# INSPECTION REPORT

Sedimentation Structure

BM-B

Black Mesa Mine

Navajo County, Arizona

for

PEABODY COAL COMPANY


Dames & Moore
10139-011-22

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## INTRODUCTION

Sedimentation Structure BM-B is a partially incised structure with an earthen embankment, designed and constructed in 1983 by Peabody Coal Company as a temporary sedimentation structure to control runoff and sediment from the disturbed mining areas of the Black Mesa Mine. The location of Structure BM-B is shown on Plate 1, Site Plan.

This inspection report contains information specific to Structure BM-B. Regional site information is presented in the "General Report, Kayenta and Black Mesa Mines, Navajo County, Arizona for Peabody Coal Company," along with the methods and results of analyses used for slope stability, hydrology and hydraulics.

## INSPECTION

Structure BM-B was inspected on August 29, 1985 by an interdisciplinary team of engineers from Dames & Moore. The purpose of the inspection was to assess the safety and general condition of the structure with respect to United States Department of Interior, Office of Surface Mining (OSM) regulations.

Dames & Moore's inspection was performed in accordance with applicable 30 CFR 780 and 816 regulations and included a review of the BM-B project files and a field inspection of the structure. The most current information contained in the Peabody Coal Company files includes the 1984 and current survey data and inspections performed in 1984 and 1985 by

Peabody Coal Company. The survey data developed in August 1984 was used in the analyses of the structure. Results of the field inspection are included in this report as Appendix A.

## SITE DESCRIPTION

### LAND USE

Structure BM-B has a 51.9-acre tributary drainage area and is located near Moenkopi Wash at the Black Mesa Mine. The watershed is classified as 87% Sagebrush/grass and 13% disturbed.

### EMBANKMENT

Structure BM-B is a homogeneous earthen embankment classified as a cross-valley embankment. Physical characteristics of the embankment are listed in the following table:

Structure BM-B

| | |
|---|---|
| Embankment | Residual Sandstone Soils |
| Foundation | Sandstone |
| Right Abutment | Residual Sandstone Soils |
| Left Abutment | Residual Sandstone Soils |
| Height | 7.5 ft |
| Crest Width | 14.0 ft |
| Upstream Slope | 2.2 H : 1 V |
| Downstream Slope | 2.75 H : 1 V |

A cross-section of the embankment is shown on Plate 2, Existing Maximum Cross Section BM-B, A-A'.

## ANALYSES

### STABILITY

Structure BM-B is a category A-5 embankment. A standard category A-5 embankment has static and seismic factors of safety of 1.5 and 1.2, respectively, under the following conditions:

1. Maximum height = 10 ft
2. Maximum upstream slope = 1.5 H : 1 V
3. Maximum downstream slope = 2.5 H : 1 V
4. Normal pool with steady seepage saturation conditions

The BM-B embankment is lower in height and has flatter slopes than the category standard; therefore, the embankment has factors of safety greater than the design minimum.

### HYDROLOGY

The hydrologic analysis was completed using the U.S. Army Corps of Engineers generalized computer program HEC-1, Flood Hydrograph Package. Structure BM-B is not in series with any other structure and therefore the spillway was analyzed using the 25-year, 6-hour storm. The storage capacity of Structure BM-B was analyzed using the 10-year, 24-hour storm.

The following parameters were used in the hydrologic analysis:

| | | | |
|---|---|---|---|
| 1. | Water Course length, L | 0.371 | mi |
| 2. | Elevation Difference, H | 128 | ft |
| 3. | Time of Concentration, $T_c$ | 0.128 | h |
| 4. | Lag time, $0.6T_c$ | 0.077 | h |
| 5. | SCS Curve Number | 82 | |
| 6. | Rainfall Depth, 10-year, 24-hour storm | 2.1 | in. |
| | 25-year, 6-hour storm | 1.9 | in. |
| 7. | Drainage Area | 51.9 | acres |

HYDRAULICS

The HEC-1 program was used to evaluate inflow to the sedimentation structure, outflow from the structure and the resulting water surface elevations. The initial conditions and results of the analysis are summarized in the following table.

