Design Guidelines for Coal Refuse Piles and Water, Sediment, or Slurry Impoundments and Impounding Structures

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

Informational Report
IR 1109
1979

Design Guidelines for Coal Refuse Piles and Water, Sediment, or Slurry Impoundments and Impounding Structures

U.S. Department of Labor
Ray Marshall, Secretary

Mine Safety and Health Administration
Robert B. Lagather, Assistant Secretary
1979

IR 1109

Mine Safety and Health Administration
Informational Report 1109

DESIGN GUIDELINES FOR COAL REFUSE PILES AND WATER, SEDIMENT, OR SLURRY IMPOUNDMENTS AND IMPOUNDING STRUCTURES

by

Staff, Mine Waste Branches

ERRATA

On page 1, Introduction, the second sentence of the first paragraph should read: "These regulations are set forth in Title 30, Code of Federal Regulations, Sections 77.214 to 77.217."

CONTENTS

	Page
Abstract	1
Introduction	1
General design considerations	2
Hydrologic considerations	2
General	2
Design storms	4
Precipitation data	4
Runoff determination	6
Hydraulic considerations	6
General	6
Freeboard	6
Drawdown criteria	8
Diversion and collection ditches	8
Decant system	13
Spillway systems	13
Geotechnical considerations	13
General	13
Foundation preparation	19
Stability	19
Seismic loading	19
Seepage control	21
Upstream method of construction	23
Dewatered slurry	23
Appendix.--Plan review checklist	27

ILLUSTRATIONS

1.	Erosion at abutment contact of coal waste embankment	3
2.	Probable maximum precipitation, 6-hour, 10 square miles	5
3.	Spillway channel being excavated in original ground	7
4.	Inadequate freeboard to divert runoff around embankment	9
5a.	Embankment crest of uncompacted waste with little freeboard	10
b.	Improved embankment with adequate freeboard	11
6.	Diversion ditch around disposal site	12
7.	Trashrack in plane of decant pipe entrance	14
8.	Trashrack on vertical riser	15
9.	Trashrack with small openings	16
10.	Spillway channel protected by gabions	17
11.	Spreading and compacting coal waste	18
12.	Seismic zone map	20
13.	Blanket drain with perforated pipe	22
14.	Typical slurry discharge procedure	24
15.	Filter cake deposited on coal waste embankment	25

DESIGN GUIDELINES FOR COAL REFUSE PILES AND WATER, SEDIMENT, OR SLURRY IMPOUNDMENTS AND IMPOUNDING STRUCTURES

by

Staff, Mine Waste Branches [1]

ABSTRACT

This publication presents the guidelines used by the Mine Waste Branches of the Mine Safety and Health Administration's Denver Technical Support and Pittsburgh Technical Support Centers and by MSHA district managers in their review of engineering plans for coal refuse impoundments. These guidelines give detailed information on the hydrologic, hydraulic, and geotechnical factors that should be considered in planning such structures. A plan review checklist is included.

INTRODUCTION

The current Mine Safety and Health Administration amended regulations on refuse piles and impounding structures became effective on November 1, 1975. These regulations are set forth in Title 30, Code of Federal Regulations, Sections 77.215 to 77.217. The regulations on refuse piles include requirements for reporting pertinent information, identification, construction, and certifying stability. The regulations on impounding structures include requirements for development and approval of construction plans, notification of potentially hazardous conditions, and identification.

The MSHA district managers have the responsibility to approve the engineering plans for proposed construction or modification of waste disposal facilities before the plans are carried out. On request, the Mine Waste Branches provide the district managers with technical reviews of and recommendations on these plans. To minimize any differences in the philosophy used by each branch in their review of plans, the design guidelines presented in this publication were jointly developed. These guidelines should be followed in the preparation of submittals as required in the regulations. This will speed the review process by eliminating the need for MSHA to request additional work and resubmittal. Supporting data and engineering calculations for stability, hydrology, hydraulics, and laboratory data should be submitted along with the engineering plan and specifications.

[1] Technical Support, Denver, Colo., and Pittsburgh, Pa.

The guidelines presented here evolved from several earlier sets of such guidelines, informally distributed to the mining industry in the past and successively revised on the basis of experience and advances in knowledge. They will continue to be updated as the state of the art for the safe and orderly deposition of coal waste is advanced.

GENERAL DESIGN CONSIDERATIONS

Disposal of coal waste is an integral part of the mining operation, and economics dictates that a waste embankment be properly designed to maintain a safe site while keeping the cost for disposal as low as possible.

The cost of engineering design and inspection to ensure stability is small in comparison to the cost of emergency measures to avert a developing failure or the resulting law suits if a failure should occur. Competent and experienced consultants should be used unless the company engineers have extensive experience in the design and construction of coal refuse disposal facilities.

Because of the long operating life of coal refuse facilities, it is important that the embankment be designed to remain stable during all stages of construction. Also, the facility should be designed to free the company of all need to perform maintenance after abandonment (see fig. 1).

The engineer must anticipate and design for the worst possible condition--that is, ultimate height, maximum phreatic line, saturated soils, and any seismic activity. The technology developed for water storage dams can be used in the design and construction of coal waste disposal facilities.

Site conditions, including hydrology, geology, and downstream development and hazard potential in case of embankment failure, need to be assessed in detail.

