

SECTION 12: Recommendations

12.A – Overview

PADEP tasked the University with providing data-based recommendations on how Act 54 and its provisions performed during the 5th assessment period including suggestions for program improvements. These recommendations arise from the analyses conducted by the University and are offered to enhance PADEP's ability to effectively and efficiently evaluate and regulate the impacts of mine subsidence.

12.B – Recommendations for Act 54: Methods

1. In the review of data collected for this assessment, the University recognized that the extent of mining reported in the 4th assessment (Tonsor et al. 2014) did not match the extent indicated on records provided for the 5th assessment. This is not unexpected given the challenges in creating an annual report from reported data spread over six-month cycles. However, in this assessment period the University also requested the mapped face positions to analyze other questions. Once received, these data revealed a similar problem for extents of longwall mines during the 5th assessment periods (see Section 2). This was discovered too late to correct for the analyses presented in Sections 4, 5, and 6. However, use of these maps seems an effective means to accurately delineate mining activity.

The University recommends inclusion of face position mapping for longwall mining panels as part of the base data for future assessments.

2. In the 4th assessment there were a wide variety of recommendations for improvements to BUMIS. PADEP made notable progress on data management and infrastructure. In this assessment, while the University was able to recognize the progress in data management, the challenges in the BUMIS data structures grew more obvious. The University could not easily be provided access to the data viewing and entry screens the PADEP uses to enter and use BUMIS. This led to confusion and misinterpretation on the University side. For example, the narrative documented in BUMIS by field agents was not included in initial data transfers to the University. These data were not provided to the University until September 2018, well into the project period. This led to substantial effort to understand strange cases, many trivial questions from the University to the PADEP in early periods, and temporary confusion by both parties. In addition, much of the regulatory activity relies upon spatial data. BUMIS, as currently configured, would be very difficult to interface with modern GIS tools. There is no apparent evidence that PADEP meshes two of their primary tools, BUMIS and GIS in their work. The BUMIS data infrastructure needs to be modernized to enable PADEP field and technical staff to effectively and efficiently execute Act 54 requirements.

The University strongly recommends that the PADEP modernize the data infrastructure their data tracking tool relies upon. The University's role is not to recommend specific software or approaches; however, this underlying structure has to be compatible (i.e.,

simple for a common user to open, manipulate, and evaluate data) with the everyday tools their staff uses, from analysis packages to GIS packages. The database software has to be versatile and adaptable to future challenges and changes in analysis needs. This is potentially the most important recommendation and a consistent theme through three assessments.

3. Another recommendation made in the 4th assessment report (Tonsor et al. 2014) was for requirement of electronic versions of data at submission. This has not improved. In fact, in terms of hydrologic monitoring reports, reports were beginning to be submitted as spreadsheets at the end of the last assessment period are once again submitted solely as hard documents. Digitization of hard copies creates inefficient work (optical character recognition and organization into a spread sheet takes time) and degrades accuracy (optical character recognition software can make mistakes).

The University strongly recommends the PADEP determine what is necessary to enable expanded submission of electronic versions of documents and require these for all data submissions. Submission of electronic versions of documents will improve efficiency and accuracy.

12.C – Recommendations for Act 54: Structures/Water Supplies/Land

1. There were five inactive mines with structural report effects during the 5th assessment period. Subsidence impacts over room-and-pillar mines permitted since the passage of Act 54 are relatively rare. Subsidence impacts over longwall and pillar recovery mining sections most frequently occur shortly after undermining. Therefore, when large number of reported effects occur after mining has ceased, further investigation is warranted. Sixty-four reported effects were associated with five inactive mines during the 5th assessment period. During the 3rd and 4th assessment, there were a combined 19 reported effects from inactive mines, all occurring in the 4th assessment period. Therefore, the number of reported effects from inactive mines tripled from the 4th to the 5th assessment. The Maple Creek Mine had the most reported effects with 55 (Figure 4-11). Fifteen of which were determined to be company liable, ten company not liable, and 30 are still in interim resolution. The Maple Creek Mine was a room and pillar and longwall mining operation that was last active in the 3rd assessment period. However, within this mine are areas where pillar retreat mining occurred. The map in Figure 4-11 shows the location of all reported effects. These impacts were not located over the longwall areas of the mine. Land movements associated with longwall mining almost always occur within months of panel extraction and this is reinforced by the lack of impacts near longwall panels. The mechanics of why so many unexpected reported effects occurred in Maple Creek are not known.

