APPENDIX E: Location of Mining Activity

E.1 – Spatial Patterns in Mining During 5th Assessment Period

The distribution of acres mined in the ten Pennsylvania counties was not uniform. Three geological factors responsible for the lack of uniformity were identified in the 4th assessment that still apply in the 5th assessment period:

1. The occurrence of bituminous coal thick enough to be extracted with modern mining techniques,
2. The overburden above the minable coalbed greater than 100-ft but less than 1,200-ft. At present there is very little coal mined at depths greater than 1,200-ft in Pennsylvania, and
3. The coal has sufficient quality to compete in either the electric generation or metallurgical markets.

The ten Pennsylvania counties listed in Figure E-1 have all these geological factors but they occur in varying quantities and qualities. As a result, Green and Washington Counties, contain thick deposits of the Pittsburgh coalbed (nominally 7-ft thick) with acceptable overburdens for longwall mining of 600 to 1,000-ft and quality that meets current electric generation requirements. The other eight counties mine the Freeport and Kittanning Coalbeds (nominally 4-ft thick) with acceptable overburdens for room-and-pillar mining of 300 to 600-ft and quality that meets metallurgical coal requirements. Greene County had the most mining activity during 5th assessment period, with eight active mines. However, five of the active mines were longwall mines. The remaining active longwall mines, Enlow Fork and Tunnel Ridge were in Washington County which had the second most mining activity occur. The remaining counties had all the room-and-pillar mines dispersed over them. These county trends are expected to continue unless the fundamental geological factors listed above are changed by mining technology or market requirements.

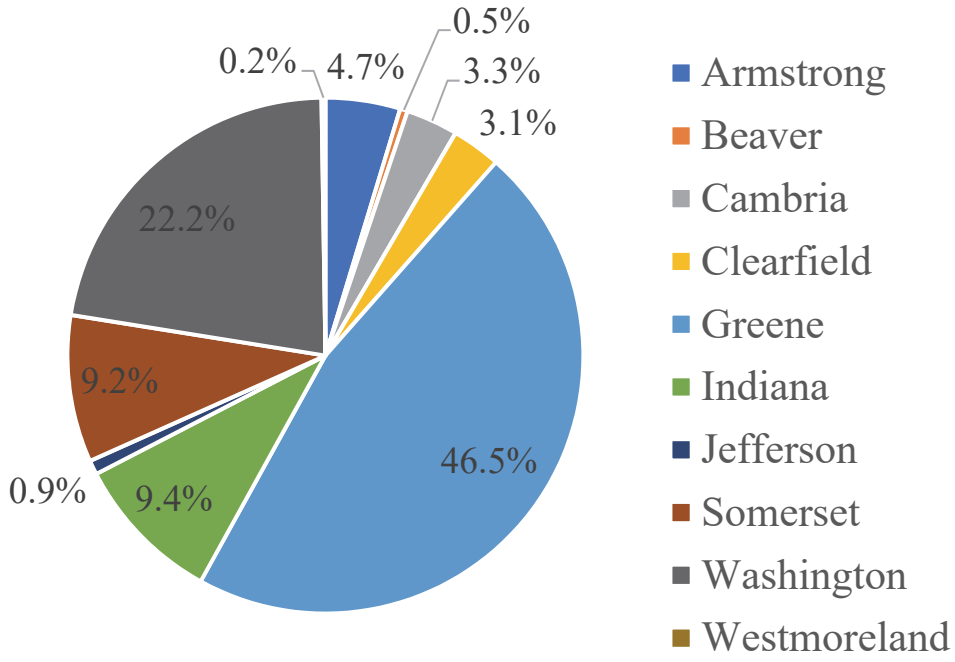

Figure E-1 Percentage of Total Area undermined in Pennsylvania during the 5th assessment period by county

E.2 - Stratigraphic Influences on Mining (Mining in Different Coalbeds)

Pennsylvania is the third largest producer of coal in the nation (U.S. Energy Information Agency, 2019). The coal resources in Pennsylvania are contained within the Pennsylvanian and Permian Geological Systems, however in the 5th assessment only coalbeds located in the Pennsylvanian System were mined. These strata are from 299 to 318-million years old (U.S. Geological Survey Geologic Names Committee 2007) and range in thickness from 1,300-1,500-ft (Edmunds et al. 1999). The six most commonly mined formation in this region of the Pennsylvanian System (Figure E-2):

