined for contour mining, or each outcrop for Multiple Contour Operations.

The Secretary shall also assess the road configuration to assure the roads and safety berms are no larger/wider than necessary.

The design of the roads only applies to the determination of backfill volumes for the AOC Model. The final design and configuration need not conform to the AOC Model.

2.4.6 Maximum Backfill Requirements (**MBR**)

The crest of the backfill ridge must accommodate the mining equipment that transports and places the spoil but the crest must not be unnecessarily wide. For purposes of this AOC Model, the backfill crest width shall not exceed 100 feet. The applicant must justify, based on operation specific details, any backfill crest width in excess of 30 feet.

The AOC Model can create an anomaly when the extent of the mined area is significantly increased due to contour mining within the perimeter of valley fills. As the total mined area expands, the potential backfill height increases. In certain instances, the AOC Model generates a peak backfill elevation that is substantially higher than the surrounding terrain. To avoid this anomaly, an applicant shall not be required to design backfill higher than the peak pre-mining elevation within the mined area for purposes of calculating backfill volume and excess spoil volume using this model.

The MBR applies only for the determination of backfill volumes for the AOC Model. The final design and configuration need not conform to the AOC Model as it does not establish a ceiling elevation above which no backfill material can or must be placed in the actual Mine Plan. Incorporating the other components of the AOC definition in the proposed final regrade configuration will prevent the development of a flat plateau in the Mine Plan.

INSERT GRAPHIC 4

Figure 4. Restoring contours and meeting performance standards

3. AOC Determination (Mountaintop Mining)

3.1 Introduction

Applying these performance requirements in the mine planning process will determine the amount of total spoil material that must be retained in the mined area to satisfy the objective criteria for AOC. The calculations and drawings developed through application of this plan are used to determine the volumetric components of AOC.

3.2 Backfill Spoil Determination Model

The backfill material that will be placed within the mined area can be backfilled so that the resulting post-mining configuration closely resembles the pre-mining topography, thus satisfying not only the access, drainage, sediment, and stability performance standards of SMCRA and WVSCMRA, but also providing flexibility and meeting the AOC requirements.

Restating the AOC Model from the previous section:

OC – (SR + DR + SCR + AR + MBR)= AOC

Step 1: Determine original or pre-mining configuration Original Contour (**OC**)

Step 2: Subtract from Original Contour:

Volume displaced due to Stability Requirements (**SR**)

Volume displaced due to Sediment Control Requirements (**SCR**) which include Drainage Requirements (**DR**) except for clean water diversion ditches, as defined above

Volume displaced due to Access Requirements (**AR**)

Volume displaced due to Maximum Backfill Elevation Requirements (**MBR**)

Step 3: The remaining volume is the initial backfill (**IBKF**) which is the spoil material placed in the mined area prior to the placement of any excess spoil areas.
Therefore, the relationship becomes:
IBKF = **OC** – (**SR** + **DR** + **SCR** + **AR** + **MBR**)

3.3 Excess Spoil Determination

The parameters used in the AOC Model for determining the **TSM** also are used to determine the quantity of excess spoil. This approach provides an objective process for determining what is excess spoil (**ES**).

The additional terms and concepts used are:

IBKF Volume of backfill or spoil material placed in the mined area prior to the placement of any excess spoil areas

ES Volume of excess spoil remaining after satisfying AOC by backfilling and grading to meet **SR, DR, SCR, AR, MBR**.

OSDV Volume of spoil material placed in an approved off-site location

The **ES** quantity, as determined by the following formula, is obtained by complying with the stability standards and other performance standards.

The excess spoil relationships:

ES = TSM - IBKF

Therefore:

ES = TSM - (OC - (SR + DR + SCR + AR + MBR))

3.4 Adjustment to ES and BKF to reflect Off Site Disposal

Operations may use adjacent pre-existing benches (without coal removal occurring) as part of the permitted area for excess spoil disposal. If pre-existing benches are to be used as excess spoil disposal sites, the capacity of each pre-existing bench area must be calculated.

Additional off-site material disposal locations include Abandoned Mine Land (AML) sites, Bond Forfeiture sites and civil works projects approved by the Secretary.

Excess spoil may be placed on adjacent, post SMCRA, mine sites that have suitable locations for spoil disposal. Any such areas used for spoil disposal must be appropriately permitted and bonded.

The total quantity of off-site disposal volume (**OSDV**) shall be calculated and details shall be provided to the Secretary. The information submitted shall be sufficient to allow the Secretary to review the adequacy of calculation.

As an incentive to use previously disturbed areas, the quantity of off-site disposal **OSDV** shall be deducted from the Total Spoil Material (**TSM**), resulting in a reduction in both the Excess Spoil (**ES**) and the Initial Backfill (**IBKF**). The allocation of this volume shall be based on the ratio of Excess Spoil (**ES**) to Total Spoil (**TSM**).

The deduction decreases the volume of Total Spoil Material; therefore, the new value for Total Spoil Material ($\mathbf{TSM_N}$) is defined as:

$$\mathbf{TSM_N = TSM - OSDV}$$

The new value for the Excess Spoil volume ($\mathbf{ES_N}$) shall be defined as:

$$\mathbf{ES_N = ES - (OSDV \times (ES/TSM))}$$

The new value for the Backfill volume ($\mathbf{IBKF_N}$) shall be defined as:

$$\mathbf{IBKF_N = IBKF - (OSDV \times (1 - (ES/TSM)))}$$

If the applicant intends to use off-site disposal areas, all subsequent references in this document to **ES** and **IBKF** shall be replaced with $\mathbf{ES_N}$ and $\mathbf{IBKF_N}$.

3.5 Additional Backfill Capacity Required by AOC Model

The AOC Model requires that the excess spoil disposal fill is raised to an elevation above the lowest seam to be mined. The backfill slope must start at the vertical projection of the outcrop of the lowest seam being mined. The toe of the slope may be set back from the vertical projection of the lowest seam by a distance equal to the width of the sediment requirements (**SR**) plus the drainage requirements (**DR**). For the purpose of the AOC Model the access roads shall be located on the excess spoil disposal area.

This concept determines the demarcation between the backfill area **(BFA**) and the excess spoil disposal area (**ESDA**). (See Figure 6) This demarcation can be used consistently in any steep slope mining situation, and is determined using the following process:

- Locate the outcrop of the lowest seam being mined within each excess spoil disposal area, whether contour cut only or removal of the entire seam. (See Figure 6)
- Project a vertical line upward beyond the crest of the fill and backfill elevations (See Figure 7).
- The area where coal removal occurs, to one side of this line, is backfill area (**BFA**); and, the area on the other side of the line, including the valley bottom, is excess spoil disposal area (**ESDA**) (see Figure 7).

The initial volume of material placed on the mined area with no influence of any valley fills shall be referred to as the Initial Backfill (**IBKF**).

The revised location of the toe of the backfill slope to the **BFA / ESDA** demarcation line, as a result of the construction of an excess spoil disposal facility, results in additional backfill volume. This is referred to as Additional Backfill (**ABKF.**)

The total volume of backfill material (**BKF**) placed in the backfill area (**BFA)** consists of the initial backfill (**IBKF**) plus the additional backfill (**ABKF)**. Therefore:

BKF = IBKF + ABKF

The volume of excess spoil remaining after deducting the total backfill volume shall be placed in an excess spoil disposal facility. This volume of material is the Excess Spoil Disposal Volume (**ESDV**).

Establishing this boundary between excess spoil areas and backfill areas is the same procedure used in determining where permanent diversion ditches must be located.

INSERT GRAPHIC 5

Section 6 and Section 7 of this guidance document contains an optimization procedure for mountaintop mining and contour mining respectively, for excess spoil disposal plans. Successful optimization is attained through elevating excess spoil fills to a target height above the mined area, thus converting a portion of Initial Excess Spoil **(IES**) to additional backfill volume (**ABKF**) and thereby reducing the size and impact of valley fills.

3.6 Summary of Volume Allocations

Summarizing the previous terms and relationships, excess spoil is the total spoil produced from mining the property less the amount that can be backfilled in the mined area:

IES = TSM – IBKF

Through the use of previously mined benches, AML projects, and other off-site disposal sites, the volume of both Excess Spoil and Backfill may be reduced. As a result of these reductions:

$$\mathbf{ES_N = TSM_N - BKF_N}$$

If spoil is placed in the mined area, this volume is converted from **IES** to Additional Backfill volume (**ABKF**). The Excess Spoil Disposal Volume (**ESDV**) is the Initial Excess Spoil (**IES**) less that volume converted to backfill as **ABKF**.

IES = ABKF + ESDV

or

ESDV = IES - ABKF

Resolving the two relations defined above:

TSM – IBKF = ABKF +ESDV

or

TSM = ESDV + (IBKF + ABKF)

INSERT GRAPHIC 6

3.7 Isolated Coal Seams

After designing the optimized mine plan and spoil disposal plan, excess spoil disposal areas may cover coal seams that will be rendered unminable once the fill is placed. Therefore, treatment of contour mining in such seams as ordinary "mined area" under this model may create a disincentive to the recovery of that coal.

In order to allow the extraction of coal that would otherwise be lost, the applicant may submit a request to designate a contour-mined seam as "isolated". The Secretary may designate a contour-mined seam as an "isolated coal seam" only if:

- the "isolated coal seam" is mined only within the excess spoil disposal areas
- that this "isolated coal seam" may not be added to the permit by revision or amendment or be included in an adjacent permit
- no additional excess spoil disposal area may be permitted to accommodate spoil from future mining of the "isolated coal seam"

- the mineral removal area associated with the "isolated coal seam" contouring is not contiguous to the primary mountaintop seam mineral removal area or to mineral removal areas related to other contiguous contouring
- the "isolated coal seam" area could not reasonably be extended to become contiguous to the mountaintop mined mineral removal area

In no event shall a contour mined area where the top of the highwall extends to within 50 feet vertically of the elevation of the primary mountaintop seam be designated as an "isolated coal seam".

The Secretary may determine that the above criteria is satisfied and that, based on documentation provided by the applicant only if this "isolated coal seam" could not be feasibly mined as an independent or "stand-alone" operation. The mined areas of the "isolated" coal seam shall not be used to define the lowest seam mined for demarcation between the **ESDA** and **BFA**.

4. Excess Spoil Disposal Area Definition

4.1 Introduction

A standardized approaches for characterizing excess spoil disposal sites allows consistent and reproducible analysis and calculation of both the Excess Spoil Disposal Volume (**ESDV**) and the Additional Backfill (**ABKF**) volume resultant from the construction of excess spoil disposal site(s).

The calculations defined in this section are used for the excess spoil disposal optimization process discussed in of this document.

4.2 Equivalent Swell Height

The equivalent swell height, in feet, (**ESH**) is calculated by dividing the total spoil material (**TSM**) (in bank cubic feet) by the mineral extraction area, in square feet, (also termed Backfill Area **BFA**), and then multiplying that value by the determined bulking factor (**BF**) as utilized by the applicant in the AOC Model.

ESH = (**TSM** / **BFA**) x **BF**

For example, a bulking factor of 25% shall be expressed as 0.25 in this relationship.

4.3 Target Fill Elevation

The target fill elevation for each valley fill is defined as the sum of the average elevation of the outcrop of the primary mountaintop seam within each valley selected for fill placement, plus the **ESH**. To simplify volume calculations and solely for calculation, each excess spoil disposal area shall be assumed to have a horizontal top surface.

5. Excess Spoil Disposal Optimization (Mountaintop Mining)

5.1 Introduction

The procedure described in this section applies only to those watersheds in which mountaintop mining is proposed. If mountaintop mining is not proposed in a specific watershed but other mining types (e.g. contouring) are to be used, the excess spoil optimization procedure specific to those mining types shall be employed for any fill within that watershed.

5.2 Spoil Disposal Plan Approval

An application for a mountaintop surface mine permit shall be deemed to have an optimized spoil disposal plan only if the:

- plan satisfies the Presumed Criteria Test, or
- total non-mineral removal area affected by valley fills does not exceed the "Excess Spoil Disposal Area Bank" (**ESDA Bank**) plus the Acreage Tolerance

Under unusual circumstances the AOC / Fill Optimization Panel may approve exceptions to fill optimization as described in Section 8 of this guidance document. Mining operations receiving such approved exceptions do not have optimized spoil placement plans.

If an applicant is seeking an AOC variance, the applicant must follow the appropriate procedures described in Section 9.2 of this guidance document.

5.3 Presumed Criteria Test

The proposed excess spoil disposal plan in the AOC Model shall be presumed to be optimized if it meets the Presumed Criteria Test. The excess spoil disposal plan is optimized with regard to spoil disposal and the disturbed area associated with valley fills when **every** proposed valley in the AOC Model achieves the "target fill elevation." This design approach establishes the toe of each valley fill.

Calculation of the "presumed criteria" valley fill toes shall comply with the following steps:

Step 1 Select the valleys to be considered or qualified for excess spoil disposal.

Step 2 Determine the maximum downstream toe location to be considered for each valley fill. Environmental factors, statute, rules, property rights, operational issues, and other factors will influence this location.

Step 3 Define the value for Excess Spoil (**ES**) based on backfilling with no valley fills. The initial backfill volume (**IBKF**) will be determined using the AOC Model.