Further investigations of the mechanisms and factors driving subsidence impacts in inactive mines are recommended.

2. There was an increase in company purchased properties (54) for water supply company liable impacts in the 5th assessment from the 3rd and 4th assessment. In the 3rd

assessment there were 34 company purchased properties, and in the 4th assessment there were 37. Once a company purchases a property, information about impacts on this property is recorded but no longer tracked by PADEP. Companies can purchase properties prior to mining. This may be advisable in areas where subsidence damage is expected. Companies can also purchase properties after mining. The University was not able to determine reasons for post-mining property purchases, but it is logical to assume that these properties were impacted by subsidence. However, if a company purchases the property it is difficult to determine what the nature of the damage was or if there even was any damage.

The University recommends examination of this emerging trend in property transactions, particularly given the broader importance for the Act 54 amendments (e.g., does this subsidence impact management practice “erode the tax base of the affected municipalities”?)

12.D – Recommendations for Act 54: Hydrologic Balance

1. The inconsistency between stream impairments tracked during the Act 54 process and streams tracked in more comprehensive programs such as the 303(d) listings of impaired streams creates a challenge in assessment of the stream impacts relative to other hydrologic stressors in the Commonwealth. Therefore, neither the impairment or the recovery of streams in subsidence impacted areas are apparent to residents of the Commonwealth.

The University recommends integration of subsidence impact tracking with broader hydrological management frameworks to make the subsidence impacts and repair more apparent to all citizens of the Commonwealth.

2. The water quality parameter suite specified by Permit 5600-PM-BMP0324 is effective at assessing contributions from mine drainage, but of limited utility for assessment of subsidence impacts. However, there is great flexibility in the definition of required chemical parameters. The University recommends two parameters to enhance ability to assessment of emerging water quality risks.
 - a. *The University recommends addition of calcium to the water quality monitoring parameter list for full extraction mining to evaluate the contribution of grout inputs to local water chemistry.*
 - b. *The University recommends addition of nitrate to the water quality monitoring parameter list for full extraction mining to evaluate the contribution of increased hydrologic connectivity to septic systems in local water chemistry.*
3. All stream recovery evaluation (SRE) reports provided to the University were analyzed to evaluate if the hydrologic monitoring data collection guidance outlined in the TGD were

met. This process involved the optical character recognition of data in paper documents submitted to PADEP. This process is laborious, particularly the quality assurance checks necessary to ensure the record was captured accurately.

The University recommends digital submission of SRE report data to simplify and improve assessment of hydrologic change, as recommended in the 4th assessment report (Tonsor et al. 2014). This recommendation is particularly important if more complicated flow monitoring schedules are implemented.

4. The mine operators are required to monitor flow in all undermined streams. The consistent gaps in monitoring frequency (Table 7-1) suggest this did not reliably occur. The University assumes all available flow data are presented in the SRE reports, and, as reported these data are incorrect. Currently, these data are only reported if recovery is evaluated (i.e., if there is an impact in the reach).

The University recommends compilation of these pre-monitoring data as mining progresses and as the streams are undermined, to ensure complete pre-mining baseline data are available.

5. Stream recovery is not evaluated based on a single metric for evaluation of flows focused on the range in low flows. Adequate evaluation of flow needs to check for biases that can affect low flow differentiation.

The University recommends a set of relatively straightforward, simple measures of 1) flow, and 2) bias in sampling to clarify the range of low flows observed in undermined streams. These analyses have been completed for each of the SRE reports made available to the University and are included in the Appendix F to this report.