BM-B HYDRAULICS

| | Units | 10-year 24-hour Storm | 25-year 6-hour Storm |
|---|---|---|---|
| Initial Reservoir Volume Condition | | Empty | Full to the spillway elevation |
| Inflow | | | |
| Peak Flow . . . . . | cfs | 61 | 78 |
| Volume . . . . . | acre-ft | 3.3 | 2.60 |
| Storage | | | |
| Peak Stage . . . . . | ft | 6366.42 | 6374.66 |
| Spillway Elevation . . | ft | 6373.80 | — |
| Peak Storage . . . . . | acre-ft | 3.3 | — |
| Storage Capacity . . . | acre-ft | 13.2 | — |
| Outflow | | | |
| Peak Flow . . . . . | cfs | 0 | 5 |
| Embankment Crest Elevation . . . . . | ft | — | 6375.40 |
| Peak Stage . . . . . | ft | — | 6374.66 |
| Freeboard . . . . . | ft | — | 0.74 |
| Mannings "n" . . . . . | | — | 0.040 |

Approach Channel

The existing approach channel for BM-B has a trapezoidal channel with following dimensions:

| | |
|---|---|
| Channel width | 15 ft |
| Channel length | 100 ft |
| Side slopes (horizontal to vertical) | 3:1 |
| Average slope | 5 percent |

There is presently no erosion protection within the channel.

Spillway Channel

The existing spillway for BM-B has a trapezoidal channel with the following dimensions:

| | |
|---|---|
| Channel depth | 2 ft |
| Channel width | 21 ft |
| Channel length | 25 ft |
| Side slopes (horizontal to vertical) | 2:1 |
| Average exit slope | 0 percent |

There is presently no erosion protection within the channel.

Outflow Channel

The existing outflow channel for BM-B has a U-shaped channel with the following dimensions:

| | |
|---|---|
| Channel width | 24 ft |
| Channel length | 34 ft |

There is presently no erosion protection within the channel.

## STORAGE CAPACITY

The impoundment volume-elevation curve is based on site specific surveys conducted for Peabody Coal Company's August 1984 inspection, and 1985 resurveys, where available. Additionally, the most current topographic maps available were used in developing Plate 3, Volume-Elevation Curve, BM-B.

The calculations for the sediment load entering Structure BM-B were made utilizing the Universal Soil Loss Equation with the following parameters:

1. Rainfall Factor, R . . . . . 40
2. Soil Erodibility Factor, K . . . . . 0.21
3. Slope Factor, LS . . . . . 4.15
4. Cover Factor, C . . . . . 0.443
5. Erosion Control Factor, P . . . . . 1.0

The hydrologic analysis gives the storage volume required to contain the 10-year, 24-hour storm, and the remaining storage volume available for storing sediment. The existing storage capacity of BM-B and the results of the sediment inflow analysis are summarized in the following table.

BM-B STORAGE

| | | |
|---|---|---|
| Total Storage Capacity . . . . . | 12.76 | acre-ft |
| 10-year, 24-hour Storm Inflow . . . . . | 3.3 | acre-ft |
| Available Sediment Storage Capacity . . | 9.46 | acre-ft |
| Sediment Inflow Rate . . . . . | 0.372 | acre-ft/yr |
| Sediment Storage Life . . . . . | 25 | yrs |

## REMEDIAL COMPLIANCE PLAN

### GEOTECHNICS

The inspection of Structure BM-B indicated that the geotechnical problems consist of rill and gully erosion on the upstream and downstream slopes, the side slopes and bottom of the approach and spillway channel and the left abutment; and a steep downstream slope. Correction of erosion is considered a periodic maintenance task and does not require remedial action.

### HYDRAULICS

The storage capacity of Structure BM-B is adequate but the spillway capacity is inadequate. The structure does not have an adequate outflow channel. The bottom elevation of the existing spillway channel should be lowered to elevation 6373.55 while maintaining the bottom width of 20 feet as shown on Plate 5. A trapezoidal outflow channel with the same bottom width as the spillway should be constructed along the alignment shown in Plate 1. The channel profile is shown in Plate 4 and the required dimensions are shown in Plate 5. Both the spillway and outflow channel should be protected against erosion using geotextile and gravel as shown in Plate 5.

Lowering the spillway elevation to 6373.55 feet decreases the storage capacity and increases the freeboard. The analysis of these conditions is summarized in the following table.

