INSPECTION REPORT

Sedimentation Structure

J16-G

Kayenta Mine

Navajo County, Arizona

for

PEABODY COAL COMPANY


Dames & Moore
10139-011-22

TABLE OF CONTENTS

## INTRODUCTION

Sedimentation Structure J16-G is a partially incised structure with an earthen embankment, designed and constructed in 1982 by Peabody Coal Company as a temporary sedimentation structure to control runoff and sediment from the disturbed mining areas of the Kayenta Mine. The location of Structure J16-G is shown on Plate 1, Site Plan.

This inspection report contains information specific to Structure J16-G. 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 J16-G was inspected on September 10, 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 J16-G 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 J16-G has a 272.0-acre tributary drainage area and is located near Moenkopi Wash at the Kayenta Mine. The watershed is classified as 80% disturbed, 16% Sagebrush/grass, and 4% reclaimed.

### EMBANKMENT

Structure J16-G is a homogeneous earthen embankment classified as a sidehill embankment. Physical characteristics of the embankment are listed in the following table:

Structure J16-G

| | |
|---|---|
| Embankment | Residual Sandstone Soils |
| Foundation | Residual Sandstone Soils |
| Right Abutment | Residual Sandstone Soils |
| Left Abutment | Residual Sandstone Soils |
| Height | 12.9 ft |
| Crest Width | 25 ft |
| Upstream Slope | 2.9 H : 1 V |
| Downstream Slope | 1.7 H : 1 V |

A cross-section of the embankment is shown on Plate 2, Existing Maximum Cross Section J16-G, A-A'. Grass provides erosion protection on the upstream and downstream slopes of the embankment.

## ANALYSES

### STABILITY

Structure J16-G is a category A-1 embankment. A standard category A-1 embankment has static and seismic factors of safety equal to or greater than 1.5 and 1.2, respectively, under the following conditions:

1. Maximum height = 20 ft
2. Maximum upstream slope = 2.0 H : 1 V
3. Maximum downstream slope = 4.0 H : 1 V
4. Normal pool with steady seepage saturation conditions

The J16-G embankment is lower in height; however, the downstream slope is steeper than the category standard; therefore, the embankment has factors of safety less 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 J16-G is located downstream from the proposed new Structure J16-G1. The two structures have a combined storage capacity that is greater than 20 acre-feet. Therefore, the spillway for J16-G was analyzed using the 100-year, 6-hour storm. The storage capacity of Structure J16-G was analyzed using the 10-year, 24-hour storm.

The following parameters were used in the hydrologic analysis:

| | | 10-year, 24-hour Storm | 100-year, 6-hour Storm | |
|---|---|---|---|---|
| 1. | Water Course length, L . . . . . | 0.106 | 0.477 | mi |
| 2. | Elevation Difference, H . . . . | 107 | 144 | ft |
| 3. | Time of Concentration, $T_c$ . . . | 0.032 | 0.163 | h |
| 4. | Lag time, $0.6T_c$ . . . . . | 0.019 | 0.098 | h |
| 5. | SCS Curve Number . . . . . | 91 | 90 | |
| 6. | Rainfall Depth . . . . . | 2.1 | 2.4 | in. |
| 7. | Drainage Area . . . . . | 11.2 | 272.0 | 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 10-year storm was routed through Structure J16-G1 and into Structure J16-G. The 100-year storm was analyzed without Structure J16-G1. The initial conditions and results of the analysis are summarized in the following table.

| | Units | 10-year 24-hour Storm | 100-year 6-hour Storm | |
|---|---|---|---|---|
| Initial Reservoir Volume Condition | | Empty | Full to the spillway elevation | |
| Inflow | | | | |
| Peak Flow . . . . . | cfs | 28 | 960 | |
| Volume . . . . . | acre-ft | 1.11 | 31.5 | |
| Storage | | | | |
| Peak Stage . . . . . | ft | 6566.20 | 6579.57 | |
| Spillway Elevation . . | ft | 6576.40 | -- | |
| Peak Storage . . . . . | acre-ft | 1.11 | -- | |
| Storage Capacity . . . | acre-ft | 20.7 | -- | |
| Outflow | | | | |
| Peak Flow . . . . . | cfs | 0 | 674 | |
| Embankment Crest Elevation . . . . . | ft | -- | 6580.80 | |
| Peak Stage . . . . . | ft | -- | 6579.57 | |
| Freeboard . . . . . | ft | -- | 1.23 | |
| Spillway Channel | | | | |
| Flow Depth . . . . . | ft | -- | 3.17 | |
| Critical Velocity. . . | fps | -- | 7.1 | |
| Manning's "n" . . . . | | -- | 0.040 | |
| Outflow Channel | | | Section I | Section II |
| Slope . . . . . | % | -- | 2.5 | 17 |
| Normal Velocity. . . . | fps | -- | 7.6 | 14.0 |
| Normal Depth . . . . . | ft | -- | 1.62 | 0.92 |
| Manning's "n" . . . . | | -- | 0.040 | 0.040 |

