# Section 6: Land Damages

## 6.A - Overview

The University of Pittsburgh analyzed data collected from the state and mining companies to assess the damages done to land from underground mining from 21 August 2013 to 20 August 2018. There were 3,296 land parcels undermined and 124 land "Reported Effects" to the PADEP. Of this total, 66 were found to be "Company Liable." The University investigated the following:

- the number and percentage of impacts a) reported to the PADEP or reported effects; and b) determined to be the responsibility of the company to fix or compensate the property owner or company liable,
- the length in time it took to reach a final resolution,
- the location of the impacts, and
- the type of impact that occurred.

The number of land impacts that occurred in the previous Act 54 Assessments analyzed by the University were compared with the most recent data to examine how land impacts have changed over 15 years.

## 6.B - Data Sources

The land impacts were identified based on the parcel IDs used to identify property ownership. The property lines were obtained through:

- 6-month mine maps submitted to the CDMO,
- AutoCAD maps provided by the mining companies, and
- ArcGIS property lines shapefiles for Washington and Greene counties.

Land impacts were obtained from the BUMIS database updated by the CDMO. All photographs were obtained from the mine shadow's files or from site visits to impacted land taken by the University.

All property that intersected a projection of the mine outlines on the surface, including the 200-ft buffer around the 5$^{th}$ assessment mining extents were mapped in ArcGIS. All properties with reported effects that were outside of the 200-ft buffer were also mapped. Lastly, the distance from mine workings and topographic elevation for each property were analyzed.

### 6.B.1 - Land Tracked by PADEP

Subsidence control plans are required by Pennsylvania for any structures that will be undermined (Pennsylvania Code, Title 25, Chapter 89.142a). The regulations required for the subsidence control plans of structures are summarized below.

### 6.B.1.a - Damage to Surface Lands

*§89.142a(e)* The operator is responsible to correct the material damage to surface land that results from subsidence caused by the underground mining operations in the most technologically and economically feasible ways.

### 6.B.2 - University's Process for Tracking Land

The University developed a tracking protocol to categorize and map all properties and land impacts from the 5th assessment period. Land damage in BUMIS is often associated with a particular property. Therefore, significant effort was required to obtain the most up to date property line files necessary to identify changes in ownership and accurately map the location of the damage. The BUMIS database was then used to determine which land parcels had a reported effect. The parcels were identified using the common parcel number located in BUMIS and on the ArcGIS maps. If the parcel number did not exist in BUMIS or on the map, the PADEP was contacted to clarify the exact location of the reported effect. All properties with reported effects were mapped over the mining extent in two layers. The two layers categorized the land impacts based on a) their final resolution or b) status of mining company liability for each of the reported effects.

## 6.C - Summary of Trends in Land Impacts during the 5th assessment period

During the 5th assessment, forty-nine (49) active mines undermined at least a portion of 3,296 land parcels. Of the 124 land reported effects, 110 were over active mines and 14 over inactive mines (Table 6-1). In addition, 66 were determined to be company liable, 30 were "Company not Liable", and 28 reported effects were classified as "Interim Resolution". Eighty percent of all reported effects were over active longwall mines, and 95 % of the company liable reported effect were over active longwall panels. The remaining 5 % occurred over inactive mines.

*Table 6-1. Total of undermined land parcels and land parcels with reported effects by mine. type.*

| Mining Type | Undermined Land Parcels | Reported Effects | Company Liable |
|---|---|---|---|
| Room-and-Pillar | 1,771 | 8 | 0 |
| Pillar Recovery | 284 | 3 | 0 |
| Longwall | 1,241 | 99 | 63 |
| Mines not active in the 5th assessment | - | 14 | 4 |
| TOTAL | 3,296 | 124 | 67 |

While room-and-pillar mines undermined the most land parcels in the 5th assessment, longwall mines had the most significant impact on land. The University could not directly compare the total land parcels that were undermined in the 3rd and 4th assessment with the 5th assessment due to changing land ownership and the resultant subdivision of properties that can occur during transfer. Given the caveat that property lines shift, there were 108 land reported effects in the 3rd assessment and 106 in the 4th assessment (Table 6-2). This number has increased an average of

16 % over the last 15 years, while the total acres undermined has decreased by nearly 25 % and the acres undermined by longwall mines has decreased by 30 % since the 3rd assessment (Section 3).

*Table 6-2. Total number of land reported effects per assessment period.*

| Assessment Period | Total Reported Effects |
|---|---|
| 5th | 124 |
| 4th | 106 |
| 3rd | 108 |

In both the 3rd and 4th assessments, 88 % of the land reported effects occurred over active longwall mining operations (Iannacchione et al. 2011; Tonsor et al. 2014). The high percentage of reported effects and associated company liable events can be attributed to the formation of the subsidence basin associated with longwall mining. As described in Appendix D, the total extraction of the longwall can cause significant changes in ground deformation and strains.