Section 77.216-2(a) of Title 30, Code of Federal Regulations, lists specific items that must be included in every plan for a water, sediment, or slurry impoundment submitted to MSHA.

HYDROLOGIC CONSIDERATIONS

General

Hydrology is the study of climatic and physical conditions that govern the natural occurrence of flows in rivers, streams, and channels. All coal refuse embankments are subject to the effects of precipitation. It is necessary to determine how much water will flow onto, around, through, and over a coal refuse disposal facility in order to handle those flows in a safe, economical and environmentally acceptable manner. The selection of an appropriate inflow design flood is an essential part of the engineering studies for developing a refuse disposal plan.

FIGURE 1. - Erosion at abutment contact of coal waste embankment. Coal waste embankments must be protected from surface runoff. Lack of drainage protection at abutment can lead to severe erosion. A gully can develop rapidly during one large rainstorm.

Design Storms

Selection of an appropriate design storm for coal refuse disposal facilities requires determining the hazard potential in the event of failure.

Current, prudent engineering practices require a conservative approach to provide maximum flood protection for water-retention structures located where failure may cause loss of life or serious property damage. Therefore, designs of water, sediment, or slurry impoundments in such areas should be based on the probable maximum precipitation (PMP) of 6-hour duration. A 20-percent reduction in the PMP is allowed for impoundments east of the 105th meridian with drainage areas less than 10 square miles. For areas west of the 105th meridian, inflow design floods should be prepared using both the probable maximum thunderstorm 1-hour rainfall and the probable maximum 6-hour general-type storm rainfall. The more critical of the two inflow design floods should be used in the design of the structure.

If a coal company submits information demonstrating that the failure of an impounding structure would not cause loss of life or serious property damage, then a lesser design criterion may be used. A 100-year frequency storm of 6-hour duration (one percent probability) is the minimum storm permitted in the design of any impoundment.

For impounding structures without adequate emergency type spillways, which rely primarily on storage to control flood flows, the 6-hour general-type storm values should be extended to periods up to 36 hours by constants obtained from the MESA contract report, Engineering and Design Manual, Coal Refuse Disposal Facilities,[2] and the USBR's Design of Small Dams.[3]

The selection of the design storm is related to the size of the impoundment and the hazard potential of the disposal facility. The recommended minimum design storm criteria for three categories of size and hazard potential are discussed in the Engineering and Design Manual, Coal Refuse Disposal Facilities. Appropriate design storms for unavoidable short-term conditions (2 years or less) are also recommended in the design manual.

Precipitation Data

Precipitation data can be obtained from the Engineering and Design Manual, from Design of Small Dams, and from the most recent National Weather Service publication applicable to the area under study (see fig. 2).

---

[2]Mining Enforcement and Safety Administration. Engineering and Design Manual, Coal Refuse Disposal Facilities. Contract report, prepared by E. D'Appolonia Consulting Engineers Inc., 1975, 798 pp.

[3]U.S. Bureau of Reclamation. Design of Small Dams. Water Resources Technical Publication, 2d ed., rev. repr., 1974, 816 pp.