- Uniontown-Late Pennsylvanian shales, sandstones, and thin coalbeds
- **Pittsburgh**- minable coalbeds, shales, sandstones, and limestones
- Casselman-claystones, shales, sandstones, and thin limestones
- Glenshaw-claystones, shales, sandstones, and thin limestones
- **Allegheny**- minable coalbeds, shales, claystones, sandstones, and limestones
- Pottsville- early Pennsylvania shale and sandstones

Figure E-2 shows the stratigraphic columns for the two coal bearing formations within Pennsylvania. All coalbed mined in the 5th assessment period were part of the Allegheny and Pittsburgh formations.

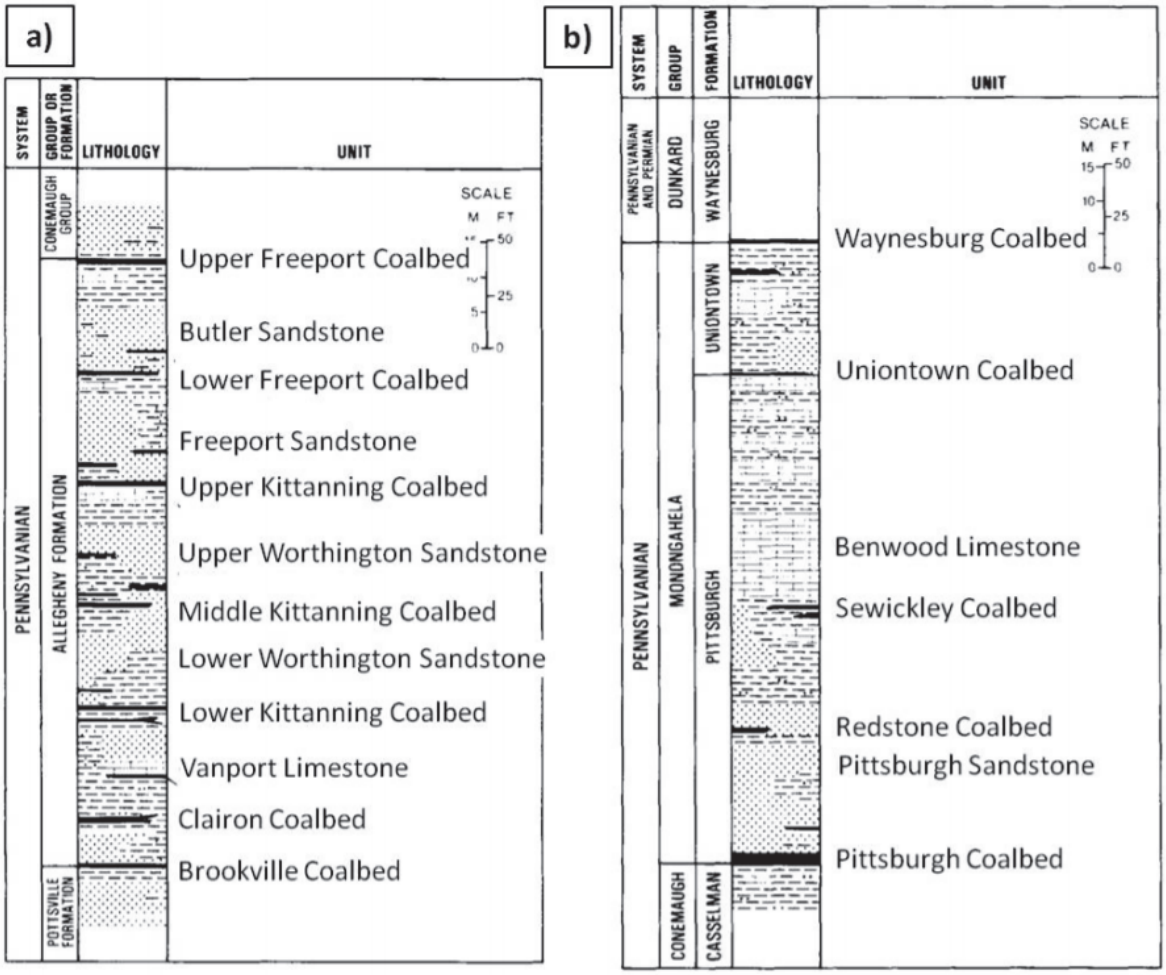

Figure E-2. Stratigraphic sections of the (a) Allegheny and (b) Pittsburgh formations and the minable coalbeds contained in them (Edmunds, et al. 1999).

