SECTION 9: Effects of Mine Subsidence on Streams

9.A – Overview

This report section addresses the impact of mine subsidence on streams in Pennsylvania. The University reports the length of streams undermined and impacted during the 5th assessment period. The University also provides an assessment of the effect of mining on five pre-selected streams based on a comparison of pre- and post-mining aquatic macroinvertebrate community composition. The stream recovery reports submitted to PADEP by the mine operators are assessed. Finally, stream monitoring pre- and post-mining, methods of flow loss mitigation, and incidental observation and reporting of fish kills by PADEP agents following undermining are examined.

9.B – Length of Streams Undermined During the 5th Assessment

The University was tasked with reporting the total lengths of streams undermined during the 5th assessment period, categorized by mining method and impact type. ArcGIS was used to clip (spatially associate) stream layers to the geographical extent of room-and-pillar, longwall, and pillar recovery mining types, and to a 200-foot buffer zone around each of the applicable mining types. The "Networked Streams of PA" layer available on PASDA was the source of the stream layer, as in previous reports. This layer does not include all small-order streams, particularly intermittent reaches, so the total length of undermined streams is an underestimation of the actual length undermined. Some of mine operators provided more detailed stream layers in environmental resource mapping, therefore the level of resolution among mines was inconsistent. Using these more detailed stream data for only some of the mines in the analysis of undermined lengths would result in higher stream mileage for those mines. Not only would this inaccurately suggest differences among mine operators in their undermining of waterways, it would create a distinct data set that cannot be directly compared to previous Act 54 assessments. Therefore, the "Networked Streams of PA" layer was used for consistency both among mines and across reports.

In total, 126.98 miles of streams (86.16 miles directly over mining and 40.82 over the 200-foot buffer around mining activity) were undermined during the 5th assessment period. Divided based on mining method, 46.75 miles were undermined by longwall mining, 38.89 miles by room-and-pillar mining, 0.53 miles by pillar recovery, and 40.82 miles were within the 200-foot buffer zone (Table 9-1). In terms of ongoing variability in subsidence impacts, the total length of streams undermined decreased by 10 % compared to the 4th assessment period. For longwall mining, the undermined stream mileage dropped from 50.59 in the 4th assessment to 46.75 in the 5th assessment, and for room-and-pillar mining from 45.04 to 38.89 (Table 9-1).

Table 9-1. Length of streams undermined by mine and mining method during the 5th assessment period, with and without the 200-ft buffer.

Mine	Stream Length Undermined by Mining Method				Total without Buffer (mi)	Total Stream Length (mi)
	Room-and-Pillar Length (mi)	Longwall Length (mi)	Pillar Recovery Length (mi)	Buffer Zone Length (mi)		
4 West	5.51	0.00	0.39	2.86	5.90	8.76
Acosta	0.00	0.00	0.00	0.00	0.00	0.00
Bailey	3.58	7.74	0.00	3.15	11.31	14.46
Barbara 2	0.00	0.00	0.00	0.12	0.00	0.12
Barrett	0.56	0.00	0.00	0.38	0.56	0.94
Beaver Valley	0.06	0.00	0.00	0.23	0.06	0.29
Brubaker	0.00	0.00	0.00	0.02	0.00	0.02
Brush Valley	2.00	0.00	0.00	1.68	2.00	3.68
Cass 1	0.50	0.00	0.00	0.11	0.50	0.61
Cherry Tree	0.36	0.00	0.00	0.19	0.36	0.54
Clementine 1	0.08	0.00	0.00	0.33	0.08	0.41
Coral Graceton	0.03	0.00	0.00	0.09	0.03	0.13
Crawdad Portal B	0.18	0.00	0.09	0.04	0.27	0.31
Cresson	0.00	0.00	0.00	0.00	0.00	0.00
Crooked Creek	0.93	0.00	0.00	1.36	0.93	2.29
Cumberland	2.21	8.48	0.00	2.41	10.69	13.10
Darmac 2	0.23	0.00	0.00	0.70	0.23	0.93
Dutch Run	0.40	0.00	0.00	0.37	0.40	0.77
Emerald	0.39	1.32	0.00	1.74	1.71	3.44
Enlow Fork	4.93	17.36	0.00	5.33	22.29	27.62
Gillhouser	0.00	0.00	0.00	0.06	0.00	0.06
Harmony	0.47	0.00	0.00	0.52	0.47	0.99
Harvey	2.38	6.21	0.00	2.64	8.60	11.24
Heilwood	0.61	0.00	0.00	0.72	0.61	1.34
Horning Deep	0.00	0.00	0.00	0.00	0.00	0.00
Kimberly	0.04	0.00	0.00	0.20	0.04	0.24
Kingston-West	0.05	0.00	0.00	0.10	0.05	0.14
Knob Creek	0.81	0.00	0.00	1.10	0.81	1.91
Kocjancic	0.38	0.00	0.00	0.19	0.38	0.57
Logansport	0.28	0.00	0.00	0.32	0.28	0.60
Lowry	0.48	0.00	0.00	0.92	0.48	1.41
Madison	0.41	0.00	0.00	1.42	0.41	1.83
Maple Springs	0.35	0.00	0.00	0.39	0.35	0.73
Mine 78	3.27	0.00	0.00	2.40	3.27	5.67

Table 9-1 continued.

Mine	Stream Length Undermined by Mining Method				Total without Buffer (mi)	Total Stream Length (mi)
	Room-and-Pillar Length (mi)	Longwall Length (mi)	Pillar Recovery Length (mi)	Buffer Zone Length (mi)		
Monongalia Co.	2.29	5.64	0.00	2.35	7.93	10.28
Nolo	0.03	0.00	0.00	0.28	0.03	0.30
North Fork	0.00	0.00	0.00	0.05	0.00	0.05
Ondo	0.50	0.00	0.00	0.17	0.50	0.67
Parkwood	1.26	0.00	0.00	1.50	1.26	2.77
Penfield	0.94	0.00	0.00	0.98	0.94	1.92
Prime 1	0.00	0.00	0.00	0.00	0.00	0.00
Quecreek	1.56	0.00	0.05	2.01	1.60	3.61
Roytown	0.00	0.00	0.00	0.00	0.00	0.00
Starford	0.07	0.00	0.00	0.10	0.07	0.17
TJS 6	0.06	0.00	0.00	0.09	0.06	0.16
Toms Run	0.53	0.00	0.00	0.41	0.53	0.95
Tracy Lynne	0.03	0.00	0.00	0.22	0.03	0.26
Tunnel Ridge	0.14	0.00	0.00	0.51	0.14	0.65
Twin Rocks	0.00	0.00	0.00	0.06	0.00	0.06
Total	**38.89**	**46.75**	**0.53**	**40.82**	**86.16**	**126.98**

9.C – Lengths of Streams Impacted During the 5th Assessment

Table 9-2 reports the stream lengths experiencing either a flow loss or pooling impact during the 5th assessment period. The term "stream length" is defined herein as the measured length of a stream reach that has been identified as being undermined. A stream reach is a segment of stream under which mining has occurred. In reporting lengths of stream impacted, the University is reporting the summed lengths of all stream segments (reaches) for which an impact was reported, not the summed length of the stretches within a reach in which flow was lost or pooling occurred. In contrast, Tables 9-3 and 9-4 summarize the number and actual lengths of flow loss and pooling impacts for each longwall mine. Specific details regarding each flow loss and pooling impact, including length and location, can be found in Appendix I. The lengths and locations reported in Tables 9-3 and 9-4 were obtained from BUMIS. This is an example of where improved data tools (i.e., BUMIS upgrades) allow simpler and more powerful analyses of stream impacts. BUMIS contained records for the start and end points of both flow loss and pooling impacts. The coordinates of these points were used to plot their location in ArcGIS. Once plotted the University used a tool that snaps the points to the nearest stream segment within a target stream layer. In cases where the impacts belonged to the streams that are a part of the "Networked Streams of PA" layer, they were snapped to this layer. In cases where the impacts belonged to small order streams that were not included in the "Networked Streams of PA" layer, they were snapped to the more detailed streams layer that some mine operators provided in environmental resource maps. This snapping was only used for analysis of impacted streams. Overarching sums of stream lengths, as noted above, are based on the "Networked Stream of PA" data. Once all points were snapped the flow loss and pooling impacts could be traced and digitized from start to end points in a GIS layer. After this process, the lengths and locations for each impact were mapped and recorded.

