MSHA HANDBOOK SERIES

U.S. Department of Labor
Mine Safety and Health Administration
Mine Safety and Health Enforcement

January 2021

Handbook Number: PH21-V-6

DAM INSPECTION AND PLAN REVIEW HANDBOOK

PREFACE

This handbook sets forth general procedures for conducting inspections of impoundments and tailings dams at coal and metal and nonmetal mines consistent with Section 103(a) of the Mine Act. This handbook supersedes instructions included in a separate Coal handbook that MSHA previously issued. The guidance is general and persons should refer to the Federal Mine Safety and Health Act of 1977, as amended (Mine Act or the Act), the Mine Improvement and New Emergency Response Act of 2006 (MINER Act), and 30 Code of Federal Regulations (CFR).

This handbook provides MSHA personnel with procedures, tools and general guidance for inspecting dams and reviewing engineering design plans for dams; all activities should take into account specific conditions and practices at a mine.

Not all procedures and requirements are applicable for all mine types. Inspectors should base any deviation from procedures in this handbook on their professional judgement and discussions with their supervisor.

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Timothy R. Watkins

Administrator for Mine Safety and Health Enforcement

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CHAPTER 1 - INTRODUCTION

The objective of MSHA mine inspection and investigation activities is to promote a safe and healthful working environment for miners, and in the case of impoundments and tailings dams, protect the public. MSHA personnel work to achieve this objective in three ways: (1) by enforcing the Federal Mine Safety and Health Act of 1977, (Mine Act or the Act) (PL 95-164) as amended (30 USC 801 et seq.), the Mine Improvement and New Emergency Response Act of 2006 (MINER Act) (PL 109-236), and title 30 of the Code of Federal Regulations (CFR); (2) by conducting education and training activities; and (3) by providing technical assistance to the mining community including coordination with other public agencies.

A. Purpose

This handbook provides MSHA personnel with procedures and guidance for inspecting dams and reviewing engineering design plans for dams. This handbook also describes the MSHA Dam Safety Program.

B. Authority

Section 103(a) of the Mine Act provides Authorized Representatives (ARs; also referred to as inspectors) of the Secretary of Labor with the authority to conduct inspections of coal and other mines.

The Powerplant and Industrial Fuel Use Act of 1978 requires Federal agencies to use their existing authorities to protect the general public from the dangers associated with mining dams. 42 U.S.C., Chapter 92, Subchapter VI, Section 8401(i) of the regulations titled "Protection from Certain Hazardous Actions" states the following:

> "Federal agencies having responsibilities concerning the health and safety of any person working in any coal, uranium, metal or nonmetallic mine regulated by any Federal agency shall interpret and utilize their authorities fully and promptly, including the promulgation of standards and regulations, to protect existing and future housing, property, persons, and public facilities located adjacent to or near active and abandoned coal, uranium, metal, and nonmetallic mines from actions occurring at such activities that pose a hazard to such property or persons."

C. Responsibility

The Administrator for Mine Safety and Health Enforcement has the primary responsibility for enforcing the Mine Act, and the standards and regulations relating to mines. Regional Administrators have overall responsibility for management and oversight of the districts within their respective regions. Shared responsibility rests with the inspectors, right-of-entry personnel, District and Assistant District Managers, Specialists, and supervisors. Inspectors are responsible for conducting inspections and investigations.

The Federal Emergency Management Agency (FEMA) within the Department of Homeland Security is responsible for administering the National Dam Safety Program (NDSP). Authorization for the NDSP is through the National Dam Safety Program Act, as amended (33 U.S.C. §§ 467f *et seq.*). FEMA publishes the Federal Guidelines for Dam Safety, which are the guiding principles for all Federal Agencies involved with dam safety. MSHA's responsibilities include coordination and collaboration with FEMA and other agencies, through regular participation in the NDSP and as needed.

Appendix 1 describes the MSHA Dam Safety Program and the roles and responsibilities for each MSHA organizational area involved.

Appendix 2 describes the Dam Safety Program training.

CHAPTER 2 - INTRODUCTION TO DAMS

The most common dam structures are embankments constructed of earth and rockfill. Mining dams can be constructed of natural soils or waste produced during the mining and milling process. In the coal mining industry, the most common construction material is the coarse fraction (typically sand size and larger) of refuse from the coal cleaning process. In the metal and nonmetal mining industry, dams are often constructed of natural soils or the coarse fraction (sand size) of waste from the milling process. The fine fraction (clay and silt size) of waste produced from both industries is typically pumped behind the dam. Water may be mixed with these materials, sometimes in significant volumes, to form a slurry, facilitating the mobilization and placement of the embankment or fill materials.

Dams used for the purpose of water control or storage are typically constructed over a shorter discrete timeframe. Dams used for mine waste storage are typically constructed continuously over the life of the mine. This time period may often be decades.

A. Dam Configuration and Construction Method

Embankment dams may be configured as a cross-valley embankment, side-hill embankment, or diked embankment. These configurations are shown in Figures 1 through 3. The biggest factor influencing the configuration is the ground topography or terrain at the site. Relatively narrow-valley terrain is ideal for a cross-valley embankment. A wide valley or rolling terrain is better suited for side hill embankments. Relatively level terrain is needed for diked embankments.

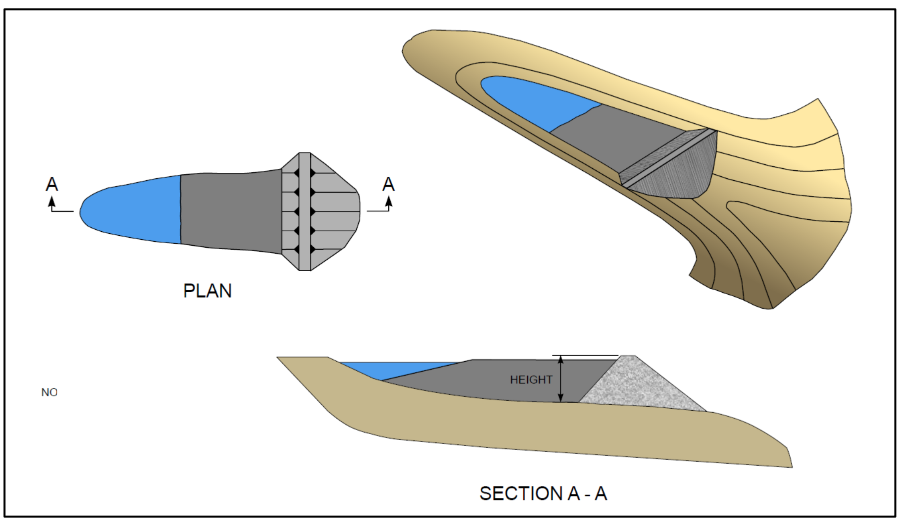


Figure 1. Cross-valley impounding embankment.

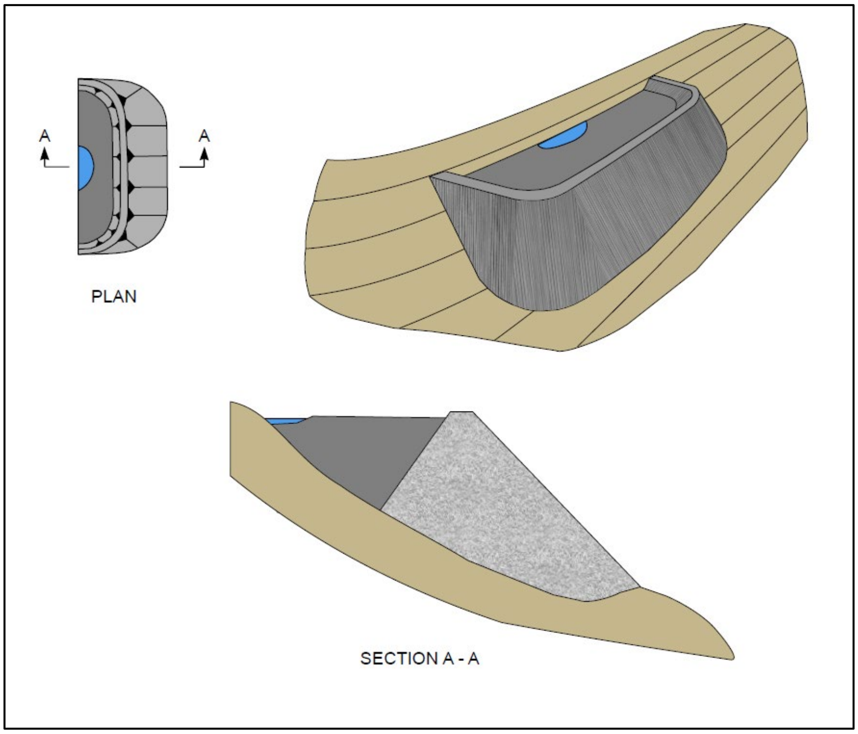


Figure 2. Side-hill impounding embankment.

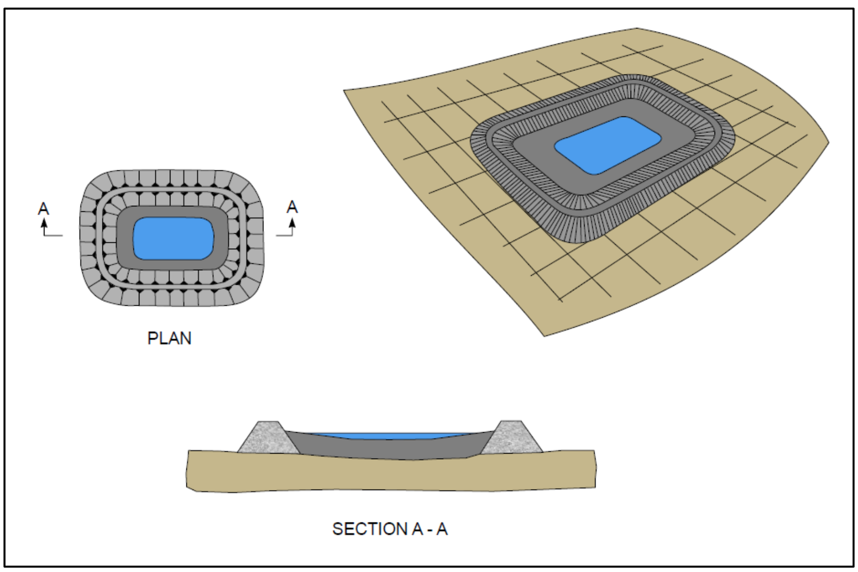


Figure 3. Diked impounding embankment.

Embankments may be constructed using the downstream, upstream, or centerline method, as shown in Figures 4 through 6. It is not uncommon for a combination of methods to be found at a site. In the downstream method, the crest of the dam moves in a downstream direction as the embankment is raised. In the upstream method, the crest of the dam moves in an upstream direction as the embankment is raised. The centerline method is a combination of the downstream and upstream methods with the crest moving neither downstream nor upstream.

The construction method used at a site is often a function of land and construction material availability. Downstream construction requires the most land for the embankment footprint and the most material to construct the embankment. The upstream method minimizes the footprint of the dam and requires the least material for dam construction.

As shown in Figures 4-6, the dam's available storage volume is affected by the construction method. The impoundment total storage volume increases as the embankment rises. However, when the upstream construction method is used, each stage adds incrementally less storage due to the embankment occupying some of the volume.

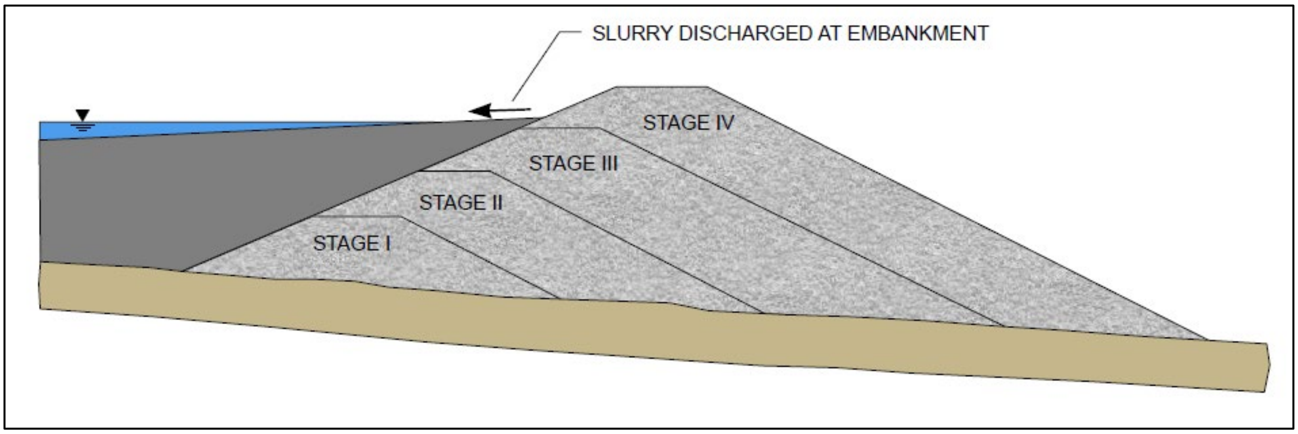


Figure 4. Downstream construction method.

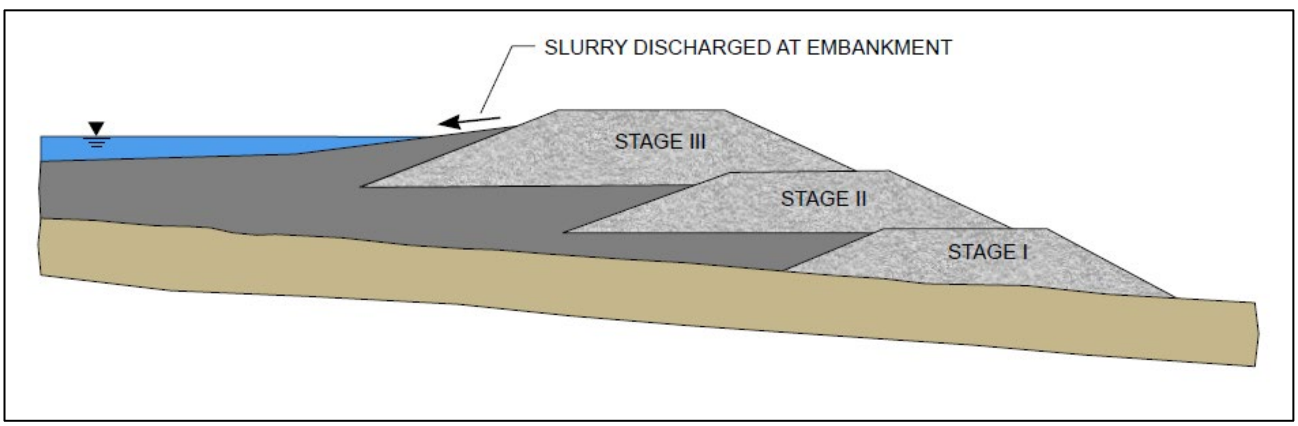


Figure 5. Upstream construction method.

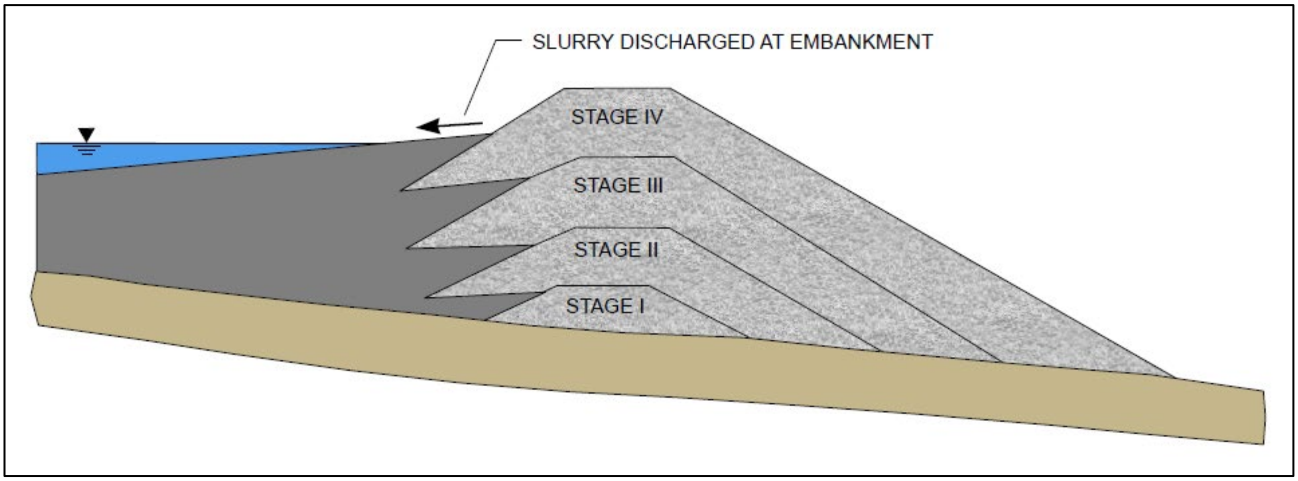


Figure 6. Centerline construction method.

A unique mine waste disposal site is the slurry cell impoundment shown in Figure 7. The embankment may use any of the configurations and construction methods previously discussed. However, instead of pumping fine waste to fill the entire impoundment behind the embankment, it is placed in relatively small cells constructed across the top of the site. Once the cells are filled, they are covered and the site is raised and another layer of cells is created. This type of impoundment is often used when there is a high likelihood of a breakthrough of stored material into nearby underground mine works. The site is designed to minimize the amount of water and fine refuse that could flow if a breakthrough occurred. This type of site is considered an impoundment.

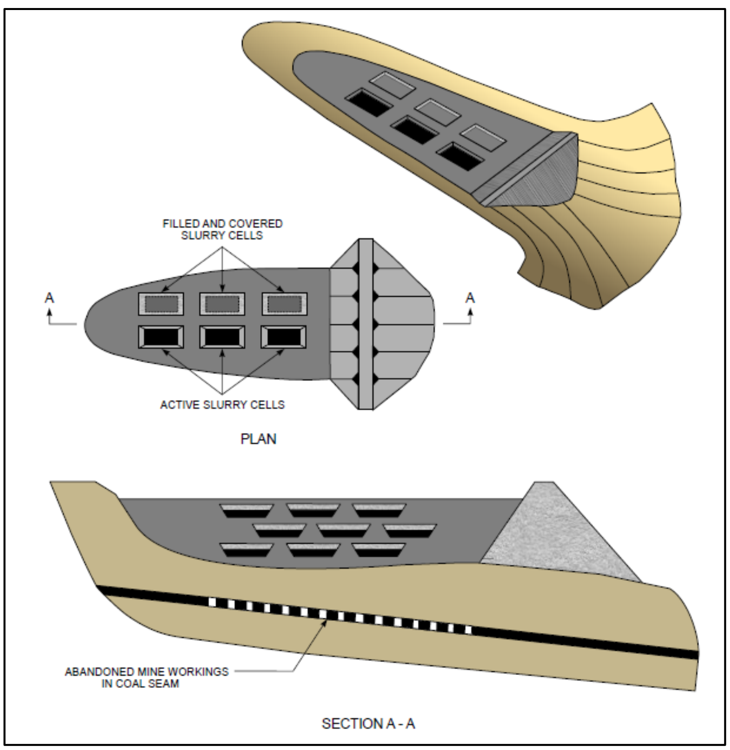


Figure 7. Slurry cell impoundment.

Another unique site is the incised impoundment as shown in Figure 8. An incised impoundment is one where storage volume is excavated into natural ground. An incised impoundment may also have storage capability above the natural ground surface as shown in the figure. For MSHA storage volume calculations, only the storage volume above natural ground is considered.

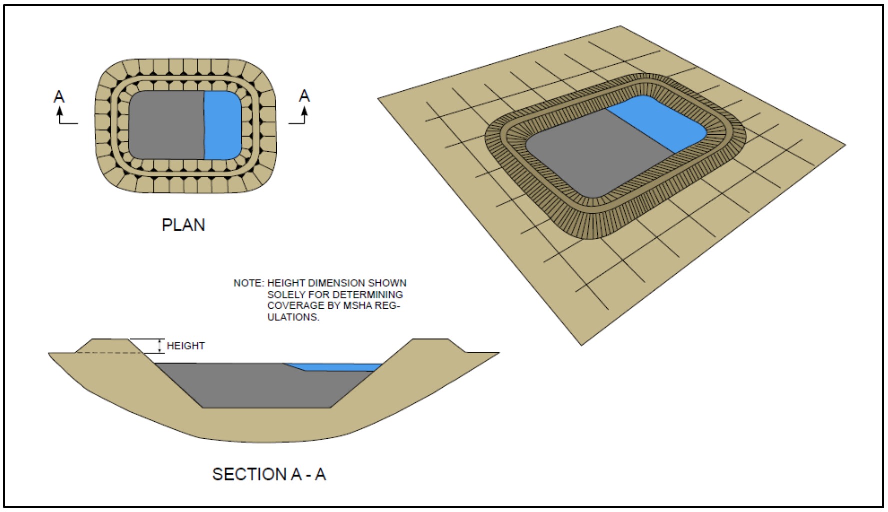


Figure 8. Incised impounding facility.

B. Anatomy of an Embankment Dam

All embankments have the same general features, see Figure 9. The dam may consist of the main embankment and saddle dams. The main embankment is the primary impounding structure while saddle dams are smaller structures built in low points, or gaps, in the natural ridgeline around the pool. The embankment may be zoned or separated into sections, as shown in Figure 10. Each zone of the embankment may be constructed of different materials to serve a particular function. For example, the core is typically a low permeability material to hinder seepage through the embankment. The downstream zones may be a high permeability material that allows water to freely drain. Rockfill is often used for downstream zones. The upstream zone is typically a lower permeability material (not as low as the core) in place to protect the core.

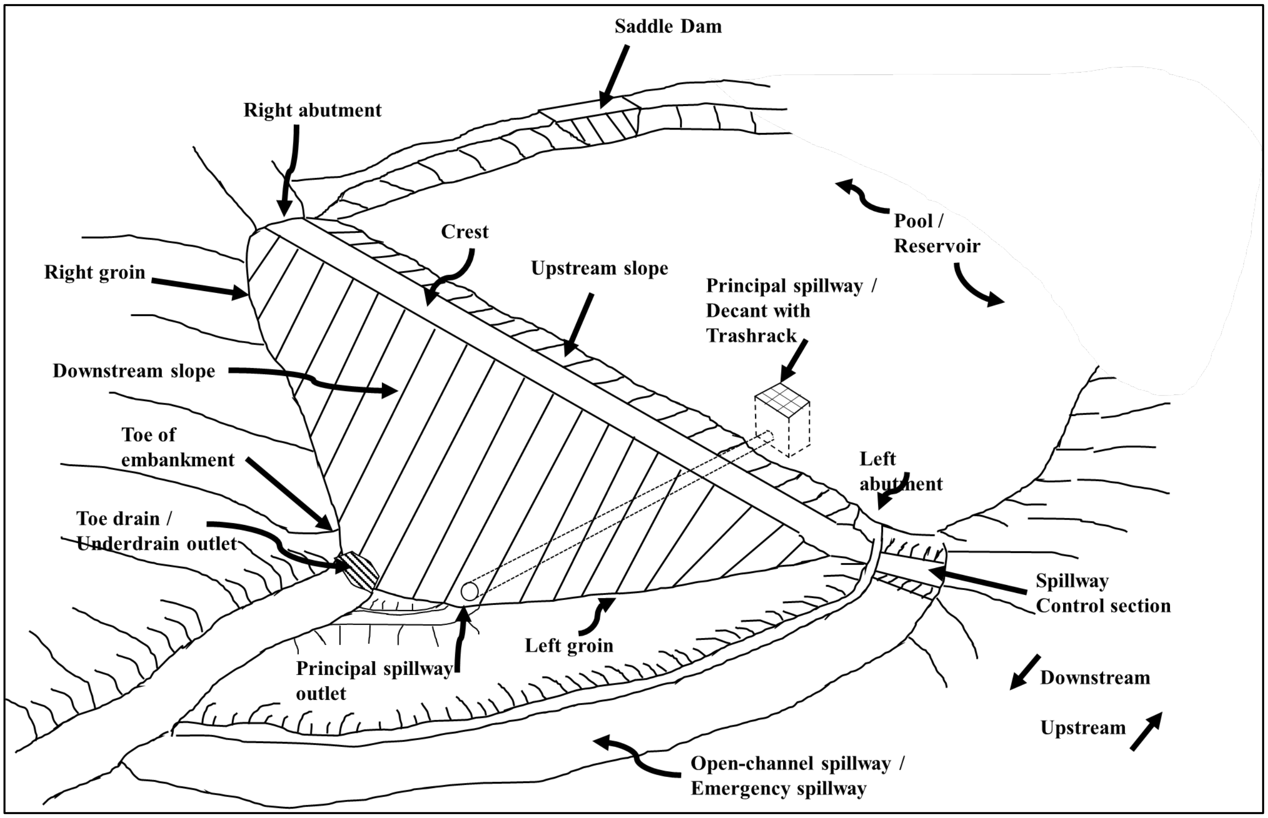


Figure 9. Embankment dam terminology.

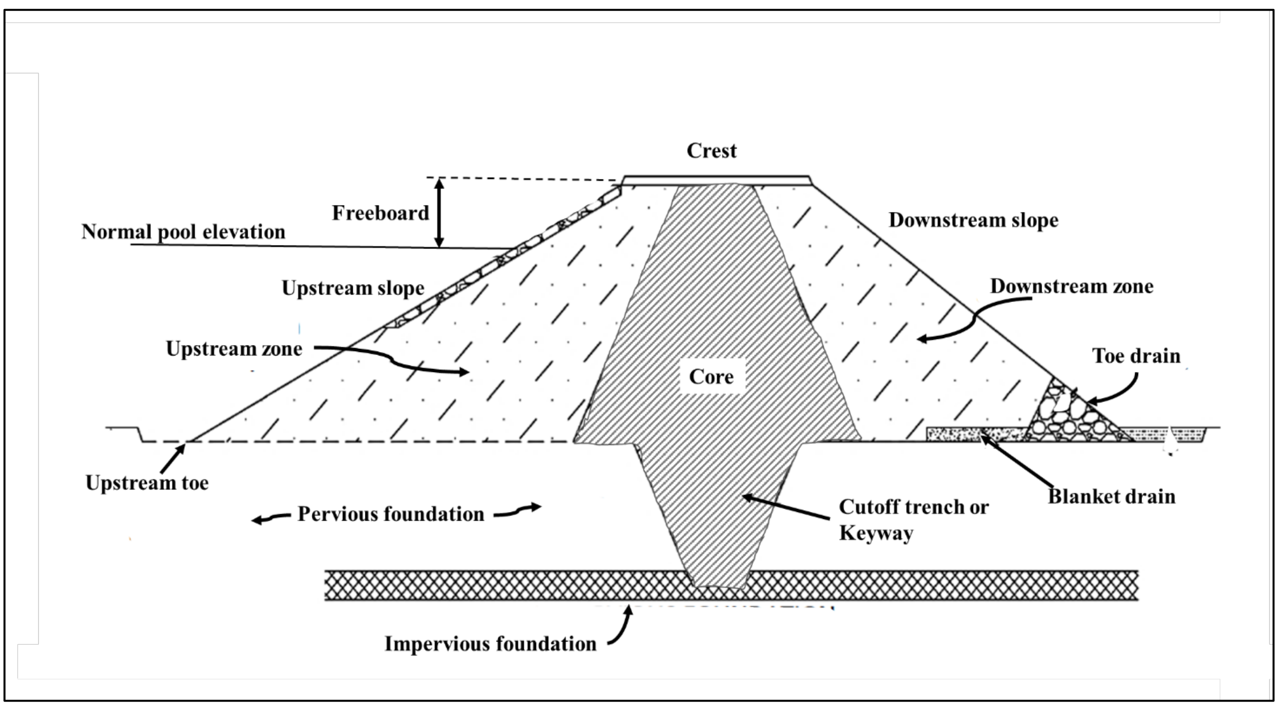


Figure 10. Typical zoned embankment dam profile and terminology.

C. Construction and Operation of the Dam

Dam embankment construction material may be soils from a nearby source or the coarse fraction of waste from the coal or mineral processing operation. At conventional dams and coal impoundments, embankment material is often delivered by haul truck and occasionally by conveyor system. At some metal and nonmetal tailings dams, embankment material may be delivered via slurry pipeline. Embankment material should be spread and compacted to improve the engineering properties (Photos 1 and 2).

Photo 1. Construction of a coal impoundment embankment.

Photo 2. Construction of a metal and nonmetal tailings dam embankment.

After the dam has been constructed, the site is ready to impound water, sediment, or other refuse from the mining operation. At a coal impoundment, fine refuse is usually pumped to the site as a slurry. The refuse may also be delivered by haul or tanker trucks depending on the moisture content of the material. At metal and nonmetal sites, the waste material is referred to as tailings and is not usually separated into coarse and fine fractions at the processing plant, but is composed of sand-sized and smaller particles. At larger metal and nonmetal operations, slurry pipelines deliver the waste material and cyclones or other methods may be used to separate the coarse and fine portions of the waste. Photos 3 and 4 show delivery of slurry and tailings. It is advisable to discharge slurry along the upstream slope of the embankment so that coarser, heavier material settles out of the flow near the embankment while finer, lighter material flows away from the discharge point into the pool area. At the point of deposition, the coarser material typically forms a beach, which slopes downward from the discharge point.

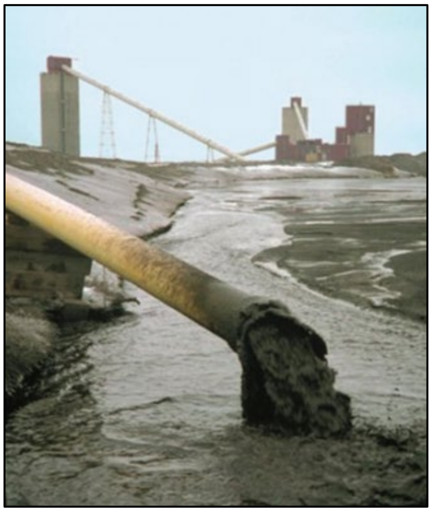


Photo 3. Delivery of fine refuse to a coal impoundment.


Photo 4. Delivery of waste to a metal and nonmetal tailings dam.

Water storage, flood control, and sediment control dams are typically constructed to their final height and physical shape in one stage before being used. At water storage or sediment control dams, the reservoir is allowed to fill with water. Flood control dams typically do not impound water until a precipitation event occurs. The dam collects and retains the runoff to prevent inundation of downstream assets, typically a mine pit.

Tailings dams are often constructed in stages as shown in Figures 4 through 6. The embankment is continually raised to stay ahead of the rising fine refuse or tailings level. At tailings dams where the coarse and fine waste is delivered together by a slurry pipeline, the material is separated at the site. As the level of tailings approaches the crest of the embankment, the coarser materials are plowed up to raise the crest (Photo 2).

For all dams, it is critical to control the elevation of the water pool and tailings in relation to the elevation of the embankment crest. Sufficient storage volume must be maintained to store or pass the runoff from a precipitation event, also known as a design storm. To control the normal pool elevation, a principal spillway or decant is constructed in the pool area. The spillway may consist of a vertical drop-inlet system or culvert inlet (Figures 11 and 12). This spillway helps ensure the pool will be low enough so that the runoff from a storm does not overtop the dam. As added precaution, some dams will include an emergency open-channel spillway that will evacuate water if it reaches the spillway inlet elevation. Occasionally, a dam will only have a principal spillway or only an open-channel spillway. Even rarer is that a dam may have no outlets and relies on pumping to evacuate stored storm water. In this situation, the dam typically must store the runoff from two consecutive design storms to provide an adequate factor of safety against overtopping. All hydrologic and hydraulic conditions must be evaluated to ensure the dam is able to control runoff without overtopping.

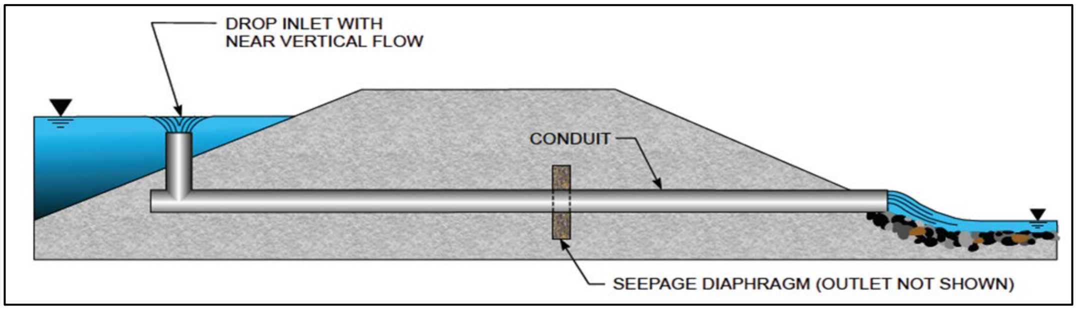


Figure 11. Drop-inlet decant system.

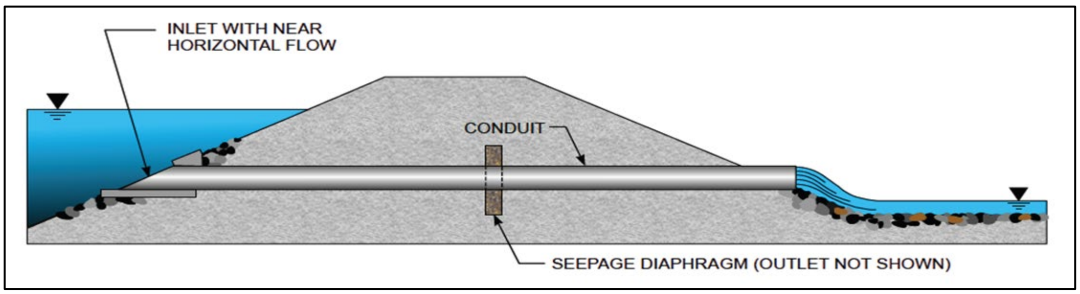


Figure 12. Culvert inlet decant system.

The water impounded by the dam will seep into the embankment. This internal water must be controlled to ensure it does not rise too high in the embankment or that it does not erode portions of the embankment where it exits. The top surface of the internal water level is known as the phreatic surface. A high phreatic surface could affect the embankment's stability. To control seepage, drains are often constructed inside the embankment to collect and safely remove the water (Figure 13). It is important that these drains remain operable during the life of the dam. To help ensure their operation, graded aggregate or geotextile filters are placed around the drain to prevent finer soil particles from entering and clogging the drain.

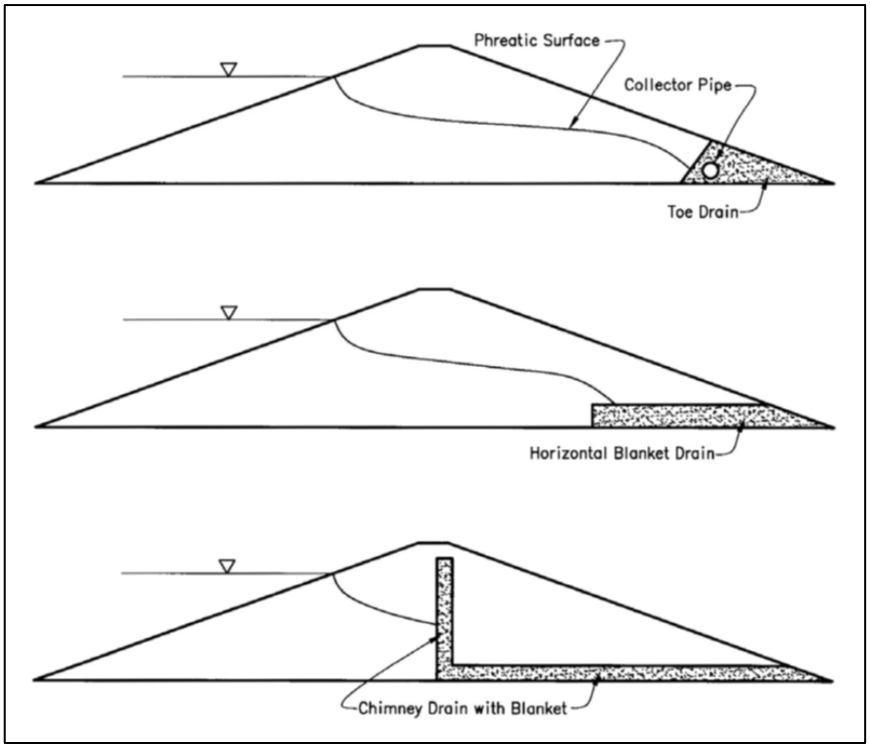


Figure 13. Typical embankment dam internal drains to collect and carry off seepage water. Toe and blanket drains are most common in dams seen by MSHA.

