

## **2.0 SITES SELECTION**

### **2.1 APPROACH TO SITES SELECTION**

The approach to sites selection included the determination of selection criteria and the identification of three groups of three study sites with suitable forestland in Washington and Greene counties, with each group having one study site in each of the following three categories:

- Sites which have experienced subsidence due to longwall mining prior to 1990;
- Sites which have experienced subsidence due to longwall mining between 1995 and 1999; and
- Sites which have not experienced subsidence due to longwall mining and have not been influenced by subsidence.

Factors which influenced the selection of study sites included extent of forest cover; forest type, density and condition; access to site areas; topography; surface soil types; location and orientation of mine panels; geology and overburden depth to the mine; site hydrogeology; and mine extraction. Each group of three sites was chosen such that the three sites were as close together as practicably possible in order to minimize differences in factors such as forest composition, topography, soil types, etc.

Mine maps of operating and non-operating mines in Washington and Greene counties were reviewed in order to identify longwall panel sections that met the first two mining conditions discussed above. Potential study panels where substantial forestland was present, as determined from aerial photographs, were then selected for further evaluation. Field reconnaissance of these identified forest stands was then performed in order to observe forestland conditions and to assess the suitability of the panel areas for the next phase of the project. Older, more developed forest stands, representing greater resource value, were considered more desirable than younger successional stands.

Candidate study sites of 300 or more acres that corresponded to the mining conditions above, had relatively uniform forest cover, and best met other sites selection criteria were

chosen. Additional control sites in close proximity to the mined sites that had not been undermined by longwall systems or influenced by subsidence were then selected. In selecting sites that were not undermined by longwall systems, sites with forest stands underlain by room and pillar workings were considered as non-undermined sites, so that control sites could be located as closely as possible to the sites where longwall mining had occurred.

## **2.2 DEVELOPMENT OF SITES SELECTION CRITERIA**

### **2.2.1 Criteria Considered**

Criteria considered for the selection of sites for application of remote sensing techniques for determining the effects of mine subsidence on the tree canopy included the following:

*Extent of forest cover* is a very important selection criterion. Greene County has significant wooded sections, but substantial portions of Washington County have relatively little forest cover. Aerial photographs showing land cover were obtained from the Pennsylvania Spatial Data (PASDA) website on the Internet and were reviewed.

*Forest type, density and condition* is also an important selection criterion. Some types of trees may be more susceptible to subsidence-induced stress than others. Tree density may be related to observed effects. Stress effects due to diseases, drought and insect infestations may be similar to those caused by mine subsidence.

*Site access* is an important criterion because gaining access to heavily wooded sites with rugged terrain, or sites with multiple private ownership can be a difficult and time-consuming task. Access issues associated with the terrain and forest cover were considered based on the aerial photographs and topographic maps, which also identified utility right-of-ways as potential access points. Ownership issues were determined from property maps and information from mining permits, along with information on state game lands and other public lands. The optimum situation was considered to be a site located on public lands owned by the state.

*Topography* is important because the effects of mine subsidence on soil moisture and drainage are more pronounced at sites where the ground is relatively level. In Washington and Greene counties, the ground surface is generally likely to have a significant slope except along stream valleys.

The sites in each group of three should be chosen such that they have stream valleys and hillsides of similar character.

**Surface soil type** is important because, where drainage impacts are anticipated, it is desirable to have the same or similar soil types for each group of three sites in order to reduce potential effects resulting from differing soil conditions.

**Overburden depth** should be in a consistent range for each group of three sites. The surface effects of subsidence diminish with the depth of the mined seam below the surface.

**Geologic conditions.** Geologic conditions should be similar for each group of three study sites. This should not be difficult to achieve for three sites located relatively close together.

**Hydrogeologic conditions.** Hydrogeologic conditions should be similar for each group of three study sites. This should not be difficult to achieve for three sites located relatively close together.

