Final Report

Effects of Longwall Mining On Real Property Value and the Tax Base of Greene and Washington Counties, Pennsylvania

Commonwealth of Pennsylvania
Department of Environmental Protection
Bureau of Mining and Reclamation

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SUMMARY OF FINDINGS

This study was designed to determine if longwall coal mining has had an effect on residential property values, and the real estate tax bases of Greene and Washington Counties. In short, the study is intended to determine if there are broad relationships between longwall mining and the:

- Assessed value of residential properties.
- Sale prices of residential properties.
- Tax revenue available to the county

Since the research was intended to discover overall trends or common factors, the effort used generalized information (averages, approximate location, etc.) to examine these issues. Conclusions developed by the study are, therefore, general in nature. Individual properties may or may not conform to the following overall trends:

- There is a relationship between location with respect to longwall mining and the assessed valuation as determined by the county.

- There appears to be no consistent relationship between the sales price of properties and presence of longwall mining.

- There is a relationship between the number of assessment appeals and the amount of assessment appeals and longwall mining. While most property owners do not appeal taxes, more appeal in longwall areas than in similar non-longwall areas.

- Taxes generated from longwall operations exceed the tax reductions granted to surface properties overlying longwall mines.

- Total compensation (including damage and incidental expenses) provided by the coal companies for surface damage exceeds the total value reductions determined in assessment appeals. The experience of individual properties may vary.

The analysis period of 1993 to 2002 was selected to represent a period of significant mine development, to capture assessment appeals and assessment changes, to capture residential property sales, and to capture compensation claims and payments. With the exception of compensation records all analysis is based on available public records including:

- Property assessment records
- Sales records
- Historic mining records and maps

In addition, confidential coal company reimbursement records were examined. A

confidentiality agreement was used to allow the review of a portion of the records.

To complete the study, value as recorded by the individual counties had to be standardized. County assessment records show an assessed value as of the date of the assessment. The assessed value of property is related to an approximate market value (the value a property ought to sell for) by way of the assessment ratio. Each county uses different pre-established assessment ratios. These ratios are checked by the counties and the state each year to determine a "current ratio". For this study the assessed value was divided by the current ratio to estimate or imply a "county value" – a rough approximation of market value. This allowed the analysis to compare information across county lines and to compare tax revenue gained or lost by assessment appeal results and coal mine development. It must be emphasized that "county value" is used to make comparisons among groups of properties by type and location, it does not represent the fair-market-value of individual properties.

In summary:

- The study indicates that there is a much stronger correlation between the county value of residential properties and access to public utilities (sewer and water) than between the county value and proximity to longwall mining.

  The relationship between residential county value and mining is not consistent from place to place across either county. In contrast, the relationship between access to sewer and water is relatively consistent across both counties.

  While undoubtedly the real estate truism: "value is derived from three factors – location, location, location," is based in fact, in general, proximity to a longwall mine does not appear to be the major factor in determining "county value" and therefore assessed value. Other factors such as access to utilities (public sewer and water), proximity to major roads, density of residences, and the desirability of surrounding land uses appear more likely to influence the general taxable value (county value) of residential properties.

- The sales prices of residential properties sold during the study period was compared to the county value assigned to the property. The ratio of sales price to county value was compared to location with respect to longwall mining. There was no correlation between location with respect to longwall mining and the ratio of sales price to county value. Nearly the same proportion of properties sold for less than county value in the longwall areas as those that sold for less than the county value outside of the longwall areas. In fact, the proportions were nearly the same between longwall and non-longwall areas for properties selling for more than the county value and for properties selling at or near the county value.
- The statistical review did demonstrate that, on average, properties located above longwall mining operations are more likely to receive assessment reductions from County Assessment Boards than properties located

elsewhere in the County. Obviously, the reduction in value granted by the counties reduces the taxable value of the individual parcels. However, the total reductions to date represent only a small portion of the tax base within the longwall mining areas. Less than half of the longwall related properties that were granted a tax reduction were later restored to the higher valuation. Over time this would appear to have resulted in the slightly average lower per acre county value in the longwall areas than in the non-mining areas of the counties.