Step 4 Define the "equivalent swell height" (**ESH**)

Step 5 Define the average elevation of the primary mountaintop seam, upstream of the maximum downstream toe (as defined in Step (2) in each valley selected for the placement of excess spoil

Step 6 Determine the Target Fill Elevation (**TFE**) for the top of each excess spoil disposal structure. The **TFE** is the average elevation of the primary mountaintop seam plus the equivalent swell height as defined in Step 4

Step 7 Draw a profile along each valley to be filled from the top of the backfill (from the first iteration of the AOC Model) to the logical toe. The baselines should be oriented perpendicular to the face of the anticipated valley fills at their logical toe

Step 8 Locate the toe for the Initial Increment for each fill. The toe location for the Initial Increment shall be the lowest stratigraphically of either:

- the most upstream toe that complies with the geotechnical stability requirements defined by the regulations
- 50 horizontal feet downstream of the outcrop of the lowest seam to be mined

Step 9 Calculate the excess spoil disposal volume (**ESDV**) and the additional backfill volumes (**ABKF)** associated with the Initial Increment. For this optimization model only, assume a constant valley fill front face slope for all valley fills and all “slices” of 2.4h:1v.

Step 10 Separate the remaining portions of all of the selected fills into equal length increments referred to as “slices” (these slices are perpendicular to the baseline constructed in Step 7). These “slices” shall extend from the Initial Increment all the way along the profile to the toe selected in Step 2. The slice length along the profile shall be selected by the applicant but may be no greater than 500 feet. The slice length shall be consistent for all fills and all slices.

Step 11 Calculate the excess spoil disposal volume (**ESDV**) and the additional backfill volume (**ABKF)** associated with each “slice”. As in Step 9, these volumes include the additional backfill volumes defined by the AOC Process.

Step 12 Develop a matrix indicating the volume of excess spoil disposal volume (**ESDV**) and additional backfill volume (**ABKF**) for each Initial Increment plus each of the “slices” for each valley fill under consideration.

Step 13 Determine the volume of **ES** to be allocated to each fill and then select the applicable number of slices to accommodate those volumes. The **ES** per fill will occur as both **ESDV** and **ABKF**; i.e., the volume of additional backfill created by the fill must be considered along with the excess spoil disposal volume.

Step 14 For the combination of the **ESDV** and **ABKF** required to contain the **ES** volume, establish the toe location for each fill.

Step 15 Design the mine and spoil areas in any sequence or configuration as long as the toe located in Step 8 does not move downstream and the design complies with Section 9.1 of this document.

Step 16 Document compliance with the above criteria by preparing and submitting as part of the surface mine application details of each valley fill model developed in Step 7. Each model shall include a plan view and profile view at a scale of 1”=200’ (or as otherwise approved) and appropriate engineering calculations.

Positive Determination — If the proposed toe location for each valley fill is maintained at or upstream of the toe location established for each valley fill in accordance with the above AOC Model procedure, the Secretary shall find that the Excess Spoil Disposal Area (“**ESDA**”) has been optimized.
Negative Determination - If any of the proposed valley fills have a toe location that does not permit the fill to meet the Presumed Criteria Test as described, the Secretary shall notify the applicant that it must submit calculations to define the **ESDA Bank**.

5.4 “ESDA Bank” Analysis

If the proposed excess spoil disposal plan does not achieve a positive determination under the Presumed Criteria Test, the excess spoil disposal plan will be evaluated using the **ESDA Bank** analysis. This analysis employs the procedures defined in the preceding sections of the AOC Model except that the crest elevation of each fill is fixed to calculate the **ESDA Bank**.

This procedure provides a standardized means of comparing and rating available excess spoil disposal sites to achieve the most efficient placement of the excess spoil. Each fill is evaluated to determine its spoil disposal capacity per specified length of valley. The total volume of excess spoil is then assigned to the fills in descending order based on each fill’s relative “efficiency.” The result will be the optimum placement of spoil in terms of cubic yards per acre of **ESDA**.

Calculation of the **ESDA Bank** shall comply with the following steps:

Step 1 Define the primary mountaintop mining seam. This is the lowest seam within each proposed valley fill site that is being mountaintop mined

Step 2 Select the valleys to be considered or qualified for excess spoil disposal

Step 3 Determine the maximum downstream toe location to be considered for each valley fill. Environmental factors, statutes, rules, property rights, operational issues, and other factors will influence this location

Step 4 Define the value for Excess Spoil (**ES**) based on backfilling with no valley fills. The backfill volume (**IBKF**) will be determined using the AOC Model

Step 5 Define the “equivalent swell height.”(**ESH**)

Step 6 Determine the Target Fill Elevation (**TFE**) for each excess spoil disposal structure. The TFE is the average elevation of the primary mountaintop seam plus the equivalent swell height as defined in Step 5

Step 7 Construct a straight baseline from the logical toe to the top of backfill (**IBKF**) generally along the centerline of each valley to be filled. The baselines should be oriented perpendicular to the face of the anticipated valley fills at their logical toe. Draw a profile along the baseline for each valley to be filled from the top of the initial backfill.

Step 8 Locate the toe for the Initial Increment for each fill. The toe location for the Initial Increment shall be the lowest stratigraphically of either:

- the most upstream toe that complies with the geotechnical stability requirements defined by the regulations, or
- 50 horizontal feet downstream of the outcrop of the lowest seam to be mined

Step 9 Calculate the excess spoil disposal volume (**ESDV**) and the additional backfill volumes (**ABKF)** associated with the Initial Increment. For this optimization model only, assume a constant valley fill front face slope for all valley fills and all “slices” of 2.4h:1v.

Step 10 Separate the remaining portions of all of the selected fills into equal length increments referred to as “slices” (these slices are perpendicular to the baseline constructed in Step 7). These “slices” shall extend from the Initial Increment all the way along the profile to the toe selected in Step 2. The slice length along the profile shall be selected by the applicant but may be no greater than 500 feet. The slice length shall be consistent for all fills and all slices.

Step 11 Calculate the excess spoil disposal volume (**ESDV**) and the additional backfill volume (**ABKF)** associated with each “slice”. As in Step 9, these volumes include the additional backfill volumes defined by the AOC Process.

Step 12 Develop a matrix indicating the volume of excess spoil disposal volume (**ESDV**) and additional backfill volume (**ABKF**) for each Initial Increment plus each of the “slices” for each valley fill under consideration.

Step 13 Calculate the optimum configuration of fill “slices.” This optimization shall be based on the sequential inclusion of each Initial Increment for the valley fills under consideration. The selection process shall continue until the excess spoil volume (including additional backfill volume) equals the Excess Spoil (**ES**). If the sum of all the initial increments equals or exceeds the ES volume proceed to Step 16.

Step 14 If the volume of all of the Initial Increments does not meet the ES volume, sequentially include the increment with the greatest volume (excess spoil disposal volume (**ESDV**) plus additional backfill volume (**ABKF**)). Continue to select the “slice” with the next highest volume (naturally each fill must be selected in logical order). The selection process shall continue until the excess spoil volume (including additional backfill volume) equals the Excess Spoil (**ES**).

Step 15 If sufficient disposal volume is not available within the defined logical toes, the elevation of the valley fill surface shall be increased, and the iterations run again, thus creating further **ESDV** and A**BKF**.

Step 16 For the combination of the “Initial Increments” and “slices” required to contain the **ES** volume, determine the total area used for excess spoil. This area is referred to as the **ESDA Bank**. The **ESDA Bank** shall be the planimetric area of the excess spoil disposal area portion of the valley fill. (i.e. the area outside the mined area but contained by the fill between the toe and the outcrop of the lowest seam mined.)

Step 17 Develop the Mine Plan in any sequence or configuration as long as the area used for excess spoil disposal does not exceed the **ESDA Bank** plus the specified acreage tolerance. The only limitation on the design is that it must comply with Section 9.1.

Step 18 After the applicant has defined the excess spoil disposal areas for the Mine Plan, the total area utilized for excess spoil under this configuration (Proposed Excess Spoil Disposal Area) shall be compared to the optimum excess spoil disposal area (**ESDA Bank.**)

Acreage Tolerance: An acreage tolerance factor shall be applied to the **ESDA Bank**. The Acreage Tolerance shall be ten percent (10%) of the area below the outcrop of the primary mountaintop seam but contained within the valley fill footprints.

Positive Determination - The Secretary shall find that the Proposed Excess Spoil Disposal Area has been optimized and permit review may proceed if the proposed excess spoil disposal area for the entire permit area does not exceed the **ESDA Bank** plus the Acreage Tolerance.

Negative Determination - If the application does not meet the above criteria, the Secretary shall issue a written “notice of negative excess spoil optimization” to the applicant and the permit application shall be submitted to an independent AOC / Fill Optimization Panel for consideration. Mining operations that receive a negative determination do not have an optimized spoil disposal plan.

6. AOC Determination (Contour Mining)

To be Completed

7. Excess Spoil Disposal Optimization (Contour Mining)

To be Completed

8. AOC / Fill Optimization Panel

In accordance with procedures described in Section 5 and Section 7 of this AOC Model, the Secretary shall promptly notify an applicant when an application does not comply with the spoil optimization guidelines. Upon receipt of a "notice of negative excess spoil optimization" the applicant may:

- Withdraw the permit application
- Revise the permit application to request an AOC variance
- Revise the permit configuration in order to meet the excess spoil optimization criteria, or
- Submit the excess spoil handling plan to the "AOC / Fill Optimization Practices Advisory Panel" (the "Panel") for evaluation.

If the applicant submits the excess spoil handling plan to the Panel for evaluation, the Secretary shall convene the Panel.

Following submittal of the excess spoil handling plan to the Panel, the applicant shall provide detailed plans and calculations clearly stating why it believes the proposed permit configuration cannot be optimized. Throughout the process, the burden of proof will remain on the applicant to justify its proposal.

The Panel shall be comprised of, an appointee of Mountain State Justice, Inc. or its assigns, an appointee jointly made by the West Virginia Coal Association and West Virginia Mining and Reclamation Association, or its assigns, and a neutral member jointly selected by those panel members. The State will pay reasonable hourly rates and expenses for panel members within the 60 calendar days of submission of invoice.

The appointees must have a degree in Mining Engineering or Civil Engineering. The members need not be registered professional engineers. The appointees may have no interest, financial or otherwise, in the surface mining permit under review. If a conflict of interest arises, the panel member with the conflict shall be replaced by an alternate appointed by the appropriate party.

A Panel meeting shall be scheduled and convened within twenty-one (21) days of the submittal of the required information to WVDEP, as determined by the Secretary. The Panel shall hear the applicant's argument in support of its plan. Following the meeting of the Panel, the Panel shall issue a written recommendation within fifteen (15) days of the completion of the hearing. An exception to optimization may be recommended only after the Panel makes specific and detailed findings that there is no reasonable alternative to the exception. A majority vote of the Panel shall constitute a decision.

The "ESDA Limit" is the sum of **ESDA Bank** and the Acreage Tolerance, as established in Section 5.4.

For Mountaintop Mining the Panel may recommend by majority vote an exception of up to 10% greater than the "ESDA Limit". When this occurs the fill placement is not optimized.

The Secretary shall not be bound by the recommendation of the Panel. However, if the Secretary does not follow the recommendation of the Panel, the Secretary shall make written findings justifying his decision. In no event however may The Secretary approve an AOC compliant plan for Mountaintop Mining that is more than 10% greater than the "ESDA Limit."

9. AOC Compliance / AOC Variance Requests

9.1 AOC Compliance Determination

This AOC Process provides an objective means of assessing compliance with AOC specifically for steep-slope mining applications.

The "AOC Model" determined by the application of design components generates a volumetric determination of AOC. The AOC Process does not require that the Mine Plan matches the configuration of the "volumetric AOC Model".

The applicant shall submit detailed plans, cross sections and calculations as part of the permit application to define the Mine Plan. This documentation shall provide a clear indication to the Secretary relating to compliance with the tests detailed below. In addition, the documentation shall include the final reclamation plan, which clearly indicates the proposed post mining configuration.

The Secretary has the authority to determine that the final reclamation plan is not compliant with the AOC, even if is compliant with the volumetric requirements of the AOC Process (e.g. that it does not satisfy the aesthetic components of AOC). In addition, the Secretary shall assure that the final reclamation plan conforms to the following tests.

- **Backfill Volume**: The quantity of spoil material to be returned to the mined area (**BKF**) (or **BKF_N** if applicable) is calculated in Section 3.4. The final spoil balance and regrade design must demonstrate that **at a minimum** this volume of spoil to be placed as backfill in the Mine Plan.
- **Valley Fill Design**: The spoil optimization procedures in this AOC Process establish the maximum downstream toe location for each valley fill. Those maximum downstream locations must not be exceeded in the final Mine Plan.
- **Backfill Configuration**: Strict adherence to the "volumetric AOC Model" will often result in a reclaimed site that appears rigidly uniform and artificial. Therefore, applicants shall develop and submit as part of the permit application regrade plans that address aesthetic values along with engineering issues. This can be accomplished through the incorporation of landforms and other creative types of landscaping. However, the applicant must comply with certain objective configuration criteria that are established by this AOC Process.
  - **Watershed Pattern**: The final "volumetric AOC Model" will create a readily identifiable ridge system separating the regraded site into discrete watersheds. This general watershed pattern must be maintained in the final Mine Plan. In those areas where the **MBR** constraint affects the AOC Model, a series of subwatersheds that reflect the pre-mining watershed system are to be established in the Mine Plan
  - **Backfill Inflection Points**: A boundary is established in the AOC Model between the backfill slopes and the generally level or moderately sloped areas used for access, drainage features, and sediment control. This boundary is the demarcation between the Backfill Area (**BFA**) and the Excess Spoil Disposal Area (**ESDA**). To maintain the general configuration generated by the "volumetric AOC Model", this boundary is to be preserved in its approximate location in the final mine plan. Approximate is defined as being within 100 feet of the location of the **BFA / ESDA** boundary as defined in this AOC Process. Variations in elevation are allowable to promote drainage and to provide flexibility in shaping the final regraded configuration as defined in the Mine Plan.