**Precipitation history** may tend to increase or decrease the effects of observed stresses. Precipitation history for the last few years in each of the site areas may be important. However, the location of all of the sites in a relatively limited two-county area tends to make these data similar.

**Orientation of mining to surface features.** For any group of three sites the orientation of mining to the surface topography should be similar, with the main objective being a relatively transverse orientation of panels to stream valleys.

**Availability of reliable mine maps and subsidence data.** It is desirable to have reliable mapping of mine workings and subsidence data obtained from mine records to utilize in the evaluation of observed surface vegetation stresses.

While all of the criteria discussed above have relevance to the project, some are relatively more important while others are of secondary importance. The review of data encompassed the submittals associated with the mine permits, as well as published information, topographic maps and aerial photographs. After review of these data, several primary selection criteria were identified, as discussed in order of overall importance in Section 2.2.2.

The remaining evaluation criteria have been grouped into a category of secondary selection criteria. These criteria, which are presented in Section 2.2.3, are roughly comparable in importance and have not been ranked in any order.

## **2.2.2 Primary Sites Selection Criteria**

### **2.2.2.1 Extent of Forest Cover**

Extent of forest cover was determined to be the most important sites selection criterion. The forest cover was determined from evaluation of published forestry information and aerial photography for the two counties. The photographic data were obtained from the Pennsylvania Spatial Data (PASDA) Internet website. Digital orthographic quarter quadrangle photos (DOQQs) were downloaded from the PASDA site for evaluation. The DOQQs are orthorectified aerial photographs of one quarter of a USGS quadrangle topographic map. The data are generally seven to eight years old. A preliminary reconnaissance was performed during early May 2000 to confirm the conditions indicated in the photographs.

### **2.2.2.2 Forest Type, Density and Condition**

Tree types vary in their reaction to stress. Thus, to the extent possible, sites should be chosen with comparable tree types and density so that the effects of stress resulting from subsidence can be consistently detected. We reviewed available information relative to stresses induced by recent drought, disease and insect infestation. Sites selection included field observations in early May 2000 (Section 2.4.3).

### **2.2.2.3 Site Access for Ground Truthing**

Unrestricted access to the sites selected for the remote sensing evaluation is a critical part of the study. The optimum situation would be that study sites are located in areas of public or state-owned lands, where free access is available. The mine locations were plotted on maps of Washington and Greene Counties showing the locations of state game lands. However, in general, the mine workings and the state game lands did not overlap with the exception of the Bailey and Enlow Fork mines. The DOQQs were also reviewed in order to determine if access could be gained through public roads and utility right of ways.

### 2.2.3 Secondary Sites Selection Criteria

Secondary sites selection criteria included the following:

- Topography
- Surface soil types
- Overburden depth
- Geologic conditions
- Hydrogeologic conditions
- Precipitation history
- Orientation of mining to surface features
- Availability and reliability of mine maps and subsidence data

### 2.3 IDENTIFICATION OF CANDIDATE SITES

There are eight operating and four non-operating longwall mines in Washington (W) and Greene (G) counties. The operating mines and the counties in which they are located are indicated in the following list:

<u>Mine</u>	<u>Location</u>
Maple Creek	W
Eighty Four	W
Enlow Fork	W, G
Bailey	W, G
Dilworth	G
Emerald	G
Cumberland	G
Blacksville No. 2	G

Table 1 presents a summary of key mine information obtained from the DEP permit files, including coal seam, panel width, panel length, gate width, and overburden and extraction characteristics. The mines are typically in the Pittsburgh Coal seam, with extraction thicknesses averaging between 6 and 7 feet and overburden thicknesses averaging in the range of 600 to over 1,000 feet. Mine panel widths and lengths are typically on the order of 900 and 10,000 feet, respectively. Smaller panels were encountered at some of the older mine workings.