BM-B HYDRAULICS FOR REDESIGNED SPILLWAY

| | Units | 10-year 24-hour Storm | 25-year 6-hour Storm |
|---|---|---|---|
| Initial Reservoir Volume Condition | | Empty | Full to the spillway elevation |
| Inflow | | | |
| Peak Flow . . . . . | cfs | 61 | 78 |
| Volume . . . . . | acre-ft | 3.30 | 2.60 |
| Storage | | | |
| Peak Stage . . . . . | ft | 6366.42 | — |
| Spillway Elevation . . | ft | 6373.55 | — |
| Peak Storage . . . . . | acre-ft | 3.30 | — |
| Storage Capacity . . . | acre-ft | 12.76 | — |
| Available Sediment Storage Capacity . . | acre-ft | 9.46 | — |
| Sediment Inflow Rate . | acre-ft/yr | 0.372 | — |
| Sediment Storage Life. | yrs | 25 | — |
| Outflow | | | |
| Peak Flow . . . . . | cfs | — | 6 |
| Embankment Crest Elevation . . . . . | ft | — | 6375.40 |
| Peak Stage . . . . . | ft | — | 6374.41 |
| Freeboard . . . . . | ft | — | 0.99 |
| Spillway Channel | | | |
| Flow Depth . . . . . | ft | — | 0.86 |
| Critical Velocity. . . | fps | — | 2.1 |
| Manning's "n" . . . . | | — | 0.035 |
| Outflow Channel | | | |
| Slope . . . . . | % | — | 8 |
| Normal Velocity. . . . | fps | — | 2.7 |
| Normal Depth . . . . . | ft | — | 0.11 |
| Manning's "n" . . . . | | — | 0.035 |

*  *  *

The following plates and appendix are attached and complete this inspection report.

Plate 1 - Site Plan BM-B

Plate 2 - Existing Maximum Cross Section BM-B, A-A'

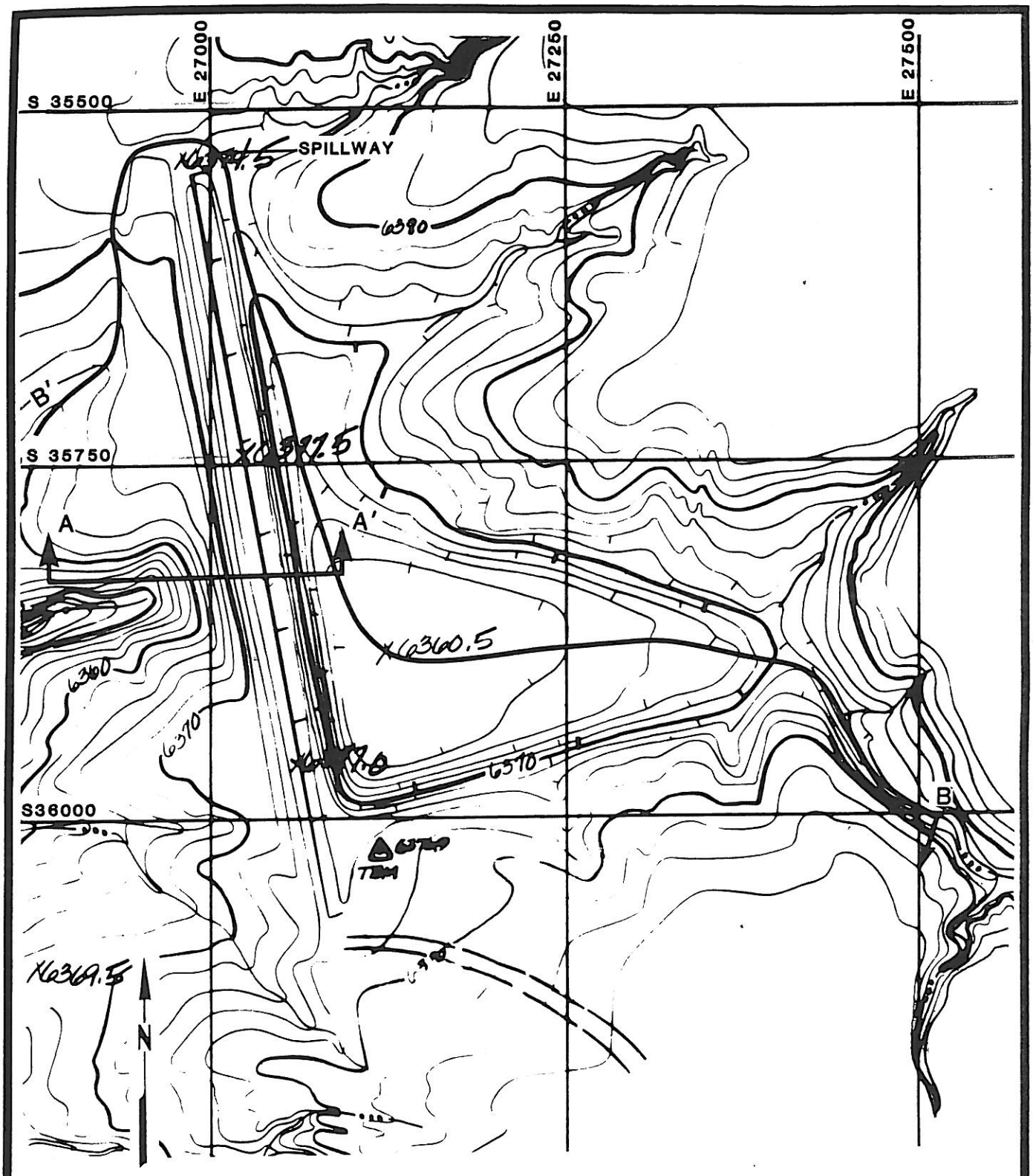
Plate 3 - Volume-Elevation Curve BM-B

Plate 4 - Channel Profile BM-B, B-B'

