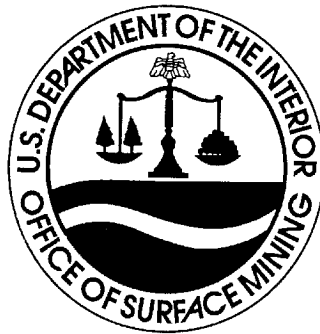


**OFFICE OF SURFACE MINING
APPALACHIAN REGIONAL COORDINATING CENTER**

**CRITERIA FOR EVALUATING THE POTENTIAL FOR
IMPOUNDMENT LEAKS INTO UNDERGROUND MINES
(EXISTING AND PROPOSED IMPOUNDMENTS)**



**Prepared by
The Lexington Field Office and
The Appalachian Regional Coordinating Center Impoundment Team
(in cooperation with Kentucky, Virginia, and West Virginia State Regulatory Authorities)**

July 2001

**CRITERIA FOR EVALUATING THE POTENTIAL FOR IMPOUNDMENT LEAKS
INTO UNDERGROUND MINES
(EXISTING AND PROPOSED IMPOUNDMENTS)**

As a result of several breakthroughs over the last few years, and the latest in Martin County, Kentucky, the Office of Surface Mining (OSM) developed an action plan for initiating an effort to assure that impoundment breakthroughs into underground mine works do not occur in the future. To accomplish the objectives spelled out in the OSM action plan, ARCC has established specific tasks concerning identification and technical evaluation of impoundment breakthrough potential, correction of identified problems, and oversight of the state programs to ensure that the Surface Mining Control and Reclamation Act of 1977 requirements related to impoundments are being fully met. These tasks will be accomplished with a maximum level of coordination among the Region's Field Offices, states, and the Mine Safety and Health Administration (MSHA), in order to ensure consistency and to minimize duplication of effort to the extent possible.

Task 2 of ARCC's Implementation Plan provides for a joint technical committee comprised of OSM, state and MSHA technical representatives. The committee, using their combined expertise along with information gained from the Kentucky and Virginia experiences, will:

- Develop criteria that should be considered in re-evaluating existing high-risk impoundments over or adjacent to underground mine works.

This review is being conducted concurrent with the National Academy of Science (NAS) "Study on Preventing Coal Waste Impoundment Failures and Breakthroughs." The NAS study may provide information pertinent to the impoundment review, and consequently, it may be necessary for the Regulatory Authorities (RA) to reconsider the findings of some of their reviews. However, because of the serious adverse effects that can occur as a result of breakthroughs, OSM does not believe it is prudent to delay the impoundment review until the completion of the NAS study.

This paper was prepared to implement Task 2. The Lexington Field Office in coordination with ARCC, the Knoxville Field Office, and the Kentucky, Virginia, and West Virginia RAs prepared the paper. The paper will be used for the evaluation of impoundments according to Task 3 of the ARCC Implementation Plan.

A. OBJECTIVE

The objective of this paper is to provide the RAs with criteria for evaluating impoundments to prevent unplanned and unpermitted discharges into underground mines. Such events have the potential to harm underground miners, and may also result in discharges from the underground mines to the surface. Discharges to the surface may harm people and adversely affect property and the environment.

B. SCOPE

RAs should distribute this paper to their permit reviewers and inspection personnel to assist in evaluating breakthrough potential for existing or proposed impoundments. Distribution to industry, consultants, and others involved in new application development or modification to existing structures to minimize breakthrough potential is also recommended.

The immediate focus of this paper concerns the review of existing water, sediment, and slurry impoundments and impounding structures that meet the MSHA criteria of 30 CFR 77.216(a). According to the criteria, "MSHA class" impoundments: 1) store 20 acre-feet or more of water, sediment, or slurry; or 2) impound water, sediment, or slurry to a depth of 20 feet or more above the upstream toe of the embankment.