Internal seepage may occasionally intersect a horizontal layer of material that is relatively impervious. Because the seepage cannot flow vertically through this layer, it will travel horizontally and emerge on the downstream slope of the embankment. This seepage must be monitored and controlled to ensure it is not damaging the embankment. Instruments called piezometers are used to monitor the water level or water pressure within the embankment.

D. Dam Construction Sequence

Tailings dams are often constructed in phases or stages. Stage 1 of the embankment is often called a "starter dam." The starter dam may contain impervious material to help control seepage through the lower portions of the embankment. Following the starter dam, the embankment is raised as the refuse level in the impoundment rises to maintain freeboard while continuing operation.

The upstream construction method used for coal waste impoundments may require several construction phases, as shown in Figure 14. After an initial or previous stage is completed, fine refuse slurry is deposited to create a beach, or delta. Raising the embankment will involve an upstream pushout of material over the settled fine coal refuse. Depending on the condition of the delta, pushout material may sink in to the fine refuse creating a zone of mixed material (coarse and fine refuse). Upon completion of the pushout, piezometers are usually installed and the upstream embankment raise completed. Photo 5 shows coarse coal refuse being pushed out over settled fine refuse. It is less obvious, but the embankment being raised at the metal and nonmetal tailings dam in Photo 2 is also being raised by the upstream construction method.

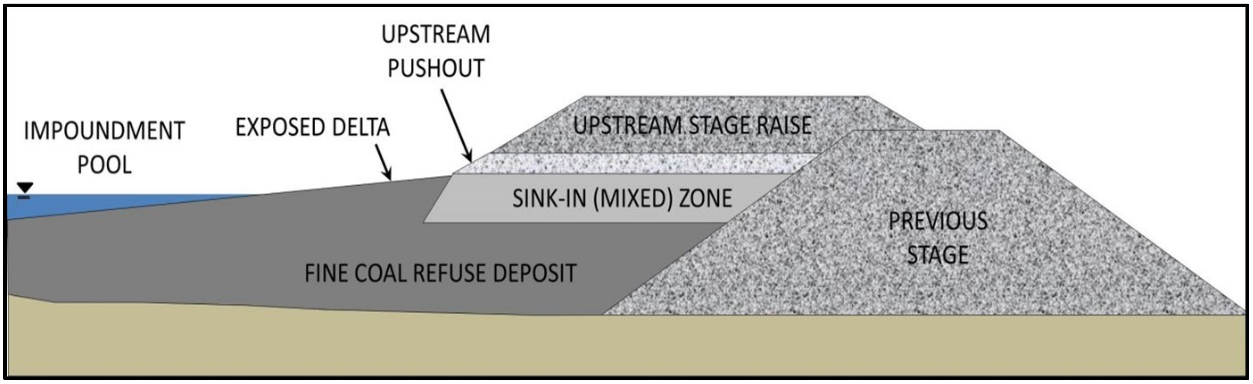


Figure 14. Typical construction sequence for a coal impoundment using the upstream construction method.

Photo 5. Construction of initial pushout at a coal impoundment.

At the conclusion of mining operations or when the dam has been raised to its maximum height, the dam should be breached to eliminate the storage of water, or capped to help isolate the stored material and reduce future infiltration of water. In some instances, the owner may request to leave the dam in place for recreational or other purposes. Capping the impoundment area is typically performed on tailings dams while breaching is performed on water storage dams. Plans should be developed for this work to help ensure long-term stability of the dam.

CHAPTER 3 - ADMINISTRATIVE ISSUES

This chapter describes administrative requirements and issues related to the regulation of mining dams. Topics covered include the following.

- Identification number
- Hazard potential classification
- Inventory of dams
- Impoundment plan tracking
- Annual report
- Notification of failures and incidents

A. Identification Number

Dam identification numbers are used to uniquely identify a dam. Dams at coal and metal and nonmetal mines are assigned a unique identification number if they meet the criteria described below. Appendix 4 contains a flowchart for determining whether a dam meets the criteria for assigning an identification number and entering the dam into the Impoundment and Refuse Pile Inventory (described in Section C below).

Coal Mines

- Dam meets the criteria described in Title 30 CFR § 77.216.

Metal and Nonmetal Mines

- Dam classified as significant or high hazard potential (see Section B), or

- Dam classified as low hazard potential and meeting at least one of the following:
  - Exceeds 6 feet in height above the upstream toe and has an impounding capacity of 50 acre-feet or more (approximately 16.3 million gallons).
  - Equals or exceeds 25 feet in height above the upstream toe and has an impounding capacity exceeding 15 acre-feet (approximately 4.9 million gallons).

Dam height is defined as the vertical distance (feet) between the lowest point on the crest of the dam and the upstream toe. Impounding capacity is defined as the total volume (acre-feet or gallons) available for storage between the elevation of the lowest point on the crest of the dam and the elevation of the upstream toe. The upstream toe is the point where the upstream face of the dam meets the natural ground. Any impounding capacity that is incised, meaning it is excavated below undisturbed natural ground, should not be included in the impounding capacity or the dam height used in the size criteria above.

The identification number will be assigned by the District Manager when the mine operator informs MSHA of their intent to construct a new site (prior to submittal of initial design plan) or when MSHA becomes aware of an existing un-documented dam. Any dam not meeting the above criteria can have a number assigned if the District desires to include the site in MSHA's inventory of dams.

New dams are assigned a number using the following format. Historically, MSHA has used this format for identification of dams at metal and nonmetal mines.

12-34567-89

Where:
- 12 - two-digit state code,
- 34567 - five-digit mine identification number (12-34567 is full mine ID number), and
- 89 - two-digit sequential number identifying the unique structure at this mine.

Individual structures at a mine will be numbered consecutively (01-99). This structure identification number is unique and should not be reissued to another structure at the mine even if the structure is not part of ongoing operations (e.g., abandoned), or sold to another owner or operator.

Existing dams at coal mines will continue to use their existing identification number format. This format is as follows.

KY07-12345-67

Where:
- KY - two-character state identifier code,
- 07 - two-digit coal District identifier,
- 12345 - last five digits of mine ID number, and
- 67 - two-digit sequential number identifying the unique structure at this mine.

B. Hazard Potential Classification

Each dam is assigned a "hazard potential" classification. The classification indicates the potential for danger to life, property, or the environment in the event of an unintentional release of water or slurry from the dam. Three hazard potential classifications are defined in the *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams* (FEMA P-333, 2004)[1]:

1. **Low Hazard Potential** – Assigned to dams where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses.

[1] https://www.fema.gov/media-library-data/20130726-1516-20490-7951/fema-333.pdf

2. **Significant Hazard Potential** – Assigned to dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.

3. **High Hazard Potential** – Assigned to dams where failure or mis-operation will probably cause loss of human life.

The hazard potential classification defines the consequences in the event of a dam failure and is not an indication of the condition of the dam or the likelihood of failure. The hazard potential classification is important because the engineering criteria used in designing the dam becomes stricter as the potential for loss of life and/or property damage increases. MSHA also uses the hazard potential classification to inform ongoing inspections and investigations.

A coal mine dam will be classified by the mine operator or the design engineer in the required design plan. At metal and nonmetal mines, the MSHA inspector should ask the mine operator if they have classified the dam. If they have not, MSHA will evaluate the conditions and assign a classification. In both industries, when the operator has assigned a classification, MSHA independently evaluates the classification to ensure it appears correct. MSHA may require the mine operator to perform a dam breach analysis, or may perform their own, to verify the classification.

When determining or evaluating a hazard potential classification, the following factors should be considered.

- Presence of downstream populations (towns, offices, etc.) and critical infrastructure (electrical substations, highways, etc.).
- Distance to downstream populations and critical infrastructure.
- Volume of water and tailings that could be released.
- Flow path for released water and tailings and size of receiving stream/floodplain.
- Potential extent of inundation at downstream locations.
- No allowances for downstream evacuation or other emergency actions should be considered.

The MSHA Engineering and Design Manual for Coal Refuse Disposal Facilities discusses several unique situations that may affect a site's hazard potential classification. Those situations include flood control dams and dams in series. Technical Support's Mine Waste and Geotechnical Engineering Division should be contacted when the hazard potential classification cannot be confidently determined.

C. Inventory of Dams

The MSHA Impoundment and Refuse Pile Inventory (IRPI) is a database to catalogue dams at mining operations meeting certain hazard potential and size criteria. The database also inventories coal refuse piles. The IRPI is part of the MSHA Standardized Information Systems (MSIS). The availability of basic information on the number, location, and characteristics of dams is needed to respond to requests for information that MSHA receives and to assist in managing MSHA's dam-safety activities. The database also includes information that MSHA is required to collect and report for the National Inventory of Dams[2].

Criteria for including a dam in the inventory are identical to that for assigning an identification number. The criteria is provided in Section A of this chapter. If a dam is assigned an identification number, it is catalogued in the inventory.

See Appendix 3 for a list and explanation of data fields in IRPI. Appendix 4 contains a form to be used during the initial visit to a new dam. Certain data fields are mandatory and are designated as such on the form.

Designated personnel in each District are able to add or modify information for their District, view data from all Districts, and generate summary reports. The District should contact the Enterprise Help Desk to request or modify access to the IRPI.

Designated personnel should immediately update information in the IRPI after each inspection of a dam. For inactive sites, the information is to be updated at least annually with information obtained from field inspections, District records, and annual reports.

Once a dam is added to the inventory, it should not be removed unless the site was added to the inventory in error. In that case, the site should simply be deleted from the database. Dams that are modified to preclude the impoundment of water or solids (above existing tailings levels) should be designated as "abandoned." Dams where an owner is no longer available should be designated as "orphaned." The treatment of orphaned dams is explained in Chapter 6.

D. Impoundment Design Plan Tracking

Dams at coal mines require a design plan be submitted to MSHA and approved by the District Manager, if it meets the criteria of 30 CFR § 77.216. All documents received by MSHA, including design plans, drawings, annual reports, and correspondence will be logged in a database developed for this purpose. The following two databases are used by Mine Safety and Health Enforcement:

[2] https://www.fema.gov/emergency-managers/risk-management/dam-safety/national-inventory-dams

- Mine Plan Approval (MPA) database accessible through MSIS
- District plan tracking spreadsheet

The MPA is used to track the status of plans under review. District personnel should enter information enabling identification of the plan as well as the status.

District plan tracking spreadsheets are found on the MSHA network at W:\SPECPROJ\Impoundments\Plans\X, where "X" is the District identifier. Each District has its own spreadsheet. Information requirements for these files are described in Appendix 6. Information should be initially entered or updated in the file at the following times.

- Upon receipt of the information and prior to forwarding the information to Technical Support for their review.
- When a technical review begins and ends.
- When the District receives a recommendation from Technical Support.
- When the District sends correspondence to the operator regarding the status of the plan.

Properly tracking the receipt and status of each plan received is important for agency accountability and maintaining an awareness of each dam's status.

E. Annual Report

Annual reports submitted for coal dams as required by 30 CFR § 77.216-4 should be reviewed by District personnel to determine whether the information appears accurate and factual. A copy of the report should be forwarded to Technical Support's Mine Waste and Geotechnical Engineering Division (MWGED). In addition to the requirements listed in 30 CFR § 77.216-4, Districts are encouraged to request the following information in the annual report:

- A narrative describing all work that has occurred at the facility during the reporting period.
- Drawings showing the current configuration.
- A narrative explaining the fluctuation in instrumentation readings and monitoring data as well as an evaluation of the data. It is recommended that instrumentation readings and monitoring data, as well as the impoundment pool levels, be provided in numeric and graphical format.
- A narrative explaining the fluctuation in pool elevations.
- A list of violations (if any) received during the year and a description of what has been done to prevent recurrence of the condition.
- A description of any significant events that have occurred at the site during the year. A significant event would be any time operation or performance of the dam was outside expected conditions or design criteria.

- A copy of the dam's emergency action plan, if one exists.

The District shall acknowledge receipt of the annual report and provide the due date for the next submittal. If all required information is not submitted, the operator shall be notified in writing that additional information is needed.

District personnel shall enter applicable information from the annual report into the IRPI database. A copy of the annual report shall be maintained in the District office and a copy shall be sent to the MWGED. Information can be sent via mail to the attention of the Division Chief or can be sent electronically to TS_MWGED_Plans@dol.gov.

F. Notification of Failures and Incidents

The District Dam Safety Representative (DSR) and the Dam Safety Officer (DSO) shall be notified of all incidents, unusual events, and failures. As defined by the National Performance of Dams Program[3], an incident is defined as an event which is of general or engineering interest due to the insights it provides on the operational and structural performance of dams and miner/public safety. This definition includes cases involving failure (i.e., breach and uncontrolled release) as well as a broader scope of events (e.g., unstable conditions, unsatisfactory performance of any portion of a dam or its appurtenant structures, mis-operation of a dam, signs of distress that are indicative of a potential loss of structural/operational integrity, or any unintended condition).

The DSO will document the event in a database. Incidents are evaluated collectively on an ongoing basis to determine if action is needed and whether modifications to MSHA's Dam Safety Program are warranted.

[3] https://www.fema.gov/emergency-managers/risk-management/dam-safety

CHAPTER 4 - DAM INSPECTION FREQUENCY

Early detection and evaluation/correction of potential problems is critical to the safe operation of a dam. Minimum inspection frequencies are based on the hazard potential classification, as well as the conditions under which the dam is operating.

A. MSHA Inspection Frequency

MSHA Dam Inspection Frequency

Condition	Inspection Frequency	Inspector
All dams associated with underground mines.	Once each quarter	Mine S&H Inspector
All dams associated with surface mines.	Once every 6 months	Mine S&H Inspector
All high hazard potential dams.	At least once each quarter	Impoundment Specialist/Inspector
All significant hazard potential dams.	At least every 6 months	Impoundment Specialist/Inspector
Critical construction activities at high and significant hazard potential dams. +	As needed *	Impoundment Specialist/Inspector
Unusual event (weather or seismic).	As needed **	Mine S&H Inspector or Impoundment Specialist/Inspector

+ - critical construction items are listed in Chapter 5.
* - MSHA presence not required if design engineer or their representative are present and construction is adequately documented with photographs.
** - initial inspection by Mine Safety and Health Inspector is acceptable, with follow-up as needed by Impoundment Specialist or Impoundment Inspector.

B. Mine Operator Inspection Frequency

The mine operator should have a defined inspection and monitoring program. At a minimum, the program should identify the following information: inspection/monitoring frequency, required qualifications of inspection/monitoring personnel, and management review of inspection results. It is recommended that standardized inspection forms be used to help ensure complete coverage of the dam and that monitoring data be documented graphically to identify trends.

Owners of dams at coal mines must conduct inspections of their dams according to 30 CFR § 77.216-3. Owners of other dams should conduct inspections with the following guidance in mind.

Common Inspection Frequencies for High or Significant Hazard Potential Dams

Inspection and Monitoring Category	Inspection and Monitoring Frequency
Construction inspections	Daily – Weekly
Informal inspections during operation	Daily
Normal inspections during operation	Every 7 days
Formal inspections during operation	Yearly
Extreme weather or first filling	As needed per occurrence
Seismic event	As needed, and see table below

Construction Inspections

Inspection of construction activities should take place at a frequency appropriate to ensure the work complies with acceptable construction practices or as specified in an available design plan. The operator, design engineer, or their representatives may need to perform inspections daily or more often. For example, the rate of construction may dictate the frequency for compaction testing.

Informal Inspections During Operation

All personnel working on or around a dam should be familiar with the operation of the dam and trained to recognize unusual conditions.

Normal Inspections During Operation

During normal operation, once construction has been completed or idled, or in areas of the dam not under active construction, inspection frequency should refer back to the minimum as required by 30 CFR § 77.216-3(a)(1) or as recommended in the table above. If deficiencies are identified, inspection and monitoring frequencies may need to be increased until the condition has been mitigated. Individuals trained to recognize potentially hazardous conditions should perform these inspections. Inspections at dams associated with coal mines will be conducted by the Qualified Person. The facility designer or their representative is encouraged to visit the site at least quarterly.

Formal Inspections During Operation

For high and significant hazard potential dams, a qualified Professional Engineer familiar with the design and construction requirements of the facility, preferably the design engineer, should perform a formal dam safety inspection at least annually. The annual inspection should include a review of critical aspects of the facility and a thorough inspection of the facility including embankments, abutments, and appurtenant structures. Plotted instrumentation records and construction data should be reviewed and evaluated by the engineer to determine whether the dam is performing as intended.

Pre- and Post-Extreme Weather or First Filling Inspections

Unusual event inspections and related monitoring should be performed by an individual trained to recognize potentially hazardous conditions or a qualified Professional Engineer. The 100-year[4] storm for the location of the dam is an appropriate event to trigger these examinations. Examples when an inspection is recommended regardless of the regular schedule are the following.

- Prior to a predicted major rainstorm or heavy snowmelt. Check freeboard, trashracks, spillways, channels, pumps, and erosion protection on upstream slopes and in spillways/ditches.
- During or after a severe rainstorm. Check seepage locations, spillways, slopes, channels, pumps, and erosion protection.
- During or following a severe windstorm if the pool is appreciably long in the direction of the wind (fetch). Check performance of erosion protection on upstream slopes and in spillways.
- During and immediately after the first reservoir filling, primarily if dam is for water storage or treatment. More frequent complete inspections should be conducted until the pool and internal water levels stabilize to assure that design and site conditions are performing as predicted. In particular, examine the downstream slopes and abutments for emerging seepage, the pool area for whirlpools or eddies, and the areas around decant pipe inlets and outlets for unusual flow. Instrumentation and drain outflow should be monitored.

Post-Seismic Event Inspections

Inspection by the operator should be conducted immediately upon the conclusion of a seismic event if the event is felt at or near the dam or per the guidelines below. Increased inspections may be warranted for some time after the event to detect any delayed effects.

[4] NOAA's Precipitation Frequency Data Server: https://hdsc.nws.noaa.gov/hdsc/pfds/

Earthquakes Prompting Inspection Event[5]

Earthquake Magnitude/Location
≥ 4.0 within 25 miles
≥ 5.0 within 50 miles
≥ 6.0 within 75 miles
≥ 7.0 within 125 miles
≥ 8.0 within 200 miles

The inspection should include the following.

- Examine the crest and embankment slopes for cracking, slips, and settlement. Monuments can be surveyed if installed at site.
- Examine ditches and spillways/decants to ensure they remained unobstructed, erosion protection remained intact, and are still capable of functioning properly.
- Evaluate piezometer levels for sudden changes in the phreatic level.
- Examine slopes for new or increased seepage.

[5] Based on United States Society on Dams, "Guidelines for inspection of dams after earthquakes," 2003.

CHAPTER 5 - INSPECTION OF DAMS

Inspections are conducted to determine if the dam is functioning as intended and to identify conditions that could negatively impact the performance of the dam. MSHA Specialists/Inspectors should also ensure mine operators are conducting thorough examinations. Dams shall be inspected at least every quarter if associated with an underground mine, or every six months if associated with a surface mine or facility. The District Manager shall require additional inspections at high hazard potential dams associated with surface mines or facilities, sites undergoing critical construction phases, where other potentially hazardous conditions are identified, or before or after significant events.

A. Pre-Inspection Procedures

Prior to conducting the field portion of the inspection, preparatory work in the office will help ensure the inspection is thorough.

In-office Inspection Preparation

Prior to conducting the field portion of an inspection, an inspector should:

- Review the Inspection Application System (IAS) for open events with impoundments.
  - Impoundment inspections shall be conducted during a Regular Inspection (E01). Inspections at other times should be conducted as an Impoundment Spot Inspection (E23) or Spot Inspection (E16).
- Review District information or the IRPI database in MSIS for the date of the last inspection.
- Review information from previous inspections (notes, photographs, instrument readings, etc.).
- Review Impoundment Data Sheet-Uniform Mine File (UMF).
  - The data sheet contains basic information relevant to impoundment plan requirements. Verify this information during the inspection of the site. In the event of missing information, needed clarification, or construction stage change, the District Impoundment Supervisor, Specialist, or Dam Safety Representative should be contacted.
- Review UMF for previous and outstanding citations/orders.
- Review status of submitted design plans.
- Review latest design plan (if available).
  - Basic site information (history, adjacent mining, staging, instrumentation)
  - Construction specifications (material placement, quality control testing)
  - Drains
  - Spillways

  - Instrumentation and monitoring requirements
  - Drawings (crest layout, spillway location, drains, instrumentation, mine maps)
- Review latest annual report (if available).
- Review correspondence files for relevant information.

Recommended Inspection Equipment

Equipment that may be needed during an inspection includes the following.

- Note pad / Inspection form
- Weir and pipe flow charts to convert flow depth to flow quantity
- Camera and extra batteries
- Calculator
- Global Positioning Unit (GPS)
- Measuring tape and 6-foot ruler
- Range finder or Abney level
- Water level indicator
- Survey ribbon
- Graduated bucket or container of known volume
- Clear container for checking clarity of flow
- Watch or timer
- Binoculars
- Shovel
- Sealable plastic bags
- Handheld spotlight
- Personal protective equipment:
  - Hardhat
  - Boots
  - Safety glasses / Sun glasses
  - Clothing appropriate for conditions
  - Insect repellent
  - Gloves
  - Sunscreen
  - Snake chaps/gators
  - Walking stick
  - Hearing protection

Mine-office Inspection Preparation

Upon arrival at the mine site, the following activities should be performed in the mine office with the person responsible for dams. A portion of this information will be needed for the MSHA Dam Inspection Form.

- Review operator inspection records
- Review monitoring data
- Review material placement records (if required)
- Review Qualified Person training records (if required)
- Review on-shift inspection records

- Review rainfall data (if available)
- Discuss activities at site since previous MSHA inspection
- Discuss personnel changes on site and their impact
- Discuss construction/operation/maintenance issues

B. Conducting the Inspection

The entire site should be examined for indications the dam is not functioning as intended or deficiencies that could affect the performance of the dam. Areas to be inspected include the pool area, embankment crest, and upstream and downstream slopes, abutments, foundation, downstream toe area, water control structures and their outlets, and seepage control measures. Figure 11 in Chapter 2 shows the parts of an embankment dam.

Inspections may begin at the crest of the dam and proceed downward or begin at the toe and proceed upward. In most instances, beginning at the crest is preferred due to the increased ease of navigating the site. The upstream and downstream face of the dam should be traversed using one of the methods shown in Figures 15 and 16. When a full traverse of the slopes is not practical, observing the slopes from several vantage points should be conducted.

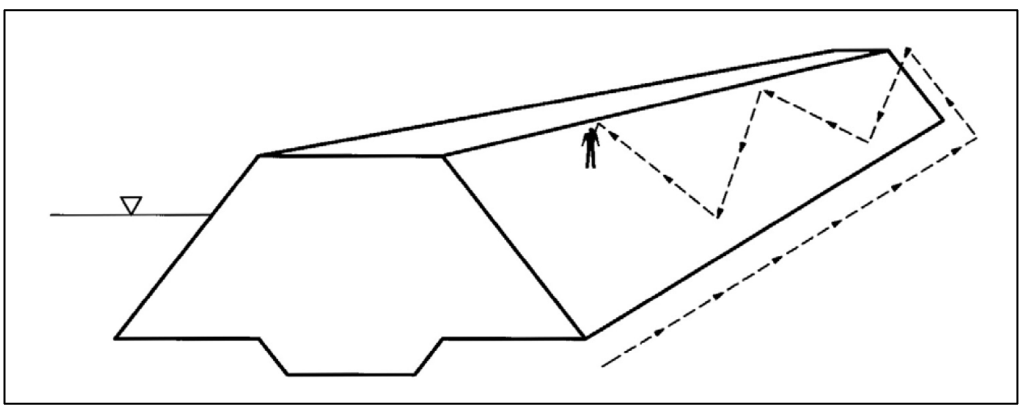


Figure 15. Zig-zag inspection path.

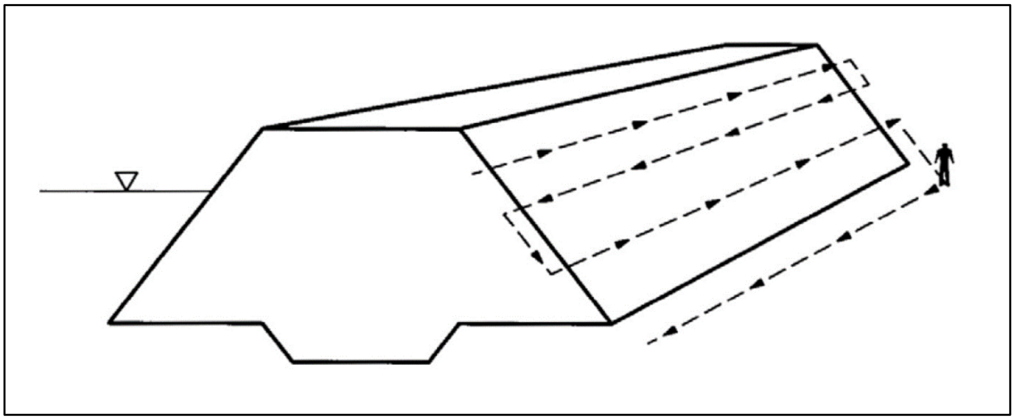


Figure 16. Parallel inspection path.

C. Critical Construction Items and Activities

"Critical construction" is an item or activity that is particularly important to the overall stability and performance of the dam. The following activities are considered "critical construction":

- Foundation preparation and grubbing
- Foundation cutoff trench
- Mine, auger, and highwall miner openings
- Construction of drains and filters
- Installation or abandonment of principal spillway or decant system
- Construction of and erosion protection for open-channel spillways and diversion ditches
- Initial pushout on a stage of an embankment using upstream construction
- Installation of instrumentation

The Specialist/Inspector should pay careful attention when inspecting critical construction. Critical construction should be documented with photographs. Inspection issues for each item are provided in the following section.

The design engineer or their representative, or a person familiar with the design, should oversee critical construction and document the work.

D. Inspection Criteria

The following describes inspection criteria for specific components of the dam. For every component, field conditions should be examined for compliance with the design plan (if available).

Site Configuration

- The operator should have records of the current site configuration, including the pool elevation, principal spillway crest or decant inlet elevation, emergency spillway invert elevation, and the lowest elevation of the embankment crest.

- The vertical distance between the minimum crest elevation and the principal spillway/decant inlet elevation should be checked to ensure the impoundment can handle the design storm with adequate freeboard in its current configuration.

Watershed Conditions

The design of an impoundment is based in large part upon the anticipated amount and rate of runoff from rainfall on the watershed that drains into the impoundment. Any changes in the watershed that could bring about an increase in the amount of this runoff could cause the impoundment to be overtopped. Typical changes in the watershed that could increase runoff include logging operations; farming or surface mining; increases in residential or commercial development; and changes in the upstream road patterns that may affect the path or volume of water runoff. Changes could also involve the discharge from mine openings that flow into the impoundment. Dams upstream of the dam being inspected, such as recreation ponds or water supply dams, would also be noteworthy since failure of these structures could affect any downstream impoundment. During the initial inspection, the watershed conditions should be documented and any significant changes should be documented thereafter.

Crest Conditions

The crest should be inspected for cracks or scarps. Excessive cracking or the presence of scarps on or near the embankment crest could indicate either inadequate fill compaction or, more seriously, instability in the embankment or its foundation. As the width of a crack increases and begins to show signs of vertical displacement (scarp), or if cracks progressively appear farther back from the edge of the slope, the potential for the occurrence of a failure increases. Cracks running parallel (longitudinal) to the crest are more indicative of slope movement (Figures 17 and 18). Randomly oriented cracks may result from surface drying.

Cracks may develop transverse to the embankment. Transverse cracks develop and extend in a direction perpendicular to the length of the crest of the dam (Figure 19). Transverse cracking may be an indication of differential settlement. Such cracks may create a potential for seepage through the embankment. The crest width should be measured to ensure that it is consistent with the embankment cross-section in the design plan.

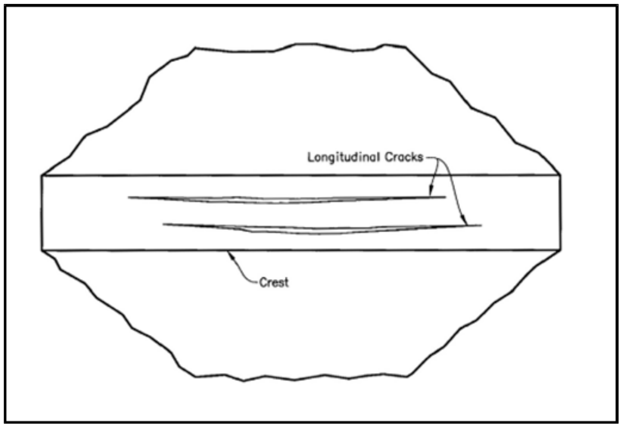


Figure 17. Longitudinal cracks on crest.

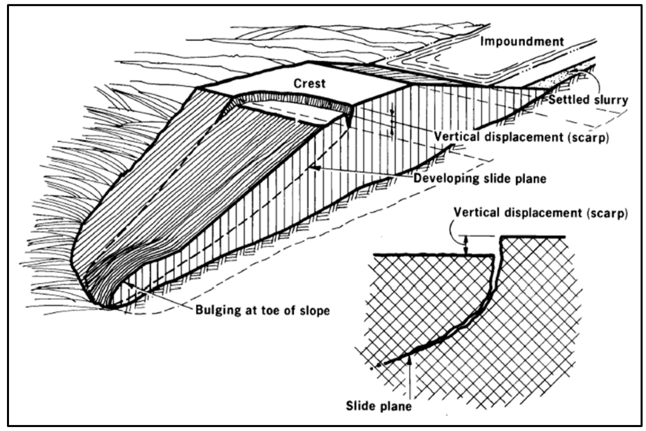


Figure 18. Longitudinal cracks on crest may be a sign of slope movement.

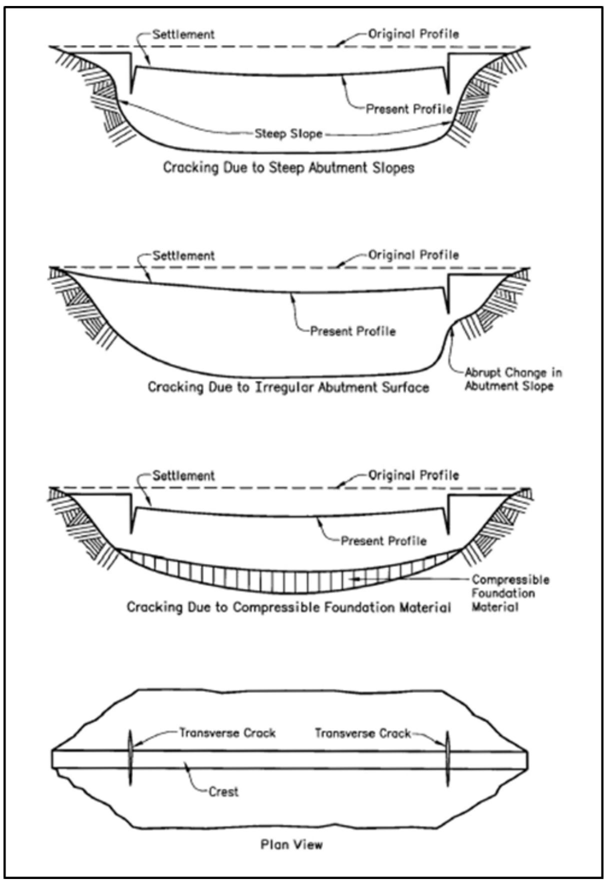


Figure 19. Transverse cracks and their causes.

Foundation Preparation

Construction of a new dam or a new stage of an existing dam requires foundation preparation in the valley bottom or along the abutments. At a minimum, this construction usually requires the removal of vegetation and topsoil from areas that will be covered by the embankment. The condition of the foundation and any work performed to improve it should be documented by the operator.

- Wet, soft, or compressible soils should be removed or modified to improve their condition. Improvement may be through drying, compaction, or treatment with additives to enhance the properties. Unanticipated wet conditions, such as a spring, may require the construction of a collection drain.
- Open joints exposed in the foundation or abutments need to be treated to prevent them from providing a path for uncontrolled seepage or internal erosion. Typically, open joints are handled by cleaning them out and then filling with grout.
- Vegetation should be stripped from the foundation. The rotting of large trees and their stumps can create voids within the embankment resulting in settlement and seepage issues.
- Dams may require a keyway or cutoff trench if the foundation material is highly fractured or highly pervious (Figure 10). After excavation, the trench is typically filled with low permeability soil. The trench should be wide enough to allow mobile equipment to operate in it and deep enough to penetrate the pervious layer beneath the embankment. For cutoffs excavated into rock, the sides should be sloped back to eliminate compacting against steep slopes and the surface of the rock should be cleaned before fill is placed. Cutoffs against foundations containing open cracks should be protected with a soil or geotextile fabric filter.
- Construction of a keyway or cutoff trench should be done in a manner that does not endanger personnel working within the cut. Cut slopes should be stable against slides of material and falling material.
- Special foundation construction measures may be necessary on sites that are steeply sloping. Any overhangs should be eliminated as they prevent adequate compaction against the foundation or abutment. Failure to adequately bond embankment material to a sloping base can cause future downslope movements or allow excessive seepage and potentially lead to failure.

Blanket, Toe, Spring Collection, or Internal Drain Installation

- Drains are used to collect seepage water and convey it safely outside the embankment (Figure 13).
- The material used in constructing a drainage blanket normally consists of graded sand, a graded sand-gravel mixture, or crushed stone with a limited amount of fines. The drainage materials vary with each site and depend upon the grain size and characteristics of the embankment material placed above, and the grain size and characteristics of the natural foundation material under the drainage blanket. The drainage material must be hard, strong, durable, resistant to acid attack, and sized to provide adequate flow capacity. The gradation of the drain material itself or of an intervening filter layer must prevent the migration of embankment or foundation soil particles into and possibly through the drainage material. Filter or transition zones may consist of specifically graded granular material or a layer of a geotextile (Photo 6).

Photo 6. Construction of blanket drain.
Note layer of cushioning material at bottom.

- In some instances where a natural spring is located within the foundation area, a drainage collector system is often required. The intent of this type of drainage collector is to prevent spring flow from saturating embankment material by collecting seepage and directing it either into the embankment's main underdrain system or past the toe of the embankment.
- When a geotextile fabric is used, be alert to any practices that could result in a tear, puncture, or gap in the fabric. For example, the material on which the fabric is placed should be fairly uniform so that the fabric does not have to bridge over large voids. Rocks should not be placed on the fabric, nor equipment operated on it, in a manner that could damage the fabric. Seams should be either sewn, or sufficiently overlapped and pinned, so that they cannot open.

Embankment Fill Placement

- Details of the embankment fill placement should be documented. These details should include the equipment used to spread the fill and equipment used for compaction. If fill placement methods vary for different zones of an embankment, the differences should be documented.
- The approximate lift thickness should be recorded. When fill material is dumped from trucks, notice whether the piles are spaced far enough apart to allow the material to be efficiently spread to the required loose lift thickness.
- If possible, observe a cycle of fill placement to see how well the material is being compacted. Soft areas or rutting or pumping of the fill surface may be indications that adequate compaction is not being achieved.
- Check for evidence that lifts are receiving complete coverage by the compaction equipment (Photos 7 through 10).

Photo 7. Poor placement and compaction.

Photo 8. Compaction of tailings dam raise.

Photo 9. Proper placement and compaction.

Photo 10. Poorly compacted tailings embankment raise.