- **Final Pit**: It is recognized that it is not practical to fully restore the final pit area to the configuration developed by the AOC Model due to the lack of available material. The inability to meet the ideal configuration shall not require an AOC variance, if the applicant can demonstrate in the Mine Plan that it has adequately addressed the issue of final pit reclamation through measures such as downsizing the active pit as mining draws to a close. However, the final pit regrade shall conform to the watershed pattern requirement and shall not result in any change to the quantity of BKF placed in the mined area.

These criteria will provide the regulatory authority with an objective, quantifiable means of assessing the Mine Plan's compliance with the approximate original contour requirements. For purposes of incorporating environmental enhancements into the final reclaimed configuration, the Secretary may allow a adjustment to the Backfill Volume test so that up to ten percent (10%) of **BKF** may be converted to **ESDV**, provided that the toe of each optimized valley fill shall not be moved downstream.

This adjustment is granted to encourage stream restoration projects, wetlands development, and similar aquatic habitat projects. The applicant is encouraged to restore streams by configuring the fills so that there is a positive grade from one side of the fill to the other so that the lower side of the fill intercepts the down dip pavement of the primary mining seam.

9.2 AOC Variance Request Evaluation

When an applicant applies for an AOC variance for a mountaintop surface mine, the applicant shall include a complete excess spoil-handling plan that includes excess spoil optimization in compliance with the AOC Process. This plan shall be based on returning the mined area fully to AOC and shall include all calculations and other details needed to establish the **ESDA Bank (AOC)** without the AOC variance.

The **ESDA Bank** procedure shall be repeated using the proposed alternate post-mining configuration instead of the AOC configuration to determine the corresponding **Alternate ESDA Bank** acreage. The applicant shall present both analyses in a clear and organized manner, complete with all supporting documentation. All variance requests shall indicate the additional excess spoil disposal area in excess of that required to achieve AOC. This additional area is the difference between the **Alternate ESDA Bank** and the **ESDA Bank** (AOC).

This procedure will provide the Secretary a quantifiable means of evaluating the impact of the alternate post-mining configuration versus the projected impacts if the site were returned to AOC by providing a specific additional acreage resulting from that variance request.

Any spoil disposal plan for which the **Alternate ESDA Bank** is greater than the **ESDA Bank (AOC)** shall not be considered optimized.

10. Permit Revisions and Amendments

10.1 Mine Plan Revisions

The optimization of the excess spoil disposal area, as defined in Section 5 and 7, for a particular permit remains valid only if the operation is in compliance with its approved mine plan.

The operator shall submit to the Secretary a semi-annual report certified by a Professional Engineer registered in West Virginia, that the operation is in compliance with its spoil handling plan and that the operation can maintain the excess spoil optimization plan as included in the permit.

The Secretary shall require a permit revision prior to the operator implementing any material changes in the mine operation and mine plan. The operator must justify in the semi-annual report why any changes are necessary. A material change is defined as any change that is greater than 5%. Changes include

- the volume of overburden generated
- the quantity of coal to be mined
- the spoil balance
- change the final regrade configuration so it does not comply with Section 9.1
- increase the **ESDV**
- move the toe of any valley fill downstream
- impact the approved excess spoil optimization plan

An operator who places spoil under a non-compliant spoil handling plan shall be deemed to be in serious violation of its permit. The Secretary shall deem this as significant imminent environmental harm to land and water resources and a cessation order shall be issued pursuant to 38 C.S.R. 2-20.3.a.1.

The permit revision shall include the following:

- A description of the proposed change to the mine plan
- A revised and updated material balance
- The status of each valley fill, particularly those completed or in progress
- An updated AOC Process
- A revised excess spoil optimization evaluation

If using the ESDA Bank method, the volume of spoil already placed in any valley fill must be addressed prior to completing the optimization process for any permit revision. This shall be done by determining the minimum configuration of each fill that can accommodate the volume of material already placed, then deducting the corresponding existing excess spoil disposal area from the calculated optimum before the remaining area is reallocated.

10.2 Permit Amendments to add Mineral extraction

Mineral removal area added to an existing permit affects the material balance and consequently will impact the excess spoil optimization plan.

Should the Secretary determine that the change to the spoil balance may have a significant effect on the spoil optimization plan, the permittee shall be required to include an updated excess spoil optimization plan. Significance is defined as increasing the **ESDV** by greater than 5%, or moving the toe of any valley fill downstream.

If significant the permit amendment application shall include the following:

- A revised and updated material balance for the entire permit area
- The status of each valley fill, particularly those completed or in progress
- An updated AOC model that incorporates the amended permit area
- A revised excess spoil optimization evaluation for the total permit area

If using the ESDA Bank method, the volume of spoil already placed in any valley fill must be addressed prior to completing the optimization process for the amendment. This shall be done by determining the minimum configuration of each fill that can accommodate the volume of material already placed, then deducting the corresponding existing excess spoil disposal area from the calculated optimum before the remaining area is reallocated.

10.3 Adjacent Permits or Permit Amendments

The objective of this section is to ensure that segmented permitting actions such as a "string of pearls" is not used to evade the intent of spoil optimization.

If an application for a permit by an operator is adjacent to or contiguous with another active permit or permits controlled or operated by that operator, then the Secretary shall consider the operation as a "total operation" if:

- Excess spoil disposal areas on the permit under consideration receive spoil from more than one permit, or
- The post mining contours at the boundary between the permits are different from the pre-mining contours. This means that if the regrade at the permit boundary continues between the two permits and is continuous and different from the pre-mining elevation
- The operation does not have total independent utility, including sediment control structures and access roads

If a permit is part of a "total operation" then the application shall meet the requirements of the AOC Model for the "total operation" including the new permit under consideration. The AOC Model shall consider the total volumes in the operation and shall either:

- Ensure that all fills meet the presumed criteria test, or
- Use the ESDA Bank analysis. In using the ESDA Bank any existing fills on the "total operation" shall be deducted from the ESDA Bank before reallocation of any residual ESDA.

Nothing in this section shall be construed to limit Off Site Disposal Areas (**OSDA**).

ENGINEERING PROCEDURE 2.1
STEEP SLOPE MINING: AOC and EXCESS SPOIL DETERMINATION

I. Introduction and Purpose:

This procedure applies to steep slope mining operations that remove all or a large portion of the coal seam or seams running through the upper fractions of a mountain and propose to return the site to AOC. Such operations include mountaintop removal mines with variances from AOC, contour mines, and mountaintop mines. Many variables, such as stability requirements, drainage requirements, and sediment control requirements, affect or determine the postmining surface configuration or shape of the land at a steep slope surface coal mining operation proposing to return the site to AOC. Incorporating compliance with these performance standards into the proposed permit application requires the applicant to carefully plan the mining and reclamation phases of the proposed surface coal mining operation. This process includes, among other requirements, plans showing: pre-mining contour maps; post-mining contour maps; cross-sections and profiles; spoil volume calculations; drainage structure designs; sediment control structure designs; access road designs (if justified); spoil placement sequences; and excess spoil determinations and calculations.

II. Policy and Procedure - Mountaintop AOC Mines:

Determining AOC Configuration:

Sufficiently detailed topographic maps, adequate numbers of cross-sections, or labeled 3-D model grids/graphics should be submitted that illustrate the representative pre-mine topography and slopes of the proposed permit area. Digital data should be submitted with the application in a format and on a media acceptable to the Knoxville Field Office (KFO).

After determining the premining configuration, the foundation for backfilling and grading is determined. The foundation is the bench that will be the starting point for placing spoil material in the mined out area to achieve AOC (see Figures 1 and 2).

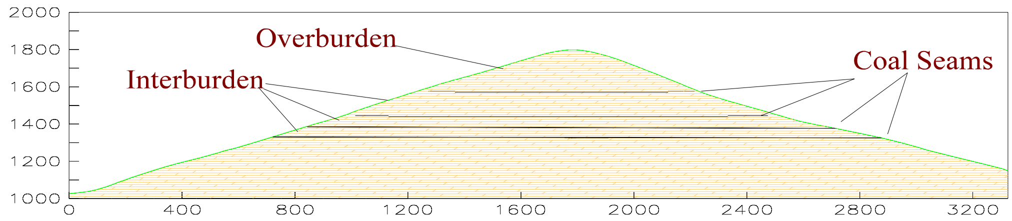


Figure 1. Pre-mining configuration

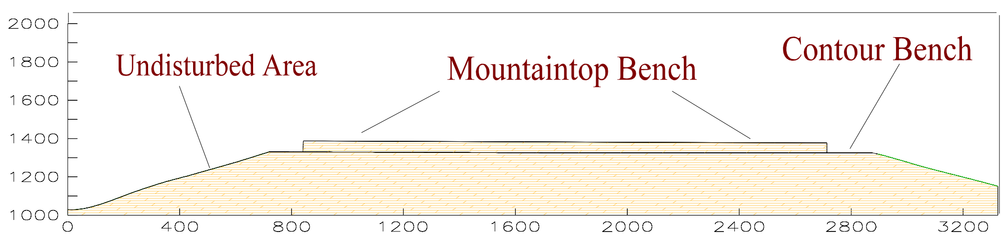


Figure 2. Foundation for backfilling and grading

From this starting point the configuration of the backfill is determined, allowing for stability requirements, drainage requirements, and sediment control requirements. Following is a discussion of how these requirements must be considered when determining the AOC configuration.

<u>Stability Requirements</u> - Spoil must be placed in the mined out area in a manner that will result in a 1.3 static safety factor.

Grading the backfill slopes (between the terraces) on a 2 horizontal to a 1 vertical ratio (2H:1V) and placing terraces, where appropriate, is a generally acceptable practice, unless it results in a safety factor of less than 1.3. Placing spoil on slopes steeper than 2H:1V is theoretically possible, but MSHA recommends that slopes not be greater (steeper) than 2H:1V, because that is the maximum safe slope for operation of tracked-equipment.

If the pre-mining slopes are less than 2H:1V (26.6°), the backfill slopes may be graded to match the pre-mining slope. In this case the backfill slopes must be at least as steep as the pre-mining slope unless the 1.3 factor of safety cannot be obtained. Steeper slopes are acceptable if stability is demonstrated.

The top of the backfill can be no wider than is necessary for safely negotiating the largest reclamation equipment utilized for the mine site. Areas larger than necessary to work this equipment would need to be approved by KFO.

Drainage Control Requirements - Drainage control may be allowed at the toe of the outslope. Erosion control measures may be incorporated by providing twenty feet wide terraces every fifty feet in vertical height. The size and location of these structures necessarily reduce backfill spoil volume because of the flat area required to properly construct effective structures and meet drainage requirements.

Sediment Control Requirements - As with drainage structures, the size and location of sediment structures dictate the amount of flat area that will displace backfill spoil storage. When reviewing the size and placement of these structures for adequacy in meeting effluent and drainage control requirements, KFO will also assess the design plans to assure the structures are no larger/wider than needed for proper design.

Access/Maintenance Roads - These structures are often necessary to gain access to sediment control structures and reclamation areas. The size and location of these roads or benches will vary throughout the minesite and should be based on documented need. If, for example, the road purpose is for cleaning sediment structures, it will be a different size than a road used for main terrace access. KFO will evaluate the necessity for roads in the final reclamation configuration and approve only those widths necessary. Typically, a twenty feet wide access road is acceptable.

Typical Backfill Configuration - The backfill slope, associated terraces, drainage conveyances, and access roads will determine the ultimate backfill height for the mined area.

This final elevation may be lower than the pre-mining elevation, approximate the pre-mining elevation, or exceed the pre-mining elevation. Applying these performance requirements in the mine planning process will determine the amount of total spoil material which must be retained in the mined out area. The resultant post-mining configuration should closely resemble the pre-mining topography, thus satisfying not only the access, drainage, sediment, and stability performance standards of SMCRA, but AOC as well. (see Figure 3).

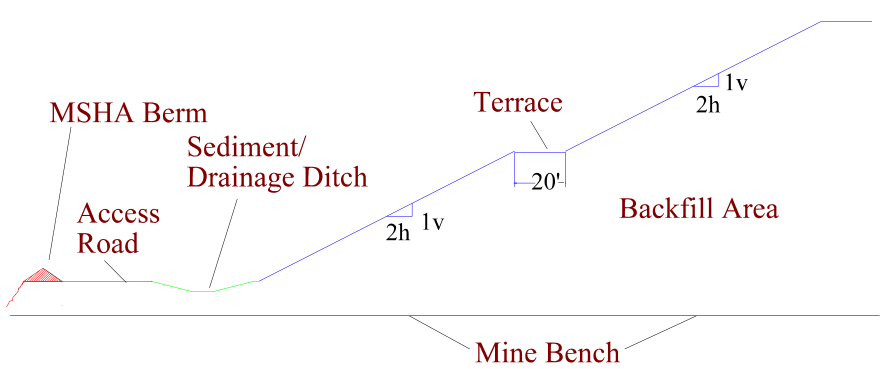


Figure 3. Typical backfill outslope configuration

As can be seen in Figure 4, this reclamation technique results in a configuration or shape that closely resembles the pre-mining configuration.

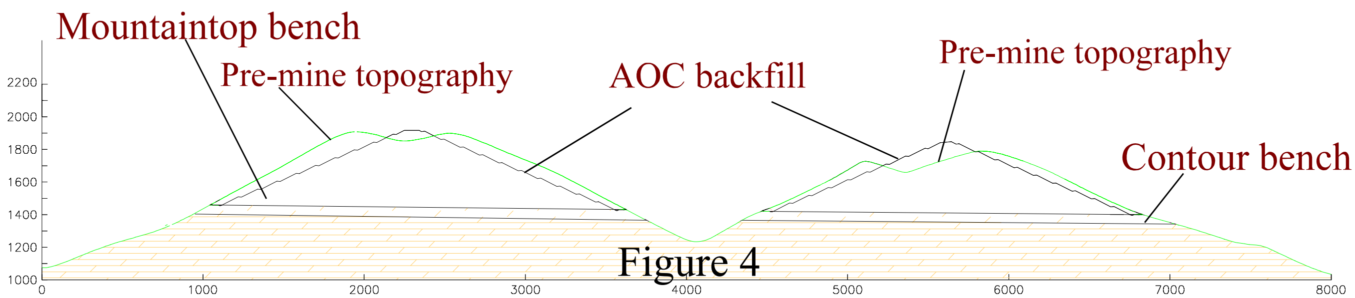


Figure 4

<u>Determining Spoil Volumes</u>:

Total Spoil Material:

Total spoil material is all overburden handled as a result of the proposed mining operation. The applicant must place total spoil material either in the mined area or in excess spoil disposal sites (valley fills or pre-existing benches). Total spoil material is determined by combining the overburden (**OB**) volume over the uppermost coal seam to be excavated with the interburden (**IB**) volumes between the remaining lower coal seams. This value is typically expressed as bank cubic yards (bcy).