The review should include all MSHA class impoundments that are currently covered by a surface mining bond, including impoundments that have been reclaimed and are pending final bond release. This includes acid mine drainage treatment ponds, coal waste/flyash facilities, etc., in addition to water, sediment and slurry impoundments.

OSM believes it is prudent for the RAs to also review the breakthrough potential for non-MSHA class impoundments during the normal course of inspection and permitting activities. Some states may have several hundred impoundments that do not meet MSHA class criteria. However, because these impoundments do not contain as much water and solids as MSHA class structures, OSM does not believe it is necessary in most cases to perform the same in-depth review as is necessary for MSHA class structures. The Soil Conservation Service Technical Release (TR) No. 60, hazard classification for the non-MSHA class structures, may not have a direct correlation with the adverse effect that could occur as a result of a breakthrough. Also, the hazard ratings may not be directly related to the amount of water stored by the impoundments. The hazard ratings are primarily based on the damage that could occur as a result of dam failure. Consequently an impoundment may have a low hazard rating under TR No. 60 due to lack of dwellings in the watershed downstream from the dam, but that impoundment may pose considerable risk to residences in other watersheds that could be effected by a breakthrough. Based on potential dam failure impacts, TR No. 60, classifies impoundments as Class C (high hazard), Class B (medium hazard), and Class A (low hazard).

The RAs should conduct the impoundment reviews in cooperation with MSHA, whenever possible. OSM technical assistance may also be requested. The RA and MSHA District Manager may find it appropriate to establish procedures to coordinate the inspections and plan revisions.

Some of the RAs may have previously reviewed the impoundment in a manner consistent with these review criteria. OSM does not expect the RA to conduct another review in such cases. However, it is anticipated that the OSM Field Office will review, under its oversight responsibility, the RA's findings.

C. BACKGROUND

There have been several unplanned and unpermitted, discharges from impoundments into underground mines. Attachment 3 provides a description of six of the events. Four of the six events resulted in discharges to the surface.

Following the three events in Virginia during 1996, OSM drafted guidelines for the evaluation of breakthrough potential. The guidelines were drafted in cooperation with the Virginia Division of Mined Land Reclamation (DMLR). DMLR also developed evaluation procedures and used them to evaluate the MSHA-class impoundments in Virginia. As a result of DMLR's review, they required some operators to prepare remediation plans. OSM met with MSHA and discussed evaluation procedures.

Following the events in Virginia, MSHA issued Program Information Bulletin (PIB) No. P00-16, December 1, 2000 (Attachment 4). The PIB was issued to make the industry aware of the dangers associated with unintentional slurry releases and to address precautionary measures to alleviate the potential problem. MSHA also developed procedures for the evaluation of the breakthrough potential in Procedure Instruction Letter (PIL) No. I97-V-11, effective December 1, 1997. The PIL has been reissued as No. I99-V-3 (Attachment 5). The PIL uses Bureau of Mines Information Circular (IC) 8741, *Results of Research to Develop Guidelines for Mining Near Surface and Underground Bodies of Water* (Attachment 7) to evaluate breakthrough potential. Using the PIL, MSHA conducted a review of the MSHA class impoundments. OSM advised the states to coordinate with MSHA and to keep current with MSHA's actions to ensure that the RA's concerns were addressed and that any permit revisions would be made as necessary. MSHA required remedial action for some impoundments based on its review. MSHA also prepared an inventory that listed the impoundments and their risk rating according to the PIL guidance. Following the October 2000 Martin County Coal Corporation event, MSHA conducted another round of field reviews generally using the PIL evaluation procedures.

D. EVALUATION PRIORITY

The RA review will be conducted according to the following priority:

1. Sites with previous problems (e.g., uncontrolled seepage, drainage to/from adjacent underground mines, subsidence features near the impoundment).
2. Unless a higher priority is assigned by the RA based on its knowledge of an impoundment, or on information provided by the public, the remaining sites should be reviewed in the order established by the "Evaluation Priority Level" assigned by MSHA during the 1997/1998 and 2000 evaluations. For the priority levels, see Attachment 3 of the PIL No. I99-V-3.