Approach Channel

The existing approach channel for J16-G has a U-shaped channel with following dimensions:

| | |
|---|---|
| Channel width | 30 ft |
| Slope | 4 percent |

There is presently no erosion protection within the channel.

Spillway Channel

The existing spillway for J16-G has a trapezoidal channel with the following dimensions:

| | |
|---|---|
| Channel depth | 8 ft |
| Channel width | 55 ft |
| Channel length | 40 ft |
| Side slopes (horizontal to vertical) | 2:1 |
| Average exit slope | 2 percent |

Rock provides some but inadequate erosion protection within the channel.

Outflow Channel

The structure presently has no outflow 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, J16-G.

The calculations for the sediment load entering Structure J16-G were made utilizing the Universal Soil Loss Equation with the following parameters:

1. Rainfall Factor, R . . . . . 40
2. Soil Erodibility Factor, K . . . . . 0.246
3. Slope Factor, LS . . . . . 2.87
4. Cover Factor, C . . . . . 0.827
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 J16-G and the results of the sediment inflow analysis are summarized in the following table.

J16-G STORAGE

| | | |
|---|---|---|
| Total Storage Capacity . . . . . | 20.7 | acre-ft |
| 10-year, 24-hour Storm Inflow . . . . . | 1.11 | acre-ft |
| Available Sediment Storage Capacity . . | 19.89 | acre-ft |
| Sediment Inflow Rate . . . . . | 0.642 | acre-ft/yr |
| Sediment Storage Life . . . . . | 31 | yrs |

## REMEDIAL COMPLIANCE PLAN

### GEOTECHNICS

The inspection of Structure J16-G indicated that the geotechnical problems consist of rill and gully erosion on the upstream and downstream slopes and the side slopes and bottom of the spillway channel. Correction of erosion is considered a periodic maintenance task and does not require remedial action. The upstream and downstream slopes of the embankment are uneven and should be trimmed smooth to prevent masking of future potential problems. The downstream slope should be flattened to 4.0 horizontal to 1 vertical to meet stability requirements.

### HYDRAULICS

The storage capacity and spillway capacity of Structure J16-G are adequate; however, the spillway does not have an adequate outflow channel. A trapezoidal outflow channel and a stilling basin should be constructed along the alignment B-B' shown in Plate 1. The channel and stilling basin profile is shown in Plate 4 and the required dimensions are shown in Plate 5 and Plate 6. The spillway channel, outflow channel and stilling basin should be protected against erosion using geotextile and riprap as shown in Plate 5.

The present storage capacity of Structure J16-G exceeds 20 acre-feet. The spillway should be lowered to elevation 6576.00 feet to reduce the storage capacity to 19.65 acre-feet. The analysis of these conditions is summarized in the following table.

## J16-G HYDRAULICS FOR LOWERED SPILLWAY

| | Units | 10-year 24-hour Storm | 100-year 6-hour Storm | |
|---|---|---|---|---|
| Initial Reservoir Volume Condition | | Empty | Full to the spillway elevation | |
| **Inflow** | | | | |
| Peak Flow | cfs | 28 | 960 | |
| Volume | acre-ft | 1.11* | 31.51 | |
| **Storage** | | | | |
| Peak Stage | ft | 6566.20 | 6579.19 | |
| Spillway Elevation | ft | 6576.00 | — | |
| Peak Storage | acre-ft | 1.31 | — | |
| Storage Capacity | acre-ft | 19.65 | — | |
| Available Sediment Storage Capacity | acre-ft | 18.34 | — | |
| Sediment Inflow Rate | acre-ft/yr | 0.642 | — | |
| Sediment Storage Life | yrs | 29 | -- | |
| **Outflow** | | | | |
| Peak Flow | cfs | 0 | 680 | |
| Embankment Crest Elevation | ft | — | 6580.80 | |
| Peak Stage | ft | — | 6579.19 | |
| Freeboard | ft | — | 1.61 | |
| **Spillway Channel** | | | | |
| Flow Depth | ft | — | 3.19 | |
| Critical Velocity | fps | — | 7.1 | |
| Manning's "n" | | — | 0.040 | |
| **Outflow Channel** | | | Section I | Section II |
| Slope | % | — | 2.5 | 17 |
| Normal Velocity | fps | — | 7.6 | 14.0 |
| Normal Depth | ft | — | 1.62 | 0.92 |
| Manning's "n" | | — | 0.040 | 0.040 |