It took an average of 149 days for reported land effects to reach a final resolution (Table 6-3). The longest average land final resolution was for "Repaired" land damage at 585 days (Table 6-3). Within the repaired land damage cases, resolution took longest over inactive mines, requiring 700 days (Figure 6-6). Between the three impact categories studied (structures, water supplies, and land), land impacts had the most final resolutions that ended up categorized as "Repaired" (17 %). The inactive mines had the longest time to repair for company liable effects (Figure 6-1). The repairs for land company liable impacts include, but are not limited to, grading the ground to eliminate ponding, filling tension cracks, and stabilizing mass wasting.

*Table 6-3. Determination of liability based on final resolution category as recorded in BUMIS as of 20 August 2018.*

| **Final Resolution** | | **Number** | **Average Time to Resolution (Days)** |
|---|---|---|---|
| **Class** | **Category** | | |
| Company Not Liable (Unaffected/No Liability) | Damage Claim Form Not Returned to CDMO | 7 | 132 |
| | No Liability | 0 | 0 |
| | Not Due to Underground Mining | 19 | 99 |
| | Withdrawn | 4 | 41 |
| Company Liable (Assigned/Assumed Liable) | Agreement (Pre-Mining) | 4 | 33 |
| | Agreement (Unspecified) | 19 | 369 |
| | Closed/Info Appended to Another Case | 0 | 0 |
| | Company Purchased Property | 19 | 90 |
| | Compensated | 4 | 130 |
| | Landowner Negotiations | 0 | 0 |
| | Repaired | 16 | 585 |
| | Resolved | 4 | 306 |
| TOTAL | | 96 | 149 |

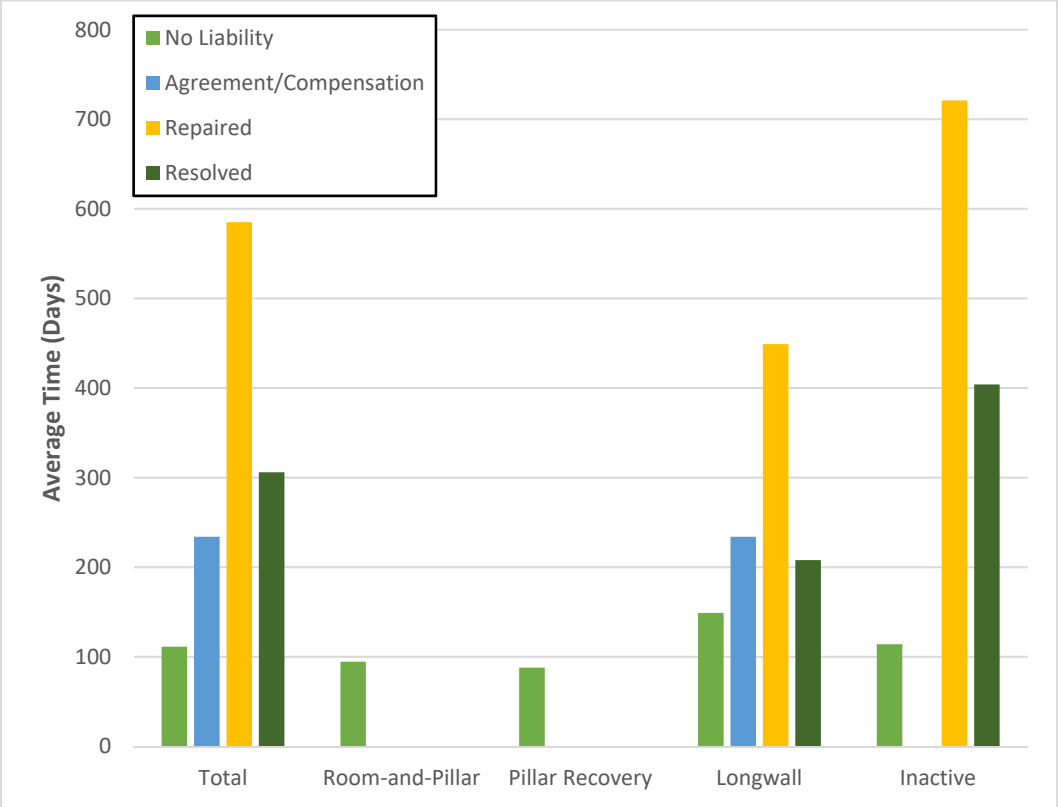


*Figure 6-1. Average days required to resolve land reported effects based on mining type.*

### 6.C.1 - Land Impact Categories

#### 6.C.1.a - Tension Cracks

The University was able to categorize the land impacts into four main impact types: tension cracks, mass wasting, flooding, and other. The "other" category contains all remaining impacts that were not cracks, mass wasting, or flooding. Tension cracks were a common land impact during the 5th assessment, with 36 occurrences of tension cracks out of the 110 reported effects from active mining. Tension cracks can extend tens to hundreds of feet in length and can reach several feet in depth and width. They can be caused by the formation of the final subsidence basin as well as the dynamic subsidence wave that occurs during extraction. A tension crack may stay open or close shortly after opening. Some may also be subjected to compressional forces complicating their appearance on the surface.