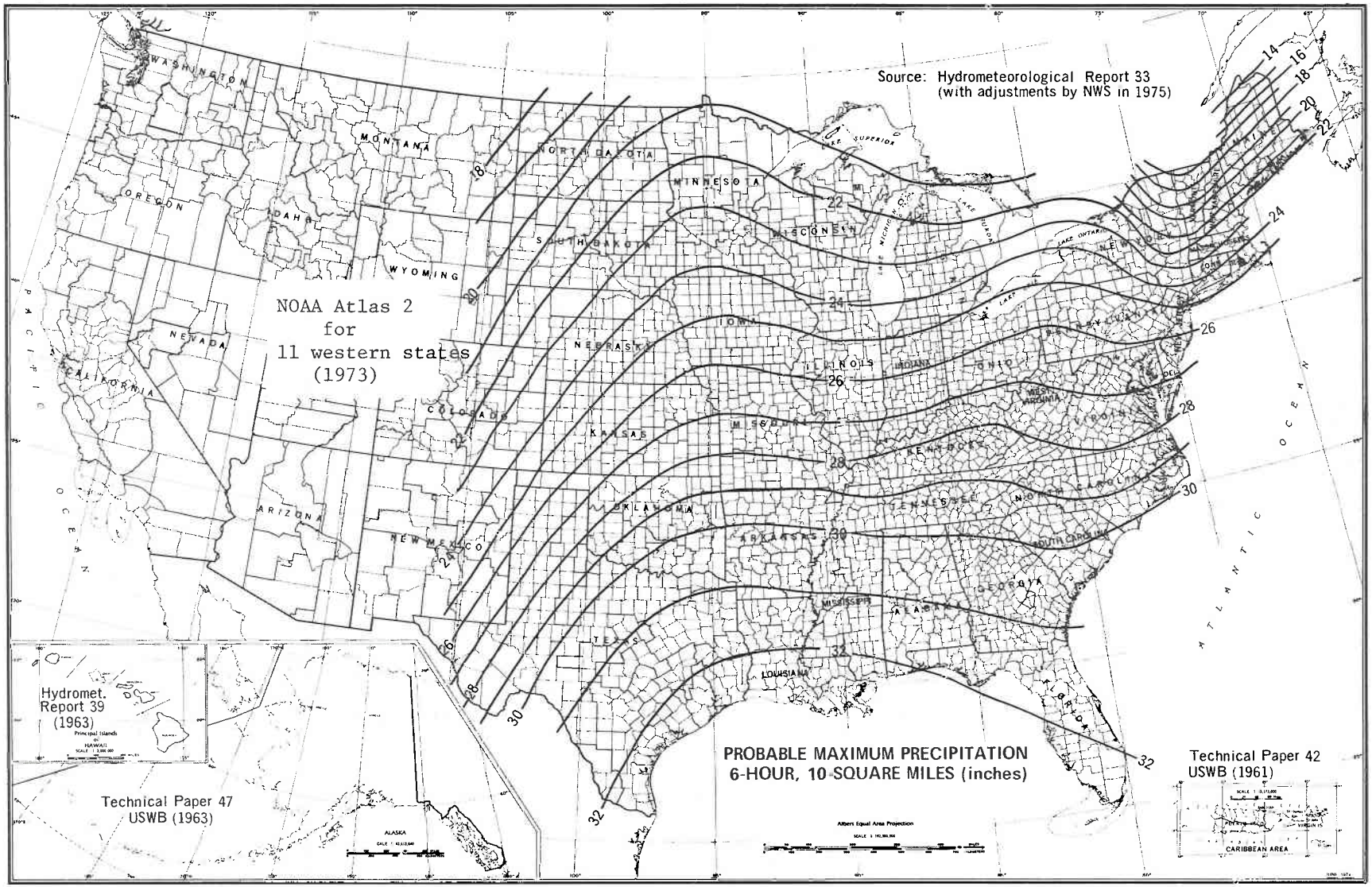

FIGURE 2. - Probable maximum precipitation, 6-hour, 10 square miles.

Runoff Determination

The most important aspect of hydrologic analyses relating to disposal facility performance during and after storm rainfall is the determination of the peak inflow rate and/or the total inflow volume at the point of interest. The flood inflow may be determined by a method developed by the U.S. Soil Conservation Service for estimating runoff on the basis of soil type and cover.[4]

Other methods of determining runoff for use in preliminary system sizing or for designing minor drainage structures are discussed in the Engineering and Design Manual.

HYDRAULIC CONSIDERATIONS

General

The planning and design requirements for hydraulic systems to safely transport the outflow through, around, and beyond a coal refuse disposal facility vary for each situation. Disposal facilities normally change in configuration from day to day as additional coal refuse is deposited. Also, coal refuse disposal facilities are used for a limited time, after which they must be abandoned in a manner that assures safety and minimizes long-term environmental liabilities. Thus, complex hydraulic structures, such as those often used for water-impounding dams, are generally impractical for coal refuse disposal facilities. Instead, such facilities usually make use of excavated channels in natural soil or rock and/or a system which includes a pipe beneath the embankment (see fig. 3).

The planning and design of these systems require a combination of hydrologic, hydraulic, and geotechnical expertise. It is most important that all hydraulic appurtenant structures used for releasing flows from impounded waters to the downstream channel be designed to prevent damage to the impounding structure.

Freeboard

The runoff from the design storm is flood routed through the impoundment and spillway to determine maximum pool elevation and spillway discharge. The freeboard distance between the low point on the crest of an impounding structure and the maximum water elevation must be sufficient at all times to prevent overtopping by waves and should include an allowance for settlement of the foundation and embankment.

Normally, the design freeboard distance between the low point on the crest of an impounding structure and the maximum water elevation for the anticipated design capacity should be at least 3 feet. However, where documentation is provided indicating that there is enough freeboard that there is no possibility of the embankment being overtopped, a lesser freeboard may be

---

[4] U.S. Soil Conservation Service. National Engineering Handbook, Section 4, Hydrology. 1972.

FIGURE 3. - Spillway channel being excavated in original ground. Channel extends beyond toe of embankment. Care must be taken to minimize the sloughing of the sides of the channel.

acceptable. Many factors are involved in the determination of freeboard requirements. Items that should be considered include duration of high water level in pond, effective wind fetch, water depth, potential wave runup on embankment slope, and the ability of the embankment to resist erosion. The crest should slope to force all drainage to the upstream side of the embankment (see figs. 4 and 5).

In a channel conducting flow, freeboard should be provided to prevent bank overtopping due to variations in roughness, wave action, air bulking, curvature of channel, splash and spray. The design freeboard distance between the top of the bank of any spillway or diversion channel and the maximum water surface in the channel should be at least $1.0' + .025v(d)^{.33}$, where v = velocity in ft/sec and d = depth of flow in feet.

Drawdown Criteria

The usual decant is too small to consider in routing the flood flow through the pond. However, its discharge capacity should be considered when storage and drawdown are primary factors in handling the design storm. To assure adequate continued capacity in the event that two or more high intensity storms should occur within a short time, the flood storage of the first flood must be discharged through the decant system within a reasonable period.

Impoundments in which part or all of the inflow from the design storm is to be stored are subject to a drawdown criterion. The criterion is met if 90 percent of the volume of water stored during the design storm can be evacuated from the facility within 10 days.

Diversion and Collection Ditches

Diversion and collection ditches are used to divert flow of small storms from hillsides draining toward an embankment to minimize environmental problems, to maintain embankment stability, or to decrease the amount of water handled by the decant (see fig. 6).