Plate 5 - Spillway and Outflow Channel Cross Section BM-B

Appendix A - Inspection Check List

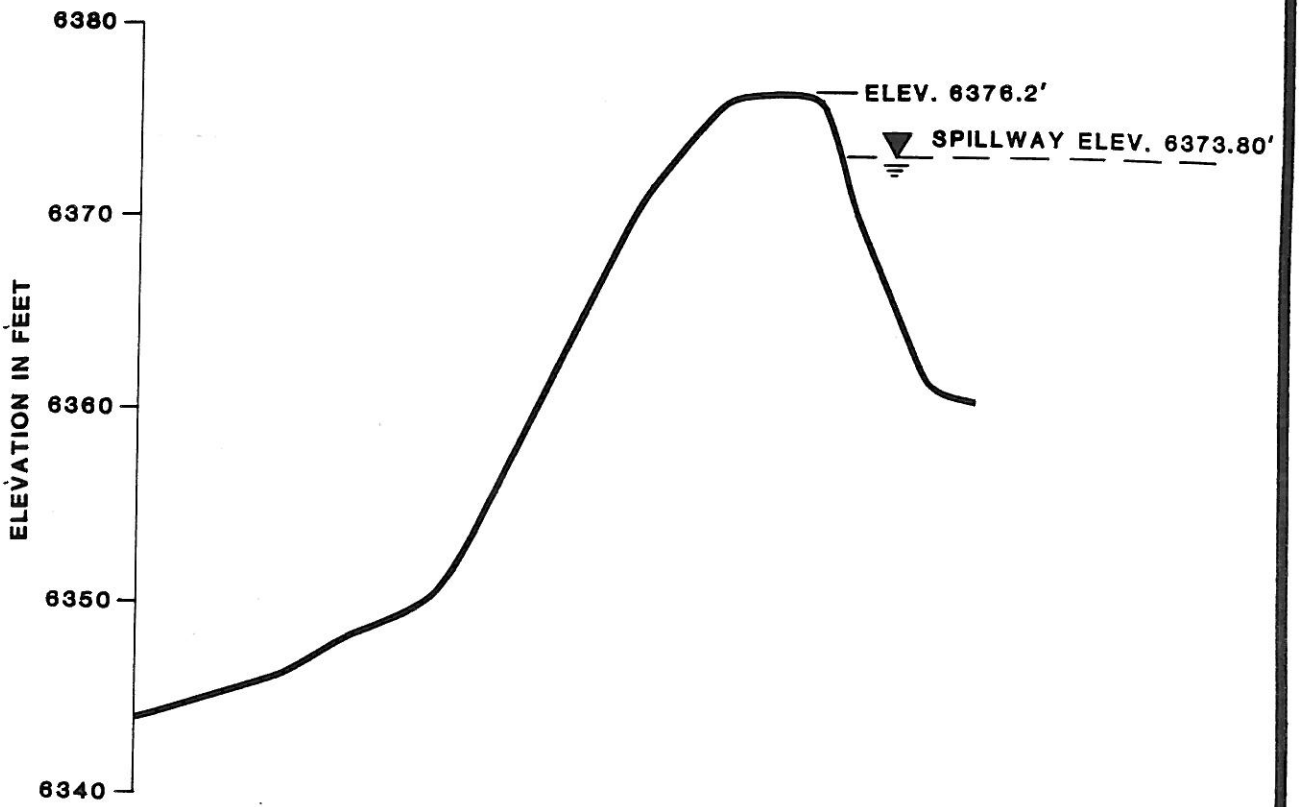
Appendix B - Hydrology and Hydraulic Calculations