The RAs are advised to compare their inventory with the MSHA inventory to ensure that all MSHA class impoundments are listed. If the MSHA inventory does not include all the impoundments, the RAs will assign a Priority Level to the impoundments using the PIL, except that “manmade barriers” should not be automatically used to lower a Risk Potential. At this time, OSM does not believe it is prudent to assign a lower priority based on a manmade barrier in consideration that a manmade barrier was in-place at the time of the October 2000 Martin County Coal Corporation (MCCC) breakthrough. However, the RA, after conducting a technical review of the adequacy of the design and construction of such a barrier, may determine that it is justifiable to assign a lower risk rating.

Based on the RA’s knowledge of an impoundment, the RA may believe a higher Priority Level is warranted and that an expedited review should be conducted. Some factors that might warrant an expedited review would be the heightened potential for affecting the general public, major public facilities, and sensitive environmental areas. In the interest of RA’s time and travel considerations, the RA may also review a lower priority site(s) located in the vicinity of a higher priority site.

During the RA’s review of an impoundment, the RA should establish a Priority Level based on its review findings. The “Executive Summary of Findings” form (Attachment 1) contains space for the Priority Level assigned by MSHA’s and a “Remediation Priority Level” assigned by the RA (see section F.2.e). The RA’s remediation priority contains: 1) a prefix which classifies the relationship of the impoundment and adjacent underground mines, and 2) the RA’s assigned Priority Level. (The RAs may develop and use a form of their own design, however, it should contain similar items as contained in the Executive Summary.)

E. FAILURE MECHANISMS

Potential failure mechanisms include but are not limited to:

1. Failure of sealed underground mine openings - The opening seal (rock/soil or other material) fails, thus allowing water/slurry to flow in an uncontrolled manner into the underground works. Underground mine openings include, but are not limited to, unintentional “punchouts,” (i.e., an intentional or unintentional void or tunnel-like connection of the underground mine to the surface), portals, horizontal drainage and ventilation borings, vertical utility or ventilation borings, adits (another term for a type of underground mine entry) and underground mines), and auger holes that connect with underground mines.

2. Breakthrough at an unsealed underground mine opening - Water/slurry flow into a mine opening that has not been sealed. These openings may have only been covered with soil.
3. Breakthrough at coal barriers (e.g., outcrop barriers; barriers between contour and underground mines; barriers between auger holes and underground mines; barriers between small drift mines or house coal adits - Pressures resulting from deposition of water/slurry/other materials may cause a failure at the coal barrier and allow water/slurry to enter the mine in an uncontrolled manner.
4. Breakthrough at strata overlying the coal seam - Water/slurry flow into a mine through natural fractures and joints and mining-induced fractures (e.g., roof falls, sinkhole subsidence, and trough subsidence).

The failure mechanisms apply to impoundments that have a considerable clear water pool depth and also to impoundments that have minimal clear water or have been reclaimed. The slurry in these structures may remain near or above the liquid limit for extended periods of time. Slurry at or above the liquid limit can flow as a viscous fluid if not contained. Reclaimed slurry impoundments may be a risk for breakthrough, resulting from long-term pillar deterioration, earthquake, or other factors that may affect the loading and stability of an impoundment and adjacent underground mine.

F. EVALUATION PROCEDURES

The following procedures are structured in consideration that the evaluations will be conducted by the RA's technical staff with possible assistance from OSM and cooperation with MSHA. Consequently, the procedures focus on the review items rather than the specific analytical tools. Attachment 1 is an "Executive Summary of Findings." The attachment also contains space for some basic information pertinent to impoundments. As previously noted, the RAs may develop their own forms.

1. Information Review

Attachment 2 contains numerous review items that are applicable to impoundments where the water/slurry elevation is above, or will be above, the elevation of the underground mines. The items may not be applicable depending on the site-specific conditions and the spatial relationship of the impoundment and underground mines. The attachment can be used as a checklist to ensure the completeness of the review.