*Inflow volume for tributary drainage area between Structures J16-G and J16-G1.

The storage capacity is reduced when the spillway elevation is lowered. The capacity was reanalyzed considering the reduced storage and inflow from Structure J16-G1. Structure J16-G1 is located upstream from Structure J16-G and contributes excess flow to J16-G during the 10-year, 24-hour storm. Therefore, the structures must be combined to determine the total sediment storage capacity. The results of the combined sediment inflow analysis are summarized in the following table.

COMBINED STORAGE FOR J16-G AND J16-G1

| | J16-G1 | J16-G | Total | |
|---|---|---|---|---|
| Total Storage Capacity . . . . . | 19.14 | 19.65 | 38.79 | acre-ft |
| 10-year, 24-hour Storm Inflow . . . . . | 25.21 | 1.15 | 26.36 | acre-ft |
| Available Sediment Storage Capacity . . | -- | -- | 12.43 | acre-ft |
| Sediment Inflow Rate . . . . . | 2.32 | 0.642 | 2.96 | acre-ft/yr |
| Sediment Storage Life . . . . . | -- | -- | 4 | yrs |

* * *

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

Plate 1 - Site Plan J16-G

Plate 2 - Existing Maximum Cross Section J16-G, A-A'

Plate 3 - Volume-Elevation Curve J16-G

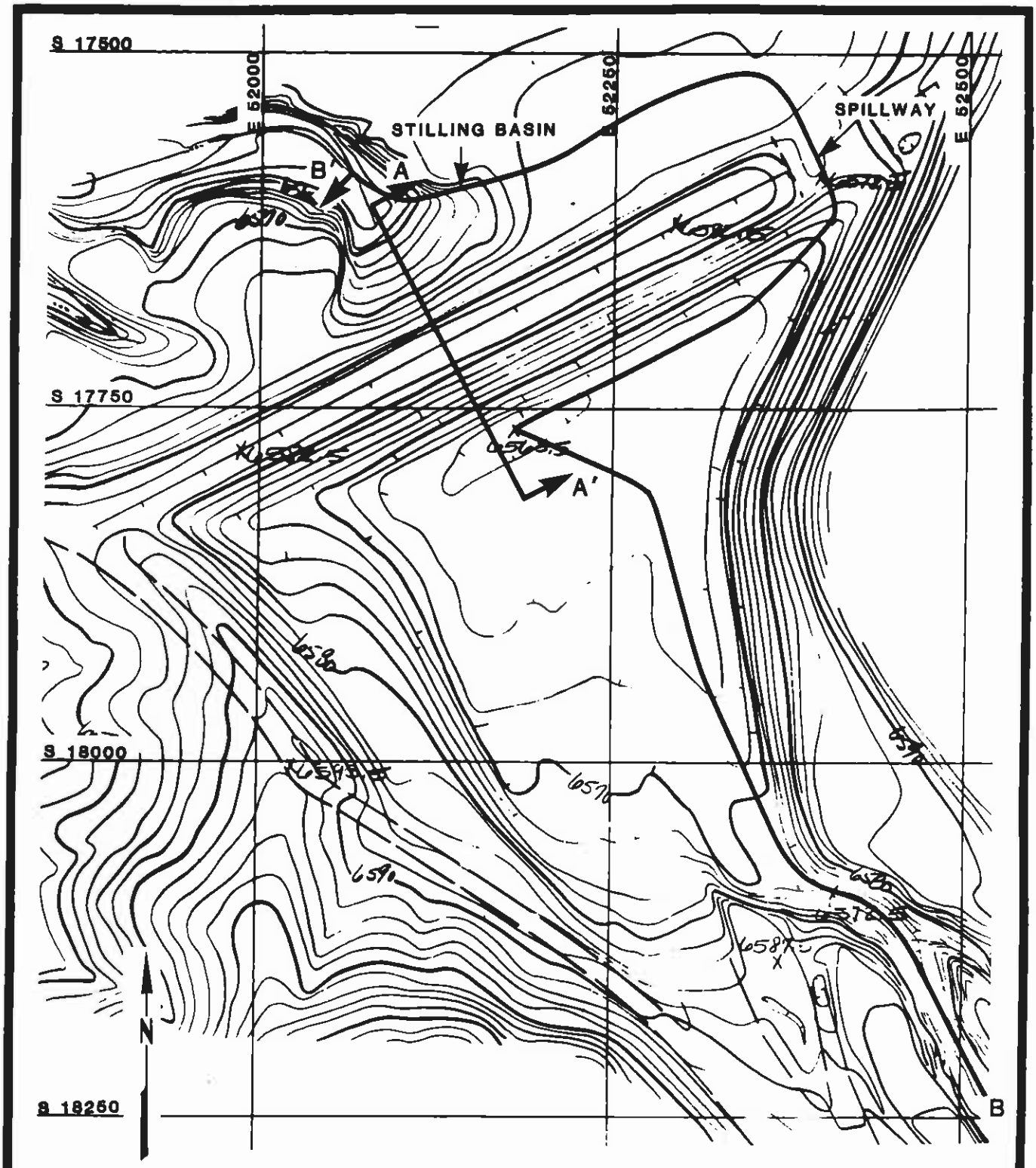
Plate 4 - Channel Profile J16-G, B-B'