Figure 6-2 show tension cracks that formed over the Bailey 3L panel shortly after the longwall undermined the property. This impact was repaired by the company. Figure 6-3 is another example of a tension crack in the Bailey Mine, but this tension crack is much smaller in width, but longer in length. The tension crack extends from the road into the hill side. This crack formed approximately one month after the longwall face had passed and is still in interim resolution.

*Figure 6-2. Tension cracks formed during undermining of a property in the Bailey 3L panel (Photographs from the PADEP files).*


*Figure 6-3. Tension cracks in roadway and hillside formed a month after the Bailey 5L longwall face had passed (Photographs from the PADEP files).*

### 6.C.1.b - Mass Wasting

There were 46 instances of mass wasting in the 5th assessment, making it the most commonly reported land impact. Mass wasting is the downward movement of soil and rock due to the force of gravity. There are several types of mass wasting as depicted in Figure 6-4. The formation of the subsidence basin can cause existing slopes to become unstable and fail. The geology of Western Pennsylvania, especially the Greater Pittsburgh region, is especially suspectable to landslides (Pomeroy, 1982).

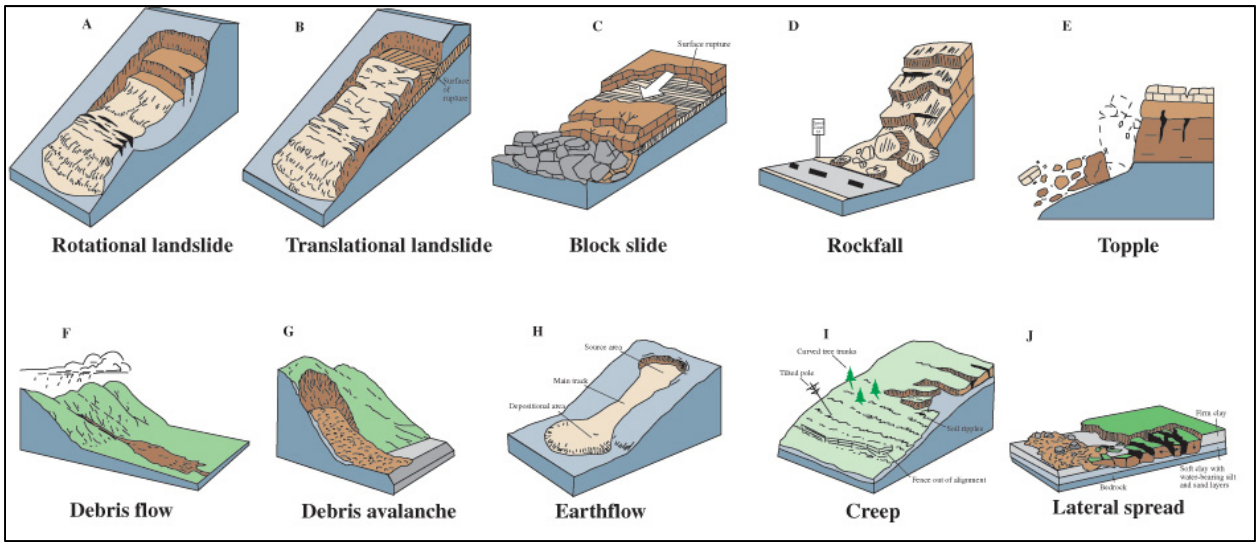


*Figure 6-4. Types of mass movement taken from Lumen Learning ("Types of Mass Movement | Geology").*

Figure 6-5 shows a slide that occurred over the Harvey Mine during the 5th assessment period. This is a transitional landslide according to Figure 6-4.