During the 5th assessment period over longwall mines, 30.96 miles of stream reaches experienced flow loss, 6.2 miles experienced pooling, and 14.82 miles experienced both flow loss and pooling, for a total of 51.98 miles of undermined stream reaches experiencing some sort of impact (Table 9-2). Overall, impacted stream reaches account for 64 % of the 80.78 miles of streams undermined by longwall mines (including the 200-ft buffer) during this assessment. For comparison, 77 % of undermined stream miles were impacted by longwall mining during the 4th assessment period. This information may be more valuable to landowners and managers when expressed in terms of the proportion of reaches impacted. Of 148 stream reaches undermined in the 5th assessment period, 40 % or 59 total stream reaches were impacted by underground mining.

During the 5th assessment period, a total of 153 flow loss impacts occurred over 24.60 miles of streams (Table 9-3), and a total of 30 pooling impacts occurred over 2.83 miles of streams (Table 9-4), for a total length of 27.26 miles of streams directly impacted. Areas above Enlow Fork experienced the most flow loss impacts (n=77), totaling 9.95 miles, while areas above Tunnel Ridge experienced none. Areas above Enlow Fork also experienced the most pooling impacts (n=11), totaling 1.51 miles, while areas above Monongalia County and Tunnel Ridge experienced none.

Table 9-2. Lengths of undermined streams categorized by impacts that occurred on the stream. These lengths do not represent the actual length of the impacts, rather the lengths of the undermined stream reaches that experienced impacts.

Mine	Flow Loss			Pooling			Flow Loss and Pooling			Unaffected		
	Longwall Length (mi)	Room-and-Pillar Length (mi)	Buffer Length (mi)	Longwall Length (mi)	Room-and-Pillar Length (mi)	Buffer Length (mi)	Longwall Length (mi)	Room-and-Pillar Length (mi)	Buffer Length (mi)	Longwall Length (mi)	Room-and-Pillar Length (mi)	Buffer Length (mi)
Bailey	2.77	0.47	1.24	1.89	1.07	0.18	2.34	0.33	0.23	0.73	1.71	1.49
Cumberland	2.02	0.25	0.21	0.00	0.00	0.00	5.11	0.85	0.62	1.34	1.12	1.58
Emerald	0.13	0.02	0.12	0.00	0.00	0.00	1.19	0.04	0.26	0.00	0.33	1.36
Enlow Fork	8.90	1.93	0.93	2.21	0.35	0.50	1.87	0.55	0.40	4.38	2.10	3.50
Harvey	5.05	1.24	0.99	0.00	0.00	0.00	0.86	0.07	0.10	0.30	1.07	1.55
Monongalia Co.	3.52	0.59	0.58	0.00	0.00	0.00	0.00	0.00	0.00	2.13	1.70	1.76
Tunnel Ridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.51
Total	**22.39**	**4.50**	**4.07**	**4.10**	**1.42**	**0.68**	**11.37**	**1.84**	**1.61**	**8.88**	**8.17**	**11.75**
	30.96			**6.20**			**14.82**			**28.80**		

Table 9-3. Total number and length of flow loss impacts for each longwall mine.

Mine	Number of Flow Loss Impacts	Total Length of Flow Loss Impacts (mi)
Bailey	29	5.17
Cumberland	20	3.89
Emerald	5	0.98
Enlow Fork	77	10.07
Harvey	13	3.37
Monongalia Co.	9	1.12
Total	**153**	**24.60**

Table 9-4. Total number and length of pooling impacts for each longwall mine.

Mine	Number of Pooling Impacts	Total Length of Pooling Impacts (ft)	Total Length of Pooling Impacts (mi)
Bailey	5	1,580	0.30
Cumberland	9	4,346	0.82
Emerald	4	911	0.17
Enlow Fork	11	7,991	1.51
Harvey	1	104	0.02
Total	**30**	**14,932**	**2.82**

9.D – Stream Recovery Evaluation Reports Submitted During the 5th Assessment Period

A stream recovery evaluation (SRE) report is submitted by a mine operator following mitigation on an impacted stream to demonstrate recovery of the stream and to demonstrate flow has returned to pre-mining ranges and release the operator from responsibility for continued stream repair. During the 5th assessment period, 82 SRE reports were submitted to the PADEP (Table 9-5 and 9-6, information in Appendix F). This increase from the 4th assessment period when only 14 SRE reports were submitted reflects changes in procedure and policy dictated by TGD 563-2000-655. All but one of the SRE reports submitted (1512, Patchin Run over Harmony Mine) were for streams over longwall mines. Over half (43) of the SRE reports were submitted regarding streams above the Enlow Fork Mine. As of the end of the 5th assessment, 42 of the 82 streams were released by PADEP. The remaining 40 have not yet been resolved. Table 9-6 provides the status for each of the 82 streams associated with SRE reports. During the 5th assessment period, time in days from submission of the SRE report until resolution for the 42 released streams ranged from 3 to 713 days, with an average of 258 days.

Table 9-5. Status of the 82 SRE reports submitted during the 5th assessment period.

SRE Status	# SRE reports
Final: Released	42
Interim: Not Released	40
Total	**82**

Table 9-6. A list of the 82 SRE reports submitted during the 5th assessment period and their status.

Mine	Stream	Panel(s)	SRE Report #	Status	Days from Submission to Release
Bailey	Barney's Run	11-12I, 16-17H	1735	Released	123
Bailey	South Fork	7-8, 10-15I	1603	Not released	
Bailey	South Fork 2R	8I	1516	Released	96
Bailey	ST32532	14H	1514/1601	Released	713
Bailey	ST32539	9-11I	1201/1733	Not released	
Bailey	ST32541	13H, 11I	1513	Not Released	
Bailey	ST32543	16H	1736	Released	123
Bailey	ST32544	16H	1736	Released	123
Bailey	ST32545	18H	1737	Released	123
Bailey	ST32546	11I	1734	Not released	
Bailey	ST32549	10-12I	1515	Released	112
Bailey	ST32551	15I	1740	Released	213
Bailey	ST32553	15-16I	1738	Released	123
Bailey	ST32554	16I	1739	Released	123
Bailey	ST32566	14-15I	1731	Released	123
Bailey	ST32567	15I	1732	Released	123
Bailey	ST32596	1-4I	1604	Not released	
Bailey	Strawn Hollow	13-14I	1618	Released	419
Cumberland	ST40592 L7	LW60	1503/1631	Released	99
Cumberland	ST40611 L2	no data	1502/1629	Released	577
Cumberland	ST40614	no data	1402/1501/1630	Released	577
Cumberland	ST40607	LW61-62	1701	Released	3
Cumberland	ST41264	LW49-53	1626	Released	100
Cumberland	ST41267	LW49-52	1628	Released	100
Cumberland	ST41282	LW54-46	1627	Released	429
Emerald	ST40450	E1/E2	1802	Not released	
Emerald	ST40410	C1	1632	Released	99

Table 9-6 continued.