The potential for a breakthrough is limited in cases where the mines are outside the "zone of no extraction" (Zone A) and the "zone of extraction using the guidelines" (Zone B) shown in IC 8741, see Figure 1.

Figure 1 (from IC 8741)

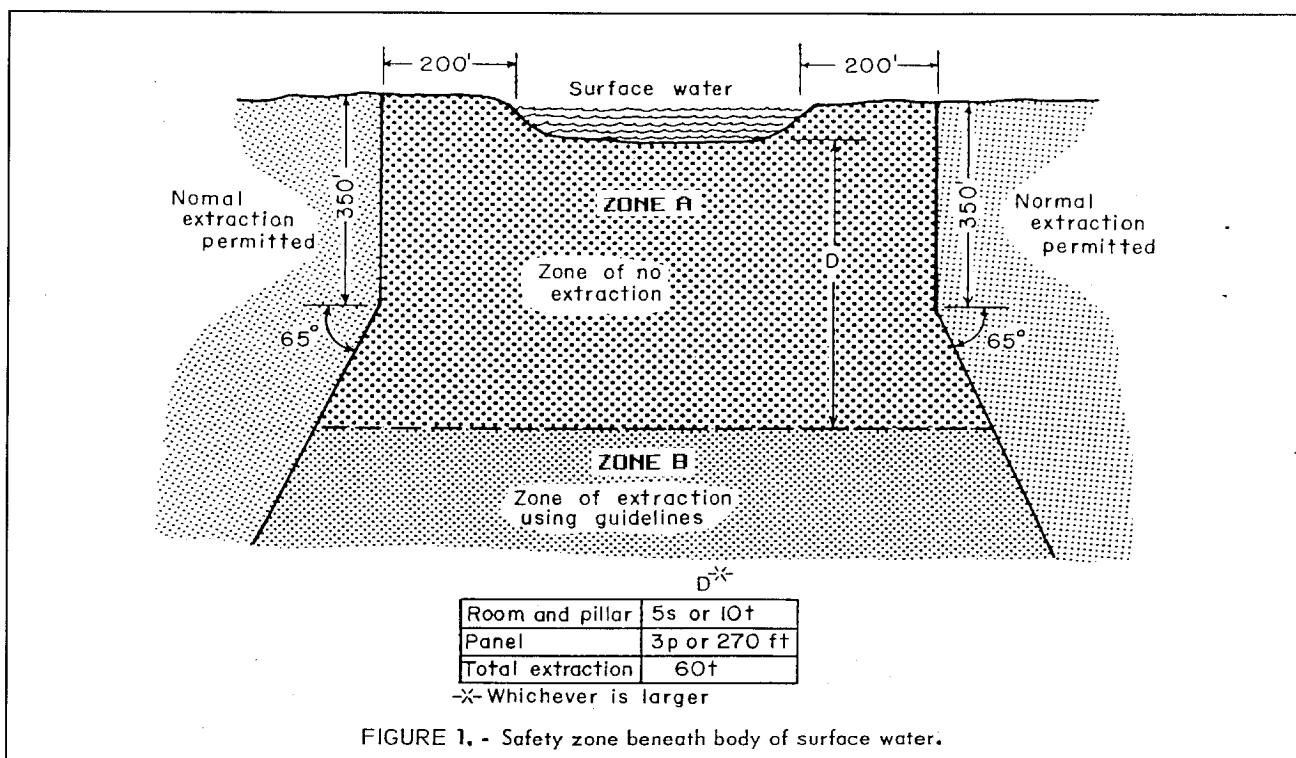


FIGURE 1. - Safety zone beneath body of surface water.

Where: (s) is the entry width, (t) is the entry/mining height, and (p) is panel width. Zone A and B added to figure by LFO.