Non-operating longwall mines in Washington and Greene Counties, which were considered in the sites selection process, included:

<u>Mine</u>	<u>Location</u>
Warwick	G
Humphrey No. 7	G
Blacksville No. 1	G
Gateway	G

With the exception of the Warwick Mine in the Sewickley Coal seam, the non-operating mines are all located in the Pittsburgh Coal seam.

The Blacksville No. 1 Mine and the Blacksville No. 2 Mine have been combined for purposes of this study. This was done because of their close proximity and because the combined mines provided the three types of sites discussed in Section 2.1.

Mine maps for the mines listed above are available in a variety of scales and levels of reproduction quality from DEP longwall mine permits. Additionally, the extent of surface features shown on the mine maps (which allows for the direct referencing and determination of latitude and longitude of mine panels) is variable. However, most of the maps of the operating mines were legible and could be readily referenced to surface features.

In addition to locating mine panels, the relative extent of subsidence extending beyond panel boundaries was estimated for the purpose of establishing study site boundaries. As indicated in Table 1, information on subsidence profiles was obtained from DEP files for only a few operating mines. However, most of the mines extract coal from the Pittsburgh seam where relatively consistent results have been observed with respect to subsidence prediction parameters.

Typically, subsidence movements occur within a few hundred feet of longwall panel boundaries or across gate pillars to adjacent panels, depending on the extraction height and overburden thickness. Accordingly, the boundaries of the selected study sites extended 400 feet or more beyond the longwall panel boundaries and across gate pillars into adjacent panels. Thus, the study sites incorporated the range of tension/compression stresses associated with a longwall panel, including terrain effects that could impact surface drainage.

The locations of the mines discussed above are shown in plan on Figures 1 and 2. The shaded areas indicate the total extent of the mines. The mine areas shown are based on data from mine maps that were transferred to surface maps, and minor positional discrepancies may exist. In some cases, not all of the mined areas are depicted on the mine maps. Also, an overlap occurs between the Warwick and Humphrey No. 7 mines where coal extraction was in different seams.

## **2.4 EVALUATION OF CANDIDATE SITES**

### **2.4.1 Review of Aerial Photographs**

The first step in the evaluation of candidate sites was to obtain aerial photographs of the ground surface at the mines. As discussed previously, the photographs were obtained from the PASDA Internet site. Digital ortho quarter quadrangle (DOQQ) photographs were obtained for nearly all of the areas of interest. For some areas only digital ortho quadrangle (DOQ) photos were available, but these photos were converted to the same scale as the DOQQs. The aerial photography for the DOQs and DOQQs was generally performed in 1993 and 1994.

Concurrently, published literature from the U.S. Government and Pennsylvania State agencies was searched for recent information on forests in the two-county area. This information provided some characterization of the potential species, density and condition of the forestlands observed on the aerial photographs.

In order to facilitate identification of candidate sites in the field, the locations of longwall panels associated with the various mines were drawn on reproductions of the aerial photographs. Individual forest stands associated with specific longwall panels were identified from the aerial photographs for evaluation in the field.

Based upon published information on southwestern Pennsylvania forests and evaluation of the aerial photography in the areas where mine panels were located, forest stands at and adjacent to the longwall mines indicated above were identified for further evaluation in the field. A summary of this initial screening is presented in Table 2. Generally Washington County was found to have substantial development and agricultural land use

that resulted in relatively few forest stands that were suitable for evaluation at the Maple Creek and Eighty-Four mines. Greene County and southern Washington County (near the Enlow Fork and Bailey mines), on the other hand, are less developed, and the forest density is much higher. The Bailey, Enlow Fork, Blacksville and Humphrey No. 7 mines were found to have many forest stands that were worthy of field evaluation.