Mine	Stream	Panel(s)	SRE Report #	Status	Days from Submission to Release
Emerald	ST40461-R25	E1	1725	Released	286
Emerald	ST41239	B1	1702	Released	290
Enlow Fork	BufC-11R,1R	F22-23	1746	Not released	
Enlow Fork	BufC-9L,1L	F23	1743	Released	90
Enlow Fork	Buffalo Creek	F20-28	1741	Not released	
Enlow Fork	Craft's Creek	E15-20	1623	Released	100
Enlow Fork	CrC-1.5R	E20-21	1619	Released	475
Enlow Fork	CrC-1.7R	E20-21	1625	Released	498
Enlow Fork	CrC-6L	E19	1621	Released	498
Enlow Fork	CrC-9L	E18	1622	Released	498
Enlow Fork	ST32739	F17-18	1616	Not released	
Enlow Fork	ST32742	F16-18	1610	Not released	
Enlow Fork	ST32743	F17-19	1606	Not released	
Enlow Fork	ST32744	F18-20	1607	Not released	
Enlow Fork	ST32745	F19-20	1608	Not released	
Enlow Fork	ST32783-TF	F13-16	1101/1615	Released	540
Enlow Fork	ST32996	F21-23	1742	Released	90
Enlow Fork	ST32997	F23	1744	Released	90
Enlow Fork	ST32998	F22	1745	Released	90
Enlow Fork	ST32999	F21	1747	Not released	
Enlow Fork	ST33000	F21	1639	Released	483
Enlow Fork	ST40939	E21-22	1202/1638	Released	460
Enlow Fork	ST40940	E22-23	1637	Released	460
Enlow Fork	ST40941	E21	1624	Released	498
Enlow Fork	ST40942	E17-19	1728	Not released	
Enlow Fork	ST40943	E21	1727	Not released	
Enlow Fork	ST40944	E16-20	1729	Not released	
Enlow Fork	ST40944	E16-20	1726/1729	Not released	
Enlow Fork	ST40945	E16-17	1620	Released	475

Table 9-6 continued.

Mine	Stream	Panel(s)	SRE Report #	Status	Days from Submission to Release
Enlow Fork	ST40949	E22-24	1749	Released	90
Enlow Fork	ST40950	E23	1752	Not released	
Enlow Fork	ST40951	E22-23	1750	Released	90
Enlow Fork	TemF-21L,0.9L	F16	1730	Not released	
Enlow Fork	TemF-25L,1L	F16-17	1611	Not released	
Enlow Fork	TemF-28L,2R	F20	1609	Not released	
Enlow Fork	TemF-29L	F20	1613	Not released	
Enlow Fork	TemF-33R	E19	1614	Not released	
Enlow Fork	Templeton Fork	F13-19, E22	1612	Not released	
Enlow Fork	TenC-10R	E24	1755	Not released	
Enlow Fork	TenC-12R	E24	1756	Not released	
Enlow Fork	TenC-8L, 1R	E24	1751	Not released	
Enlow Fork	TenC-8L,2R,1L	E23	1753	Not released	
Enlow Fork	TenC-8L,2R,2R	E24	1754	Released	90
Enlow Fork	Tenmile Creek	E23-29	1748	Not released	
Enlow Fork	TF21L-1L-2L	F18-20	1617	Not released	
Harmony	Patchin Run	N/A	1512	Not released	
Mine 84	ST40824	6B	1505	Not released	
Mine 84	ST40829	6B	1401	Released	131
Monongalia Co.	ST41809	19M	1404	Not released	
Monongalia Co.	ST41812	15-18W	1508	Not released	
Monongalia Co.	ST41813	13W	1507	Not released	
Monongalia Co.	ST41819	14-18W	1509	Not released	
Monongalia Co.	ST41820	15W	1506	Not released	

Table 9-6 continued.

Mine	Stream	Panel(s)	SRE Report #	Status	Days from Submission to Release
Monongalia Co.	ST41826	17-20W	1504	Not released	
Monongalia Co.	ST41831	19M	1403	Not released	

9.E – Pre- and Post-Mining Total Biological Score Analysis on Five Pre-determined Stream Sections

9.E.1 – Methods

The University was tasked with comparing pre- and post-mining total biological scores (TBS) on five predetermined stream sections. Pre- and post-mining TBS can be found in the 82 SRE reports submitted during the 5th assessment period. The five streams were determined by randomly choosing an SRE report from each longwall mine for which SRE reports were submitted during this assessment period (n=5). However, the University found that there were no TBS data in the SRE reports for Monongalia County Mine, so a second SRE report was then chosen from Enlow Fork because this was the mine with the most SRE reports submitted during the 5th assessment period.

9.E.2 – Analysis

Table 9-7 lists the five streams chosen for the pre- and post-mining TBS analysis. Four of the five had two monitoring points used for analysis, and one had three monitoring points. In order for a stream to be released, the post-mining TBS must be within 88 % of the pre-mining TBS. All of the post-mining scores for this analysis met this criterion, and with the exception of three monitoring points, all post-mining scores were actually greater than the pre-mining scores. This result is expected because a mine operator would not submit an SRE report for a stream that has not attained a post-mining score within 88 % of the pre-mining score, as it would not be released by PADEP. The University does not have access to any source of post-mining biological scores for streams for which there has not been an SRE report submitted yet, so biological recovery cannot be evaluated for these streams.

Table 9-7. Five streams chosen for pre- and post-mining TBS analysis.

Mine	Stream	Panel	Pre-mining TBS Mean	Post-mining TBS Mean	Post-mining TBS as a % of Pre-mining TBS
Bailey	UNT 32539 to South Fork Dunkard Fork	9I	57.4	63.8	111.1
		11I	50.9	45.6	89.6
Cumberland	UNT 40607 to Pursley Creek	LW-61	67.9	75.9	111.8
		LW-61	68.6	65	94.8
Emerald	UNT 40410 to Coal Lick Run	LW-C3	55.3	67.2	121.5
		LW-C3	36.3	38.3	105.5
Enlow Fork	UNT 32745 to Templeton Fork	F19	52.2	54.8	105.0
		F20	62.8	77.2	122.9
Enlow Fork	UNT 32998 to Buffalo Creek	F22	47.9	84.3	176.0
		F23	69.5	71.2	102.4
		F22/Gate	79.6	77.1	96.9

9.F – Stream Monitoring in Advance of, During, and After Longwall Undermining

Surface subsidence has the potential to disrupt the hydrological balance within and outside of an area undermined by longwall extraction.

9.F.1 – Heaves and Fractures in Relation to Face Positions

Longwall mining causes overburden movement and surface subsidence. A potential result of this overburden movement is called heaving, where horizontal forces cause upward movement in valley bottoms due to lateral compression. A variety of factors influence heaving, therefore the precise locations of mining-induced impacts on streams are difficult to predict (Kay et al. 2006). In Australia, where some of the only published research on heaving is described, the longest distance of fracture site from closest edge of a longwall or series of longwalls was measured at 1,950 feet for fractures caused by longwalls directly under a river or creek, and 1,300 feet for fractures caused by longwalls not directly under a river or creek (Kay et al. 2006). Observations in Pennsylvania suggest that fractures and heaves are more likely to occur when there is high horizonal stress from the strata and the orientation of the stream is at 90° the direction of greatest stress.

9.F.2 – Sufficiency of pre-mining monitoring periods

Given the potential for heaves and fractures occurring at 1,950 feet away from the longwall face (Kay et al. 2006), monitoring a stream for mining-induce heaves and fractures before the longwall face approaches is important. At this distance, it is likely that mining will take more than two weeks to reach the heave. The TDG 563-2000-655 "Surface Water Protection – Underground Bituminous Coal Mining Operations" (PADEP 2005) specifies that daily monitoring of stream flow begin two weeks before the panel is expected to reach the stream:

> Daily measurements commencing two weeks prior to undermining the area of concern and continuing until the potential for mining induced flow loss becomes

negligible. (In the case of longwall mining daily measurements should continue until the longwall face has progressed a distance equal to the cover thickness beyond the area of concern.)