- Of the records examined, coal companies typically pay more to the landowner for damages than the landowner is granted in county value reduction. The statistical review showed that the aggregate of coal company payments for damages exceeds the aggregate county value reductions granted by the assessment appeal boards. Comparison of county value reductions and individual damage settlements vary widely.

- County tax revenue generated by coal mining is significant. In Washington County longwall mine operators account for nearly 5% of the tax base. In the more rural Greene County, longwall operators account for nearly 30% of the countywide tax base. In southwest Washington and northwest Greene counties, longwall operators represent 50% of the local tax and school district bases.

- Longwall mining operations tend to be located in the more rural and remote sections of both counties. Thus, for the most part, the operations do not affect the more densely developed surface areas. As a result, while the operations cause subsidence and may cause significant damage to individual properties, the damages tend to be limited to a relatively small number of structures. On a per acre basis, the coal parcels associated with longwall mining operations are typically assessed at higher values than most other property types within these remote and rural areas in either Greene or Washington counties. In fact, active longwall mining coal parcels are assessed at twice or more per acre values than other mining and five to ten time the value of reserve coal tracts. For the most part, coal taxes are based on the market value of coal and the quantity of minable coal in place. The longwall mining operations are assessed at higher per acre values than other mining operations because there is more minable coal available. They are assessed at least five times higher than reserve coal tracts because reserve tracts are considered speculative and are not now generating income.

- To date, the annual property taxes generated from longwall coal mining has more than offset the annual tax revenue lost from those surface property assessment reductions related to longwall mining. However, unless the surface value is restored, this offset may be temporary. As the coal is mined, the taxable real estate value is depleted.

One of the issues identified for study was whether property values decrease in anticipation of mining – does the announcement of future mining cause a reduction of property values? Most mining area boundaries were established before the beginning of the study period (1993) making analysis of potential value changes related to the anticipation of mining difficult. Ideally, the analysis would involve paired sales – sales of the same property before and after the announcement of the mine plan. There were too few paired sales to complete this analysis. Instead, county records for the three year period prior to initiation of individual mine panels were searched to find assessment reductions that might be related to the anticipation of mining activity. These reductions could be indicators of a general relationship between future mining and a general unsupported opinion of value. There were not enough of these changes to reach any conclusions. Most assessment reductions were assigned after mining commenced.

Longwall mining causes surface property damage. The amount of damage to individual structures varies widely – with some structures receiving little measurable damage and others receiving substantial damage. The study showed that, overall, homeowners are receiving more in compensation than they are claiming as losses for property tax reductions. The study also showed that, overall, the receipt of compensation is not reflected in a restoration of taxable value to the counties - either the compensation is not being used to repair the properties or the counties are not often notified when repairs are completed. The study showed that there is no distinguishable correlation between the difference in sale values and assessments as they relate to the location of longwall mining. Other factors appear to affect value more significantly than mining – sewer, water, road access, etc. Finally, the taxes generated from longwall operations are significant but temporary.

Individual property experiences may differ from the overall trends identified in this study. To the extent that these individual experiences may be instructive they should be studied. In theory, properties that were granted reductions in assessment value due to damage caused by longwall mining should return to their original value after repair or compensation from the mining company. Just over 5,000 improved residential properties are located in the longwall regions of both counties. Of these, slightly under 3,000 are located in areas where longwall mining was active from 1993 through 2002. The vast majority of these properties did not file compensation claims or assessment appeals during the ten year period. In theory:

- Owners of Properties damaged by mining should file for and receive compensation