Plate 5 - Spillway and Outflow Channel Cross Section J16-G

Plate 6 - Spillway Stilling Basin Plan J16-G

Appendix A - Inspection Check List

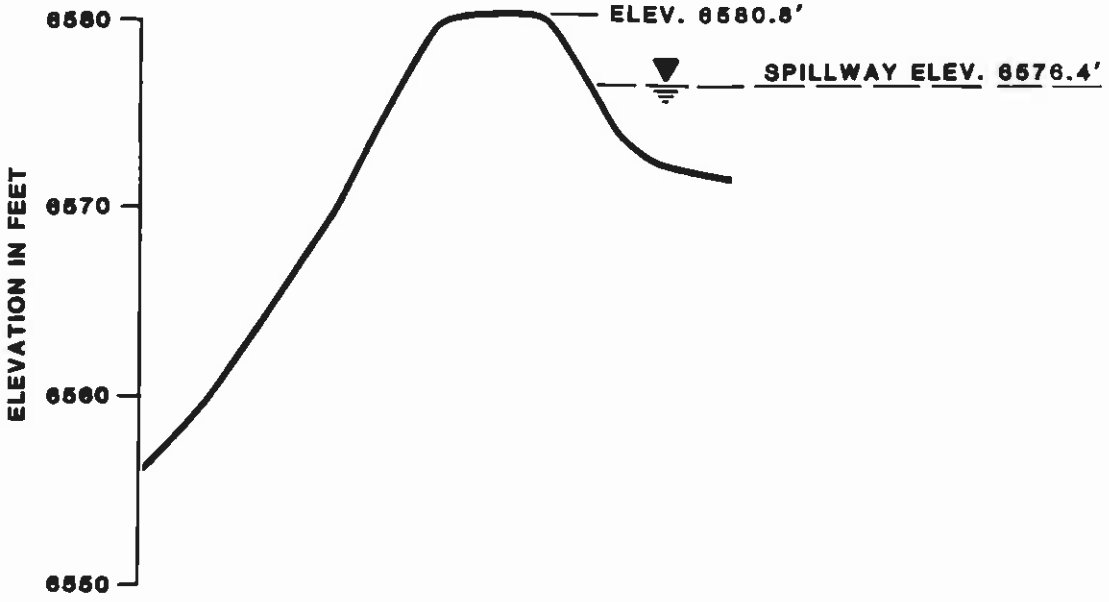
Appendix B - Hydrology and Hydraulic Calculations