If heaves occur in locations that are not reached by mining within this two-week period, there is a potential that flow loss may be missed or the range of flows artificially diminished during the subsequent two-week period. To evaluate whether this two-week lead time is sufficient to monitor flow impacts prior to the longwall face undermining the stream, heave data from BUMIS were compared with face position mapping. During the 5th assessment period the streams over Bailey Mine were monitored by PADEP and the mine operator more than two weeks in advance of the longwall face undermining the streams. At Bailey Mine, heaving was observed at least two weeks prior to mining for four streams (Table 9-8). The longest lead time prior to longwall face nearing a stream was six weeks (Kent Run was not undermined but panel 2L caused heaving six weeks before the longwall face is estimated to have neared the stream). There were six cases in which heaving was observed in advance of the longwall face undermining the stream in an adjacent panel (Table 9-9). In addition, there were five cases for which heaving was observed during mining in adjacent panels (Table 9-10). Two of these heaves (1,450 feet in unnamed tributary 32618 and 1,500 feet in Whitethorn Run) were a longer distance from the panel face than observed and reported in the literature for longwall mining (1,300 feet for the Cataract River; Kay et al. 2006). These observations suggest the period of daily monitoring of two weeks may not be adequate to capture impacts in advance of the longwall face.

A more comprehensive examination of these data is not possible (i.e., across mines). The University carefully examined the records provided, primarily BUMIS, however, in most other cases heaving was not detected this far out. There are many cases in this location because these streams experiencing heaves far from the longwall face were at a location that were the focus of contentious legal processes and additional effort was devoted to observing the areas in advance of mining. The precision in the location of these heaves allows this analysis. Other records note heaving potentially far from the longwall face, but the precision of the measurements did not allow accurate measurements. Therefore, these data cannot clarify among two potential explanations for the observed heaving: 1) The geology of this location is prone to more intense subsidence impacts and this leads to anomalous heaving further from mining than most places.; or 2) Heaving can occur further from mining than often expected, however, because heaving is not expected this far out, it is not detected. Additional data are necessary to make this determination. Clarification of heaving distances in advance of mining is necessary to avoid potential biasing of pre-mining baseline measurements.

Table 9-8. Heaves and fractures observed in streams at least 14 days in advance of longwall face over the same panel being mined.

Mine (Panel)	Stream	Date of Observation	Longwall Face Distance from Stream	Date Panel Face Reached Stream
Bailey (1L)	Kent Run	6/15/2015	610 feet	6/29/2015 (14 days)
Bailey (2L)	Kent Run	4/25/2016	1,300 feet	6/6/2015 (42 days)
Bailey (3L)	Polen Run	11/21/2016	1,400 feet	12/19/2016 (28 days)
Bailey (2L)	32620	7/30/2015	550 feet	8/19/2015 (20 days)
Bailey (2L)	Whitethorn Run	11/24/2015	635 feet	12/11/2015 (17 days)

Table 9-9. Heaves observed in advance of longwall face over an adjacent panel.

Mine	Stream	Date of Observation	Longwall Face Distance from Stream	Date Panel Face Reached Stream
Bailey	32605	9/18/2015	Heave in 3L panel (2L panel 900 feet from the stream)	11/22/2016 (3L)
Bailey	32618	11/24/2014	Heave in 2L panel (400 feet downstream of 1L)	12/10/2014 (1L) 10/13/2015 (2L)
Bailey	32618	9/11/2015	Heave in 3L panel (1,450 feet away from 2L face)	10/13/2015 (2L) 8/29/2016 (3L)
Bailey	32618	9/30/2015	Heave in 3L panel upstream of previous heave	10/13/2015 (2L) 8/29/2016 (3L)
Bailey	Whitethorn Run	11/3/2015	Heave in bedrock over 3L panel 1,150 feet from location of 2L panel face	12/11/2015 (2L) 10/10/2016 (3L)
Bailey	Whitethorn Run	11/24/2015	Cracks over 3L section of stream, 1,500 feet from 2L panel face	12/11/2015 (2L) 10/10/2016 (3L)

Table 9-10. Heaves and fractures observed over an adjacent panel during or after longwall face progression under stream.

Mine	Stream	Date of Observation	Longwall Face Distance from Stream	Date Panel Face Reached Stream
Bailey	Kent Run	7/17/2015	900 feet north of 1L panel	6/29/2015 (1L) (outside of panels)
Bailey	Polen Run	3/23/2015	Heave and fracture 550 feet downstream of 1L panel edge	3/23/2015 (1L) 3/7/2016 (2L)
Bailey	Polen Run	12/19/2016	Bedrock bowing and cracking 620 feet and 780 feet outside of 3L panel to south (4L panel)	12/19/2016 (3L) 9/5/2017 (4L)
Bailey	32605	8/7/2017	Heave and fracture over 5L panel (4L mining beneath stream)	8/7/2017 (4L) 4/2/2018 (5L)
Bailey	Whitethorn Run	10/14/2016	Bedrock heave in 4L section of stream as 3L panel undermined	10/14/2016 (3L) 5/22/2017 (4L)

9.G – Reasons for Augmenting and Mitigating Stream Impacts

9.G.1 – Fish Kills

Augmentation and mitigation are required for streams undermined by longwall because of the impacts on stream resources (water sources for augmentation are discussed in Section 8). One immediate consequence of disrupted flow without adequate augmentation before mitigation can be fish kills, which result in a loss of resource use (Figure 9-1, Table 9-11). Fish kill events are only recorded if encountered and reported by PADEP, mine operators, or landowners. The PADEP recorded in BUMIS 12 instances of dead fish resulting from loss of flow in nine streams undermined during the 5th assessment period. Five of these instances did not have the number of dead fish recorded in BUMIS.

In addition to the 12 fish kills from loss of flow, one fish kill occurred in unnamed tributary 41639 despite the mine operator following the PADEP stream protection policy (TGD 563-2000-655), which specifies “that the augmentation water is suitable in terms of quantity and quality for maintaining the stream’s water uses.” In this event, the mine operator used a landowner’s well to augment the stream after the stream started to lose flow from undermining. The mine operator pump tested the landowner’s well prior to using its water for augmentation, and aluminum was not initially present. However, over time, the well water quality deteriorated from increased aluminum levels. This event was not noted in BUMIS.

PADEP does not have jurisdiction in cases of fish kills. One initial step in the prevention of future resource loss is improved coordination with the Pennsylvania Fish and Boat Commission on increasing awareness of fish presence and improved management practice and polity to protect the resource. Pennsylvania baseline fish data are lacking for most of the streams in the region undermined during the 5th assessment and for the majority of the 86,000 miles of streams throughout the state (53,000 miles remained unassessed in 2017; Weber and Simpson 2017). The Pennsylvania Fish and Boat Commission is looking to rectify this problem through the Unassessed Waters Initiative (PAFBC 2019). Coordination between the Fish and Boat Commission and PADEP in this disrupted landscape would provide data to enhance protection of use in undermined streams.

Figure 9-1. Photographs of fish kills in Whitethorn Run, Bailey Mine from a) Family Cyprinidae (Blacknose Dace, Central Stoneroller, Creek Chub on 10/4/2016, b) darters (Family Percidae: Etheostoma sp.) and cyprinids (Family Cyprinidae) on 10/14/2016, c) Family Cyprinidae and possibly other species on 10/17/2016, and d) desiccated fish remains (unidentifiable) on 6/12/2018.

Table 9-11. Dead fish observed in streams undermined by longwall mining during the 5th assessment period and recorded in BUMIS.