The first step to take in the review is to determine the elevation of the underground mines, if any, with respect to the elevation of the actual and planned water/slurry elevation. For cases where the water/slurry will be below the elevation of the underground mine, the review write-up can be limited to the information that supports that finding. However, during the course of the review of such sites, it is prudent to review the outcrop barrier of works located above the impoundment and assess their potential to blow-out into the impoundment.

It is also logical to limit the review of impoundments where the underground mines are a considerable distance from the impoundment, provided that there are no other underground works, adits, auger holes, surface mines, shafts, or borings between (or in/around) the impoundment and the underground mine.

2. Assessment of Breakthrough Potential

The breakthrough potential is a function of a number of factors (e.g., proximity of the underground mine; location of the mine with respect to natural fracture systems, such as

side hill and valley bottom stress relief fractures; type/thickness of outcrop barrier and overburden material; floor, pillar, and roof stability; outcrop barrier stability; subsidence potential and the type(s) and location of potential subsidence; seepage and piping potential through fractures, the outcrop barrier, and overburden). Numerous research addresses these items. It is beyond the scope of this paper to list the research and its applicability to individual factors.

The evaluation, and the assessment of breakthrough potential, will be performed by the RA's technical staff, with possible assistance as needed from OSM. Because of the variety of conditions, the following does not provide a "cookbook" on how to evaluate the critical components related to potential failures.

The RAs are advised to use the PIL primarily for rating purposes. The RAs actual technical evaluations should be based on engineering principles applicable to the specific site conditions. Pillar stability calculations should be made with currently recognized formula such as those included in OSM's Surface Deformation Prediction System (SDPS), and the pillar loading should consider not only the weight of overburden, but also the overlying weight of the water and slurry.

During the course of site classification and evaluation, the RAs are encouraged to examine the outcrop barriers of mines located above the impoundment. These outcrop barriers should be examined to determine if there is a potential that they could blowout into the impoundment. A blowout could cause adverse impoundment impacts, such as overtopping, failure of the upstream face, wave run-up, and/or erosion. The examination should include: 1) a review of the underground maps to determine head potential, 2) a review of the surface and underground maps to determine approximate outcrop barrier width—give special attention to the manner used to delineate the cropline and whether the underground maps indicates unsurveyed areas, 3) a review and the land surface for features that reduce the barrier width, 4) seepage that may indicated a narrower barrier than indicated on the maps or a higher head potential than expected, and 5) geologic information concerning the composition of the outcrop barrier material.

The evaluation priority is addressed in Section D. However, in order to further aid in the assignment of appropriate personnel during the technical review, the following site classification system is recommended. These classifications are also recommended for use in conjunction with inventories to enable a third party to visualize the location of the underground works relative to the impoundment. The site should be classified before the assessment is conducted.

- a. **Site Classification Aa:** water/slurry elevation at or above the elevation of the underground mines and 1) there is mining within the "zone of no extraction" (Zone A) shown in IC 8741, Figure 1, and 2) there is mining within the "zone of extraction using the guidelines" (Zone B) of IC 8741, Figure 1.

1. What are the likely failure mechanisms?
 2. Identify the critical components (e.g., outcrop barrier width and stability, competent overburden thickness, water/slurry depth, subsidence potential) related to the failure mechanisms. Make note of any components that cannot be assessed because of the absence or reliability of data.
 3. Provide an assessment of the critical components and determine if a failure is possible.
 4. If a failure is possible, identify the type and location of the possible failure and describe the potential impacts (e.g., will breakthrough and be retained in underground mine; will discharge from underground mine and possibly damage dwellings; will be retained in mine but the mine's down-dip outcrop barrier may not handle the head).
 5. If a failure is possible, describe the possible magnitude of the potential impacts.
 6. What is the operator's opinion concerning the potential for a breakthrough?
 7. What measures has the operator taken, or plans to take, to prevent a breakthrough?
 8. What measures have MSHA or the RA required?
 9. If the operator has taken action to prevent a breakthrough, provide an assessment of the reliability of the measures taken.
 10. Is additional remediation necessary? If yes, describe the action required by the RA.
 11. For underground mines located above the impoundment, is there an outcrop barrier blowout potential? If yes, describe the action required by the RA.
 12. Based on the above, assign a "Remediation Priority" for the site. See G. below.
- b. **Site Classification Ab:** water/slurry elevation at or above the elevation of the underground mine(s) and 1) there is mining within the "zone of no extraction" (Zone A), however 2) there is no mining within the "zone of extraction using the guidelines" (Zone B).