E.2.1 -- Coalbeds Mined

The complete listing of bituminous coalbeds mined underground in Pennsylvania over the last 15 years are shown in Table E-1. The Lower Kittanning Coalbed has had the highest number of mines (n=42). The Middle Kittanning and Brookville coalbeds have been mined in the 5th assessment for the first time in 15 years. Several mines have mined more than one coalbed, i.e. Heilwood, Starford, and Crooked Creek

Table E-1. Coalbeds with active mines, listed by number and formation.

Formation	Coalbed	Number of Mines		
		3rd Assessment	**4th Assessment**	**5th Assessment**
Pittsburgh	Sewickley	5	4	3
	Pittsburgh	9	7	7
Allegheny	Upper Freeport	14	9	10*
	Lower Freeport	2	3	6
	Upper Kittanning	8	8	7*
	Middle Kittanning	0	0	2
	Lower Kittanning	12	15	15*
	Brookville	0	0	1*
Total		50	46	49

**Heilwood mined the Lower Kittanning and Brookville coalbeds, and Crooked Creek mined the Upper Freeport and Upper Kittanning coalbeds.*

Eight coalbeds were actively mined in the 5th assessment period. The longwall mines exclusively extracted the Pittsburgh coalbed within the Pittsburgh formation. The Pittsburgh coalbed, unlike most of the other minable coalbeds in Pennsylvania, is both persistent in thickness and quality over large area of Washington, Greene, Fayette, Westmoreland, and Allegheny Counties. Three of the pillar recovery mines extract the Sewickley coalbed in the Pittsburgh formation. All room-and-pillar mines and one pillar recovery mines extracted the remaining six coalbeds in the Allegheny Formation.

The Pittsburgh coalbed lateral consistency in thickness and quality have made it a premier target for the longwall mining method (Figure E-3). The Pittsburgh coalbed extracted the highest number of acres in all three assessment periods for this reason. Within southwestern Pennsylvania, the Pittsburgh coalbed has a consistent thickness averaging 7-ft and ranging from 0 to 11-ft. The other coalbeds located in the Allegheny formation are not as consistently thick. Because of this, the room-and-pillar mining method is preferred over the longwall mining method.

