SECTION VII: Effects of Mining on Land

VII.A - Overview

Through an examination of the BUMIS files, the University found 108 land reported effects that occurred during the 3rd assessment period. Ninety-seven of these cases were from active mines and 11 were from inactive mines. Another five cases, not included in the total of 108, occurred during a previous assessment period.

All longwall mines, with the exception of Shoemaker where minimal mining occurred within PA, have land reported effects. Conversely, five land reported effects occurred over room-and-pillar mines but only in two of these was the company (Ridge Mine) held liable.

VII.B – Land Reported Effects by Mining Type

The distribution of the 108 land reported effects during the 3rd assessment period and overlying 13 active and closed mines is shown in (Figure VIII-1). Nine longwall mines accounted for 95.4-pct of the total while four room-and-pillar mines provided the remaining 4.6-pct. Eleven of the reported effects came from four mines that did not operate during the 3rd assessment period. These were Maple Creek (8), Dilworth (1), Humphrey No.7 (1), and Tanoma (1). Of the four room-and-pillar mines (Figure VII-1), only the Tanoma Mine practiced pillar recovery.

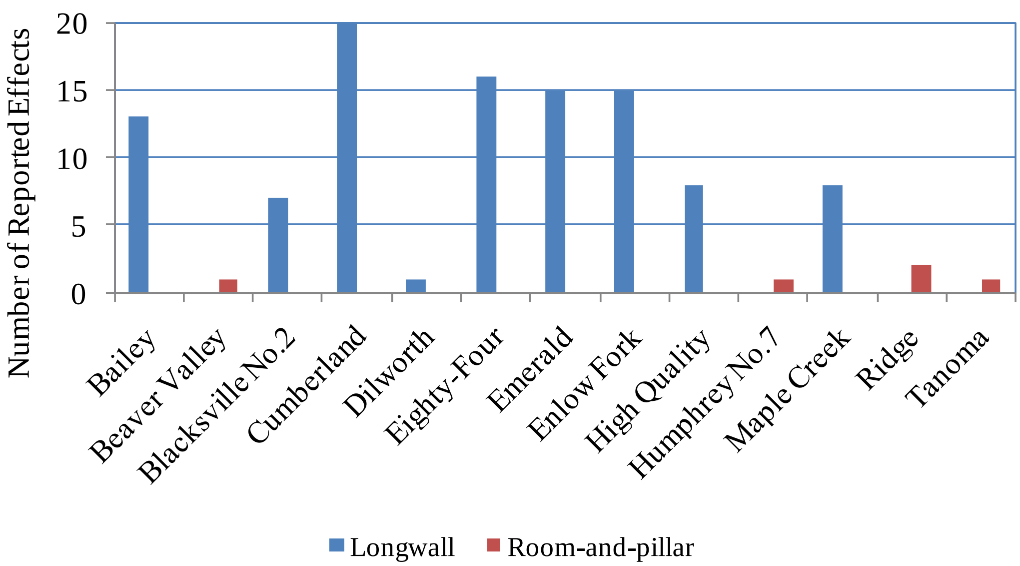

Figure VII-1 – The distribution of 108 land reported effects over 13 mines

One way to evaluate the rate at which land reported effects took place was to analyze the frequency of occurrence by mining type (Table VIII-1). This analysis covered only mines that operated during the 3rd assessment period. The percent of properties with reported effects (Table VII-1) provided some insight as to the significance of land impacts. In this study, the vast majority of room-and-pillar mines, with and without pillar recovery, had near zero land reported effects while longwall mines had an average of 6.0-pct.

Table VII-1 – Percent of properties with land reported effects organized by mining type.

Mining Type	Land Reported Effects	Properties Undermined	Percent Properties with Reported Effects
Longwall (active mines)	94	1,571	6.0
Longwall (in-active mines)	9	NA	NA
Room-and-pillar (active mines)	3	1,738	0.2
Room-and-pillar (in-active mines)	2	NA	NA
Room-and-pillar with pillar recovery	0	277	0
Total	108		

NA – Not Available (mines were not part of 3rd assessment period)

VII.B.1 – Days to Resolve Land Reported Effects

The University collected information related to the date of occurrence, interim resolution, and final resolution for every land reported effect. Of the 108 reported effects that occurred during the 3rd assessment period, 87 had final resolutions. It took an average of 206 days for these cases to reach a final resolution (Table VII-2). The average days to an interim resolution was 109 days.

Table VII-2 – The number of days to resolve land reported effects and number of resolved / unresolved cases for all mines in the 3rd assessment period.

	Interim	Final
Mean, days	109	206
Standard Deviation, days	207	256
Median, days	13	105
Minimum, days	0	0
Maximum, days	1,164	1,253
Number of Resolved Cases	85	87
Number of Unresolved Cases	23	21

VII.B.2 – Resolution Status of Land Reported Effects

The land resolution status at the end of the 3rd assessment period was presented in Table VII-3. Of the 87 final resolutions, 57-pct, or 50, were assigned as Company Liable. The other 43-pct, or 37, were assigned as Company Not Liable. Of the remaining 21 land reported effects, 18 had an Interim Resolution but no final resolution and three had an outstanding reported effect with No Interim Resolution (Table VIII-3).

Table VII-3 - Resolution status at the end of the 3rd assessment period for all reported effects sorted by active and in-active mines.

Mine Name	Final Resolution		Interim Resolution	Outstanding Reported Effect (No Interim Resolution)	Mine Total	Total
	Company Liable	Company Not Liable				
Active Mines						
Bailey	3	7	3		13	
Beaver Valley		1			1	
Blacksville No.2	3	2	2		7	
Cumberland	11	6	3		20	
Eighty-Four	7	3	3	3	16	
Emerald	5	6	4		15	
Enlow Fork	12	1	2		15	
High Quality	5	3			8	
Ridge	2				2	
Sub-total	48	28	18	3		97
In-active Mines						
Dilworth		1			1	
Humphrey No.7		1			1	
Maple Creek	2	6			8	
Tanoma		1			1	
Sub-total	2	9				11
Total	50	37	18	3		108

For the 50 Company Liable reported effects, the most common resolution, with 52-pct (26 cases), was to Repair the property (Table VII-4). This was followed by private agreements, both pre- and post-mining, with 24-pct (12 cases) and some form of compensation to the land owner with 14-pct (7 cases). In five cases, the company purchased the property.

Table VII-4 - Results of land reported effects where the final resolution was Company Liable.

Mine Name	Company Purchased Property	Compensated / Resolved / Settled	Repaired	Agreement	Total
Bailey		2	1		3
Beaver Valley					
Blacksville No.2			3		3
Cumberland			8	3	11
Dilworth					
Eighty-Four	1		4	2	7
Emerald	1	1	2	1	5
Enlow Fork	3	4		5	12
High Quality			4	1	5
Humphrey No.7					
Maple Creek			2		2
Ridge			2		2
Tanoma					
Total	5	7	26	12	50

For 37 land reported effects, Company Not Liable was found (Table VII-5). The most frequent reason for no liability was Not Due to Underground Mining with 83.8-pct of the total. The other reasons accounted for only 16.2-pct of the total and include Withdrawn (2.7-pct), No Actual Reported Effect (2.7-pct), No Liability (5.4-pct), and Not Covered by BMSLSA (5.4-pct).

Table VII-5 - Results of land reported effects where the final resolution was Company Not Liable.

Mine Name	With-drawn	No Actual Reported Effect	No Liability	Not Due to Underground Mining	Not Covered by BMSLCA*	Total
Bailey			1	6		7
Beaver Valley				1		1
Blacksville No.2				1		1
Cumberland				6		6
Dilworth				1		1
Eighty-Four				3		3
Emerald	1			5		6
Enlow Fork			1			1
High Quality		1		2		3
Humphrey No.7					1	1
Maple Creek				6		6
Tanoma					1	1
Total	1	1	2	31	2	37

*BMSLCA = *Bituminous Mine Subsidence and Land Conservation Act*

VII.B.3 – Resolution Status from Land Reported Effects from the 2nd Assessment Period

Five reported effects were carried over from the 2nd assessment period. Four were resolved during the 3rd assessment period, taking an average of 583 days to reach a final resolution (Table VII-6). Of the four resolved cases, three were found to be Company Liable and one Company Not Liable. The one unresolved reported effect had an interim resolution on August 21, 2007, but was still being litigated as of August 20, 2008. All of these reported effects were from longwall mines.

Table VII-6 – Days to resolve reported effects from the 2nd assessment period.

	2nd Interim Resolution	2nd Final Resolution
Mean		583
Standard Deviation		455
Median		576
Minimum		63
Maximum	1999*	1115
Number Resolved		4
Number Unresolved	1**	0

* - Interim resolution on August 21, 2007
** - Case being litigated as of August 20, 2008

VII.C – Land Reported Effects by Cause

The University categorized the cause of the land reported effects from Agent Observations found in BUMIS. This was necessary because BUMIS descriptions were written by multiple authors using a wide variety of terms, definitions, and descriptive language. Five categories were established: *mass wasting, tension cracks, settlements, compression ruptures, and unknown*. The University used the term compression ruptures to represent the following BUMIS terms: compression fractures, heaves, or heaving. Seventy-six cases are identified where land reported effects had resolutions with a Company Liable or an Interim / Outstanding condition at the end of the 3rd assessment period (Table VII-7). Tension cracks accounted for 48.7-pct of the total causes followed by mass wasting with 26.3-pct and settlement with 15.8-pct. No compression ruptures were found among these cases; however, ruptures caused some stream damage (Section VII.C.4).

Table VII-7 – Cause of land reported effects where Company Liable or Interim Resolution / Outstanding Claim existed at the end of the assessment period.

Mine Name	Mass Wasting	Tension Cracks	Settlement	Unknown	Total
Bailey	3	1		2	6
Blacksville No.2	3		3		6
Cumberland	2	9	3	1	15
Eighty-Four	3	6	3	1	13
Emerald	4	4		2	10
Enlow Fork	5	10	2		17
High Quality		3	1	1	5
Maple Creek		2			2
Ridge		2			2
Total	20	37	12	7	76

VII. C. 1 – Causes Related to Tension Cracks

Tension cracks were a dominate cause of land reported effects. There were 37 claims with tension cracks identified as the primary cause (Table VII-6). These features were associated with the formation of the subsidence basin (Section IV, V, and VI). Typically, the largest tension cracks were curvilinear and extended for hundreds of feet along the surface with an open fracture several feet in depth (Figure VII-2). In one case, the property owner reported hearing a loud boom and, upon inspection the next day, found a large crack in their front yard. When the tension cracks were smaller in scale, i.e. tens of feet, they might be associated with other causes such as mass wasting or settlement.