The assessment for this classification is generally the same as for Site Classification Aa.

- c. **Site Classification Ac:** water/slurry elevation at or above the elevation of the underground mine(s) and 1) there is no mining within the “zone of no extraction” (Zone A), however 2) there is mining within the “zone of extraction using the guidelines”(Zone B).

The assessment for this classification is generally the same as for Site Classification Aa.

- d. **Site Classification B:** water/slurry elevation below the elevation of the underground mine, and the mine is within the “zone of no extraction” (Zone A). The permit allows the water/slurry elevation to exceed the elevation of the underground mine. There is no mining within the “zone of extraction using the guidelines” (Zone B).

The assessment for this classification is generally the same as for Site Classification Aa. However, the potential for breakthrough will not exist until the pool is above the elevation of the underground mine.

- e. **Site Classification C:** water/slurry elevation above, or will be above the elevation of the underground mine; however, the mine is outside the “zone of no extraction” (Zone A). There is no mining within the “zone of extraction using the guidelines” (Zone B).

The sites have a limited potential for water/slurry to discharge into underground mines. No further assessment required unless there is an outcrop barrier blowout potential from an underground mine above the impoundment.

- f. **Site Classification D:** water/slurry elevation below the elevation of the underground mine, and the permit does not allow the water/slurry elevation to exceed the elevation of the underground mine floor. There is no mining within the “zone of extraction using the guidelines” (Zone B).

The sites do not have a potential for water/slurry to discharge into underground mines. No further assessment required unless there is an outcrop barrier blowout potential from an underground mine above the impoundment.

- g. **Site Classification E:** no adjacent or subjacent underground mines.

- h. **Remediation Priority.** The Remediation Priority will be used for inventory purposes as well as for assignment of technical resources necessary for the plan reviews.

For Site Classifications A and B, the Remediation Priority is a combination of the site classification and the evaluation priority based on MSHA's PIL. For example, a Remediation Priority of Aa-AIH2 means: 1) this a "site classification **Aa**" impoundment, 2) it has an **A** priority level according to the PIL, 3) the underground mine lies below the impoundment—Category **I**, 4) the impoundment has a (**H**) high potential for breakthrough, and 5) the breakthrough could impact (impact **2**) the safety of the general public.

Based on the RA's findings, the RA's "breakthrough risk potential" rating and "impact potential" may be different than the rating given by MSHA. For example the RA may determine that the outcrop barrier is narrower than previously report or that the RA may identify old adits exist within the impoundment area that were not previously show on the mine maps.

For Site Classifications C, D, and E the Remediation Priority is the site classification followed by NRR for "no remediation required," e.g., C-NRR.

MSHA's PIL rating system is summarized below.

Category:

- I. Deep mining where the coal seam does not intersect the surface of the impoundment.
- II. Deep mining where the coal seam intersects the surface of the impoundment.
- III. Auger mining where the coal seam intersects the surface at the impoundment.

Impact Potential:

1. Breakthrough impacts the safety of miners on mine property.
2. Breakthrough impacts the safety of the general public.
3. Breakthrough impacts property (major roads, utilities, structures).
4. Breakthrough floods and is safely retained within abandoned mine.