Total spoil material volumes are determined by using standard engineering practices, such as average-end area, stage-volume calculations, or 3-dimensional (3-D) grid subtraction methods. KFO must have adequate information from the applicant to properly evaluate spoil volume calculations. If the applicant utilizes an average-end area method, cross-sections must be provided for a base line or lines, at intervals no less than every 500 feet, or more frequently, if the shape of the pre-mined area is highly variable between the 500-foot intervals. If the applicant utilizes a stage-storage method, planimetered areas must be provided on a contour interval that is representative and reflects any significant changes in slope (20' or less contour interval recommended). If a 3-D model is used, the applicant should provide a pre-mining contour map and, if possible, a 3-D model graphic. The applicant should identify the grid node spacings used in generating volumetrics. If the applicant utilizes digital data, it should be in a format and on a media acceptable to KFO.

Total spoil volume **(TSV)** is determined by calculating the in-situ overburden and interburden volume, multiplied by a “bulking” factor **(BF)**. Bulking factors are calculated by a two-step process: 1) “swell” volume is determined from the amount of expected expansion of in-situ material through the incorporation of air-filled void spaces; 2) “shrink” volume is calculated from the amount the swelled material compacts during placement (reducing the void spaces and, consequently, the volume). Thus, the bulking factor is the swell factor minus the shrink factor, which varies, based on the overburden lithology (e.g., sandstone swells more and shrinks less than shales). Total spoil volume is reported in cubic yards (cy), in the following equation form:

(OB + IB) x BF = TSV.

For example, if the in-situ volume of overburden material is 300,000 bcy, the interburden volume is 700,000 bcy, and the weighted bulking factor is 125%, TSV would be determined as follows:

(OB + IB) x BF = TSV
(300,000 bcy + 700,000 bcy) x 1.25 = 1,250,000 cy

Spoil Volume Required to Achieve AOC:

The applicant calculates the volume of spoil material required to be returned to the mined out area based on the configuration of the reclaimed area as determined by considerations for stability, drainage control, sediment control and access. These volumes are expressed as bulked volumes.

Excess Spoil Volume:

Spoil material unable to be placed in backfill area is excess spoil, and must be placed in an approved excess spoil disposal site(s) (see Figure 5). The excess spoil quantity is obtained by determining the difference in the total spoil volume and the volume required to backfill the mined area to AOC.
KFO will carefully evaluate the spoil balance information provided in the permit application to assure that excess spoil volumes are accurate. Permits that propose to conduct mountaintop mining operations, but change plans due to unanticipated field conditions, should submit permit revisions containing revised volumetric calculations and excess spoil designs.

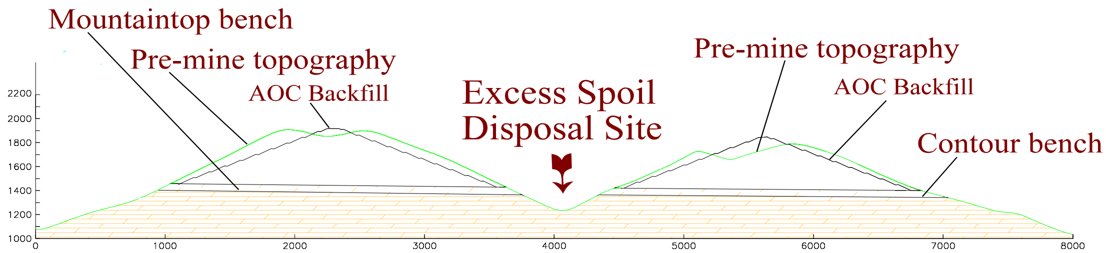


Figure 5. Potential excess spoil disposal site

Excess Spoil Disposal Sites:

Generally the volume of excess spoil, and/or mining logistics, requires more than one excess spoil disposal site. Typically, in steep-slope regions of Appalachia, excess spoil is placed in adjacent valleys. In areas where extensive “pre-law” mining has occurred, pre-existing benches are also used. Performance standards for excess spoil disposal areas are found in 30 CFR 816.71-816.73 and in 30 CFR 816.74 for pre-existing benches.

The most common site selected to place excess spoil is in the adjacent valleys. The permit application should contain the stage-storage-volume calculation for the valley capacity for excess spoil storage dependent on toe location and crest (top) elevation.

If the applicant utilizes pre-existing benches as excess spoil disposal sites, he/she must calculate the capacity of each pre-existing bench area. Typically these calculations utilize the average-end area method, based on cross-sections representing the site configuration.

The applicant must design excess spoil fills in order to attain a long-term static safety factor of 1.5 and, if a durable rock fill, an earthquake static safety factor of 1.1. The applicant may propose to construct terraces on the outslopes, where appropriate or required. The grade of the outslopes, between the terraces, may not exceed 2H:1V. Additionally, where the natural slope in the disposal area exceeds 36 percent, or such lesser slope as designated by the regulatory authority, the applicant shall construct keyway cuts or rock toe buttresses to ensure stability of the fill.

Determining the location of the toe of the fill requires the available backfill and excess spoil material to balance. After this material balance is achieved, the applicant designs the excess spoil disposal areas to accommodate this quantity of excess spoil. If the excess spoil disposal site is a valley fill, this design will determine the height or elevation of the crest of the excess spoil disposal site or fill. If the top of the fill elevation is above the elevation of the lowest coal seam mined, as illustrated in Figure 6, then the applicant must reconsider the AOC or backfill configuration.

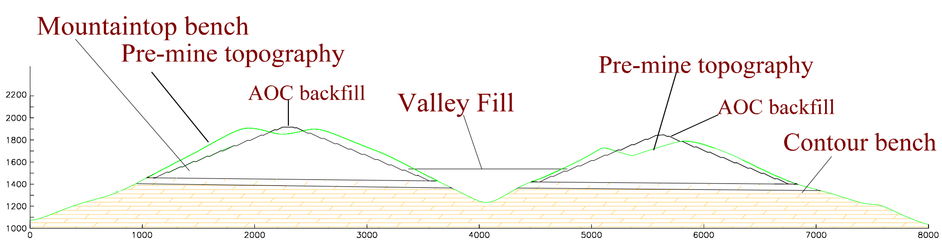


Figure 6. Sizing valley fills by material balance

At this point the applicant must make a second determination of AOC to establish the final reclamation configuration. Before performing a new AOC determination, the applicant will determine the interface between the backfill area and the excess spoil disposal area:

- Locate the outcrop of the lowest seam being mined
- Project a vertical line upward beyond the crest of the fill as shown in Figure 7.

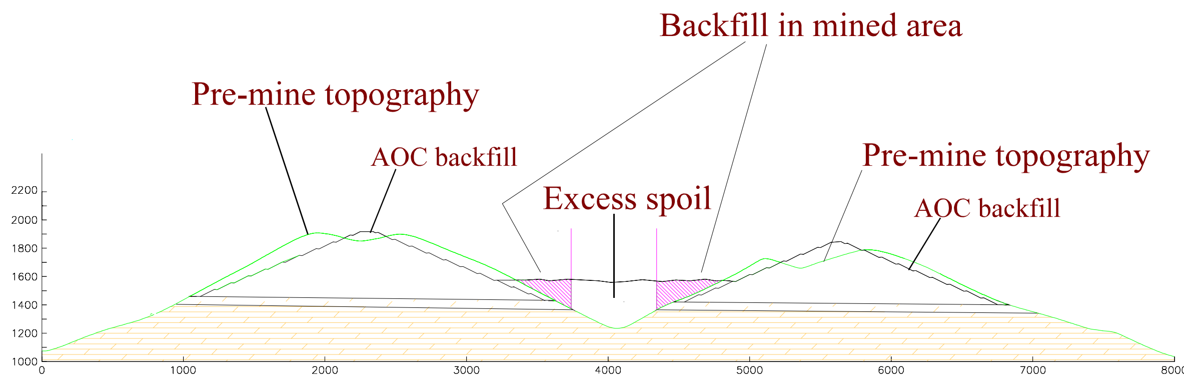


Figure 7. Distinguishing backfill and excess spoil areas

The additional material placed on the mined area as a result of this process creates the need to perform another material balance exercise. This rebalancing of material may result in a reduction of excess spoil volume. Reevaluation of fill designs, using this second iteration, becomes an important component of the permit design. Reduction in fill lengths may result in the toe of the fill being placed upon too steep of a slope requiring additional material excavation for a keyway cut, or additional material placement for stabilizing the toe buttress. The point on the crest of the fill becomes a reference line to perform the second AOC determination. Figure 8 demonstrates the second AOC determination and Figure 9 shows the final configuration.

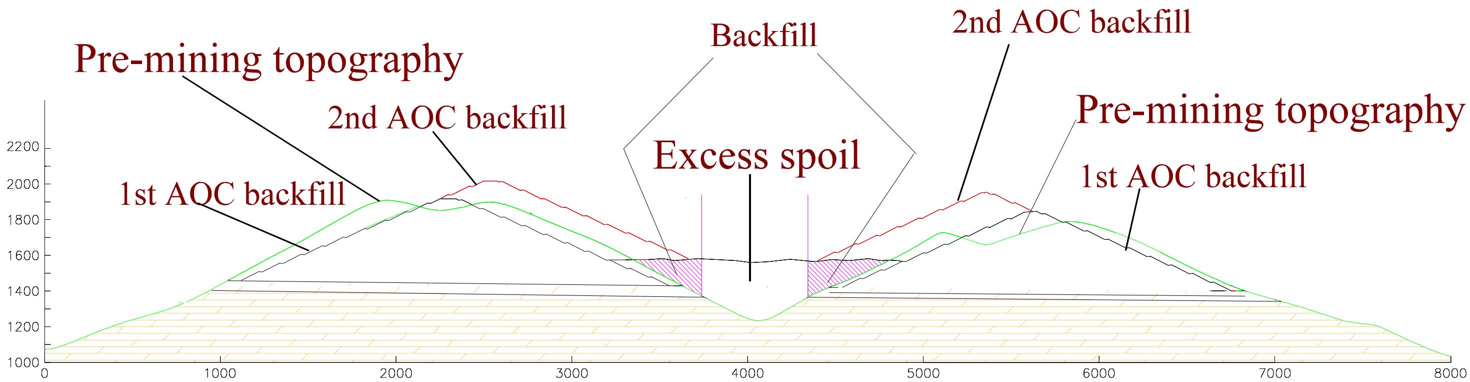


Figure 8. Second iteration-placement of additional spoil material within the mined area

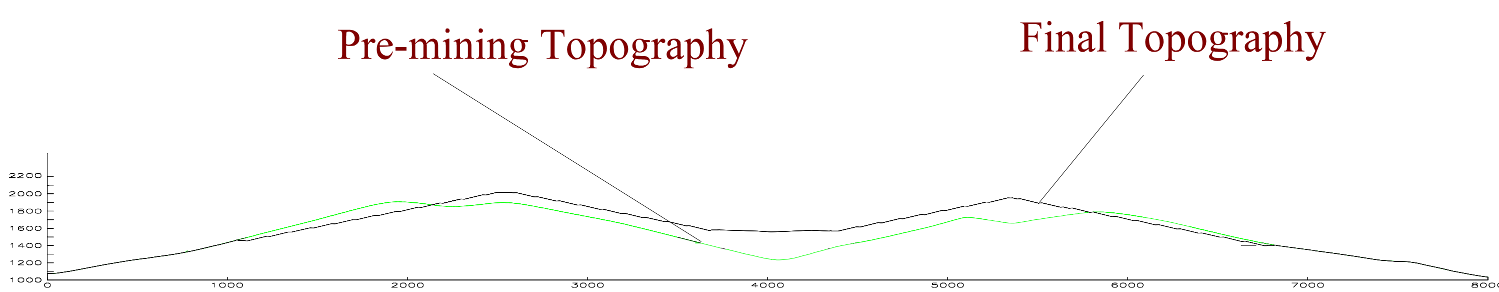


Figure 9. Configuration after AOC process

III. Policy and Procedure -Contour Mining Operations:

The AOC/excess spoil determination, described earlier, is used to determine AOC and excess spoil volumes for contour surface mining operation as well.

A contour mine typically takes one (1) contour "cut" and progresses around the coal outcrop, leaving a highwall and bench after the coal is removed. In reclaiming the site to AOC, documentation is required showing drainage structure designs, access road requirements, and properly designed sediment structures. A generally acceptable practice, unless it results in a static safety factor of less than 1.3, includes grading the backfill slopes (between terraces) on a 2H:1V slope as shown in Figure 3. However, in all cases, the highwall must be eliminated. If compliance with the other performance standards, i.e., drainage, access, and sediment control, result in backfill out-slopes being steeper than 2H:1V, the application should contain adequate documentation that the backfill configuration meets a 1.3 static safety factor. Documentation is not required where slopes flatter than 2H:1V are proposed.

Whenever contour mining operations encounter long, narrow ridges or points (see Figure 10), the same principles and performance standards apply, i.e. stability, drainage, sediment control, and access requirements.