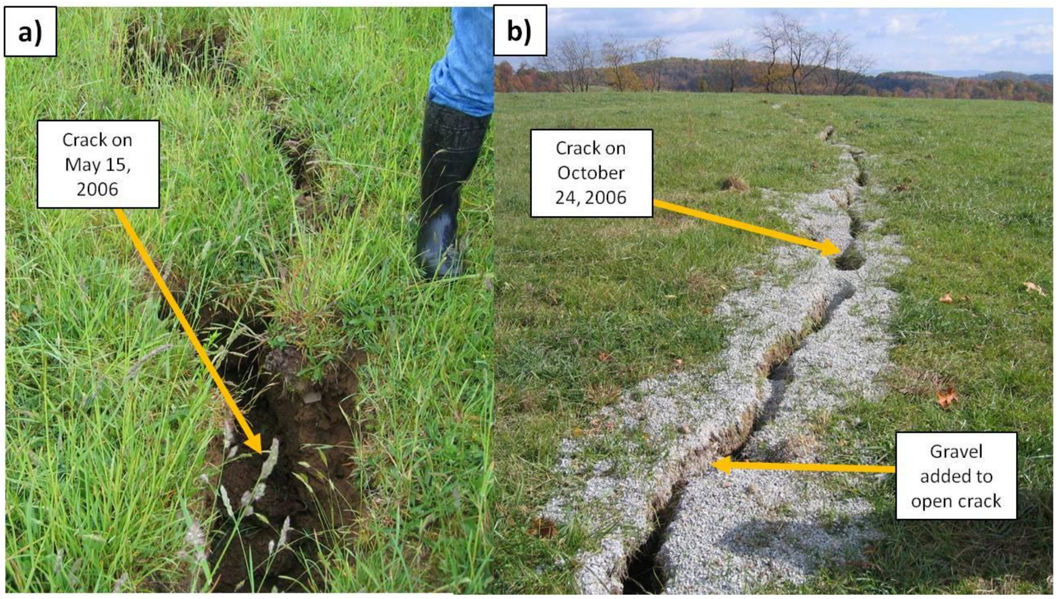

Figure VIII-2 – Photograph of large tension crack a) open shortly after the underlying longwall panel was mined, and b) partially repaired by filling with gravel and other aggregate products until the ground surface becomes level (Photographs from PA DEP files).

VII.C.2 – Causes Related to Mass Wasting

Mass wasting (20 reported cases) is the process whereby soil and rock move down slope under the force of gravity. There are many forms of mass wasting including: creep, landslides, flows, topples, and slumps. These forms produce slips, humps, and scarps in the ground surface. The speed at which the material moves ranges from a fraction of inches per day to feet per second. Seventeen of the 20 claims are deemed to be related to mass wasting.

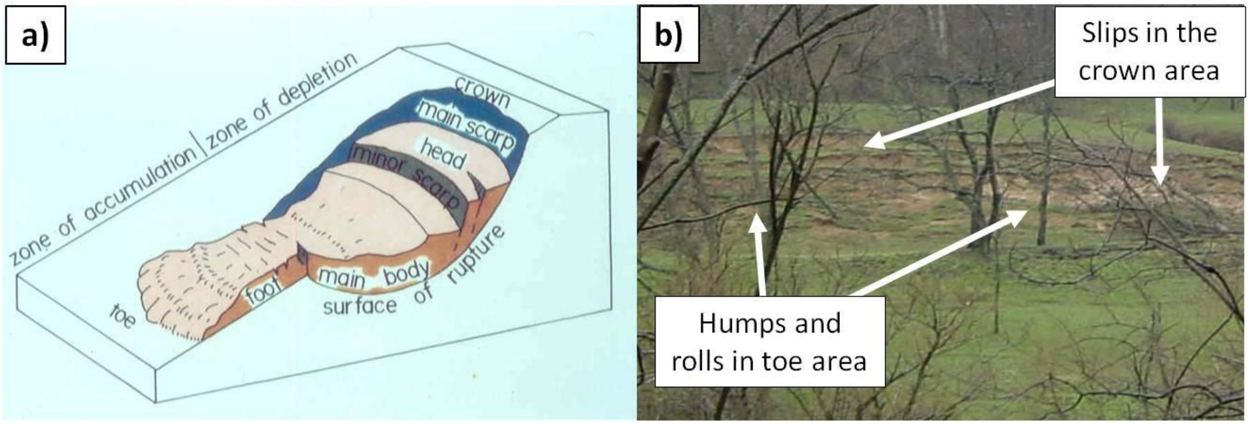

Figure VII-3 – a) General characteristics of mass wasting episodes taken from Varnes (1978) and b) large mass wasting event in Greene Co., PA (photograph from PA DEP files).

Western Pennsylvania is known to have significant problems with mass wasting (Davies, et al. 1978; and Hackman, et al, 1978). These problems are particularly acute in Greene and Washington Counties where steep slopes contain thick masses of slumped hummocky soil and rock from ancient remnants of mass wasting events. When a subsidence basin is formed above a longwall panel, these thick colluvial slopes can become unstable. Iannacchione and Ackman (1984) mapped several such features similar to the one shown in Figure VII-3b over the Gateway Mine. In that study, the two largest reactivated landslides occurred above a thin sandstone strata with several associated springs, and ranged from 100 to 300-ft in length and from 100 to 200-ft in width. The maximum scarp-slope displacements were approximately 7-ft. The University found a few examples of similar large mass wasting cases in the PA DEP files. The sizes of these mass wasting events could only be estimated from photographs.

Less dramatic mass wasting occurs when the colluvial soil layer is thinner. This type of mass wasting is associated with creep or flowing colluviums that produce rolling features with occasional slip surfaces (Figure VII-4). The Agent Observations found within BUMIS of mass wasting were mainly of this nature.

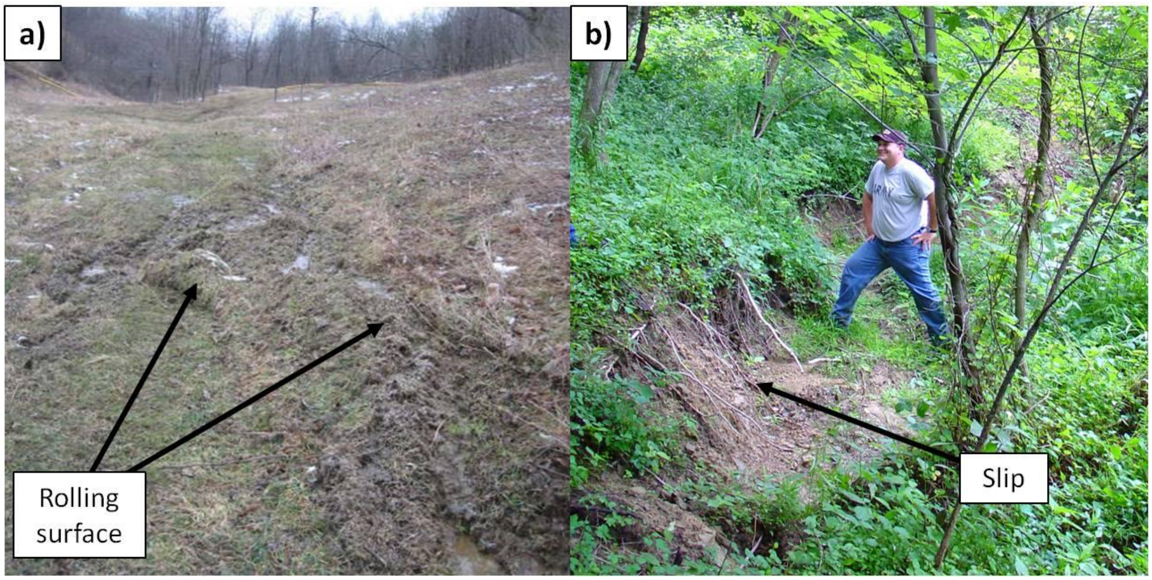

Figure VII-4 - Photographs of a) rolling surface and b) slip (Photographs from PA DEP files).

Determining the triggering mechanism for mass wasting is not always straight forward. Mass wasting can also be triggered by dynamic ground vibrations, increased water content, or undercutting of the slope by excavation or erosion.

VII.C.3 – Causes Related to Settlement

Twelve cases were classified as caused by settlement. When a subsidence basin is formed in relatively flat topography, settlement of the ground produced depressions that impact the normal use of the land. The maximum vertical subsidence over a Pittsburgh Coalbed longwall panel reached over 4-ft (see Section IV). This amount of surface elevation change can disrupt drainage patterns which can in-turn allow water to pond (Figure VII-5). Ponding of water in fields, pastures, and residential lawns impacts the intended use of this land.

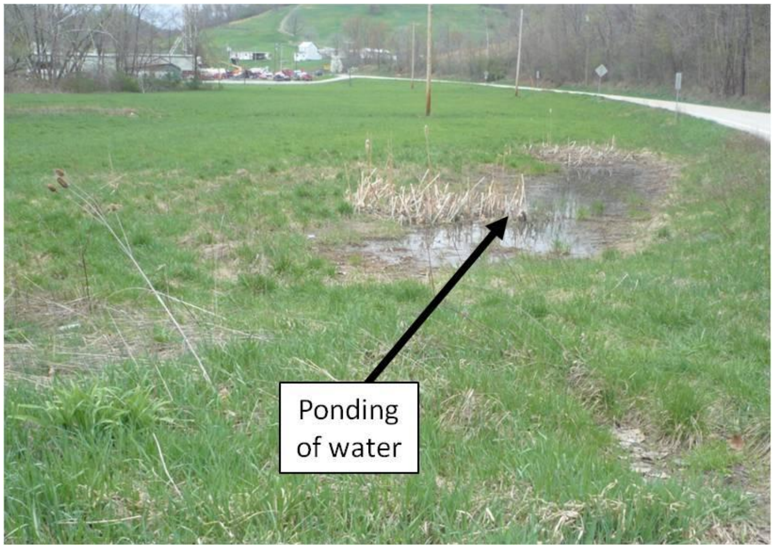

Figure VII-5 - Ground settlement over a longwall panel allowed water to pond in depression (Photograph courtesy of N. Iannacchione).