It is often sufficient if diversion ditches around an impoundment are designed in accordance with the appropriate State regulations. Diversion ditches around embankments that cannot impound water are generally required to pass the runoff from a 6-hour duration, 100-year frequency storm.

When an emergency outlet structure for an impounding facility is being evaluated, any diversion ditches should normally be neglected as part of the outlet structure. If a diversion ditch is to be used to pass runoff around an impoundment, in lieu of a spillway, the ditch should be designed and constructed under the same design specifications as a spillway.

To reduce erosion, diversion ditches are needed around refuse disposal facilities that are being abandoned. They must be designed to function properly with limited repair for extended periods. The channel surfaces should be capable of withstanding the expected maximum velocity of the flow without undue erosion or scour.

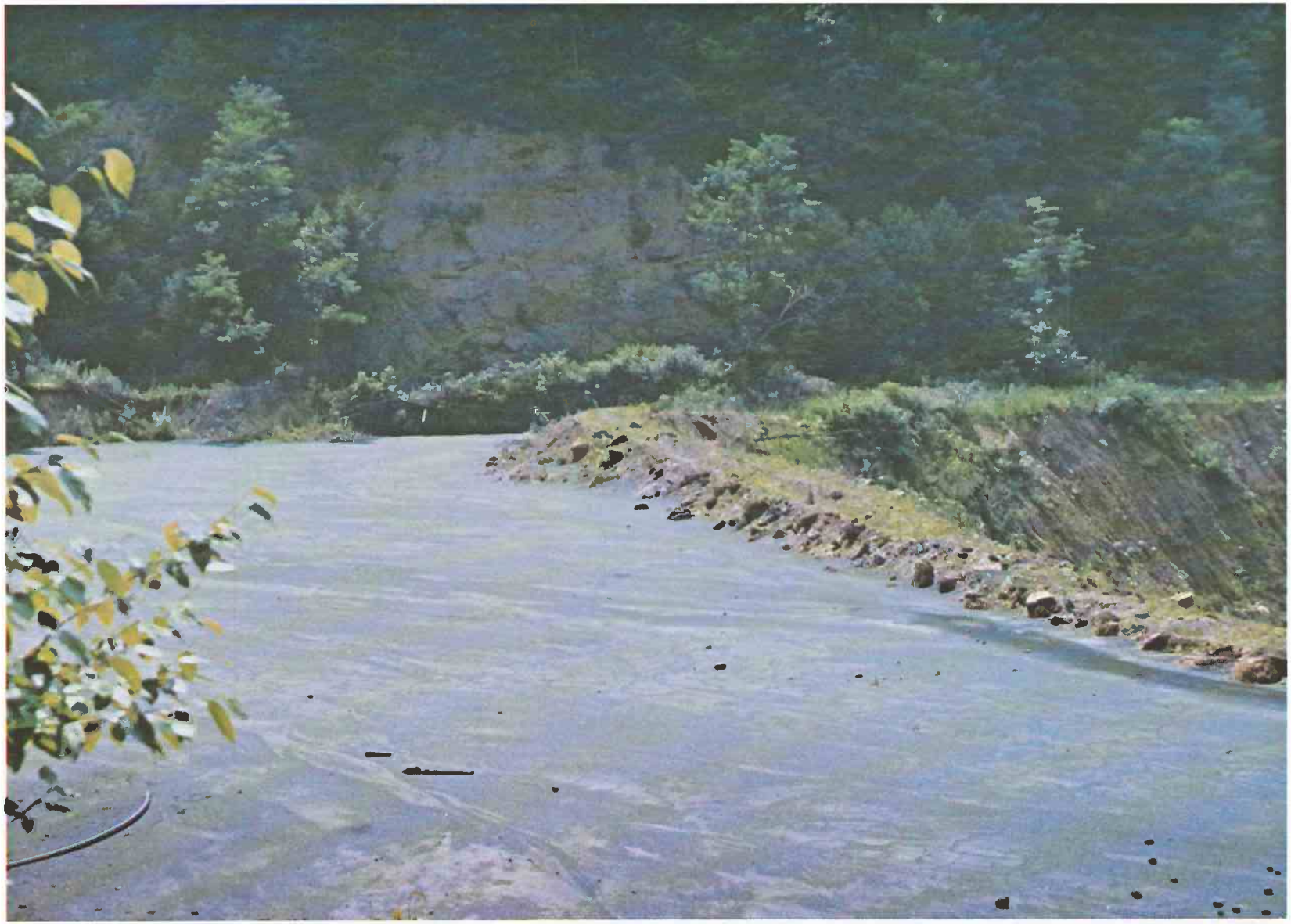

FIGURE 4. - Inadequate freeboard. The freeboard at this site could not protect the embankment even during a small storm runoff.

FIGURE 5a. - Embankment crest of uncompacted waste with little freeboard. This coal waste disposal site was constructed of uncompacted coarse waste with steep slopes, little freeboard, and no spillway.

FIGURE 5b. - Improved embankment with adequate freeboard. The same coal waste embankment has been improved by adding material to flatten the slopes and provide adequate freeboard.

FIGURE 6. - Diversion ditch around disposal site. This diversion ditch will divert flow of small storms around the site. The diversion ditch should not be considered when evaluating an emergency outlet structure.

Decant System

Decant systems at impounding sites serve to remove clarified water during normal disposal of fine refuse; to provide outflow during low precipitation storms so as to maintain storage capability in case a large storm occurs; and to discharge water stored due to inflow of a large storm.