SCALE
0 100 200
FEET

# SITE PLAN
# J16-G

BY **Dames & Moore** Plate 1




SCALE
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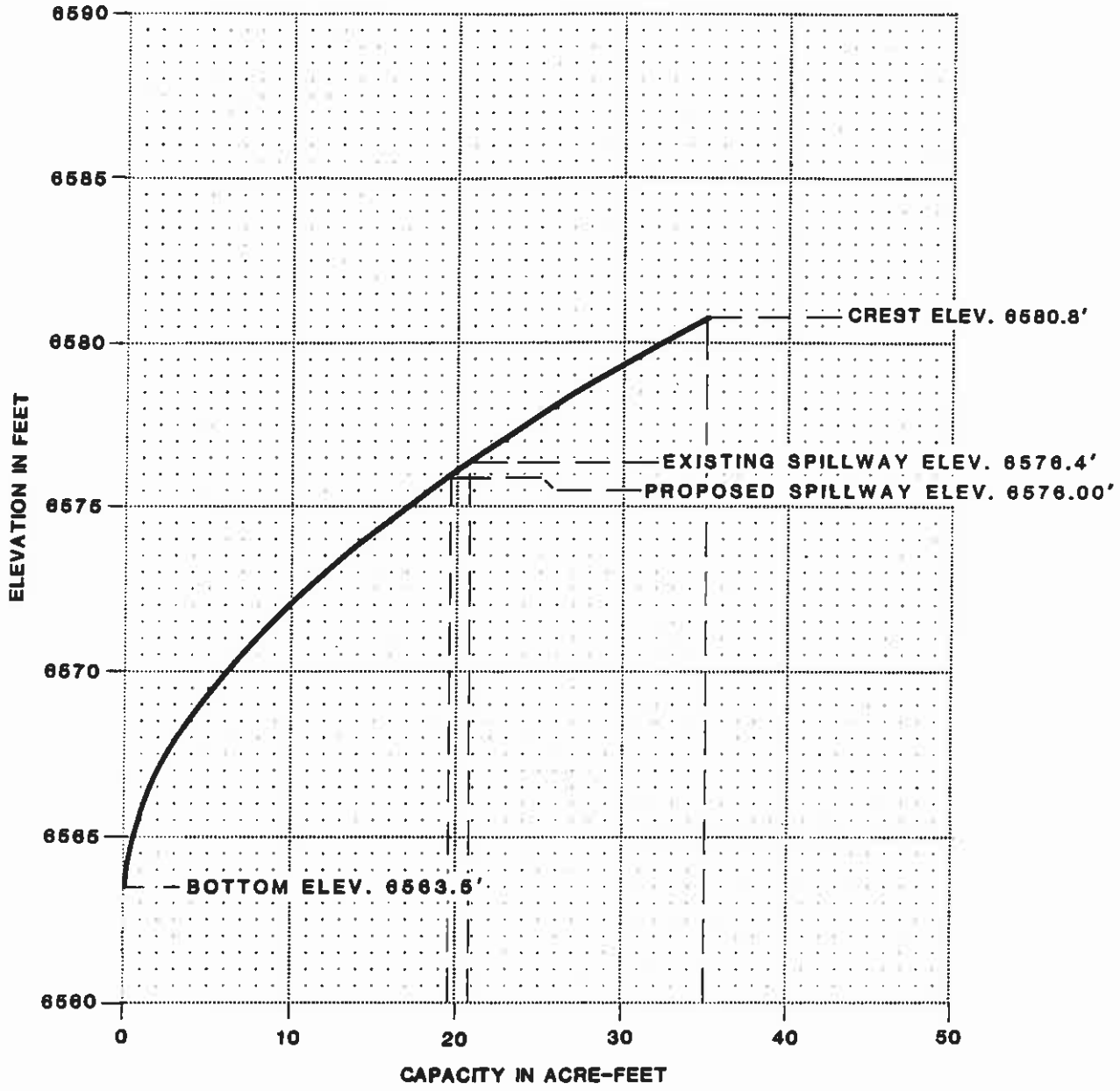
FEET