VII.C.4 – Causes related to Compression Rupture

Subsidence basins associated with longwall mining and room-and-pillar mining with pillar recovery produce significant horizontal compressive forces in ground surface (see Section IV). The subsidence event causes the surface to curve in a manner that compresses the strata, producing a buckling failure. These buckling failures often compress the ground surface into features described as bumps or humps. The impact of these compression features on highways and structures was discussed in Section IV and V. When these events occur in an open field or within a forested area, their impact often goes unnoticed for they might not affect property owners' land use requirements. However, in some circumstances the creation of a linear elevation increase of a few feet can disrupt drainage patterns or impair road surfaces. The University found that most significant impact of surface compression ruptures was the damage caused to a small percentage of the streams in Greene County.

VII.C.2.a – Source of Excessive Compression Forces

The Northern Appalachian Coal Basin has long been known to contain excessive amounts of horizontal stresses within both coal measure and limestone rock formations (Mark and Gadde, 2008). Detailed horizontal stress measurements have shown a regional stress field with an orientation of approximately N 70° to 80° E that is many times higher than the overburden stress (Table VII-8).

Table VII-8 – Stress and strain measurements within Pennsylvania coal and limestone mines (Iannacchione, et al, 2002).

Strata	Max. Stress, psi	Max. Stress Orientation	Max. Horizontal Strain	Depth, ft	Estimated Vertical Stress, psi	Ratio Horizontal-to-Vertical Stress
Kittanning Coalbed Site No.1	3,340	N 87° E	575	719	790	4.2
Kittanning Coalbed Site No.2	3,020	N 75° E	721	551	606	5.0
Pittsburgh Coalbed Site No.1	1,320	N 32° E	736	400	440	3.0
Pittsburgh Coalbed Site No.2	2,360	N 78° E	557	699	769	3.1
Pittsburgh Coalbed Site No.3	3,080	N 70° E	461	801	881	3.5
Loyalhanna Limestone	6,920	N 71° E	607	400	440	15.7

VII.C.2.b – Horizontal Stresses Concentrated in Stream Valleys

Molinda, et al. (1992) reported a close relationship between the valley bottom and unstable roof conditions at Mine 60. This mine is located adjacent to Mine Eighty-Four. The unstable conditions are often associated to compression ruptures occurring in the mine's roof rock. Mining professionals refer to this condition as cutter-roof failures (Figure VII-6). These compression ruptures buckle the strata, producing a very distinctive inverted "tee pee" shaped structure. Local mine operators reported that the most severe roof rock conditions occurred in north-south oriented entries (Molinda, et al., 1992), especially at low overburden (< 300-ft). Numerical modeling exercises indicated that steep-walled valleys concentrate more horizontal stress than broad-bottom valleys (Molinda, et al., 1992).

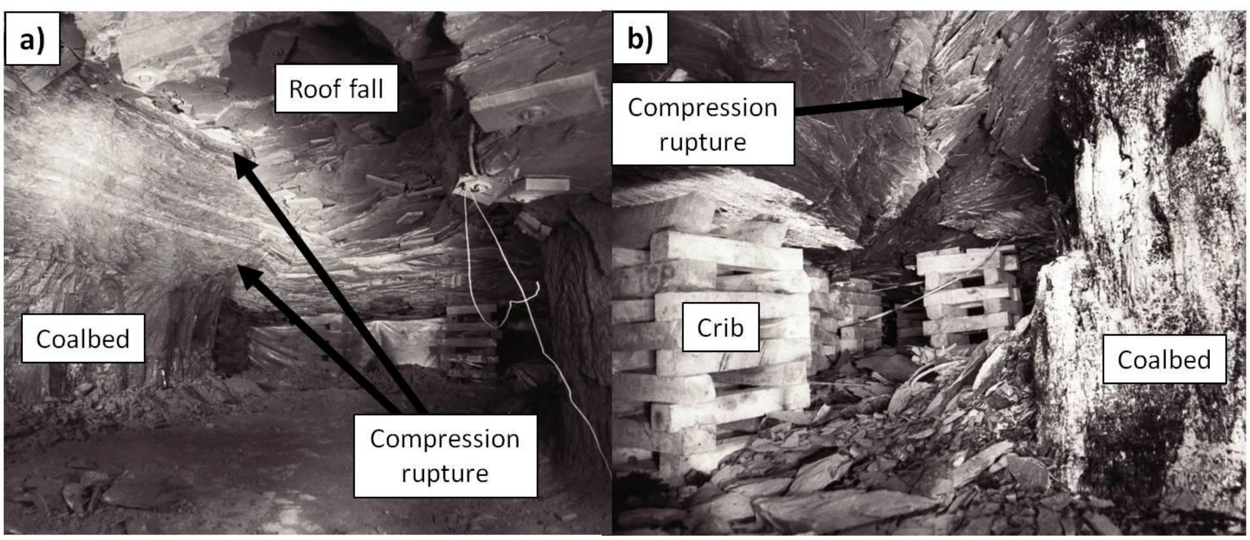

Figure VIII-6 - Photographs of compression ruptures a) along the side of a roof fall and b) close up within the roof-rib intersection area, Kitt Mine, northern West Virginia (photograph courtesy of A. Iannacchione).

VII.C.2.c – Expressions of Stream Bed Compression Ruptures

Compression ruptures, similar to those found in unstable roof rock conditions below north-south trending steep-sided stream valleys, can be found in several stream beds undermined by longwall mining. These compression ruptures buckle the strata, producing a distinctive "tee pee" shaped structure (Figure VII-7). These features are immediately subjected to the pull of gravity and to weathering, making them somewhat short-lived. When observed in the field, it is a relatively recent occurrence. Also, when stiff rocks like sandstone and siltstones rupture in response to compressive forces, the rupture surface propagates rapidly. Some residences have reported loud rumblings during the times when compression ruptures presumably occurred.

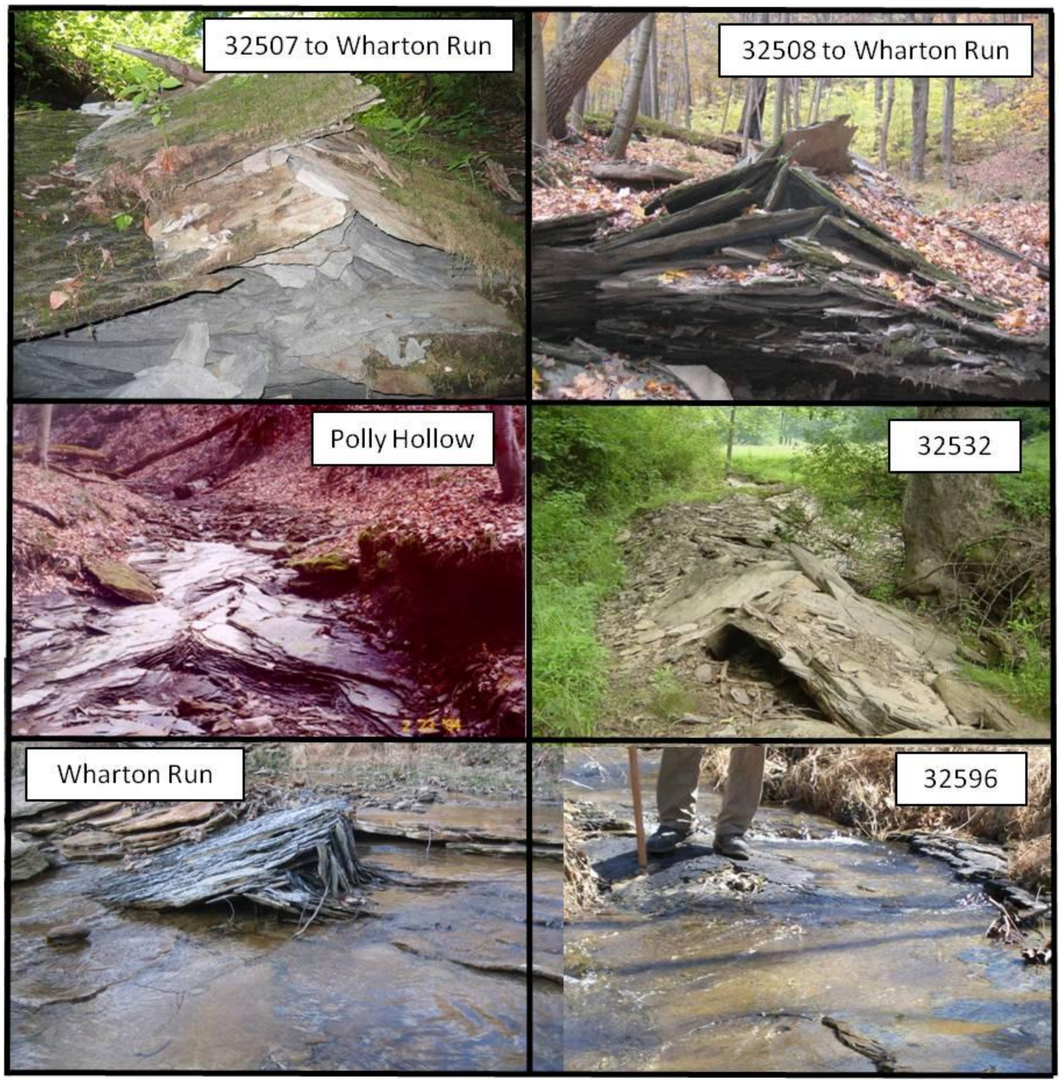

Figure VII-7 –Photographs of compression ruptures found in stream beds over the Bailey Mine (Photographs from PA DEP files).