- a. *The University recommends visualization of log transformed flows in conjunction with the normal flow plots to clarify low flow ranges and distributions.*
 - b. *The University recommends two distribution comparisons to assess potential biases: 1) the distribution of flows; and 2) the distribution of flow measurements across the year.*
6. Decisions on flow attainment are not adequately documented. In reviewing SRE reports, the University noted that the hydrologist and aquatic biologist have final say in the approval of stream release. In some cases, apparent reservations from field agents were not formally rebutted in the release decisions.

The University recommends that field staff (shadows) participate more equally in the release process decisions. The shadows have experience monitoring each stream before, during, and after undermining. The University also recommends more formal

documentation of discussions about stream release and improved documentation of the final decision about release.

12.E – Recommendations for Act 54: Groundwater

1. The only consistent source of groundwater data for evaluation of subsidence effects are the hydrologic monitoring reports. Monitoring of these sites generally only occurs on a quarterly basis. Undermined streams are sampled on a much more frequent basis during the period before mining. The impacts to groundwater are likely to be connected to the impacts to surface water. Documentation of the relationship between groundwater and surface water hydrology is necessary to demonstrate stream recovery.

The University recommends that future HMR groundwater monitoring points be sampled for groundwater elevation at a frequency that is at least consistent with sampling dictated for surface water protection during the pre- and post-mining period (TGD 563-2000-655), if not more frequent.

2. In the existing technical guidance, there is no formal description of the characteristics of an impacted aquifer storage system. In terms of stream impacts, there can be pooling or flow loss. Water supplies and springs can be lost or diminished. There is no similar definition of an impacted aquifer. Nor is there a timetable specified for the repair of groundwater impacts.

The University recommends the PADEP define how to determine if a groundwater aquifer is impacted and the time frame for implementation of the repairs. If this is not possible, then another option is to define methods to identify the influence of groundwater impacts on other impacted hydrologic components (streams, wetlands, etc.) to clarify mitigation efforts in the other components.

3. In Pennsylvania, the landowner owns both the stream (and access rights to it) and the streambed if they own the property. If the stream bisects two properties, then each landowner owns to the middle of the stream. This is important because if the mine operator cannot obtain landowner permission to access the stream, then they cannot augment without trespass. There exist only two examples of this problem recorded in BUMIS during the 5th assessment, but it does highlight a disruption of the hydrologic balance. There were other instances in BUMIS where a landowner did not provide access to augment (and the stream went dry), but the mine operator had permission to access and augment from a neighboring property.

The University recommends that PADEP require that access to all streams be negotiated and settled prior to undermining. Failure to attain access to streams for collection of pre-mining data or post-mining augmentation results in an unacceptable impact to Waters of the Commonwealth of Pennsylvania. If access for augmentation cannot be obtained prior to mining, then mine operators are not meeting the regulatory requirement to take

measures “to ensure the protection of the hydrologic balance and to prevent adverse hydrologic consequences” (25 PA Code § 89.36(a)).

4. In addition to the cases of augmentation with stream water, there are examples in BUMIS of water being pumped from streams to tanks to later serve as augmentation in case this water is needed to maintain sufficient flow. If water is pumped from a stream to augment upstream or if water is pumped from a stream to store in tanks to feed the same stream, then flows are double counted to obscure loss of natural flow. The hydrological balance is not maintained.

The University recommends PADEP limit the practice of stream augmentation with stream water only to those cases where this practice will allow mine operators to avoid other measures harmful to the hydrological systems. In these cases, the University recommends formal justification of tradeoffs.

5. In some of the HMR data, piezometers that are destroyed do not seem to be replaced after destruction. This eliminates the possibility of any pre- vs. post-mining comparisons. This failure therefore eliminates one of the primary reasons for the monitoring.

The University recommends that PADEP require replacement of groundwater monitoring equipment if this equipment is destroyed during undermining and enforce this requirement.

6. HMR points are a challenge to locate due to limited required precision in reporting. Five decimal degrees are generally sufficient to accurately locate a point.

The University recommends that PADEP require at least five decimal degrees of precision when coordinates are submitted as latitude and longitude.