# EXISTING MAXIMUM CROSS-SECTION A-A' J16-G

FOR LOCATION SEE PLATE 1

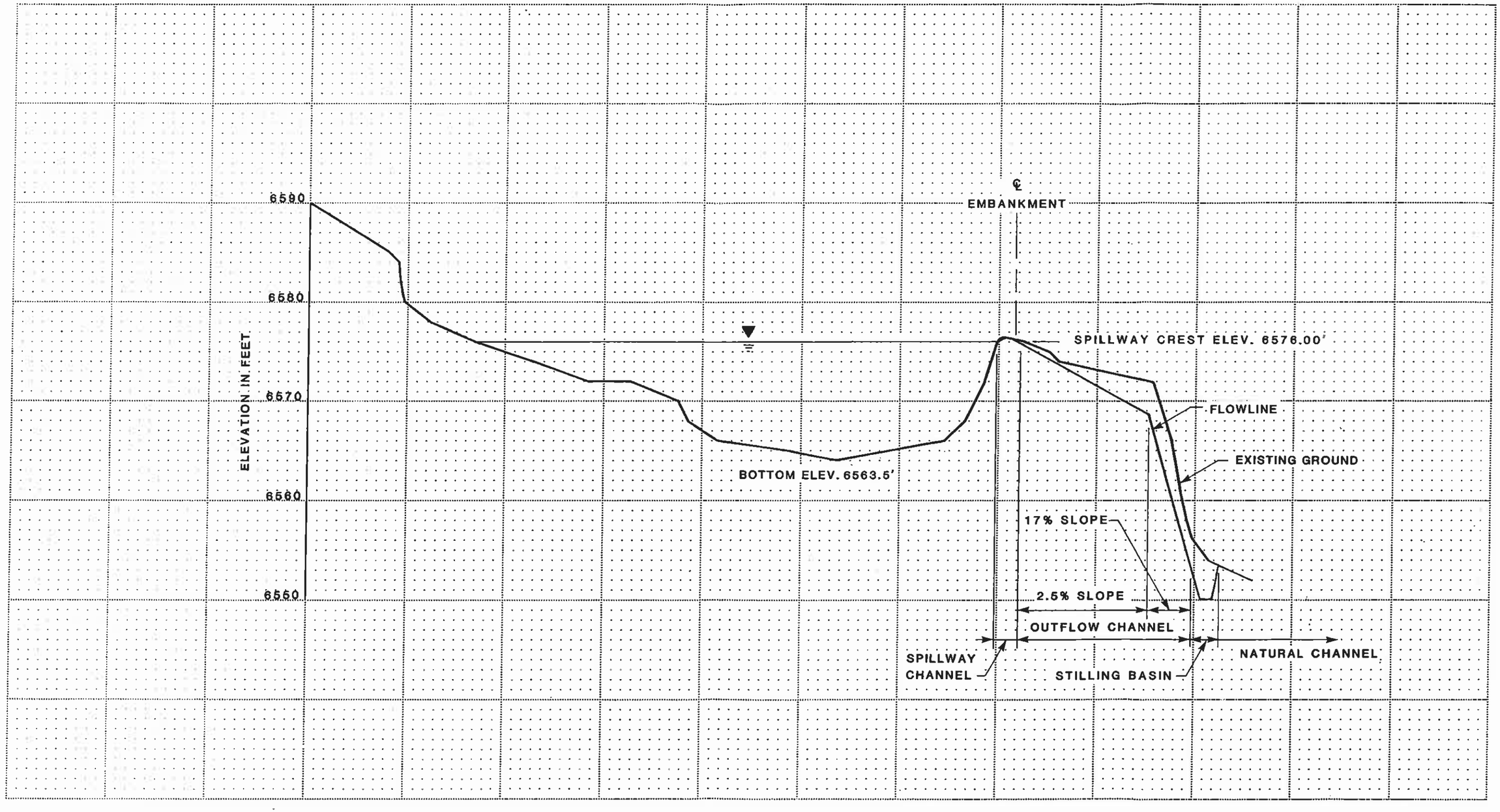
BY **Dames & Moore** Plate 2




# VOLUME-ELEVATION CURVE

J16-G

BY **Dames & Moore** Plate 3

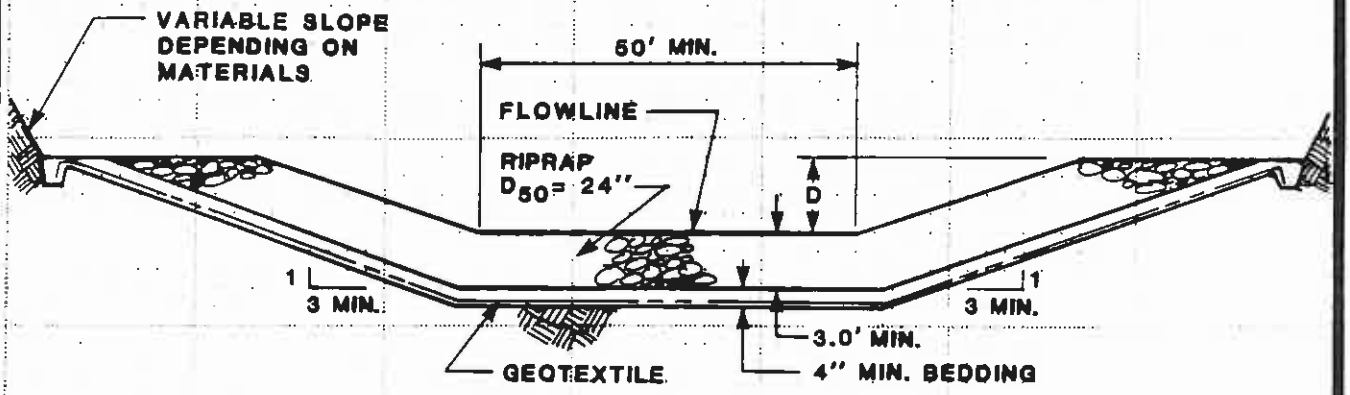