When a compression rupture occurs, the stream flow can be diverted beneath the surface. For this to occur, the rupture must extend many feet into the stream bed and propagate the entire length of dry sections. The force needed to generate ruptures of the magnitude shown in Figure

VII-7 must be large. The University observed grout pumped into the rupture along stream No. 32596 (Figure VII-7). This grouting effectively filled the voids associated with the rupture surface and kept the water flowing across the top of the stream bed.

VII.C.2.d – Location of Stream Beds Impacted by Compression Ruptures

The compression ruptures shown in Figure VII-7 were located over the Bailey Mine (Figure VII-8). The majority of the segments were oriented in the Northeast direction. Molinda, et al. (1992) reported similar stream orientation for areas of increased roof instabilities in coal mines. The University believes that streams oriented in this direction have a higher likelihood for compression ruptures. Also note that most of the streams with compression ruptures were located within the Washington and Waynesburg Formations (Figure VII-8).

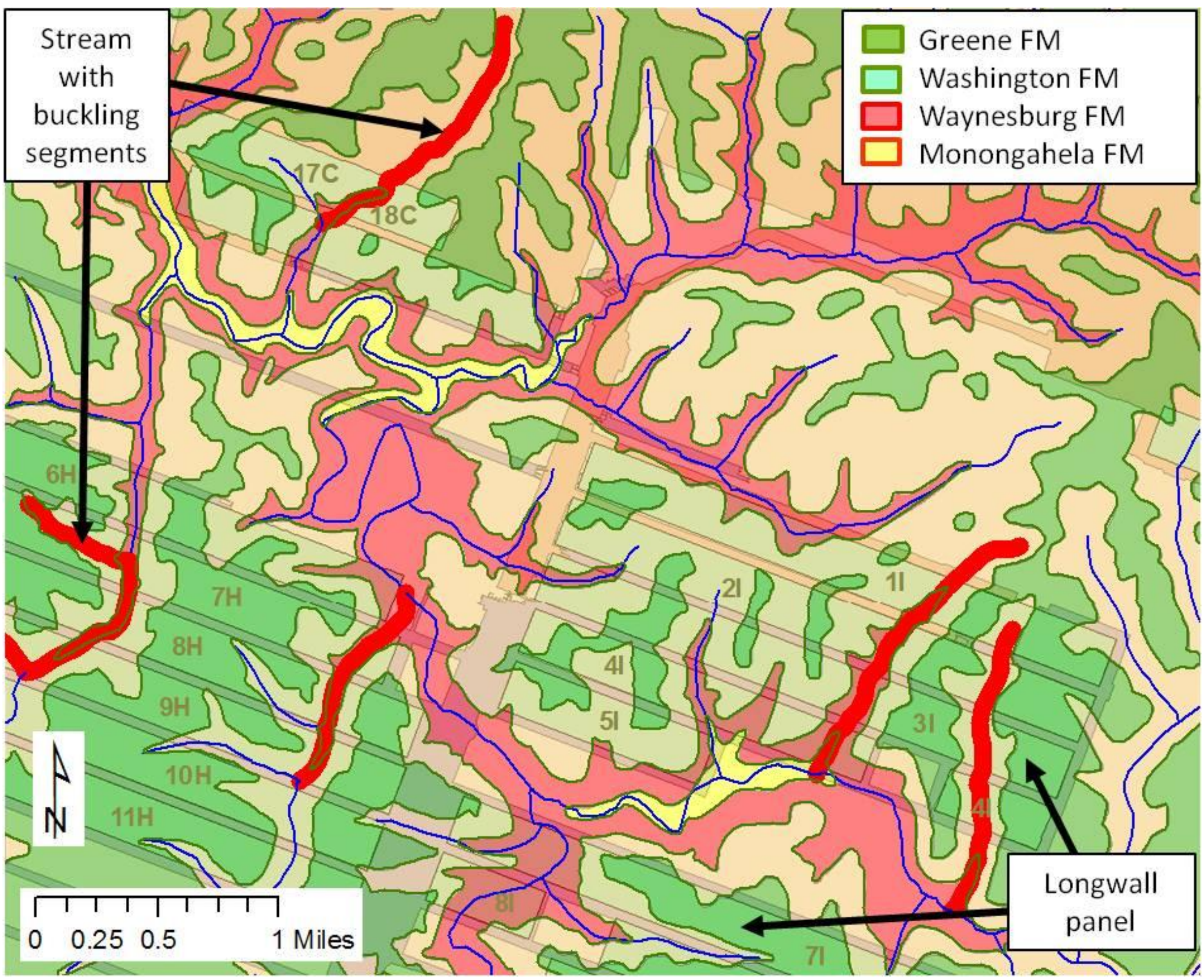

Figure VII-8 – Location of stream segments with compression rupture (thick red lines) above the Bailey Mine. Rock formations outcrop areas are also shown: Greene FM, Washington FM, Waynesburg FM, and Monongahela FM.

It should be noted that the Bailey Mine is not the only mine with reports of compression ridges. These features were also recognized by PA DEP agents along Bulldog Run over the Blacksville No.2 Mine, Dutch Run and Dyers Fork over the Cumberland Mine, and tributaries to Rocky Run and Templeton Fork over the Enlow Fork Mine (Appendix D). The orientation of these streams is predominately North-northwest:

- Bulldog Run is oriented North-northeast,
- Tributary 32721 to Rock Run is oriented North-northwest,
- Tributary 32740 to Templeton Fork is oriented North-northwest,
- Dutch Run over Panels 52 and 53 is oriented North-northwest, and
- Dyers Fork over Panels 52 and 53 is oriented Northwest.

The University believes that some stream valleys in PA's coal fields contain elevated levels of horizontal stresses and have the potential to cause compression ruptures within stream beds if undermined by a longwall panel. This potential is influenced by the magnitude and orientation of the stress field, the shape and orientation of the valley, and the physical properties of the strata.

VII.D – Examples from Mines

The University located examples of land reported effects where the outcome had been Company Liable or Interim Resolution. These examples provided an opportunity to examine the nature of the impacts in more detail and to assess the remediation efforts used to mitigate their impact.

VII.D.1 - Bailey Mine

The Bailey Mine had 13 land reported effects. The location of the six assigned as Company Liable or Interim Resolution are shown in Figure VII-9. The three properties having impacts caused by mass wasting were adjacent to one another. The two unknown causes were related to driveway impacts. The one property with tension cracks was located over a gate road.

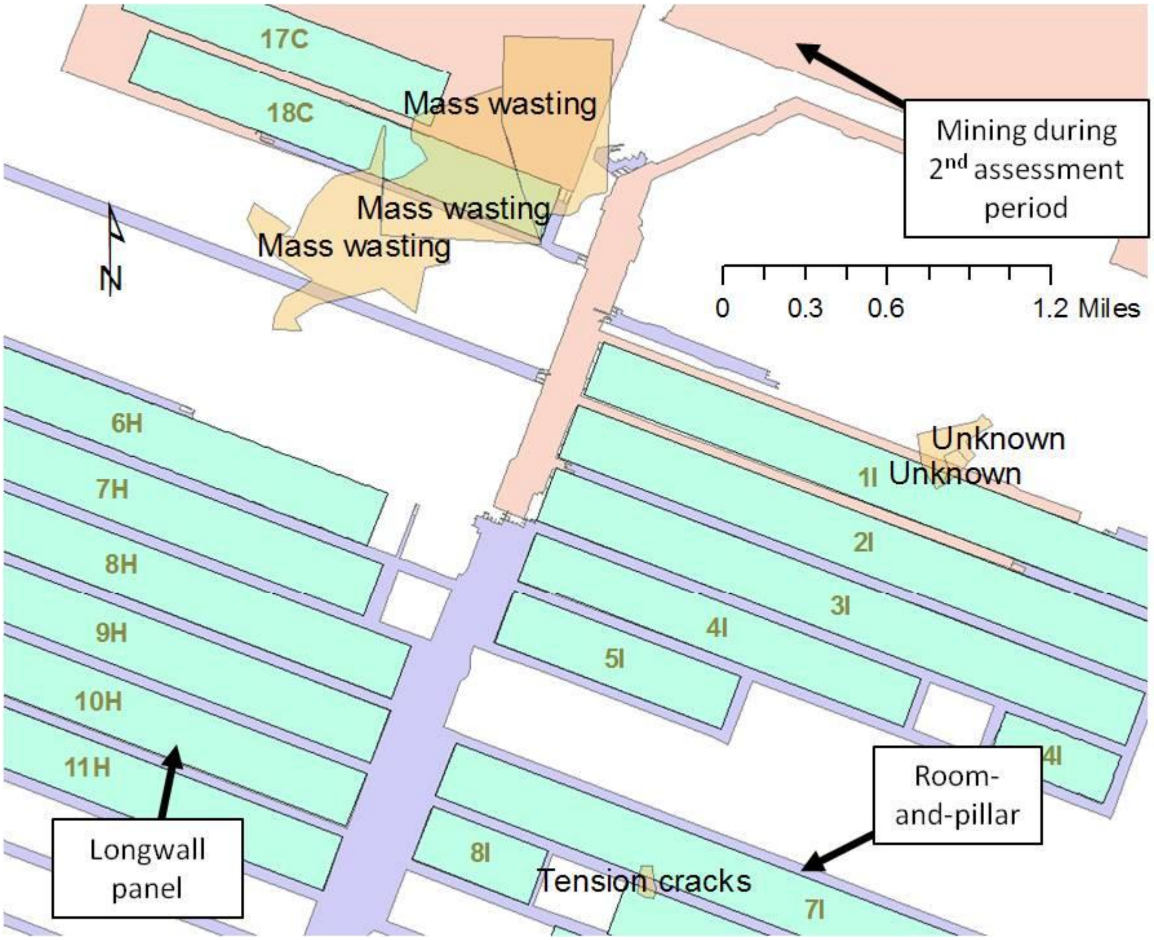

Figure VII-9 - Location of properties with land reported effects where Company Liable or Interim Resolution was the outcome at the Bailey Mine. Note – property boundaries are in tan and the principle causes are highlighted.