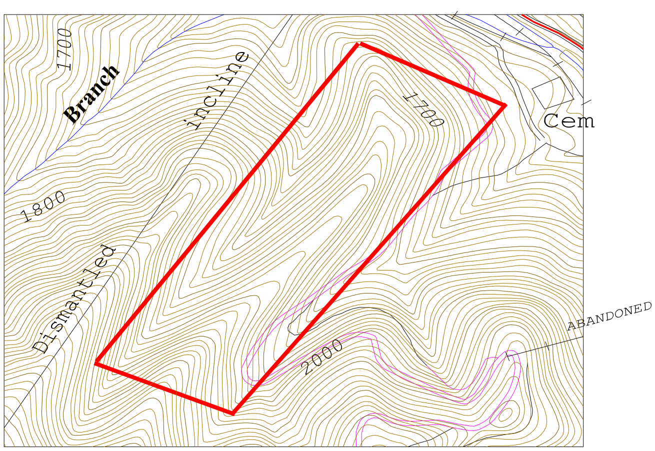
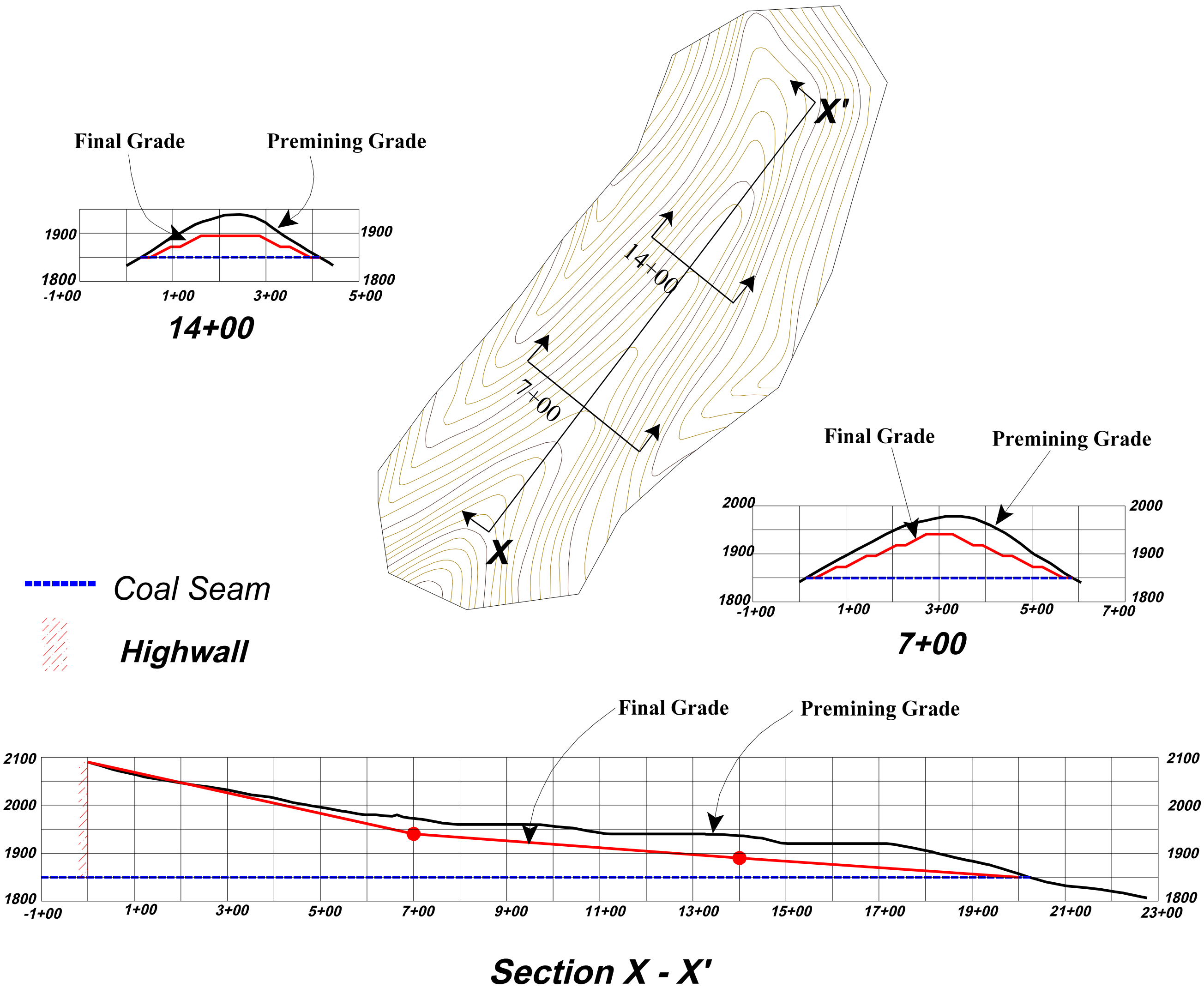


Figure 10

In order to determine the AOC configuration for a finger ridge mining operation, the applicant must utilize orthogonal cross sections (see Figure 11). A single longitudinal cross section running down the ridge line and perpendicular to the highwall is not adequate. Additional cross sections perpendicular to the longitudinal cross section are also required to determine the final backfill configuration. Often returning these sections to 2H:1V dictates the AOC configuration and establishes the longitudinal profile (see Figure 11). The applicant must completely eliminate the highwall.


Final Grade
Premining Grade
1900
1900
1800
1800
-1+00
1+00
3+00
5+00
14+00
X'
14+00
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X
Final Grade
Premining Grade
2000
2000
1900
1900
1800
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-1+00
1+00
3+00
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Coal Seam
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2100
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-1+00
1+00
3+00
5+00
7+00
9+00
11+00
13+00
15+00
17+00
19+00
21+00
23+00
Section X - X'

Figure 11

IV. **Policy and Procedure - Mining Operations with AOC Variances:**

The determination of backfill and excess spoil volumes for mining operations proposing variances from AOC are performed in essentially the same manner as described in Section III . The difference in these calculations for AOC variances is that a certain volume of spoil material becomes excess due to regrading to flat or gently rolling terrain in the process of attaining the approved post-mining land use (PMLU). For instance, an AOC variance for an industrial area would require only that amount of backfilling in the mined area necessary for drainage controls or buried utilities for water and sewer lines. The mining plan would show the post-mining configuration necessary to achieve a landform with appropriate infrastructure and site conditions supporting the PMLU (see Figures 12 and 13).

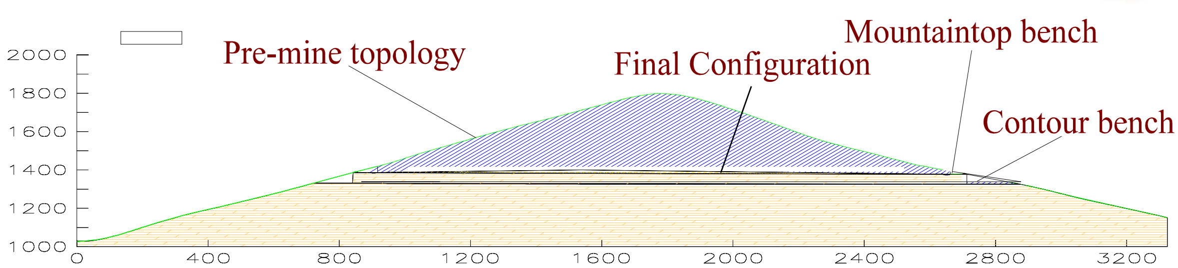

Figure 12. AOC Variance--potential industrial example

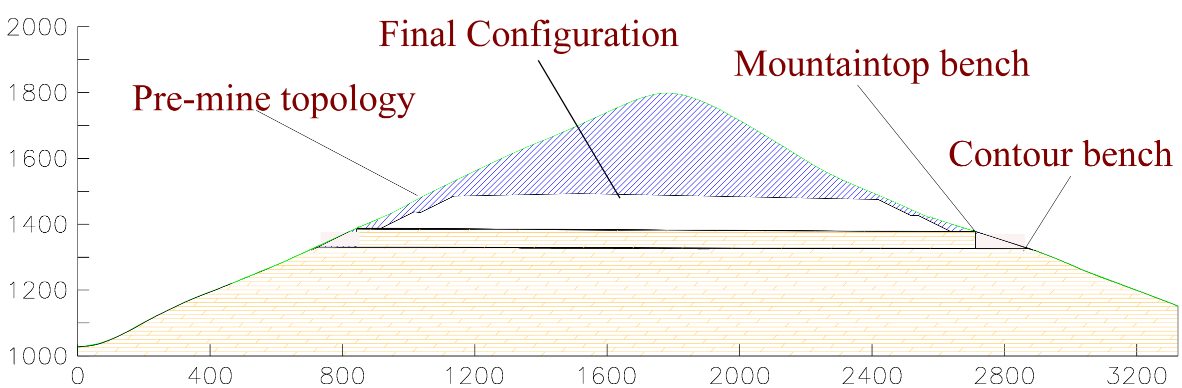

Figure 13. Other potential AOC variance configurations

KFO will carefully review the AOC variance plan to assure that excess spoil volumes do not exceed the necessary amount required for the designated PMLU in order to minimize stream and terrestrial habitat degradation. AOC reclamation variance proposals must also conform with the need, feasibility, financial assurance, and other demonstrations required by SMCRA Section 515(c)(3) and (e).

V. Related Procedures

- Slope Stability and Regulations Analysis Requirements - Engineering Procedure 8.1
- Excess Spoil - Engineering Procedure 3.0
- MSHA Regulations

APPENDIX K

FLOODING ANALYSIS GUIDELINES

Summary of Changes to Surface Mining Reclamation (38-2) Rule
March 7, 2003

Changed U. S. Soil Conservation Service to U. S. Natural Resources Conservation Service and removed reference to Handbook throughout rules.

Page 22 – Insert New -3.7.d. A survey of the watershed identifying all man made structures and residents in proximity to the disposal area to determine potential storm runoff impacts. At least thirty (30) days prior to any beginning of placement of material, the accuracy of the survey shall be field verified. Any changes shall be documented and brought to the attention of the Secretary to determine if there is a need to revise the permit.

Page 34 - 3.22.f.5.A. The plan shall contain a description of the measures, which will be taken to replace water supplies that are contaminated, diminished, or interrupted to include:

Page 34 - 3.22.f.5.A.1. Identification of the water replacement, which includes quantity and quality descriptions including discharge rates, or usage and depth to water;

Page 34 - 3.22.f.5.A.2. Documentation that the development of identified water replacement is feasible and that the financial resources necessary to replace the affected water supply are available; and

Page 44 - 3.31.a. To qualify as a Federal, State, County, Municipal or other local government-financed highway or other construction project, the construction must be funded fifty percent (50%) or more by the relevant government agency. Funding at less than fifty percent (50%) may qualify if the construction is undertaken as an approved government reclamation contract, ~~and once~~ Once the exemption is granted, the person doing the construction must have on site available for inspection, the following:

Page 57- 58 - 5.4.b.4. Have the capacity to store 0.125 Acre/ft. of sediment for each acre of disturbed area in the structures watershed; provided, that consideration may be given for reduced storage volume where the preplan and site conditions reflect controlled placement, concurrent reclamation practices, or use of sediment control structures; provided further, that reduced storage volume will be approved only where the operator demonstrates that the effluent limitations of subdivision 14.5.b of this rule will be met. The disturbed area for which the structure is to be designed will include all land affected by previous surface mining operations that are not presently stabilized and all land that will be disturbed throughout the life of the permit. All sediment control systems for valley fills, including durable rock fills, shall be designed for the entire disturbed acreage of the fill and shall include a schedule indicating timing and sequence of construction over the life of the fill.

Page 58 - 5.4.b.11. Control discharge by use of energy dissipaters, riprap channels or other devices to reduce erosion, to prevent deepening or enlargement of stream channels and to minimize disturbance of the hydrologic balance. Discharge structures shall be designed using standard engineering procedures. The location of discharge points and the volume to be released shall not cause a net increase in peak runoff from the proposed permit area when compared to pre-mining conditions and shall be compatible with the post-mining configuration and adequately address watershed transfer**.**

Page 62 – Insert New -5.6 Storm Water Runoff

5.6.a. Each application for a permit shall contain a storm water runoff analysis which includes the following:

5.6.a.1. An analysis showing the changes in storm runoff caused by the proposed operation(s) using standard engineering and hydrologic practices and assumptions.

5.6.a.2. The analysis will evaluate pre-mining, worst case during mining, and post-mining (Phase III standards) conditions. The storm used for the analysis will be the largest required design storm for any sediment control or other water retention structure proposed in the application. The analysis must take into account all allowable operational clearing and grubbing activities. The applicant will establish evaluation points on a case-by case basis depending on site specific conditions including, but not limited to, type of operation and proximity of man-made structures.

5.6.a.3. The worst case during mining and post-mining evaluations must show no net increase in peak runoff compared to the pre-mining evaluation.

5.6.b. Each application for a permit shall contain a runoff-monitoring plan which shall include, but is not limited to, the installation and maintenance of rain gauges. The plan shall be specific to local conditions. All operations must record daily precipitation and report monitoring results on a monthly basis and any one (1) year, twenty-four (24) storm event or greater must be reported to the Secretary within twenty-four (24) hours and shall include the results of a permit wide drainage system inspection.