*Figure 6-5. Mass wasting occurring over the Harvey Mine during the 5th assessment (Photographs from the PADEP files).*

**6.C.1.c - Flooding**

There were 12 land impacts that specified flooding as the problem description. Flooding, like tension cracks and mass wasting, can be destructive. The formation of the subsidence basin causes the ground to form local depressions. Rainwater or parts of the flow from a nearby stream can fill the depressions. Periodic ponding can result in ground saturation, impacting the economic yield of a field or leading to mass wasting. Ponding and increased soil moisture can also impact agriculture production (Darmody et al., 1989; Lechner et al., 2016). The ponding can also bring unwanted wildlife to the area, disrupting the natural habitat of the area. For example, during field visits to undermined areas, the University found that beavers have inhabited areas where ponding occurred and constructed dams, perpetuating the inundation. Figure 6-6 is an example of ponding that occurred in low areas over the Cumberland Mine.

*Figure 6-6. Ponding in low area over Cumberland Mine (Photograph taken from PADEP file).*

**6.C.1.d - Methane**

There were two reported effects that cited a methane related issue. Methane is released form the coal and surrounding strata during mining operations. Low concentrations of methane (between 5 to 15 %) can be explosive, making this impact extremely dangerous. Certain coal seams are known to have higher methane concentration than others (McCulloch, 1975). The methane gas migrates from the gas bearing coalbeds into the broken strata associated with the longwall panel. Here the gas is free to flow from these areas of elevated pressure to the atmospheric conditions on the surface through connecting fracture systems. All mines have a mechanical ventilation system capable of removing methane from the underground workings. Figure 6-7 shows an example of methane moving through rock fractures, potentially intercepting water wells and foundations of structures on the surface.

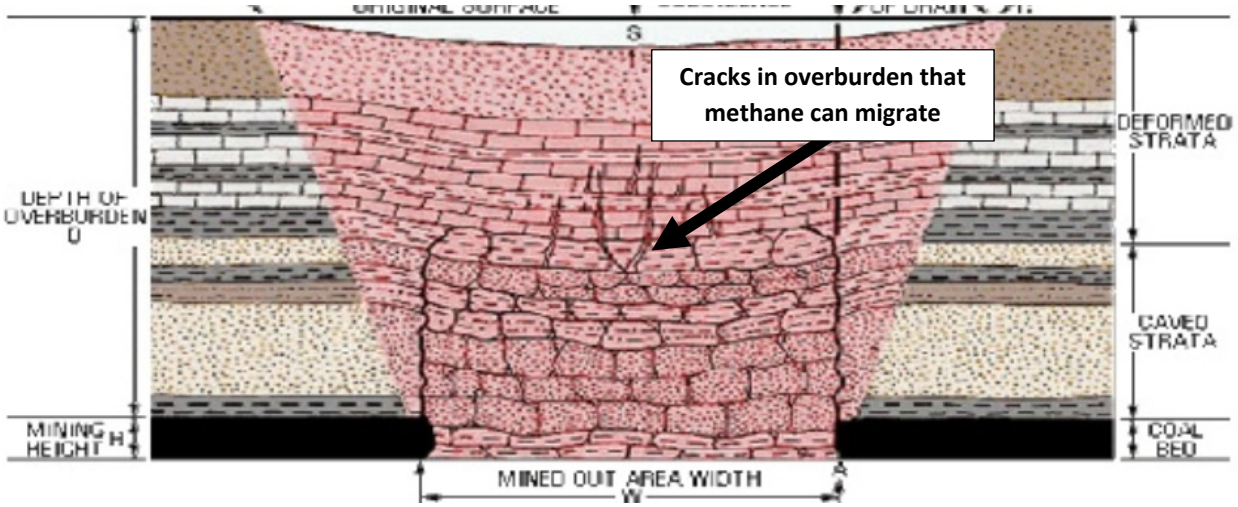


*Figure 6-7. Methane migration patterns as a result of longwall mining* (Singhal, 2014, slide 2).

## 6.D - Land Impacts and Mining Types

### 6.D.1 - Active Longwall Mines

The seven active longwall mines accounted for 80 % of all reported land effects that occurred in the 5th assessment. Table 6-4 list the number of reported effects per mining operation. Enlow Fork undermined the largest number of land parcels and had the most company liable impacts.

*Table 6-4. Reported Land Effects and liability per active longwall mining operation.*

| Mine Name | Total Number of Land Parcels | Company Liable | Company Not Liable | Interim Resolution |
|---|---|---|---|---|
| Bailey | 99 | 11 | 5 | 5 |
| Cumberland | 179 | 6 | 0 | 5 |
| Emerald | 271 | 3 | 7 | 1 |
| Enlow Fork | 431 | 31 | 1 | 5 |
| Harvey | 135 | 5 | 1 | 3 |
| Monongalia County | 76 | 4 | 1 | 0 |
| Tunnel Ridge | 50 | 3 | 0 | 2 |

The university found that 72 of 99 total land reported effects were located directly over the longwall panels (Figure 6-8). Fifty-four of the reported effects found over the longwall panels were company liable. The area that had the least amount of effects was the room-and-pillar developments associated with longwall mining. This is significant since many of these room-and-pillar developments are located next to the longwall panels. Several of the reported effects, occurred outside of the 200-ft buffer. In most cases these impacts were attributed to adjacent inactive mining operations rather than active mining.