VII.D.2 - Blacksville No.2 Mine

The Blacksville No.2 Mine had seven land reported effects. The location of the six assigned as Company Liable or Interim Resolution are shown in Figure VII-10. Three were caused by settlement and three from mass wasting. All three of the properties with settlement impacts were located over areas mined during the 2nd assessment period. Two of the three properties with mass wasting impacts were located, at least in part, over longwall panels mined during the 3rd assessment period.

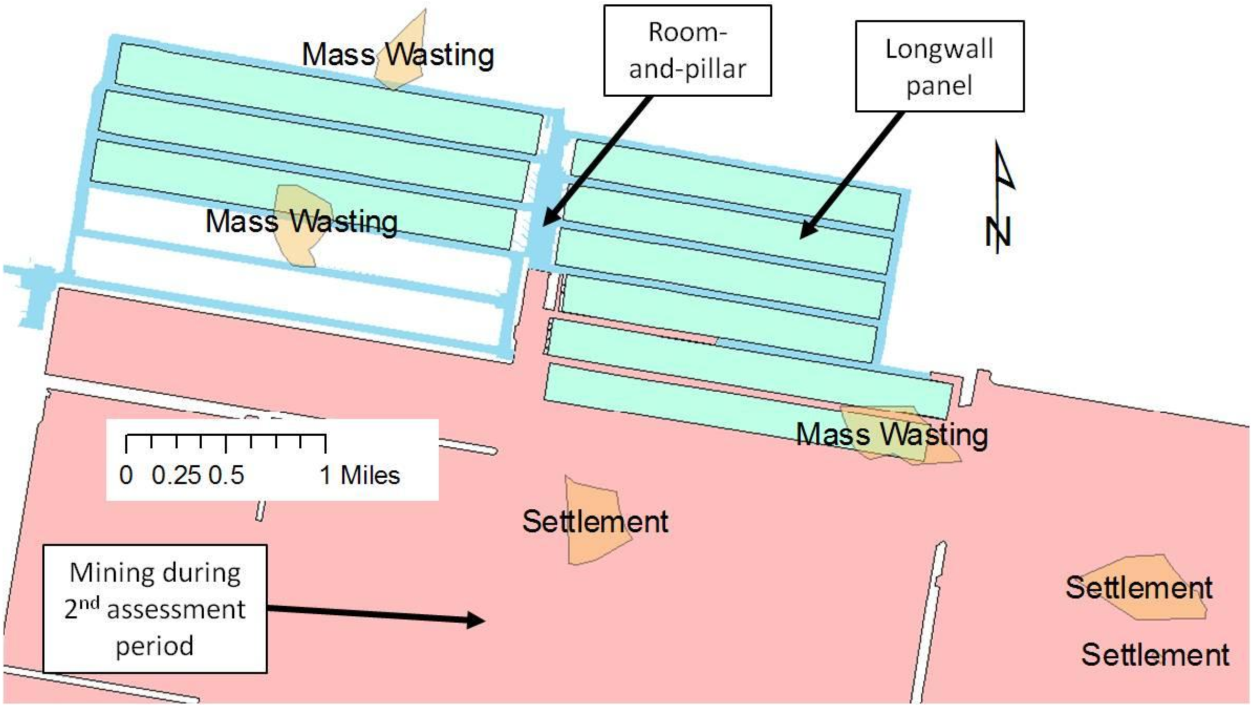

Figure VII-10 – Location of properties with land reported effects where Company Liable or Interim Resolution was the outcome at the Blacksville No. 2 Mine. Note – property boundaries are in tan and the principle causes are highlighted.

When the settlement impact resulted in ponding within a field or pasture, the repairs often occurred in the following manner:

- The extent of abnormal standing water was established (Figure VII-11a),
- A ditch was established to improve drainage (Figure VII-11b),
- The settled area was re-graded (Figure VII-11c), and
- The site was re-vegetated (Figure VII-11d).

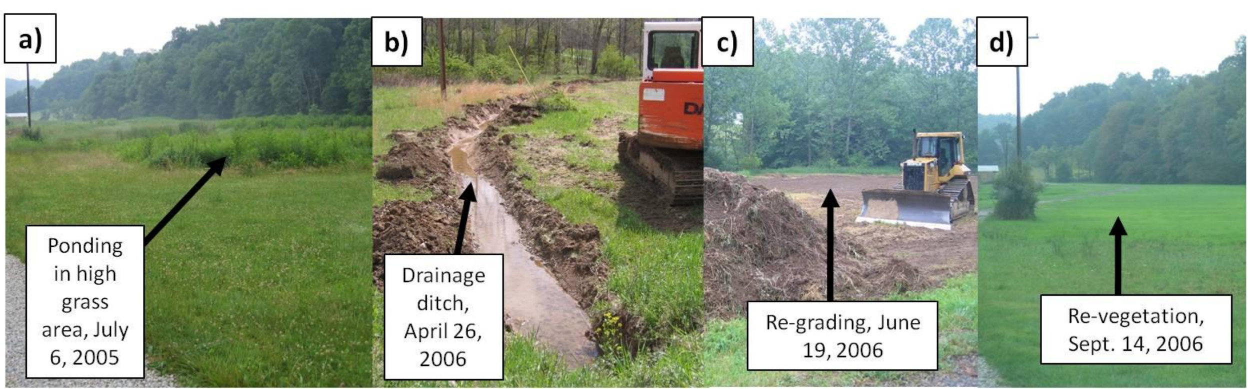

Figure VII-11 – Photographs of a commonly used method to repair settlement impacts after ponding resulted within a field or pasture (Photographs from PA DEP files).

If the settlement impact was adjacent to a stream, the repairs follow a slightly different sequence:

- The extent of abnormal standing water was established,
- The bank of stream was built-up to prevent the stream from flooding the adjacent field or pasture (Figure VII-12a),
- The settled area was re-graded (Figure VII-12b), and
- The site was re-vegetated (Figure VII-12c).

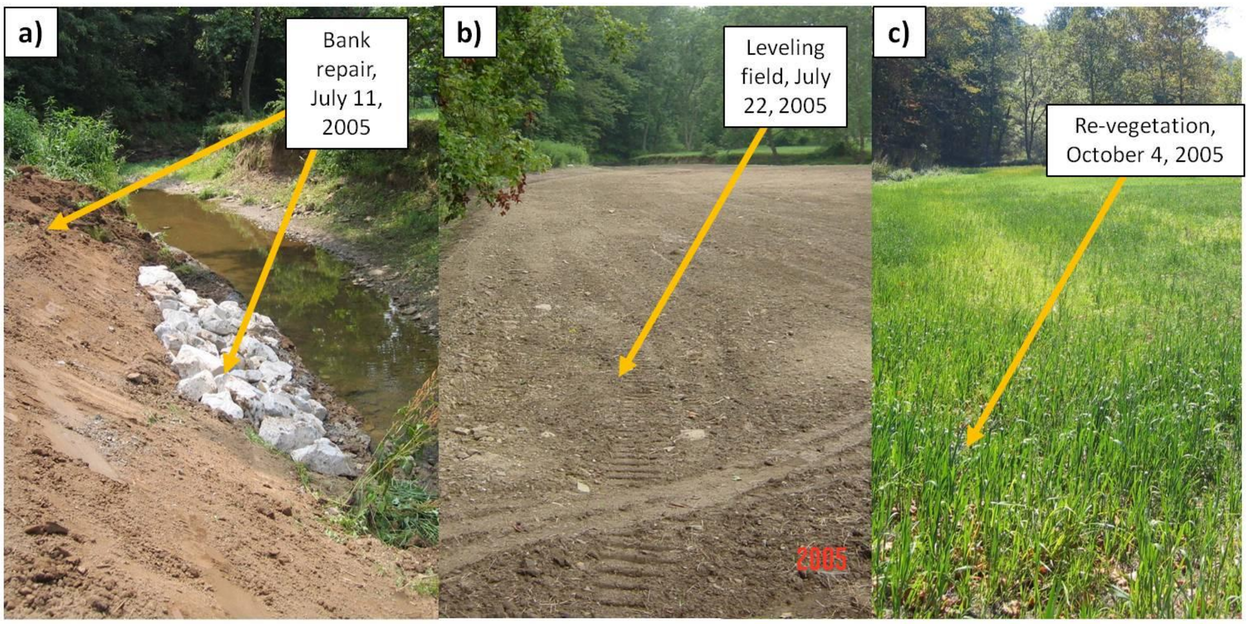

Figure VII-12 – Photographs of a common repair technique for settlement impacts adjacent to streams that caused ponding within a field or pasture (Photographs from PA DEP files).

VII.D.3 - Cumberland Mine

The Cumberland Mine had 21 land reported effects. The location of the 15 assigned as Company Liable or Interim Resolution are shown in Figure VII-13. The 14 properties, having impacts caused by tension cracks, settlement or mass wasting, were all over longwall panels or gate road entries. The one unknown reported effect occurred late in the 3rd assessment period and a cause has not been established.