Evaluation Priority:

Priority Level	Category	Breakthrough Risk Potential (refer to PIL for specifics)	Impact
A	I, II, III	High	1, 2
B	I, II, III	High	3
C	I, II, III	Moderate	1, 2
D	I, II, III	High	4
E	I, II, III	Moderate	3, 4
F	I, II, III	Low	1, 2, 3
G	I, II, III	Low	4
H	I, II, III	High	5
I	I, II, III	Moderate	5
J	I, II, III	Low	5

G. REMEDIATION PLANS

Because the remediation plans will be site-specific, and the remedial measures may vary considerably from site to site, the following section describes the general process for the plans and does not attempt to delineate specific remedial measures.

For sites where assessment identifies a high breakthrough potential, the RA should require the operator to prepare a plan to address the conditions. Because the plans may require both MSHA and RA approval, the RA should coordinate the plan requirements (and review of plans, once submitted) with MSHA. MSHA may not be reviewing low risk sites, however coordination with MSHA is still encouraged to ensure that the MSHA and RA plan revisions are consistent.

During the development of the remedial requirements, the reviewer may find that the permit and other data sources do not provide sufficient information to evaluate the breakthrough potential. This may be related to the reliability of the underground maps; the absence of information related to mining activities along the outcrop barrier or under the impoundment; the reliability of the cropline location; insufficient information to determine subsidence potential, etc. For such sites, the RA should require the operator to take the actions to develop and provide the reliable data necessary to enable the RA to complete the breakthrough evaluation. This may require exploratory drilling, surveying, geophysical, or other evaluations and the preparation and certification of maps and cross-sections that accurately show the relationship of the impoundment and underground mine.

When exploration is required to fully analyze a site, the exploration should be conducted at a sufficient number of locations to ensure that the data fully represents the site conditions. The

drilling should be to a sufficient depth to identify all mined coal seams. When drilling is conducted, it is recommended that continuous soil samples and rock cores be obtained and stored in secured facilities. The soil samples and rock cores should be tested for strength parameters and permeability. The use of geophysical or other methods must be “ground-truthed” by sufficient drilling or other validation techniques (e.g., entry into the mine and documentation of geometry, conditions, etc.).

For sites that have a high potential for breakthrough that could cause harm to people, property, and environmental features, the RA should require the operator to take immediate action to prevent the breakthrough. These measures may be temporary or permanent actions to allow stopgap attention to the high-potential situation until such time as an adequate evaluation and longer-term remedial plan is implemented.

H. EMERGENCY ACTION PLANS

MSHA requires the impoundment operators to submit an Emergency Action Plan (EAP) (see Attachment 6-- Program Information Bulletin No. P94-18 issued June 18, 1994). The EAP addresses the hazard area and the procedures for notifying and coordinating actions when a hazardous condition develops. The RA’s regulatory program may also require an emergency action plan.

During the impoundment breakthrough review, the RA should review the operator’s EAP submitted to MSHA and, if a plan is required by the RA, the plan submitted to the RA. This review should examine the plans to ensure that they cover impacts downstream from portals, blowouts, or other sites where breakthroughs result in surface discharges of water, slurry, and/or other impounded materials. Reviews of EAPs should also consider impacts associated with embankment failure. If plans have been submitted to both MSHA and the RA, the RAs should review both plans to ensure that they are consistent.

ATTACHMENTS

1. Impoundment Review–Executive Summary of Findings.
2. Evaluation Procedures, Information Review.
3. Breakthrough Events 1994 to 2000.
4. MSHA Program Information Bulletin No. P00-16, Unintentional Release of Water or Slurry From Impoundments Into Active or Abandoned Mines.
5. MSHA Procedure Instruction Letter No. I99-V-3, Evaluating Breakthrough Potential and Impact of an Unintentional Release of Water or Slurry From an Impoundment: District Response Procedures.
6. MSHA Program Information Bulletin No. P94-18, Emergency Action Plan.
7. Bureau of Mines Information Circular 8741, Results of Research to Develop Guidelines for Mining Near Surface and Underground bodies of Water.

8. ARCC Implementation Plan January 19, 20001, "Prevention of Impoundment Leaks into Underground Mines."