- The method of scarifying the top of a compacted lift prior to the placement of the next lift should be observed. Adequate scarification is important to tie a lift into the lift below and to prevent horizontal seepage planes and perched water tables from developing.
- Where additional fill is to be placed on an existing embankment slope, the new fill should be benched into the existing slope so that the potential sliding surface is eliminated, the materials are tied together, and the new fill is compacted against a horizontal surface. In addition, it is advisable to remove the top layer of old soil because it may be degraded due to weathering and equipment travel.
- Density testing should be observed, whenever possible, and questions should be asked to determine how the tests are conducted. It is important that density testing be conducted so that information is provided on the density and moisture content for the entire lift thickness.
- Determine how the locations for compaction tests are selected. Test locations should be random and representative of the compaction being achieved over the entire

compacted lift. In addition to testing in random areas, tests should be conducted in any areas where there is evidence that compaction may not be adequate.

- Whenever a density test shows that adequate compaction is not achieved, check what actions are being taken to correct the situation. Additional passes of the compaction equipment may correct the problem. If the moisture content is out of specification, the material will need to be re-worked until the moisture is in compliance. The moisture content of the material during compaction should be within the range given in the compaction specifications.
- The embankment fill and the crest area should be checked for oversize material such as large rocks greater than one-third the lift thickness, which might hinder adequate compaction.
- The embankment fill and the crest area should also be checked for the presence of extraneous or combustible material. This material should be removed before additional fill is placed.
- When combined coal refuse is used for embankment construction, particular attention must be given to its placement. Due to its high water content, combined refuse can present handling and structural stability problems. Normally, it must be spread out to allow some drainage and drying before it can be effectively compacted. Disposal plans involving combined refuse may have special placement procedures, which may differ in structural versus non-structural portions of the embankment.
- When fly-ash, bottom-ash, or other additives are incorporated into embankment fill material, placement procedures should be compared to plan requirements.

Upstream Pushouts or Construction of the Initial Lifts of an Upstream Stage

- The design plan may specify the size and type of the equipment used to construct a pushout as well as the material placement procedures. Verify that the equipment being used conforms to the design plan and is compatible with site conditions. The characteristics of the initial and subsequent pushouts should be observed to determine that the pushout procedures are not creating a hazardous situation for equipment operators.
- The design plan should be consulted to determine whether a pushout can be extended into standing water or a dry beach is required. Depositing material into water can cause stability issues.
- Some sites require the use on unmanned, remotely controlled, equipment for spreading and compacting embankment material. Verify the equipment is present and the operator is positioned in a safe location.
- The initial pushout lift of embankment fill material for an upstream stage will typically sink into and displace fine refuse slurry as it is pushed. The amount of slurry displaced will depend on the moisture content, permeability and strength of the slurry and will vary from impoundment to impoundment and possibly even from one side of an impoundment to the other. The initial pushout lift must be thick

enough to support the equipment. In some cases, several pushouts will have to be made before the embankment fill will remain above the slurry.

- Examine the pushout work surface for cracks and scarps. Personnel and manned mobile equipment should not operate on the pool side of cracks and scarps until the ground has been evaluated by an engineer or tested (Photo 11).

Photo 11. Failure of upstream pushout.

- The weight of the initial pushout and subsequent lifts can cause an increase of pore-water pressure in the material beneath the pushout. With time, the pore-water pressure will dissipate. However, subsequent lifts will further increase the pore-water pressure. The low strength of saturated, unconsolidated material, along with the increase in pore-water pressure, will lead to a situation of marginal stability. If the pushout lift thickness is too great or if the subsequent lifts are constructed too fast, the pore-water pressure can rise and delay material strength gain. This situation can result in an upstream failure. The rate of construction of an upstream stage should therefore be closely tied to the pore-water pressure in the material. Subsequent lifts should not be started until the pore-water pressure in the material in that area has had sufficient time to dissipate. Piezometers are often installed below the base of the initial lift to monitor pore-water pressure in the material beneath the pushout and to assist in determining a safe rate of upstream fill placement. The design plan should be checked for applicable guidance on pushout fill placement rate, allowable pore-water pressure in the material, and corresponding piezometer readings.
- Upstream pushouts will encroach upon the storm storage capacity of the impoundment. Pushouts must only be performed within the design staging sequence of the impoundment to ensure that adequate storm storage is maintained.

Upstream Slope and Pool

- Check the upstream slope for uniformity of the slope angle. Irregular slopes and changes in slope angle can indicate slope instability or poor construction practices.
- Measure the upstream slope angle and compare it to the listed slope angle in the design plan.
- Check the upstream slope for evidence of cracking, sliding, bulging, or extensive erosion.
- Obtain elevations for the low point on the embankment crest and the decant inlet. Alternatively, estimate, as closely as possible, the vertical distance between the decant inlet and the low point on the embankment crest.
- Check for evidence of unusual rises or falls in the pool level. Also, check for the presence of whirlpools or eddies in the pool, which may be an indication of concentrated seepage. If observed, examine the downstream area and adjacent mine openings for corresponding seepage discharge and for the presence of fines being carried by the seepage.
- The pool area should be free of floatable debris that could block spillways.

Slurry/Tailings Discharge Location and Slurry/Tailings Surface

- Observe conditions at the slurry/tailings discharge. Note the material discharge location and indications of whether the discharge has been moved. As the material is pumped into the impoundment, the heavier, coarser particles will settle out closer to the discharge end of the slurry line. The water and finer material are forced farther away from the discharge point. In order to minimize seepage related stability problems at an impoundment, it is desirable to keep the water portion of the impoundment as far away from the embankment as is practical. This is typically accomplished by locating the discharge line at points along the upstream face of the dam (Photo 12).

Photo 12. Discharge lines for placement of tailings along the upstream slope.

- Check that slurry discharge locations comply with the design plan (if available), and note if a significant slurry delta has formed.
- Check that measures are taken, if necessary, to prevent significant erosion at the slurry discharge point. Also, note if the delta surface is above the elevation of the decant inlet. Slurry deposited above the decant inlet elevation reduces storm storage and could adversely affect the impoundment's ability to safely handle the design storm.
- Examine the appearance of the exposed surface of the settled fines for signs of concentrated seepage, sinkholes, or whirlpools (Photo 13). If present, examine the downstream slope and foundation area for seeps that show evidence of transported fine refuse material. If fines are being carried out of the embankment, then a condition known as "piping" may be occurring, which can result in a cavity, and progressively more seepage, developing through the embankment. If piping has developed, it will have serious implications if not promptly corrected. Any appearance of sinkholes should be evaluated immediately.
- Visible sinkholes or eddies occurring on the pool may also indicate that fines are being transported by water seeping into mine workings adjacent to, or underneath, the impoundment. If this occurs, adjacent mine openings or hillside seeps should be examined for changes in flow quantities or appearance.

Photo 13. Sinkhole in pool area.

Principal Spillway or Decant Installation

Principal spillway or decant construction is a particularly important phase of construction. A poorly installed spillway can lead to excessive pipe deflection; can cause excessive seepage and piping around the outside of the conduit; or can result in a failed pipe that impairs the ability to control the impoundment's normal pool level and discharge storm runoff. To the extent practical, inspections should be conducted during decant installation to check for compliance with the construction specifications (Photo 14).

Photo 14. Principal spillway installation in trench.

If the decant pipe is being installed, note the following conditions.

- The location and elevation of the inlet and grade on the outlet pipe.
- The decant pipe material, outside diameter, and wall thickness.

- The method of joining the pipe sections.
- The method of installing the decant pipe and any handling practices which might damage the pipe.
- Any corrosion-protection measures (steel pipes).
- The type of bedding and backfill material being placed around the pipe, and the foundation material.
- The lift or layer thickness of the backfill.
- The adequacy of the compaction measures for the bedding/backfill in the pipe's haunch area (Figure 20); it is important that full contact be achieved between the bedding/backfill and the pipe.

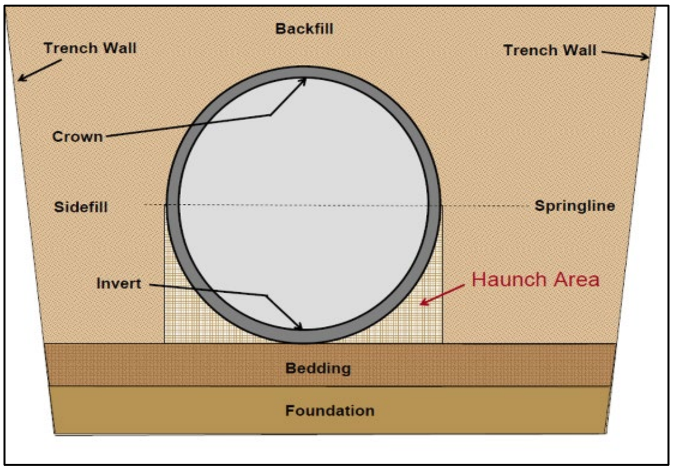


Figure 20. Terminology related to buried conduits.

- Compaction testing of the backfill: the load carrying capacity of flexible pipe comes from the support provided by the backfill; poorly compacted backfill may allow excessive seepage along the pipe and excessive deflection of the pipe.
- Provisions to prohibit heavy equipment from traveling over the pipe before sufficient fill has been placed to prevent damage to the pipe.
- If seepage collars are being installed, the material, dimensions, location, method of attachment to the pipe, and the method of compaction around the seepage collar.
- If a seepage diaphragm is being installed, the location and dimensions of the diaphragm as well as the type and size of aggregate, and the type and location of drain outlet.
- If a decant riser section is being sealed, note the method of sealing and compare with the riser sealing specifications in the design plan.
- The presence and type of trashrack and anti-vortex device, if required, on the decant inlet.
- The location and dimensions of concrete thrust and reaction blocks (Photo 15).

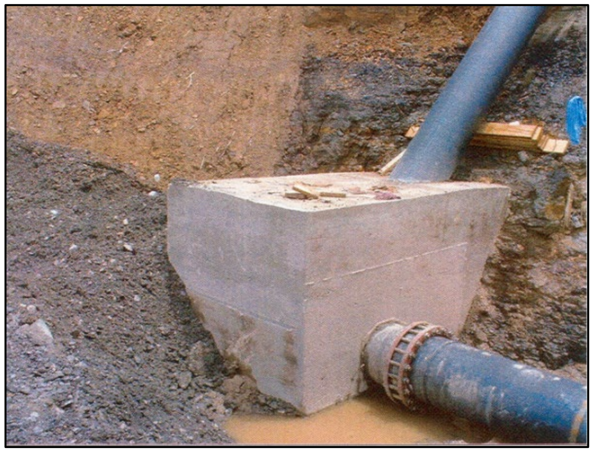


Photo 15. Thrust block at bend in pipe.

- If pipe pressure testing is being conducted, note test method, maximum pressure, and how long the pressure is held as well as rates of pressure loss or leakage.
- Type of erosion protection provided at the decant pipe outlet and extent of coverage of this erosion protection.
- Any requirements for monitoring the deflection of flexible decant pipes (flexible pipes that will eventually be buried under high fill heights are often surveyed for internal deflections, soon after installation, to establish a baseline for future deflection monitoring).

Principal Spillway or Decant Inlet Condition

- The decant inlet should be checked for signs of clogging. Clogging of the inlet can render the spillway ineffective for storm routing and possibly for normal pool level maintenance (Photos 16 and 17).
- The trashrack and any anti-vortex plate should be checked for corrosion, structural damage, and secure attachment to the pipe inlet. Trashracks need to be cleaned periodically and possibly repaired.
- If the inlet can be viewed close-up, the conduit should be checked for signs of cracking, crushing, corrosion, or other indications of distress which may be occurring in other portions of the spillway.
- Pipes placed into the inlet can reduce the flow capacity (Photo 18).

Photo 16. Trashracks on principal spillway inlets.

Photo 17. Clogged trashrack.

Photo 18. Pump lines inserted in principal spillway inlet.

Open-Channel or Emergency Spillway Construction

Some dams will include an open channel in addition to a principal spillway. An open-channel spillway is sometimes called an emergency spillway because it may only operate during large storms. Open-channel spillways are often cut into natural ground (Photo 19). The primary design criterion for the spillway is to ensure its ability to handle safely the maximum design storm flow depth, volume, and velocity without overtopping and without allowing significant erosion of the spillway to occur.

Photo 19. Open-channel spillway excavated in rock.

Note the following open-channel spillway features.

- The approximate invert elevation of the emergency spillway or the approximate vertical distance between the invert and the low point on the crest and/or the decant inlet.
- The bottom width, side slope angles, and depth of the channel at various locations; these dimensions are most critical in areas where the spillway is adjacent to the embankment and where failure or overtopping of the spillway could result in flows onto the embankment.
- The approximate bottom slope of the spillway, the locations where the bottom slope changes, and the approximate length of the spillway for each bottom slope.
- Erosion protection measures:
  - The location, extent, and type of erosion protection measures should be documented.
  - A bend in the spillway's alignment typically requires that the erosion protection extend farther up the side slope on the outside of the bend.
  - If a section of the spillway is specified to be excavated into rock, the presence and condition of the rock should be verified.

- Where a concrete lining or a concrete-filled fabric lining is used, examine the following.
  - The type and size of lining as well as the method and details of the lining anchorage.
  - The material under the lining, and any filter layers, should be prepared.
  - The extent of the lining should be verified with plan requirements.
  - Particular attention should be paid to requirements for burying the lining at its inlet and along its edges.
  - If reinforced concrete is being laid, reinforcement should meet requirements in the plan specifications.
  - The design plan specifications for concrete often require a minimum number of samples to be taken during each pour for strength verification testing.
  - Concrete and concrete-filled fabric liners often require the installation of "weep" holes to prevent the build-up of excessive pressures under the liner.
  - Reinforced concrete and concrete-filled fabric liners should be inspected for signs of excessive cracking, spalling, or deterioration.
- Where riprap is used for erosion protection, compare its condition to the specifications in the design plan, including the following.
  - Rock type: easily weathered rocks, such as shale, are not suitable and only durable rocks should be used. The design plan usually includes a rock-type specification and abrasion and soundness laboratory testing is often done to ensure the durability of the riprap.
  - Rock gradation: riprap rock size gradation will be included in the design plan and the rock being placed should be visually checked for presence of fines, amount of gravel-size material, and for largest rock size. Riprap should be installed so that the smaller pieces of rock are worked into the spaces between the larger pieces of rock.
  - Bedding: riprap is typically placed over a filter bed and geotextile fabric to hold the material beneath the riprap in place and allow for drainage.
  - For grouted riprap, specifications include the type and strength of grout, consistency or slump of grout, and the minimum depth of grout penetration into the riprap. Grouted riprap normally includes the installation of "weep" holes to prevent the build-up of excessive water pressures underneath the riprap.
- Since required layers under an erosion lining, as well as trenches and other anchorage measures, are not visible after construction, to the extent practical, inspections should be conducted during spillway construction to check for compliance with the plan specifications.
- Construction of spillway cuts should be done in a manner that does not endanger persons working within the cut.
- Check that the ground above the open-channel spillway is sufficiently stable to prevent slides or falls of significant volumes of material. A slide or fall of material into the spillway could cause blockage and possibly allow the spillway, or the crest of the embankment, to be overtopped during a large storm. Rockfalls could also damage erosion protection.

- Overhanging trees can create a potential spillway blockage hazard during design storm conditions and trees should not be in a position where they might easily be blown or toppled into the open-channel spillway.
- Any blockage should be cleared from within the spillway.
- "Weep" holes should be clear and free of debris.
- Low flow, low velocity spillways may require a stand of vegetation as erosion protection. If vegetation is specified, it should be an appropriate type, well-maintained, and not allowed to be overgrown with unwanted trees and plants.
- The open-channel spillway should be extended far enough downstream so that spillway flows will not contact, erode, or in any fashion adversely affect the stability of the impounding embankment. Also, the discharge from the spillway should not be located or aligned so that design storm flow discharge might endanger people or structures downstream.

Pumps

- Pumps may be used to maintain normal pool levels below the principal spillway or decant inlet. The use of pumps decreases the likelihood of a water discharge during smaller storm events. The plan should be checked to determine if the normal use of pumps is required.
- When pumping is required to maintain normal pool levels, the type, number, and capacity of each pump being used should be checked against plan requirements. Pump breakdowns should be resolved in a timely manner.
- If pumping capacity is required for drawdown of the design storm pool, the availability of the proper number and capacity of pumps should be verified. The design plan should address storage and testing of the pumps. When no plan is available, the following are prudent practices for pumps.
  - be kept either on site or nearby,
  - be operated upon installation for a sufficient length of time to ensure proper operation of the system,
  - be periodically activated for a short time to ensure that damage has not occurred within the system,
  - have an internal combustion engine that is either coupled to the pump or to an adjacent generator specifically for the pump, and
  - have the internal combustion engine's fuel supply stored in a specified manner.

Diversion Ditches

Diversion ditches may be used around the perimeter of the pool to intercept runoff from precipitation events. This prevents the runoff from entering the pool, thereby limiting the pool rise during and after the precipitation. Diversion ditches are not common, but when used, the embankment can be designed for less precipitation runoff. However, it is critical the diversion ditches be maintained in good condition to be effective.

- If diversion ditches are depended on to route all of the design storm flood, the ditches need to be designed to control the same storm as the open-channel spillway or embankment. The ditches must be constructed and maintained with the same level of care as the open-channel spillway. In this case, the inspector should check the same details discussed in the open-channel spillway section, including the integrity of the erosion protection (vegetation, liner, or rock surface), the extent of the erosion protection, and blockage or potential blockage of the ditch.
- More typically, diversion ditches are installed to prevent water from smaller storms from entering the pool. These ditches should be clear and free of obstruction, slides, and excessive erosion. The discharge from diversion ditches should be directed downstream of the dam crest and not cause erosion in critical areas around the embankment or the impoundment appurtenances.

Mining Adjacent to or Under Impoundments

Mining adjacent to or under the site presents two issues: damage to the dam due to subsidence and potential breakthrough into the underground mine. Subsidence can cause seepage issues. If a breakthrough potential exists, a hazard exists for miners in the mine and personnel located downstream of mine openings where outflow may occur.

- The inspector should become familiar with mining conditions in the impoundment area. This knowledge can then be used onsite to determine what areas might be most critical for signs of subsidence or underground mine discharge. The plan will also contain information related to required subsidence monitoring, mine pool level monitoring, and mine water discharge monitoring points.
- Where a compacted barrier is being placed between the slurry/tailings disposal area and a hillside to prevent a breakthrough into underground mine workings, the barrier, like the embankment fill, is to be placed according to specifications in the design plan. The plan will specify:
  - the width of the barrier. If the barrier is not constructed sufficiently wide it may not provide the breakthrough protection intended; if it is too wide and it is built above the decant inlet elevation, it may reduce the impoundment's storm storage;
  - the starting (lowest) elevation of the barrier;
  - the top elevation of the barrier;
  - fill lift thickness, minimum compaction density, and moisture content; and
  - details for internal drain installation including drain location, dimensions, aggregate and filter specifications, and the drain outlet location and details.
- Where mine portals are located within the potential pool area or within the embankment footprint, they should be backfilled and sealed, and/or drainage provided. (Figure 21 and Photo 20)

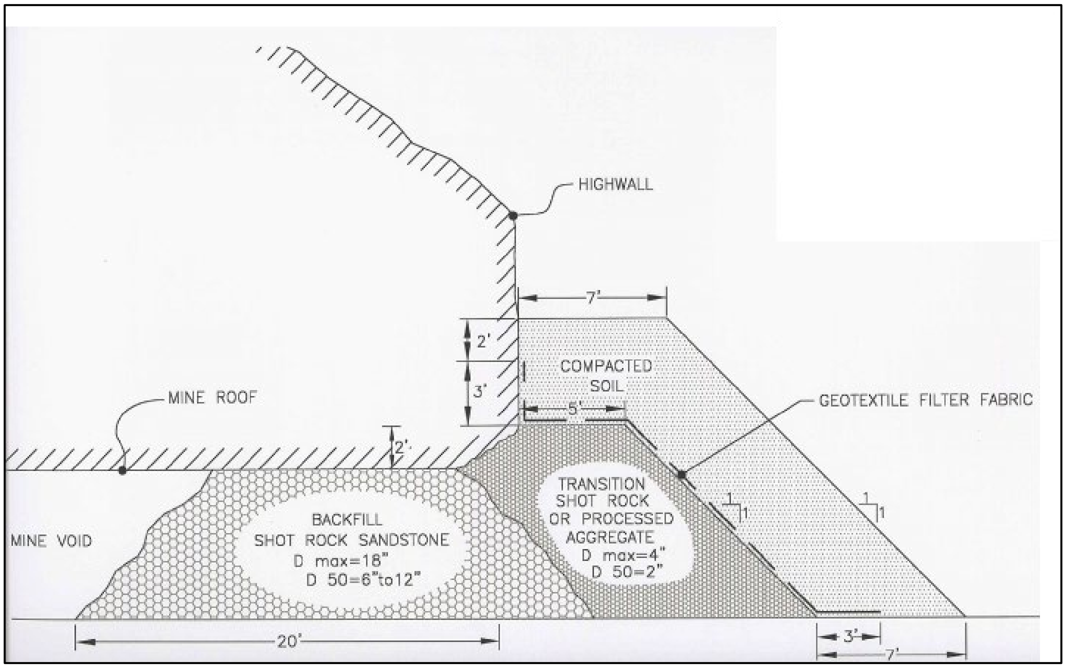


Figure 21. Method for supporting and covering mine openings.

Photo 20. Backfilling mine entries.

- Where auger holes or highwall miner openings are located within the embankment footprint or where there is a potential for them to intersect mine voids, they will typically have to be backfilled and sealed, and/or drainage provided.

- If a mine outcrop barrier is present under the dam or in the reservoir area, the integrity of the barrier area, and the overburden above the barrier, should be checked.
- Where mining has been conducted in the area under or adjacent to the impoundment, the area above and near the mining should be checked for signs of subsidence, especially where shallow overburden lies between the mine and the impoundment, where there is total extraction mining (i.e., longwall or secondary mining), or where multiple seam mining has been done at any depth. Any signs of subsidence should be documented.
- Visible sinkholes occurring on the refuse surface or eddies in the pool may be an indication that fines are being transported by water seeping into mine workings adjacent to or underneath the impoundment. If such sinkholes are observed, adjacent mine openings or hillside seeps should be examined. An unusual change in either the flow quantities (e.g., a flow increase that does not correlate to rainfall) or the appearance of the flow (e.g., carrying fines) may be an indicator of internal erosion and warrants further investigation.

Downstream Slopes and Benches

- Check the downstream slope for the uniformity of the slope angle. Irregular slopes and changes in slope angle can indicate slope instability or poor construction practices.
- Measure the downstream slope angle and compare this to the downstream slope angle in the design plan.
- The downstream slopes should not have extensive erosion. Minor surface erosion is a typical condition on most slopes before vegetation is established and final drainage ditches are constructed. While such conditions should be documented and brought to the attention of the mine operator for correction, they are not necessarily a cause for immediate safety concern.
- Severe erosion that cuts deep gullies on either the slope surface or at the abutment can be serious. This type of erosion can become much worse during a single rainstorm. When a gully becomes sufficiently deep, support to the adjacent embankment is lost and major sliding can occur. Any time an area of deep erosion is observed, its location should be documented and the inspector should attempt to determine the source of water that is causing it. If the cause is not obvious, the inspector should determine if major seepage is occurring in the zone being eroded. Zones of seepage are normally more susceptible to erosion because of their water-induced softness.
- Benches should be sloped so that surface water does not run down the slope and cause erosion. Rather, each bench should drain into the abutment area and into the groin ditch. Where flows are carried through culverts, the culverts should be kept unobstructed and crushed culverts should be repaired or replaced.
- The slope should be walked and checked for signs of seepage. Seepage may be indicated by soft areas or areas of lush vegetation, dead vegetation, changes in color

on the slope, rapid snow melt, or unusual ice buildup (Figure 22, Photos 21 and 22). The location of areas of general seepage should be documented as well as the appearance (e.g., clear, muddy, carrying fines, etc.) and approximate flow rate. Concentrated seeps should be carefully located on a plan drawing and the flow rate and appearance should be documented.

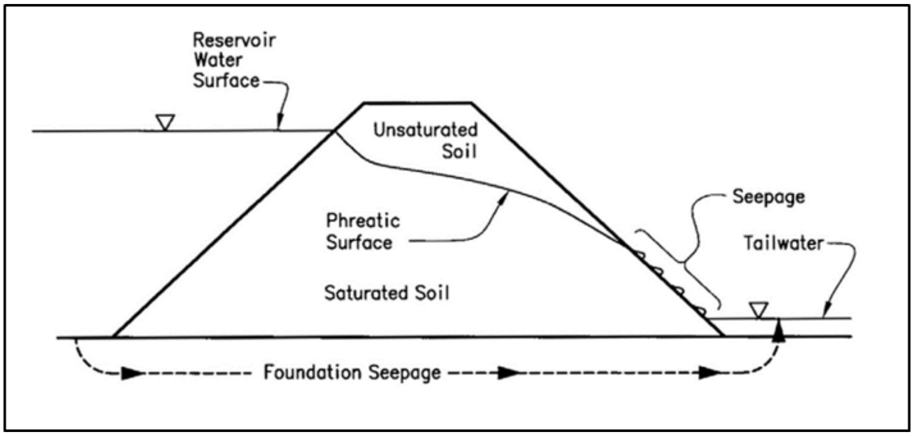


Figure 22. Seepage through embankment and foundation.

Photo 21. Cattails and lush vegetation are potential signs of seepage.

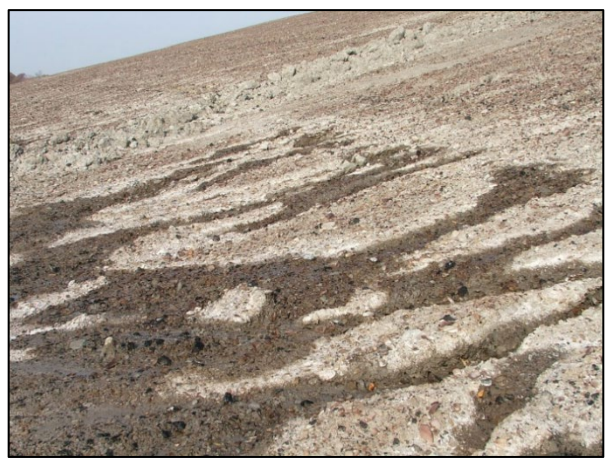


Photo 22. Seepage emerging on downstream slope.

- Careful attention should be given to areas close to both abutments. Signs of seepage, sloughing, and sliding should be documented.
- Changes in any seepage pattern, flow rate, or appearance should be documented. These changes can be the result of increased infiltration of surface water if it has rained recently, increased seepage resulting from the raising of the pool, or a significant change in the seepage pattern within the embankment. Photographs from the same vantage point are a good way to compare seepage conditions over time.

- In evaluating seepage, a critical factor is whether fine particles are being carried with the flow. If particles are being carried, it is an indication of "piping," or internal erosion. Piping is a serious condition that requires prompt evaluation, as a void can be created back into the embankment that can enlarge over time and lead to failure. Observe the points where seepage emerges for the presence of fine particles in the flow. If the seeping water can be collected in a container without disturbing the material at the seepage point, examine it for color and the presence of solids.
- Small slope movements usually occur long before a larger, more observable failure. A very important part of the slope inspection involves locating any indications of these smaller slope movements. While signs of minor movement do not necessarily mean that failure is imminent, they should be technically evaluated as quickly as possible. Signs of movement should be carefully documented, including:
  - Cracks on the embankment slope – Normally, such cracks will be near the top of the slope, although they can occur at any location (Photo 23). Vertical movement can indicate the initiation of a large slide plane, which could move more rapidly at any time. The existence of many small, short cracks at several levels down the slope may indicate a slow or creeping movement that is less likely to move rapidly. A description of the number, length, and location of all observed cracks should be documented.
  - Bulging – When a large crack is observed, it indicates that a portion of the slope has moved. This movement usually produces a bulging of material at the bottom of the slide area (Photo 24). A bulging condition is often easier to detect than a crack, which may be disturbed and disguised by ongoing operations on the embankment surface. The most frequent bulge location is at the toe of the embankment where the slope meets the foundation. However, bulges can also occur in the middle of the slope or downstream from the toe in the foundation material. When bulging at any location is observed, the area above the bulge should be inspected to try to locate a corresponding crack at the top of the slumped area. The accurate location of both conditions is very important.
  - Sloughing – One final type of sliding failure that has less initial importance to safety, but which can progress to a more critical condition if left uncorrected, is a shallow surface movement of a small area on the slope. This type of movement most frequently occurs on slopes during the spring thaw period.

Photo 23. Cracks on embankment slope.

Photo 24. Toe bulge.

- In addition to noting the presence of any cracks, bulges, or surface movement of material, the inspector should also describe the approximate width of each crack, its length, and any vertical displacement. The size of any bulging and the overall size of any surface displacement should be recorded. A sketch should be made of the location of each of these signs of instability, describing any observed relationship between seepage areas and bulging, cracking, or surface movement. It is useful to photograph cracks, with a scale or ruler in the photograph, to document their condition and changes over time.
- Once a crack is located, measures should be taken to monitor the crack for movement and to investigate its cause. The rate of movement provides important information on the level of significance of the crack. Monitoring the slope movement can vary from simply checking the distance between stakes driven into the ground below and above the crack, to the use of instrumentation such as inclinometers.
- Check the location and number of piezometers on the crest and downstream slope.
- Vegetation on the downstream slope should be maintained so that the downstream slope conditions can be examined and the vegetation does not interfere with the inspection process. Trees with diameters in excess of 2 inches should be cut. When the trunk diameter exceeds 4 inches, the root system can provide a seepage path through the embankment. The inspector should consult the FEMA reference titled *Technical Manual: Impacts of Plants on Earthen Dams* (FEMA P-534, 2005)[6] for additional guidance.

Principal Spillway or Decant Discharge Condition

- The outlet should be inspected for signs of cracking, crushing, corrosion, or other indications of distress which may be occurring in other portions of the spillway. The outlet should be clear and free of obstructions.

[6] https://www.fema.gov/sites/default/files/2020-08/fema-534.pdf

- The outlet should be inspected for signs of concentrated seepage on the outside of the pipe. Seepage along the outside of a pipe can lead to serious piping problems and is typically controlled with internal drainage diaphragms or seepage collars. Concentrated flows may indicate a problem with these seepage control measures.
- The outlet channel should provide for the safe discharge of flow away from the dam without significant erosion (Photos 25 and 26). The outlet channel should be inspected for clogging, deterioration, or other maintenance problems. If the decant pipe discharges into a groin ditch, check the erosion protection, ditch dimensions, and any evidence that flow has left the confines of the protected area of the ditch.

Photo 25. Construction of erosion protection at pipe outlet.

Photo 26. Headwall and concrete erosion protection at pipe outlet.

Downstream Foundation Area

- The area downstream of the embankment should be inspected for signs of instability including seepage flows or boils (Figure 23, Photos 27 and 28); foundation movement, such as bulging indicated by unnaturally tilted vegetation; and severe erosion.

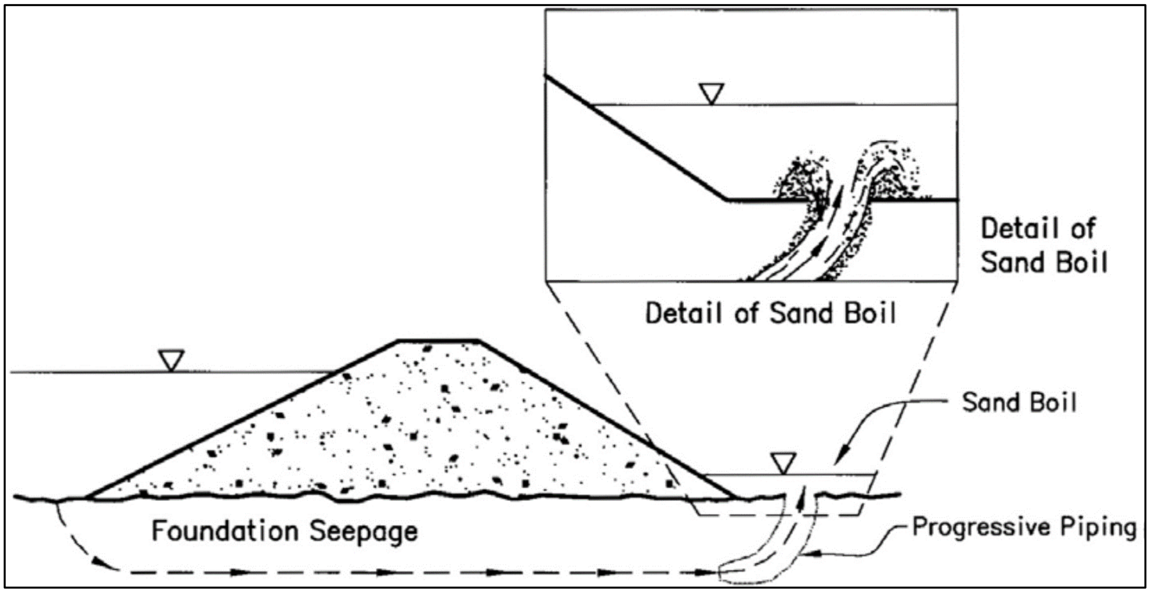


Figure 23. Formation of boil at downstream toe.

Photo 27. Boil beyond toe of dam.

Photo 28. Boil.

- Seepage from the impoundment area that flows through foundation material and either emerges at the toe, or some distance downstream, can be more critical than seepage emerging low on the embankment slope.
- Conversely, if seepage is caused by natural groundwater flowing through hard-rock fractures beneath an abutment, the condition may not have any effect on the stability of the embankment.
- A serious indication of downstream foundation seepage is the formation of boil-like features in the saturated areas. These distinctive features have the appearance of small volcanoes and normally occur in the flatter portion of the downstream valley floor. A special inspection effort must be made to detect this type of seepage when it occurs under water in either a shallow stream or in a ponded area.

- The most critical aspect of inspecting for downstream foundation seepage is not only to locate the existence of the seepage flows, but also to compare the amount and appearance of such flows from one inspection to the next. Any significant changes should be documented.
- Often seepage through an embankment is anticipated, and a drain will be placed within the structure during its construction to collect the water before it surfaces on the downstream slope. The drainage material may extend to the downstream slope, or pipes may be placed within the drain to collect and discharge the water away from the slope. The inspector should become familiar with the location of any underdrains and underdrain pipes exiting from a slope. Check for material that impedes drainage, such as material that has sloughed over top of the drain outlet and check that silting (partial or full blockage of the pipe by soil) has not developed at the outlet end of pipes which would restrict the flow. Any pipe damage due to crushing, clogging, or corrosion should be documented.
- During the examination for seepage zones, the inspector should also look carefully for any signs of downstream foundation movement. If this movement is linked with slope movement, it will usually occur in a horizontal direction away from the slope, or can be a bulging movement, where the foundation material is pushed upwards. Some of the more common indicators of foundation movement are sharply rising ridges that can vary in height from inches to several feet and run parallel to the toe of the slope or the unnatural tilting of trees or other vegetation.

Instrumentation

Various types of instruments are used to monitor conditions at, and performance of, an impoundment or tailings dam. Instrumentation can be placed either on the surface of a structure or within its interior, depending on the nature of the instrumentation and the monitoring requirements. The inspector should become familiar with these instruments and their location on a dam. Check that the type, number, and location of instrumentation are as called for in the plan. Typical instruments found on a dam include the following.

- Piezometer. Instruments used to measure either the depth to the saturation level (phreatic surface) or the water pressure at a given depth inside the embankment. The saturation level or water pressure is compared to allowable values in the plan.
  - Types of piezometers include the following.
    - An observation well, or open borehole, is the simplest type of piezometer. The water level in such a piezometer represents the contribution of water from all layers intercepted by the borehole.
    - Isolated tip piezometers are installed with their tips, or the point where water enters the piezometer, isolated so that the water pressure at that particular depth can be measured. A zone of clean sand or gravel backfill surrounds the tip of the piezometer, and this zone is isolated by a bentonite seal above and below it. In some cases, multiple piezometers are installed in the same borehole with each piezometer tube having an isolated tip at a different elevation.