5.6.c. Each application for a permit shall contain a sediment retention plan to minimize downstream sediment deposition within the watershed resulting from precipitation events. Sediment retention plans may include, but are not limited to decant ponds, secondary control structures, increased frequency for cleaning out sediment control structures, or other methods approved by the Secretary**.**

5.6.d. After the first day of January two thousand four, all active mining operations must be consistent with the requirements of this subdivision. The permittee must demonstrate in writing that the operation is in compliance or a revision shall be prepared and submitted to the Secretary for approval within the schedule described in 5.6.d.1. Full compliance with the permit revision shall be accomplished within 180 days from the date of Secretary approval. Active mining operations for the purpose of this subsection exclude permits that have obtained at least a Phase I release and are vegetated. Provided, however, permits or portions of permits that meet at least Phase I standards and are vegetated will be considered on a case by case basis.

5.6.d.1. Schedule of Submittal.

5.6.d.1.a Within 180 days from the first day of January two thousand four all active mining operations with permitted acreage greater than 400 acres must demonstrate in writing that the operation is in compliance or a revision shall be prepared and submitted to the Secretary for approval.

5.6.d.1.b Within 360 days from the first day of January two thousand four all active mining operations with permitted acreage between 200 and 400 acres must demonstrate in writing that the operation is in compliance or a revision shall be prepared and submitted to the Secretary for approval.

5.6.d.1.c. Within 540 days from the first day of January two thousand four all active mining operations with permitted acreage between 100 and less than 200 acres must demonstrate in writing that the operation is in compliance or a revision shall be prepared and submitted to the Secretary for approval.

5.6.d.1.d. Within 720 days from the first day of January two thousand four all active mining operations with permitted acreage between 50 and less than 100 acres must demonstrate in writing that the operation is in compliance or a revision shall be prepared and submitted to the Secretary for approval.

5.6.d.1.e. Within 900 days from the first day of January two thousand four all active mining operations with permitted acreage less than 50 acres must demonstrate in writing that the operation is in compliance or a revision shall be prepared and submitted to the Secretary for approval. Provided, however, an exemption may be considered on a case by case basis. Furthermore, haulroads, loadouts, and ventilation facilities are excluded from this requirement.

Page 97 - 8.2.e. In order to promote the enhancement of food, shelter and habitat for wildlife, the practice of creating a timber windrow is encouraged. All unmarketable timber may be used to create a windrow within the permitted area as approved by the Secretary in the mining and reclamation plan. The windrow shall be designed and approved as part of a wildlife planting plan and authorized where the postmining land use includes wildlife habitat. In planning and constructing the windrow, care shall be taken not to impound water or and shall not be placed in such manner or location to block natural drainways. The windrow shall be placed in a uniform and workmanlike parallel line and located so as to improve habitat, food and shelter for wildlife. Areas in and around the windrow shall be seeded after construction with approved, native plant species to provide for erosion control and wildlife enhancement. Construction of the wildlife timber windrow shall take place within the permit area and should be placed immediately below or adjacent to the sediment control system, maintaining a sufficient distance to prevent mixing of spoil material with the selectively placed timber. The placement of spoil material, debris, abandoned equipment, root balls and other undesirable material in the windrow are prohibited.

Summary of Changes to Surface Mining Reclamation (38-2) Rule
March 7, 2003

Page 97- 9.1.a. Each surface mine operator shall establish on all regraded areas and all other disturbed areas a diverse, effective and permanent vegetative cover of the same seasonal variety native to the area of disturbed land, or introduced species that are compatible with the approved postmining land use. Reforestation opportunities must be maximized for all areas not directly associated with the primary approved post mining land use. All revegetation plans must include a map identifying areas to be reforested, planting schedule and stocking rates.

Page 99 - 9.3.d. *second sentence* In evaluating vegetative success, the Secretary shall use a statistically valid sampling technique with a ninety (90) percent statistical confidence interval ~~from the Handbook~~ ~~from the Handbook~~.

Page 100 - 9.3.f. Where the post mining land use requires legumes and perennial grasses, the operator shall achieve at least a ninety (90) percent ground cover and a productivity level as set for ~~in the Handbook~~~~in the Handbook~~ by the Secretary during any two years of the responsibility period except for the first year.

Page 148 - 14.5.h. Added to the end of the first sentence Provided, however, the requirement for replacement of an affected water supply that is needed for the land use in existence at the time of contamination, diminution or interruption or where the affected water supply is necessary to achieve the post-mining land use shall not be waived.

Page 160 - 14.14.g. Durable Rock Fills.

14.14.g.1. Fills proposed after January 1, 2004, the ~~The~~ Secretary may only approve the design, construction, and use of a single lift fill with an erosion protection zone or a durable rock fill designed to be reclaimed from the toe upward, both consisting of at least eighty (80) percent durable rock if it can be determined, based on information provided by the operator, that the following conditions exist:

14.14.g.1.A. Examination of core borings and the geologic column show that the overburden consists of durable sandstone, limestone, or other durable material in sufficient thickness and amounts to generate spoil material that is eighty (80) percent or greater durable rock. Where the fill will contain non-cemented clay shale, clay spoil, or other nondurable material, such material must be mixed with the durable rock in a controlled manner such that no more than twenty (20) percent of the fill volume is not durable rock. Tests shall be performed by a Registered Professional Engineer and approved by the Secretary to demonstrate that no more than twenty (20) percent of the fill volume is not durable rock.

14.14.g.1.B. The durable rock shall not consist of acid-producing or toxic-forming material, will not slake in water, and will not degrade to soil material. For purposes of this paragraph only, soil material means material of which at least fifty (50) percent is finer than 0.074 mm, which exhibits plasticity, and which meets the criteria for group symbol ML, CL, OL, MH, CH, or OH, as determined by the Unified Soil Classification System (ASTM D-2487).

14.14.g.1.C. The toe of the fill will rest on natural slopes no steeper than twenty (20) percent.

14.14.g.2. Design Specifications and Requirements of Single Lift Fills with an Erosion Protection Zone. In addition to the requirements of this subdivision, the design, specifications and requirements of single lift fills with an erosion protection zone shall be in accordance with the following:

14.14.g.2.A. Erosion Protection Zone.
The erosion protection zone is a designed structure constructed to provide energy dissipation to minimize erosion vulnerability and may extend beyond the designed toe of the fill.

14.14.g.2.A.1. The effective length of the erosion protection zone shall be at least one half the height of the fill measured to the target fill elevation or fill design elevation as defined in the approximate original contour procedures and shall be designed to provide a continuous underdrain extension from the fill through and beneath the erosion protection zone.

14.14.g.2.A.2. The height of the erosion protection zone shall be sufficient to accommodate designed flow from the underdrain of the fill and shall comply with 14.14.e.1. of this rule.

14.14.g.2.A.3. The erosion protection zone shall be constructed of durable rock as defined in 14.14.g.1. originating from a permit area and shall be of sufficient gradation to satisfy the underdrain function of the fill.

14.14.g.2.A.4. The outer slope or face of the erosion protection zone shall be no steeper than two (2) horizontal or one (1) vertical (2:1). The top of the erosion protection zone shall slope toward the fill at a three (3) to five (5) percent grade and slope laterally from the center toward the sides at one (1) percent grade to discharge channels capable of passing the peak runoff of a one-hundred (100) year, twenty-four (24) hour precipitation event.

14.14.g.2.A.5. Prior to commencement of single lift construction of the durable rock fill, the erosion protection zone must be seeded and certified by a registered professional engineer as a critical phase of fill construction. The erosion protection zone shall be maintained until completion of reclamation of the fill.

14.14.g.2.A.6. Unless otherwise approved in the reclamation plan, the erosion protection zone shall be removed and the area upon which it was located shall be regraded and revegetated in accordance with the reclamation plan.

14.14.g.2.B. Single Lift Construction Requirements.

14.14.g.2.B.1 Excess spoil disposal shall commence at the head of the hollow and proceed downstream to the final toe. Unless required for construction of the underdrain, there shall be no material placed in the fill from the sides of the valley more than 300 feet ahead of the advancing toe. Exceptions from side placement of material limits may be approved by the Secretary if requested and the applicant can demonstrate through sound engineering that it is necessary to facilitate access to isolated coal seams, the head of the hollow or otherwise facilitates fill stability, erosion, or drainage control.

14.14.g.2.B.2. During construction, the fill shall be designed and maintained in such a manner as to prevent water from discharging over the face of the fill.

14.14.g.2.B.2.(a) The top of the fill shall be configured to prevent water from discharging over the face of the fill and to direct water to the sides of the fill.

14.14.g.2.B.2.(b) Water discharging along the edges of the fill shall be conveyed in such a manner to minimize erosion along the edges of the fill.

14.14.g.2.B.3. Reclamation of the fill shall be initiated from the top of the fill and progress to the toe with concurrent construction of terraces and permanent drainage.

14.14.g.3. Design Specifications and Requirements for Durable Rock Fills designed to be reclaimed from the toe upward. Durable rock fills that are designed to be reclaimed from the toe upward shall comply with all requirements of this subdivision including the following:

14.14.g.3.A. Transportation of Material to toe of fill. The method of transporting material to the toe of the fill shall be specified in the application and shall include a plan for inclement weather dumping. The means of transporting material to the toe may be by any method authorized by the Act and this rule and is not limited to the use of roads.

14.14.g.3.A.1. Constructed roads shall be graded and sloped in such a manner that water does not discharge over the face. Sumps shall be constructed along the road in switchback areas and shall be located at least 15 feet from the outslope.

14.14.g.3.A.2. The constructed road shall be in compliance with all applicable State and Federal safety requirements. The design criteria to comply with all applicable State and Federal safety requirements shall be included the permit.

14.14.g.3.B. Once the necessary volume of material has been transported to the toe of the fill, face construction and installation of terraces and permanent drainage shall commence. The face construction and reclamation of the fill shall be from the bottom up with progressive construction of terraces and permanent drainage in dumping increments not to exceed 100 feet.

Old 14.14.g.2. becomes 14.14.g.4 and the rest of the 14.14.g. is renumbered accordingly.

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Page 163 - 14.15.a.2. All permit applications shall incorporate into the required mining and reclamation plan a detailed site specific description of the timing, sequence, and areal extent of each progressive phase of the mining and reclamation operation which reflects how the mining operations and the reclamation operations will be coordinated so as to minimize the amount of disturbed, unreclaimed area, minimize surface water runoff, comply with the storm water runoff plan and to quickly establish and maintain a specified ratio of disturbed versus reclaimed area throughout the life of the operation.

Page 165 - 14.15.c. Reclaimed Area. For purposes of this subsection, reclaimed acreage shall be that portion of the permit area which has at a minimum been fully regraded and stabilized in accordance with the reclamation plan, ~~and~~ meets Phase I standards and seeding has occurred.

Page 167 - 14.15.g. Variance – Permit Applications. The Secretary may grant approval of a mining and reclamation plan for a permit which seeks a variance to one or more of the standards set forth in this subsection, if on the basis of site specific conditions and sound scientific and/or engineering data, the applicant can demonstrate that compliance with one or more of these standards is not technologically or economically feasible and demonstrate that the variance being sought will comply with section 5.6 of this rule. The Secretary shall make written findings in accordance with the applicable provisions of section 3.32 of this rule when granting or denying a request for variance under this section.

Page 173 - 17.1. *Paragraph 2 inserted* The Secretary shall establish a formula for allocating funds to provide services for eligible small operators if available funds are less than those required to provide the services pursuant to this section.

Page 189 - 20.6.a. Assessments. ~~Assessment Officer Duties. For the purposed of this section, the assessment officer~~ The Secretary shall not determine the proposed penalty assessment until such time ~~as the Secretary has caused~~ an inspection of the violation ~~to be~~ has been conducted and the findings of that inspection are submitted to the ~~assessment officer~~ Secretary in writing. The Secretary must conduct the inspection of the violation within the first fifteen (15) days after the notice or order was served.

~~The assessment officer may continue conferences, conduct investigations, and interview witnesses as necessary.~~

Page 190 - 20.6.c. ~~The Secretary shall also give notice including any worksheet, in person or by certified mail, to the operator of any penalty adjustment as a result of an informal conference within thirty (30) days following the date of the conference. The reasons for reassessment shall be documented in the file by the assessment officer.~~ The reason for reassessment shall be documented in the file by the Secretary. (added before the last sentence)

Page 190 - 20.6.d. Notice of Informal Assessment Conference. The Secretary shall arrange for a conference to review the proposed assessment or reassessment, upon written request of the person to whom the notice or order was issued, if the request is received within fifteen (15) days from the date the proposed assessment or reassessment is received. Provided, however, the operator shall forward the amount of proposed penalty assessment to the Secretary for placement in an interest bearing escrow account. The Secretary shall assign an assessment officer to hold the assessment conference. The time and place of an informal assessment conference shall be posted at the nearest Department of Environmental Protection regional office to the operation, at least five days prior to the conference date. Any person shall have the right to attend and participate in the conference. Any person, other than the operator and Department of Environmental Protection representatives, may submit in writing at the time of the conference a request to present evidence concerning the violation(s) being conferenced. Such request shall be granted by the assessment officer. Should problems arise due to scheduling, the assessment officer may continue the conference to a later time and/or date as the assessment officer deems necessary to honor other scheduled conferences.

Page 190 - 20.6.e. Informal Conference. An informal conference on the assessment or reassessment must be scheduled within 60 days of the receipt of a request, pursuant to paragraph (1) subsection (d) of section 17, of the Act. Failure to hold an informal conference in the time limits specified in this subsection will not be considered as grounds for dismissal of the assessment, unless the operator proves actual prejudice and makes timely objection to the delay. The assessment officer shall consider all relevant information on the violation including information which may be provided pursuant to subdivisions 20.6.b and 20.6.d of this subsection. The assessment officer shall also give notice including any worksheet, in person or by certified mail, to the operator of any penalty adjustment as a result of an informal conference within thirty (30) days following the date of the conference. The reasons for the assessment officer's action shall be documented in the file. Within thirty (30) days after the conference is held the assessment officer shall either:

Page 191 - 20.6.f. An increase or reduction of a proposed civil penalty of more than 25 percent and more than $500.00 shall not be final and binding until approved by the Secretary.