SCALE
0 200 400
FEET

# CHANNEL PROFILE B-B'
J16-G

FOR LOCATION SEE PLATE 1

BY **Dames & Moore** Plate 4




**SPILLWAY CHANNEL**

D = 4.6'

LENGTH = 40'

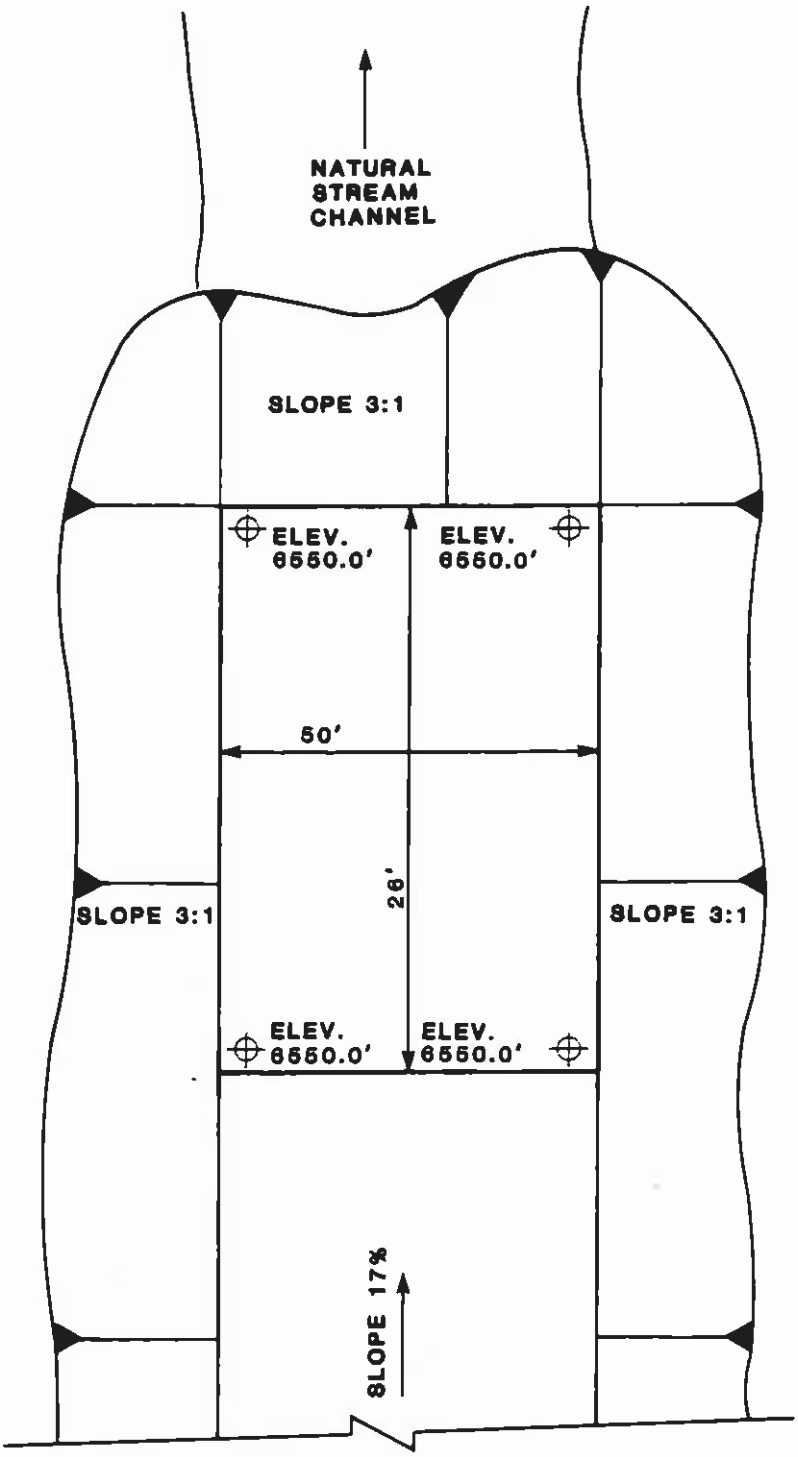
FLOWLINE ELEV. = 6576.00'