  - o Pneumatic piezometers measure water pressure at the location of the tip. Pneumatic piezometers contain a transducer that is sealed in a borehole, or embedded in fill or slurry/tailings. Tubes run from the transducer to a terminal at the surface.
  - o Vibrating wire piezometers also measure water pressure at the instrument's tip. Vibrating wire piezometers have vibrating wire transducers that are typically sealed in a borehole at a specific location, but they can also be embedded in the embankment, in sand, and then covered with hand-compacted select fill, or embedded in slurry/tailings. Signal cables are routed though trenches and covered with compacted fill.
  - o Electrical piezometers consist of a sealed housing containing a pressure transducer. The piezometer is placed in a borehole or embedded in the embankment at the point to be monitored and a cable extends to the ground surface where it is connected to a readout or data-logger. The pressure transducer is a ceramic diaphragm containing a resistance strain gauge bridge. As pressure changes, the diaphragm deflects and changes the resistance of the bridge. A readout or data-logger measures the resistance of the strain gauge bridge.
- – The water level in open piezometers is measured by using a "water level indicator," which contains a probe that is lowered down the piezometer tube and registers when contact with the water surface completes an electrical circuit. The depth of the probe is indicated by depth markings on a graduated line.
- – Typically, the depth-to-water reading is subtracted from the known elevation at the top of the piezometer casing and the resulting water level elevation is compared to the maximum permissible level described in the design plan. The depth to water or water surface elevation should be recorded for comparison during subsequent inspections.
- – The surface area around the piezometer should be graded and sealed to prevent surface drainage from entering.
- – Piezometer tubes should be protected with a cap or lid to prevent material or objects from inadvertently dropping down the tube, which could interfere with water level measurements.
- – Piezometer tubes should be painted and otherwise marked to be highly conspicuous so that they are not damaged by mobile equipment.

- Weir. The monitoring of seepage and drain discharges can provide critical information in evaluating the safety of a dam. The use of a V-notch, rectangular, or pipe weir can be helpful in measuring discharges (Photos 29 and 30). A weir is calibrated so that the discharge over it can be determined by measuring the head of water upstream of the notch with a staff gage. Any problems with a weir, such as becoming filled in with sediment, or erosion under or around the weir, should also be documented and corrected.


Photo 29. V-notch


Photo 30. Pipe weir.

- Flume. Flumes may be used in lieu of weirs to measure flow quantity. Flumes are sized based on the expected flow to be measured. Any flow that can be channelized may be measured with a flume. Flumes should be unobstructed and maintained as originally installed.

- Pipe Discharge. Measurement of discharge at the outlet of pipes is often done for decants, drain discharge pipes, and pipes discharging water from underground mines. The inspector should note and report any pipe deterioration, clogging, or other type of obstruction of the pipe outlet. Often the discharge is estimated simply by determining the time to fill a container of known volume, or by measuring the depth of flow at the outlet of the pipe. The flow measurement or estimate should be documented.
  - Flow measurement example:
    - Time to fill a 1-gallon bucket = 25 seconds.
    - Calculation: (1 gallon / 25 seconds) x (60 seconds / minute) = 2.4 gallons/minute

- Survey Monument. Survey monuments are used to monitor for settlement or movement. They can be constructed in a number of ways that vary from simply driving a reinforcing rod into the embankment to constructing more permanent monuments of poured concrete with protective covers. Monuments should be installed deep enough that they are not affected by freezing and thawing. Monument locations should be conspicuously marked to prevent inadvertent disturbance.

- Extensometer. Extensometers are used to measure movements deeper within the embankment or in the foundation. They are often installed in areas potentially subject to subsidence. There are various types of these instruments. The design plan should be examined to determine the type and location of these instruments.

- Staff gauge. Staff gauges are placed in the pool to indicate the pool elevation (Photos 31 and 32).

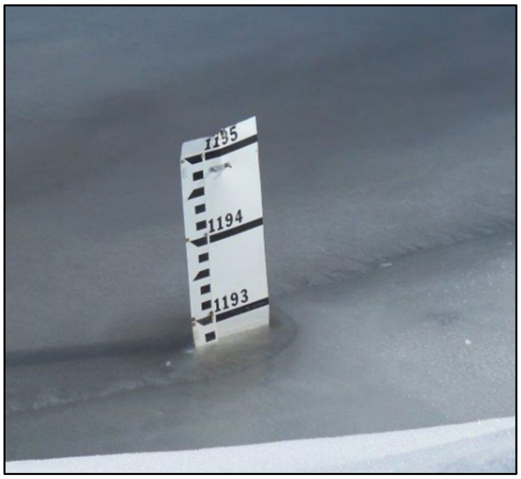


Photo 31. Staff gauge showing pool elevation.

Photo 32. Staff gauge showing depth.

- Other Instrumentation. These instruments include casings or wells in which inclinometers are used to measure internal horizontal movement, settlement gauges used to measure vertical movement within an embankment, and thermocouples used to measure temperatures within the embankment. These instruments are not common and are typically installed to monitor specific problems. A rain gauge may be specified, particularly at sites with breakthrough potential, to allow correlation between rainfall and underground mine discharges.

Hazard potential classification

For an impoundment at a coal mine, the hazard potential classification is documented in the design plan and on IRPI data sheets. At a metal and nonmetal mine, the inspector should ask the operator what hazard potential classification has been assigned in the design of the dam. If a classification has been assigned, the inspector should examine the dam and its downstream area to determine whether the classification appears to be reasonable (Chapter 3).

If the classification does not appear to be reasonable, or if no classification has been assigned by the dam designer or operator, then the inspector should make a judgment of the hazard potential classification. Where the classification is uncertain, the District Dam Safety Representative should be contacted for assistance in determining the appropriate hazard potential classification and discussing the classification with the mine operator. Assistance can also be requested from Technical Support's Mine Waste and Geotechnical Engineering Division.

E. MSHA Dam Inspection Form

Inspectors will use the “MSHA Dam Inspection Form” when they inspect a dam. This form, along with a description of each data field, is in Appendix 5. The MSHA Dam Inspection Form is organized assuming the inspection will begin in the mine office followed by travel to the crest area and then proceeding down the embankment.

CHAPTER 6 - DAM ABANDONMENT AND MISCELLANEOUS ISSUES

The following topics will be discussed in this chapter.

- Abandonment/Reclamation of dams
- Incised ponds that present a hazard
- Embankments not intended to impound water
- Emergency action plans

A. Abandonment/Reclamation of Dams

Mine operators should remove or breach their water storage or flood control dams when they no longer need them. Tailings dams may contain impounded materials that are potentially harmful to the environment and typically cannot be removed. Dams at mining operations can be left in place under an abandonment plan meeting the requirements of 30 CFR § 77.216-5(b) or another adequate engineering plan.

The material in place at the time of closure for a tailings dam must be stored indefinitely. The long-term stability of the embankment and any seepage containment system is critical. Tailings dams are typically abandoned by modifying the site to ensure it is not capable of impounding water above the tailings in place at the time of mine closure. Modifications typically include breaching the embankment to prevent future impoundment of water and capping the tailings to minimize infiltration of water.

Dams at Active Mines

MSHA requires the following for abandoning a dam at an active mine.

- Dams at coal mines – MSHA will continue to inspect the dam at its normal frequency until the site is abandoned according to the design plan or the provisions of 30 CFR § 77.216-5(b) are met.
- Dams at metal and nonmetal mines – MSHA will continue to inspect the dam at its normal frequency until the dam is modified to preclude the future impoundment of water. This may involve capping the pool area or cutting a notch in the embankment.

Once the above abandonment conditions are met, the District shall abandon the identification number, discontinue inspection activities, and retire the records in accordance with National Archives and Records Administration's guidelines. In addition, the District shall notify the Division of Safety, who will notify the applicable state authority, that the site will no longer be inspected by MSHA. The IRPI will be updated to reflect the status of the dam. The District should ensure the IRPI record is accurate regarding the dam's location, height, stored volume, etc.

Dams at Inactive Mines

Mines may become inactive for various reasons, including during winter months or decreased market demand for their product. The following guidance should be followed regarding MSHA's inspection of dams at these operations.

- Dams at coal mines – MSHA will continue to inspect at its normal frequency. Until a dam is abandoned under 30 CFR § 77.216-5, it is considered an active dam for inspection purposes regardless of the mine's operational status.

- Dams at metal and nonmetal mines – MSHA will cease inspection and notify the Division of Safety, who will notify the applicable state authority that it will no longer be conducting inspections at the operation until it re-opens. The IRPI record for the dam will be modified to indicate the dam is inactive. The IRPI status should be updated again if the mine resumes operation.

Dams at Orphaned Mines

MSHA defines an orphaned mine as one in which there is no responsible mine operator. An orphaned dam is one present at an orphaned mine that has not been properly abandoned under 30 CFR § 77.216-5 or another engineering plan in the case of dams at metal and nonmetal mines.

MSHA should take the following actions regarding orphaned dams.

- District personnel shall make every effort to contact and encourage the operator of record to inspect and maintain the dam, or abandon the dam in accordance with 30 CFR § 77.216-5(a) or another engineering plan.
- An inspection shall be conducted and the Impoundment Specialist/Inspector shall take the appropriate enforcement action and immediately notify the District Dam Safety Representative of the situation. If there is no representative of the operator on-site, the enforcement action shall be sent via certified mail to the last known operator of record. If the certified mail is returned undeliverable, the violation(s) shall be forwarded to the Office of Assessments.
- If the operator of record cannot be contacted or does not have the ability to inspect or maintain the dam, the District Manager shall notify the Division of Safety that this dam should be classified as an orphaned dam.
  - Dams at coal mines – the Division of Safety will notify the U.S. Office of Surface Mining Reclamation and Enforcement (OSMRE) that the dam has been classified as an orphan and that MSHA will no longer inspect the site.
  - Dams at metal and nonmetal mines – the Division of Safety will notify the applicable state authority that the dam has been classified as an orphan and that MSHA will no longer inspect the site.
- If a condition is found at the site that may constitute a hazard, the District shall immediately notify the Division of Safety and request that OSMRE or the state

regulator be immediately made aware of the condition. All information, including violations, notes, sketches, and an evaluation of the hazardous condition(s) at the site shall be immediately forwarded to the Division of Safety.

- After the Division of Safety has notified OSMRE or the state authority, a mine status update shall be completed, placing the mine in a permanently abandoned status and no further inspections of the dam will be conducted by MSHA.
- IRPI data for the dam will be updated to reflect the status of the dam. The District should ensure the record is accurate regarding the dam's location, height, stored volume, etc.

Abandonment Allowing for the Continued Existence of the Dam

Although rare, for various reasons a mine operator may desire to abandon a dam yet allow for the future impoundment of rainfall runoff. The operator must demonstrate that the mine will no longer use the dam in any way. MSHA actions regarding this situation depend on the industry, as follows.

- Dams at coal mines – mine operators desiring the abandonment of a dam, while still allowing for its continued existence, must submit a plan according to 30 CFR § 77.216-5(b). The District should inspect the dam to ensure it is in accordance with the approved abandonment plan, and that it contains no defects.

- Dams at metal and nonmetal mines – there is no provision for abandoning the site as an active dam. MSHA will continue to inspect the dam at its normal frequency until the dam is modified to preclude the future impoundment of rainfall runoff. This may involve capping the pool area or cutting a notch in the embankment. MSHA inspections should continue as long as regular mine inspections are conducted.

Once the above conditions are met, the District will notify the Division of Safety, who will notify the applicable state authority, about the status of the dam. In addition, the District shall abandon the identification number, retire the records, and discontinue inspection activities. IRPI data for the dam will be updated to reflect the status of the dam. The District should ensure the record is accurate regarding the dam's location, height, stored volume, etc.

Dams at Abandoned Mines

Mines or facilities cannot be placed in abandoned status by the District if dams associated with those mines or facilities are still intact and are not properly abandoned or transferred as specified by 30 CFR § 77.216-5 or another engineering plan.

MSHA must continue to inspect the dam until it has been properly abandoned or transferred to another regulatory authority. Even if the mine or facility has been closed by the operator, the status of the mine or facility must remain in non-producing status and the dam must continue to be examined by the operator and inspected by MSHA. In the event that the dam was associated with an underground mine that is closed and abandoned, the District should encourage the operator to abandon the underground mine identification number and apply for a surface identification number. This action places it in the proper status as a surface operation.

B. Incised Ponds that Present a Hazard

A situation may arise where surface mining approaches an incised impoundment (Figure 24). Mining (surface and underground) approaching a surface body of water may reduce the width of natural ground to the point where the impoundment now presents a hazard to miners. This situation may result in MSHA now classifying the incised pond as an impoundment.

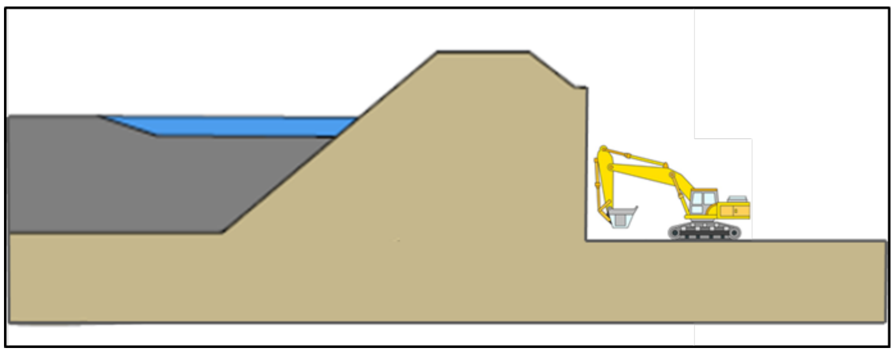


Figure 24. Mining approaching an incised impoundment.

The following information needs to be considered in determining whether the site should be categorized as a regulated impoundment.

- Is the natural ground soil or rock?
- What is the thickness of the remaining barrier?
- Is water seeping through the barrier? Water pressure within a barrier can lead to a less stable barrier. Seepage water can also create piping, which can cause a catastrophic failure.

C. Embankments Not Intended to Impound Water

Situations may arise where an embankment that is not intended to form an impoundment has the capability to temporarily retain water. An example would be a roadway embankment across a valley. In such cases, a culvert is normally installed under the embankment to provide drainage (Figure 25). A potential problem is that if the culvert is undersized or becomes clogged, then an impoundment situation may be created. If this impounded water could present a hazard, then situations with this potential need to be evaluated.

Whether an embankment constitutes an impoundment must be interpreted conservatively so as to further the purposes of the Act with respect to safety. Many embankments of this type present no hazard even under severe storm conditions. However, some embankments not intended to impound water do have the potential to retain sufficient water to impact the stability of the embankment. The determination of whether a particular embankment should be classified as a dam should take into account the following factors.

- Ability of the embankment's drainage to draw down the volume of water resulting from a 100-year storm event in a timely manner.
- Stability of the embankment when water is retained.
- Potential for clogging of the drainage system.
- Potential for overtopping of the embankment.
- Potential consequences of failure.
- Any other factors that may contribute to a safety hazard.

This case-by-case approach shall be used to determine whether an embankment should be classified as an impounding structure.

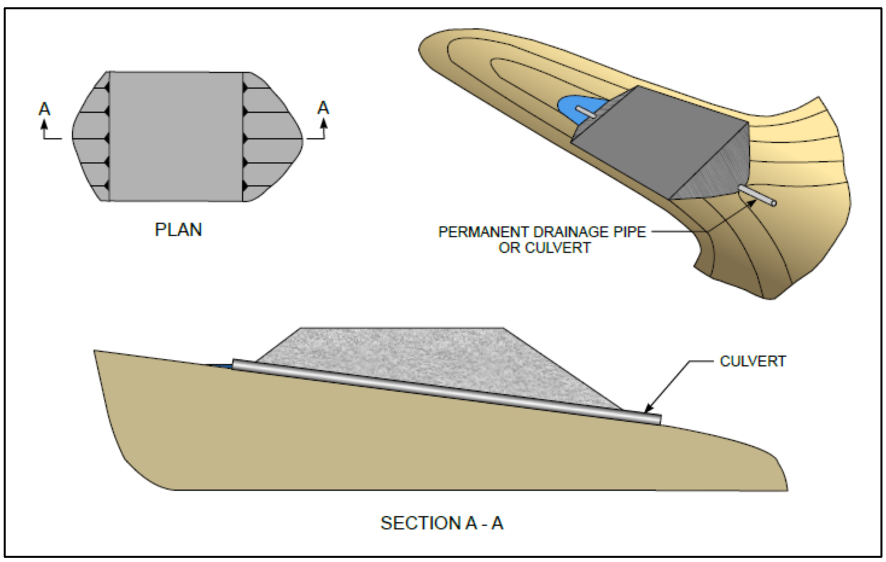


Figure 25. Cross-valley non-impounding embankment.

D. Emergency Action Plans

An Emergency Action Plan (EAP) is a written document that identifies the areas downstream of a dam that can be affected if a dam failure were to occur and specifies pre-planned actions to be followed to protect downstream lives and property. Guidance for development of an EAP is available in *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams* (FEMA P-64, 2013)[7] and other widely available documents.

[7] https://www.fema.gov/sites/default/files/2020-08/eap_federal_guidelines_fema_p-64.pdf

MSHA standards address the need to protect and potentially evacuate miners in the event that a hazardous condition develops. This typically would not be considered an EAP. MSHA should encourage mine operators to develop an EAP for all high and significant hazard potential dams to protect all persons potentially affected by a dam breach. Mine operators should continuously update and routinely practice the plan.

The level of detail in the EAP should be appropriate for the dam's hazard potential classification, with plans for high hazard potential dams being the most detailed. To be complete, an EAP should cover the following topics.

- Notification flowchart – indicating who is to be notified, by whom, and in what priority. This typically includes local emergency management personnel and law enforcement.
- Emergency detection, evaluation, and classification – procedures for the reliable and timely identification of an emergency situation.
- Responsibilities – explanation of responsibilities and coordination with local authorities.
- Preparedness – actions to prevent or lessen the impact of a failure.
- Inundation mapping – delineation of the areas potentially affected by a failure.

CHAPTER 7 - REVIEW OF ENGINEERING DESIGN PLANS

Dams at coal mines meeting the size or hazard potential criteria in 30 CFR § 77.216 require a design plan to be submitted to and approved by MSHA. In addition, engineering plans may be required for dams with violations at metal and nonmetal mines. Qualified engineers, or others trained and experienced in the principles of dam design, construction, and operation, in a District or Technical Support, can review submitted engineering plans. This chapter describes the various types of plans and outlines the recommended minimum qualifications to conduct reviews.

When plan reviews for high and significant hazard potential dams are conducted in the District, copies of the plan as well as all correspondence related to the plan are to be sent to Technical Support's Mine Waste and Geotechnical Engineering Division (MWGED). MWGED maintains a complete file for these dams so that all pertinent information will be available in the event that MWGED personnel are requested to review a plan submittal or provide technical assistance.

Plans forwarded to the MWGED should be sent to the attention of the Division Chief. Alternatively, plans in electronic format can be sent to the email address TS_MWGED_Plans@dol.gov.

A. Plan Categories

The plan category is based on the purpose for submitting the plan. Plan categories consist of the following.

- New Plan – information pertaining to a new dam proposed by the operator. Will contain information covering every aspect of dam design, construction, and operation.
- Modified Plan – information pertaining to changes proposed by the operator to an existing dam. Will contain information pertinent to the proposed modification.
- Revised Plan – information submitted in response to MSHA's review of a previously submitted new, modified, or revised plan. Will contain information specific to the issues raised during MSHA's review.

B. District Administrative Review

- The District administrative review is a cursory review of submitted plans to verify that the plans appear complete and the 17 items required by 30 CFR § 77.216-2 are included. These items are evaluated to ensure that they are addressed in the submitted plan. Plans should also be reviewed for obvious errors and omissions. At the completion of this review, the District can determine whether they will do a complete technical review of this submittal or have the plan reviewed by the MWGED.

- A District Impoundment Specialist/Inspector shall conduct the District administrative review.
- The District administrative review should be completed 2 weeks from the date the plan is received in the District and before the plan is forwarded to the MWGED.
- If it is determined that the plan is incomplete, the issues should be resolved with the operator before the plan is forwarded to Technical Support or the District's full technical review begins.

C. Experience and Knowledge Required for a Plan Reviewer

MSHA personnel who review dam design plans need to have adequate knowledge and experience commensurate with the complexity of the plan. Guidance on plan complexity and the corresponding recommended reviewer knowledge/experience is provided below.

When a plan is reviewed in a district or MWGED by a person with less than the recommended qualifications, the reviewer's work should be overseen by an engineer with the appropriate level of experience and knowledge.

Advanced-Complexity Plans

Examples:

- Plans for dams with a high hazard potential classification, where loss of life is likely in the event of failure.
- Plans that will significantly affect the dam's stability, flood routing, breakthrough potential, or seepage.
- Plans where the embankment is to be raised using upstream construction.
- Plans where there are underground mine workings, highwall miner openings, or auger holes beneath or adjacent to the embankment or reservoir.
- Embankments that will reach a height of over 100 feet.

Requires specialized knowledge obtained from experience and/or education equivalent to a Master's Degree in civil engineering with advanced courses in soil and rock mechanics, hydrology, and hydraulics, and at least 6 years of recent experience related to dam design/construction. Registration as a Professional Engineer is recommended.

It is recommended that reviews be conducted by Technical Support's MWGED for plans in this category.

Intermediate-Complexity Plans

Examples:

- Plans for dams with a significant hazard potential classification.
- Plans for minor modifications to high hazard potential dams.
  - Plans involving the design of internal drains and filter layers.
  - Plans involving pipes to be buried under less than 50 feet of cover.
  - Plans involving the use of spillway liners.
  - Plans involving construction on surface mine spoil.
  - Plans involving special treatment of the foundation or abutment, such as grouting or cutoff trenches.

Requires knowledge obtained from experience or education equivalent to a civil engineering graduate with undergraduate courses in hydrology, hydraulics, and soil mechanics, and at least 4 years of recent experience related to dam design/construction.

Plans in this category can be reviewed in the District only if the District staff has the knowledge, experience, and time to identify and address all potential safety issues. Otherwise, plans in this category should be forwarded to Technical Support's MWGED.

Lower-Complexity Plans

Examples:

- Plans for dams with a low hazard potential classification.
- Plans for minor modifications to significant hazard potential dams.
  - Plans proposing an increase in the decant inlet level combined with an increase in the embankment's crest elevation.
  - Plans involving no upstream construction and no underground mine workings, highwall miner openings, or auger holes.
  - Plans involving minor changes in the geometry of the dam.
  - Plans involving small increases in the height of the dam.

Requires knowledge obtained from experience and/or education equivalent to a civil engineering graduate with course work in soil mechanics, hydraulics, and hydrology.

Plans in this category can be reviewed in the District if the District staff has the knowledge, experience, and time to identify and address all potential safety issues. Otherwise, plans in this category should be forwarded to Technical Support's MWGED.

D. Plan Review Guidance

Appendix 7 contains a plan review checklist that can be used to help ensure all major technical topics have been addressed and reviewed. Appendix 10 contains a list of references with which a plan reviewer should be familiar.

E. Results of Plan Review and Mine Operator Notification

The review will determine whether the plan is technically acceptable or deficient. When reviews are performed by the MWGED, correspondence will be sent to the District Manager documenting the review and providing a recommendation whether the plan should be approved. At the completion of reviews where changes are being made to the crest, pool, or instrumentation, the reviewer will complete an IRPI Data Sheet and an Impoundment Data Sheet for each stage of the dam (Appendix 8). The District impoundment design plan database will be updated when technical reviews begin and end. The outcome of each review will be documented in the database.

The following actions take place regarding notification of the mine operator at the completion of a plan review.

- If the plan or revision is technically acceptable, the District Manager will send written notification to the operator that approval is granted.
- If the plan has been determined by MSHA to be inadequate or unsuitable, the District Manager will advise the operator in writing of the deficiencies of the proposed plan or revision. If the plan or revision cannot be approved, MSHA procedures established in the Program Policy Manual, Volume V, V.G-4 will apply.

APPENDIX 1

MSHA DAM SAFETY PROGRAM

The purpose of the Dam Safety Program is to ensure dams used in the mining industry are designed, constructed, operated, maintained, and closed in a safe manner. The Dam Safety Program is overseen by a Dam Safety Officer and encompasses several program areas, namely, the MSHA program areas Mine Safety and Health Enforcement, Technical Support, and Education and Policy Development. This section describes the roles of personnel involved in the Dam Safety Program.

A. DOL/MSHA Dam Safety Officer

The Director of Technical Support appoints the Dam Safety Officer (DSO) with the concurrence of the Assistant Secretary and Administrator for Mine Safety and Health Enforcement. The DSO may concurrently be Chief of Technical Support's Mine Waste and Geotechnical Engineering Division (MWGED), or the DSO may be another technically-qualified individual.

The DSO has the following duties and responsibilities:

- Oversee the MSHA Dam Safety Program.
- Ensure MSHA's Dam Safety Program is aligned with FEMA's Federal Guidelines for Dam Safety.
- Ensure MSHA technical methods, policies, guidelines, and directives are aligned with current, prudent engineering practices for dam safety.
- Represent DOL/MSHA at meetings of FEMA's Interagency Committee on Dam Safety (ICODS) and the National Dam Safety Review Board (NDSRB), and the Department of Homeland Security's Government Coordinating Council – Dams Sector (GCC).
- Monitor all dam-related training provided by MSHA for content, coverage, and relevance.
- Oversee the planning and presentation of MSHA's Dam Safety Training along with the Dam Safety Training Committee.
- Coordinate the maintenance and updating of MSHA's Impoundment and Refuse Pile Inventory (IRPI) and provide inventory information to the Army Corps of Engineers for inclusion in the National Inventory of Dams.
- Provide information on MSHA's dam safety activities to FEMA, as needed for inclusion The National Dam Safety Program Biennial Report to the United State Congress.

- Conduct an annual meeting with all involved MSHA program areas involved in the Dam Safety Program to obtain information related to the functioning and effectiveness of the Dam Safety Program.
- Author an annual report for the Assistant Secretary summarizing the functioning and effectiveness of MSHA's Dam Safety Program.

B. Mine Safety and Health Enforcement

The Mine Safety and Health Enforcement (MS&HE) program area has the following responsibilities related to MSHA's Dam Safety Program.

- Ensure Headquarters and each District identifies a Dam Safety Representative (DSR). The DSR is the primary point of contact when information related to dams is needed or needs to be disseminated. The DSR should have a working knowledge of dam operations and safety principles and be familiar with MSHA's administrative procedures pertaining to dams. Typically the DSR is the District supervisor responsible for dams.
- Ensure at least one inspector in each District maintains a high level of knowledge and experience on the subject of dam safety. The inspector preferably has a degree in civil engineering with coursework in soil mechanics, hydrology, and hydraulics. The inspector should be thoroughly familiar with dam design, construction, operation, and maintenance. This inspector will be referred to as Impoundment Specialist or Impoundment Inspector within this handbook.
- Ensure every MSHA inspector receives a minimum of 4 hours of dam safety refresher training annually. This training will, at a minimum, cover applicable MSHA regulations, dam hazard potential classification, and recognition of deficiencies that could affect the stability or safe performance of the dam and include review of the Dam Inspection and Plan Review Handbook.
- Ensure every MSHA Impoundment Specialist, Impoundment Inspector, and every inspector responsible for inspecting high or significant hazard potential dams receives a minimum of 24 hours of dam safety training each year. This training can be obtained by attending MSHA's annual Dam Safety Training (Appendix 2).
- Conduct inspections of dams at mining operations to ensure compliance with MSHA regulations and engineering design plans.
- Conduct inspections of dams at mining operations for signs of instability or other deficiencies that could affect the performance of the dam.
- Ensure plan reviews conducted in District Offices are performed by qualified engineers or other persons (Chapter 7).
- Process, review, and approve engineering design plans submitted by mine operators (Chapter 7).
- Ensure information pertaining to coal mine dams in the Mine Plan Approval system and the District's plan database is accurate and up to date (Chapter 3).
- Investigate dam failures and unusual conditions.

- Notify the District DSR and DSO of failures and unusual conditions.
- Provide information to the DSO from each District for development of the MSHA Dam Safety Program report and for submission to FEMA.
- Provide inspectors for MSHA's Dam Safety Training Committee.
- Ensure MSHA's IRPI is accurate and up to date.

C. Technical Support

Technical Support and the MWGED have the following responsibilities related to MSHA's Dam Safety Program:

- The Director appoints the Dam Safety Officer.
- Maintain expertise in all engineering fields involved with dam safety.
- Provide dam safety assistance (consultation, training, investigation) to MSHA program areas, and as applicable, to the mining community and other agencies.
- Conduct technical reviews of engineering design plans for dams forwarded by MS&HE (Chapter 7).
- Conduct dam investigations with MS&HE to assess conditions or determine a cause of failure.
- Chair the MSHA Dam Safety Training Committee. This is typically an engineer in the MWGED.
- Provide personnel to MSHA's Dam Safety Training Committee.
- Provide information to the DSO for development of the MSHA Dam Safety Program report and for submission to FEMA.
- Support membership on industry committees pertaining to mining dams.

D. Education and Policy Development

Education and Policy Development (EPD) has the following responsibilities related to MSHA's Dam Safety Program.

- Ensure instructors presenting dam safety training maintain a working knowledge of dam operations and safety principles.
- Develop and present dam safety training to new and journeyman mine inspectors.
- Develop and present annual refresher training for every mine inspector.
- Provide personnel to MSHA Dam Safety Training Committee.
- Assist with MSHA's annual Dam Safety Training.
- Provide information to the DSO for development of the MSHA Dam Safety Program report and for submission to FEMA.

APPENDIX 2

DAM SAFETY TRAINING

Continuous training on dam safety issues is an important element of maintaining an effective dam safety program. Of primary importance for every inspector is training to recognize developing conditions or deficiencies that could affect the safe operation of the dam.

A. Training for MSHA personnel

New Inspector Training

New mine inspectors should receive training on the following dam safety issues.

- Overview of the MSHA Dam Safety Program.
- Overview of the Dam Inspection and Plan Review Handbook.
- Purpose of dams (conventional and mining dams).
- Overview of dam hazard potential classification.
- Historic dam failures (conventional and mining dams).
- Overview of the design, construction, operation, maintenance, and closure of dams.
- Discussion of dam modes of failure.
- MSHA regulations, policies, and guidance related to dams.
- Inspection for conditions or deficiencies that could affect the safe operation of the dam.
- Introduction to the MSHA Impoundment and Refuse Pile Inventory.

Journeyman Inspector Training

Experienced mine inspectors should receive annual 4-hour refresher training on the following dam safety issues.

- Review of MSHA regulations, policies, and guidance.
- Overview of dam modes of failure.
- Inspection for conditions or deficiencies that could affect the safe operation of the dam.
- Discussion of applicable historic or recent dam incidents and the role of inspection.

Impoundment Specialists, Impoundment Inspectors, Technical Support Engineers, and Inspectors of High or Significant Hazard Potential Dams

Specialists, engineers, and inspectors involved with high or significant hazard potential dams should receive a minimum of 24 hours of annual training on the following topics, as applicable.

- Principles and practices related to dam design, construction, operation, maintenance, and closure.
- Inspection for conditions or deficiencies that could affect the safe operation of the dam.
- Collection and interpretation of monitoring data.
- Analysis of hydrologic, hydraulic, seepage, and stability conditions.
- Discussion of failures and unusual conditions occurring during the previous year.
- Computer applications used to analyze conditions.
- Exposure to new equipment and techniques in the dam safety environment.
- Review of MSHA administrative procedures related to the Dam Safety Program.

This training can be obtained through MSHA's annual Dam Safety Training or by attendance at webinars, short courses, or university courses.

B. MSHA Dam Safety Training

Each year, MSHA will conduct dam safety training for its Impoundment Specialists, Impoundment Inspectors, engineers, and others inspecting high or significant hazard potential dams. The agenda and presenters for the training will be developed by the Dam Safety Training Committee with guidance from the DSO. The Dam Safety Training Committee will be composed of inspectors from at least three MS&HE Districts, at least one representative from MS&HE Headquarters, a representative of EPD, and three representatives from the MWGED. The Dam Safety Training Committee will be chaired by a representative from MWGED.

The Committee will plan a 24-hour training event for Impoundment Specialists, Impoundment Inspectors, engineers, and others. At the conclusion of the event, a summary report will be provided to the Administrator for MS&HE documenting the agenda, attendance, and attendee evaluations of the training.

C. Training Requirements for Industry Personnel

Qualified Persons and Other Dam Inspectors

Each coal operator owning, operating, or controlling a dam which is required to be inspected by a Qualified Person must provide initial training and annual retraining for the Qualified Person as required by 30 CFR § 77.107-1(b).

In accordance with 30 CFR § 77.107, the training and retraining program for such Qualified Persons must be submitted to the appropriate District Manager for approval. Although MSHA does not have a "Qualified Person" requirement for dams at metal and nonmetal mines, operators of these mines are encouraged to maintain at least this level of training for their dam inspectors.

- Initial Training

The initial course, to be at least 8 hours in duration, should as a minimum consist of the following subjects and topics.

Initial Training Course – 8 hours:

1. Introduction to Embankment Engineering and Behavior
   a. Engineering terms
   b. Failure types, including breakthrough into mine workings
   c. Effect of saturation on stability
   d. Issues concerning upstream pushouts (slurry dam)
   e. Relationship of hydrology and emergency discharge structures

2. Inspection Path
   a. Crest and slurry surface
   b. Upstream Slope
   c. Abutments, downstream slope, and toe
   d. Discharge facilities
   e. Location of critical seepage areas
   f. Location of mine openings or potential subsidence
   g. Instrumentation
   h. General site safety

3. Potentially Hazardous Conditions
   a. Seepage, piping
   b. Cracking, slumping, and bulging
   c. Fires
   d. Failure of water control structures

   e. Location of phreatic surface
   f. Subsidence, sinkholes, or the appearance of depressions on slurry surfaces or eddies in the pool
   g. Inadequate freeboard

4. Inspection Records
   a. Recording material placement (test location, lift thickness, and compaction)
   b. Recording instrumentation readings
   c. Recording potentially hazardous conditions

In addition to the completion of the initial training, all persons must pass an examination in order to become qualified. The person must achieve a minimum final examination grade of 80%. The examination must be administered by an MSHA representative.

- Annual Refresher Training

All Qualified Persons must receive at least 4 hours of annual refresher training within twelve months from the date of the initial or last annual refresher training. Persons taking annual refresher training will not be required to take additional examinations. The annual retraining course should be a refresher of the subjects covered in the initial training with special emphasis given to areas specific to the dams to be inspected. The operator must maintain a list of all Qualified Persons designated to perform dam inspections as required by 30 CFR § 77.106.

The District Manager may grant requests for limited extensions of time to complete annual refresher training.

If qualification has expired due to not receiving annual refresher training, a person must complete annual refresher training and pass the initial training examination with a score of at least 80%. The examination must be administered by an MSHA representative.

MSHA-Approved Industry Instructors

Any person may request to become an approved instructor for a dam inspection qualification course. All applicants must complete the initial 8-hour training, achieve a minimum grade of 90% on an examination administered by an MSHA representative, and meet the requirements of 30 CFR § 48.23(h). Upon approval from the District Manager, the instructor can present the 8-hour initial training and 4-hour annual refresher training courses. An approved industry instructor may never administer the examination that qualifies a person to conduct dam inspections.

An instructor, who is also a Qualified Person, can satisfy the annual Qualified Person training requirement by either attending a 4-hour annual refresher course or by teaching an initial or annual refresher course. Instructors not completing the requirements for annual refresher training lose qualification for purposes of performing inspections, but may retain approved instructor status.

Instructors may have their approval revoked by MSHA if a course is not taught at least once every 24 months as per 30 CFR § 48.23(i).

APPENDIX 3

Impoundment and Refuse Pile Inventory (IRPI) Data Fields

The Impoundment and Refuse Pile Inventory is accessed through the MSHA Standardized Information System (MSIS). After entering a mine identification number, the system will display the impoundments and refuse piles in the inventory for that mine. The user will then have the option to create a new site or modify an existing site. Data fields are organized into related topics. The tables below describe data fields available on the "Create New Structure" and "Modify Structure" screens for impoundments.