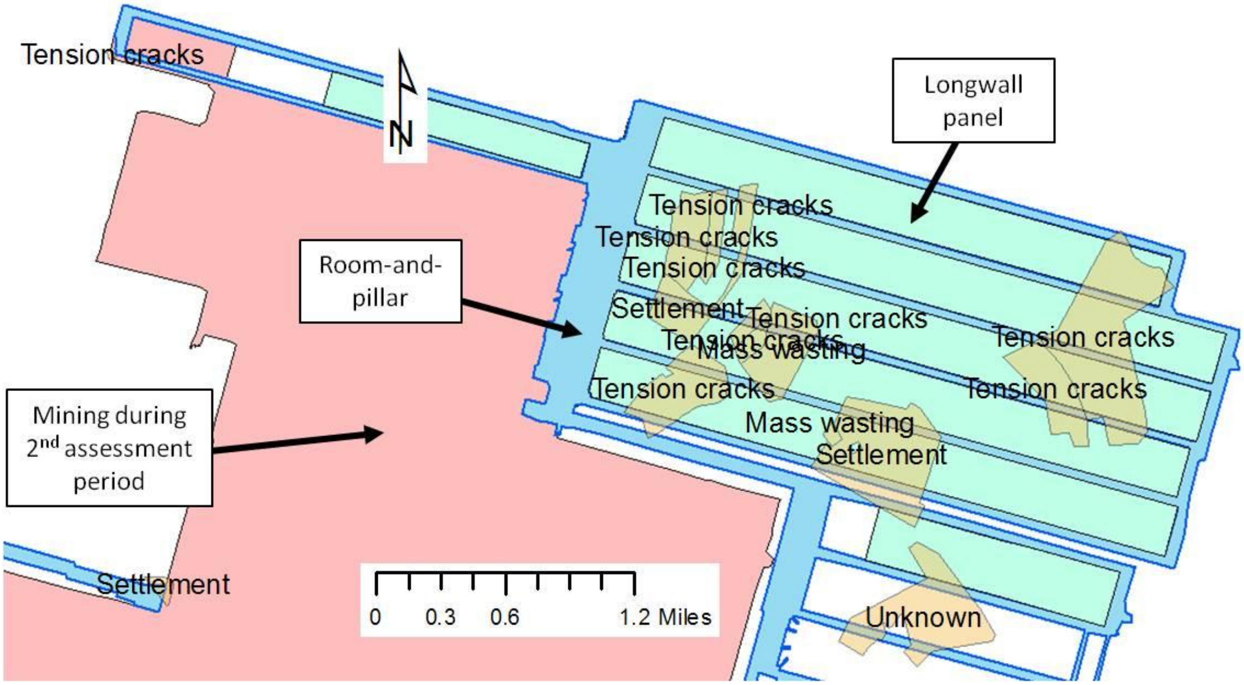

Figure VII-13 – Location of properties with land reported effects where Company Liable or Interim Resolution was the outcome at the Cumberland Mine. Note – property boundaries are in tan and the principle causes are highlighted.

Examples of a tension crack and a mass wasting impacts are shown in Figure VII-14. Tension cracks like the one shown in Figure VII-14a can present a hazard for people and animals traveling over them. Determining the cause of mass wasting impacts requires professional judgment. Figure VII-14b shows a mass wasting impact over the Cumberland Mine that was not classified as a reported effect.

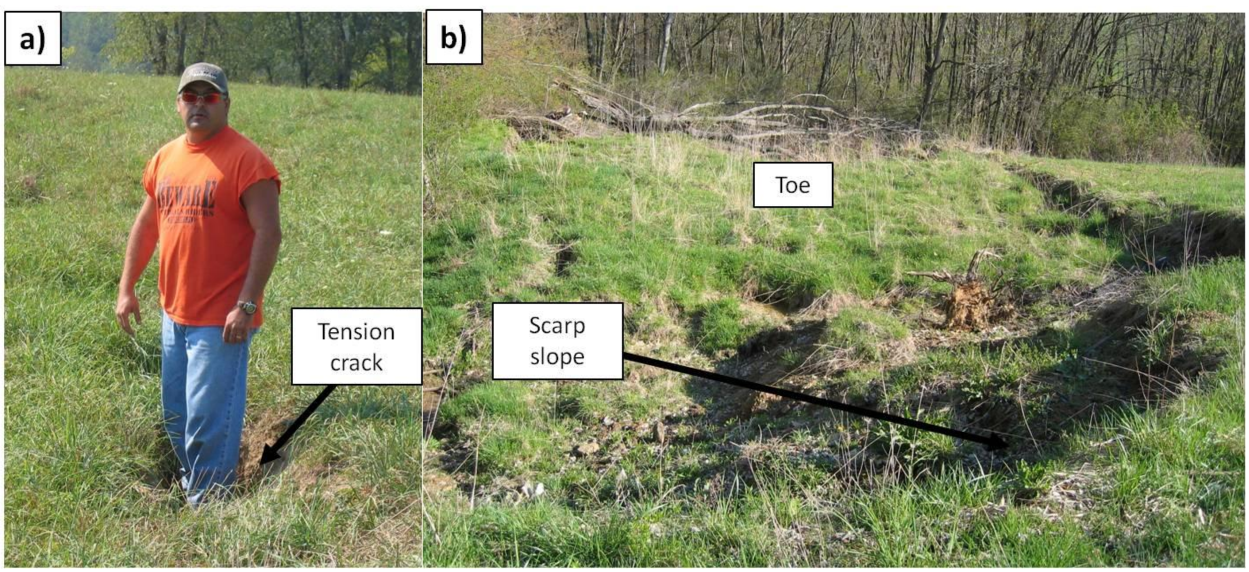

Figure VII-14 - Photographs of a) tension crack and b) mass wasting impacts to the surface. The first is a reported effect and the second is not (Photograph from PA DEP files).

VII.D.4 – Mine Eighty-Four

The Mine Eighty-Four had 16 land reported effects. The location of 12 of the 13 assigned as Company Liable, Interim Resolution or, No Resolution are shown in Figure VII-15. One of these properties is far to the north, located over areas mined during the 2nd assessment period. Twelve of the properties were located over longwall panels and gate road entries mined during the 3rd assessment period.

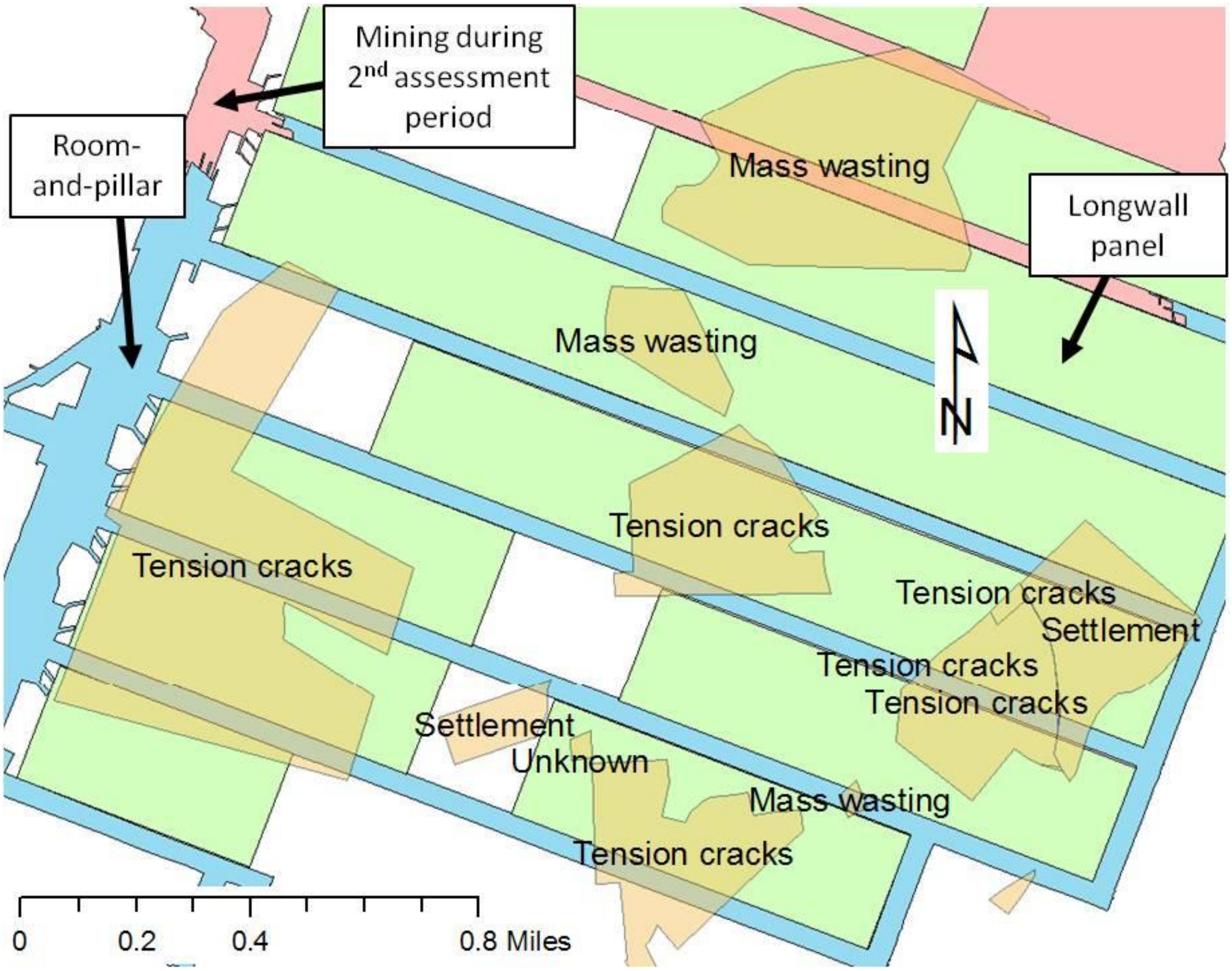

Figure VII-15 - Location of properties with land reported effects where Company Liable or Interim Resolution was the outcome at Mine Eighty-Four. Note – property boundaries are in tan and the principle causes are highlighted.

VII.D.5 – Emerald Mine

The Emerald Mine had 15 land reported effects. The location of seven of the properties assigned as Company Liable or Interim Resolution at the end of the 3rd assessment period are shown in Figure VII-16. Two other properties could not be located. It is possible that they were located over areas mined during the 2nd assessment period.