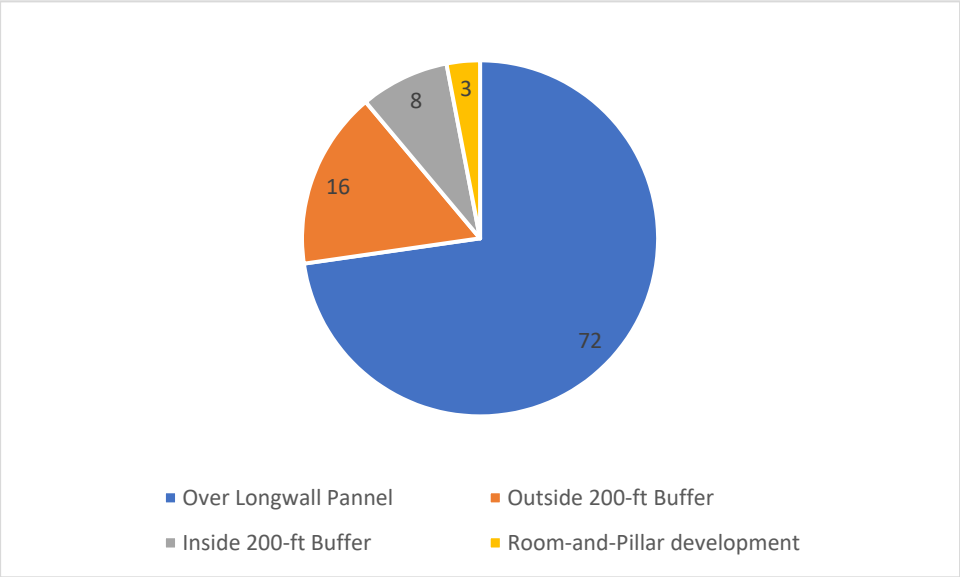


*Figure 6-8. Location of reported effects over active longwall mining.*

Of the 99 total land reported effects, 78 had reached a final resolution as of 20 August 2018, and 21 were still classified as an interim resolution. On average, it took 197 days to reach a final resolution for the land impacts over active longwall mining (Table 6-5). Unspecified agreements and company purchased properties were the most common resolution for impacts that were company liable. Overall, the resolution that took the longest to complete was the repair of land impacts and the resolution that had the shortest time was a pre-mining agreement. Pre-mining agreements were one of the least common final resolutions for land damage over longwall mining.

*Table 6-5. Determination of liability for longwall mines based on final resolution category as recorded in BUMIS as of 20 August 2018.*

| Final Resolution | | Number | Average Time to Resolution (Days) |
|---|---|---|---|
| **Class** | **Category** | | |
| Company Not Liable (Unaffected/No Liability) | Damage Claim Form Not Returned to CDMO | 3 | 199 |
| | No Liability | 0 | 0 |
| | Not Due to Underground Mining | 12 | 99 |
| | Withdrawn | 0 | 0 |
| Company Liable (Assigned/Assumed Liable) | Agreement (Pre-Mining) | 4 | 33 |
| | Agreement (Unspecified) | 19 | 369 |
| | Closed/Info Appended to Another Case | 0 | 0 |
| | Company Purchased Property | 19 | 90 |
| | Compensated | 4 | 130 |
| | Landowner Negotiations | 0 | 0 |
| | Repaired | 14 | 449 |
| | Resolved | 3 | 208 |
| TOTAL | | 78 | 197 |

The distribution of the type of reported effects for active longwall mining follows the overall pattern described above, with mass wasting accounting for 45 % of land impact type (Figure 6-9). All (2) methane related impacts occurred over active longwall mining operations.