General Information		
Field Name	**Mandatory Field?**	**Description**
Structure Type	Y	The classification of the structure type according to its purpose. An impoundment is capable of storing water, while a refuse pile does not. Select from the following options. • Impoundment • Refuse Pile
State	Y	The two-character state code where the main embankment of the structure is located, even if the mine is located elsewhere. Should match the state designation used in the Impoundment_ID field.
County	Y	The county name where the structure is located, even if the mine is located elsewhere.
Owner Name	N	The official name of the person or company who owns the dam.
Structure Name	Y	The official name of the impoundment or refuse pile as assigned by the mine operator. Do not abbreviate unless it is part of the official name. Maximum of 65 characters.
MSHA ID Number	Y	The structure's unique identification number as assigned by MSHA.
ID Issue Date	Y	The date that the MSHA Impoundment ID number was issued. Format: mm/dd/yyyy
Latitude	Y	The latitude value obtained at the center of the dam crest. Latitude is a positive value for most of MSHA dams located north of the equator. Enter the degrees, minutes, and seconds components in the three corresponding fields and round the values to the nearest whole number.

Longitude	Y	The longitude value obtained at the center of the dam crest. Longitude is a negative value since MSHA dams are located west of the Prime Meridian. The negative is already incorporated into the program. Enter the degrees, minutes, and seconds components in the three corresponding fields and round the values to the nearest whole number.
Nearest Downstream Town	N	The name of the nearest city/town downstream of the impoundment that would be affected by floods from a dam failure.
Distance to Nearest Downstream Town	N	The distance from the impoundment to the nearest affected downstream city/town. Enter the distance in miles to the nearest tenth in the numeric field.
Stage	Y	The designation for the current construction stage of the impoundment.
Phase	Y	The current construction status of the structure. Select the phase from the available options. • Under Construction • Construction Completed
Emergency Action Plan	Y	Indicator whether an Emergency Action Plan exists for the site. Select from the following options. • Yes: if an EAP exists • No: if an EAP does not exist, but one is required by the state • Not Required: if an EAP is not required and it does not exist
Status	Y	The official operational status of the impoundment. Select from the available options. • Abandoned: if site can no longer impound and has been reclaimed • Active: if site is capable of impounding • Orphaned: if site is not reclaimed and no operator exists

Embankment Construction Material		
Field Name	**Mandatory Field?**	**Description**
Embankment Construction Material	Y	The primary material used for the construction of the embankment structure. Select the primary material from the available options. For multiple materials, select the material(s) and click the Add button. Select from the available options. • Earth (includes coarse coal refuse or tailings) • Rockfill • Other

Other Structure Names and Purposes		
Field Name	**Mandatory Field?**	**Description**
Other Structure Names	N	The names that identify the structure other than the official name used for its identification.
Purposes	Y	The primary purpose for which the structure is used. For multiple purposes, select the purpose(s) and click the Add button. Selection from the available options. • Tailings Disposal • Water Supply • Sedimentation • Treatment Pond • Other

Structure Designers and Modifications		
Field Name	**Mandatory Field?**	**Description**
Structure Designers	N	Name of the engineering firm designing the structure. Multiple names can be added by clicking the Add button.
Modification Year	N	Enter the year modifications are made to the site.
Modification Type	N	Indicate the general type of modification made. Multiple selections can be made by clicking the Add button. Select from the available options. • Structural • Foundation • Mechanical • Seismic • Hydraulic • Other

Certification / Contact Information		
Field Name	**Mandatory Field?**	**Description**
Company Contact	Y	The name company's lead contact person for the structure.
Company Phone	Y	The area code and phone number of the company's lead contact person.

Inspection Information		
Field Name	**Mandatory Field?**	**Description**
Event	N	Select the enforcement event number for the inspection.
Start Date	N	Date enforcement event initiated.
End Date	N	Date enforcement event ended.
Activity	N	Enforcement code for type of inspection.
Date of Inspection	N	Date of impoundment inspection. Format: mm/dd/yyyy
Comment	N	Comments related to inspection.

Abandoned / Orphaned Impoundment Information (fields active if Status selected as Abandoned or Orphaned)		
Field Name	**Mandatory Field?**	**Description**
Abandonment Date	Y	The date that the structure was abandoned, orphaned, or otherwise removed from MSHA jurisdiction. Format: mm/dd/yyyy
Referred to Agency Name	N	The Federal of state agency that assumed responsibility for the structure after it was removed from MSHA jurisdiction.
Agency Notified Date	N	The date that the referred agency was notified about the site being removed from MSHA jurisdiction. Format: mm/dd/yyyy

Other Impoundment Information		
Field Name	**Mandatory Field?**	**Description**
State Regulated	Y (if applicable)	Indicate whether a State agency regulates the structure. Select from the available options. • Yes • No

State Regulatory Agency	Y (if applicable)	The name of the state agency responsible for regulating the site (inspects the site or requires permits).
Type of Construction	N	The type of construction method used for the construction of the structure. Select the type of construction from the available options. If a combination of methods is being used, select the most complex method. Order of increasing complexity is Downstream, Centerline, then Upstream.
Dam Length	Y	The distance along the crest from abutment to abutment, including the spillway width if an open-channel spillway is present. Enter the length in feet.
Dam Height	Y	The vertical distance from the upstream toe of the embankment to lowest point of the crest.
Maximum Storage	Y	The storage that is below the design storm maximum water surface elevation, including existing and available storage. For an incised impoundment, any storage that is below the natural ground level is not included in the calculation. The design plan may contain this information in the form of a stage-storage chart, or it can be estimated, if necessary. Enter the maximum storage value in acre-feet in the numeric field.
Decant Pipe Type	Y	The type of material used to manufacture the decant pipe. decant pipe is the primary spillway pipe that is used to manage pool water discharge. Select the type of material from the available options. • None • Reinforced Concrete • Corrugated Metal • HDPE • Welded Steel • Other
NID Number	N (if available)	The national inventory of dam number (NID number) as assigned by the State regulatory agency's dam safety coordinator. Format: WV12345
Downstream Hazard Potential	Y	The hazard potential to the downstream area resulting from a dam failure. Select from the available options. • High • Significant • Low

Mining Underneath	Y	Indicate whether there has ever been mining activities beneath or adjacent to the structure. Select from the available options. • Yes • No
Breakthrough Potential	Y	Indicate whether a breakthrough potential has ever existed at the subject site, such as deep mining near the outcrop or a low overburden. Select from the available options. • Yes • No
Condition Assessment Date	Y	The date of the most recent MSHA condition assessment of the structure. Format: mm/dd/yyyy
Condition Assessment	Y	The assessment that best describes the condition of the structure based on the inspection or available information. Select the condition assessment from the available options. • Fair (deficiency recognized that would only be affected by rare or extreme events) • Not Rated - Dam has not been inspected • Not Rated - Not under state jurisdiction • Poor (deficiency recognized for loading conditions that may realistically occur) • Poor - More Analysis Needed • Satisfactory - Meets applicable hydrologic and seismic regulatory criteria (site has approved design plan) • Satisfactory - Meets applicable tolerable risk criteria • Unsatisfactory (deficiency recognized that requires immediate or emergency action)
Slurry Remining	Y	Indicate whether slurry remining has ever occurred at the site. Select from the available options. • Yes • No
Upstream Construction	Y	Indicate whether the upstream construction method has ever been used to construct any stages of the structure. Select from the available options. • Yes • No
Slurry Cells	Y	Indicate whether slurry cell construction has ever occurred within the structure. Select from the available options. • Yes • No

Mitigation (field active if Breakthrough Potential selected as Yes)		
Field Name	**Mandatory Field?**	**Description**
Mitigation	N	Indicate the methods used to mitigate breakthrough potential at the site. Multiple selections can be made by clicking the Add Button. Select from the available options. • Barrier • Bulkhead • Mine Backfill • Monitoring • Slurry Modification

Designation of Saddle Dams		
Field Name	**Mandatory Field?**	**Description**
Designation of Saddle Dams	N	Enter the name of saddle dams associated with the main dam. For multiple saddle dams, enter the name(s) and click the Add button.

APPENDIX 4

Initial Assessment and IRPI Data Collection Form

Initial Assessment and IRPI Data Collection Form

ADMINISTRATIVE INFORMATION	
Page 1 of this form should be completed for all dams found during an initial mine site assessment. The entire form will be completed for dams classified as having high or significant hazard potential and for low-hazard-potential dams meeting the dam height and storage volume criteria for their respective industry (see IRPI Criteria Flowchart). For the same Mine ID Number, report each dam on a separate form. Fill out as much information as can be obtained from the operator or directly determined. The information collected for dams that meet the criteria referenced above should be entered into the Impoundment and Refuse Pile Inventory (IRPI) database, which is accessed through the MSHA Standardized Information System (MSIS). Fields below with an asterisk are mandatory fields in the IRPI database.	
Inspector Name(s):	AR No(s).:
District:	Field Office:
Event No.:	Date/Time:
Weather:	Temperature:
Type of Inspection:	
Accompanied by:	

GENERAL INFORMATION
1. Mine ID and Mine Name:
2. Owner/Operator Name:
3. Company Contact Name and Phone*:
4. Industry: Coal ☐ MNM ☐
5. Mine Product(s):
6. State and County*:
7. Structure Name(s)*:
8. Purpose(s) of Dam*: Tailings ☐ Water Supply ☐ Sedimentation ☐ Treatment Pond ☐ Other ☐
9. Latitude and Longitude (degrees, minutes, seconds)*:
10. Nearest Downstream Town and Distance (miles):
11. Status*: Abandoned ☐ Active ☐ Orphaned ☐
12. Emergency Action Plan*: Yes ☐ No ☐ Not Required ☐
13. State Regulated*: Yes ☐ No ☐
14. State Regulatory Agency*:
15. Structure Designers:
16. National Inventory of Dams (NID) Number (if available):

IRPI CRITERIA AND MSHA ID NUMBER
17. Downstream Hazard Potential Classification*: High ☐ Significant ☐ Low ☐
18. Describe Reasoning for Hazard Potential Classification Indicated:
19. Dam Height (feet)*:
20. Reservoir Area: Width (feet) _________ , Length (feet) ________ ➡ Area (acres)_____________ (W x L / 43,560)
21. Maximum Storage Volume (acre-feet) (see IRPI Flowchart for calcs.)*:
22. Does the dam meet the IRPI criteria based on the hazard potential classification, height, and storage volume for its respective industry? (see IRPI Criteria Flowchart) Yes ☐ No ☐ If yes, the site should be assigned an MSHA ID Number and the remainder of the form should be completed. The information collected should be entered into the IRPI database through MSIS. If the dam does not meet the IRPI criteria, no further information is needed; however, page 1 of this form should be retained as a record that an initial assessment of the dam was conducted.
23. MSHA ID Number Assigned and Issue Date*:

DAM DESCRIPTION
24. Phase*: Under Construction ☐ Construction Completed ☐
25. Stage*:
26. Embankment Construction Material*: Earth/ Refuse/Tailings ☐ Rockfill ☐ Other ☐
27. Configuration (see Figure 1): Cross-Valley ☐ Side-Hill ☐ Diked ☐
28. Type of Construction (see Figure 2): Downstream ☐ Centerline ☐ Upstream ☐
29. Saddle Dam(s): Yes ☐ No ☐
30. Designation/Name of Saddle Dams:
31. Slurry Cells (see Figure 3)*: Yes ☐ No ☐
32. Slurry/Tailings Remining*: Yes ☐ No ☐
33. Mining Underneath*: Yes ☐ No ☐
34. Breakthrough Potential*: Yes ☐ No ☐
35. Breakthrough Mitigation Measure(s): Barrier ☐ Bulkhead ☐ Mine Backfill ☐ Monitoring ☐ Slurry/Tailings Modification ☐ None ☐ Not Applicable ☐
36. Dam Length (feet)*:
37. Normal Pool Elevation (feet) and Storage Volume (acre-feet):
38. Freeboard (feet):
39. Drainage Area (sq. miles):

OUTLET STRUCTURE(S) INVENTORY
40. Decant Pipe: Yes ☐ No ☐ a. Type*: Reinforced Concrete ☐ Corrugated Metal ☐ HDPE ☐ Welded Steel ☐ Other ☐ b. Size (see Figure 4): Inside Diameter (inches) _________ -or- Width (inches) _________ and Height (inches) ___________
41. Open-Channel Spillway (see Figure 5): Yes ☐ No ☐ a. Shape: Trapezoidal ☐ Triangular ☐ Rectangular ☐ Irregular ☐ b. Depth (feet): ____________________ c. Bottom Width (feet): ____________________ d. Top Width (feet): ____________________
42. Describe Other Outlet Type(s):

CONDITION ASSESSMENT AND RECORDKEEPING
43. Date of Inspection (using MSHA Dam Inspection Form) to Assess Condition*:
44. Condition Assessment*: Fair ☐ Unsatisfactory ☐ Not Rated – Dam has not been inspected ☐ Poor – Deficiency Recognized ☐ Not Rated – Not under state jurisdiction ☐ Poor – More Analysis Needed ☐ Satisfactory – Meets applicable hydrologic and seismic regulatory criteria ☐ Satisfactory – Meets applicable tolerable risk criteria ☐
45. Describe any failures or incidents at the site that resulted in a partial/complete loss of the dam or its hydraulic structures, or a partial/complete unintentional release from the reservoir and when it occurred:
46. Has information on this form been reviewed by Imp. Supervisor/Specialist/etc.: Yes ☐ No ☐
47. Has the information collected been entered into IRPI: Yes ☐ No ☐
48. Date entered into IRPI:

Description of Initial Assessment and IRPI Data Collection Form Fields

Each initial dam assessment must be comprehensive and thoroughly documented. This Handbook contains an "Initial Assessment and IRPI Data Collection Form" that shall be used for documentation of the initial assessment of a dam and for the determination of whether the dam should be assigned an MSHA ID Number and its information entered into the Impoundment and Refuse Pile Inventory (IRPI) database (Chapter 3). The IRPI database is accessed through the MSHA Standardized Information System (MSIS).

The inspector shall complete the Initial Assessment and IRPI Data Collection Form when a new dam is discovered on a mine site. The form is organized such that Page 1 will be completed for all dams found on a mine site. At the end of Page 1, information regarding hazard potential and size are used to determine whether to assign an identification number and enter the site into IRPI. The entire form will be completed for dams classified as having high or significant hazard potential and for low-hazard-potential dams meeting the dam height and storage volume criteria for their respective industry (see IRPI Criteria Flowchart). For the same Mine ID Number, the inspector shall report each dam on a separate form. The form should be filled out with as much information as can be obtained from the operator or directly determined in the field. Any fields with an asterisk are mandatory fields in the IRPI database.

Each item in the form is described below.

Administrative Information

- ***Inspector Name(s), AR No(s).*** – indicate the MSHA personnel involved with the initial dam assessment.
- ***District, Field Office*** – indicate the District and Field Office for the MSHA personnel involved with the initial dam assessment.
- ***Event No.*** – enforcement event number under which the assessment is being conducted.
- ***Date / Time*** – self explanatory.
- ***Weather, Temperature*** – indicate the general weather conditions at the time of the initial dam assessment.
- ***Type of Inspection*** – – indicate the code for the type of inspection conducted (e.g., E01, E04, E23, etc.). Also indicate if there is a specific purpose for this inspection. Also indicate if there is a specific purpose for this inspection.

- ***Accompanied by*** – document others that were present during the initial dam assessment.

General Information

1. ***Mine ID and Mine Name*** – indicate current mine name and mine ID.

2. ***Owner/Operator Name*** – indicate the current mine owner and operator names.

3. ***Company Contact Name and Phone Number**** – provide the name and phone number for the company representative responsible for the dam.

4. ***Industry*** – indicate whether the dam is associated with a coal or metal and nonmetal mine.

5. ***Mine Product(s)*** – indicate what material(s) are extracted at the mine.

6. ***State and County**** – indicate the state and county where the dam is located.

7. ***Structure Name(s)**** – provide the name for the dam. If the site is known by more than one name, provide all names and identify the primary name.

8. ***Purpose(s) of Dam**** – indicate how the dam is used by the operator. Available options are tailings disposal, water supply, sediment control, treatment pond, and other (e.g., flood control).

9. ***Latitude and Longitude**** – provide the coordinates for the dam, at the center of the crest if possible. The coordinates should be in degrees, minutes, seconds for IRPI database input.

10. ***Nearest Downstream Town and Distance*** – provide the name of the nearest downstream town, as well as the distance to the town in miles.

11. ***Status**** – indicate whether the dam is active, abandoned, or orphaned.

12. ***Emergency Action Plan**** – indicate if the dam has an emergency action plan (EAP), or if a plan is not required. If the dam has an EAP, the inspector should request a copy of the plan that the operator may have for dams on the property. These plans are required by many state agencies.

13. ***State Regulated**** – indicate if the dam is regulated by a state agency.

14. ***State Regulatory Agency**** – if the dam is regulated by a state agency, provide the name of the state regulatory agency.

15. ***Structure Designers*** – provide the name of consulting firm or engineer that designed the dam.

16. ***National Inventory of Dams (NID) Number*** – if available, provide the NID number for the dam.

IRPI Criteria and MSHA ID Number

The information in this section will be used to determine whether the dam should be assigned an MSHA ID Number and its information entered into the IRPI database. The required information should be obtained from the operator/design plan, in the field, or using satellite imagery. Refer to the IRPI Criteria Flowchart for the hazard potential, size criteria, and storage calculation guidance.

17. ***Downstream Hazard Potential Classification**** – check the box to indicate the hazard potential classification for the site (Chapter 3).

18. ***Describe Reasoning for Hazard Potential Classification Indicated*** – provide an explanation for the hazard potential classification indicated. For high or significant hazard potential dams, provide a list of any towns, structures, roads, utilities, etc. that may be impacted by a dam breach/failure.

19. ***Dam Height**** – provide the height of the dam in feet. The height is the vertical distance from the upstream toe of the embankment to the lowest point of the crest. If the elevation of the upstream toe is not available, the elevation of downstream toe can be used to determine the dam height. Additionally, any portion of the structure that is incised, meaning it is excavated below undisturbed natural ground, should not be included as part of the dam height.

20. ***Reservoir Area*** – provide the reservoir area in acres. Measurements obtained in the field to determine the width and length of the reservoir should be taken at the crest. The reservoir area can be calculated by multiplying the width and length, and then dividing by 43,560. Satellite imagery (planimeter function) can also be utilized to confirm or obtain the reservoir area.

21. ***Maximum Storage Volume**** – provide the maximum storage volume in acre-feet. The dam height, reservoir area at the maximum storm pool or crest, and reservoir area at the bottom (if available) are used to calculate the maximum storage volume of the dam. Refer to the IRPI Criteria Flowchart for storage volume equations. Additionally, any portion of the storage that is contained

within an incised part of the structure should not be included within the storage volume calculation.

22. ***Does the dam meet the IRPI criteria based on the hazard potential classification, height, and storage volume for its respective industry?*** – indicate if the dam meets the IRPI hazard potential, size, and storage volume criteria. Refer to the IRPI Criteria Flowchart.

    If yes, the site should be assigned an MSHA ID Number and the remainder of the form should be completed. The information collected should be entered into the IRPI database through MSIS. If the dam does not meet the IRPI criteria, no further information is needed; however, page 1 of the form should be retained as a record that an initial assessment of the dam was conducted.

23. ***MSHA ID Number Assigned and Issue Date**** – provide the MSHA-assigned identification number and the date that it was issued.

Dam Description

24. ***Phase**** – indicate whether the dam is under construction or construction has been completed to its final configuration.

25. ***Stage**** – document the stage or phase through which the dam is completed (e.g., Stage 2, Phase 3c). If construction is occurring, document the stage/phase under construction. If operator has no stage/phase identifier, state "Construction completed to crest <elevation>."

26. ***Embankment Construction Material**** – indicate what material was used to construct the dam. Typical materials include earth/refuse/tailings, rockfill, or other.

27. ***Configuration*** – indicate the configuration of the dam. Typical configurations include cross-valley, side-hill, and diked.

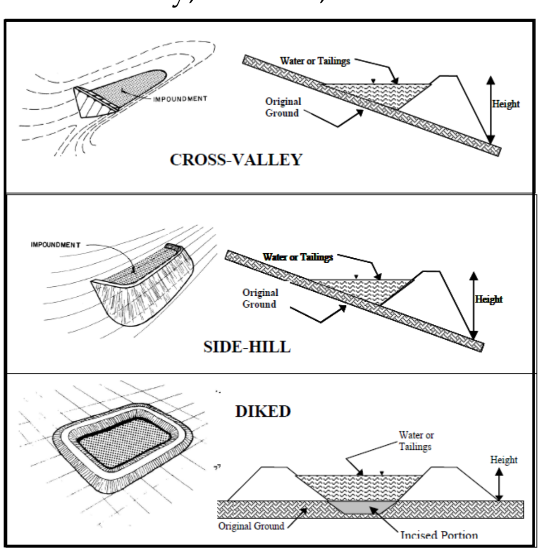


Figure 1. Embankment Configurations

28. *Type of Construction* – indicate the type of dam embankment construction method. Types of construction include downstream, centerline, and upstream. The most complex type should be chosen and entered into IRPI. Order of increasing complexity is Downstream, Centerline, and then Upstream.

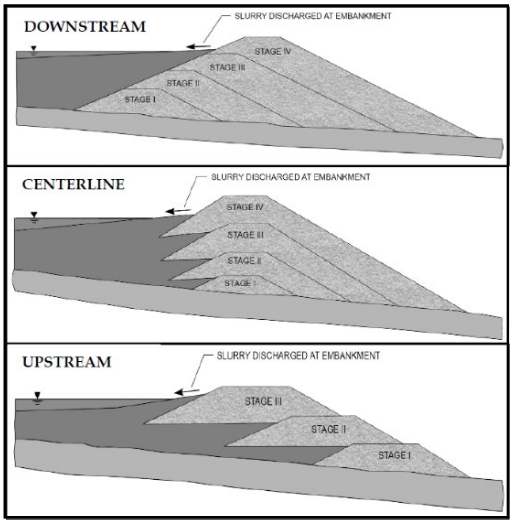


Figure 2. Embankment Construction Methods

29. *Saddle Dam(s)* – indicate if there are any saddle dams**.**

30. *Designation/Name of Saddle Dam(s)* – if there are saddle dams, provide the designation/name for each saddle dam.

31. *Slurry Cells** – indicate whether there are slurry cells**.** See Chapter 2 for additional information on slurry cells.

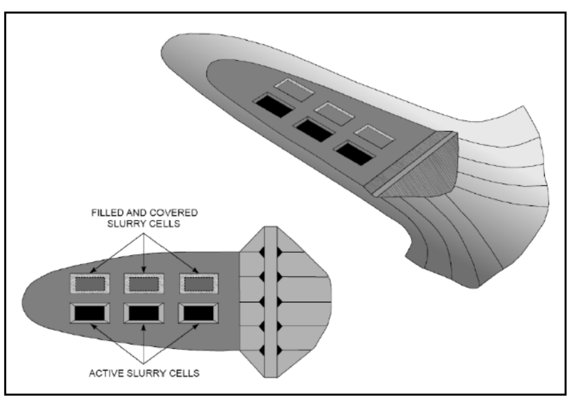


Figure 3. Example of Slurry Cells

32. *Slurry/Tailings Remining** – indicate if remining of the slurry or tailings is occurring.

33. *Mining Underneath** – indicate if there is mining beneath the dam or the reservoir.

34. ***Breakthrough Potential**** – indicate if there is the potential for breakthrough into mines beneath the reservoir.

35. ***Breakthrough Mitigation Measure(s)*** – indicate if there are any mitigation measures in place to reduce the breakthrough potential. Mitigation measures include construction of mine barrier or bulkheads, mine backfill, slurry/tailings modification, or monitoring. If there are no mitigation measures, select none. If there is no mining underneath and no breakthrough potential, select not applicable.

36. ***Dam Length**** – provide the length of the dam along the crest in feet.

37. ***Normal Pool Elevation and Storage Volume*** – provide the normal pool elevation in feet and the corresponding storage volume in acre-feet. The normal pool elevation is the elevation of the invert (entrance) of the lowest outlet structure (decant or open channel). If no outlets are present, use the pool elevation. The normal pool storage volume can be calculated using the IRPI Criteria Flowchart equations, considering the reservoir area at the normal pool elevation.

38. ***Freeboard*** – provide the freeboard distance in feet. Freeboard is the vertical distance between the lowest ungated outlet/normal pool to the lowest point of the crest. If no outlets are present, use the current pool elevation.

39. ***Drainage Area*** – provide the drainage area in square miles. The drainage area is the area that contributes runoff into the reservoir. It must be obtained from the operator or a topographic map.

Outlet Structure(s) Inventory

40. ***Decant Pipe*** – indicate if a decant pipe is present.
    - **a.** ***Type**** – indicate the type of decant. Typical decant materials include reinforced concrete, corrugated metal, HDPE, and welded steel. Other can also be selected if the typical materials do not apply.
    - **b.** ***Size*** – provide the diameter in inches if the decant is circular, or the width and height in inches if the decant is rectangular.

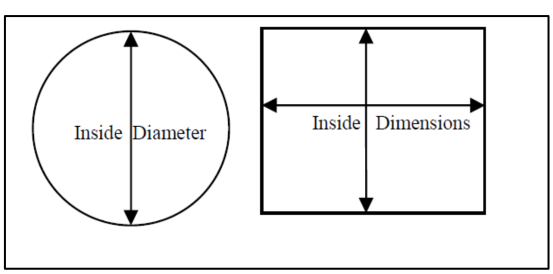


Figure 4. Decant Pipe Size Determination

41. ***Open-Channel Spillway*** – indicate if an open-channel spillway is present.
   a. ***Shape**** – indicate the shape of the channel. Typical open channel shapes include trapezoidal, triangular, rectangular, or irregular.
   b. ***Depth*** – provide the depth of the open-channel spillway in feet.
   c. ***Bottom Width*** – provide the bottom width of the open-channel spillway in feet.
   d. ***Top Width*** – provide the top width of the open-channel spillway in feet.

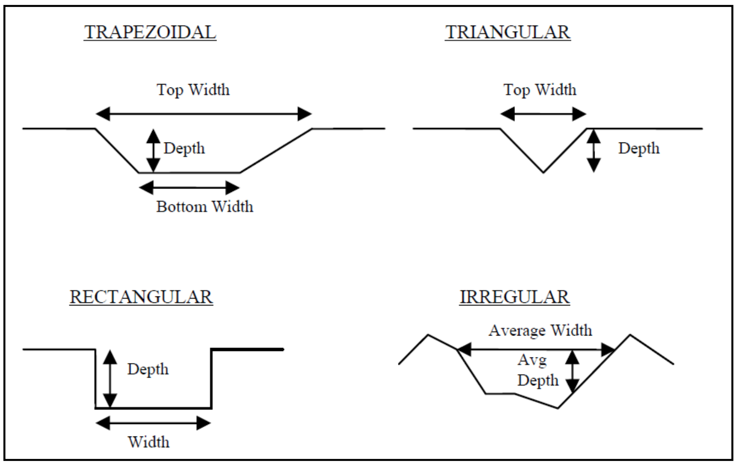


Figure 5. Open-Channel Spillway Geometry

42. ***Describe Other Outlet Type(s)*** – provide detailed information for any other outlet structure(s) or if a pumping system is used for pool control. The information provided for additional outlet structures should be identical to the information provided in the previous items. If a pumping system is used, details regarding the number and capacity of pumps, as well as the availability of a fuel source should be provided.

Condition Assessment and Recordkeeping

43. ***Date of Inspection (using MSHA Inspection Checklist) to Assess Condition**** – provide the date that a complete inspection took place. This inspection should utilize the MSHA Dam Inspection Form (Appendix 5).

44. ***Condition Assessment**** – indicate the condition assessment that best describes the dam after a thorough inspection using the MSHA Inspection Checklist has been completed. Available condition assessment options include the following.
   a. Fair – deficiency recognized that would only be affected by rare or extreme events;
   b. Not rated – dam has not been inspected;
   c. Not rated – not under state jurisdiction;
   d. Poor – deficiency recognized for loading conditions that may realistically occur;

e. Poor – more analysis needed;
f. Satisfactory – meets applicable hydrologic and seismic regulatory criteria (site has an approved design plan);
g. Satisfactory – meets applicable tolerable risk criteria; or
h. Unsatisfactory – deficiency recognized that requires immediate or emergency action.

"Rare or extreme events" would include the probable maximum precipitation or large magnitude earthquakes. "Loading conditions that may realistically occur" would include the 100-year precipitation.

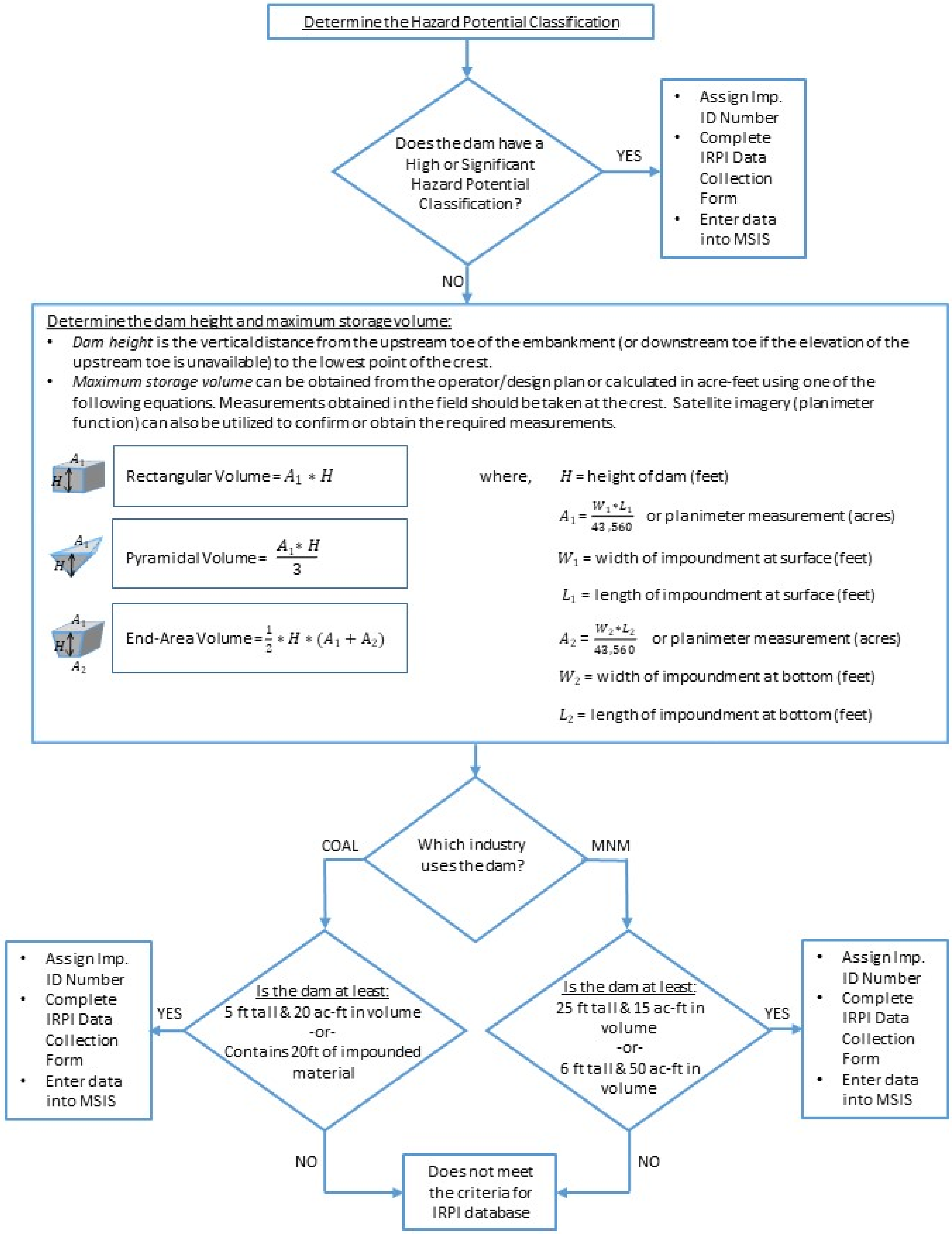
45. ***Describe any failures or incidents at the site that resulted in a partial/complete loss of the dam or its hydraulic structures, or a partial/complete unintentional release from the reservoir and when it occurred*** – provide an explanation for any known failures or incidents that have occurred at the dam. Relevant details include when it occurred, the location, consequences/effects of the incident, operator actions/repairs, etc.

46. ***Has information on this form been reviewed by Imp. Supervisor/Specialist/etc.*** – indicate whether the information collected on this form has been reviewed by the impoundment supervisor, impoundment Specialist, dam safety representative, etc.

47. ***Has the information collected been entered into IRPI*** – indicate whether the information collected on this form has been entered into the IRPI database.

48. ***Date entered into IRPI*** – provide the date that the collected information was entered into the IRPI database.

Determining if an MSHA Dam needs to be entered into the IRPI Database



APPENDIX 5

MSHA Dam Inspection Form

Administrative Information	
Mine Name:	Mine ID:
Operator Name:	Industry: Coal ☐ MNM ☐
Site Name:	Facility ID:
Hazard Potential Classification: High ☐ Significant ☐ Low ☐	
Purpose(s) of Dam: Tailings ☐ Water Supply ☐ Sedimentation ☐ Treatment Pond ☐ Other ☐	
Inspector Name(s):	AR No(s).:
Event No.:	Date/Time:
Weather:	Temperature:
Type of Inspection:	
Accompanied by:	

For coal impoundments, some information requested below will be obtained from the approved design plan. For other dams, information may be obtainable from available design plans, IRPI database, discussions with mine operator, direct measurement, or not available at all. This form is organized such that the inspection is conducted starting at the crest to the downstream toe.

Deficiencies identified during the inspection could affect performance of the dam and should be reported to the Impoundment Specialist, Supervisor, or District Manager for further evaluation. Observations that result in a "no" response on this form indicate a potential problem. For these items, a comment should be provided explaining the condition. The inspector should also indicate whether photographs, sketches, comments, or other supporting information has been included by checking the appropriate box at the end of each subject area.

General Information

(Obtained From Design Plan, Impoundment Data Sheet, IRPI Database, Previous Inspection Records, or at the Mine Office.)