SITE PLAN
BM-B

SCALE
0 100 200
FEET

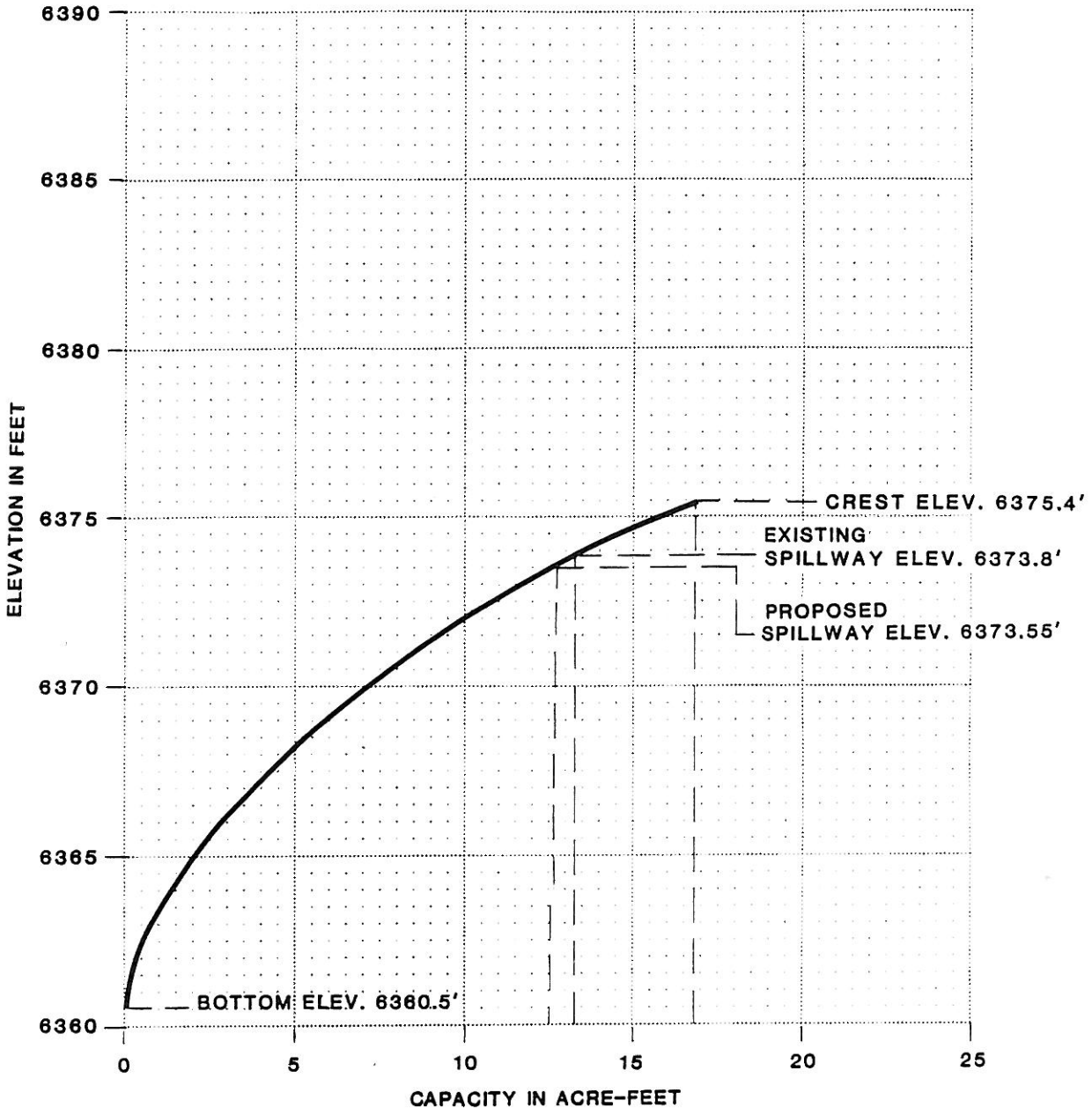
BY Dames & Moore Plate 1




SCALE
0 50 100
FEET

# EXISTING MAXIMUM CROSS-SECTION A-A' BM-B

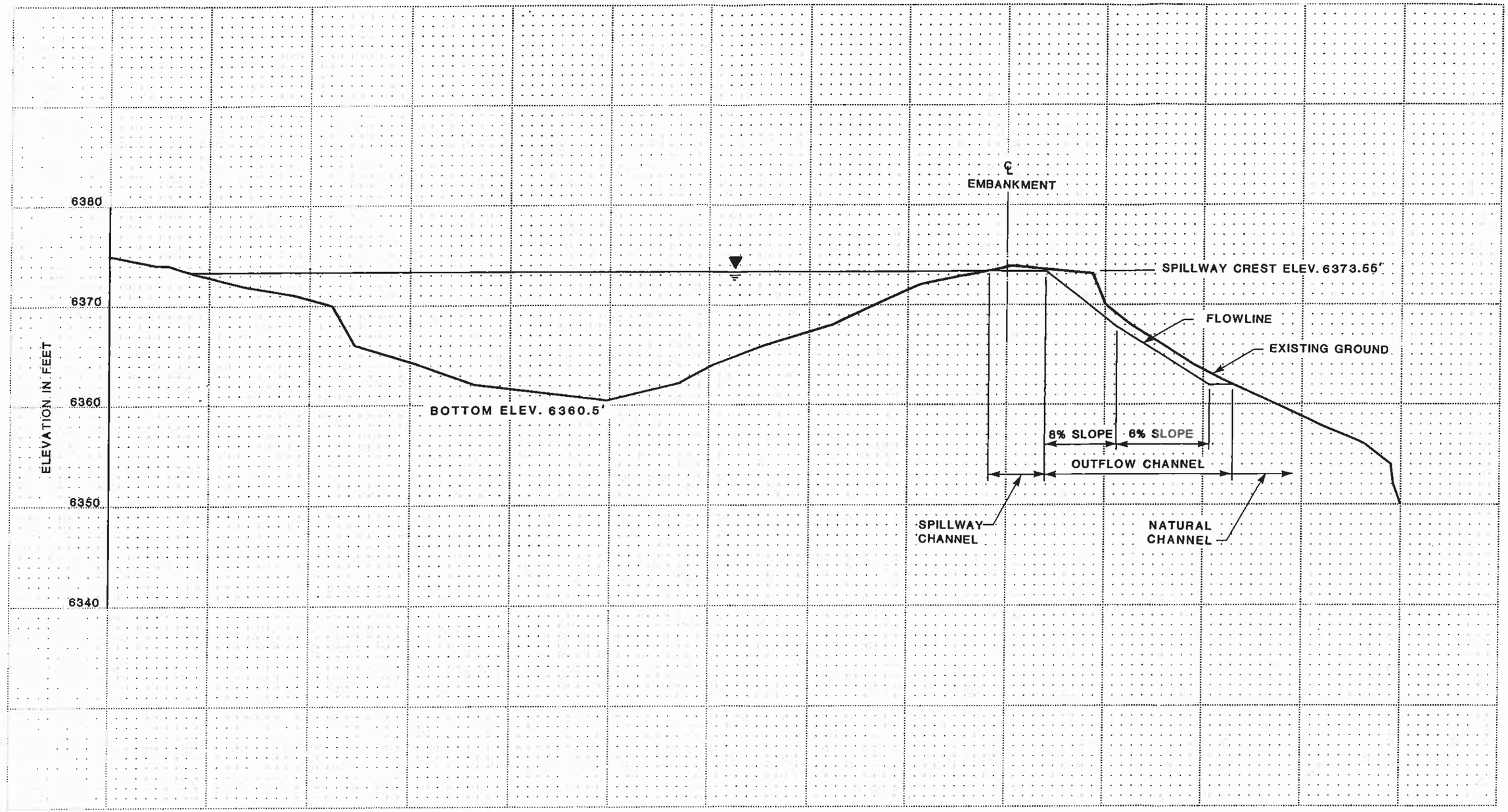
BY **Dames & Moore** Plate 2




# VOLUME-ELEVATION CURVE

## BM-B

BY **Dames & Moore** Plate 3

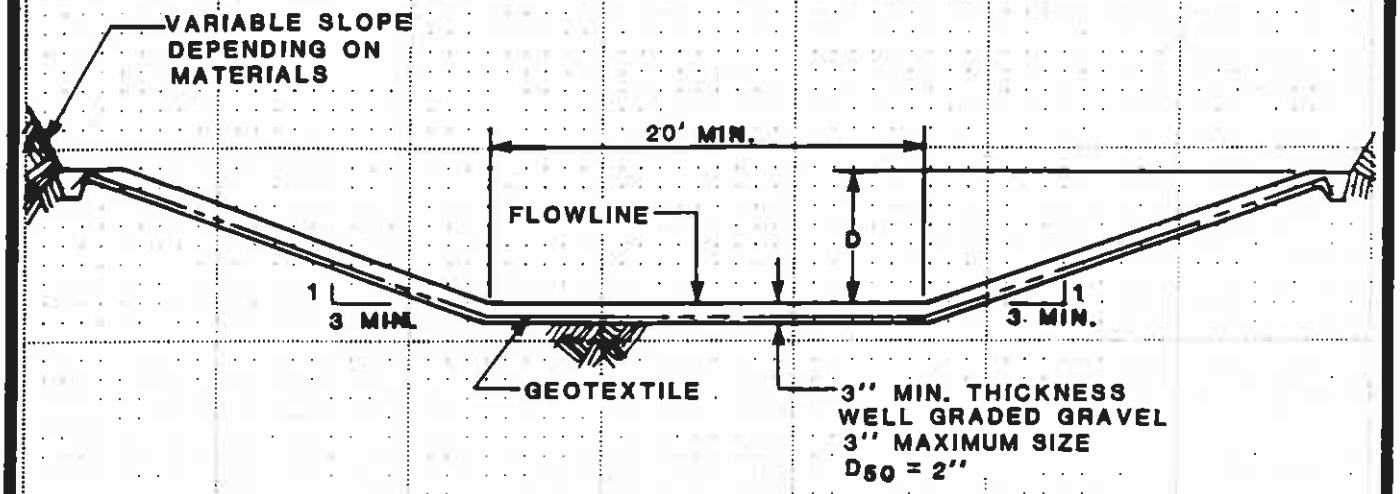



SCALE
0 100 200
FEET

# CHANNEL PROFILE B-B'
# BM-B

FOR LOCATION SEE PLATE 1

BY **Dames & Moore** Plate 4




**SPILLWAY CHANNEL**

D = 1.9'

LENGTH = 30'

FLOWLINE ELEV.= 6373.55'

**OUTFLOW CHANNEL**

D = 1'

# SPILLWAY AND OUTFLOW CHANNEL CROSS SECTION BM-B

BY **Dames & Moore** Plate 5

# APPENDIX A

# INSPECTION CHECK LIST

## INSPECTION CHECK LIST

| ITEM | YES | NO | REMARKS |