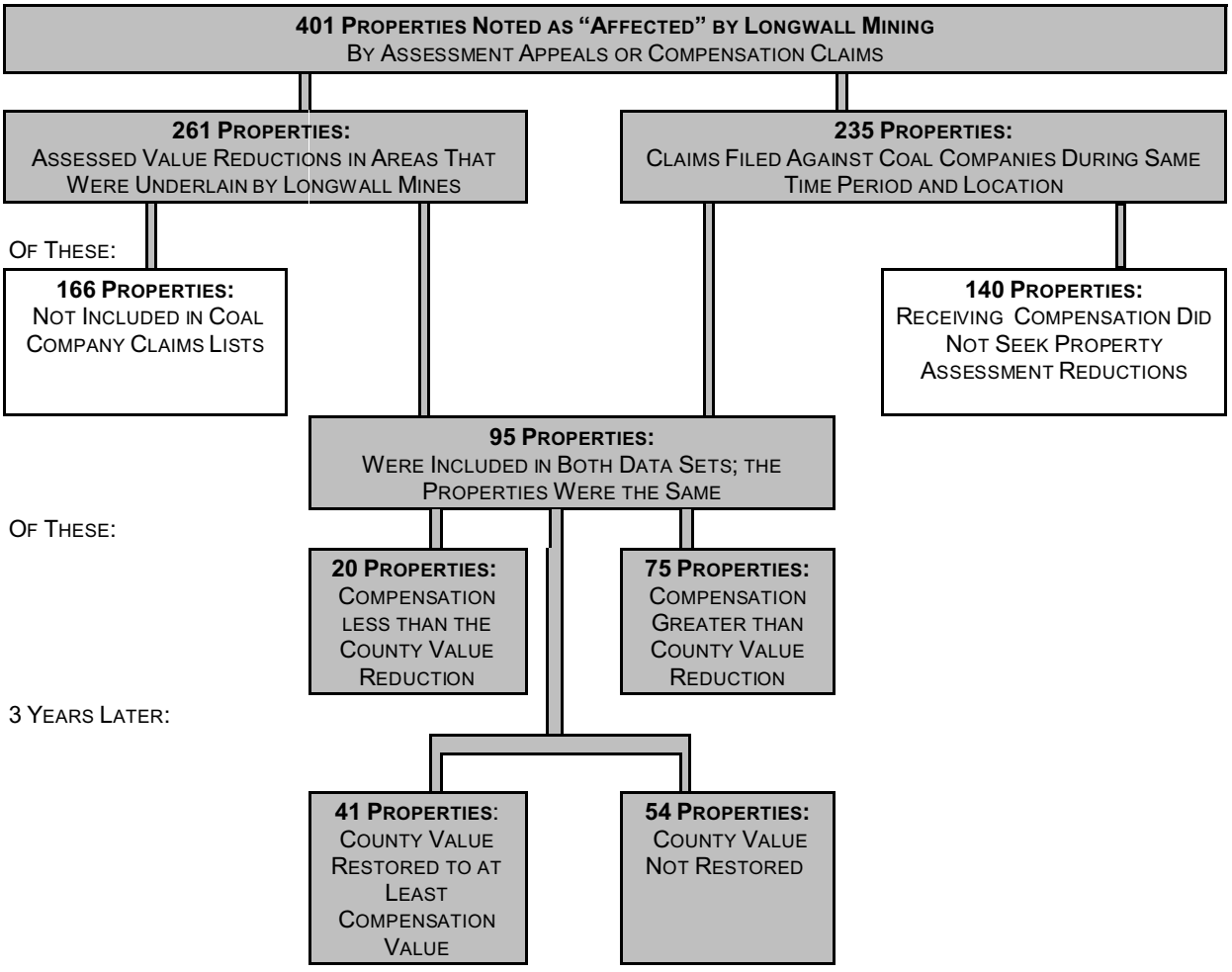
- Owners of Properties so damaged could also file for and receive either

temporary or permanent tax relief (reduction in county value)

- The value of the compensation should somehow relate to the reduction in county value granted.

- Properties restored by way of compensation should return to or exceed the original county value.

As shown below, not all of the properties that received assessment reductions filed for claims and not all of the properties that filed for claims received assessment reductions. Only 95 of the properties received compensation and assessment reduction. Also as shown below, very few of the properties were ever returned to the original values (54).



Future studies should focus on the evaluation of a subset of these 401 properties. The 95 properties where claims and assessment histories can be tracked could be studied in detail, if the home-owners and the coal companies agree to a releases of confidentially held settlement information. Additional studies might focus on:

- The rationale for not restoring the value to the original county value
- Not filing a compensation claim when an assessment appeal was filed
- Not filing an assessment appeal when a compensation claim was filed

This report will allow any future study to focus on specific issues at specific locations.