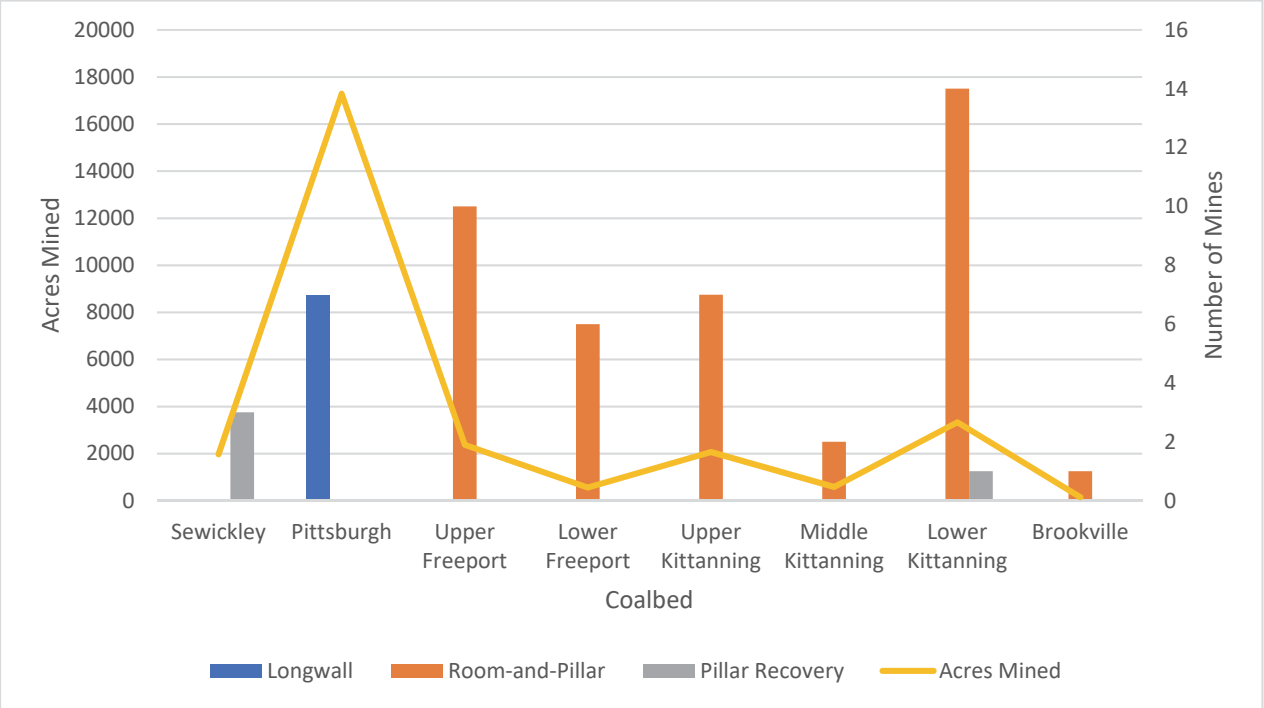

Figure E-3. The number of mines and acres mined per coalbed.

The range in areas mined during the 5th assessment period is shown in Figure E-4. Enlow Fork, a longwall mine, has extracted the largest area and Roytown, a room-and-pillar mine, has extracted the smallest area.