#### **2.4.2 Review of Published Data**

Available data from the literature and from U.S. Government and Pennsylvania State agencies were reviewed as part of an initial evaluation of candidate sites in Washington and Greene counties. Undermined areas were located relative to the forestland data by transferring the longwall mine sections of interest from mine maps to county maps via surface reference points. The latitude and longitude of points on main mine sections were determined and were subsequently used to define the mine boundaries as polygons for location on county maps. The results of this process for Washington and Greene counties are presented on Figures 1 and 2, respectively.

Discussions related to forest type and density in southwest Pennsylvania and to general tree health and previously observed problems from disease and insects are presented in the Sites Selection Report. The US Department of Agriculture, Forest Service has classified most of the forestland within Washington and Greene counties in the general oak-hickory group, with a small scattering of sections classified within the maple-beech-birch group<sup>(7)</sup>. Forest resources in Washington County are concentrated mainly in the southwestern corner of the county, whereas forestlands are more widely distributed in Greene County.

Forest Service data from 1963 to 1998 indicate that Washington and Greene counties have generally been less affected by insects and disease than some other areas of Pennsylvania. Distress to forests in Pennsylvania from all causes for the period from 1963 to 1998 based upon data from the Pennsylvania DCNR<sup>(8)</sup> is shown on Figure 3. A substantial portion of the distressed areas shown on the figure is associated with gypsy moth damage in 1996. Locust leaf miner is not mentioned in the data. As subsequently discussed in Section 6.0, infestations of locust leaf miner were widely observed in Washington and Greene counties and throughout Western Pennsylvania during the summer of 2000.

### **2.4.3 Field Reconnaissance**

A general description of the field reconnaissance associated with evaluation of candidate study sites is provided in the following paragraphs. A more detailed description of this effort is presented in the Sites Selection Report. Field reconnaissance of forest stands identified from aerial photography was performed during early May 2000 by Dr. Davis and D'Appolonia professionals.

Observations by the field reconnaissance team confirmed that most of the forest stands observed in Greene and Washington counties constitute part of the mixed mesophytic forest, which is characteristic of much of southwestern Pennsylvania. The mixed mesophytic forest is dominated by a mixture of hardwood tree species such as sugar maple, black cherry, yellow-poplar, buckeye and many others. Forests of this type are common on the more mesic (moderately moist) sites. However, within the forests observed in this study, communities on the south- and southwest-facing slopes, as well as the drier sites, did occasionally give way to the less luxuriant oak-hickory communities, consistent with the Forest Service data discussed in the Sites Selection Report. Red maple, an opportunistic tree species that has greatly increased in abundance in recent years, is a common species within both types of forest communities.

In evaluating forest stands in the field the reconnaissance team looked for established stands of trees with relatively extensive and solid canopy cover of similar type, density and condition, with relatively easy access and similar topography (for potential sites at one mine). Sites that subjectively met these criteria are hereinafter referred to as suitable.

Agriculture or development limited the extent of available forest stands, particularly at mines in central Washington County and parts of Greene County. Another limiting factor was locating suitable forestland areas that would meet the mining criteria for both time frames of interest (undermined between 1995 and 1999 and undermined in or before 1990) and that were in close proximity, preferably over the same mine. Table 2 presents a summary of the initial field reconnaissance at the longwall mines, and indicates the presence of forested areas over mine panels that met the mining criteria for both time frames of interest. Extensive and suitable forestland at the Maple Creek, Eighty-Four, Enlow Fork, Dilworth, Gateway, Emerald and Warwick Mines that included undermining

during both time frames of interest could not be located. An attempt was made to combine sites between the Humphrey No. 7 Mine and the Warwick Mine, but suitable sites from the Warwick Mine that were close to sites from the Humphrey No. 7 Mine could not be identified.

Overall, the Bailey Mine had many suitable forest stands associated with mining in the two time frames of interest. The Blacksville Mine (Nos. 1 and 2) also had suitable stands in both time frames, but ranked slightly below the Bailey Mine. The Cumberland Mine had suitable forest stands in both time frames, but the quality of the forest stands ranked below the Blacksville Mine. Panels from the Humphrey No. 7 Mine included some suitable forest stands in both time frames that were roughly comparable to the Cumberland Mine.