Stream	Date	Number of Dead Fish	Notes
Kent Run	7/15/2016	Not recorded (reported by operator)	Longwall panel did not undermine stream (100 feet away)
Polen Run	6/14/2016	30 (reported by operator)	Dry section 130 feet; upstream of 4R tributary
Whitethorn Run	10/4/2016	90	Dry section 700 feet
Whitethorn Run	10/14/2016	100	Dry section 2,650 feet; 1,400 feet of flow
Whitethorn Run	10/17/2016	200	Dry section 3,450 feet
Whitethorn Run	6/12/2017	300	Augmentation for stream was off
Unnamed tributary 41741 to Tustin Run	10/21/2015	7	Several fish trapped in pools similar to previous observation on 10/16/20
Unnamed tributary 32984 to Sawhill Run	7/11/2016	40	Stream flowing into fracture/hole at upstream end of F26 Panel; operator unaware that fish were in this stream; augmentation installed by end of next day
Unnamed tributary 40952 to Tenmile Creek	4/21/2014	Not recorded	Dry section at mouth 250 feet; flow loss due to fracture
Unnamed tributary to Sawhill Run	7/17/2014	Not recorded ("several")	Dry section 145 feet, upstream of heave; and dry pool
Unnamed tributary to Tenmile Creek	9/3/2015	Not recorded (dead minnows)	Dry section 75 feet; communicated to operator who confirmed augmentation line to be installed
Unnamed tributary to Tenmile Creek	9/8/2015	Not recorded ("many" dead minnows)	Dry section 265 feet

9.H – Stream Mitigation During the 5th Assessment

9.H.1 – Methods

Four types of stream mitigation are tracked by PADEP. These are gate cuts, grouting, synthetic liners, and alluvial amendments. BUMIS provided complete and adequate information on grouting and most liners but tracking of gate cuts was less effective. The University determined that two alluvial amendments were installed from SSA Excel tracking files kept individually for each mine and photographic documentation found in the PADEP files. However, this information was not entered into BUMIS because the undermining occurred before the 5th assessment period. For this assessment, gate cut information was sent separately as an Excel file. An equivalent file with similar information would be useful for grouting as well, particularly date of release and panel information. The University provides recommendations for improving the stream mitigation data entered into BUMIS in Section 12.F.

9.H.2 – Gate Cuts

An intermittent or perennial stream channel with a gradient of 2.0 % (a 2-foot drop in elevation over a 100-foot length of stream) or less is considered a potential site of mining induced pooling following subsidence. For pooling impacts, TGD 563-2000-655 requires that mitigation be performed when the pool depth increases exceed one foot, or when other adverse conditions are created (e.g. loss of riffle habitat, sedimentation, nuisance to property owners; PADEP 2005).

Gate cuts are performed on streams where pooling has occurred, generally when the edge of the subsidence basin (i.e., the boundary between the longwall panel and the gate roads) cross stream and the subsidence basin creates a barrier to stream flow. The water is no longer able to flow over the unsubsided ground on the upstream side of the gate road, causing it to back up and form a pool. During a gate cut, a channel is cut through this barrier to recreate the water surface elevation gradient and water can again flow downstream unimpeded (see Figure 9-2). The applicant must submit mitigation plans and the GP-105 for all potential gate cuts prior to the PADEP approving and issuing the permit. The applicant must acquire the Army Corps of Engineers permit to dredge bed material and disrupt the flow of the stream prior to beginning any mitigation work. All streams with pooling must be mitigated unless there a site-specific reason, but this rarely occurs.

During the 5th assessment period, 29 gate cuts were performed over longwall mines (Table 9-12). This number is comparable to the 28 gate cuts that were completed during the 4th assessment . Twenty-four of the gate cuts completed prior to the 5th assessment were released during the 5th assessment (Table 9-13). In two cases gate cut dates were listed simply as 2013 and additional precision could not be provided to the University. These cuts were counted in the 5th assessment period, but it is not clear if they occurred during the 4th or 5th assessment period. They were both released during the 5th assessment period. There was one instance of a gate cut that was completed prior to the 5th assessment (Mt. Phoebe Area B7 over Emerald Mine in June 2013) that had not yet been released by the end of the 5th assessment.

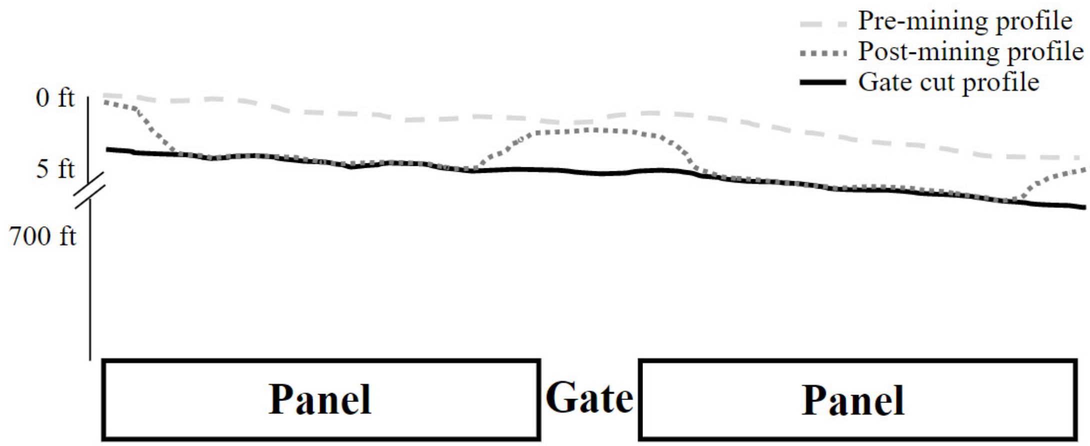

Figure 9-2. An illustration depicting how a gate cut restores the gradient of a stream to mitigate pooling. Figure is not to scale, note break in axis scale.

One of the gate cuts performed during the 5th assessment was an emergency gate cut (Mudlick Creek over Bailey Mine in September 2013) and monitoring was not required for release. It is not clear why this emergency gate cut was exempted from monitoring, and the University recommends that all gate cuts be monitored beginning before the project starts and continue to periods following completion. Of the remaining 28 gate cuts, 16 have already been released, and 12 are still being monitored.

Of the 42 gate cut projects that were released during the 5th assessment, the average time to PADEP's biological release from the time of undermining was 7 years 11 months, with the shortest time being 3 years 9 months and the longest time being 13 years 10 months.

Table 9-12. A list of the 56 gate cuts performed or monitored during the 5th assessment.