Remainder of subsection renumbered accordingly.

Page 191 - 20.6.~~i~~j. Escrow. If a person requests an informal conference or judicial review of a proposed assessment, the proposed penalty assessment shall ~~continue to~~ be held in escrow until completion of the conference or judicial review.

Page 201 - 22.4.g.3.A. An impoundment designed without discharge structures shall be capable of storing a minimum of two (2) six (6) hour duration probable maximum storms. A system shall be designed to dewater the impoundment of the probable maximum storm in ten (10) days by pumping or by other means. The requirements of 38-4-25.14 shall also be met. ~~Water shall be removed from the impoundment to its lowest practical level within ten (10) days after the storm event by pumping or by other means if storm water reduces the storage capacity to one probable~~

~~maximum storm or less.~~ For existing structures exceeding the minimum 2 PMP volume requirement, the dewatering system shall be installed when the containment volume is reduced to 2 PMPs.

Page 202 - 22.4.i.6. Use of Corrugated Metal Pipes -Corrugated metal pipes, whether coated or uncoated, shall not be used in new or unconstructed refuse impoundments or slurry cells . If an existing corrugated metal pipe has developed leaks or otherwise deteriorated so as to cause the pipe to not function properly and such deterioration constitutes a hazard to the proper operation of the impoundment, the Secretary will require the corrugated metal pipe to be either repaired or replaced.

Remainder of subsection renumbered accordingly

Page 210 - 24.3. Water Quality. A coal remining operation which began after February 4, 1987, and on a site which was mined prior to August 3, 1977, may qualify for the water quality exemptions set forth in subsection (p), section 301 of the Federal Clean Water Act, as amended or a coal remining operation as defined in 40 CFR Part 434 as amended may qualify for the water quality exemptions set forth in 40 CFR Part 434 as amended .

Page 210 - 24.4.Requirements to Release Bonds. Bond release for remining operations shall be in accordance with all of the requirements set forth in subsection 12.2 of this rule and the terms and conditions set forth in the NPDES Permit in accordance with subsection (p), section 301 of the Federal Clean Water Act, as amended or 40 CFR Part 434 as amended. Provided that there is no evidence of a premature vegetation release.

JAMES E. BICKFORD
SECRETARY

PAUL E. PATTON
GOVERNOR

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR SURFACE MINING RECLAMATION & ENFORCEMENT
FRANKFORT, KENTUCKY 40601
CARL E. CAMPBELL
COMMISSIONER

January 25, 2000

Mr. William J. Kovacic, Field Office Director
Office of Surface Mining
2675 Regency Road
Lexington, Kentucky 40503-2922

Dear Mr. Kovacic:

Enclosed is the Final Report of the Joint OSM Special Study on Drainage Control. This report concludes the Special Study that was initiated by the 1996 Performance Agreement Although the report does not find any major programmatic issues with drainage control structures in Kentucky, we have taken steps to improve the modeling of drainage areas above drainage control structures as well as improve inspection processes to ensure drainage areas are in conformance with the approved permit.

Thank you for the participation of your staff in the conduct of the study as well as their assistance in the compilation of the Final Report. If you or your staff have any questions, please contact me or Mark Thompson.

Sincerely,

Carl E. Campbell

Carl E. Campbell
Commissioner

CEC/mwt/chs

C: Mark Thompson
Jeff Taylor
Keith Smith
Fred Craig

Enclosure

EDUCATION PAYS

JOINT OSM-DSMRE SPECIAL STUDY

REPORT ON DRAINAGE CONTROL

FINAL REPORT

DECEMBER, 1999

FINDINGS

The joint OSM-DSMRE Drainage Control Study Team (DCST) conducted investigations into 10 mine sites that were alleged, via citizen's complaints, to have caused or significantly contributed to downstream flooding and/or flood related adverse impacts to citizens, property or the environment.

The study team found no corroborating evidence to support the allegation that surface mining operations had an adverse impact on the flooding potential for citizens and residences downstream, when DSMRE's hydrologic policies and procedures were followed. The problems discovered in the course of this study appeared to result from a failure to follow set guidelines either in the permitting process or in the on ground reclamation process, or a combination of the two. In addition some areas of the SEDCAD hydrology and flood potential modeling as presently applied were found to have possible weaknesses. *Also* field personnel should more closely monitor the mining operations to ensure that approved drainage schemes are being followed and that proper erosion control devices are installed below spillways on steep slope areas.

Factual results garnered from the study indicate that the majority of the alleged downstream flooding problems were more a result of localized, extremely heavy precipitation events that led to flash flooding, which would have occurred with or without the mining operations being present.

BACKGROUND

A joint special study was initiated, via the 1996 Oversight Agreement, to review the adequacy of drainage control in watersheds impacted by surface mining. The pre-determined focus of the study was to ascertain if mine drainage was causing or contributing to off-site impacts to downstream areas. The field investigation parameters included delineation and measurements of watershed boundaries, then comparing pre-mine versus post-mining drainage patterns and volumes. Field reconnaissance would also include verification that the sediment stmctures were properly built and certified, review of the approved hydrology scheme in the permit, and an on-site inspection of the alleged off-site damage. The-data collected was then evaluated to determine if the mining operations had any effect on the downstream hydrology, particularly the flood potential for the downstream citizens and property.

Team members were selected from both OSM and DSMRE as a mixture of engineers and environmental specialists from both agencies, ail with a minimum of at least 15 years experience in mining reclamation and enforcement. Team members from the Lexington Field Office of OSM were Gail Smith and Ralph Blumer. Field inspectors George Morgan and Charles Saylor also participated in several of the investigations. Team members from Kentucky DSMRE included Jesse Gilpin, Paul Travis, Jeff Hall and Jeff Taylor.

The study was initiated after both OSM and DSMRE received an increase in citizen complaints that often involved life threatening, property damaging "washouts". Several complainants were alleging that the large volumes of water they observed were caused by the upstream mining operations.

The original intent of this study was to investigate 15 citizen complaints that alleged flood damage caused by mining operations. However after three years of monitoring complaints, only 10 sites with possible flood related damage have been reported, therefore the team concluded the study at this point.

REVIEW FINDINGS

The basic responsibility of the DCST was to determine whether there was any relationship between surface mining and reclamation processes and an increase in the flood potential for areas downstream of these mining operations.

The DCST conclusions are based on factual data gleaned from the on-site investigations, as well as "Best Available Technology" (BAT) hydrology modeling and any other sources of obtainable information. Sources other than those previously mentioned include the approved drainage plan in the permit, rainfall data for the dates of the flooding events and any first-hand eyewitness reports of these events.

Of the ten sites investigated in the course of the study, three of the cases resulted in an actual increase in flood potential and enforcement action being taken by DSMRE. In each of these three instances the mine operation had significantly increased the volume of precipitation runoff flowing into an off-permit natural drain as compared to the pre-mining baseline runoff. In each of these cases the permittee/operator failed to properly follow the approved drainage plan in their reclamation operations. For more detailed information on the individual site investigations, please see the synopsis attached to this report.

Statutes and regulations govercing mining require that runoff from disturbed areas as defined in 405 KAR 16:070, Section 1 (1)(d), pass through a sediment control structure prior to leaving the site. In order to comply with these requirements mine operators usually permit and construct diversion ditches to divert any runoff to an approved structure. This situation often causes a larger acreage of runoff than natural to be concentrated to a narrow outlet, which is usually the spillway of the sediment structure. Although energy dissipators such as riprap are used to prevent the eroding effects below the spillway that sometimes occurs in these instances, heavy rainfall events sometimes produce such large volumes of runoff that gully erosion occurs below the spillway nevertheless. The study team found five of the ten sites investigated to have sufficient erosion below the spillway to warrant issuance of a non-compliance (Note: Two of these permits cited were a result of extreme rainfall events and not due to an increase in the flood potential).

The Division of Permits requires each permit applicant to prove by BAT hydrology modeling that the drainage plan for each sediment structure will not have a significant adverse impact on the hydrological balance of adjoining areas. This is usually done by a computer program called SEDCAD, which has been utilized by mining engineers in different forms for the last couple of decades. SEDCAD is a nationally recognized computer hydrology modeling system developed by the University of Kentucky- Biosystems and Agriculture Engineering Department. Mining engineers and the Division of Permits reviewers use SEDCAD to determine the sizes, locations and drainage areas of sediment structures in order to prevent any adverse impact to the areas downstream from mining.

Data results from the study found no evidence that mining increased the flood potential or had any adverse hydrological impact when a correctly permitted drainage scheme-was followed. The three study sites on which enforcement actions were taken had experienced an increase in the drainage area due to the post-mining backfilling and grading configurations and/or extension of the diversions beyond designed limits, which increased the watershed of the sediment structure to a level in excess of what was approved in the permit package.

The regulations require that all mine operations control drainage to prevent an increase of flooding potential. Mine engineers and Division of Permits reviewers accomplish this by:

1) Estimating the premining drainage for the watersheds within the mine area using BAT, and
2) Designing mine drainage and ponds in order that drainage from the impoundments will not exceed the premining drainage from the watershed.

If the premining drainage is overestimated, drainage from the permitted ponds may cause localized flooding that would not have occurred prior to mining. The accuracy of the findings and conclusions of this report are dependent upon the accuracy of the SEDCAD modeling, particularly the pre-mining data. As SEDCAD and other mine engineering technologies advance, improvements in flood potential prediction and analysis decrease any likelihood that mining might adversely impact a downstream landowner or community. Recommendations # 1 through **4** in the concluding section of this report hopefully will help to make flood potential prediction and modeling more accurate fir future mining permits.

A synopsis with the situations and conclusions of each site investigation is attached as an addendum to this report.

RECOMMENDATIONS

Although the study team found no major flaws in the methods DSMRE utilizes in its hydrology modeling, some concerns and potential areas for improvement were noted.

(1) The study team recommends that the Division of Permits consider refusing to allow permittees to use "instantaneous time of concentration" (I-Tc) in the pre-mining SEDCAD hydrology modeling. Discussions with Dr. Richard Warner of the University of Kentucky, a co-creator of SEDCAD, and recent projects under the direction of Dr. Warner have confirmed that the use of "instantaneous" can often cause elevated pre-mine estimates of average runoff. When (I-Tc) is used in pre-mining hydrology modeling, the model runs its program such that any and all rainfall that hits within the model watershed is projected to be at the watershed outlet immediately. While this scenario is appropriate for certain SEDCAD modeling situations, it artificially increases pre-mining peak .flows and thus does not provide an appropriate base for comparison of post-mining discharge. Obtaining the most precise pre-mine runoff data possible is essential to ensure that the mine drainage schemes are designed to prevent adverse impacts to the hydrologic balance and citizens and property downstream.

(2) The three sites from which enforcement actions (for an increase in flood potential) were cited all had the same problem; a significant increase in the sediment's watershed after backfilling and grading was completed. It is recommended that permittees and especially field inspection personnel be reminded to ensure that the approved drainage plan in the permit is followed, including diversion ditches.

(3) The DCST recommends that the permit 'method of operation' section be expanded to include drainage scheme information that is pertinent to the proposed mining plan. For example, it was noted and discussed on a few of the study sites that the approved drainage plan was designed for only a maximum of 10% disturbed area in a watershed. Team members and Division of Permits representatives agreed that this is rarely an accurate on-ground scenario. **A** majority agreed that the Division of Permits should include information from the drainage plan that is associated with the method of operation into both sections of the permit, making it easier for everyone to understand the approved mining plan.

(4) The DCST's final recommendation is that closer scrutiny is given to ensure that adequate energy dissipator/erosion control devices are used below spillways of dugout structures, especially those that flow out to steep slope areas. The study team found some areas that had moderate to severe erosion when the spillway emptied onto natural ground where there was no previous natural drain, causing sediment deposition problems downstream where the topography leveled off. **A** check of these areas on complete inspections and/or after severe storm events should not be overly burdensome on inspectors and could prevent damage to downstream landowners. It is recommended that dugout structures be placed in pre-existing natural drains unless there is a substantial reason it should be placed otherwise.

It should be noted that the Division of Permits has already implemented one recommendation of this team. In the early portion of this study it was discovered that permittees were sometimes allowed to use different modeling programs for the pre-mining versus the during-mining hydrology data. This appeared to be a possible loophole for ‘tweaking’ of the hydrology data to allow a greater volume of runoff than would otherwise be permitted. Paul Travis, an engineer and team member from the Division of Permits, enacted a new reviewer policy to ensure that the pre and post-mining hydrologic data were designed by the same methods.

DCST SITE SPECIFIC RESULTS

1. **Holston Mining P.N.** 898-0349- Danny May Complaint- Flooding and sediment deposition damage to property was alleged to be the result of Holston Mining's operations approximately 1700 feet up the mountainside from Mr. May's residence.

   The Drainage Control Study Team (DCST) could find no evidence to support **Mr.** May's allegation that the mining and in particular SS# 38 was responsible for the flooding and sedimentation deposits on his property. The team conducted a thorough investigation of the mined watershed, SS# 38, and an on-ground reconnaissance of the hillside between the minesite and Mr. Mays property. There was substantial erosion and debris spread all along this area of Pike County, apparently due to an intense storm cell that dumped approximately 3 inches of rain in less than four hours. It appears that the flood damage was due to the large precipitation event that flowed down the mountainside carrying sediment and debris with it. The drainage area above Mr. May's property included both a gas well and' a logging operation, which contributed to the sediment and debris deposited on Mr. May's yard.

   SEDCAD modeling was conducted comparing pre-mine to post-mining effluent for a 25yr/24hr storm to determine if Holston Mining was responsible for increasing the flood potential for the area downstream of SS# 38. The data results are as follows:

   Pre-mine flow.......17.17 **cfs**
   During-mining. .....16.37 **cfs**

   This data suggests that Holston Mining had a negligible effect on the flood potential for the area downstream of SS# 38.