#### **2.4.4 Evaluation of Site Access Conditions**

Ownership and physical accessibility were evaluated for the various forest stands observed at each mine. Most forest stands were individually owned property (as opposed to public land or mine-owned), with accessibility from public roads or right-of-ways, or across other private lands. As a result, they were rated lower than public or mine-owned property, where access should generally be easy.

Notably two forest stands at the Bailey Mine and one forest stand at the Blacksville Mine received a higher accessibility rating because of public or state game lands. Four forest stands at the Cumberland Mine and five at the Blacksville Mine were owned by the mining company. Thus, the Bailey, Blacksville and Cumberland mines were rated higher on access. The remaining mines ranked below these three and were essentially equivalent with respect to access.

## **2.5 SCREENING AND SITES SELECTION**

### **2.5.1 Initial Screening of Candidate Mines**

On the basis of the review of aerial photographs and the field reconnaissance, it was apparent that some of the longwall mines in Washington and Greene counties had low potential for selection as candidate sites while others had excellent potential. Still others had some suitable forest stands, but not for both desired mining periods. The Maple

Creek, Eighty-Four and Dilworth mines were eliminated from further consideration because suitable forest stands were not available.

The Bailey, Blacksville, Cumberland, Enlow Fork and Humphrey No. 7 mines are located in well-forested portions of the two counties and generally had a number of suitable forest stands. For the Bailey, Blacksville, Cumberland and Humphrey No. 7 mines, suitable forest stands were associated with both undermining time frames. For the Enlow Fork Mine, however, only recently undermined panels were available. The Enlow Fork Mine was eliminated from consideration because there were many forest stands associated with mining in the 1995-99 time frame, but none associated with mining prior to 1990.

The Emerald and Warwick mines generally had some suitable forest stands, but did not have suitable forest stands for both the recent and prior to 1990 time frames. Thus, based upon the aerial photograph evaluation and field reconnaissance, the mines that remained as candidates for groups of three sites included:

- Bailey
- Blacksville (Nos. 1 and 2)
- Cumberland
- Humphrey No. 7

### **2.5.2 Secondary Screening of Candidate Mines**

The four mines determined from the initial screening were subjected to a secondary screening involving the following criteria:

- Topography
- Soil Type
- Overburden Depth
- Geology/Hydrology
- Precipitation History
- Orientation of Mining to Surface Features
- Availability of Mine Maps and Subsidence Data

Through selection of study sites of sufficient size at the candidate mines, a similar range of conditions associated with the first four criteria was achieved at locations providing

the two mining time frames of interest and a control location without longwall mining. Precipitation history was considered to be similar because of the proximity of the sites. Study sites with mine panels oriented transversely to valleys and with greater available mine data were ranked highest. In general, the evaluation of the secondary criteria did not produce significant differences among the four mines identified from the initial screening.

On the basis of the initial and secondary screening, the groups of sites associated with the mines listed above were ranked in the following order of suitability for study:

- Bailey
- Blacksville (Nos. 1 and 2)
- Humphrey No. 7
- Cumberland

After review by the DEP, the study sites associated with the Bailey, Blacksville (Nos. 1 and 2) and Humphrey No. 7 mines were chosen for application of remote sensing techniques for evaluation of stresses to the tree canopy resulting from subsidence.

### **2.5.3 Study Sites for Selected Mines**

The following paragraphs provide a description of the three study sites associated with each selected mine. The study sites are shown on Figures 4 through 6, which have photographic bases prepared from DOQQs. For each mine the longwall panels, as determined from mine maps, are shown as an overlay on the photographic base. Panels that fall into the two time frames of interest to this study are shown in solid yellow lines. Panels that were mined between 1991 and 1995 and between 1999 and the present are shown in dashed yellow lines. Where known, the dates of the beginning and ending of mining are shown at the ends of the panels. Some of the panels are numbered. These numbers are not mine designations, but were used by D'Appolonia in order to facilitate identity of field locations. Also indicated on the figures are locations of forest stand observations conducted in May 2000 as part of the sites selection process.