When a pipe or conduit extends beneath or through an embankment it must be placed on an adequate foundation to minimize differential settlement, and the design loads should be based on the eventual total height of the embankment.

All pipes and conduits through impounding embankments should be provided with anti-seep collars. The line of seepage along the line of contact between the embankment and both the barrel and the anti-seep collars should be about 20 percent longer than the pipe or conduit lying within the zone of saturation. Pipes and conduits should be constructed with provisions to prevent clogging (see figs. 7-9).

The discharge flow from the decant outlet must be controlled to prevent undue erosion that would endanger the embankment.

Spillway Systems

There will always be some drainage area to contribute runoff into the area of the mine waste disposal facility. Spillways which safely discharge outflow from large storms are the most crucial hydraulic structure of impounding coal refuse disposal facilities. The waste material is very erodable and overtopping can result in a complete and disastrous failure of the entire embankment.

Because disposal facilities constantly change configuration, concrete chute-type spillways are usually not practical. Most spillway channels are excavated into the original ground at one abutment. The excavated channel must be protected against, excessive erosion, weathering, deterioration of material, or clogging due to localized failure of adjacent natural slopes (see fig. 10).

Reservoir routing is a procedure that can be used to determine the relationship between the storage volume and the spillway size. The technique of performing a flood routing through a reservoir to determine the spillway size is described in several hydraulic references.

GEOTECHNICAL CONSIDERATIONS

General

The geotechnical considerations include the geologic conditions of the foundation, including past or future mining, the properties of coal refuse, soil and rock borrow materials, and the procedure for material placement and construction (see fig. 11). Both the foundation and embankment must be evaluated for stability, seepage, and settlement. The detail necessary will vary depending upon the site's location, size, intended use, and hazard potential.

FIGURE 7. - Trashrack in plane of decant pipe entrance. Trashrack should not be placed in the plane of the pipe entrance since this location will induce plugging. An accumulation of debris at inlet of decant causes unsatisfactory operation or malfunction.

FIGURE 8. - Trashrack on vertical riser. The trashrack can be removed and replaced as the riser is extended. Bars should extend across the top opening of trashrack.

FIGURE 9. - Trashrack with small openings. Trashracks vary greatly in size and in the material used in their construction. The openings should be of such size to remove all debris that might clog the decant or hamper the operation of gates.

FIGURE 10. - Spillway channel protected by gabions. The side of the spillway channel formed of coarse coal waste has been protected from erosion by the use of gabions.

FIGURE 11. - Spreading and compacting coal waste. Spreading coal refuse in layers with compaction will minimize air and water infiltration. This construction method will provide greater density and strength in crucial portions of the embankment.

Foundation Preparation

Surface soils are usually organic. Organic soils are generally very compressible, and have low shear strength. When saturated or under load, such a soil could act as a lubricant and cause a failure. Therefore, foundations for refuse piles and impoundments must be properly prepared by removing all vegetation and undesirable material in order to achieve a firm foundation. The foundation should be of material competent to withstand the weight of fill placed to the maximum height contemplated. Removing vegetation from the foundation area of a coal refuse embankment also minimizes the potential for spontaneous combustion.

Stability

Determining the degree of stability of a coal refuse embankment, or its safety factor, involves uncertainties about material strengths and the future loads which may be added. The safety factor is defined as the ratio of the resisting forces to the forces tending to cause movement.

A slope which is on the verge of failure has a safety factor of 1.0. The design of an embankment must be based on a safety factor greater than 1.0 to allow for differences between assumed strength parameters and those that actually exist within the slope and also so that strains will not exceed tolerable limits. An impounding structure should have minimum static and dynamic safety factors of 1.5 and 1.2, respectively, under full anticipated design capacity.

For dry refuse piles that cannot impound water, slurry, or silt, the coal refuse should be placed with side slopes no steeper than 27 degrees between benches and spread in layers a maximum of 2 feet thick. Alternatively, the refuse pile may be designed to minimum static and dynamic safety factors of 1.5 and 1.2, respectively, with steeper slopes and/or thicker layers.

These minimum safety factors were selected to allow a substantial margin for error, because sampling a coal waste embankment and testing these samples in the laboratory is difficult. Also, the embankment is continually being enlarged and the pore water pressure within the embankment changes.

When few tests are made on the embankment and foundation materials, or when test results are widely scattered, either conservative values of shear strength and pore water pressure should be used in the stability analysis or a higher safety factor should be used in the embankment design.

Suggested minimum safety factors for various hazard ratings are shown in the design manual.