1.0 BACKGROUND

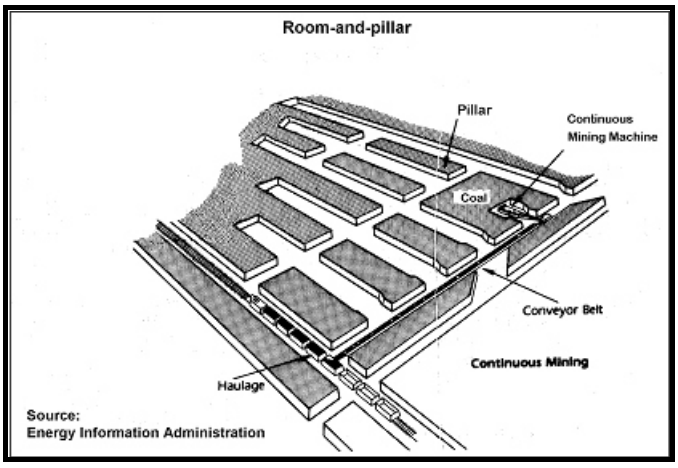
1.1 Introduction

This report analyzes the effects that longwall mining may have on property values and tax revenues in Greene and Washington Counties, Pennsylvania. Section 1 of this report provides basic information about the terms and concepts discussed.

1.2 Mining Methods and Mine Subsidence

Throughout this report, we refer to two types of deep-mining methods that have dominated Pennsylvania's underground coal mining: room-and-pillar mining and longwall mining. Before longwall mining was introduced, Pennsylvania coal miners used room-and-pillar mining to extract most of the deep coal produced in the state. Longwall mining was first used in Europe where it was found to be safer for miners and more efficient at extracting coal in mines where the equipment could be used. Today, longwall mining accounts for most of the coal produced in Pennsylvania. All of the currently active longwall mines in Pennsylvania are located in Greene and Washington Counties, where the Pittsburgh coal seam provides optimum conditions for using longwall technology.

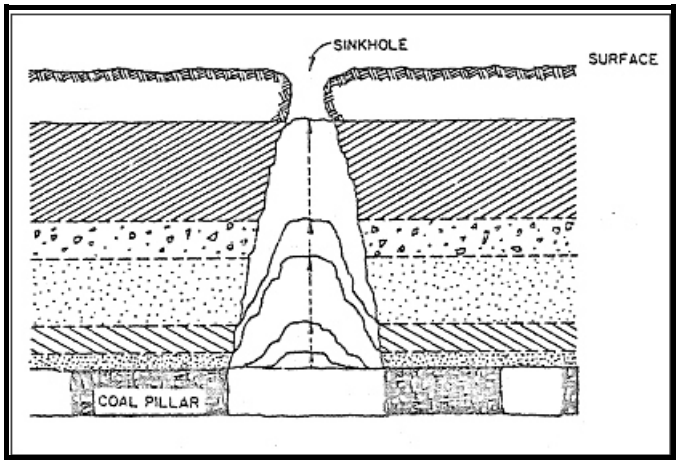
In room-and-pillar mining, intersecting tunnels of varying width and length are mined throughout a coal seam. The method leaves a checkerboard effect of empty "rooms" (mined-out voids) and unmined "pillars," which are blocks of coal left in place to prevent the ceilings of the rooms from collapsing on the miners. The pillars are essential to the further development of a typical room-and-pillar mine. Some of the protective pillars may be mined out (retreat mining) and some pillars may be left standing as mine operations end.



Room and Pillar Mining

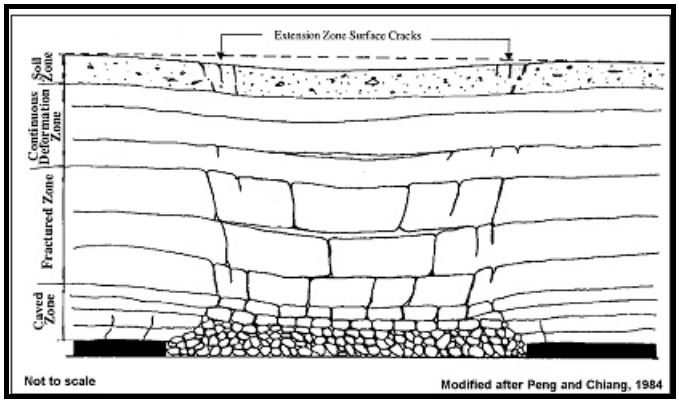
After a mine is closed (and often abandoned), pillars and ceilings can deteriorate over time from ground water flooding the empty rooms. When the pillars and ceilings rot, the rock above the ceilings can collapse without warning. As ceilings cave in, the downward movement of rock and soil can propagate up to the surface and cause subsidence, such as sinkholes or troughs. If a sinkhole, for example, is large enough, a house in its path can be damaged. Sinkholes and troughs may not occur above old room-and-pillar mines for 30 years or longer.