Mine	Panel	Stream	Undermine Completion Date	Gate Cut Completion Date	Undermining to Biological Release
Bailey	7I/8I	South Fork Dunkard Fork	June 2007	Oct 2007	5 yrs, 0 mos
Bailey	10I	South Fork Dunkard Fork	Oct 2008	Sept 2009	6 yrs, 3 mos
Bailey	11I	South Fork Dunkard Fork	May 2009	Dec 2011	5 yrs, 8 mos
Bailey	12I	South Fork Dunkard Fork	Mar 2010	Nov 2010	5 yrs, 3 mos
Bailey	13I	South Fork Dunkard Fork	Oct 2010	Oct 2012	4 yrs, 8 mos
Bailey	12I	Barney's Run	Mar 2011	Mar 2012	4 yrs, 3 mos
Bailey	14I	South Fork Dunkard Fork	Aug 2011	Oct 2012	4 yrs, 3 mos
Bailey	15I	South Fork Dunkard Fork	Feb 2012	Nov 2012	3 yrs, 9 mos
Bailey	14/15I	Mudlick Fork	June 2012	Aug 2015	5 yrs, 9 mos
Bailey	15/16I	Mudlick Fork	Mar 2013	Sept 2013	N/A
Bailey	2L	Whitethorn Run	Dec 2015	Sept 2017	monitoring
Cumberland	51	Mt. Phoebe Area #5	May 2006	2013	11 yrs, 11 mos
Cumberland	51	Dyers Fork Area #1	May 2006	2010	11 yrs, 11 mos
Cumberland	51/52	Dyers Fork Area #2	May 2006	2010	11 yrs, 11 mos
Cumberland	51/52	Dutch Run Area #6	Oct 2006	Oct 2014	11 yrs, 5 mos
Cumberland	52/53	Dutch Run Area #7	Nov 2006	Summer 2012	11 yrs, 4 mos
Cumberland	53/54	Dutch Run Area #8	Aug 2007	Summer 2012	10 yrs, 7 mos
Cumberland	53/54	Dyers Fork Area #4	Dec 2007	Summer 2011	10 yrs, 4 mos
Cumberland	52/53	Dyers Fork Area #3	Jan 2008	Aug 2014	10 yrs, 2 mos
Cumberland	54	Dutch Run Area #5	June 2008	Sept 2013	9 yrs, 9 mos
Cumberland	54/55	Dyers Fork Area #6	June 2008	Mar 2014	monitoring
Cumberland	55	Whiteley Creek Area 3	Oct 2008	Aug 2014	9 yrs, 5 mos
Cumberland	56	Whiteley Creek Area 4	Apr 2009	Oct 2013	8 yrs, 11 mos
Cumberland	56	Whiteley Creek Area 2	June 2009	Mar 2014	monitoring
Cumberland	57	Whiteley Creek Area 1	Mar 2010	Dec 2013	8 yrs, 0 mos
Cumberland	58	Pursley Creek Area #58	Oct 2010	2012	7 yrs, 5 mos
Emerald	B-6	Dutch Run Area #B6	Mar 2008	2014	10 yrs, 0 mos
Emerald	B-6	Mt. Phoebe Area #B6	Dec 2008	Aug 2014	9 yrs, 4 mos
Emerald	B-7	Dutch Run Area #B7	May 2009	2013	8 yrs, 10 mos
Emerald	C-2/C-3	Muddy Creek Area 3	Dec 2009	Spring 2015	8 yrs, 5 mos
Emerald	C-3	Muddy Creek Area 5	Dec 2009	Aug 2015	8 yrs, 5 mos
Emerald	C-3	Muddy Creek Area 2	Jan 2010	Spring 2015	8 yrs, 4 mos
Emerald	B-7	Mt. Phoebe Area B7	Feb 2010	June 2013	monitoring
Emerald	D-1	Jackson Run D-1	Aug 2014	July 2016	monitoring
Emerald	D-2	Jackson Run D-2	June 2015	Dec 2016	monitoring
Enlow Fork	E9	Rocky Run	May 2004	Sept 2013	13 yrs, 10 mos
Enlow Fork	F13	Templeton Fork	Nov 2006	Feb 2010	9 yrs, 4 mos

Table 9-12 continued.

Mine	Panel	Stream	Undermine Completion Date	Gate Cut Completion Date	Undermining to Biological Release
Enlow Fork	F14	Templeton Fork	July 2007	Nov 2010	8 yrs, 8 mos
Enlow Fork	F15	Templeton Fork	Feb 2008	May 2011	8 yrs, 1 mo
Enlow Fork	F16	Templeton Fork	Sept 2008	Sept 2011	7 yrs, 6 mos
Enlow Fork	F17B	Templeton Fork	Jan 2009	Oct 2010	5 yrs, 8 mos
Enlow Fork	F17A	UNT Templeton Fork	May 2009	Oct 2009	8 yrs, 11 mos
Enlow Fork	E18	Craft's Creek	May 2009	Aug 2010	5 yrs, 4 mos
Enlow Fork	E20	Craft's Creek	Nov 2009	June 2013	8 yrs, 5 mos
Enlow Fork	F18	Templeton Fork	Dec 2009	Nov 2010	4 yrs, 9 mos
Enlow Fork	E19	Craft's Creek	Dec 2009	Sept 2010	4 yrs, 9 mos
Enlow Fork	E23	Tenmile Creek	Feb 2012	Dec 2013	6 yrs, 2 mos
Enlow Fork	E24	Tenmile Creek	Apr 2013	Apr 2015	5 yrs, 2 mos
Enlow Fork	F22	Buffalo Creek	Mar 2014	Apr 2016	4 yrs, 3 mos
Enlow Fork	E25	Tenmile Creek	Apr 2014	Nov 2017	monitoring
Enlow Fork	F23A	Buffalo Creek	Jan 2015	July 2016	monitoring
Enlow Fork	F24B	Buffalo Creek	Dec 2015	Dec 2017	monitoring
Monongalia Co.	15/16W	Blockhouse Run	2010	Fall 2015	monitoring
Monongalia Co.	14/15W	Blockhouse Run	2011	Nov 2013	monitoring
Monongalia Co.	14W	Blockhouse Run	2011	Fall 2015	monitoring
Monongalia Co.	14W	Blockhouse Run	2011	Fall 2015	monitoring

Table 9-13. The number of gate cuts performed or monitored during the 5th assessment from each longwall mine.

Mine	Number of gate cuts completed during 5th assessment	Number of gate cuts completed prior to and released during 5th assessment	Number of gate cuts completed during the 4th assessment and not yet released by the end of the 5th assessment
Bailey	3	8	0
Cumberland	8	6	0
Emerald	7	0	1
Enlow Fork	7	10	0
Monongalia Co.	4	0	0
TOTAL	**29**	**24**	**1**

9.H.3 – Grouting

Subsidence can cause stream beds and underlying rock to fracture which leads to flow loss when the water flows into and through these cracks instead of downstream. Grouting is a technique used to restore flow to a stream by sealing these cracks.

During the 5th assessment period, grouting was performed 60 times on 46 streams over longwall mines (Table 9-14). In comparison, 57 streams were grouted in the 4th assessment (the number of projects is unknown). Table 9-15 summarizes the streams grouted during the 5th assessment period. Eight of these 60 projects were grouted a second time when the first was unsuccessful.

Overall, a total of 8.65 miles of streams were grouted during the 5th assessment (Table 9-14). In the 4th assessment report, total lengths of stream grouting could not be determined, but an estimate was made using limited data found for Bailey Mine, indicating that half of the undermined stream length was likely grouted. For this report, the University found only 13.8 % of undermined stream lengths were grouted, but the proportion of streams grouted in each mine varied widely, from 3.2 % for Harvey to 59.8 % for Emerald (Table 9-15). However, since Harvey recently began mining and Emerald recently stopped, these two percentages are skewed (grouting has yet to begin for many streams undermined by Harvey and grouting has continued for streams over Emerald even though mining has ceased). The University also notes that grouting can occur over streams that do not appear on the "Networked Streams of PA" layer (used to determine the total mileage of undermined streams in this report), so these percentages do not include smaller headwaters streams not mapped in the Networked Streams of PA data.

Table 9-14. Grouting that occurred during the 5th assessment period.