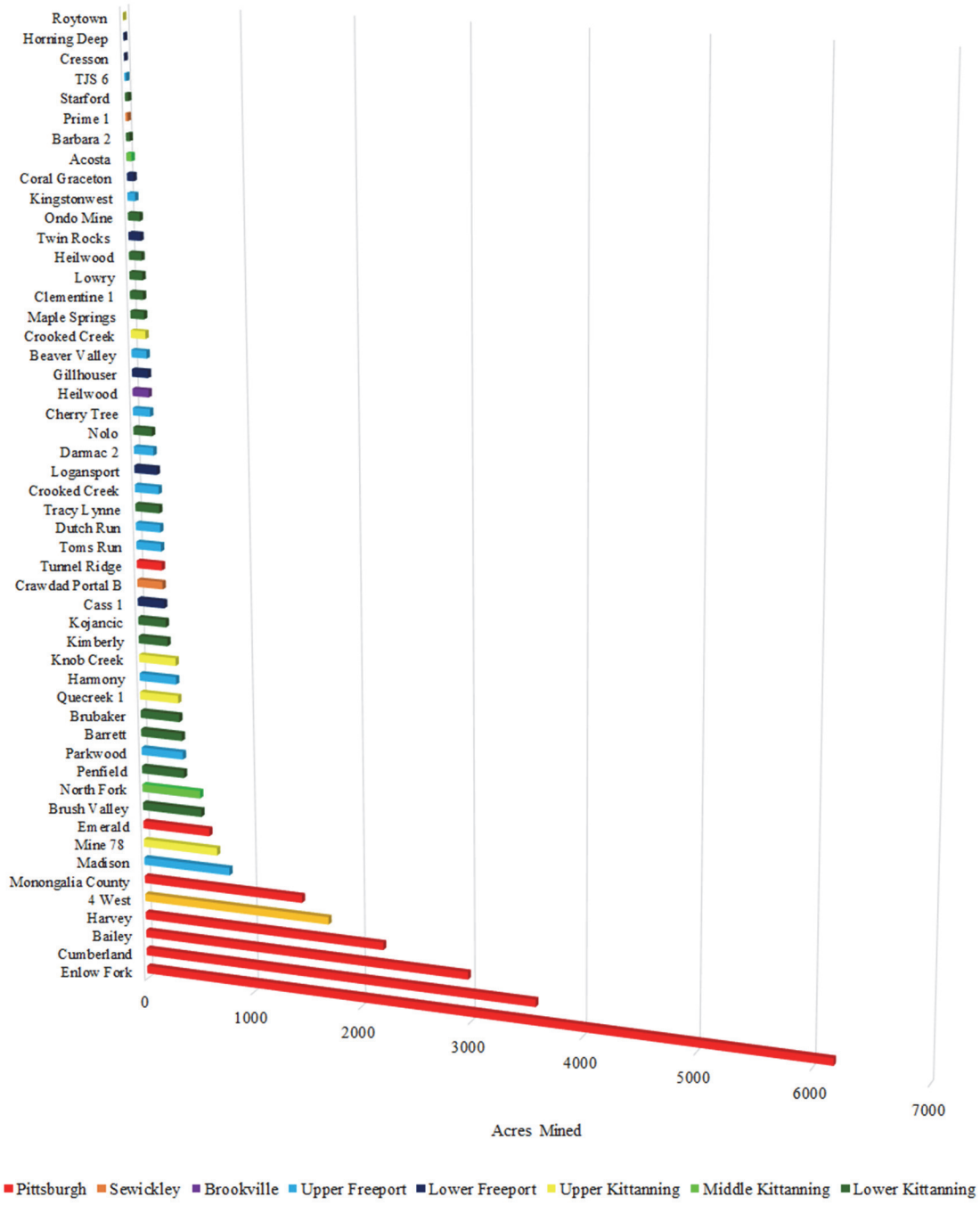

Figure E-4. Areas mined and coalbeds for all 49 mines for the extent of total mining. It should be noted that this only counts areas mined within the state of Pennsylvania, as some mines span across state lines. Two mines also appear twice on this chart because they mine two coalbeds.

E.3 - Future Mining Trends

In the Introduction (Section 1) and Appendix C the importance of coal mining in Pennsylvania in the past as well as the projected demand for it in the future was discussed. In sections above, the dominance of the longwall mines in the Pittsburgh coalbed has been demonstrated. In this subsection, the future mining trends within the Pittsburgh coalbed is analyzed specifically as it relates to overburden conditions and unmined reserves.

E.3.1 - Data Collection

All Pittsburgh coalbed longwall mines active during the 5th assessment period were verified from 6-month mine maps obtained through the PADEP permit files. The older mines of the Pittsburgh coalbed were obtained through the PADEP abandoned mines database found on the Pennsylvania Spatial Data Access (PASDA) site. To date, thirteen longwall mines have operated since the introduction of longwall mining in the late 1960s. It should be noted that over 300 longwall panels were mined in coalbeds other than the Pittsburgh. All of these mines ceased operation by the mid-to-late 1990s. The following analysis focuses on the future longwall mining in the Pittsburgh coalbed. The University does not have sufficient information available to do a similar analysis of future room-and-pillar mining in Pennsylvania.

E.3.2 - Changes in the Pittsburgh Coalbed

The outline of the thirteen Pittsburgh coalbed longwall mines is shown in Figure E-5. This figure also shows the changes in overburden. The overburden values of the unmined areas should be noted because these areas show variable overburden conditions within the 5th assessment periods. The northern area of the coalbed has shallower overburden ranging from 100 to 300-ft while the southern area has overburden exceeding 1,000-ft. The average overburden in the 5th assessment period was previously calculated at 810-ft, which is higher than previous assessment periods. The unmined permit areas of the active mines in the 5th assessment period were all located in areas of deeper overburden except for the Tunnel Ridge Mine. So as future mining continues the operators will encounter deeper overburden (Section E.4.4.). As overburden increases, stress within the surrounding strata and methane content increases. These factors require innovations in mining equipment and methods to keep pace with these ever-present hazards.