Sinkhole subsidence is also known as pothole subsidence because of the deep and narrow holes (tens of feet in depth and in diameter) created as the earth subsides. Sinkholes usually occur when the ceiling of a mine room falls between pillars or when pillars collapse. Typically where sinkholes form, the mine is at a relatively shallow depth below the surface. Because old room and pillar mines have often been abandoned and the mine operator has gone out of business, DEP offers Mine Subsidence Insurance as a low-cost, long-term solution to handle this risk.



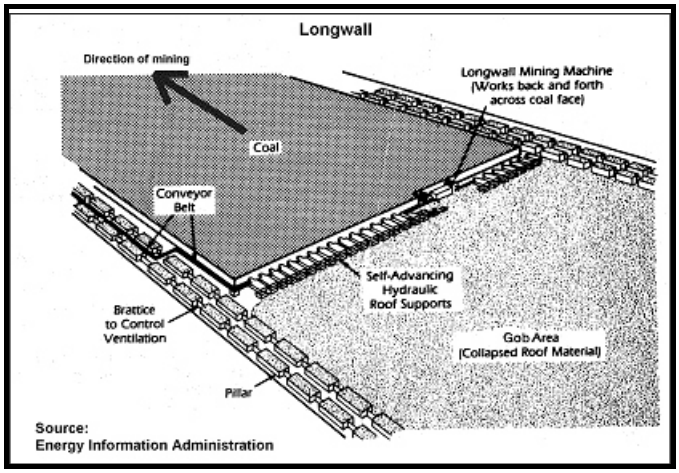
Sinkhole Subsidence

Trough subsidence looks more like a shallow and wide depression of a few feet deep and a 100 feet or larger in diameter. Troughs usually occur when pillars in an old mine deteriorate over a wide area causing larger roof collapses. Like sinkhole subsidence, trough subsidence over room-and-pillar mines usually occurs long after mining has ceased, but troughs can occur soon after pillars are removed during retreat mining. Troughs can be large enough to affect neighborhoods.



Trough Subsidence

In longwall mining, pillar-supported hallways(entries) are carved into the coal seam and wide (600 feet to 1,000 feet) panels of coal to be mined with longwall mining machinery are left between these entries. The entries provide access and ventilation to the workers and to the equipment mining the panel. Along the face of the panel, a longwall machine digs out all of the coal in its path across the seam between the entries. The machinery incorporates a system of supports that cover it and prevent the ceiling of the



Longwall Mining

mine from collapsing and burying it and its operators. As a longwall mining machine moves forward into the coal seam, however, its supports move with it, and the ceiling behind the supports, which is no longer supported, collapses. The movement of falling rock and debris can propagate up to the surface of the earth as a large subsidence trough and can cause damage to overlying property.

Trough subsidence is the predominant subsidence associated with longwall mining where wide and long blocks of coal are completely mined out. A typical longwall panel today may be 1,000 feet wide and 10,000 feet long. Most trough subsidence occurs concurrently with longwall extraction of the coal, but residual subsidence may occur several months to a year after mining. Complete subsidence may take a year or two, and may be affected by mining of an adjacent panel. Important to this study, subsidence from longwall mining occurs while the mine operator is still in business and is legally bound to pay for damage to the surface. Research on the effects of subsidence on manmade surface structures and on springs, wells, and streams is discussed in Section 2.3 of this report.

Recently published reports required of the Pennsylvania Department of Environmental Protection (DEP) expand on these discussions. The four illustrations shown in this section are taken from these reports. Pennsylvania law that requires the DEP to assess the surface effects of underground mining on structures, water supplies, and streams every five years. The study period began in 1993. To prepare the report, DEP compiled information on 1,884 properties that were undermined between August 1993 and August 1998. A supplement to this report was published in February 2001. The supplemental study revealed that subsidence damage from underground mining was reported on nearly half of the properties in the study area. Of these properties, 70% of the damages were resolved by the time the study was published. As required by law, the mine operators had provided temporary and replacement water supplies, repaired land and structure damage, and compensated property owners.