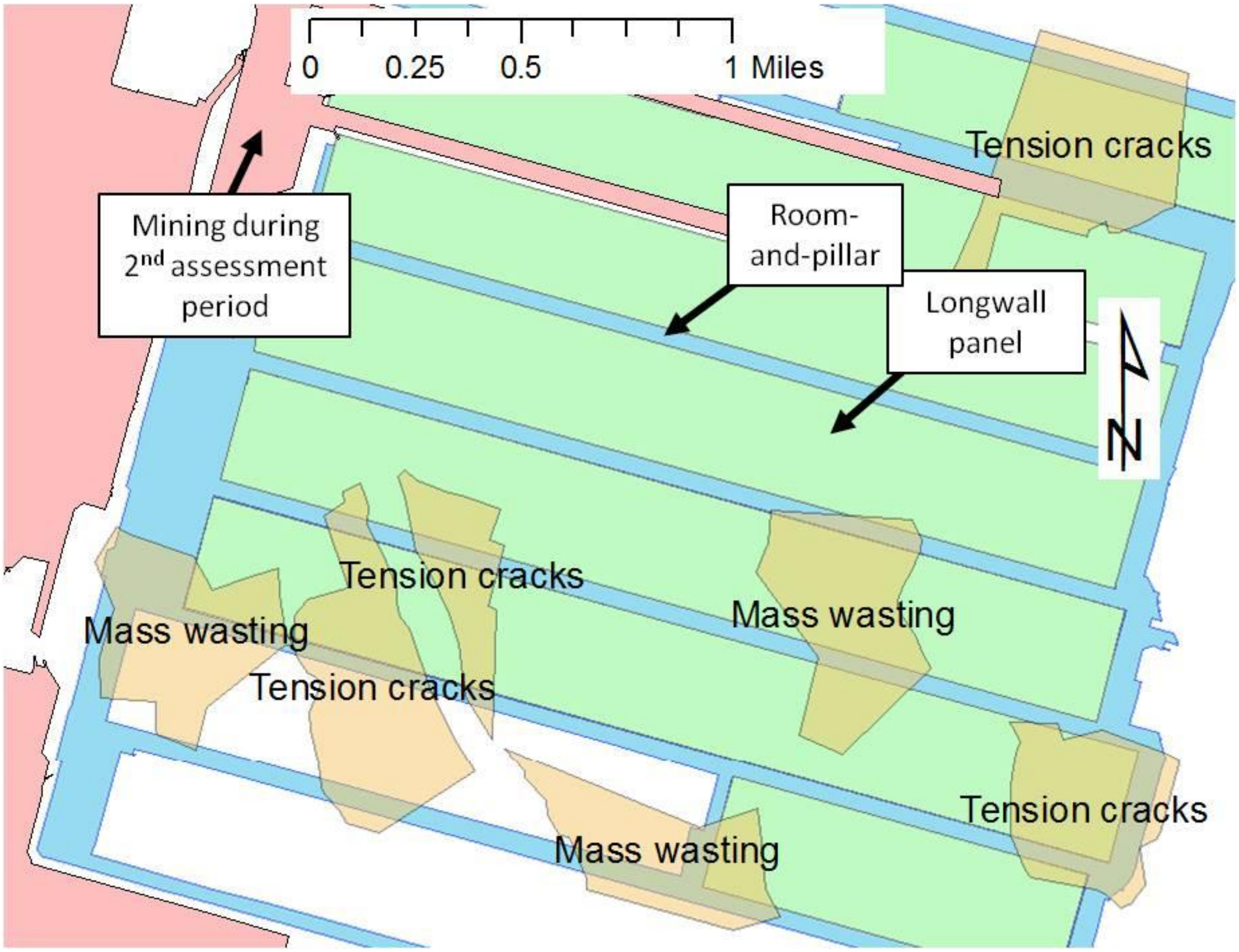

Figure VII-16 - Location of properties with land reported effects where Company Liable or Interim Resolution was the outcome at the Emerald Mine. Note – property boundaries are in tan and the principle causes are highlighted.

VII.D.6 - Enlow Fork Mine

The Enlow Fork Mine had 18 total reported effect, three occurring during the 2nd assessment period. The location of the 17 assigned as Company Liable or Interim Resolution are shown in Figure VII-17. There were ten properties with tension cracks as the main cause, five with mass wasting, and two with settlement. Only one of the properties was not over an area mined during the 3rd assessment period.

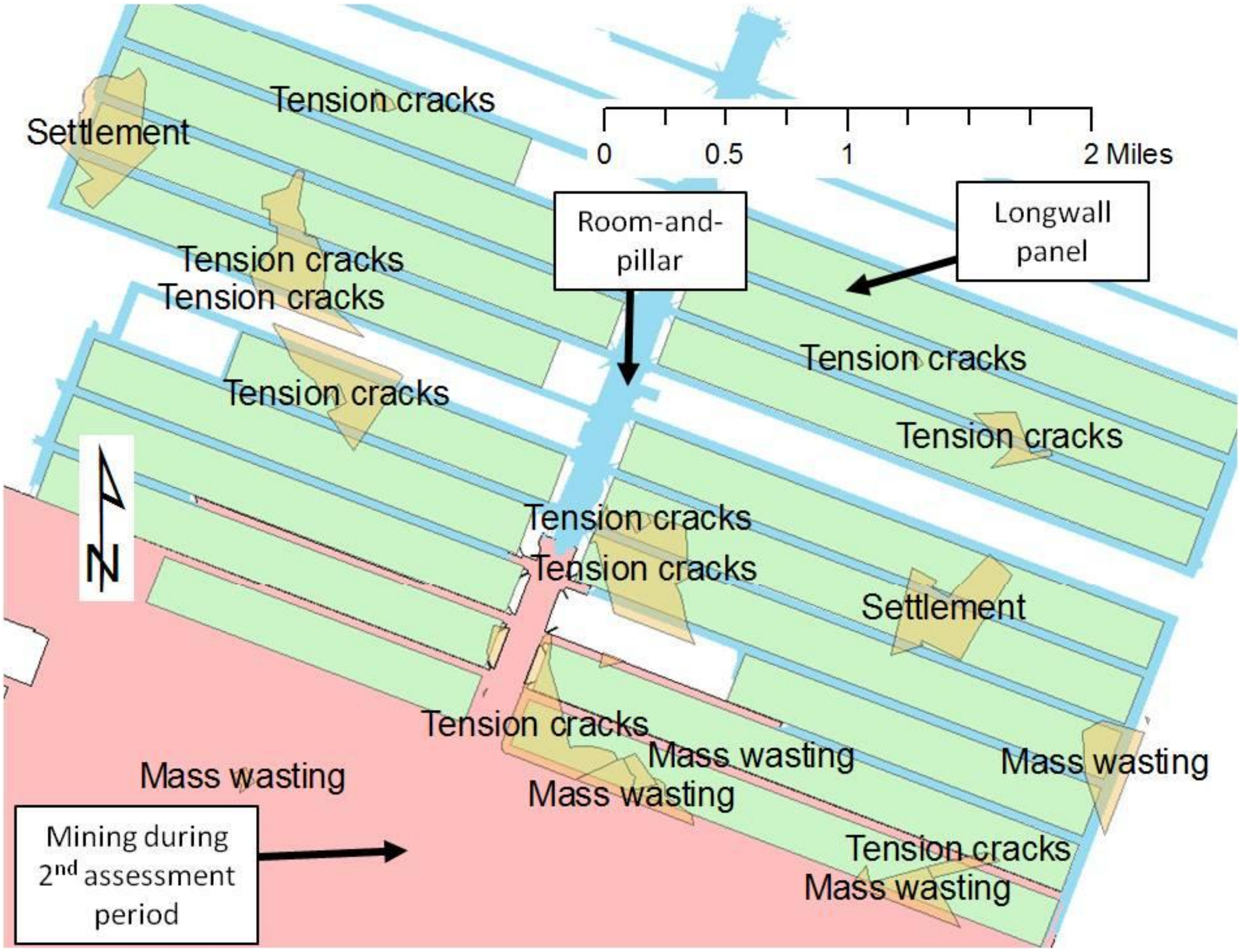

Figure VII-17 - Location of properties with land reported effects where Company Liable or Interim Resolution was the outcome at the Enlow Fork Mine. Note – property boundaries are in tan and the principle causes are highlighted.

VII.D.7 - High Quality Mine

The High Quality Mine had eight land reported effects. The location of the five assigned as Company Liable or Interim Resolution are shown in Figure VII-18. There were three properties with tension cracks as the main cause, one with settlement, and one unknown.

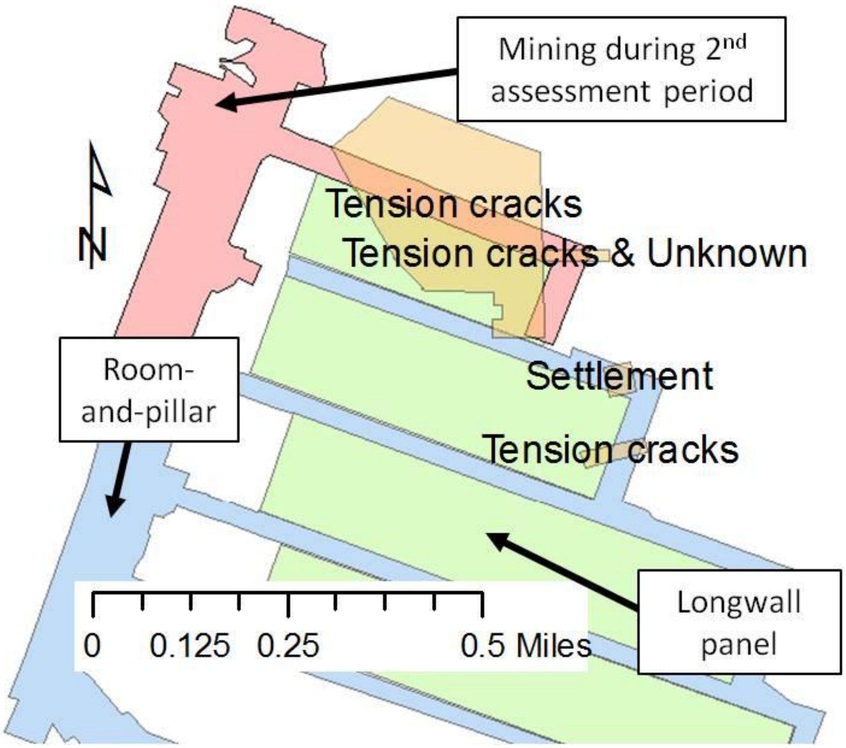

Figure VII-18 - Location of properties with land reported effects where Company Liable or Interim Resolution was the outcome at the High Quality Mine. Note – property boundaries are in tan and the principle causes are highlighted.

VII.D.8 – Ridge Mine

The Ridge Mine had two land reported effects and both were Company Liable (Figure VII-19a). Both property descriptions involved cracks in the ground surface. BUMIS listed pillar failure as the source of the impact, but the pillar layout does not change over the mine (Figure VII-19b) and the overburden above the room-and-pillar areas of the two properties was shallow (< 185-ft, Table II-16). The ARMPS program was used to examine the stability factor for this design. Using the 6-ft extraction height that is common for the Pittsburgh coalbed, 32 by 32-ft pillars, 16-ft entry widths, and an overburden of 150-ft, a stability factor of approximately six was calculated (Figure VII-19c). With a stability factor this large, it is highly unlikely that pillar failure was the cause of these reported effects. An alternative cause might be associated with roof falls that occurred in different parts of the mine where the overburden ranges from 100 to 200-ft. These roof falls were found on 6-month mining maps. It is possible that the surface could develop tension cracks above large roof fall areas underground, when overburden is low.