2. **Coal Mac Tnc. P.N. 836-0229**-Amarine Conn Complaint- Three silt structures were involved, SS# 2, 2A, and 4. Alleged that mining had caused severe flooding in Ned's Fork area of Floyd Co.

   Residents of the Ned's Fork area alleged that two separate severe flood events had occurred within the past year. The latest had occurred on August 8^{th}, 1996, with floodwaters jumping the ditchlines and almost washing away a car driven by Mrs. COM. The study team conducted a thorough investigation of the mining area and the immediate downstream area, including the Ned's Fork community. A video of the August 8^{th} event was provided by Mrs. Conn. **A** thorough investigation was initiated involving comparison of the pre-mine versus the post-mining watershed, verification of the correct design and construction of the sediment structures, accumulation of any local rainfall data, and interviews with citizens and mine personnel.

   As a precautionary measure the team did a cross-sectional profile survey of the Ned's Fork area where floodwaters had overtopped the county road culvert just upstream from Mrs. Conn's residence. Using a video taped by Mrs. Conn on the day of the flooding tc determine the height and volume of the floodwaters, the engineering results determined that the county road culverts in this area were inadequate to handle a large storm event.

SEDCAD results totaled at a point just below the confluence of all three structures found

Pre-mining = 441.28 **cfs**
During mining = 365.02 **cfs**

The team could find no violations or negligence on the part of Coal Mac, Inc., and its mining operations in this area. The mined watershed was not changed from the pre-mine configuration, and all silt structures appeared to be built and functioning adequately. Also there was a large unmined area adjacent to the minesite and upstream of Ned's Fork that apparently contributed to the flooding of the downstream community.

3. **Kentucky May Coal Co. P.N.** 898-0475- Marvin Bentley Complaint-Alleged that SS#4 deposited sediment in yard, created slumps and erosion on hillside below the pond, pond leakage..

An investigation of the site found a significant increase in the during mining as compared to the pre-mining effluent flow in the watershed of SS#4 directly above Mi-. Bentley's residence. Survey results showed an increase in the affected drain .acreage from 0.6 acres pre-mine to an acreage of 4.21 acres after mining and diversions were completed. ***An*** on-site inspection discovered that a diversion ditch feeding SS#4 had been extended approximately 150 feet further than approved in the permit plan, thereby causing the additional effluent.

SEDCAD runs taken at the discharge point of SS#4 were **Pre-mine. ....** 1.36 **cfs**
During mining.. .. 8.92 **cfs**

An additional SEDCAD run was conducted to determine the increased hydrological impact at the toe of the slope behind the impacted residence, or approximately 800 feet below the SS#4 spillway. Results of the SEDCAD runs were **Pre-mine ....** 21.69 **cfs**
During mining...29.59 cfs

Enforcement action was taken, and SS#4 and associated diversions have been eliminated, returning the area to the approximate pre-mine drainage scheme.

4. **Holston Mining P.N.** 898-0349-Columbia Gas Complaint- Gas company alleged that Holston caused slide and instability in gas-line bench from effluent and seepage emanating from SS#37.

The DCST could not find sufficient evidence to link the gas bench slide and instability to the mining operations, due in part to a photograph taken by the mine inspector showing the gas bench sliding several months prior to the construction of SS#37. However, effluent emanating from below the spillway outlet of SS#37 had caused guiiy erosion and exposure of the gas line. A survey comparing the pre-mine versus the post mining watershed showed a large increase in the post mining watershed of SS#37. SEDCAD data results for a 25 yr/ 24 hr event comparing the pre-mine vs. post-mine watershed were:

Pre-mine .... 1.65 **cfs**
During mining...25.91 **cfs**

Enforcement action was taken, and Holston Mining repaired the gas line and gully erosion on the gas bench, as well as returning the watershed of SS# 37 to pre-mine levels. No further problems have been reported.

5. **Alley-Cassetty Coal Company PN** 816-01**05-** Earl Combs Complaint- Downstream private lake alleged mine sediment muddying up lake. *Also* was concerned that sediment might cause a fish kill.

Investigation found that an extremely heavy rain event (estimated between a fifty to one hundred year storm event) combined with a large disturbed area caused a temporary overload of the company's SS#1. This watershed area also had a considerable acreage of forested area between the minesite and the lake that had some logging activity in the past. NO violations were cited. Lake cleared up quickly with no further problems.

6. **Lodestar Energy, Inc. P.N.** 836-0231-Raymond Ratliff Complaint- Mr. Ratliff alleged runoff from the minesite, specifically dugout no. **8,** caused erosion of his hillside and siltation of his paylake.

Investigation by study team found that the operator had allowed an approximate 6 acres increase in the drainage area feeding SS#8, thereby significantly contributing to erosion on the hillside below the structure and potential siltation of the paylake. SEDCAD modelling was based on the entire (mined and unmined **)** watershed of the paylake.

SEDCAD results were **Pre-mine.. .....78.64 cfs**
Post-mine ......103.12 **cfs**

These results showed an approximate increase of runoff into the payiake of 3 1%. Based on these findings enforcement action was taken and Lodestar Energy quickly complied to return the drainage scheme to reflect the approved plan in the permit.

7. **Miller Brothers Coal Inc. P.N.** 897-0379-Claude Coots Complaint-Mr. Coots alleged drainage from SS#2 caused erosion and water damage to his property.

Study team found the structure was leaking but not causing any erosion or other damage to Mr. Coot's property. Company had made two previous unsuccessful attempts to seal the structure. Decision was made to eliminate structure and return area to natural pre-mine drainage. No further problems reported. No SEDCAD data required.

8. **Coal Mac, Inc. P.N.** 898-0517-Thacker and Woods Complaint-Alleged drainage from the minesite and SS#1 responsible for downstream flooding to property-.

Investigation results found no discernable mining related impacts to the downstream hydrological balance. The causation of the flooding appeared to be the combination of a large precipitation event (approximately **4.5** inches of rain in a 29 hr. period) and the junction of two large watersheds less than 100 feet from the Thacker residence. SEDCAD modeling was not necessary for this investigation.

9. **Colonial Coal Corporation P.N.** 898-0467-Numerous Complainants-Alleged flooding due to mine and related silt structure.

   Study Team investigation could find no causal relationship between the mined area and the flooding downstream in relation to the hydrological aspects; however sedimentation and debris washed downstream from the minesite did contribute to property damage downstream. Some errors were found in the permit modeling in relation to sedimentology also. However, the study could not find sufficient evidence to show that either the mining or the silt structure involved had any effect on the flood potential for the affected areas downstream. The damage once again appears to be the direct result of a severe storm cell that dumped somewhere in the neighborhood of 5.5 to 6 inches of rainfall, according to local estimates. Since mining had not increased the drainage area for this watershed, SEDCAD runs were not needed. Problems with the permitted sedimentology modeling were forwarded to the Division of Permits for review.

   No further problems on this site have been reported.

10. **Lodestar Energy, Inc. P.N.** 836-0261-Confidential Complaint-Alleged flooding and sedimentation of Stratton Branch downstream from silt structure #7.

   The study teams investigation could find no evidence that Lodestar Energy's mining had any significant impact on the flood potential for the Stratton Branch community. It appears from talking to the inspector and the mine foreman that this particular flood event was the result of a high intensity storm cell that produced large volumes of precipitation within a relatively short period of the. **A** noii-compliance was issued by the state inspector for a settable solids violation as a result of these events. SEDCAD results were as follows:

   Premine ....422.33 cfs
   During mining.. ....462.66 **cfs**

   Although these results show a 9.5% increase in flow from the mined area during a precipitation event, this is not considered to be a significant increase and is within the accepted margin of error for this program. This minesite has since been revegetateci and is presently under construction as a future golf course and residential area. No further problems have been reported.

JAMES E. BICKFORD
SECRETARY

PAUL E. PATTON
GOVERNOR

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR SURFACE MINING RECLAMATION & ENFORCEMENT
FRANKFORT, KENTUCKY 40601
CARL E. CAMPBELL
COMMISSIONER

MEMORANDUM

TO: Technical Review Staff

FROM: Larry D. Adams, Director
Division of Permits

DATE: August 7, 2002

SUBJECT: Sediment / Flood Control Design Considerations

Mining disturbances have the potential to alter watershed characteristics and increase peak flows due to changes in topography and vegetation. Whether or not flooding occurs is a site specific circumstance based on the degree of flow alteration caused by the mining activities and the downstream channel capacity and geometry, as well as the influence of other manmade alterations to channels and flood plains (e.g., roads, culverts, stream crossings, bridges, residential or business fills encroaching on stream beds, and other obstructions).

A Joint Special Study was conducted by OSM and DSMRE on drainage control at ten mine sites in Kentucky. Site selection was based on citizen complaints alleging life threatening "wash-outs" were caused by mining or mining otherwise significantly contributed to downstream flooding. Of the ten sites investigated, three were determined to have increased flood potential based on the operators failure to follow the approved drainage plan. The report concluded that compliance with the approved regulatory program effectively minimized flooding potential.

Recommendations of the Joint OSM – DSMRE Special Study Report on Drainage Control are summarized as follows:

- Permitted worst case models must reflect on anticipated ground site conditions to insure the adequacy of sediment / flood control measures, To assist in site inspections, the method of operation should be expanded to include drainage information.

- Reclamation timing that is pertinent to the proposed mining plan. For example, if end-dumped durable rock hollow fills are modeled with the lower lifts aged, the hollow fill narrative must address the timing of reclamation. Alternatively, if the applicant proposes to breakdown an end-dumped fill at the conclusion of mining within the subject watershed, the worst case model should reflect the fill fully disturbed, bare.

- Pre-mining, during mining hydrologic analyses must be modeled using the same methodology to insure comparable peak run-off values. Pre-mining hydrologic analyses should not typically be modeled with an instantaneous time of concentration (Tc). When an instantaneous time of concentration is modeled with SEDCAD, the model immediately projects all rainfall within the subject watershed to the outlet resulting in an elevated pre-mining run-off estimate. While the use of an instantaneous time of concentration is appropriate in some during mining models, it may artificially increase pre-mining peak flow and would not provide an appropriate base for comparison of post-mining discharge.

- Energy dissipaters / erosion control devices should be required at pond outlets. To the extent possible, on bench dugout structures should be located so as to discharge into preexisting natural drains.

In addition to the study report recommendations, the following sediment / flood control design considerations are to be implemented.

Hollow Fill Design and Modeling

1. In light of common end-dump hollow fill construction practices observed in the mining industry, it is prudent, in assessing the projected hydrologic Ioad on sediment structures, *to* assume a **default modeling configuration** comprised of;

   a) Fill at full capacity/size,
   b) Surface condition of entire fill is bare spoil, no seeding/mulching, no final grading, no terraces,
   c) Slope and, more importantly, slope lengths used in T_c, Muskingum **k,** and sedirnentology inputs should reflect absence of terraces, considering the full lengths *of* the downstream face.
   d) The remainder of the mining activity within the watershed should be modeled for an acceptable worst-case estimation, and the pond performance assessed accordingly.

2. The applicant/engineer may substitute a **design modeling configuration** for the default scenario to only such degree that is supported by specific construction practices and sequence as are delineated within the **plans,** specifications, and drawings. Those specifications should address the following areas;

   a) an estimation of the time to required for completion of the fill, from initial clearing through final grading and establishment of vegetation,
   b) Maximum height of fill/volume of fill to *be* exposed **at** arty time before initiation of grading/vegetation,
   c) Hollow fill aging (in the modeling) should reflect the reclamation pattern described in the specifications, including variable cover conditions **(based** on history) **and including the maximum allowable height of the exposed fill face.**

3. If there is more than one hollow fill within **a** drainage area, the narrative should specifically address the relative reclamation status of the fills, either accounting for or precluding multiple fill sites active at any time.

4. The specifications should clearly stipulate placement of the rock check structure (below the toe of the fill) at the beginning of fill operations, and drainage **structures** (perimeter diversions) **as** soon as practicable.

Contemporaneous Reclamation Variance

1. For applications containing a request for a contemporaneous reclamation variance, additional information relating to potential storm flow increases **and** sediment discharge should be considered. This information should address;

   a) Consideration of sedimentology / hydrology impacts of extensive open pits or un-vegetated area, along with **any** appropriate controls. Additional modeling scenarios may be necessary to analyze during mining conditions versus reclamation condition for worst case impacts.
   b) Consideration of the worst case hollow fill status during development of the open highwall.

   Likewise, the applicant may choose ***to*** utilize a design modeling configuration taking into account specific reclamation timing / sequence factors similar to that addressed in hollow fill design and modeling considerations.

Ponds in Series

1. Where ponds are proposed in series, extra diligence should be employed in assessing the worst case sediment and storm load. **This** is particularly true for instances where multiple on-bench dugout structures are proposed in support of a downstream impoundment. Additional modeling scenarios may be necessary for fully assess the projected load on the lowest downstream discharge point.

2. In no case should the watershed plan be approved based solely on a demonstration showing all active disturbances above an upper level structure. Consideration must **be** given to the predicted storm performance, sediment accumulation, and effluent for the lowest structure in the watershed under the maximum predicted load for that structure.

Proximitv of Downstream Development

1. For watersheds **with** a higher risk of negative impacts due to flooding or inadequate sediment controls (highly populated or developed areas, particularly if the natural or constructed drainage course is only marginally adequate before mining), additional precautions should be taken. These precautions should include;

   a) Because *of* the potential impacts from high rainfall rates, particular **care** should be employed in considering the watershed routing to, and through, the impoundment.
   b) Recommendation should **be** made as to appropriate additional control measures, such as on-bench rock checks, more aggressive reclamation provisions, and/or additional sediment control measures.