1.3 Coal Ownership, the Estate of Coal, and the Right to Subside

Who owns the coal beneath the surface of land in Pennsylvania? Who owns the rights to extract coal from beneath the surface? Why are coal companies allowed to extract coal in a manner that can lead to subsidence and surface property damage? The answers to these questions lie within Pennsylvania's legal definitions of real property, which includes rights to the surface, support of the surface, and the subsurface, including underground coal.

Title to all real property (real estate) in Pennsylvania, if traced back to the original title, includes full ownership rights to both the surface and the subsurface. Over time, many owners of real estate chose to convey by sale or lease their rights to subsurface coal to others, including mining companies. Often owners also sold or leased their right to the support of the surface, which, in essence, conveyed the right to mine the coal. With these transfers of property rights, a mine operator could mine subsurface coal without further

encumbrance. Without the right of support, a surface owner had little recourse when surface damages were caused by underground mining of the coal.

Before 1966, the rights to support of the surface were defined only in a property's title, as described in a property deed. The Bituminous Mine Subsidence and Land Conservation Act of 1966 modified those rights and provided many homeowners with protections against subsidence damage, which were not contained in their deeds. However, many others were left without such safeguards.

In 1994, Act 54 amended the 1966 Act to require mine operators to compensate all homeowners for damages caused by their underground coal mining operations. At the same time, Act 54 removed most rights that surface property owners had to the support of the surface, thereby allowing mine operators to mine under and cause damage to almost any structures. By passing Act 54, the General Assembly of the Commonwealth intended both to protect surface property owners from economic loss and to provide the coal mining industry in Pennsylvania a means to remain competitive in the world market.

With this study, DEP is seeking to learn the following:

- How does longwall mining activity affect the value, in general, of homes on the overlying surface property?
- If longwall mining affects the value of homes on the overlying surface property, how does such mining affect the property taxes that Greene and Washington Counties collect from homeowners?
- If longwall mining affects the property taxes that homeowners pay, how do the taxes that coal companies pay offset any gains or losses from homeowners' taxes?
- How does longwall mining affect the taxes that coal companies pay on mined coal and the remaining coal reserves?
- Does longwall mining impact the value of properties scheduled to be undermined?

2.0 NATURE AND SCOPE

2.1 Methodology and Overview

Resource Technologies Corporation was engaged by the Pennsylvania Department of Environmental Protection to analyze and report the effects that longwall mining may have on the value of residential properties and on the property tax bases of Greene and Washington Counties, PA. Two methods were considered to conduct such a study.

Method 1. Evaluate individual properties on an in-depth basis. By definition, this procedure would focus on specific properties damaged (or claimed to be damaged) by longwall mining activities. Because of time and financial limits this method could only have worked by using a small sampling of properties. Such a site-specific procedure could not adequately consider properties that have not been damaged by mining activities, nor properties not within the longwall mining areas. This method was rejected because of its limitations and because it would potentially violate confidentiality agreements between mine operators and home owners.

Method 2. Evaluate all real property sales and assessment data available. By definition, this method would require working with the different data sets to allow a fair comparison of sales and assessments. Similar data sets could be obtained from both counties, which maintain property assessments, assessment appeals, and sales records by tax record number. The tax record number contains a location coordinate (tax map number) that could be used to fix the general location of properties on a map. The maps could then be used to track the relationship of property value to longwall mining.

The average tax map in both counties contains approximately 350 acres and encompasses approximately 50 properties, with the average property containing 10 acres. To maintain privacy, individual properties included in the study would not be located precisely on any map (average location resolution is approximately 3,500 feet – that is, a property can be mapped within about three-quarters of a mile of the actual location). The longwall mines tend to be located in less densely populated areas of the counties. The average tax map in the longwall areas contains nearly 1,000 acres and encompasses approximately 40 properties, with the average property containing 25 acres. The tax map location number in the more rural longwall areas provides an average resolution of approximately 6,000 feet.