Seismic Loading

Seismic loading should be of concern in designing any impounding structure. High hazard dams located in seismic zones 3 and 4 on the seismic risk map (see fig. 12) should be designed using suitable dynamic procedures and analyses. These include "state of the art" procedures involving seismological

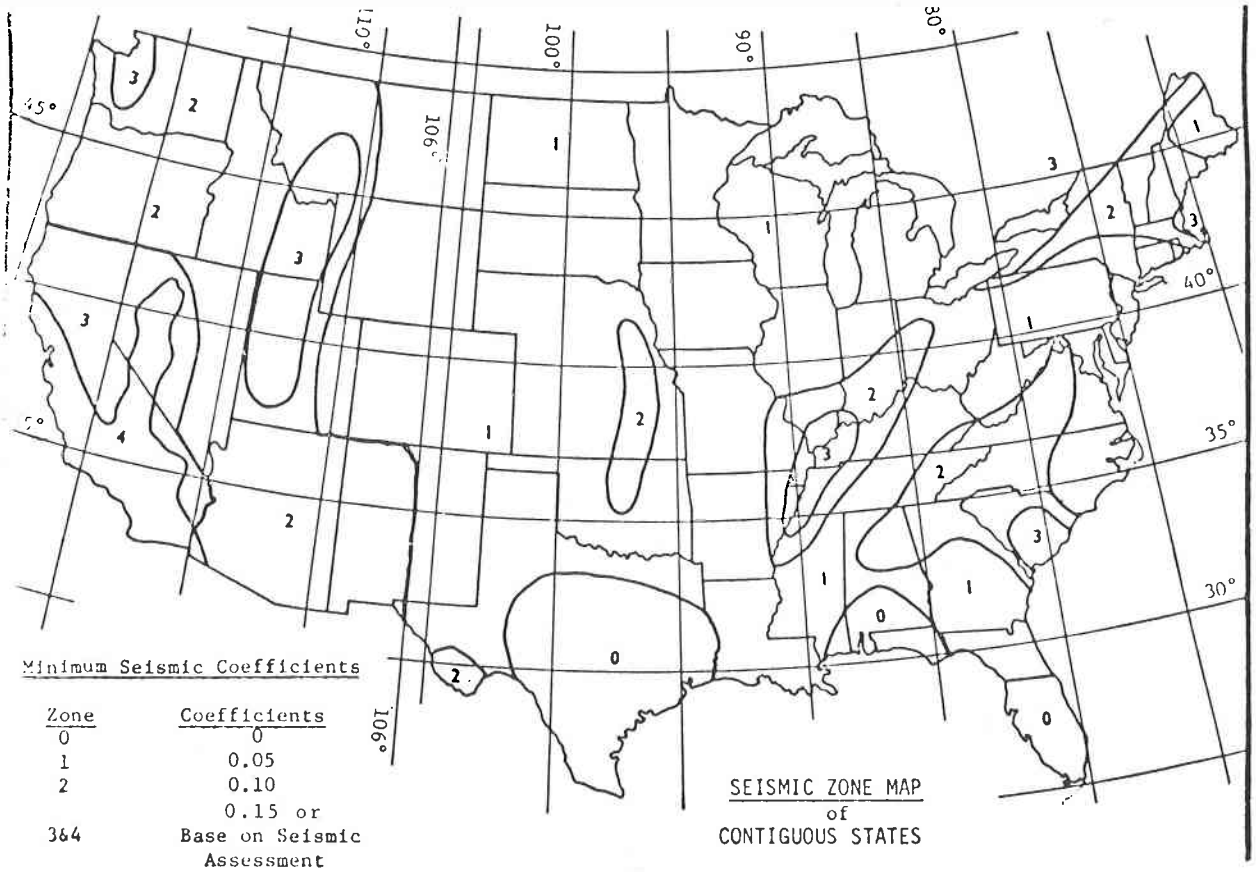

FIGURE 12. - Seismic zone map.

and geological studies to establish earthquake parameters for use in dynamic stability analysis and, where appropriate, the dynamic testing of materials.

Analysis of all other dams may use conventional pseudo-static methods employing constant horizontal seismic coefficients based on the seismic risk map. These coefficients are 0, 0.05, 0.10, and 0.15 for zones 0, 1, 2, and 3 and 4, respectively.

For any dam subject to liquefaction, that is, containing low density, saturated uniform sands, consideration should be given to the incorporation of earthquake defensive design measures, for example:

1. Allow ample freeboard for settlement, slumping and fault movement.

2. Zone the embankment to minimize saturation of material.

3. Use wide transition zones of material not vulnerable to cracking.

4. Use wide core zones of plastic material not vulnerable to cracking.

5. Use well-graded filter zones upstream of the core to serve as crack stoppers.

6. Use ample chimney drains near central portions of embankments.

7. Flare embankment impervious zones at the abutment contacts.

8. Provide erosion resistant crest and downstream slopes.

9. Stabilize slopes around the reservoir to prevent slides into the reservoir.

Seepage Control

It is not possible to eliminate all seepage through an embankment. Seepage control may be required to minimize the loss of process water, to retain polluted water, or to preserve the structural integrity of the embankment. The control of water within an embankment is a very important factor affecting stability.

The two most common types of embankment failures which are directly related to seepage are slope sliding and "piping." Slope stability is affected by the location of the phreatic surface. If the phreatic surface rises above the level used in the design, the embankment's stability could decrease to the point where a slide will occur. Water emerging from an embankment slope could cause progressive deterioration by washing fine soil particles from the embankment through a "piping" action. The inclusion of drainage and filter zones within the embankment is specifically intended to eliminate the possibility of these two types of failures. The most common methods of controlling seepage in an embankment are (1) a vertical or steeply sloping "chimney" drain, which collects seepage before it reaches the vicinity of the downstream slope, (2) a horizontal blanket drain extending under the downstream slope, lowering the seepage phreatic surface, and (3) a triangular or trapezoidal drain placed at the downstream toe. Perforated pipe drains may be incorporated into these systems, and they should be designed to withstand the maximum anticipated load of the overlying material (see fig. 13).