12.F – Recommendations for Act 54: Streams

1. The TGD 563-2000-655 specifies that if criteria for stream release “are not met within five years and the district mining office determines that the mine operator has done what is technologically and economically feasible to restore the affected stream, it [District Mining Office] may allow the operator to compensate for the impairment of the affected stream by restoring or enhancing an equivalent length of stream in the same watershed or a nearby watershed in lieu of continuing to perform mitigation measures.” The University identified streams that, according to PADEP records, have not met the criteria for attaining use and have not been released after five years. In materials provided to the University, there exists no evidence of additional mitigation or compensatory stream rehabilitation having been required by PADEP when a stream had not met attainment standards after five years.

The University recommends that the restoration time period of five years be evaluated. This evaluation might focus on streams that have not recovered after five years. If analyses indicate that the recovery period can sometimes exceed five years, the

University further recommends re-evaluation of the determination of permanent non-attainment schedule.

2. The University was tasked with reporting the total lengths of perennial streams undermined during the 5th assessment period, categorized by mining method and impact type. There is not a complete georeferenced stream layer for all undermined perennial streams. This is particularly problematic for evaluating impacts to first-order headwater streams. This assessment relied on the “Networked Streams of PA” layer to remain consistent with previous reports. This layer does not include all first-order headwater streams, including streams impacted during this assessment, so total lengths of undermined streams are underestimates.

The University recommends PADEP consider whether additional accuracy in the determination of undermined stream mileage is warranted. If so, the University recommends that PADEP consider defining a DEM resolution and flow accumulation threshold to identify streams that are not included in “Networked Streams of PA” layer.

3. For at least one stream, a mine operator was not aware that fish were present prior to undermining. Because the stream lost flow prior to augmentation, a fish kill resulted.

The University recommends that PADEP and mine operators coordinate with Pennsylvania Fish and Boat Commission to inventory stream fish fauna and water quality as part of the Unassessed Waters Initiative, or other quantitative surveys, before and after such streams are undermined. Alternatively, the University recommends requiring that mine operators survey headwater streams for fish before undermining occurs. Some mine operators have surveyed for fish populations on their own to document impact even without this additional requirement (e.g., Nuttle et al. 2017).

4. For at least one stream, a fish kill resulted despite the mine operator doing everything required according to policy regarding stream augmentation (PADEP 2005; 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.

The University recommends that a temporal requirement be added to ascertain the quality of water over the course of augmentation. If levels of contaminants are tested as augmentation continues, the likelihood of fish kills and loss of resource use will be reduced.

5. The TGD 563-2000-655 (PADEP 2005) specifies that daily monitoring of stream flow begin two weeks before the panel face is expected to reach the stream. During the 5th assessment period heaving in streams was observed sometimes much longer than two weeks prior to undermining. For example, in Kent Run, though the stream was not directly undermined, a heave appeared six weeks before the longwall panel is estimated to have reached the stream.

The University recommends that the duration of pre-mining daily monitoring specified in TGD 563-2000-655 be re-evaluated. The observation of stream impacts (heaving and fracturing) up to six weeks prior to undermining indicate the two-week time period may not be adequate to capture the occurrence of pre-mining impacts.

6. Identification and collection of SRE reports submitted during the 5th assessment period was sometimes a challenge. The PADEP provided the University an Excel tracking sheet that was very helpful and allowed the University to effectively procure these documents from PADEP personnel.

The University recommends that SRE reports be tracked in BUMIS including status from submission to final resolution. This will build upon the progress made in the addition of stream impacts that occurred during this assessment.

7. The University was tasked with comparing pre- and post-mining TBSs on five pre-determined stream sections. It was found that the best source of pre- and post-mining TBS data is in the SRE reports, so five of these (with complete TBS data) were randomly chosen and used for the analysis. However, these reports are only submitted by operators when they feel the stream has recovered, and the post-mining TBS requirement is met, biasing the scores provided to the University. The University is less certain about the TBS scores in streams that are not considered recovered by the operator.