This method would rely on statistical analyses of summary data from property sales, county property tax assessments, and assessment appeals.

Method 2 was selected for this study because it protects the privacy of information on specific properties, while providing a comprehensive overview of trends and relationships between property values and longwall mining. Method 2 also provides a baseline of information that can be used in future studies of longwall mining's effects.

This report presents the results of a comprehensive study of the effects of longwall mining on the value of surface property and on Greene and Washington Counties' real estate tax bases. The report presents the results of statistical comparisons of sale prices and assessed values in areas overlying longwall panels and control areas without mining (Area Sets). The comparisons were carried out on two area sets in Washington County and three area sets in Greene County.

The report also evaluates the effect that longwall mining has on the rate of coal extraction and the effect the rate of extraction has on tax receipts from coal reserves and mined coal. Finally, the report addresses how tax revenues on longwall coal reserves, insurance claim payments, and coal company settlements offset potential property value losses.

The following questions are addressed:

1. Is there a quantifiable effect on the value of residential surface properties that overlie longwall operations?
   - A. Is there a relationship between proximity to longwall mining and sales price of properties?
   - B. Is there a relationship between proximity to longwall mining and assessed value?
   - C. Are there other factors that influence differences in value and do these factors relate to longwall locations?

2. What taxes are generated by longwall operations and how do they relate to other taxable real estate?
   - A. How do these taxes offset any gains or losses from homeowners' taxes?
   - B. How does longwall mining affect the taxes that coal companies pay on mined coal and the remaining coal reserves?

3. Does longwall mining impact the value of properties scheduled to be undermined?

Among homeowners, some will say that no amount of money can compensate for the fear and worry of one's home being undermined. Others will say they have been fully compensated, and still others will say their property was not damaged when the longwall passed underneath.

Among the coal operators, some will say that property owners are "made whole" by the payments that compensate for damage and inconvenience. In some cases, these payments exceed the appraised value of the structure in question. In other cases, the

operator may have paid the minimum possible, or legal issues may have resulted in delays. In some cases, the operator may deny responsibility.

Using a geographic information system (GIS), this study investigated the relationship of property values to mining, looking specifically at assessed values and at sales of surface properties over a ten-year period. This period corresponds with the availability of data. Where available, data such as county tax assessment files that predate this time span were used as well. Maps of longwall panel development over time and maps of areas mined using room-and-pillar techniques were used to assess the effects on surface properties. Areas where no mining has occurred were used for control, and areas where longwall mining has been announced but has not occurred were studied.

Data for the geographic analysis (GIS coverage) for Greene and Washington Counties include:

- Boundaries of longwall permit areas
- Outlines of all longwall panels and dates of completion
- Boundaries of sewer delivery districts
- Boundaries of water delivery districts
- Center lines of paved roads
- Outlines of all tax maps (1:400 scale tax assessment property maps)
- Addresses of all properties receiving damage compensation from coal companies
- Location of all subsidence insurance claims on file with the DEP Mine Subsidence Insurance program
- Location of all reported subsidence incidents handled by the U.S. Office of Surface Mining and Reclamation
- Boundaries of all closed, abandoned, or depleted mines
- Boundaries of all surface parcels in Greene County
- Digital assessment records for both counties (geocoded to tax maps)

This report is intended to serve as a baseline to analyze property value changes in Greene and Washington Counties. Follow-up research to this report would be a traditional assessment on areas of the counties addressed herein. Such follow-up would serve two purposes: first, as a field verification for the GIS approach used in the study that produced this report, and second, as a test case for improving efficiency of traditional assessment by targeting predefined areas of a county.

2.2 Background

Coal remains an essential part of today's energy production in the United States. More than 90% of the nation's coal is used to generate electricity. Nationwide, the electric utilities generate 51.4% of all electricity from burning coal (Freme, 2000). All other fuel sources – petroleum, natural gas, nuclear, hydro, wind, solar, and geothermal, combined – generate the remaining 48.6% of electricity used in the residential, commercial, and industrial sectors of the United States. In Pennsylvania, the percentage of electricity generated from coal is even higher – approximately 60%. In 1999, Pennsylvania's electric utilities produced 96,023,410,000 kilowatt hours of electricity that powered 5,104,483 consumers in the state. Among the consumers, approximately 43% were residential, 26% commercial, and 30% industrial (Energy Information Administration, October 2000).