1) Present stage: ______________________________
2) Maximum crest elevation: ______________________________
3) Downstream toe elevation: ______________________________
4) Active work surface elevation: ______________________________
5) Maximum allowable pool elevation: ______________________________
6) Outlet structure details: Drop Inlet ☐ Culvert ☐ Open-Channel Spillway ☐ Pump ☐
____
____

7) Saddle dam name(s) and details: ______________________________
____

8) Operator examinations conducted? Frequency: ____________	Y N
9) Material Placement, Compaction, and Testing:	
a. Are material placement records available?	Y N NA
b. Are the test results in compliance with the design plan?	Y N NA
c. Have failed compaction tests been retested?	Y N NA
10) Instrumentation:	
a. Record in comment section or attach supporting documentation with the number and type of instrumentation. Have details regarding instrumentation been recorded or attached?	Y N NA
b. Are instrumentation readings recorded? Monitoring frequency: ____________	Y N NA
c. Are piezometer readings within allowable values?	Y N NA
d. Considering the pool elevation/previous readings, are piezometer changes reasonable?	Y N NA
e. Are flow rates for internal drain outlets, seeps, or mine openings consistent with previous inspections?	Y N NA

Information Obtained During On-Site Inspection.
11) Briefly describe recent or current construction activities on site:

Active Construction	
12) Is the foundation preparation appropriate (removal of vegetation, stumps, topsoil)?	Y N NA
13) Conduit Installation:	
a. Is material being placed and compacted in haunches and along pipe?	Y N NA
b. Will the conduit have a seepage control device?	Y N NA
14) Embankment Material Placement and Compaction:	
a. Is material being placed in compliance with the design plan?	Y N NA
b. Is material being placed and compacted in thin, nearly-horizontal lifts?	Y N NA
c. Lift Thickness: ________ inches	
d. Is the previous lift being scarified?	Y N NA
e. Is material being adequately tied in and compacted at abutments?	Y N NA
15) Conveyor Delivery:	
a. Is equipment on-site in compliance with the design plan?	
b. Does the work surface appear compacted?	Y N NA
c. Is material being spread nearly horizontal or in compliance with the design plan?	Y N NA
16) Upstream Construction:	
a. Is the pushout or raise free of significant cracks and scarps?	Y N NA
b. Are the safety provisions in compliance with the design plan (e.g., buffer zone, crack monitoring, unmanned equipment, etc.)?	Y N NA
17) Has the designer, certifying engineer, or representative been on-site to oversee critical construction activities?	Y N NA
Photographs ☐ Sketches ☐ Comments/Supporting Information ☐	

Crest, Upstream Slope, and Pool	
18) Main Embankment Crest:	
a. Minimum Width: _________ feet	
b. Is the crest width in compliance with the design plan?	Y N NA
c. Is the crest uniform and sloped to drain?	Y N
d. Is the crest free of cracking, scarps, and significant erosion? See "Slope Stability" Flowchart	Y N
19) Saddle Dam Crest(s):	
a. Minimum Width: _________ feet	
b. Is the crest(s) width in compliance with the design plan?	Y N NA
c. Is the crest(s) uniform and sloped to drain?	Y N NA
d. Is the crest(s) free of cracking, scarps, and major erosion? See "Slope Stability" Flowchart	Y N NA
20) Pool Control Structure or Method:	
a. Is there a principal spillway pipe, open-channel spillway, or pump system?	Y N
b. Are the items listed in Item No. 6 present?	Y N NA
21) Freeboard:	
a. Lowest main embankment or saddle dam crest elevation: _________ feet	
b. Elevation of invert of outlet structure or normal pool: _________ feet	
c. Calculate freeboard from Item Nos. 21a and 21b: _________ feet	
-Or-	
Measured distance between crest and pool: _________ feet	
d. Is freeboard in compliance with the design plan or at least 3 feet?	Y N

22) If pumps are necessary to draw down the design storm pool: a. Are they present? b. Is fuel available? c. Are they tested regularly? Testing frequency:________________	Y N NA Y N NA Y N NA
23) Has the natural ground above the pool area been cleared of unstable material, trees, and other potentially floatable debris that could cause an increase in pool level or clogging of the outlet structure(s)?	Y N
24) Upstream Slope: a. Upstream Slope Inclination: ______ degrees b. Is the slope flatter than 2H:1V (i.e., 27 degrees) or as per the design plan? c. Is it free of sinkholes, significant erosion, and wave damage? See "Boil/Whirlpool/Sinkhole" Flowchart	 Y N Y N
25) Fine Refuse or Tailings Disposal: a. Is fine refuse or tailings discharged uniformly along the entire upstream slope of the embankment? b. Is the fine refuse or tailings beach area relatively uniform (e.g., no significant erosion, depressions, whirlpools, or sinkholes)? c. Min. width of fine refuse/tailings beach (distance between pool and upstream slope): _________ feet See "Boil/Whirlpool/Sinkhole" Flowchart	 Y N NA Y N NA
Photographs ☐ Sketches ☐ Comments/Supporting Information ☐	

Principal Spillway and Other Conduits	
26) Principal Spillway: a. Inlet Elevation (or distance below crest): _________ feet b. Is the inlet at or below design elevation for stage or crest elevation? c. Inlet diameter or dimensions: ________ inches d. Is the inlet configuration in compliance with the design plan or as listed in Item No. 6? e. Is water entering the inlet? Yes_____No____NA_____	 Y N NA Y N NA
27) Principal Spillway Trashrack: a. Is a trashrack present on the inlet? b. Is it in good repair and attached? c. Is it clear of debris?	 Y N NA Y N NA Y N NA
28) Is the principal spillway unrestricted (e.g., no valves, gate structures, pump discharge lines, etc.)?	Y N NA
29) Other Conduits: a. Are all other conduits unrestricted? b. If a valve or gate is present: i. Is it located at the upstream end of the pipe? ii. Is the valve/gate accessible and operable?	 Y N NA Y N NA Y N NA
Photographs ☐ Sketches ☐ Comments/Supporting Information ☐	

Open-Channel Spillway and Ditches	
30) Open-Channel Spillway Control Section: a. Invert/Bottom Elevation: _________ feet b. Bottom Width: _________ feet c. Channel Depth: _________ feet d. Side Slopes: _____ degrees e. Erosion Protection: ____ f. Is the invert elevation in compliance with the design plan for stage or crest elevation? g. Is the open-channel spillway geometry and erosion protection in compliance with the design plan?	 Y N NA Y N NA
31) Are the open-channel spillway and ditches clear of debris/obstructions?	Y N NA
32) Is the lining/erosion protection intact for the open-channel spillway and ditches?	Y N NA
33) Does the open-channel outlet extend far enough downstream to safely discharge the flow past the dam?	Y N NA
Photographs ☐ Sketches ☐ Comments/Supporting Information ☐	

Main Embankment and Saddle Dam(s)

34) Main Embankment Configuration: a. Downstream Inter-bench Slope Inclination: _____ degrees b. Bench Width(s): _________ feet c. Bench Vertical Interval(s): _________ feet d. Is the configuration in compliance with the design plan?	Y N NA
35) Saddle Dam Configuration(s): a. Downstream Inter-bench Slope Inclination: _____ degrees b. Bench Width(s): _________ feet c. Bench Vertical Interval(s): _________ feet d. Is the configuration in compliance with the design plan?	Y N NA
36) Are the main embankment and saddle dam slopes being maintained and free of: a. Scarps, sloughing, significant erosion, and bulging? b. Trees or heavy vegetation? i. Diameter of largest tree: _______ inches ii. Location of tree(s): ______________________________ c. Sinkholes, depressions, or animal burrows? d. Over-steepened slopes (i.e., steeper than 2H:1V or 27 degrees)? See "Slope Stability" Flowchart	a. Y N b. Y N c. Y N d. Y N
37) In reclaimed areas is the vegetative cover adequate to control erosion?	Y N NA
38) Is instrumentation being maintained?	Y N NA
39) Seepage: a. Are the main embankment and saddle dam(s) free of seeps or signs of seepage on the surface? b. Is the operator aware, monitoring, and taking action at all seepage locations identified? c. If the operator is not monitoring, describe the location, dimension, flow rate, and clarity of seep(s): ______________________________ ______________________________ See "Seepage" Flowchart	a. Y N b. Y N NA
Photographs ☐ Sketches ☐ Comments/Supporting Information ☐	

Principal Spillway and Drain Outlets

40) Principal Spillway Outlet: a. Is the outlet free of seepage along the outside of the pipe? b. Is the outlet unobstructed and unsubmerged? c. Is water exiting the outlet free of fines/particles? d. Do the following flow condition responses match? i. Is water exiting the outlet? Yes____ No____ NA____ ii. Was water entering the inlet (see Item No. 26e)? Yes____ No____ NA____	a. Y N NA b. Y N NA c. Y N NA d. Y N NA
41) Is the energy dissipation structure below the principal spillway outlet intact?	Y N NA
42) Internal Drain Outlet(s) a. Is the outlet(s) unobstructed and unsubmerged? b. Is the discharge free of fines/particles? c. If operator-obtained flow rate(s) from internal drain outlet(s) are unavailable: ID: _______________ Flow: ____________ gpm ID: _______________ Flow: ____________ gpm d. Are the measured/estimated flow rates consistent with previous monitoring values?	a. Y N NA b. Y N NA d. Y N NA
43) Are the discharge locations/points free from erosion and deterioration of the channel lining?	Y N NA
Photographs ☐ Sketches ☐ Comments/Supporting Information ☐	

Abutments, Foundation, and Downstream Area	
44) Seepage: a. Are the abutments, groin area, foundation, and downstream toe area free of seeps or signs of seepage on the surface? b. Is the downstream toe area free of boils? c. Is the operator aware, monitoring, and taking action at all locations identified? d. If the operator is not monitoring, describe the location, dimension, flow rate, and clarity of seep(s) or boil(s): ____________________ ____________________ See "Seepage" or "Boil/Whirlpool/Sinkhole" Flowchart	Y N Y N Y N NA
45) Is the downstream area free of impounded water against the toe?	Y N
46) Is the downstream toe area being maintained and free of trees and heavy vegetation?	Y N
47) Are the valley bottom and hillsides free of any indications of slope movement (e.g., cracks, scarps, bulging, etc.)? See "Slope Stability" Flowchart	Y N
48) Mining: a. If conditions are present that could adversely affect the main embankment or saddle dam(s) (e.g., mine openings, subsidence, auger holes, etc.), have they been addressed? b. Is the operator aware of and monitoring all discharge locations? c. If the operator is not monitoring, describe the location, flow rate, and clarity of discharge: ____________________ ____________________	Y N NA Y N NA
49) Hazard Potential Classification: a. Since the current hazard potential classification was determined, has development downstream of the facility remained unchanged? b. Does the present hazard potential classification appear appropriate based on observed downstream development?	Y N NA Y N
Photographs ☐ Sketches ☐ Comments/Supporting Information ☐	

50) Describe any additional conditions not captured in this form:

Sketches:

Additional Comments or explanation for “no” answers (attach additional sheets as needed):

Description of MSHA Dam Inspection Form Fields

Administrative Information

- ***Mine Name, Mine ID, Operator Name*** – indicate current mine name and operator for mine ID.
- ***Industry*** – coal or metal and nonmetal mine.
- ***Site Name, Facility ID*** – provide the name(s) for the dam, the MSHA-assigned ID number, and the National Inventory of Dams ID number (NID) if assigned.
- ***Hazard Potential Classification*** – check the appropriate box to indicate the hazard potential classification for the site. Hazard potential classification is defined in Chapter 2 of the Handbook.
- ***Purpose(s) of Dam*** – indicate how the dam is used by the operator. Select from the available responses: Tailings, Water Supply, Sedimentation, Treatment Pond, Other. Tailings should be used for any site where material from the processing operation will be disposed. Multiple choices can be selected.
- ***Inspector Name(s), AR No(s).*** – indicate the MSHA personnel involved with the inspection.
- ***Event No.*** – Enforcement event number under which the inspection is being conducted.
- ***Date/Time*** – indicate for first day and time on site, and note subsequent dates/times, as appropriate.
- ***Weather, Temperature*** – indicate the general weather conditions at the time of the inspection.
- ***Type of Inspection*** – indicate the code for the type of inspection conducted. Also indicate if there is a specific purpose for this inspection.
- ***Accompanied by*** – document others that were present during the inspection, including company officials, miners' representative, or others. Document names and affiliations.

General Information Obtained From Design Plan, Impoundment Data Sheet, IRPI Database, Previous Inspection Records, or at the Mine Office

The following information will be obtained from the design plan, impoundment data sheets (coal), previous inspection records, IRPI database, or discussions with the mine operator prior to beginning the on-site inspection. The inspection will include verification that the site is operating according to the design plan (if available) and examination for deficiencies.

Item numbers correspond with the numbered line on the inspection form. Key inspection items require a Yes (Y) or No (N) response. A "No" response may or may not indicate a deficiency, but should be explained in the comment section of the form, including why the condition may be contrary to good practice. Inspection items that do not apply to the current dam inspection should be marked with as Not Applicable (NA), and may also require explanation in the comment section.

1. ***Present stage*** – document the stage or phase through which the dam is completed (e.g., Stage 2, Phase 3c). If construction is occurring, document the stage/phase under construction. If operator has no stage/phase identifier, state "Construction completed to crest <elevation>."

2. ***Maximum crest elevation*** – document the maximum design crest elevation for the current stage of construction. If no plan applies, document the elevation that should be found at the crest.

3. ***Downstream toe elevation*** – document the elevation of the downstream toe. Using the maximum crest elevation and the downstream toe elevation, the structural height of the embankment can be calculated. This height can be compared to those obtained during previous inspections to help determine whether significant structural changes have been made. If it appears changes have been made, this should be discussed with the operator and documented for any deficiencies or response.

4. ***Active work surface elevation*** – document the elevation at which embankment construction work is currently taking place on the dam. Compare this elevation to previous inspection records to determine if changes to the embankment have occurred. Document the findings, including if no embankment construction work is occurring.

5. ***Maximum allowable pool elevation*** – from the design plan, document the maximum pool elevation allowed for the current crest elevation. If no plan applies, document the elevation that should be found for the pool.

6. ***Outlet structure details*** – document the types of outlet structures that should be present on the dam for the current stage of construction. Note type of outlet (Drop Inlet, Culvert, Open-Channel Spillway, or Pump). Note any pertinent information (e.g., inlet elevation, size/geometry, materials, etc.) that will be confirmed when on-site.

7. ***Saddle dam names and details*** – document the number and names of saddle dams at the site.

8. ***Operator examinations conducted*** – examine the mine operator's examination records to verify that thorough inspections are being conducted and at what frequency. Ensure the operator examinations cover all important aspects of the dam (e.g., slopes, crest, inlets, outlets, instrumentation, etc.). Ensure deficiencies found are evaluated and corrected as necessary.

9. ***Material Placement, Compaction, and Testing*** – document the required embankment placement criteria. Criteria should include lift thickness, compaction equipment, density standard, moisture content range, and field and laboratory density test frequency.
   a. Document whether the operator is maintaining records of materials placed during construction of the embankment.
   b. Document whether the operator's records show material placement is in compliance with the design plan.
   c. Document whether locations receiving failed density tests have been retested (if applicable).

10. ***Instrumentation –*** many problems at dams develop internally and are not visible on the surface. Instrumentation is important to assess whether the dam is functioning as intended and to monitor for changing conditions. The most common instruments include piezometers to measure the dam's internal water surface (phreatic surface) or pore-water pressure, weirs to measure water flow, and survey monuments or gauges to measure movement.
    a. Record the type and number of instruments that should be found at the dam. For coal impoundments, the design plan and Impoundment Data Sheet will list instruments along with their maximum allowable readings for the current stage of construction. For sites without a plan, the comment sheet of the inspection form can be used to record the instruments based on a discussion with the mine operator. Indicate on the form whether details regarding instrumentation has been attached or documented on the inspection form. Mark "NA" if no instrumentation is present on the dam.
    b. Document whether records of instrument readings are maintained by the operator. Ideally, a chart of readings versus date should be used to see trends in readings.
    c. Document whether readings are in compliance with the design plan.
    d. Piezometer readings should typically be below the elevation of the pool and rise slowly as the pool rises over time. Unexpected high or low readings could indicate a seepage problem or malfunctioning instrument and should be investigated further.
    e. Outflow from drains, seeps, and mine entries generally remain steady and may rise as the pool rises. Unexpected rises or drops in flow could indicate a problem and should be investigated further.

Information Obtained During On-Site Inspection.

Items 11 through 50 will be obtained during the on-site examination of the dam. The form is organized as though the inspection begins at the crest of the dam and proceeds down the embankment to the toe of the dam. The inspection form groups information for components of the dam that would typically be found together. At the end of each group are checkboxes to indicate whether photographs, sketches, or comments/supporting information have been included.

Photographs ☐	Sketches ☐	Comments/Supporting Information ☐

11. ***Describe recent or current construction activities on site*** – briefly explain current activities taking place at the site. Examples include "Construction of the stage 3 pushout," "Installation of piezometer #3," "No new construction. Deposition of tailings at <approximate location>."

Active Construction

Items 11 through 16 pertain to an area of **active construction on the dam**. Active construction includes work to raise or expand the embankment, installation of a conduit through the embankment, and critical construction items (see Section B of this chapter). If this work is underway or planned, these areas should be inspected even if work is not being performed at the time of the inspection.

12. ***Foundation preparation*** – the footprint beneath the future embankment should be properly prepared to reduce or eliminate potential settlement, instability, and seepage issues. The following issues should be inspected.
    - Area should be stripped of trees, large stumps, heavy vegetation, and potentially problematic soils.
    - Large cracks in rock should be filled or otherwise treated to prevent a preferential seepage path.

13. ***Conduit installation*** – conduits (pipes) through dams provide a potential seepage path directly from the pool to the downstream face. Proper backfill of pipe trenches is important to reduce seepage and provide structural support for the conduit. The following issues should be inspected.
    a. Compaction is critical in the haunch and up to the springline. Other methods to backfill the pipe trench may be used, such as flowable fill, that do not require compaction, but adequately fill the haunch area. Fill should rise equally on each side of the pipe in lifts not exceeding 6 inches.
    b. Control of seepage along a buried conduit is critical. The preferred method for controlling seepage is with the use of a filter diaphragm located between the crest of the dam and the downstream end of the conduit. The filter diaphragm collects

seepage traveling along the conduit and conveys it safely outside the dam. In some instances, such as in low hazard potential dams, anti-seepage collars attached to the conduit can be used. Careful placement and compaction of soil around the collars is critical to avoid damage to the pipe and collars and to ensure seepage will be reduced.

14. ***Embankment material placement and compaction*** – material used to construct the structural portion of the embankment should be placed in a deliberate and controlled fashion rather than simply dumped. Each layer (lift) should be compacted to improve the seepage, strength, and settlement characteristics of the material.
    a. Indicate whether the material is being placed in accordance with an available design plan. Mark "NA" if no design plan is available or embankment construction is not taking place.
    b. Indicate whether the material is being placed in thin, nearly horizontal lifts. The work surface should be graded to prevent accumulation of water. Constructing an earthen embankment at steep grades results in reduced compaction. Acceptable maximum grade is 5 percent. When a lift thickness is not specified in a design plan, the following general values are acceptable before compaction for each lift.
        - Coarse-grained soil – up to 12 inches
        - Fine-grained soil – up to 8 inches
    c. Document the loose (prior to compaction) lift thickness being used (inches).
    d. Compacted lifts should be scarified (roughed up) to eliminate any smooth surface that could result in a preferential seepage path.
    e. Embankment material should be carefully tied into the natural ground surface at the abutments to help prevent seepage problems in that area. Hand compaction may be necessary where the natural ground is very steep.

15. ***Conveyor delivery*** – some mines use a conveyor to deliver embankment construction material to the work area. This method can create problems if sufficient equipment is not available to spread and compact the material at a rate matching delivery of the material.
    a. A design plan should contain a material-handling analysis. The delivery rate of material should be analyzed along with the time to properly spread and compact the material. Using this information, the number of bulldozers and compactors required can be determined. This equipment should be operating whenever material is being delivered by the conveyor.
    b. Every lift in the embankment must be compacted by specialized compaction equipment, bulldozers, or rubber-tired vehicles. The entire work surface should be covered before placing additional material on top of it. A compacted work surface will not be loose, except possibly for the top several inches where bulldozer tracks have roughed it.
    c. Nearly horizontal lifts are necessary to achieve adequate compaction throughout the newly placed layer. Acceptable maximum grade is 5 percent.

16. ***Upstream construction*** – upstream construction is taking place when a new embankment is being constructed atop hydraulically placed fine coal refuse or tailings. In this method, the crest of the dam embankment is moving in the upstream direction. Upstream construction must be closely monitored due to the potential for the embankment to fail in the upstream direction.
    a. Sloughing, settlement, and cracking of the work surface near the leading edge of the pushout is common. However, cracking further back from the leading edge is a sign of potential instability that should be evaluated. Personnel and mobile equipment should not travel past cracks in the work surface. Cracks are openings in the soil surface. Cracks have no vertical displacement associated with the opening. Scarps are openings with vertical displacement across the opening (one side is lower). Cracks with displacement exceeding 3 horizontal inches or scarps exceeding 6 vertical inches are considered significant and should be evaluated further.
    b. For sites with design plans, the plan should cover safety aspects of the work. That includes definition of a buffer zone beyond which nothing but bulldozers or low ground pressure vehicles should travel. The plan should also address potential cracking of the work surface and how the cracks will be addressed and monitored. Some plans specify that unmanned equipment will be used within the buffer zone. The inspector should ensure the provisions of the design plan are being followed.

17. ***Design engineer, certifying engineer, or representative on site to oversee critical construction activities*** – construction activities defined as critical to the stability and performance of the dam should be overseen by the design engineer, the engineer certifying the quality of work on site, or their qualified representative. Section B of this chapter describes critical construction activities. Mark "NA" if no critical construction activities are taking place at the site.

Crest, Upstream Slope, and Pool

Items 18 through 25 pertain to the **crest, upstream slope, and pool area** of the main embankment and any saddle dams.

18. ***Main embankment crest*** – the embankment crest should be uniform in elevation and width across the length of the dam unless active construction is taking place on the crest.
    a. Document the narrowest width of the crest from downstream to upstream edge.
    b. For sites where a design plan is available, indicate whether the crest width complies with the plan. Crests should have a minimum width of 20 feet.
    c. Indicate whether the crest elevation is uniform across its length and that it is sloped to prevent accumulation of water. Water should not be allowed to pond on the crest surface because it can create problems during construction and can infiltrate into the embankment.
    d. Indicate whether cracks, scarps, or significant erosion is present on the crest. Cracks and scarps are openings in the soil as discussed under item 15a. These features on

the crest or upstream slope, with any amount of horizontal or vertical displacement, may indicate stability or settlement issues and should be evaluated further. Transverse cracks, which run from upstream to downstream face, are a direct path for water through the embankment and can result in a breach. See the Slope Stability flowchart at the end of this appendix for further information.

19. ***Saddle dam crest(s)*** – the following information relative to all saddle dams at the site should be documented.
    a. Examine all saddle dams and document the minimum crest width found.
    b. Indicate whether the minimum crest width is in compliance with the design plan (if available).
    c. Indicate whether the saddle dam crest(s) are uniform and sloped to drain.
    d. Indicate whether the saddle dam crest(s) are free of cracking, scarps, and significant erosion. See the Slope Stability flowchart at the end of this appendix for further information.

20. ***Pool control structure or method*** – the dam should have a means to control the normal pool level and to draw down the pool after a precipitation event. Dams with no method to control the normal pool may not have the freeboard available to contain precipitation runoff and could overtop.
    a. Indicate whether a principal spillway pipe (decant), open-channel spillway, or pumping system is present at the site.
    b. Compare the appurtenances present to the information obtained for item 6 of the inspection form. If the required appurtenances are not present, or no method to control the pool is present, mark "N."

21. ***Freeboard*** – all dams should maintain empty storage volume between the normal pool and the crest of the embankment. This volume is needed to temporarily store precipitation runoff and should be sufficient to prevent overtopping of the embankment.
    a. Determine the lowest crest elevation on the main embankment or any saddle dam.
    b. Determine the elevation of the invert (entrance) of the lowest outlet structure (decant or open channel). If no outlets are present, use the pool elevation.
    c. If elevations were found for items 21a and 21b, subtract 21b from 21a to determine the normal pool freeboard. If elevations could not be obtained, measure the distance between the lowest point on the embankment crest and the pool.
    d. Mark "N" if the freeboard present does not comply with the design plan or is less than 3 feet.

22. ***Pumps necessary to draw down the design storm pool –*** after a precipitation event, the pool needs to be lowered so the dam is again capable of handling a precipitation event. Conduits and open-channel spillways are the preferred methods. However, an operator may use pumps for this purpose.
    a. Pumps must be present at the dam at all times. Once the storm begins, there may not be time to bring the pumps to the site.

b. Fuel must be present for the pumps.
c. Pumps must be tested to ensure they are operable. Monthly testing is generally an acceptable frequency. Document the operator's testing frequency.

23. ***Pool area clear of unstable material, trees, and other floatable debris*** – a ground failure above the pool could result in a rise in pool elevation. Loose and floatable debris (trash, logs, etc.) in the pool area can block any outlet and prevent it from passing water as intended. Both scenarios could result in overtopping of the embankment.

24. ***Upstream slope*** – the upstream slope of the embankment should be inspected for potential signs of instability.
    a. Measure the slope of the upstream slope.
    b. Indicate whether the slope complies with the design plan. If no plan is available, mark "N" if the slope is greater than 2 horizontal feet to 1 vertical foot (2H:1V), or 27 degrees. Slopes steeper than this value could present stability problems and should be documented and investigated further.
    c. Sinkholes on the upstream slope could indicate a serious internal erosion condition. See Boil/Whirlpool/Sinkhole flowchart. Erosion gullies on the upstream slope can result in an elevated internal water surface, especially when water is impounded against the slope.

25. ***Fine refuse of tailings disposal*** – tailings and fine coal refuse may be pumped to the site as a slurry or can be trucked if it is dry enough.
    a. Ideally, tailings should be discharged or deposited along the upstream slope of the embankment rather than at some other point in the pool. This material pushes water away from the embankment, which helps reduce seepage. The material should be placed uniformly along the entire upstream slope. It is acceptable for discharge lines or dump points to be moveable.
    b. Sinkholes or whirlpools near the beach formed by the deposited tailings could indicate a serious seepage condition and must be evaluated further. See Boil/Whirlpool/Sinkhole flowchart.
    c. It is desirable to keep free-standing water as far from the embankment upstream slope as possible to reduce seepage. Determine the distance from the upstream slope to the edge of the pool.

Principal Spillway and Other Conduits

Items 26 through 29 pertain to the **principal spillway and other conduits through the embankment**. The principal spillway is the primary structure for controlling the water elevation in the pool (normal pool elevation) and may be used to draw down the pool during/after a precipitation event.

26. ***Principal spillway*** – this outlet is typically a pipe or other conveyance through the embankment with a vertical riser or horizontal inlet in the pool area.

a. Document the elevation of the inlet or the distance the inlet is below the crest of the embankment.
b. The inlet elevation determines the freeboard available. Indicate whether the value obtained for item 26a complies with the design plan for the current crest elevation. Mark "N" if the inlet is higher than the design elevation. A lower elevation is acceptable.
c. The inlet may be a vertical riser or horizontal culvert. The inlet is typically a circular or square/rectangular shapes. Document the inside diameter (pipe) or dimensions (non-circular) of the inlet.
d. Determine whether the inlet dimensions comply with the design plan or as documented in item 6.
e. Document whether water is entering the inlet. This information will be used when evaluating item 40.

27. ***Principal spillway trashrack*** – the trashrack is typically a steel grate attached to the principal spillway's inlet to prevent debris from entering the spillway that could result in blockage.
    a. Indicate whether a trashrack is present.
    b. Indicate whether the trashrack appears to be in good repair and securely attached. The trashrack should include an "anti-vortex" plate to help prevent a whirlpool from forming at the inlet, which reduces flow capacity and could lead to structural damage to the conduit.
    c. Document whether the trashrack or principal spillway inlet is clear of debris. Debris covering the trashrack or inlet reduces the spillway's capacity and could result in overtopping of the embankment.

28. ***Principal spillway unrestricted*** – valves/gates are not acceptable on the principal spillway because the spillway is needed to control the normal pool elevation and draw down the pool after a precipitation event. Valves/gates require personnel to operate, which may not be reliable. Some operations may place pump discharge lines into the principal spillway inlet. Pipes occupying more than 10 percent of the inlet's area is not acceptable because the inlet area is reduced, which reduces the capacity of the principal spillway. This practice could result in overtopping of the embankment.

29. ***Other conduits*** – pipes or other conduits may be present that are not required to control the normal pool elevation or draw down the pool after precipitation events. It is acceptable for these conduits to have restrictions such as gates or valves. However, the location of the restrictions is important.
    a. Indicate whether these conduits have restrictions.
    b. If valves/gates are present:
        i. The gate/valve should be installed at the upstream end of the conduit. Gates/valves at the downstream end of a conduit creates the condition of a pressurized pipe within the embankment, which could result in embankment damage if the conduit develops a leak.

ii. Document whether the gate/valve is accessible and operable.

Open-Channel Spillway and Ditches

Items 30 through 33 pertain to the **open-channel spillway and any ditches**. An open-channel spillway may also be referred to as an emergency spillway. Dams that do not have open-channel spillways must be carefully designed to ensure they are capable of storing or otherwise controlling the runoff from precipitation events without the dam overtopping.

Ditches are channels intended to collect and convey water in a safe manner. Diversion ditches are particularly important. They are located around the perimeter of the dam's pool area and are intended to collect precipitation runoff and prevent it from entering the pool area. The use of diversion ditches greatly affects the hydrologic design of the dam because it does not need to store or pass all the runoff volume. Careful inspection of diversion ditches is important because failure of a diversion ditch could result in the dam overtopping. Groin ditches along the embankment/abutment interface should be maintained because they convey water off the embankment slope and help prevent erosion.

30. ***Open-channel spillway control section*** – flow through an open channel is controlled to a large degree by the geometry of the channel. The critical section in the channel, the control section, is normally the point where the channel slope changes from level or upslope to downslope.
    a. Document the invert/bottom elevation of the channel.
    b. Document the bottom width of the channel at the control section.
    c. Document the sidewall height of the channel at the control section. This height can be taken to the top of rock or erosion protection material.
    d. Document the angle of the side slopes of the channel at the control section.
    e. Document the type of erosion protection used in the channel. Typical protection measures include cutting the channel in rock, or lining the channel with concrete, rock riprap, vegetation, or protective mats.
    f. Indicate whether the channel control section elevation complies with the design plan.
    g. Indicate whether the geometry and erosion protection in place complies with the design plan.

31. ***Open-channel spillway and ditches free of debris*** – blockages in the open-channel spillway or any ditch could reduce its flow capacity which could result in a higher than expected pool elevation and potential overtopping of the embankment. A blockage could also cause the channel itself to overtop and damage the main embankment. The channel or ditches should not have large vegetation growing it them (trees, bushes, tall grasses, etc.). Landslides or slope failures along the channel/ditch may also deposit soil or rock that could reduce flow capacity. Document whether the open-channel spillway and all ditches are open and free of debris that could impede flow.

32. ***Channel lining/erosion protection*** intact – indicate whether the erosion protection within the open-channel spillway and ditches is intact and appears capable of protecting the channel. Of highest importance are locations where failure of the channel or ditch could affect the safety of the main embankment. Mark "NA" if there is no open-channel spillway or ditches.

33. ***Open-channel spillway outlet location*** – flow exiting the open-channel spillway could erode the main embankment if it is not located sufficiently downstream of the toe of the embankment. This erosion could result in failure of the main embankment. Indicate whether it appears the flow exiting the open-channel spillway may impact the main embankment.

Embankment

Items 34 through 39 pertain to the **main embankment and saddle dam embankments**. The embankment is the structural portion of the dam needed to contain the impounded material. The embankment is typically constructed of soil, coarse coal refuse, or the coarse (sand-sized) portion of tailings. In general, the embankment is inspected for signs of seepage, instability, and proper geometry.

34. ***Main embankment configuration*** – a proper configuration of the main embankment is needed to help ensure stability.
    a. Document the downstream inter-bench slope inclination. If the downstream slope has benches, measure the slope of the upper slope portion from the crest to the first bench. If there are no benches, measure the slope from the crest to the toe of the embankment. This value will be used in item 34d.
    b. Document the typical width of benches present on the downstream slope of the embankment. Benches should be wide enough for vehicles if they must travel on them to access instrumentation or for other reasons. Record "NA" if no benches are present.
    c. Document the typical vertical bench interval distance. Record "NA" if no benches are present.
    d. Indicate whether the embankment's downstream slope configuration complies with the design plan.

35. ***Saddle dam configuration*** – a proper configuration of the saddle dam embankments is needed to help ensure stability. Information documented for this item should be the worst-case condition found on any saddle dam on site.
    a. Document the steepest downstream inter-bench slope inclination. If the downstream slope has benches, measure the slope of the upper slope portion from the crest to the first bench. If there are no benches, measure the slope from the crest to the toe of the saddle dam embankment. This value will be used in item 35d.
    b. Document the typical width of benches present on the downstream slopes of the saddle dam embankments. Benches should be wide enough for vehicles if they must

travel on them to access instrumentation or for other reasons. Record "NA" if no benches are present.

c. Document the typical vertical bench interval distance. Record "NA" if no benches are present.
d. Indicate whether the saddle dam embankment's downstream slope configuration complies with the design plan.

36. ***Maintenance of main embankment and saddle dam slopes*** –
    a. Document whether any of the embankment slopes appear to have signs of instability (scarps, sloughing, bulging) or significant erosion. Significant erosion includes gullies more than 2 feet deep or shallower gullies over a large area of the slope.
    b. Document whether the embankment slopes contain trees or heavy vegetation. Trees with a trunk diameter of 2 inches or greater should be cut. For trees with trunk diameters greater than 4 inches, the reference in Appendix 10 titled *Technical Manual: Impacts of Plants on Earthen Dams* (FEMA P-534, 2005) should be consulted to determine how the tree should be handled. Any vegetation that impedes the inspection or could conceal potential problems should be cut, mowed, or removed. If trees are present, document the largest diameter and the general location of the trees.
    c. Document whether sinkholes, depressions, or animal burrows are present. Sinkholes and depressions could indicate serious internal issues and must be investigated further.
    d. Indicate whether the downstream slopes are steeper than 2H:1V, or 27 degrees. Overly steep slopes could be unstable and should be evaluated to ensure they will be stable for all operating conditions of the dam.

    See the Slope Stability flowchart when additional evaluation is needed.

37. ***Vegetative cover*** – it is a good practice that portions of the downstream slope where no future work will take place be vegetated to control erosion. Indicate whether embankment slopes appear to have sufficient vegetative cover to control erosion. Mark "NA" if there are no areas in reclaimed status.

38. ***Maintenance of instrumentation*** – instrumentation present on the embankment must be protected and maintained to ensure it is able to perform its function. Instrumentation may include piezometers, weirs, surveying stations, settlement monuments, flow meters, depth indicators, and staff gauges. Instrumentation visibly marked and be protected from vehicular traffic. Protective covers should be used for sensitive instruments. Weirs should be constructed to ensure water flows through the device and not around it. Weirs and flow meters need to be free of sediment and debris to accurately measure flow rates. Indicate whether it appears instrumentation is being adequately protected and maintained.

39. ***Seepage*** – seepage through a dam embankment is common and its presence alone is not a reason for concern. However, seeps that are growing in size, increasing in flow rate, or

are carrying embankment particles should be investigated further to determine their condition. All seeps should be documented and monitored for these changes.

a. Document if seeps or signs of seepage are present on the main or saddle dam embankments. Seeps may have visible flow, may be damp spots, or may have marshy vegetation (e.g., cattails).
b. Indicate whether the operator is aware of, monitoring, and taking action at all seepage locations. Monitoring includes measuring and documenting the size, flow rate, color of the seep, and whether the flow contains soil particles. Actions may include controlling the seeps by collecting the flow and safely removing it, constructing filters to prevent soil particle migration. Actions beyond monitoring are not necessary on all seeps. However, seepage carrying particles, causing sloughs, or erosion, and seeps that have formed a hole need additional evaluation. Mark "No" when actions beyond monitoring are necessary, even if the operator is monitoring the seepage.
c. If the operator is not adequately monitoring the seepage, document the location and size (area) as well as the clarity of the seepage water.

See the Seepage flowchart when additional evaluation is needed.

Principal Spillway and Drain Outlets

Items 40 through 43 pertain to **outlets for the principal spillway and drains**. Any conduit through the embankment, especially those that travel from the pool to the downstream face such as the principal spillway, provide an avenue for concentrated seepage. In addition, the outflow from the spillway and drains should be evaluated to determine whether the device is functioning correctly.

40. ***Principal spillway outlet*** – if the spillway conduit passes through or under the embankment, the outlet will be found at some elevation on the downstream slope or downstream of the dam toe. Occasionally, the spillway conduit is not located through or under the main embankment, but a side or saddle dam. In this case, the outlet may be in a valley adjacent to the main embankment.
    a. Document whether seepage is visible along the outside of the conduit at the exit. Because the conduit passes from the pool area to an area downstream, this type of seepage can develop into a serious condition.
    b. Document whether the outlet is in good condition (not deteriorated or damaged), unobstructed by vegetation or other blockages, and not submerged.
    c. Document whether the water exiting the outlet is free of soil particles. Soil particles in the outflow could indicate a leak in the conduit. The particles could be embankment material and could lead to dam failure.

d. Pipe water-tightness assessment – mark "N" if the responses to i. and ii. below do not match. This could indicate that there is a leak in the principal spillway. The condition must be evaluated further.
   i. Indicate whether water is exiting the outlet.
   ii. Indicate whether water was entering the inlet (see item 26e).

41. ***Energy dissipation structure*** – concentrated flow from the principal spillway outlet can cause severe erosion if it is not controlled. Typical devices used for energy dissipation include plunge pools, concrete blocks, and boulders. Mark "NA" if the site does not include energy dissipation structures at the principal spillway outlet.

42. ***Internal drain outlets*** –
    a. Document whether the outlets are in good condition (not deteriorated or damaged), unobstructed by vegetation or other blockages, and not submerged.
    b. Document whether the outflow contains soil particles. Their presence could indicate the filter surrounding the drain is defective. Continued removal of soil particles from the embankment could result in failure.
    c. Document the flow rate from all drains if the operator does not collect it during their inspection.
    d. Compare current flow rates to previous values. Flows should be consistent unless there has been recent rainfall that raised the pool or infiltrated the embankment. Increases in flow for no apparent reason could indicate a developing seepage condition. Decreases in for no apparent reason could indicate a malfunctioning drain. Both conditions should be evaluated further by the operator.