Mine	Stream	Grouting Length (ft)	Start date	End date
Bailey	Kent Run	100	3-Oct-16	24-Oct-16
Bailey	Kent Run-3R	450	1-Sep-16	28-Sep-16
Bailey	NoF-14L	800	27-Mar-18	21-May-18
Bailey	NoF-17L	1,400	29-May-18	29-Aug-18
Bailey	NoF-18L, 1R	600	25-Oct-17	13-Dec-17
Bailey	NoF-19L,1L,7R	550	23-Nov-15	11-Dec-15
Bailey	NoF-4.9R	800	1-Aug-18	31-Aug-18
Bailey	Polen Run 4L	700	29-Mar-17	12-May-17
Bailey	Polen Run	100	18-Jan-17	8-Feb-17
Bailey	Polen Run 6L	600	7-Jul-16	3-Aug-16
Bailey	Polen Run 7L	600	23-May-16	1-Jul-16
Bailey	ST32545	720	19-Aug-15	25-Sep-15
Bailey	ST32554	1,850	26-Sep-14	31-Dec-14
Bailey	ST32605	1,400	22-Nov-17	26-Mar-18
Bailey	ST32605	650	18-Jun-18	13-Sep-18
Bailey	ST32618	550	1-Jun-15	30-Jul-15
Bailey	ST32618	1,700	2-Mar-16	12-May-16
Bailey	ST32618**	3,200	19-Jun-17	1-Nov-17
Bailey	ST32620	1,100	9-Nov-15	26-Feb-16
Bailey	ST32620	1,000	5-Oct-16	19-Dec-16
Bailey	ST32620*	1,200	29-Nov-17	12-Feb-18
Bailey	Whitethorn Run	700	2-Aug-16	30-Sep-16
Bailey	Whitethorn Run	250	2-Aug-16	19-Dec-16
Bailey	Whitethorn Run*	1,450	29-Jun-17	20-Nov-17
Cumberland	ST40592 Pursley Creek	1,100	1-Sep-14	20-Sep-14
Cumberland	ST40615-L3	1,000	2-Jun-14	1-Aug-14
Cumberland	ST40616	1,000	20-Sep-17	15-Dec-17
Cumberland	Bells Run (ST41733)	3,600	5-Dec-16	12-May-17
Cumberland	ST41735	1,000	11-Jul-17	7-Sep-17
Emerald	ST40447	1,000	12-Jun-15	12-Aug-15
Emerald	ST40448	3,000	16-Oct-15	27-Jan-16
Emerald	ST40449	1,400	18-Jun-15	20-Aug-15
Enlow Fork	BUFC-9R	250	1-Jun-14	31-Aug-14
Enlow Fork	BUFC-9R*	1,140	1-Jun-15	31-Aug-15
Enlow Fork	SAWHR-3L	600	1-Apr-15	31-May-15
Enlow Fork	SAWHR-4L	1,200	1-Jun-14	31-Aug-14
Enlow Fork	SAWHR-9R	400	1-Jul-14	1-Oct-14
Enlow Fork	ST32983	700	1-Nov-16	31-Jan-17

Table 9-14 Continued

Mine	Stream	Grouting Length (ft)	Start date	End date
Enlow Fork	ST32996	105	1-Dec-14	31-Dec-14
Enlow Fork	ST32996*	105	1-Nov-15	31-Dec-15
Enlow Fork	ST32997	620	1-Jun-14	30-Jun-14
Enlow Fork	ST40948	5	1-Nov-14	1-Nov-14
Enlow Fork	ST40948*	450	1-Jun-15	30-Nov-15
Enlow Fork	ST40949	590	1-Sep-13	30-Nov-13
Enlow Fork	ST40949C TENC-8L 1R	no data	1-Sep-14	30-Nov-14
Enlow Fork	ST40952	1,300	1-Jun-15	30-Nov-15
Enlow Fork	ST40954	550	1-Oct-16	31-Dec-16
Enlow Fork	TenC-17R,4R	600	1-May-16	31-May-16
Enlow Fork	UNT to Sawhill Run	1,100	1-Nov-13	30-Nov-13
Enlow Fork	UNT to Sawhill Run	1,000	1-Sep-14	1-Nov-14
Enlow Fork	UNT to Sawhill Run*	1,100	1-Dec-14	31-Dec-14
Harvey	PATCR-11R	450	28-Apr-15	21-May-15
Harvey	ST40567	1,000	5-Jun-17	20-Jul-17
Monongalia Co.	ST41815	800	26-Feb-18	9-Apr-18
Monongalia Co.	ST41823	160	9-Oct-15	21-Oct-15
Monongalia Co.	ST41823	150	25-Oct-15	10-Nov-15
Monongalia Co.	ST41826	1,200	24-Nov-14	5-Dec-14
Monongalia Co.	ST41826*	1,200	no data	no data
Monongalia Co.	ST41834	5	10-Dec-14	10-Dec-14
Monongalia Co.	TMSR-4L,2R	5	28-Apr-14	28-Apr-14

*Denotes a second grouting (first attempt unsuccessful)
**Denotes a combination of first and second grouting attempts

Table 9-15. A summary of the lengths of stream grouting compared to total length undermined for all longwall mines with grouting during the 5th assessment period. "UM" in the tile rows is "undermined"

Mine	Length of Streams Grouted (mi)*	Total UM Streams (mi)	Percent UM Streams Grouted
Bailey	3.75	11.31	33.2
Cumberland	1.46	10.69	13.7
Emerald	1.02	1.71	59.8
Enlow Fork	1.71	22.30	7.7
Harvey	0.27	8.60	3.2
Monongalia Co.	0.44	7.94	5.5
TOTAL	**8.65**	**62.55**	**13.8**

*Second grouting attempt lengths removed to avoid counting the same stream length twice

9.H.4 – Synthetic Liners

While grouting is the preferred method for mitigating flow loss on streams with bedrock substrate, grouting is ineffective on streams where the alluvial thickness is greater than three feet (Haibach et al. 2012). There was one use of synthetic liners to mitigate a stream flow loss during the 5th assessment period. This occurred over the Bailey Mine at two locations: on Polen Run in 2015 over the 1L panel and over the 2L panel in 2016 before undermining. This use of liners was a condition for granting the permit to undermine the stream (PAEHB 2017). Synthetic liners were used to mitigate 4,500 ft of this stream, compared to a total liner use of just 1,757 ft over two streams during the 4th assessment period.

Because of the impacts to Polen Run from the two liner installations during the 5th assessment period, there was a change in the legally allowed use of channel liners (PAEHB 2017). The Pennsylvania Environmental Hearing Board ruled that the use of synthetic liners cannot be permitted as part of the pre-approved mitigation mining process (PAEHB 2017):

> "When the Department (PADEP) anticipates that the impacts from longwall mining are going to be so extensive that the only way to "fix" the anticipated damage to the stream is to essentially destroy the existing stream channel and streambanks and rebuild it from scratch, the Department's decision to issue (the permit) is unreasonable and contrary to the law."

The permit revision that allowed the undermining of Polen Run by Bailey during this assessment period called for a channel liner system and a complete rebuilding of 600 feet of stream. The facts used by the PAEHB (2017) included 1) the stream no longer exists as it had before undermining, 2) the stream is shorter in length and wider in cross section, 3) groundwater no longer enters the stream normally (from hyporheic flow) because of an impenetrable liner, and 4) the scope and duration of channel liner installation caused large sections of the stream to cease functioning for an extended period of time. The channel liner system eliminated Polen Run as it previously existed, which violates previous Commonwealth case law that established the Clean Streams Law, the Mine Subsidence Act, and their regulations require that PADEP not grant permits that will result in the permanent elimination of a stream (UMCO Energy, Inc. v. DEP, 2006 EHB 489).

The PAEHB also ruled in the Polen Run case that the statutes and regulations pertaining to mine subsidence allow for stream disruption that is limited in scope and duration of impact under 25 Pennsylvania Code § 86.37(a)(3). The PAEHB (2017) relied on previous Commonwealth Court of Pennsylvania cases that determined "the Clean Streams Law and Mine Subsidence Act and their regulations do not require that longwall mining have no impact on the waters of the Commonwealth." The previous Commonwealth Court case, UMCO Energy, Inc. v. DEP, 2006 EHB 489, at. 585, established that the "permission to longwall mine is not absolute but remains subject to proper conditions."