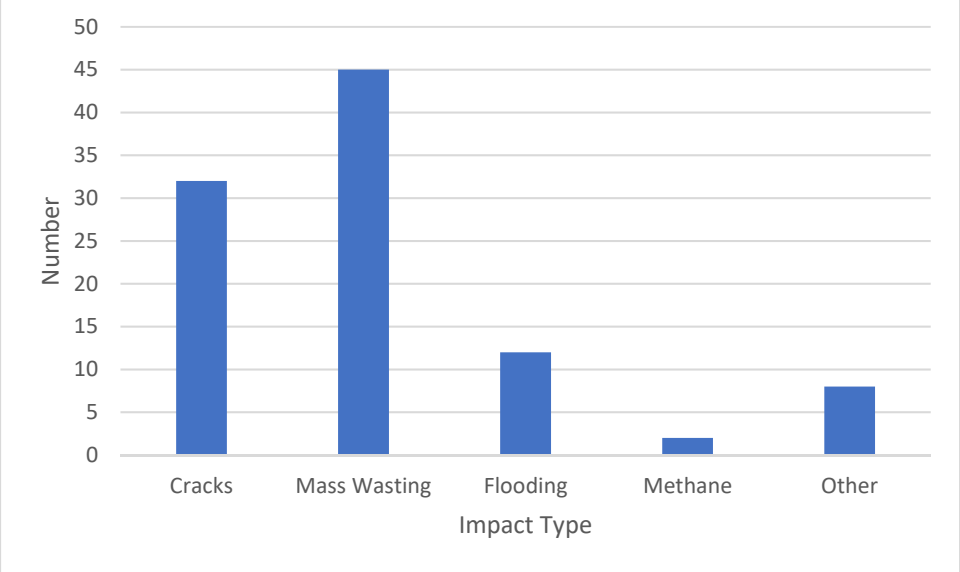


*Figure 6-9. Occurrence of reported effects for active longwall mines.*

### 6.D.2 - Active Room-and-Pillar Mines

In the 5th assessment there were eight land reported effects from room-and-pillar mining with seven determined to be company not liable and one listed as having an interim resolution. Table

6-6 shows the active room-and-pillar mining operations with land reported effects. Mine 78 undermined populated areas whose land parcels were divided into small areas, making the total number of parcels (325) much higher than the average (48). In the 3rd assessment there were three reported effects over active room-and-pillar mines with one company liable event. In the 4th assessment there were five reported effects associated with room-and-pillar mines, but data are not available about their final resolution in BUMIS. During the last 15 years, the impacts to land from room-and-pillar mining was minimal, most likely because of the low extraction ratio and lack of subsidence.

*Table 6-6. Land reported effects per active room-and-pillar operation.*

| Mine Name | Total Number of Land Parcels | Company Liable | Company Not Liable | Interim Resolution |
|---|---|---|---|---|
| Clementine 1 | 30 | 0 | 2 | 0 |
| Logansport | 35 | 0 | 2 | 0 |
| Mine 78 | 325 | 0 | 2 | 0 |
| Madison | 68 | 0 | 0 | 1 |
| Tracy Lynne | 41 | 0 | 1 | 0 |

All reported effects determined to be company liable took an average of 88 days to reach a final resolution (Table 6-7). Four of the reported effects were determined to be not due to underground mining, while the remaining three reported effects did not have their damage claim form returned to the CDMO. When a damage form is not returned to the CDMO, tracking of the claim in BUMIS ceases and the failure to return a form is the recorded resolution. All seven reported effects occurred outside of the 200-ft buffer. Five of the reported effects were classified as tension cracks, and the remaining two were not specified.

*Table 6-7. Determination of liability for room-and-pillar mines based on final resolution status as of 20 August 2018.*

| Final Resolution | | Number | Average Time to Resolution (Days) |
|---|---|---|---|
| **Class** | **Category** | | |
| Company Not Liable (Unaffected/No Liability) | Damage Claim Form Not Returned to CDMO | 3 | 109 |
| | No Liability | 0 | 0 |
| | Not Due to Underground Mining | 4 | 66 |
| | Withdrawn | 0 | 0 |
| Company Liable (Assigned/Assumed Liable) | Agreement (Pre-Mining) | 0 | 0 |
| | Agreement (Unspecified) | 0 | 0 |
| | Closed/Info Appended to Another Case | 0 | 0 |
| | Company Purchased Property | 0 | 0 |
| | Compensated | 0 | 0 |
| | Landowner Negotiations | 0 | 0 |
| | Repaired | 0 | 0 |
| | Resolved | 0 | 0 |
| TOTAL | | 7 | 88 |

### 6.D.3 - Active Pillar Recovery Mines

The pillar recovery mines had three land reported effects during the 5th assessment period, occurring over two mines. Table 6-8 shows the pillar recovery mines that had the reported effects.

*Table 6-8. Reported land effects per active pillar recovery mine.*

| Mine Name | Total Number of Land Parcels | Company Liable | Company Not Liable | Interim Resolution |
|---|---|---|---|---|
| 4 West | 173 | 0 | 1 | 0 |
| Nolo | 28 | 0 | 0 | 2 |

Of the three reported effects only one had a final resolution and it was determined to be company not liable because the damage claim form was not returned to the CDMO, it took 88 days to reach the final resolution (Table 6-9). The remaining two reported effects are in interim resolution.