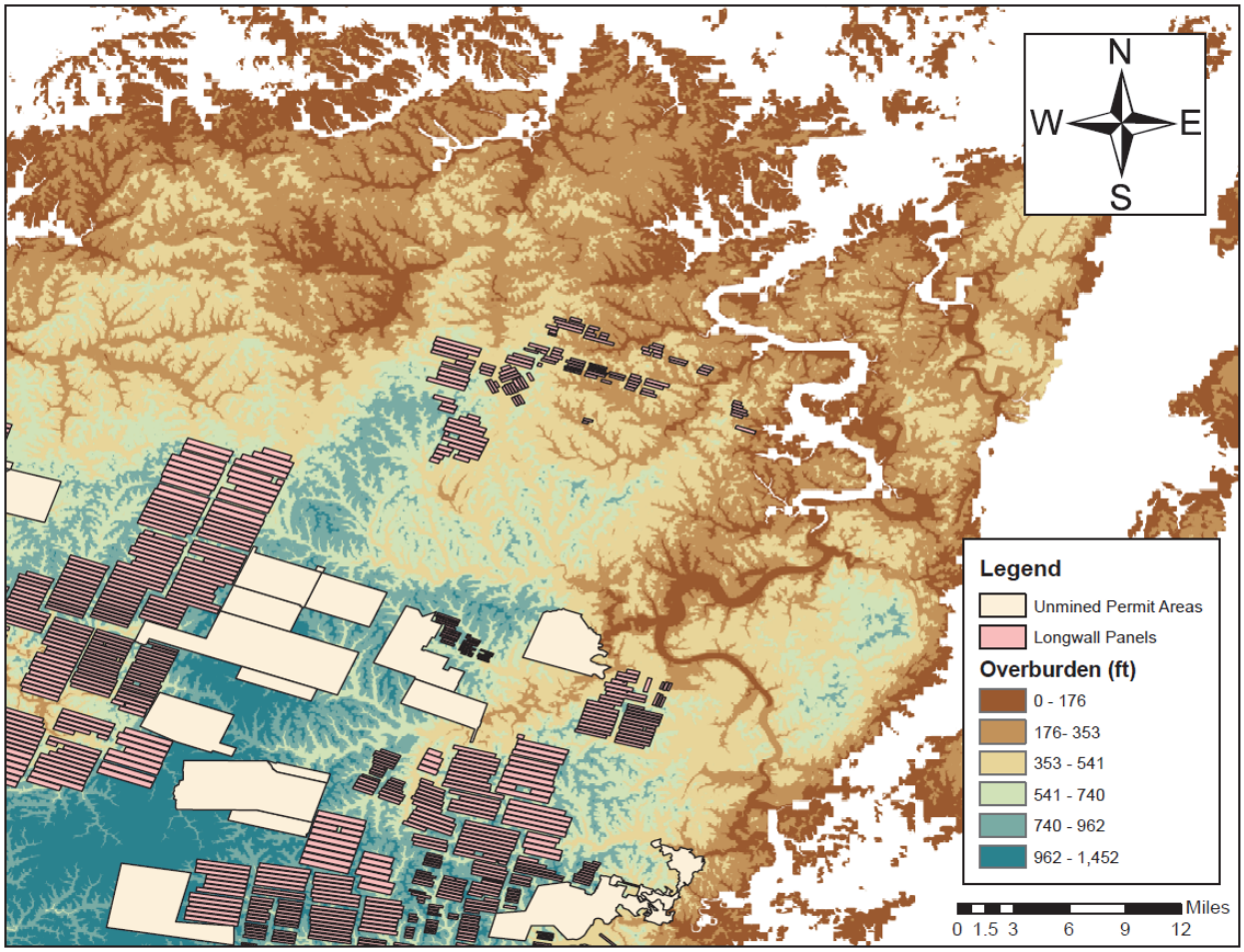

Figure E-5. Map showing the longwall mines in the Pittsburgh Coalbed. The map shows areas that have been mined and the unmined permit areas.

E.3.3 - Assumptions

This analysis of future mining assumes that technology will continue to allow for deeper longwall mining, especially for the kinds of overburdens that will occur in the future mining. This assumption is backed by the manner in which mining technology has evolved and adapted to changing conditions over the last 50 years. Figure E-6 demonstrates this capability by showing how longwall panel widths have increased through time. The wider panels are needed to allow for a decrease in gate road developments cost and an increase in resource recovery.