Filters may be required around the drains to prevent piping and subsurface erosion if there is a significant difference between gradation of the material to be protected and the material of the drain.

Filters, drainage blankets, etc., so thin that contamination may occur during construction, are not considered adequate. Normally, a blanket of well-graded material 5 feet thick is preferred; 3 feet is the minimum and will require special construction features to be acceptable. If the proposed construction requires close field control to assure that the facility is properly constructed, then especially careful consideration must be given to all elements of the design. A good reference on filter design requirements is the USBR's Design of Small Dams.

Seepage control for an existing waste embankment may be provided by drilling horizontal drains to intercept the seepage. This work should be done only under the supervision of an expert in drilling and dewatering techniques.

FIGURE 13. - Blanket drain with perforated pipe. Stability of an existing site is increased by constructing a blanket drain incorporating perforated pipe prior to placing the buttress fill.

When an existing embankment needs a buttressing fill to improve its stability, any available material may be used, provided protective filters and drains are used on the downstream face of the embankment and foundation before placing the buttressing fill.

Upstream Method of Construction

One of the more popular types of waste dam configurations is the "upstream method," which gets its name from the fact that it is constructed in stages which are successively placed on the embankment in an upstream direction. A major advantage of this method is that a minimum of specially constructed structural fill is used. However, the structural fill should generally be made wide enough that the potential failure slip surface with the lowest safety factor for all stages can be kept within the structural fill. If fine slurry layers are deposited adjacent to the outer slopes of the embankment, water percolating down from the surface of the pond could be intercepted by these layers and forced laterally toward the outer slope, permitting the development of unstable conditions. The slurry discharge should be located adjacent to the embankment to keep the pond and settled fine slurry back from the embankment (see fig. 14). Also, the largest slurry particles will settle adjacent to the embankment, offering the advantage of their greater strength and reducing settlement when constructing the next embankment stage.

Normally, to maintain stable conditions, the constructed structural portion of each stage of the disposal facility should include provisions to control seepage, as discussed in the previous section.

A disposal facility which will be developed by the upstream method should be designed by an expert in the behavior of soils and embankments.

When a coal company has requested approval to raise the height of an impoundment by upstream construction over slurry sediment, the following is recommended:

1. The coal company shall perform suitable tests on the slurry (subsurface investigation) to prove that the slurry has sufficient strength for stability and support of the added material. The construction of the dam addition must be engineer-controlled and suitably compacted in layers.

2. Dumping material over the freeboard area of the dam crest to extend and raise the embankment is not allowed unless it is in accordance with an approved plan.

Dewatered Slurry

One element in recent progress toward eliminating the threat to public safety from impoundments has been the trend to closed systems with slurry dewatering techniques. The dewatering of the fines is accomplished by a vacuum filter or centrifuge. However, the dewatered slurry (filter cake) obtained is often at a high water content, difficult to transport and dispose of as a solid waste material (see fig. 15). The dewatered slurry should be considered a material with no structural integrity.