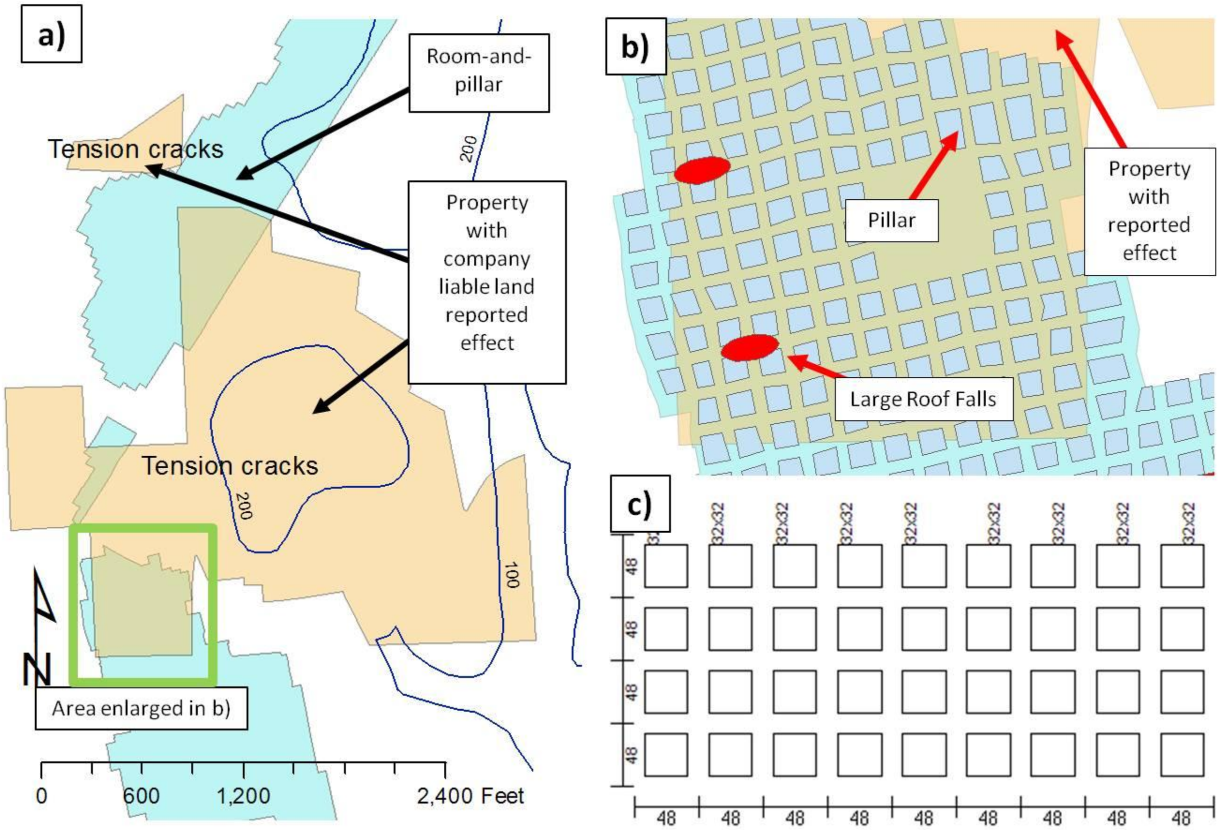

Figure VII-19 - Location of a) properties with land reported effects where the Ridge Mine is liable, b) pillar layout beneath the property where tension cracks were observed and roof falls noted on the 6-month mining maps, and c) ARMPS pillar layout characteristics.

The tension cracks associated with these land reported effects were smaller in length and narrower in width then some of the tension cracks discussed for longwall mines (Figure VII-20a). For both reported effects, the tensions cracks were filled to produce a level surface (Figure VII-20b).

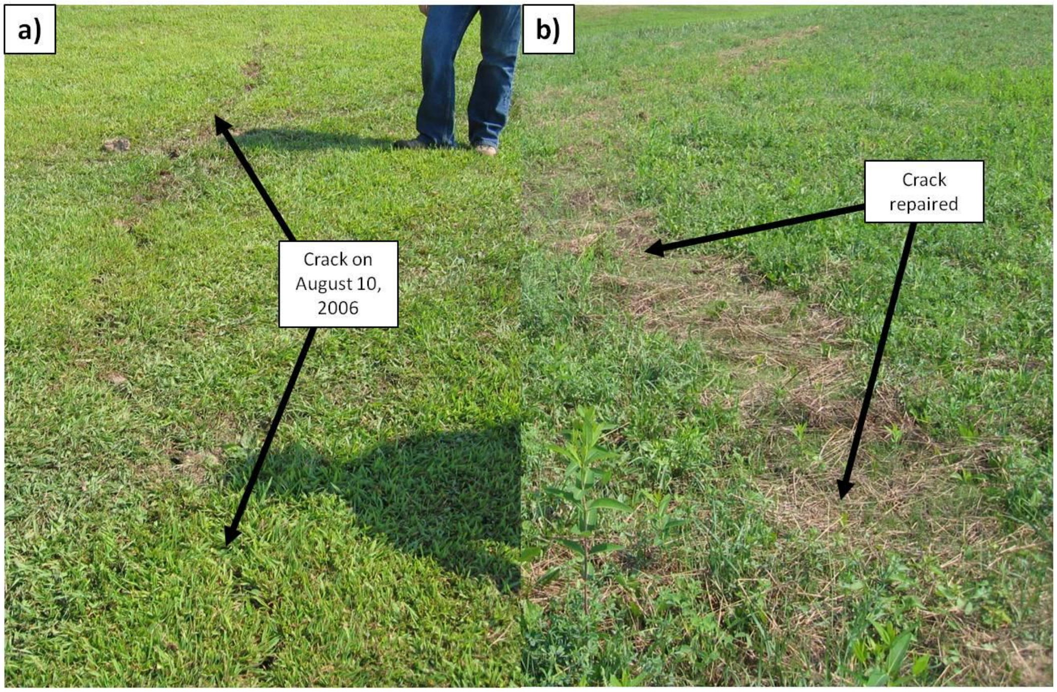

Figure VII-20 - Photographs of a) crack on August 10, 2006 and b) repair of a previous crack at the Ridge Mine (Photographs from PA DEP files).

VII.E – Summary Points

The University found 108 land reported effects during the 3rd assessment period and five from the 2nd assessment period.

VII.E.1 - Mine Type

The 108 land reported effects were distributed over 13 active and closed mines during the 3rd assessment period. Nine longwall mines accounted for 95.3-pct of the total while four room-and-pillar mines provided the remaining 4.7-pct. Properties over longwall mines had land reported effects at a rate of 6.3-pct. Room-and-pillar mines, with and without pillar recovery, had close to zero (0.02) land reported effects. Eleven of the reported effects came from mines that did not operate during the 3rd assessment period. They were Maple Creek (8), Dilworth (1), Humphrey No.7 (1), and Tanoma (1). Five additional reported effects occurred at active mines that were not resolved at the end of the 2nd assessment period.

The University collected information related to the date of occurrence, interim resolution, and final resolution for every land reported effect. Of the 113 land reported effects:

- 87 had final resolutions, taking an average of 206 days to reach a final resolution,
  - 57-pct, or 50, were assigned as Company Liable,
  - 43-pct, or 37, were assigned as Company Not Liable,
- 21 did not have a final resolution as of August 20, 2008,
  - 18 had an interim resolution,
  - 3 had an outstanding reported effect with no interim resolution, and

- 1 is from the 2nd assessment period with an interim resolution at 1,999 days and no final resolution at the end of the 3rd assessment period.

For the 50 Company Liable land reported effects, resolutions consisted of:

- 26, or 52-pct, property repaired,
- 12, or 24-pct, pre- and post-mining agreements,
- 7, or 14-pct, property owner compensated,
- 5, or 10-pct, property purchased by the company.

For 37 Company Not Liable land reported effects, resolutions consisted of:

- 31, or 83.8-pct, Not Due to Underground Mining,
- 2, or 5.4-pct, Not Covered by BMSLSA,
- 2, or 5.4-pct, No Liability,
- 1, or 2.7-pct, Withdrawn, and
- 1, or 2.7-pct, No Actual Reported Effect.

VII.E.2 - Causes

The University identified 76 land reported effects that were classified into five categories: *mass wasting, tension cracks, settlements, compression ruptures, and unknown*. These 76 cases were identified where land reported effects had resolutions with the Company Liable or with an Interim / Outstanding condition at the end of the 3rd assessment period.

- 37, or 48.7-pct, cases with tension cracks varying in scale and impact,
- 20, or 26.3-pct, cases with mass wasting ranging from large landslides hundreds of feet across (estimated from PA DEP photographs) to small mass soil movements that produced hump, rolls, and slips in the surface,
- 12, or 1.58–pct, settlement cases often disrupting drainage patterns resulting in ponding of water in fields, pastures, and residential lawns.
- 7, or 9.2–pct, cases of unknown cause.

Compression ruptures were found in steep-sided valley stream bottoms over the Bailey, Blacksville No.2, Cumberland, and Enlow Fork Mines that trend in a Northwest to Northeast direction. These compression rupture features were caused by significant levels of horizontal stresses found in Pennsylvania's near-surface strata that can be locally influenced by the shape and orientation of the stream valley and the physical properties of the bed rock strata. When compression ruptures occur, they can have an adverse impact on land in general and streams in particular.

VII.E.3 - Examples from Mines

The University presents specific examples of land reported effects and summarized some repair methods to mitigate their impact. Seven longwall mines and one room-and-pillar mine were examined. The examples from the longwall mines focused on the location and remediation of tension cracks, mass wasting, and settlement impacts. The example from the room-and-pillar mine focused on the potential cause for this un-planned event.