43. ***Condition of outlet locations*** – the principal spillway outlet and internal drain outlets are a location of concentrated water flow that could cause erosion if not controlled. Indicate whether these area have significant erosion or damage to channel linings. Mark "NA" is there is no principal spillway or internal drains.

Abutments, Foundation, and Downstream Area

Items 44 through 49 pertain to the **abutments, foundation, and area downstream of the dam**. The abutments are the areas where the pool or embankment material contacts the natural ground.

44. ***Seepage*** – in addition to water flowing through the embankment, it may also flow around or under the embankment. Seepage through the abutments and foundation is common and its presence alone is not a reason for concern. However, seeps that are growing in size, have increasing flow rate, or are carrying soil particles should be evaluated further to determine their condition. All seeps should be documented and monitored for these changes.

a. Document whether the abutments, foundation, groin area, and downstream toe area are free of seeps or signs of seepage. Although it is more common for toe seeps to occur immediately downstream of the embankment, they can occur further away. The downstream area beyond the toe equal to the lesser of the height of the dam or 100 feet should be examined if practical.
b. Document whether boils are present. They may occur anywhere seepage emerges, but are more common beyond the toe of the dam. A "boil" is the vertical flow of water that is carrying soil particles. It may have the appearance of boiling or bubbling water. This is a serious condition and immediate actions are typically required. See the Boil/Whirlpool/Sinkhole flowchart when additional evaluation is needed.
c. Indicate whether the operator is aware of, monitoring, and taking action at all seepage locations. Monitoring includes measuring and documenting the size, flow rate, color of the seep, and whether the flow contains soil particles. Actions may include controlling the seeps by collecting the flow and safely removing it, constructing filters to prevent soil particle migration. Actions beyond monitoring are not necessary on all seeps. Mark "N" when immediate action beyond monitoring is necessary.
d. If the operator is not adequately monitoring the seepage, document the location, size, and clarity of the seeps.

45. ***Water impounded against downstream toe of embankment*** – unless specifically incorporated into the design, it is not good practice to impound water against the downstream toe of the embankment. The presence of this water could prevent monitoring of outflow from drains, prevent inspection of critical areas, and raise the water level within the embankment.

46. ***Vegetation at downstream toe area*** – document whether the area downstream of the dam toe contains trees or heavy vegetation. Trees with a trunk diameter of 2 inches or greater should be cut. For trees with trunk diameters greater than 4 inches, the reference in Appendix 10 titled *Technical Manual: Impacts of Plants on Earthen Dams* (FEMA P-534, 2005) should be consulted to determine how the tree should be handled. Any vegetation that impedes the inspection or could conceal potential problems should be cut, mowed, or removed.

47. ***Valley bottom and hillsides free of slope movement*** – the foundation beyond the toe of the embankment as well as abutment hillsides should be inspected for signs of instability. Signs of instability include cracks, scarps, and bulges. See the Slope Stability flowchart when additional evaluation is needed.

48. ***Mining conditions that could affect embankment*** – past, present, and future mining near the embankment could result in problems for the dam. Subsidence could cause damage to outlet structures as well as seepage and stability issues on the embankment. A catastrophic breakthrough of the pool into the mine workings could occur endangering

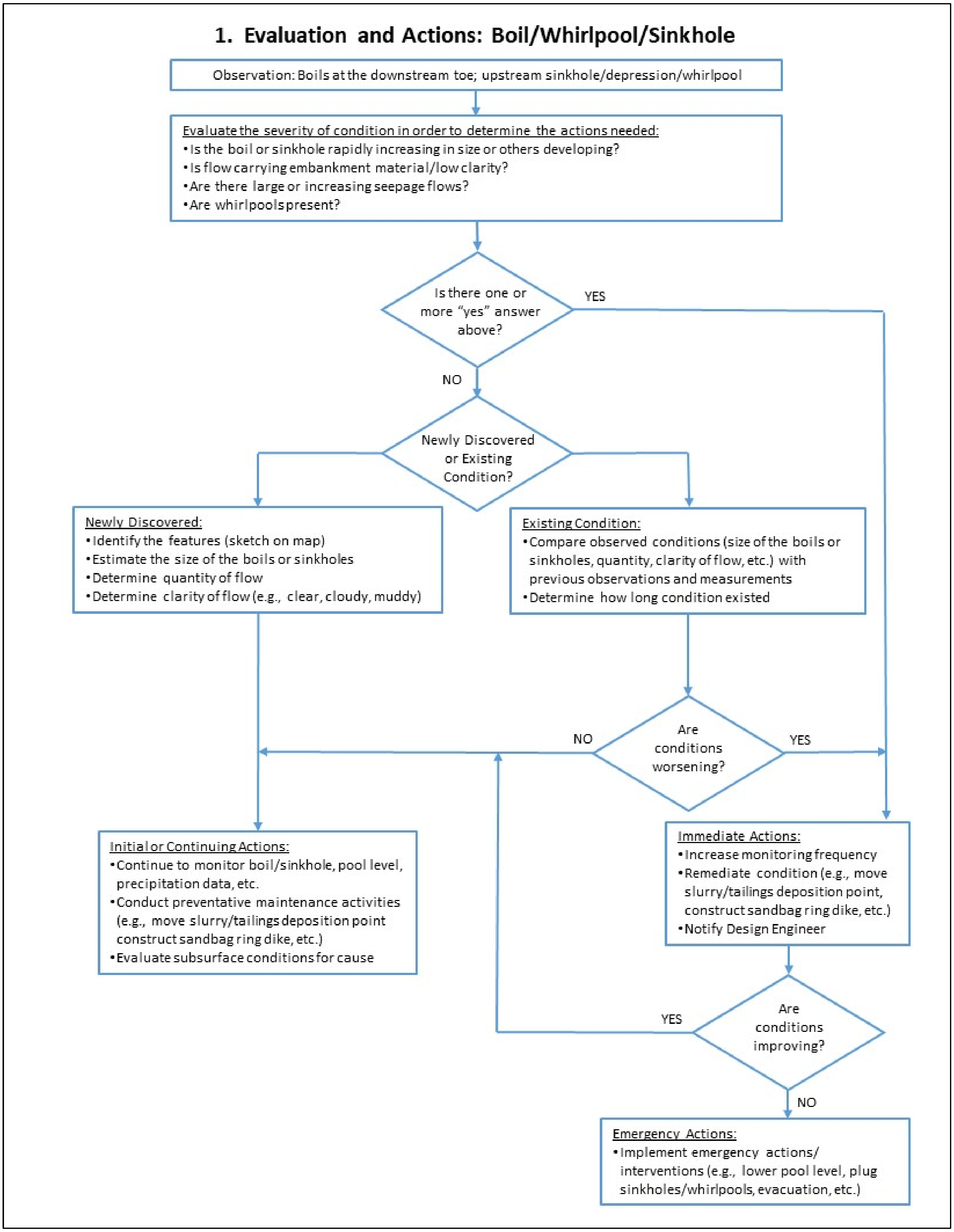
personnel in the mine or at the location where the flow exits the mine. Mine openings (portals, auger holes, etc.) that will be covered by the embankment or pool need to be protected to prevent collapse and the uncontrolled flow of seepage into the opening. Mark "NA" if there are no mine-related issues.

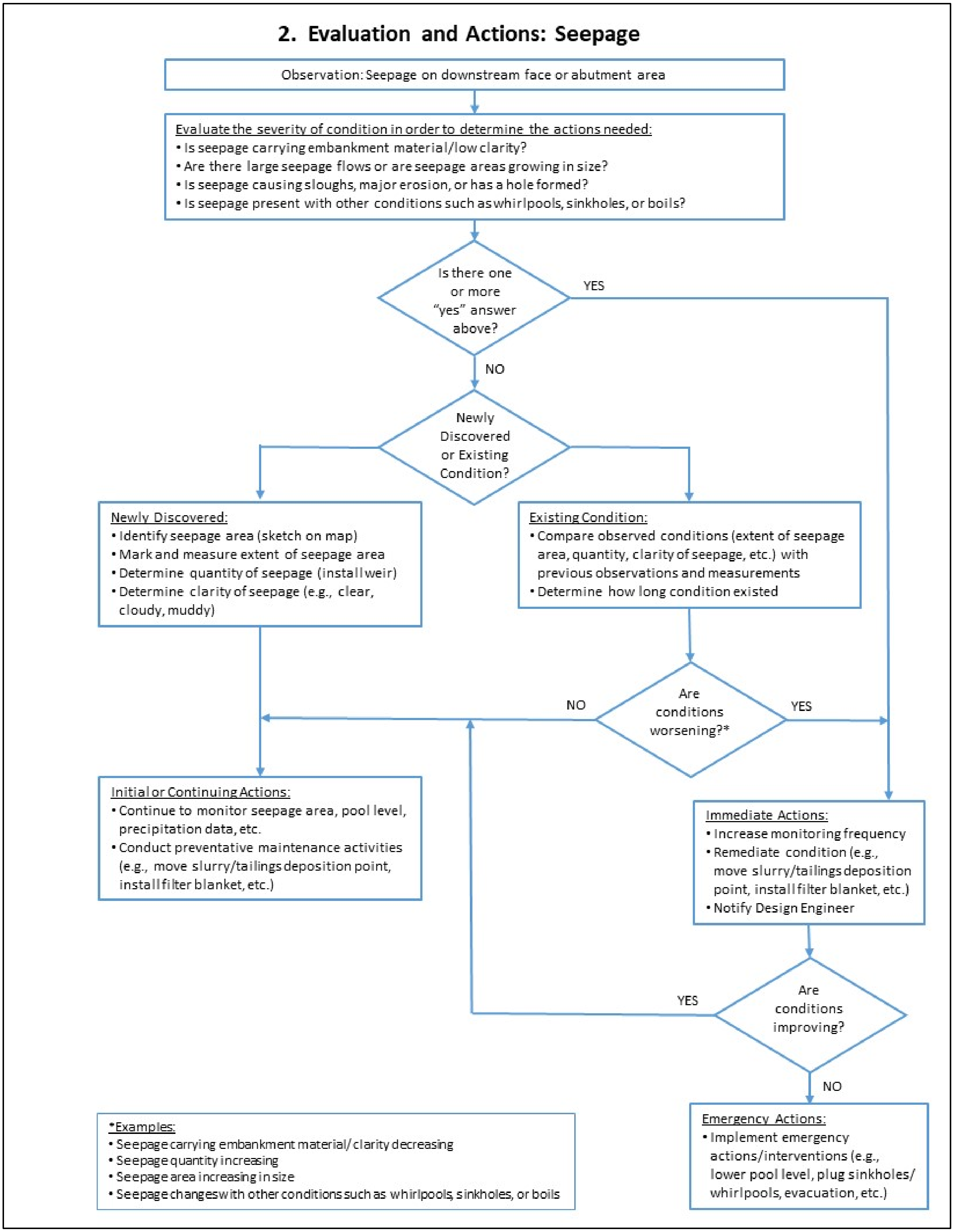
a. Indicate whether mine-related issues (e.g., mine openings, subsidence, auger holes, etc.) that could affect the main or saddle dam embankments are being addressed by the operator.
b. Indicate whether the operator is aware of and monitoring outflow from all mine discharge locations. Unexplained increases in outflow could indicate a seepage problem.
c. If the operator is not monitoring outflow, obtain the requested information for comparison during future inspections.

49. ***Hazard potential classification*** – a dam's hazard potential classification can change as downstream conditions change. Be aware that conditions downstream of a saddle dam could affect the hazard potential classification.
    a. Indicate whether development downstream of the dam or saddle dams has remained unchanged. Changes could include the addition or removal of residential or industrial developments. Mark "N" if downstream conditions have changed.
    b. Indicate whether the current hazard potential classification appears appropriate for the observed downstream development. Mark "N" if the dam's hazard potential classification should be modified.

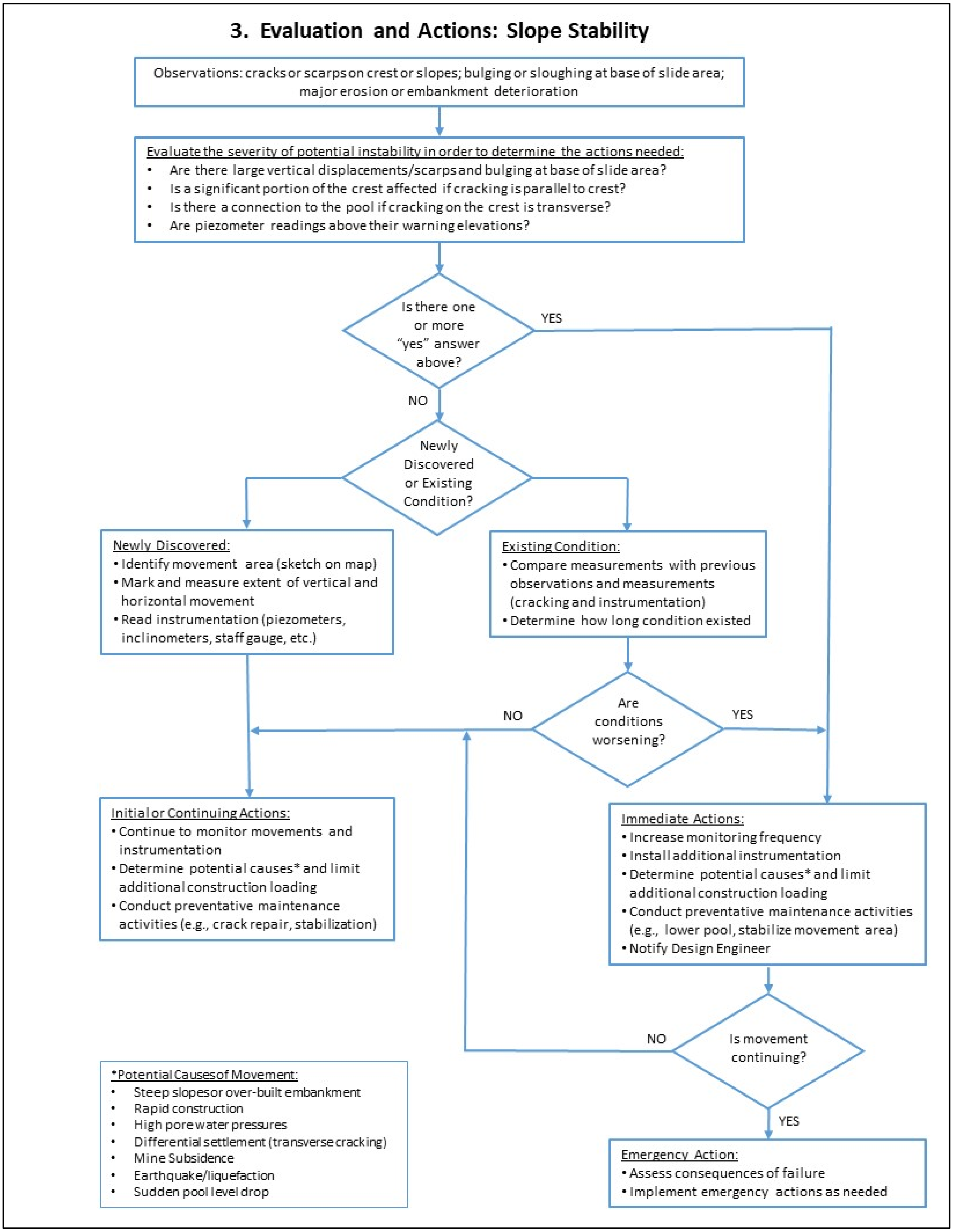
Item 50 is to document any **condition not covered by the inspection form**.

50. ***Additional conditions not captured in this form*** – document anything that was not captured by the inspection form.


1. Evaluation and Actions: Boil/Whirlpool/Sinkhole
Observation: Boils at the downstream toe; upstream sinkhole/depression/whirlpool
Evaluate the severity of condition in order to determine the actions needed:
•Is the boil or sinkhole rapidly increasing in size or others developing?
•Is flow carrying embankment material/low clarity?
•Are there large or increasing seepage flows?
•Are whirlpools present?
Is there one or more "yes" answer above?
YES
NO
Newly Discovered or Existing Condition?
Newly Discovered:
•Identify the features (sketch on map)
•Estimate the size of the boils or sinkholes
•Determine quantity of flow
•Determine clarity of flow (e.g., clear, cloudy, muddy)
Existing Condition:
•Compare observed conditions (size of the boils or sinkholes, quantity, clarity of flow, etc.) with previous observations and measurements
•Determine how long condition existed
Are conditions worsening?
NO
YES
Initial or Continuing Actions:
•Continue to monitor boil/sinkhole, pool level, precipitation data, etc.
•Conduct preventative maintenance activities (e.g., move slurry/tailings deposition point construct sandbag ring dike, etc.)
•Evaluate subsurface conditions for cause
Immediate Actions:
•Increase monitoring frequency
•Remediate condition (e.g., move slurry/tailings deposition point, construct sandbag ring dike, etc.)
•Notify Design Engineer
Are conditions improving?
YES
NO
Emergency Actions:
•Implement emergency actions/ interventions (e.g., lower pool level, plug sinkholes/whirlpools, evacuation, etc.)



Accessible Alternative to Evaluation and Actions: Seepage Flow Chart follows Appendix 10



Accessible Alternative to Evaluation and Actions: Slope Stability Flow Chart follows Appendix 10

APPENDIX 6

District Impoundment Plan Spreadsheet

District Impoundment Plan Spreadsheet Data Fields

Database Column	Field Description
A	Two-character state code (e.g., PA, VA)
B	Two-digit District identifier (e.g., 02, 12)
C	Seven-digit site identifier (e.g., 12345-12)
D	Seven-digit mine identification number (12-12345)
E	Dam name
F	Mining company name
G	Consulting firm name preparing submittal
H	Plan type (NEW, REV, MOD, NFR, AR) • NEW - original plans for a new dam • REV - plan revisions submitted in response to MSHA plan review comments • MOD - modifications submitted for an existing dam • NFR – information received that is “Not for Review” • AR – annual reports received
I	Plan title
J	Plan Date
K	Dam hazard potential classification
L	Review expedited indicator (marked “Y” if operator has expressed an urgent need for the plan review; otherwise leave blank or “N”)
M	Date received by District (e.g., 11/25/2020)
N	Plan review in District indicator (marked “Y” if submittal was reviewed wholly in the District; otherwise, leave blank or “N”)
O	Date plan sent to Technical Support
P	Date plan received by Technical Support
Q	Location of plan in Technical Support queue (must run macro to populate)
R	Date plan review begins
S	Date plan review is completed
T	Action (APP, AI, NA) • APP – plan is approved • AI – additional information is requested • NA – not applicable
U	Reviewer identifier (e.g., last name)
V	Date District receives Technical Support recommendation (if applicable)
W	Date of District action (e.g., letter to operator)
X	District action
Y	Abandoned site indicator (“Y” if site is abandoned; otherwise blank or “N”)
Z	Comments

APPENDIX 7

MSHA Impoundment Plan Review Checklist

IMPOUNDMENT INFORMATION	
Mine Name:	Mine ID:
Operator Name:	Industry: Coal ☐ MNM ☐
Site Name:	Facility ID:
Hazard Potential Classification: High ☐ Significant ☐ Low ☐	
Purpose of Dam:	Date Received:
Reviewer:	Review Start Date:
Title/Brief description of the design plan:	

ADMINISTRATIVE REVIEW (This review is typically conducted in the Enforcement District when the plan is received.)

This section identifies whether broad subject areas, if applicable for the proposed design, have been included within the plan. This review is not for the purpose of determining the validity of the information submitted. If any items are marked as "No" following the administrative review, the reviewer/supervisor may decide not to continue more detailed analyses or not to forward the plan to Technical Support until the submittal is complete.

1. Are plan and profile drawings of an appropriate size and scale included in the plan?	Yes ☐ No ☐ NA ☐
2. Has the hazard potential classification been designated for this site and does it appear reasonable?	Yes ☐ No ☐ NA ☐
3. Does the submittal include reservoir/storm routing analysis (e.g., inflow hydrograph, structure outflow calculations, stage-storage curves, etc.)?	Yes ☐ No ☐ NA ☐
4. Does the submittal contain drawings and details for the outlet structure (e.g., principal spillway pipe or open-channel spillway)?	Yes ☐ No ☐ NA ☐
5. Does the submittal include drilling logs for foundation exploration?	Yes ☐ No ☐ NA ☐
6. Does the submittal include soil testing of the foundation, embankment fill, pipe backfill, and drain materials?	Yes ☐ No ☐ NA ☐
7. Does the submittal include slope stability analyses?	Yes ☐ No ☐ NA ☐
8. Does the submittal address/indicate whether there is, or is not, any mining under or adjacent to the site?	Yes ☐ No ☐ NA ☐
9. Does the submittal include construction specifications, a list of critical construction items, and a construction schedule?	Yes ☐ No ☐ NA ☐
10. Does the submittal contain a certification by a registered engineer?	Yes ☐ No ☐ NA ☐

TECHNICAL PLAN REVIEW

This section identifies specific subjects that should be thoroughly evaluated during the plan review process. If any part of a question below is "No" the reviewer will mark "No" and explain the deficiency in the comments and potentially request additional information or analyses before recommending approval of the design plan.

References provided in the checklist should be considered a starting point on the specific topic. The reviewer should seek additional references as needed.

Date Received:	Review Start Date:	Reviewer:
Title/Brief description of the design plan:		

GENERAL

Yes ☐ No ☐ NA ☐	1. Has a realistic hazard potential classification been designated for this site and, if necessary, is it supported with details or a dam breach analysis? *(Design Manual: Ch. 3, Sect. 3.1, Pgs. 3-1 to 3-3; Ch. 9, Sect. 9.9, Pgs. 9-113 to 9-120)* ____ ____ ____
Yes ☐ No ☐ NA ☐	2. Does the plan identify all critical construction activities, require that the design engineer or representative be present during critical construction, and stipulate that the MSHA District will be notified prior to construction? *(MSHA Dam Inspection and Plan Review Handbook)* ____ ____ ____

HYDROLOGY AND HYDRAULICS

Yes ☐ No ☐ NA ☐	3. Are plan view drawings of an appropriate size/scale included that show the entire watershed and any subareas used in the analyses? *(Design Manual: Ch. 6, Sect. 6.4.1, Pgs. 6-44 to 6-49; Ch. 9, Sect. 9.2.2.1, Pg. 9-7)* ____ ____ ____

Yes ☐ No ☐ NA ☐	4. Are appropriate watershed characteristics being used: AMC, CN, Tc, Watershed size? *(Design Manual: Ch. 9, Sect. 9.6, Pgs. 9-38 to 9-60)* __________ __________ __________
Yes ☐ No ☐ NA ☐	5. Has the inflow hydrograph been developed correctly: rainfall amount, storm duration, storm distribution, computational increment, correctly input parameters into computer model (SCS, HEC, etc.)? *(Design Manual: Ch. 9, Sects. 9.5-9.6, Pgs. 9-29 to 9-60)* __________ __________ __________
Yes ☐ No ☐ NA ☐	6. Has the stage-discharge of the outlet structure(s), and stage-storage of the impoundment been adequately determined and used in the reservoir/storm routing? *(Design Manual: Ch. 9, Sects. 9.1-9.8, Pgs. 9-1 to 9-113)* __________ __________ __________
Yes ☐ No ☐ NA ☐	7. Was routing started at the principal or emergency spillway inlet? Has three feet of design storm freeboard been provided or has an analysis of required freeboard been submitted and found to be adequate? *(Design Manual: Ch. 9, Sect. 9.8, Pgs. 9-111 to 9-113)* __________ __________ __________
Yes ☐ No ☐ NA ☐	8. Can 90 percent of the design storm volume be discharged within 10 days? *(Design Manual: Ch. 9, Sect. 9.5, Pgs. 9-29 to 9-38)* __________ __________ __________
Yes ☐ No ☐ NA ☐	9. If the dam is strictly for flood control to protect a surface mine pit and the operator has proposed a lower hazard classification, has the operator specified a detailed pool monitoring and mine evacuation plan? *(Design Manual: Ch. 3, Sect. 3.7, Pgs. 3-22 to 3-24; Ch. 9, Sect. 9.5.1.3.2, Pgs. 9-33 to 9-34; Ch. 14, Sect. 14.2, Pgs. 14-1 to 14-11)* __________ __________ __________

Open-Channel Spillway and Ditches	
Yes ☐ No ☐ NA ☐	10. Are detailed cross-sections, profile, and slopes of the open-channel spillway included? *(Design Manual: Ch. 9, Sect. 9.7, Pgs. 9-60 to 9-111)* _____ _____ _____
Yes ☐ No ☐ NA ☐	11. Are the hydraulic calculations for the open-channel spillway complete and adequate? *(Design Manual: Ch. 9, Sect. 9.7.2, Pgs. 9-63 to 9-83)* _____ _____ _____
Yes ☐ No ☐ NA ☐	12. Is the spillway excavated in competent rock or has erosion protection been designed to withstand the hydraulic forces during the design storm? *(Design Manual: Ch. 9, Sect. 9.7.3, Pgs. 9-83 to 9-95)* _____ _____ _____
Yes ☐ No ☐ NA ☐	13. Has adequate bedding, anchorage, and seepage pressure relief been designed for the open-channel emergency spillway erosion protection? *(Design Manual: Ch. 9, Sect. 9.7.3, Pgs. 9-83 to 9-95)* _____ _____ _____
Yes ☐ No ☐ NA ☐	14. Are the hydraulic calculations for critical ditches complete and adequate? Has erosion protection been designed to withstand the hydraulic forces during the design storm? *(Design Manual: Ch. 9, Sect. 9.7, Pgs. 9-60 to 9-111)* _____ _____ _____
Principal Spillway Pipe	
Yes ☐ No ☐ NA ☐	15. Have characteristics of the principal spillway pipe been provided including material, diameter, wall thickness, inlet elevation(s), outlet elevation(s), slope, profile (vertical and horizontal including bends), etc.? *(Design Manual: Ch. 9, Sect. 9.7, Pgs. 9-60 to 9-111)* _____ _____ _____

Yes ☐ No ☐ NA ☐	16. Have pipe flow characteristics been adequately analyzed including weir, orifice and pressure flow regimes, effect of trash rack, and changes in flow direction? *(Design Manual: Ch. 9, Sect. 9.7.2, Pgs. 9-63 to 9-83)*
Yes ☐ No ☐ NA ☐	17. Have trash racks and anti-vortex devices been provided, evaluated, adequately sized and attached, and detailed? *(Design Manual: Ch. 9, Sect. 9.7.4.1.1, Pg. 9-97)*
Yes ☐ No ☐ NA ☐	18. Have anchor blocks for uplift and thrust blocks for changes in flow direction been adequately designed, located, and detailed? *(Design Manual: Ch. 9, Sect. 9.7.3.5, Pgs. 9-94 to 9-95; Ch. 11, Sect. 11.7.3, Pgs. 11-53 to 11-54)*
Yes ☐ No ☐ NA ☐	19. Is leak testing and pressure testing specified in accordance with manufacturer's recommended procedures or other published guidance from another recognized authority, and are the test parameters/acceptance criteria adequate. *(Design Manual: Ch. 9, Sect. 9.7.2.2.2, Pgs. 9-72 to 9-81; or pipe manufacturer's technical guidance)*
Pumps	
Yes ☐ No ☐ NA ☐	20. Pumping or siphoning systems should not be relied upon to reduce storm storage during reservoir routing of the design storm. If pumping or siphoning equipment are used for drawdown of the pool after the design storm, has it been adequately sized to meet the drawdown criteria?
Yes ☐ No ☐ NA ☐	21. Has adequate pumping equipment, periodic testing, and sufficient energy or fuel source requirements been provided/specified?

SUBSURFACE INVESTIGATION	
Yes ☐ No ☐ NA ☐	22. Is the subsurface investigation consistent with the size, complexity, and hazard potential classification of this site and the proposed modification(s)? Did the investigation identify natural soils, rock in the foundation and open-channel spillway area, and overburden composition above underground mining? *(Design Manual: Ch. 6, Sect. 6.4, Pgs. 6-43 to 6-90)* __________ __________ __________
Yes ☐ No ☐ NA ☐	23. Based on the findings of the subsurface investigation, are the proposed foundation preparation specifications adequate? *(Design Manual: Ch. 11, Sect. 11.6.3, Pgs. 11-40 to 11-41)* __________ __________ __________
Yes ☐ No ☐ NA ☐	24. Were samples representative of critical subsurface conditions collected and tested? *(Design Manual: Ch. 6, Sect. 6.4.3, Pgs. 6-50 to 6-69)* __________ __________ __________
Yes ☐ No ☐ NA ☐	25. Have appropriate strength testing methods for foundation materials been used: drained, undrained, consolidated, unconsolidated, compression, extension, simple shear, etc.; adequate sample sizes; appropriate strain rates, appropriate density, degree of saturation and moisture content, appropriate failure criteria, etc.? *(Design Manual: Ch. 6, Sect. 6.5, Pgs. 6-90 to 6-138)* __________ __________ __________
Yes ☐ No ☐ NA ☐	26. Were consolidation and permeability parameters for foundation materials characterized using appropriate laboratory tests (or estimated for low hazard potential dams)? *(Design Manual: Ch. 6, Sects. 6.5.4 & 6.5.6, Pgs. 6-109 to 6-116)* __________ __________ __________

EMBANKMENT MATERIAL SAMPLING AND TESTING

Yes ☐ No ☐ NA ☐	27. Have the properties of all pertinent embankment fill, pipe backfill, and drain materials been adequately characterized (or estimated for low hazard potential dams)? *(Design Manual: Ch. 6, Sect. 6.5, Pgs. 6-90 to 6-138)*
Yes ☐ No ☐ NA ☐	28. Have appropriate strength testing methods for embankment construction materials been used: drained, undrained, consolidated, unconsolidated, compression, extension, simple shear, etc.; adequate sample sizes; appropriate strain rates, appropriate density, degree of saturation and moisture content, appropriate failure criteria, etc.? *(Design Manual: Ch. 6, Sect. 6.5, Pgs. 6-90 to 6-138)*
Yes ☐ No ☐ NA ☐	29. Have the appropriate compaction Proctor tests or relative density tests been conducted on each type of embankment construction material? *(Design Manual: Ch. 6, Sect. 6.5.3, Pgs. 6-105 to 6-109)*
Yes ☐ No ☐ NA ☐	30. Were consolidation and permeability parameters for embankment materials characterized using appropriate laboratory tests (or estimated for low hazard potential dams)? *(Design Manual: Ch. 6, Sects. 6.5.4 to 6.5.6, Pgs. 6-109 to 6-116)*

SEEPAGE AND PHREATIC SURFACE

Yes ☐ No ☐ NA ☐	31. Were suitable seepage analyses conducted to determine the maximum phreatic level and seepage quantities for each critical construction stage using appropriate horizontal vs. vertical permeability? *(Design Manual: Ch. 6, Sect. 6.6.2, Pgs. 6-139 to 6-164)*

Yes ☐ No ☐ NA ☐	32. If the impoundment is designed to store two design storms, was the maximum pool level during the design storm considered in the seepage analyses? *(Design Manual: Ch. 6, Sects. 6.6.2 to 6.6.4, Pgs. 6-139 to 6-185)* ____
Yes ☐ No ☐ NA ☐	33. Have granular drain and filter requirements been verified for transitions between a drain and adjacent portions of an embankment and between zones of finer and coarser material within the embankment? *(Design Manual: Ch. 6, Sect. 6.6.2.3.1, Pgs. 6-146 to 6-149)*
Yes ☐ No ☐ NA ☐	34. If drains are relied upon to lower the phreatic level, were the drains properly analyzed to provide a drainage capacity at least 10-times the anticipated seepage rate? *(Design Manual: Ch. 6, Sect. 6.6.2.3, Pgs. 6-146 to 6-164; Ch. 11, Sect. 11.7.2, Pgs. 11-46 to 11-53)*
Yes ☐ No ☐ NA ☐	35. Do the drain construction specifications include details regarding the drain material gradation and durability, dimensions, construction methods, filter fabric placement, drainpipes, etc.? *(Design Manual: Ch. 11, Sect. 11.7, Pgs. 11-46 to 11-56)*
Yes ☐ No ☐ NA ☐	36. If filter fabric is proposed, have filter requirements been verified and long term clogging tests been conducted and meet acceptance criteria? If filter fabric is proposed for critical design features, will the seepage quantity be monitored for clogging? *(Design Manual: Ch. 6, Sect. 6.5.5, Pgs. 6-111 to 6-112; Ch. 6, Sect. 6.6.2.3.2, Pgs. 6-149 to 6-156)*
Yes ☐ No ☐ NA ☐	37. If no drains have been proposed, have adverse conditions such as piping and seepage discharge on the downstream face been considered and mitigated? *(Design Manual: Ch. 6, Sect. 6.3.1, Pgs. 6-19 to 6-30; Ch. 6, Sect. 6.6.2, Pgs. 6-139 to 6-164)*

STABILITY ANALYSES	
Yes ☐ No ☐ NA ☐	38. Was the most critical cross-section for each critical construction stage analyzed? Not every stage may need to be analyzed; consider the sequence of construction. *(Design Manual: Ch. 6, Sect. 6.6.4, Pgs. 6-171 to 6-185)* __________ __________ __________
Yes ☐ No ☐ NA ☐	39. Were the input parameters (geometry, material characteristics, phreatic conditions, etc.) used in the stability analyses appropriate? *(Design Manual: Ch. 6, Sect. 6.5, Pgs. 6-90 to 6-138; Ch. 6, Sect. 6.6.4, Pgs. 6-171 to 6-185)* __________ __________ __________
Yes ☐ No ☐ NA ☐	40. Have piezometers been proposed to monitor the phreatic surface within the embankment and the effectiveness of the drains? *(Design Manual: Ch. 13, Sect. 13.2.2, Pgs. 13-23 to 13-31)* __________ __________ __________
Yes ☐ No ☐ NA ☐	41. Are the allowable piezometer readings or action levels appropriate based on the slope stability and seepage analyses? Note that piezometer action levels should normally be set lower than the design phreatic surface, to be consistent with the allowable/design pore pressure at the sensing zone. *(Design Manual: Ch. 6, Sect. 6.6, Pgs. 6-138 to 6-185; Ch. 13, Sect. 13.1-2, Pgs. 13-1 to 13-41)* __________ __________ __________
Conditions Analyzed	
Yes ☐ No ☐ NA ☐	42. In addition to long-term stability using circular failure surfaces, were the following conditions analyzed where appropriate: end of construction, stage construction, rapid drawdown, sliding wedge failures, and long-term analysis of the upstream slope? Were material strength parameters appropriate for the various types of analyses? *(Design Manual: Ch. 6, Sect. 6.6.4, Pgs. 6-171 to 6-185)* __________ __________ __________

Yes ☐ No ☐ NA ☐	43. Have acceptable minimum factors of safety been determined for each of the critical cross sections and types of stability analyses? *(Design Manual: Ch. 6, Sect. 6.6.4.3, Pgs. 6-181 to 6-184)* ______ ______ ______
Yes ☐ No ☐ NA ☐	44. Was the seismic stability of the embankment adequately evaluated including post-seismic analyses and deformation analyses? *(Design Manual: Ch. 7, Pgs. 7-1 to 7D-2)* ______ ______ ______
Yes ☐ No ☐ NA ☐	45. Was the seismic hazard assessment (SHA) adequate and include determining the maximum credible earthquake magnitude and location, attenuation of strong ground motions to the site, and selection of appropriate earthquake records? *(Design Manual: Ch. 7, Pgs. 7-1 to 7D-2)* ______ ______ ______
Yes ☐ No ☐ NA ☐	46. If the USGS Probabilistic SHA was used, was the 10,000-year return period adopted, or was another return period justified based on the hazard potential or a more detailed SHA? *(Design Manual: Ch. 7, Pgs. 7-1 to 7D-2)* ______ ______ ______
Yes ☐ No ☐ NA ☐	47. Were all zones of potentially loose material (including natural foundation soils) identified and evaluated for strength loss or cyclic mobility, and the peak/residual undrained strength of these materials evaluated appropriately? *(Design Manual: Ch. 7, Pgs. 7-1 to 7D-2)* ______ ______ ______
Yes ☐ No ☐ NA ☐	48. In the post-seismic stability analyses, was the undrained strength used for all materials that are contractive, that is materials that develop positive pore pressure during undrained shear tests? Note that borderline materials may exhibit negative pore pressures (dilative) at low confinement, but positive pore pressures (contractive) at higher confinement. *(Design Manual: Ch. 7, Pgs. 7-1 to 7D-2)* ______ ______ ______