Although a few room and pillar deep mining operations still are producing coal the primary underground coal mining in Greene and Washington Counties in southwestern Pennsylvania uses the deep-mining technique known as longwall mining. This technique was first developed and extensively used in European coal fields. Introduced into Pennsylvania in 1967, longwall mining has grown in use as the larger coal mining companies apply this more efficient and productive coal extraction technique. Coupled with the highly efficient production rate is simultaneous and ongoing surface subsidence that conflicts with existing surface usage. While the subsidence movements and effects on the surface can largely be predicted, conflicts arise when surface features and structures are involved. While most of the large longwall operations to date have occurred in sparsely populated areas, some recent mine operations, particularly in Washington County, have occurred under populated areas and major roadways.

Extracting coal from tens to hundreds of feet below the surface produces the potential for surface subsidence, regardless of the mining technique used. Mining technique, however, can offer insight into the time frame when subsidence may occur. In room-and-pillar mining, subsidence can occur 30 years or more after a mine is closed – and often abandoned, whereas in longwall mining, subsidence occurs concurrently with mining and in certain circumstances can continue for almost two years. In contrast to room-and-pillar, longwall mining offers government and homeowners the benefit of having an active mine operator on the scene to repair damages.

Wherever rock or mineral is removed from underground, the void created will translate through the overlying bedrock and surficial material. The extent and control of surface movement depends on several factors, including the thickness of the mined coal, the mine geometry and mining methods, and the thickness, rock type (lithology), structure, and hydrology of the overburden (Dunrud, 1984). Much research has been done over the past 30 years in subsidence prediction and mitigation and is discussed in Section 2.3.

The political boundaries of Greene and Washington Counties encompass one of the nation's most renowned coal seams, the Pittsburgh seam. The Pittsburgh coal seam is a

single, persistent bed, with an almost horizontal structure and a thickness of four to ten feet (average six feet) across the two counties. The thickness of the overburden above the seven active longwall mines in the two counties ranges from 380 to 1,150 feet (Fiscor, 2001). The seam's structure makes it ideal for mining using the longwall technique, and the coal's lower sulfur content – typically less than two percent in these counties – makes it environmentally and technically desirable for a multitude of uses (Shultz, 1999).

Mining in the Pittsburgh seam began in Greene and Washington Counties more than a century ago where the coal outcropped along the Monongahela River and its tributaries. Despite the extensive mining of the past, the bulk of Pennsylvania coal at present – more than 80 percent – is mined from the Pittsburgh seam. Of the coal mined today, 99 percent of Pittsburgh seam coal is mined in Greene and Washington Counties. Deep mining also occurs in the Sewickley coal seam in southeastern Greene County, but it is minor by comparison (Table 2.2-1).

Table 2.2-1. Coal Production in Bituminous Deep Mines (2000)

Coal Seam	Greene County		Washington County		Pennsylvania	
	Tonnage	% of PA Total	Tonnage	% of PA Total	Tonnage	% of PA Total
Sewickley	277,872	0.48%	0	0.00%	277,872	0.48%
Pittsburgh	37,506,037	64.18%	9,283,762	15.89%	47,256,740	80.87%
Other Bituminous	0	0.00%	0	0.00%	10,903,791	18.66%
Total	37,783,909	64.66%	9,283,762	15.89%	58,438,403	100.00%

Source: Pennsylvania Department of Environmental Protection, *1999 Annual Report on Mining Activities in the Commonwealth of Pennsylvania*, revised June 2000.

The methods used for deep mining include conventional room-and-pillar, continuous mining room-and-pillar (with or without retreat mining), and longwall mining. With room-and-pillar mining, there is the possibility of leaving pillars of coal to support overlying structures, but in retreat mining, most pillars are removed. Room-and-pillar mining with retreat removes 80% to 90% of the coal. With longwall mining, continuous mining machines are used to set up the work areas for 1,000-foot-wide panels of coal that extend 10,000 feet or more in length. Within these panels longwall machines have the potential for removing 100% of the coal.

2.3 Subsidence Research