*Table 6-9. Determination of liability for pillar recovery mines based on final resolution category recorded in BUMIS as of 20 August 2018.*

| Final Resolution | | Number | Average Time to Resolution (Days) |
|---|---|---|---|
| **Class** | **Category** | | |
| Company Not Liable (Unaffected/No Liability) | Damage Claim Form Not Returned to CDMO | 1 | 88 |
| | No Liability | 0 | 0 |
| | Not Due to Underground Mining | 0 | 0 |
| | Withdrawn | 0 | 0 |
| Company Liable (Assigned/Assumed Liable) | Agreement (Pre-Mining) | 0 | 0 |
| | Agreement (Unspecified) | 0 | 0 |
| | Closed/Info Appended to Another Case | 0 | 0 |
| | Company Purchased Property | 0 | 0 |
| | Compensated | 0 | 0 |
| | Landowner Negotiations | 0 | 0 |
| | Repaired | 0 | 0 |
| | Resolved | 0 | 0 |
| TOTAL | | 1 | 88 |

The reported effect over the Nolo Mine that was found to be company not liable was located over the room-and-pillar developments. This mining method is not normally expected to produce subsidence. Subsidence is only expected to occur over areas where pillar recovery occurred. The two reported effects in interim resolution are from 4 West Mine and occurred within the 200-ft buffer, but not directly over the mine.

### 6.D.4 - Inactive Mines

There were seven inactive mines with land reported effects during the 5$^{th}$ assessment. Three of these were longwall mines and four were room-and-pillar mines. Of the 14 land reported effects from the inactive operations, four were found to be company liable, four were classified as an interim resolution, and the remaining six impacts were found to be company not liable. One of the company liable reported effects occurred over the longwall mine, Blacksville 1. The remaining three company liable impacts occurred over the room-and-pillar Ridge and TJS 1 Mines (Table 6-10).

*Table 6-10. Reported land effects per inactive mines that occurred during the 5th assessment period.*

| Mine Name | Company Liable | Company Not Liable | Interim Resolution |
|---|---|---|---|
| Maple Creek | 0 | 3 | 3 |
| Blacksville 1 | 1 | 0 | 0 |
| Keystone East | 0 | 1 | 0 |
| Long Run | 0 | 1 | 0 |
| Mine 84 | 0 | 1 | 1 |
| Ridge | 2 | 0 | 0 |
| TJS 1 | 1 | 0 | 0 |

The Ridge Mine is a room-and-pillar operation that was active in the 3rd assessment but had a land company liable impact in the 5th assessment. TJS 1 was mined prior to the 3rd assessment period and little information was available on this operation. The Ridge Mine extracted a small pocket of Pittsburgh coalbed in Armstrong County. Figure 6-10 shows the mine outline with the overburden contours and the impacted parcel. Ridge Mine was developed under shallow overburden, averaging approximately 200-ft. At shallow overburdens, the subsurface strata are more capable of transmitting mining induce fractures to the surface; and roof falls in the underground have the potential to propagate fractured strata to the surface. The area over the Ridge Mine with the land company liable impacts had tension cracks formed in the fields of the property. Three tension cracks also occurred in the 4th assessment period. One within the same property as those occurring in the 5th assessment (shown in red Figure 6-10) and two in adjacent properties.

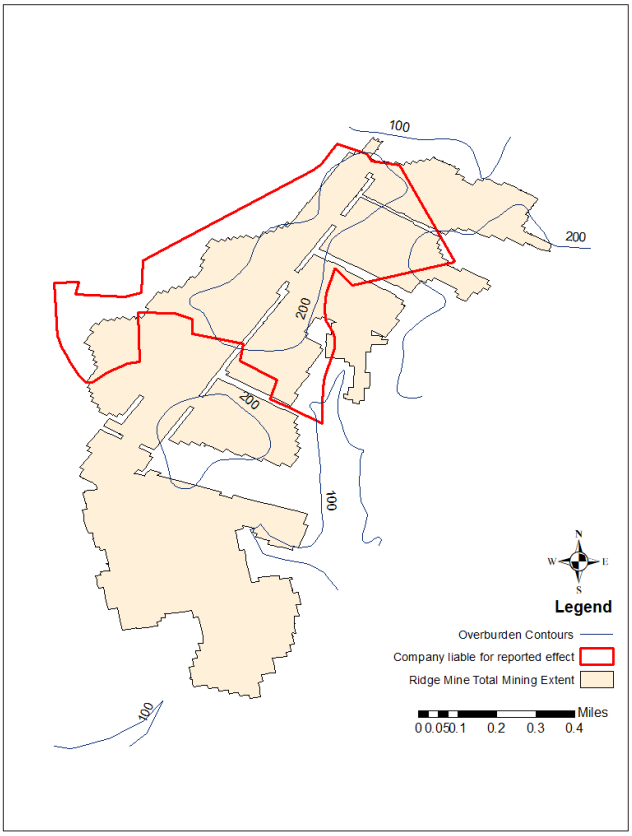


*Figure 6-10. Map of the Ridge Mine and the one land parcel with a company liable effect.*

It took on average 325 days for the final resolution determination for the ten land reported effects (Table 6-11). The inactive mines took longer to resolve than all other mine categories. The final resolution category with the most reported effects was the “Withdrawn” category. The two reported effects that were repaired had the longest average completion time.