Thus, if the alluvial thickness of a stream is known to be greater than three feet, or if mitigation is not predicted to restore stream flow, then permitting to undermine of such streams is now subject to demonstrating that stream flow can be restored without use of a synthetic liner at these magnitudes if stream flow loss occurs. The feasible mitigation space, as mandated by the Environmental Hearing Board, is illustrated in Figure 9-3.

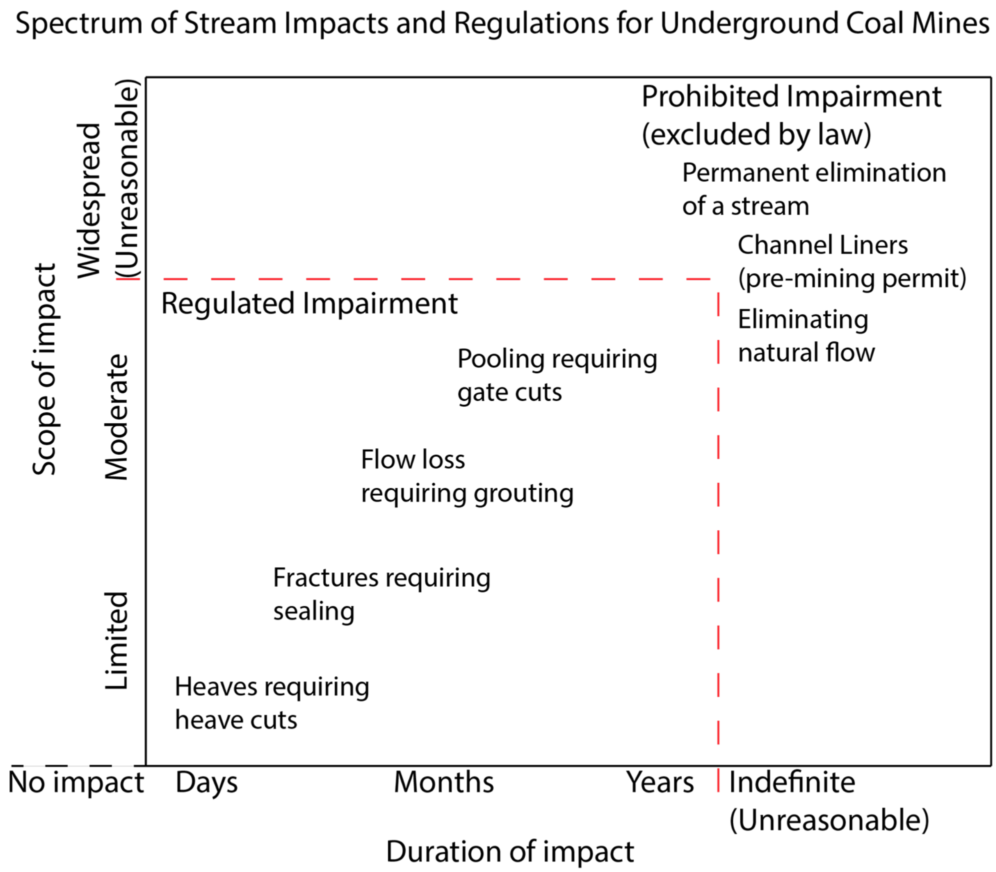

Figure 9-3. A conceptualization of the Pennsylvania Environmental Hearing Board and Commonwealth Court of Pennsylvania (PAEHB 2017). The PADEP considers whether the operator is prepared to fix a problem if one occurs (regulated impairment). The PADEP cannot pre-approve a mitigation plan if mining-induced flow loss is predicted, if a channel liner will be required, or if mining will result in permanent elimination of a stream (prohibited impairment).

9.H.5 – Alluvial Amendment Liners

Alluvial amendments mix stockpiled alluvium with bentonite clay to form a slurry, which is laid down in the excavated stream channel and compacted to create a channel lining. Following installation of the alluvial amendment liner, the stream banks are re-graded, stabilized, and planted with vegetation.

Five streams were mitigated using alluvial amendments during the 5th assessment period. Three of these streams are located over Cumberland Mine (ST40615-L3, ST41733, and ST41741), and two are located over Enlow Fork Mine (ST40944 and CrC-4R,2R). Alluvial amendments were used to mitigate 8,925 ft of streams overall, compared to just 1,200 ft (over two streams) during the 4th assessment period. Table 9-16 lists all liners, both synthetic and alluvial, used during the 5th assessment period.

Table 9-16. Instances of liners used to mitigate streams during the 5th assessment period.

Mine	Stream	Panel	Type of liner	Length (ft)	Date installed
Bailey	Polen Run	1L	synthetic	2,400	Apr-Dec 2015
Bailey	Polen Run	2L	synthetic	2,100	May-Aug 2016
Cumberland	ST40615-L3	LW-62	alluvial	1,000	May-June 2014
Cumberland	ST40615-L3	LW-62	alluvial	1,000	June-Aug 2014
Cumberland	ST40615-L3	LW-62	alluvial	500	July-Aug 2016
Cumberland	Bells Run (ST41733)	LW-64	alluvial	1,000	March 2016
Cumberland	ST41741	LW-64	alluvial	1,000	March 2016
Enlow Fork	ST40944	E16-17	alluvial	3,825	Sept-Dec 2014
Enlow Fork	CrC-4R,2R	E18	alluvial	600	Fall 2014

9.I – Summary

During the 5th assessment period, longwall coal operations undermined 81 miles of streams. A section of undermined stream is referred to as a stream reach. Those 81 miles of streams comprise 148 separate undermined stream reaches, of which 59, or 40 % experienced impacts from underground coal mining. If a stream reach was impacted, it was most often impacted multiple times. PADEP data indicate 183 total impacts during the assessment period. This translates to an average of 3.10 impacts for every impacted stream reach with 27.42 total miles of streams experiencing either flow loss or pooling.

A total of 82 stream recovery evaluation (SRE) reports were submitted to PADEP following mitigation with the intention of demonstrating stream recovery. Of those 82 SRE reports, mining operators were released from further responsibility for 42 of the stream impacts. 40 SRE reports remain unresolved. Many more stream impacts have not yet had an SRE report submitted to the DEP, indicating that the majority of the 183 stream impacts have yet to be resolved and released.

Heaves and fractures in stream beds are common following undermining. Fracture sites have occurred at distances as long as 1,500 ft from the mining front. The University suggests that the current period of daily monitoring two weeks prior to undermining may not be adequate to capture impacts in advance of the longwall face.

During the 5th assessment period, 12 instances of fish kills resulting from flow loss on 9 undermined streams were reported. Pennsylvania baseline fish inventories are lacking for most of the streams undermined in the 5th assessment period, although that will change with the PAFBC's Unassessed Waters Initiative.

Gate cuts were completed in a total of 29 instances during the 5th reporting period. In addition, 24 gate cuts that were completed in the 4th assessment period were released during the 5th assessment. The 4th assessment reports (Tonsor et al. 2014) that on average gate cuts and the subsequent stream and streamside restoration restores stream function. TBS scores pre-mining and post gate cut restoration are statistically indistinguishable.

Grouting was performed 60 times on 46 streams during the 5th assessment, for a total of 8.65 miles of grouted stream beds. About 1/8th of grouted streams are re-grouted when the first grouting is not effective. Synthetic stream liners were employed in two places on Polen Run for which grouting was predicted to be ineffective, for a total of 4,500 ft of liner installation. However, the PA Environmental hearing board ruled (PAEHB 2017) that the use of synthetic liners at this magnitude can no longer be a part of the pre-approved mitigation plan. Alluvial amendments using bentonite clay were employed on five streams during the 5th assessment period, covering 8,925 ft of stream bed.

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