Yes ☐ No ☐ NA ☐	49. In the deformation analyses, were the undrained strengths reduced to 80 percent of peak values, or were other conservative dynamic strength values justified? Note that deformation analyses based on Newmark methods are not recommended for sites that have zones of strength loss. More rigorous dynamic analyses may be necessary. *(Design Manual: Ch. 7, Pgs. 7-1 to 7D-2)*

UPSTREAM CONSTRUCTION	
Yes ☐ No ☐ NA ☐	50. Do upstream construction slope stability analyses consider critical material zones such as compacted and un-compacted embankment material, a mixed zone, consolidated and unconsolidated hydraulically-placed fine material under the stage, and hydraulically-placed fine material in the pool area? *(Design Manual: Ch. 6, Sect. 6.3.4.1 Pgs. 6-35 to 6-37; Ch. 6, Sect. 6.6.4, Pgs. 6-171 to 6-185)*
Yes ☐ No ☐ NA ☐	51. Are there provisions for field and laboratory testing to confirm: material design parameters (strength, consolidation, etc.), sink-in depth, subsurface geometry, etc. used in the upstream stability analyses? *(Design Manual: Ch. 6, Sect. 6.5, Pgs. 6-90 to 6-138)*
Yes ☐ No ☐ NA ☐	52. Does the plan stipulate that a hydraulically-placed fines delta will be established prior to upstream pushout and have provisions been included to maintain the delta in advance of the pushout? *(Design Manual: Ch. 6, Sect. 6.2.3.2 Pg. 6-10; Ch. 11, Sect. 11.5.2, Pgs. 11-33 to 11-35)*
Yes ☐ No ☐ NA ☐	53. It is not recommended that upstream pushouts are advanced directly into water; however, if it is necessary/unavoidable, have all aspects of the proposed condition (i.e., maximum depth of water, upstream stability, pushout safety provisions, etc.) been addressed? *(Design Manual: Ch. 11, Sect. 11.5.2, Pgs. 11-33 to 11-35)*

Yes ☐ No ☐ NA ☐	54. Does the plan address the potential for material sink-in and its effect on the material volume requirements and construction schedule?
Yes ☐ No ☐ NA ☐	55. Does the design take into account the possible excess pore pressures in the hydraulically-placed fine material under the pushout and in the mixed zone? *(Design Manual: Ch. 6, Sect. 6.3.4.1, Pgs. 6-35 to 6-37; Ch. 6, Sect. 6.6.4, Pgs. 6-171 to 6-185; Ch. 11, Sect. 11.5.2, Pgs. 11-33 to 11-35)*
Yes ☐ No ☐ NA ☐	56. Are there provisions for rapid response piezometers in order to monitor excess pore pressures in the hydraulically-placed fine material and the mixed zone? If the mixed zone is assumed to be consolidated, then piezometers should be installed to validate the assumption. *(Design Manual: Ch. 6, Sects. 6.6.1 to 6.6.4, Pgs. 6-138 to 6-185; Ch. 13, Sect. 13.1-2, Pgs. 13-1 to 13-41)*
Yes ☐ No ☐ NA ☐	57. Is the rate of construction specified and do the consolidation analyses and production rates support the specified rate of construction? *(Design Manual: Ch. 6, Sects. 6.6.3 to 6.6.4, Pgs. 6-164 to 6-185)*
Yes ☐ No ☐ NA ☐	58. Have provisions for an exclusion zone (i.e., buffer zone) been provided? Do stability analyses justify the distance for the exclusion zone? Are there provisions for high visibility markers to delineate the exclusion zone? *(Design Manual: Ch. 11, Sect. 11.5.2, Pgs. 11-33 to 11-35)*
Yes ☐ No ☐ NA ☐	59. Does the plan include pushout construction safety and operational procedures? *(Design Manual: Ch. 11, Sect. 11.5.2, Pgs. 11-33 to 11-35)*

Yes ☐ No ☐ NA ☐	60. If unmanned dozers are proposed, are the safety provisions adequate? *(Design Manual: Ch. 11, Sect. 11.5.2, Pgs. 11-33 to 11-35)* __________ __________ __________

MATERIAL PLACEMENT

Yes ☐ No ☐ NA ☐	61. Are complete compaction specifications provided for all fill materials: embankment structural fill, non-structural fill, pipe backfill, including density and moisture requirements, and are they consistent with lab test conditions? Do specifications provide for removal of oversize material in the fill? *(Design Manual: Ch. 6, Sect. 6.5.3, Pgs. 6-105 to 6-109; Ch. 11, Sect. 11.5.1, Pgs. 11-26 to 11-33; Ch. 11, Sect. 11.8, Pgs. 11-56 to 11-58)* __________ __________ __________
Yes ☐ No ☐ NA ☐	62. Do material placement specifications have provisions for scarification, benching of embankment fill, compaction retesting, water content control, and avoiding placement of frozen material? *(Design Manual: Ch. 11, Sect. 11.5.1, Pgs. 11-26 to 11-33)* __________ __________ __________
Yes ☐ No ☐ NA ☐	63. If belt delivery of material to the work area is proposed, has a material and equipment analysis been conducted to determine the required equipment (type and number) to meet the material delivery rate? *(Design Manual: Ch. 11, Sects. 11.3 to 11.4, Pgs. 11-19 to 11-26)* __________ __________ __________

CONDUITS THROUGH EMBANKMENTS

Yes ☐ No ☐ NA ☐	64. Does the pipe extend across zones that may experience abrupt or significant settlement, or subside, which can cause elongation, loss of lateral support, and areas of stress concentration; and have these conditions been evaluated? *(Design Manual: Ch. 5, Sect. 5.6.1, Pgs. 5-17 to 5-18; Ch. 6, Sect. 6.6.3, Pgs. 6-164 to 6-170; Ch. 6, Sect. 6.6.6, Pgs. 6-193 to 6-206; Ch. 8, Sect. 8.4, Pgs. 8-9 to 8-34)* __________ __________ __________

Yes ☐ No ☐ NA ☐	65. Are pipe backfill specifications for material placement and compaction adequate? Do they specifically address placement in the haunch area of flexible pipes? *(Design Manual: Ch. 11, Sect. 11.8, Pgs. 11-56 to 11-58; Table 12.2, Pg. 12-25 to 12-26)*
Yes ☐ No ☐ NA ☐	66. Has the pipe been analyzed for structural adequacy, which includes consideration of maximum fill height, type/compaction of bedding and backfill material, type of trench installation, and manufacturer's recommended limits on deformation, crushing, and buckling if a flexible pipe? *(Design Manual: Ch. 6, Sect. 6.6.6, Pgs. 6-193 to 6-206)*
Yes ☐ No ☐ NA ☐	67. Have provisions for minimum cover over the pipe been made to resist buoyancy in the pool area or prevent crushing by equipment traveling over the pipe? *(Design Manual: Ch. 6, Sect. 6.6.6, Pgs. 6-193 to 6-206; Ch. 12, Sect. 12.1.2.2.3, Pg. 12-12; or specific pipe manufacturer's guidance.)*
Yes ☐ No ☐ NA ☐	68. Has a seepage diaphragm been specified and has it been adequately analyzed for size, filter requirements, drainage capacity, permeability, constructability, etc., and provided with a suitable drainage outlet? Are the construction details and specifications for the seepage diaphragm adequate? *(Design Manual: Ch. 6, Sect. 6.6.2.3, Pgs. 6-146 to 6-164; Ch. 11, Sect. 11.7.2, Pgs. 11-46 to 11-53)*

MINING CONDITIONS - See Chapter 8 for a full discussion on mining	
Yes ☐ No ☐ NA ☐	69. Has all underground and surface mining at or adjacent to the site been identified? *(Design Manual: Ch. 6, Sect. 6.4, Pgs. 6-43 to 6-90)*

Yes ☐ No ☐ NA ☐	70. Are there coal seams of minable thickness beneath the site that are being shown as unmined? Has the company made a thorough search for mining records? *(Design Manual: Ch. 6, Sect. 6.4, Pgs. 6-43 to 6-90)* __________ __________ __________
Yes ☐ No ☐ NA ☐	71. Has blasting near the site been evaluated? *(Design Manual: Ch. 6, Sect. 6.6.7, Pgs. 6-206 to 6-208; Ch. 13, Sect. 13.2, Pgs. 13-2 to 13-41)* __________ __________ __________
Yes ☐ No ☐ NA ☐	72. Are detailed mine maps provided for all mining at the site including final maps for abandoned mines? Are the mine maps certified final or have adequate efforts been made to verify the extent of mining? *(Design Manual: Ch. 6, Sect. 6.4, Pgs. 6-43 to 6-90)* __________ __________ __________
Yes ☐ No ☐ NA ☐	73. Has highwall or auger mining been done at the site and has its location relative to other mining been identified and located on a map? Has ground stability been considered? *(Design Manual: Ch. 5, Sect. 5.4, Pgs. 5-13 to 5-16; Ch. 6, Sect. 6.4, Pgs. 6-43 to 6-90)* __________ __________ __________
Yes ☐ No ☐ NA ☐	74. Has pillar stability and subsidence been adequately evaluated considering second (retreat) mining, soft floor conditions, multiple seam mining, and the increased loading from the construction of the final proposed embankment? *(Design Manual: Ch. 5, Sect. 5.4, Pgs. 5-13 to 5-16)* __________ __________ __________
Yes ☐ No ☐ NA ☐	75. Has breakthrough potential been evaluated including sinkhole potential and interaction of auger holes or highwall mining entries with other mines, etc.? If breakthrough is likely, has an adequate mitigation design been proposed? *(Design Manual: Ch. 5, Sect. 5.4, Pgs. 5-13 to 5-16)* __________ __________ __________

Yes ☐ No ☐ NA ☐	76. Have the abutments of the dam been impacted by mining or by subsidence and has that impact been evaluated relative to cracking, stability, seepage, transference of elevated pore pressures toward embankment toe, and piping potential? *(Design Manual: Ch. 5, Sect. 5.4, Pgs. 5-13 to 5-16; Ch. 6, Sect. 6.4, Pgs. 6-43 to 6-90)* __________ __________ __________
Yes ☐ No ☐ NA ☐	77. Is additional mining proposed beneath the site and has its potential effect on the impoundment/embankment been evaluated? *(Design Manual: Ch. 8, Pgs. 8-1 to 8-64)* __________ __________ __________
Yes ☐ No ☐ NA ☐	78. If mining could affect the embankment, has instrumentation for monitoring subsurface and surface movement (extensometers, settlement plates, etc.) been proposed? *(Design Manual: Ch. 13, Sect. 13.2.1, Pgs. 13-3 to 13-23)* __________ __________ __________

ABANDONMENT - Design plans for new dams should consider how abandonment may be accomplished even if years in the future. Before a dam is abandoned, a detailed plan is necessary and should address the following items.	
Yes ☐ No ☐ NA ☐	79. If the abandonment plan proposes a live abandonment, have the provisions outlined in 30 CFR 77.216-5(b) been included and are they adequate? __________ __________ __________
Yes ☐ No ☐ NA ☐	80. Has a final abandonment grading plan been provided and will the facility be graded to drain adequately? Has the operator considered possible long-term settlement of the hydraulically-placed material when designing the cap grade and materials? *(Design Manual: Ch. 5, Sect. 5.9, Pg. 5-20; Ch. 6, Sect. 6.6.3, Pgs. 6-164 to 6-170; Ch. 10, Sect. 10.5, Pgs. 10-26 to 10-39)* __________ __________ __________

Yes ☐ No ☐ NA ☐	81. Have permanent drainage controls been proposed? Are the hydraulic calculations for these structures complete and adequate? Has erosion protection been designed to withstand the hydraulic forces during the design storm? *(Design Manual: Ch. 5, Sect. 5.7.1, Pg. 5-18; Ch. 9, Sect. 9.7, Pgs. 9-60 to 9-111)* __________ __________ __________
Yes ☐ No ☐ NA ☐	82. If abandonment includes eliminating the impounding capability by capping, does the plan address the pushout direction, the potential for cap material sink-in, heaving of hydraulically-placed material, and the availability of refuse or borrow material for cap construction? *(Design Manual: Ch. 5, Sect. 5.9, Pg. 5-20)* __________ __________ __________
Yes ☐ No ☐ NA ☐	83. Has long-term stability of the facility been addressed? *(Design Manual: Ch. 6, Sect. 6.6.4, Pgs. 6-171 to 6-185)* __________ __________ __________
Yes ☐ No ☐ NA ☐	84. Has an abandonment construction schedule been provided? Does the schedule provide details regarding short-term design storm criteria and outlet abandonment? *(Design Manual: Ch. 5, Sect. 5.1.2, Pgs. 5-2 to 5-3; Ch. 9, Sects. 9.5 to 9.6, Pgs. 9-29 to 9-60)* __________ __________ __________

SUPERVISOR/REVIEWER	
Yes ☐ No ☐ NA ☐	85. Has the reviewer filled out an Impoundment Data Sheet for each stage being recommended for approval? __________ __________ __________
Yes ☐ No ☐ NA ☐	86. Has the reviewer filled out an IRPI Data Form for each stage being recommended for approval? __________ __________ __________

Yes ☐ No ☐	87. Does the plan require additional information/analyses before recommending approval?

Any additional comments regarding the plan that have not been addressed in this checklist:

APPENDIX 8

Impoundment Data Sheet and IRPI Data Sheet

IMPOUNDMENT DATA SHEET

Completed by: ______________________ Date: ______________

All Information Pertains to Construction Stage ______________

Impoundment Name ______________

Site ID No. ______________

Hazard Potential Classification (Circle One) High Significant Low

CONFIGURATION

Maximum Crest Elevation ______________ feet

Minimum Crest Width ______________ feet

Minimum Required Freeboard from ______________ to Crest is ______________ feet

Decant Pipe
- Material Type ______________
- Inside Diameter ______________ inches
- Inlet Elevation ______________ feet

Open Channel (Emergency) Spillway
- Elevation ______________ feet
- Bottom Width ______________ feet
- Lining Type ______________

Embankment Slopes
- Upstream ______________
- Downstream ______________

Embankment Benches
- Width ______________ feet
- Vertical Interval ______________ feet

Groin Ditches
- Lining Type ______________

COMPACTION

Compaction Test Frequency ______________

Moisture Content Range minus ______________ % to plus ______________ %

Compaction Density Standard ______________ % Lift Thickness(es) ______________ inches

INSTRUMENTATION

Piezometer No.	Maximum Allowable Water Elevation (feet)	Piezometer No.	Maximum Allowable Water Elevation (feet)

CRITICAL CONSTRUCTION ITEMS

____

____

____

Flow Monitoring Location(s) ______________

____

____

____

____

Number of Settlement Monitoring Devices ______________

Frequency of Settlement Measures ______________

Special Notes, Observations, and Other Instrumentation ______________

____

____

____

IRPI DATA FROM IMPOUNDMENT PLANS

Date ______________________ Completed by: ______________________

(2) State ______________________ (2) County ______________________

(3) Impoundment Name ______________________

(4) Impoundment ID No. ______________________

(8) All Information Pertains to Construction Stage

(9) Nearest Downstream City/Town ______________ (10) Distance to Nearest City/Town (mi.) ________

(11) Latitude ______________________ (12) Longitude ______________________
(Degrees + (Minutes/60) + (Seconds/3600)) (Degrees + (Minutes/60) + (Seconds/3600))

(15) Stream impoundment is located on or tributary to: ______________________

(16) Section/Range/Township ______________________

(20) Company or consultant who prepared plan ______________________

(35) Foundation Type (rock; rock and soil; soil; unknown) ______________________

(37) Core Type (earth, plastic, etc.) ______________________

(38) Core Position (<u>U</u>pstream, <u>H</u>omogeneous, <u>C</u>ore) U H C

(40) Type of Construction (<u>U</u>pstream, <u>D</u>ownstream, <u>C</u>enterline) U D C

(41) Dam Crest Length ______________________ feet

(42) Structure Height (from downstream toe) ______________________ feet

(43) Open Channel Spillway Type Controlled Uncontrolled None

(44) Spillway Width at Maximum Discharge ______________________ feet

(45) Maximum Storage ______________________ acre-feet

(46) Normal Storage ______________________ acre-feet

(47) Maximum Discharge ______________________ cfs

(49) Drainage Area ______________________ square miles

(50) Surface Area ______________________ acres

(51) Decant Pipe Type ______________________

(52) Decant Pipe Diameter (ID) ______________________ inches

(54) Mining Underneath or Adjacent: Yes No

(55) Hazard Potential Classification High Significant Low

APPENDIX 9

Glossary of Terms

100-year storm. See **One-Percent-Chance Flood**.

Abutment. That part of the valley side against which the dam is constructed. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction, unless otherwise indicated.

Acre-feet. A unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet.

Appurtenant structure. Ancillary features of a dam such as outlets and spillways.

Anti-vortex device. Typically a flat metal plate which is placed on edge and mounted on a principal spillway pipe at the entrance to prevent the formation of a flow inhibiting vortex during periods of high flow. The anti-vortex plate increases the capacity during the orifice flow phase.

Beach. The beach is the subaerial fine coal or tailings deposit between the upstream slope of the embankment and the pool water. The beach becomes the foundation of the next upstream stage.

Bench. A nearly horizontal step in the sloping profile of an embankment dam. Also a step in a rock or earth cut.

Breach. An opening through a dam that allows the uncontrolled draining of a reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening caused by discharge from the reservoir and is generally associated with the partial or total failure of the dam.

Breach analysis. Calculations performed to predict the rate of outflow during a breach and the path and flow characteristics of the downstream flood (depth, time of arrival, etc.).

Breakthrough. The uncontrolled, unintended release of stored water, fine refuse, or tailings from the reservoir into an underground mine.

Boil. When water under pressure wells up through the ground and carries soil particles as it comes out onto the ground surface. The ejection of soils and water resulting from piping.

Channel. A general term for any natural or artificial facility for conveying water.

Crack. An opening with no vertical displacement.

Compaction. Mechanical action that increases the density by reducing the voids in a material.

Conduit. A closed channel to convey water through, around, or under a dam.

Consequences. Potential loss of life or property damage downstream of a dam caused by floodwaters released at the dam or by waters released by partial or complete failure of dam.

Core. A zone of low permeability material in an embankment dam.

Crest length. The measured length of the dam along the crest or top of dam.

Crest of dam. The top of dam.

Cutoff trench. A foundation excavation later to be filled with impervious material so as to limit seepage beneath a dam. Also called a keyway.

Cyclones. A hydrocyclone, also known simply as a cyclone, is a centrifugal device with no moving parts that liquid-borne waste passes through to concentrate slurries, classify solids in liquid suspensions, degrit liquids, and for washing or cleaning solids.

Dam. An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.

Dam failure. Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. These lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action.

Dam safety. Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe function is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate to the extent reasonably possible, any unacceptable risks.

Dam safety program purposes. The purposes of a dam safety program are to protect life, property, and the environment by ensuring that all dams are designed, constructed, operated, and maintained as safely and as effectively as is reasonably possible. Accomplishing these purposes requires commitments to continually inspect, evaluate, and document the design, construction, operation, maintenance, rehabilitation, and emergency preparedness of each dam and the associated public. It also requires the archiving of documents on the inspections and histories of dams and the training of personnel who inspect, evaluate, operate, and maintain them. Programs must instill an awareness of dams and the hazards that they may present in the owners, the users, the public, and the local and national decision-makers. On both local and national scales, program purposes also include periodic reporting on the degree of program implementation. Key to accomplishing these purposes is to attract, train, and retain a staff proficient in the art and science of dam design.

Decant system. A conduit system provided for discharge of clarified water and drawdown of storm storage from an impoundment. Decant systems often serve as the primary or principal spillway.

Delta. See **Beach**.

Design storm. The flood hydrograph (representing a significant precipitation event or storm) used in the design of a dam and its appurtenant works, particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.

Ditches. See **Channel**.

Diversion ditches. A waterway used to divert water from its natural course. The term is generally applied to an excavation to bypass water around a dam site.

Drain, blanket. A layer of pervious material placed to facilitate drainage of the foundation and/or embankment.

Drain, chimney. A vertical or inclined layer of pervious material in an embankment to facilitate and control drainage of the embankment fill.

Drain, toe. A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

Drainage area. The area that drains to a particular point on a river or stream.

Drawdown. The difference between a water level and a lower water level in a reservoir within a particular time. Used as a verb, it is the lowering of the water surface.

Downstream slope. The inclined surface of an embankment dam on the downstream side of the crest, above the toe. The face of a dam.

Eddy. A current of air or water running back, or in an opposite direct to the main current.

Embankment dam. Any dam constructed of excavated natural materials, such as both earthfill and rockfill dams, or of industrial waste materials, such as a tailings dam.

Emergency. A condition that develops unexpectedly, which endangers the structural integrity of a dam and/or downstream human life or property, and requires immediate action.

Emergency Action Plan (EAP). A plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood.

Energy dissipater. A device constructed in a waterway to reduce the kinetic energy of fast flowing water.

Emergency spillway. Any secondary spillway that is designed to be operated infrequently.

Erosion. The wearing away of a surface (bank, streambed, embankment, or other surface) by floods, waves, wind, or any other natural process.

Erosion protection. An element or product installed, primarily in channels and ditches, to prevent erosion of the base soil during runoff and flood flow.

Failure. See **Dam failure**.

Failure mode. A potential failure mode is a physically plausible process for dam failure resulting from an existing inadequacy or defect related to a natural foundation condition, the dam or appurtenant structures design, the construction, the materials incorporated, the operations and maintenance, or aging process, which can lead to an uncontrolled release of the reservoir.

Fetch. The area of ocean or lake surface over which the wind blows in an essentially constant direction, thus generating waves. The term also is used as a synonym for fetch length, which is the horizontal distance over which wave-generating winds blow.

Filter (filter zone). One or more layers of granular material graded (either naturally or by selection) so as to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

Filter diaphragm. A zone of granular materials used for intercepting seepage through backfill pores or cracks and to prevent internal erosion of the backfill materials along buried conduit installations through a dam.

Filter fabric. A geotextile used for drainage, filtration, and separation of materials.

Flood hydrograph. A graph showing the rate of flow (discharge versus time) at a specific point.

Flood routing. A process of determining progressively over time the amplitude of a flood wave as it moves past a dam or downstream to successive points along a river or stream.

Foundation. The portion of the valley floor that underlies and supports the dam structure.

Freeboard. Vertical distance between a specified water surface elevation and the top of the dam, without camber.

Geotextiles. Any fabric or textile (natural or synthetic) when used as an engineering material in conjunction with soil, foundations, or rock. Geotextiles have the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers, and erosion protection.

Granular material. Gravels, sands, or silts which exhibit no characteristics of cohesiveness or plasticity; more permeable than cohesive or plastic soils.

Groin area. The area along the contact (or intersection) of the face of a dam with the abutments.

Hazard. A situation that creates the potential for adverse consequences such as loss of life, property damage, or other adverse impacts.

Hazard potential. The possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. Impacts may be for a defined area downstream of a dam from flood waters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam. There may also be impacts for an area upstream of the dam from effects of backwater flooding or landslides around the reservoir perimeter.

Hazard potential classification. A system that categorizes dams according to the degree of adverse incremental consequences of a failure or misoperation of a dam. The hazard potential classification does not reflect in any way on the current condition of the dam (i.e., safety, structural integrity, flood routing capacity).

Height, above ground. The maximum height from natural ground surface to the top of a dam.

Height, hydraulic. The vertical difference between the maximum design water level and the lowest point in the original streambed.

Height, structural. The vertical distance between the lowest point of the excavated foundation to the top of the dam.

Hydrology. One of the earth sciences that encompasses the natural occurrence, distribution, movement, and properties of the waters of the earth and their environmental relationships.

Instrumentation. An arrangement of devices installed into or near dams that provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.

c. **Extensometer.** An instrument designed to measure axial displacement of a fixed point or points along its length. Extensometers can be a rod-type or a wire-type and are usually grouted into an uncased borehole. They can be installed horizontally, vertically, or at any angle.

d. **Crack monitor.** An instrument to measure movements transverse and along a joint or crack.

e. **Flow measurement device.** An instrument that measures leakage or flow quantities. (flowmeters, weirs, and calibrated bucket with stopwatch)

f. **Inclinometer.** An instrument, usually consisting of a metal or plastic casing inserted in a drill hole and a sensitive monitor either lowered into the casing or fixed within the casing. This measures at different points the casing's inclination to the vertical. The system may be used to measure settlement.

g. **Observation well.** A hole used to observe the groundwater surface at atmospheric pressure within soil or rock.

h. **Piezometer.** An instrument designed to measure water levels or pore-water pressures in embankments, foundations, abutments, soil, or rock. Open system porous-tube, and slotted-pipe piezometers, or observation wells. Closed system - hydraulic twin-tube, pneumatic, or vibrating-wire piezometers.

i. **Settlement sensor.** An instrument to monitor the difference in elevation between the sensor unit and its reservoir. (pneumatic and vibrating-wire)

Internal erosion. A process by which particles of soil are carried away by the seepage. See piping.

Inundation map. A map showing areas that would be affected by flooding from releases from a dam's reservoir. The flooding may be from either controlled or uncontrolled releases or as a result of a dam failure. A series of maps for a dam could show the incremental areas flooded by larger flood releases.

Invert. The invert level is the base interior level of a pipe, ditch, channel, or tunnel. The floor of the pipe or channel bottom. For a vertical riser, it is the crest of the riser and the lowest level at which flow will begin.

Length of dam. The length along the top of the dam. This also includes the open-channel spillway, where it forms part of the length of the dam. If detached from the dam, the spillway should not be included.

Lining. With reference to a canal, tunnel, shaft, or reservoir, a coating of asphaltic concrete, reinforced or unreinforced concrete, shotcrete, rubber or plastic to provide watertightness, prevent erosion, reduce friction, or support the periphery of the outlet pipe conduit.

Longitudinal crack. An opening in the soil running parallel to the crest of the dam embankment.

Mine tailings dam. An industrial waste dam in which the waste materials come from mining operations or mineral processing. It is usually built in stages over the life of the mine. The waste products are often conveyed as fine material suspended in water to the reservoir impounded by the embankment.

Normal pool/reservoir level. For a reservoir with a fixed overflow outlet, the lowest level of that outlet. It is the maximum level to which water may rise under normal operating conditions.

One-Percent-Chance Flood. A flood that has 1 chance in 100 of being equaled or exceeded during any year. Also called the **100-year storm**.

Open-channel spillway. A channel through which flow is discharged from a reservoir.

Phreatic surface. The free surface of water seeping at atmospheric pressure through soil or rock.

Permeability. The quality or state of being permeable - able to be penetrated or passed through by a liquid or gas. A liquid will pass through a low permeability material at a much slower rate.

Pervious layer. A layer or continuous zone of material that has a relatively higher permeability than the surrounding material, particularly the embankment or core material. A layer or zone that is prone to greater seepage flow.

Piezometer. An instrument used for measure water levels or pore-water pressures in embankments, foundations, abutments, soil, rock, or concrete. See **Instrumentation**.

Piping. The progressive development of internal erosion by seepage.

Plunge pool. A natural or artificially created pool that dissipates the energy of free falling water.

Pore-water pressure. The pressure exerted by the water in a porous medium (soil or rock) composed of a solid framework and pores filled or partially filled with water.

Principal spillway. A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir, without significant damage to either the dam or its appurtenant structures.

Probable Maximum Flood (PMF). The most critical flood hydrograph resulting from the Probable Maximum Precipitation. Generally used in the design of a mine dam with high hazard potential classification, particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.

Probable Maximum Precipitation (PMP). Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location during a certain time of the year.

Pushout. The first lift of embankment material that is placed on a beach/delta during the initial construction of an upstream stage.

Reservoir. A body of water or liquid-borne solids impounded by a dam and in which water or liquid-borne solids can be stored.

Reservoir surface area. The area covered by a reservoir when filled to a specified level.

Riprap. A layer of large uncoursed stone, precast blocks, bags of cement, or other suitable material, generally placed on the slope of an embankment or along a watercourse as protection against wave action, erosion, or scour. Riprap is usually placed by dumping or other mechanical methods, and in some cases is hand placed. It consists of pieces of relatively large size, as distinguished from a gravel blanket.

Rock-fill dam. An embankment dam in which more than 50% of the total volume is composed of compacted or dumped cobbles, boulders, rock fragments, or quarried rock generally larger than 3-inch size.

Runoff. The surface water that flows by gravity across land's surface, as it moves through a watershed into a stream or river.

Saddle dam (or dike). A subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir.

Saturated. The phase where the pore space, in a porous medium composed of a solid framework of soil or rock, is filled with water (no air).

Scarp. A step or offset on the ground surface where one side of the ground has moved vertically with respect to the other due to a slope failure.

Seepage. The internal movement of water that may take place through the dam, the foundation, or the abutments.

Seepage collars. A design measure intended for seepage control along conduits. The proper term is anti-seep collars. Anti-seep collars attach to and extend outward in all directions from, in a plane perpendicular to, the conduit. Anti-seep collars are constructed of metal, concrete, or plastic, and typically of the same material as the conduit. Anti-seep collars are no longer the preferred method to be used for conduits through dams.

Settlement. The vertical downward movement of a structure or its foundation.

Settlement, differential. The non-uniform settlement of the underlying soils. Settlement in an uneven or an abrupt fashion can cause damage to the structure relying on the soil for support.

Slope protection. Materials used to protect a slope against wave action or erosion. See Riprap.

Slump or Slough. An area of soft, wet ground that is slowly sliding and has moved a short distance down a slope. A shallow slope failure usually due to wet ground conditions.

Spillway. A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means, such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

Spillway capacity. The maximum spillway outflow that a dam can safely pass with the reservoir at its maximum level.

Stability. The condition of a structure or a mass of material when it is able to support the applied stress for a long time without suffering any significant deformation or movement that is not reversed by the release of the stress.

Storm storage. The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel.

Storage. The volume available for retention of water, sediment, or water-borne waste material.

Tailings. The fine mine waste, generally as produced by the metal and non-metal mining industry, that is pumped to a tailings dam as a slurry.

Tailings dam. See **Mine tailings dam**.

Thrust block. A massive block of concrete built to withstand a thrust or pull. Often located at bends in buried conduits.

Toe drain. See **Drain, toe.**

Toe of the dam. The junction of the downstream slope or face of a dam with the ground surface; also referred to as the downstream toe. The junction of the upstream slope with ground surface is called the heel or the upstream toe.

Trashrack. A device located at an intake to prevent floating or submerged debris from entering the intake.

Transverse crack. An opening in the soil running perpendicular to the crest of the dam (from crest upstream to downstream edges).

Upstream slope. The inclined surface of an embankment dam on the upstream side of the crest.

Valve. A device fitted to a pipeline or orifice so as to control or stop the flow.

Watershed. See drainage area. The watershed for a dam is the drainage area upstream of the dam.

Weir. A device for measuring the rate of flow of water. It generally consists of a rectangular, trapezoidal, triangular, or other shaped notch, located in a vertical, thin plate over which water flows. The height of water above the weir crest is used to determine the rate of flow.

Whirlpool. A swirling body of rotating water produced by opposing currents or a current running into an obstacle. Vortex is the proper term for a whirlpool that has a downdraft.

APPENDIX 10

Dam Safety Bibliography

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Accessible Alternative: MSHA Dam Inspection Form, page 18 of 19

2. Evaluation and Actions: Seepage

- Observation: Seepage on downstream face or abutment area
- Evaluate the severity of condition in order to determine the actions needed:
  - Is seepage carrying embankment material/low clarity?
  - Are there large seepage flows or are seepage areas growing in size?
  - Is seepage causing sloughs, major erosion, or has a hole formed?
  - Is seepage present with other conditions such as whirlpools, sinkholes, or boils?

Is there one or more "yes" answer to above?

- If yes, immediate actions:
  - Increase monitoring frequency
  - Remediate condition (e.g., move slurry/tailings deposition point, install filter blanket, etc.)
  - Notify Design Engineer
    - If conditions are not improving, follow Emergency Actions: Implement emergency actions/interventions (e.g., lower pool level, plug sinkholes/ whirlpools; evacuation, etc.)
    - If conditions are improving, follow initial or continuing actions:
      - Continue to monitor seepage area, pool level, precipitation data, etc.
      - Conduct preventative maintenance activities (e.g., move slurry/tailings deposition point, install filter blanket, etc.)

If there is not one or more "yes" answers to above, is it newly discovered or existing condition?

- If newly discovered:
  - Identify seepage area (sketch on map)
  - Mark and measure extent of seepage area
  - Determine quantity of seepage (install weir)
  - Determine clarity of seepage (e.g., clear, cloudy, muddy)
    - Follow initial or continuing actions:
      - Continue to monitor seepage area, pool level, precipitation data, etc.
      - Conduct preventative maintenance activities (e.g., move slurry/tailings deposition point, install filter blanket, etc.)
- If existing condition:
  - Compare observed conditions (extent of seepage area,. quantity, clarity of seepage, etc.) with previous observations and measurements
  - Determine how long condition existed
    - If conditions are not improving, follow Emergency Actions: Implement emergency actions/interventions (e.g., lower pool level, plug sinkholes/ whirlpools; evacuation, etc.)
    - If conditions are improving, follow initial or continuing actions:
      - Continue to monitor seepage area, pool level, precipitation data, etc.
      - Conduct preventative maintenance activities (e.g., move slurry/tailings deposition point, install filter blanket, etc.)

*Examples:

- Seepage carrying embankment material/ clarity decreasing
- Seepage quantity increasing
- Seepage area increasing in size
- Seepage changes with other conditions such as whirlpools, sinkholes, or boils

3. Evaluation and actions: Slope Stability

- Observations: cracks or scraps on crest or slopes; bulging or sloughing at base of slide area; major erosion or embankment deterioration.
- Evaluate the severity of potential instability in order to determine the actions needed:
    - Are there large vertical displacements / scarps and bulging at the base of slide area?
    - Is a significant portion of the crest affected if cracking is parallel to crest?
    - Is there a connection to the pool if cracking on the crest is traverse?
    - Are piezometer readings above their warning elevations?

Is there one or more “yes” answer to above?

- If yes, Immediate actions:
    - Increase monitoring frequency
    - Install additional instrumentation
    - Determine potential causes * and limit additional construction loading
    - Conduct preventative maintenance activities (e.g. lower pool, stabilize movement area)
    - Notify design engineer
        - If movement is continuing, implement emergency Action:
            - Access consequences of failure
            - Implement emergency actions as needed
        - If movement is not continuing, continue to initial or continuing actions:
            - Continue to monitor movements and instrumentation
            - Determine potential causes * and limit additional construction loading
            - Conduct preventative maintenance activities

If there is not one or more “yes” answers to above, is it newly discovered or existing?

- If newly discovered:
    - Identify movement area (sketch on map)
    - Mark and measure extent of vertical and horizontal movement
    - Read instrumentation (piezometers, inclinometers, staff gauge, etc.)
    - Then, continue to initial or continuing actions:
        - Continue to monitor movements and instrumentation
        - Determine potential causes * and limit additional construction loading
        - Conduct preventative maintenance activities
- If newly existing condition:
    - Compare measurements with previous observations and measurements (cracking and instrumentation)
    - Determine how long condition existed
        - If conditions are worsening, follow listed immediate actions:
            - Increase monitoring frequency
            - Install additional instrumentation
            - Determine potential causes * and limit additional construction loading
            - Conduct preventative maintenance activities (e.g. lower pool, stabilize movement area)
            - Notify design engineer
                - If movement is continuing, implement emergency Action:
                    - Access consequences of failure
                    - Implement emergency actions as needed
                - If movement is not continuing, continue to initial or continuing actions:
                    - Continue to monitor movements and instrumentation

        - Determine potential causes * and limit additional construction loading
        - Conduct preventative maintenance activities
    - If conditions are not worsening, initial or continuing actions:
        - Continue to monitor movements and instrumentation
        - Determine potential causes * and limit additional construction loading
        - Conduct preventative maintenance activities

*Potential Causes of Movement:

- Steep slopes over-built embankment
- Rapid construction
- High pore water pressures
- Differential settlement (transverse cracking)
- Mine Subsidence
- Earthquake/liquefaction
- Sudden pool level drop