Study sites selected for the evaluation of remote sensing techniques are indicated by orange dashed lines on Figures 4 through 6. At each mine, one study site (A-1, B-1, and D-1) was undermined in the 1995-1999 time frame. The second study site (A-2, B-2, and

D-2) was undermined in the prior to 1990 time frame. The third study site (A-3, B-3, and D-3) was not undermined and is in an area not influenced by longwall mining subsidence. The selected study sites were all in excess of 300 acres in area.

#### **2.5.3.1 Bailey Mine Sites**

The selected study sites at the Bailey Mine are shown on Figure 4. The Bailey study sites are associated with longwall panels that are located along the border between Washington and Greene counties just east of the West Virginia border. The entire area is generally well forested, and Pennsylvania State Game Lands No. 302 occupies a portion of the surface area. The photographic base for Figure 4 was prepared from the Majorsville NE and the Wind Ridge NW and NE DOQQs. Mine panel locations were based on maps of the Bailey Mine.

Study site A-1 extends diagonally across panels mined between 1997 and 2000. The study site lies partially in the state game lands. There were two field observations of forest stands within the site and both were found to be suitable. Study site A-2 is associated with a panel mined from late 1986 to 1987, and the eastern end of the site lies just south of the Bailey Mine preparation plant. One forest stand in this site was observed and was rated as suitable. Study site A-3 is located to the west of the other two sites and was observed at three locations. The forest stands were rated as suitable. Study site A-3 is in an area planned for future longwall mining at the Bailey Mine.

#### **2.5.3.2 Blacksville Mine Sites**

The selected study sites at the Blacksville Mine (Nos. 1 and 2) are shown on Figure 5. The Blacksville sites are associated with longwall panels located just north of the border with West Virginia. Pennsylvania SR 218 runs through study site B-2. The photographic base for the figure was prepared by combining the Wadestown NE and the Blacksville NW and NE DOQQs. Mine panel locations were based on maps of the Blacksville Mine.

Study site B-1 is primarily associated with a panel mined in 1995, and extends north to include well-forested areas over a panel mined partly in 1994 and 1995. This panel is located just north of the small town of Brave and was observed in the field at two points. The two forest stands were evaluated as suitable. Study site B-2 lies to the east of study site B-1 and is primarily associated with two panels mined in 1986 and 1987. It extends

west to include portions of a panel mined partly in 1990 and 1991. This site was observed at four points. The conditions at two of these points were rated as unsuitable, but conditions at the other two, which represented the part of the site of primary interest, were rated as suitable. Study site B-3 lies just east of study site B-2 and is well forested. This site is in an area of room and pillar mining for the Blacksville No. 1 Mine. The site was observed at one point, where the forest stand was rated suitable.

### **2.5.3.3 Humphrey No. 7 Mine Sites**

The selected study sites for the Humphrey No. 7 Mine are shown on Figure 6. The Humphrey No. 7 Mine sites are located near Interstate 79 in southern Greene County. The photographic base for the figure was prepared by combining the Oak Forest SE and the Garards Fort SW and SE DOQQs. Mine panel locations were based on maps of the Humphrey No. 7 Mine.

Study site D-1 is associated primarily with two longwall panels that were mined in 1995 and 1996. Observation of the site at two points indicated suitable forest stands. Study site D-2 lies south of study site D-1 and encompasses five longwall panels that were mined prior to 1990. The closest observation points were rated as suitable. Study site D-3 lies in a well-forested area to the northeast of study site D-1 and straddles Interstate 79. This study site was rated suitable based on one observation point and review of aerial photographs. It lies adjacent to a section of state game lands.