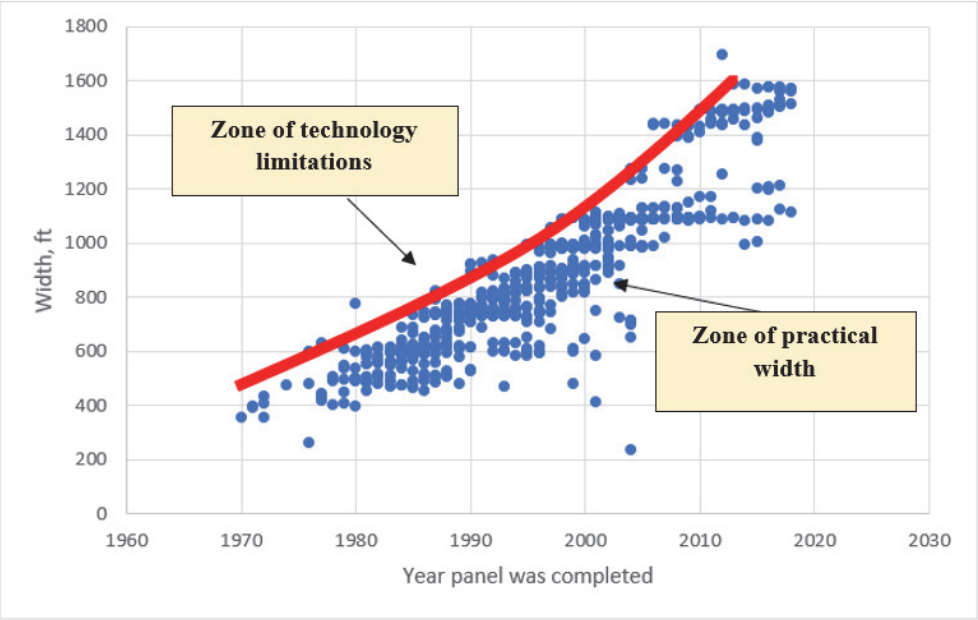

Figure E-6. How technology advances longwall mining of the Pittsburgh coalbed has influence panel width.

The need to increase panel width, and therefore overall size, is sometimes opposed by the continuity of the Pittsburgh coalbed. Geologic anomalies like sandstone paleochannels can restrict longwall mining. Another issue is landownership. Lastly, panels are also being impacted by the placement of existing and planned gas wells.

E.3.4. - Future Longwall Mining

The area depicted in green on Figure E-7 is the unmined area of the Pittsburgh coalbed. Using the trends established above and assuming that half of the reserves will eventually be mined, approximately 50 % of 280,000 acres of Pittsburgh coalbed will be mined in the future. If this reserved is mined at a rate of 3,500 acres/year, approximately 40 years of Pittsburgh coalbed longwall mining remains in Pennsylvania.