|---|---|---|---|
| 1. CREST | | | |
| a. Any visual settlements? | | | |
| b. Misalignment? | | X | |
| c. Cracking? | | | |
| 2. UPSTREAM SLOPE | | | 25° |
| a. Adequate grass cover? | | | Ask |
| b. Any erosion? | X | | Rills |
| c. Are trees growing on slope? | | X | |
| d. Longitudinal cracks? | | X | |
| e. Transverse cracks? | | X | |
| f. Adequate riprap protection? | | | NONE |
| g. Any stone deterioration? | | | NA |
| h. Visual depressions or bulges? | | X | |
| i. Visual settlements? | | X | |
| j. Animal burrows? | | X | |
| 3. DOWNSTREAM SLOPE | | | 20° |
| a. Adequate grass cover? | | | Ask |
| b. Any erosion? | X | | Rills |
| c. Are trees growing on slope? | | X | |
| d. Longitudinal cracks? | | X | |
| e. Transverse cracks? | | X | |
| f. Visual depressions or bulges? | | X | |
| g. Visual settlements? | | X | |
| h. Is the toe drain dry? | | | NA |
| i. Are the relief wells flowing? | | | NA |
| j. Are boils present at the toe? | | | NA |
| k. Is seepage present? | | X | |
| l. Animal burrows? | | X | |
| 4. ABUTMENT CONTACT. RIGHT | | | |
| a. Any erosion? | X | | Slight |
| b. Visual differential movement? | | X | |
| c. Any cracks noted? | | X | |
| d. Is seepage present? | | X | |
| e. Type of Material? | | | gray SM |
| 5. ABUTMENT CONTACT. LEFT | | | |
| a. Any erosion? | X | | gulley u.s. 3.5' DEEP x 4' WIDE |
| b. Visual differential movement? | | X | |
| c. Any cracks noted? | | X | |
| d. Is seepage present? | | X | |
| e. Type of Material? | | | brown SM |