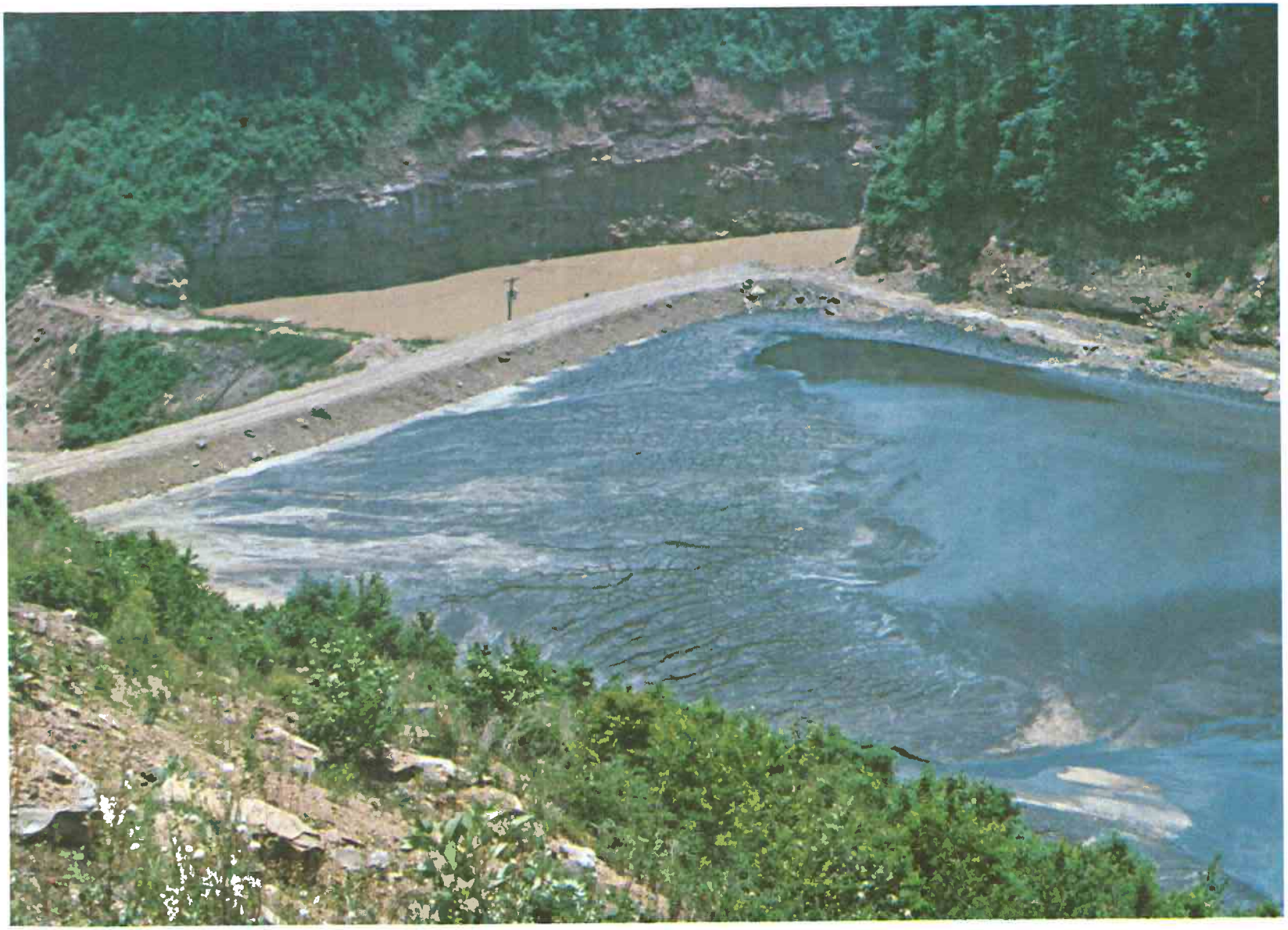

FIGURE 14. - Typical slurry discharge procedure. The slurry discharge point should be located to maintain the free water pond and settled fine slurry away from the embankment.

FIGURE 15.- Filter cake deposited on coal waste embankment. Dewatered slurry often has a high moisture content and is difficult to transport and dispose of as a solid waste material.

To facilitate transport, the filter cake is frequently mixed with coarse refuse at the preparation plant, resulting in a combined refuse that normally can be transported in conventional trucks or conveyors. However, the combined refuse may also contain so much moisture that it is not suitable for use as a structural component in an embankment. The material can be placed somewhere to drain and later moved to the embankment. If the combined refuse is near optimum moisture content and can be spread and compacted, it may be used as a structural component in an embankment. The embankment should be designed and constructed to the usual safety factors, using soil properties determined for the particular coal waste material.

To arrive at the best procedure for disposing of dewatered fine refuse filter cake and coarse refuse, a plan must be designed specifically for each site.

APPENDIX.--PLAN REVIEW CHECKLIST

The following is a list of items generally required to make a comprehensive plan and specification review.

A. SITE DESCRIPTION

1. Name of site.

2. Ownership of property.

3. Active or inactive site.

4. General description of site including downstream development.

5. Detailed location.

6. Construction history.

B. DRAWING OF SITE

A drawing showing the existing conditions and the proposed improvements in sufficient detail that specifications can be prepared and construction accomplished. The drawing should include the following as a minimum:

1. Plan view, including elevations and dimensions, at a scale large enough to show all details such as the location of (a) coal waste embankment, (b) impoundment, (c) diversion ditches, (d) spillway, (e) slurry inlet, (f) pumping and decant system, and (g) access road.

2. One or more sections through the coal waste embankment showing all dimensions and slopes.

3. Sections for the diversion ditches and spillway showing all dimensions, grades, slopes, and material.

4. Original topography.

5. Time schedule for completion of each phase of work.

C. FUTURE PLANS

1. Ultimate size of embankment and impoundment.

2. Method of removing water from impoundment during life of site.

3. Plans to change type of preparation plant system.

D. COAL WASTE EMBANKMENT

1. Type--sidehill, cross-valley, active, inactive, etc.

2. Method of construction and compaction.

3. Combustion control, methods; has it ever burned?

4. Seepage--areas and amounts.

5. Stability analysis of embankment and foundation.

6. Classification and mechanical tests of embankment materials and foundation.

E. SLURRY IMPOUNDMENT

1. Description, including area and depths of water and slurry.

2. History of impoundment.

3. Slurry inlet--location and volume.

4. Description of terrain.

5. Hydrologic study of watershed area.

6. Diversion ditches--location, size, slopes, foundation, grade.

7. Method of removing water from impoundment.

8. Spillway--type, location, size, length, grade, discharge channel.

9. Freeboard from slurry level to spillway invert and to low point on embankment.

F. ABANDONMENT PLANS

1. Plans for abandonment including an anticipated date of abandonment and reclamation of the coal waste embankment and impoundment.

2. Method of removing water from the site after abandonment.

3. Thickness and type of sealer.

4. Preparation, physical and chemical, of embankment or sealer.

5. Type of vegetation.

G. DESIGN CALCULATIONS

1. Hydrologic data and methods of calculation used to determine inflow, outflow, and storage.

2. Hydraulic data and methods of calculation used to determine channel sizes of spillways, decants, and diversion structures.

3. Soil data and methods of calculation used to determine stability of structure under varying conditions.

4. When computer facilities are used for engineering calculations, a copy of the input data and computer output listing shall be submitted for verification and checking purposes. A complete listing of computer programs used should also be submitted. Once a computer program has been sent to a district manager, future submittals to MSHA need only contain reference to the initial submittal. If a computer program is altered, a new listing should be sent.