*Table 6-11. Determination of liability inactive mines based on final resolution category as recorded in BUMIS as of 20 August 2018.*

| Final Resolution | | Number | Average Time to Resolution (Days) |
|---|---|---|---|
| **Class** | **Category** | | |
| Company Not Liable (Unaffected/No Liability) | Damage Claim Form Not Returned to CDMO | 0 | 0 |
| | No Liability | 0 | 0 |
| | Not Due to Underground Mining | 3 | 133 |
| | Withdrawn | 4 | 41 |
| Company Liable (Assigned/Assumed Liable) | Agreement (Pre-Mining) | 0 | 0 |
| | Agreement (Unspecified) | 0 | 0 |
| | Closed/Info Appended to Another Case | 0 | 0 |
| | Company Purchased Property | 0 | 0 |
| | Compensated | 0 | 0 |
| | Landowner Negotiations | 0 | 0 |
| | Repaired | 2 | 721 |
| | Resolved | 1 | 404 |
| TOTAL | | 10 | 325 |

## 6.E - Summary

One hundred twenty-four (124) land reported effects occurred from 21 August 2013 to 20 August 2018 from the 49-active longwall, room-and-pillar, and pillar recovery mines as well as seven inactive mines. Sixty-six were found to be company liable. Most (80 %) of the total land reported effects occurred over the six active longwall mines. Nearly all (95 %) of company liable impacts occurred over longwall mines. Active room-and-pillar and pillar recovery operations had nine reported effects. Of these, eight had a final resolution determined to be company not liable. Inactive mines had a larger amount of impacts in the 5th assessment than had been recognized during previous assessments. Three of the impacts were company liable. Of these four, one occurred over the Blacksville 1 longwall mine, two over the room-and-pillar Ridge Mine, and one over the TJS 1 Mine.

During the 5$^{th}$ assessment represented recorded land impacts increased (124) relative to the 3$^{rd}$ (108) and 4$^{th}$ (106) assessment periods. A significant portion of the increase was found to be associated with a spike in inactive land reported affects. The 14 land reported effects over inactive mines in the 5$^{th}$ assessment match the combined total of reported land impacts during the 3$^{rd}$ and 4$^{th}$ assessment periods.

## References

Darmody, R.G., I.J. Jansen, S.G. Carmer, and J.S. Steiner. (1989) Agricultural impacts of coal mine subsidence: effects on corn yields. Journal of Environmental Quality 18:265-267.

Iannacchione, A., S.J. Tonsor, M. Witkowski, J. Benner, A. Hale, and M. Shendge (2011). "The Effects of Subsidence Resulting from Underground Bituminous Coal Mining on Surface Structures and Features and on Water Resources, 2003-2008," University of Pittsburgh, http://www.portal.state.pa.us/portal/server.pt/community/act_54/20876.

Lechner, A.M., T. Baumgartl, P. Matthew, and V. Glenn. (2016). The. Impact. Of underground longwall mining on prime agricultural land: a review and research agenda. Land Degradation & Development 27:1650-1663.

McCulloch, C.M. (1975). "Selected Geological Factors Affecting Mining of the Pittsburgh Coalbed," US Bureau of Mines Report of Investigations 8093, p. 72.

Pomeroy, J.S. (1982). Landslide in the Greater Pittsburgh Region, Pennsylvania (Geological Survey Professional Paper No. 1229).

Singhal, A. D. (2014) *Subsidence in Coal Mines.* [PowerPoint slides]. Retrieved from https://www.slideshare.net/aakashdeepsinghal/subsidence-in-coal-mines-33967670

Tonsor, S.J., A. Hale, A. Iannacchione, D. Bain, M. Keener, E. Pfeil-McCullough, K. Garmire (2014). "The Effects of Subsidence Resulting from Underground Bituminous Coal Mining, 2008-2013" University of Pittsburgh, https://www.dep.pa.gov/Business/Land/Mining/BureauofDistrictMining/Act54/Pages/default.aspx

Types of Mass Movement | Geology. (n.d.). Retrieved April 22, 2019, from https://courses.lumenlearning.com/wmopen-geology/chapter/outcome-types-of-mass-movement/