The University recommends that a different source of data be used to compare the TBS of streams before and after mining. This would require that the professionals or institutions conducting the assessment be given access to pre- and post-mining data for all monitored streams or that the professionals or institutions conducting the assessment be contracted to conduct post-mining surveys themselves, as in prior assessment periods. In addition, with each SRE report PADEP could require operators to submit TBS data as well as the raw data used to calculate the TBS.

8. BUMIS was used to track stream mitigation efforts, but for some reason did not include gate cuts as an option for mitigation type. Instead, PADEP sent a separate Excel file listing the gate cuts for each longwall mine, which contained additional useful information not included in the BUMIS entries, such as panel information and release date. In addition, BUMIS was not always complete. The University also learned (from the SSA Excel files) of two instances of alluvial amendments being used during the 5th assessment that were not recorded in BUMIS. Finally, in some cases BUMIS records contained multiple mitigation types, creating ambiguity in the record.

The University recommends that gate cuts also be tracked in BUMIS. The University recommends that each mitigation event be entered separately (only one type of mitigation per entry) and that all active mitigation projects be entered, regardless of when the stream was undermined. Finally, the University recommends that important corresponding information (metadata) be included for each mitigation event, such as panel information and release date.

9. In one case, an emergency gate cut was performed and monitoring of biological recovery was apparently not required for release of this gate cut. Determination of the decision-making process leading to this result is beyond the scope of this assessment. However, release of an impacted and repaired stream without determination of biological recovery is not consistent with policy outlined in TGD 563-2000-655.

The University recommends that stream impact mitigation policies be enforced and all gate cuts be evaluated for recovery after repair of pooling.

12.H – Recommendations for Act 54: Wetlands

1. In conversations with PADEP personnel, the University learned that wetland mitigation success is evaluated biannually for the first two years, and annually for the next three years following completion of the project, with reports being submitted to the PADEP yearly. It is not clear how these policies are made known to the operators. For the two wetland mitigation projects active during the 5th assessment period, a single five-year report was provided by the PADEP for the Dutch Run mitigation project, and a three-year report and addendum was provided for the Whiteley Creek mitigation project.

The University recommends that the PADEP enforce its policies regarding wetland mitigation report submission in order to better monitor the progress of these mitigation projects and increase transparency.

2. Receipt of wetland data in paper format creates challenges to analysis and quality assurance. For example, the data are often lumped together across wetland types in the maps and the type of one wetland in a complex cannot be determined. Further this lumping of wetlands on paper maps makes it impossible to cross-check wetland reporting in permit applications. As a result, the University was not able to complete a full assessment of these data by wetland type, as required in the University's scope of work for the assessment (Appendix L). Delineation and identification of each wetland in a spatial data format removes ambiguity in wetlands type when evaluating these wetlands over multiple assessment methods.

The University recommends that wetland data be submitted by all longwall mine operators in a georeferenced vector-based format (e.g. shapefile, .dwg) compatible with GIS software. The professional standard is to identify different types of delineated wetlands separately and defined in a "type" field. In addition, metadata for all wetland delineations are needed for this layer (e.g., date delineated, wetland delineator, species observed).

3. Inconsistencies were noted among the wetland data contributed by the various mines (see Section 11.D.2). These inconsistencies in some cases make the University's assessment impossible. In other cases, the inconsistencies make for incomplete comparisons across mines.

The University recommends that PADEP initiate a quality control process to ensure that wetland delineations are performed in a consistent manner across mines and over time.

References

- PADEP. (2005) "Surface Water Protection – Underground Bituminous Coal Mining Operations," Technical Guidance Document 563-2000-655, October 8, 2005, 43 p.
- Nuttle, T., M.N. Logan, D.J. Parise, D.A. Foltz, J.M. Silvis, and M.R. Haibach. (2017) Restoration of macroinvertebrates, fish, and habitats in streams following mining subsidence: replicated analysis across 18 mitigation sites. *Restoration Ecology* 25(5): 820-831.
- Tonsor, S.J., A. Hale, A. Iannacchione, D. Bain, M. Keener, E. Pfeil-McCullough, K. Garmire (2013). "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>