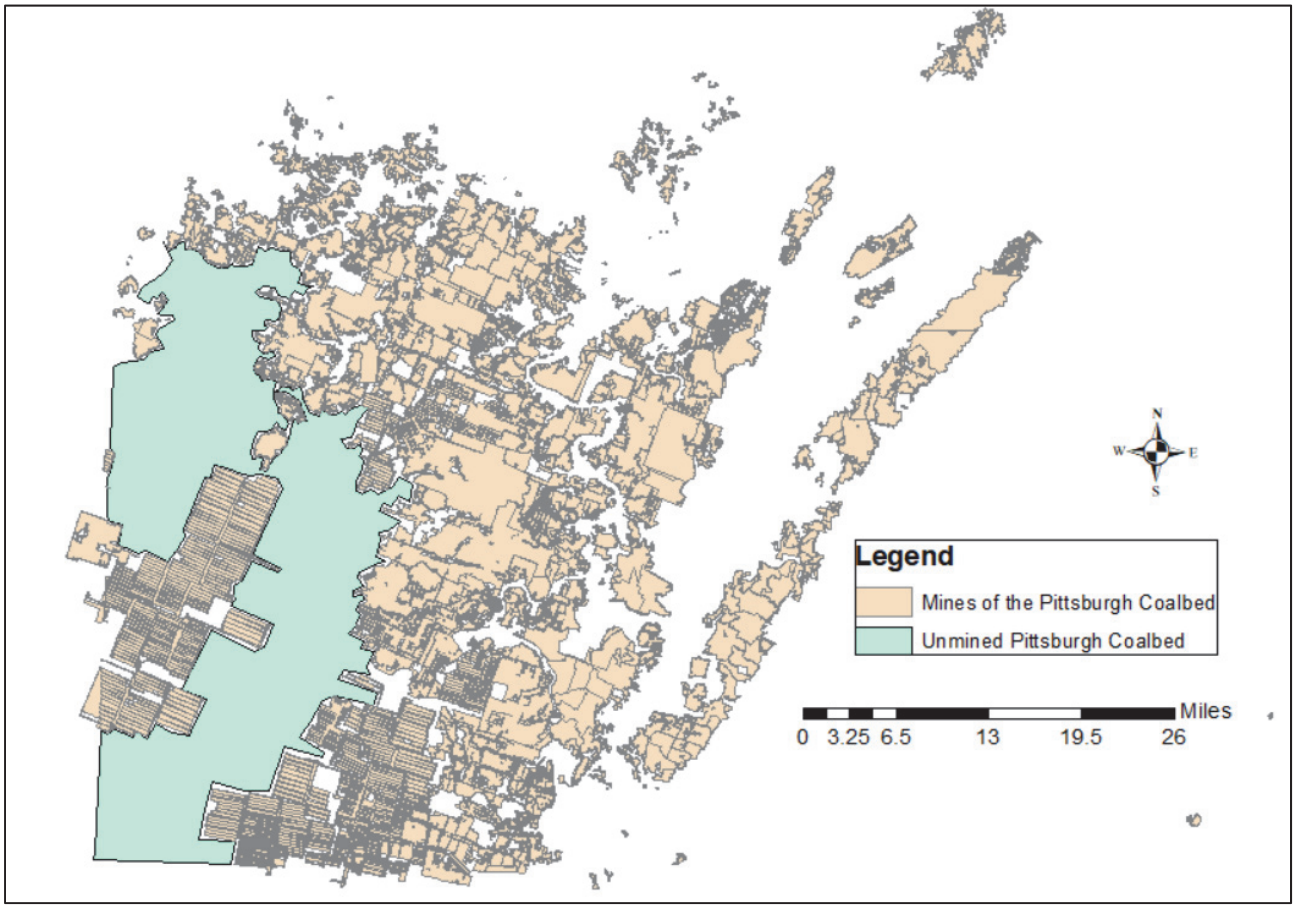

Figure E-7. Location of unmined Pittsburgh coalbed in southwestern Pennsylvania.

During the 4th assessment period there was a predicted 37 years left of mining in the Pittsburgh Coalbed. The increase in years of predicted mining from the 4th assessment to the 5th assessment can be attributed to the decreased mining rate from the 4th assessment (4,161 acres/year) to the 5th assessment (3,500 acres/year). The decreased longwall mining rate is because most longwall mines have lowered their operating hours over the last 5 years. Mines that were once working 7 days a week have dropped to operating 5 days a week.

As mentioned in Section 3.F.2 the unmined permit areas in Figure E-7 are areas of future mining typically over a 5-year period. An analysis of the overburden in the unmined permit areas shows that the average depth of these areas will be 858-ft (Table E-2). This is a 5 % increase in overburden from the 5th assessment period. The maximum overburden value is also a 5 % increase from the deepest portion of the Monongalia County Mine in the 5th assessment period. So, from this analysis it can be concluded that mining of the Pittsburgh coalbed, and hence the longwall mines in Pennsylvania, will occur at greater overburdens during the next assessment.

Table E-2. Unmined longwall permit area of the Pittsburgh coalbed overburden statistics.

Average	858-ft
Max	1364-ft
Min	97-ft
Standard Deviation	220-ft

References

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U.S. Geological Survey Geologic Names Committee (2007) Divisions of Geologic Time - Major Chronostratigraphic and Geochronologic Units, US Geological Survey: 2 p.

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