| ITEM | YES | NO | REMARKS |
|---|---|---|---|
| 6. SPILLWAY/NORMAL | | | |
| a. Location: | | | |
| Left abutment? | | | |
| Right abutment? | X | | |
| Crest of Embankments? | | | |
| b. Approach Channel: | | | Parallel to Crest |
| Are side slopes eroding? | X | | Rills |
| Are side slopes sloughing? | | X | |
| Bottom of channel eroding? | X | | gulley |
| Obstructed? | | X | |
| Erosion protection? | | X | |
| c. Spillway Channel: | | | |
| Are side slopes eroding? | X | | minor |
| Are side slopes sloughing? | | X | |
| Bottom of channel eroding? | | X | |
| Obstructed? | | X | |
| Erosion protection? | | X | |
| d. Outflow Channel: | | | Parallel to Crest |
| Are side slopes eroding? | | X | Natural swale |
| Are side slopes sloughing? | | X | |
| Bottom of channel eroding? | | X | |
| Obstructed? | | X | |
| Erosion protection? | | X | |
| e. Weir: | | X | |
| Condition? | | | |
| 7. SPILLWAY/EMERGENCY | | | N/A |
| a. Location: | | | |
| Left abutment? | | | |
| Right abutment? | | | |
| Crest of Embankments? | | | |
| b. Approach Channel: | | | |
| Are side slopes eroding? | | | |
| Are side slopes sloughing? | | | |
| Bottom of channel eroding? | | | |
| Obstructed? | | | |
| Erosion protection? | | | |
| c. Spillway Channel: | | | |
| Are side slopes eroding? | | | |
| Are side slopes sloughing? | | | |
| Bottom of channel eroding? | | | |
| Obstructed? | | | |
| Erosion protection? | | | |
| d. Outflow Channel: | | | |
| Are side slopes eroding? | | | |
| Are side slopes sloughing? | | | |
| Bottom of channel eroding? | | | |
| Obstructed? | | | |
| Erosion protection? | | | |
| e. Weir: | | | |
| Condition? | | | |

8. GENERAL COMMENTS

left abutment gully 3' deep 4' wide
dump rock to prevent further erosion

IMPOUNDMENT

WATERSHED 100% SAGE-GRASS
≈ 30% UNDISTURBED

NO WATER PRESENT

NO SINK HOLES

Some sediment in impoundment

# APPENDIX B

# HYDROLOGY AND HYDRAULIC CALCULATIONS

FILE PEABODY COAL CO 10139-011-32
SUBJECT SEDIMENT POND HYDROLOGY
BM-B
SHEET ___ OF ___

REVISIONS
BY ___ DATE ___ TO EO ___
BY ___ DATE ___ TO EO ___

## TIME OF CONCENTRATION

ELEVATION DIFFERENCE = 6502 − 6374 = 128 ft.

WATER COURSE LENGTH = 4.9 in (400 ft/in) = 1960 ft. = 0.371 mi.

$$T_c = \left(\frac{11.9(0.371)^3}{128}\right)^{0.385} = 0.128 \text{ hr.}$$

LAG TIME = $0.6 T_c$ = 0.077 hr.

## SCS CURVE NUMBER

| DRAINAGE AREA (ac) | COVER TYPE | HYDROLOGIC CONDITION | SOIL TYPE | WEIGHTED CURVE NUMBER |
|---|---|---|---|---|
| 6.9 (13%) | DIST. GRAVEL RD | — | D | 0.13(91) = 11.8 |
| 45.0 (87%) | S-G | POOR | C | 0.87(80) = 69.6 |
| | | | EH#32 | 81.4 |

USE 82 ✓

## DRAINAGE BASIN AREA

51.9 ACRES 0.081 SQ. MILES ✓

BY S. DOLAN DATE 9-9-85
CHECKED BY BHM 10/24/85
COPY TO EO ___

FILE PEABODY COAL CO 10139-011-22
SUBJECT SEDIMENT INFLOW
BM-B
SHEET ___ OF ___

REVISIONS BY ___ DATE ___ TO EO ___
BY ___ DATE ___ TO EO ___

BY ___ DATE ___
CHECKED BY BHM 10/29/85
COPY TO EO ___

# UNIVERSAL SOIL LOSS EQUATION

## RAINFALL FACTOR

R = 40

## SOIL ERODIBILITY FACTOR

SOIL TYPE = 100% EH #32 (.21)

K = .21

## SLOPE FACTOR

| LENGTH (ft.) | Δ ELEV (ft.) | SLOPE (%) | LS |
|---|---|---|---|
| 700 | 100 | 14.3 | 6.27 (.4) |
| 800 | 70 | 8.8 | 3.19 (.4) |
| 400 | 30 | 7.5 | 1.81 (.2) |
| | | use | 4.15 ✓ |

## COVER FACTOR

| AREA (ac.) | COVER TYPE | % COVER | CANOPY (%) | WEIGHTED C |
|---|---|---|---|---|
| 13% | disturbed | — | — | .13(1.0) |
| 87% | S-G | 10 | 25 | .36(.87) |
| | | | | C = .443 ✓ |

## EROSION CONTROL FACTOR

P = 1.0

## SEDIMENT INFLOW

$A = 40(.21)(4.15)(.443)(1.0) = 15.44$ ton/acre/year ✓

$A = 15.44\left(\frac{1}{2047}\right)(57.9)(.95) = .372$ acre-feet/year ✓

**Dames & Moore**