**OUTFLOW CHANNEL**

D = 3.0'

# SPILLWAY AND OUTFLOW CHANNEL CROSS SECTION J16-G

BY **Dames & Moore** Plate 5




MINIMUM HEIGHT OF RIPRAP ALONG SIDEWALLS ABOVE THE BASIN FLOOR = 7.2'

MINIMUM DEPTH OF BASIN FLOOR BELOW NATURAL STREAMBED = 3.6'

# SPILLWAY STILLING BASIN PLAN J16-G

BY **Dames & Moore** Plate 6

# APPENDIX A

# INSPECTION CHECK LIST

Sediment Impoundment Name: J16-G
Page: 4

## INSPECTION CHECK LIST

| ITEM | YES | NO | REMARKS |
|---|---|---|---|
| 1. CREST | | | 25' W |
| a. Any visual settlements? | | X | |
| b. Misalignment? | | X | |
| c. Cracking? | | X | |
| 2. UPSTREAM SLOPE | | | 19° uneven slope surface |
| a. Adequate grass cover? | X | | 60% |
| b. Any erosion? | X | | Rills |
| c. Are trees growing on slope? | | X | |
| d. Longitudinal cracks? | | X | |
| e. Transverse cracks? | | X | |
| f. Adequate riprap protection? | X | | Gravel |
| g. Any stone deterioration? | | | NA |
| h. Visual depressions or bulges? | | X | |
| i. Visual settlements? | | X | |
| j. Animal burrows? | | X | |
| 3. DOWNSTREAM SLOPE | | | 30° for top 15' uneven slope surface<br>14° from remainder to toe |
| a. Adequate grass cover? | X | | 60% |
| 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? | | X | |
| k. Is seepage present? | | X | |
| l. Animal burrows? | | X | |
| 4. ABUTMENT CONTACT. RIGHT | | | |
| a. Any erosion? | | X | |
| b. Visual differential movement? | | X | |
| c. Any cracks noted? | | X | |
| d. Is seepage present? | | X | |
| e. Type of Material? | | | brown snl rock shallow |
| 5. ABUTMENT CONTACT. LEFT | | | |
| a. Any erosion? | | X | |
| b. Visual differential movement? | | X | |
| c. Any cracks noted? | | X | |
| d. Is seepage present? | | X | |
| e. Type of Material? | | | brow sm |

| ITEM | YES | NO | REMARKS |
|---|---|---|---|
| **6. SPILLWAY/NORMAL** | | | |
| a. Location: | | | |
| Left abutment? | | | |
| Right abutment? | X | | |
| Crest of Embankments? | | | |
| b. Approach Channel: | X | | 30' W at Spill 70' W at Pond 8' below Crest |
| Are side slopes eroding? | X | | Rills & Gullys 4% slope |
| Are side slopes sloughing? | | X | |
| Bottom of channel eroding? | X | | Gullys |
| Obstructed? | | X | |
| Erosion protection? | | X | |
| c. Spillway Channel: | X | | 55' W 40' L Slope 2% |
| Are side slopes eroding? | | X | |
| Are side slopes sloughing? | | X | |
| Bottom of channel eroding? | | X | |
| Obstructed? | | | |
| Erosion protection? | X | | Rock D50 12" |
| d. Outflow Channel: | | X | |
| Are side slopes eroding? | | | |
| Are side slopes sloughing? | | | |
| Bottom of channel eroding? | | | |
| Obstructed? | | | |
| Erosion protection? | | | |
| e. Weir: | | X | |
| Condition? | | | |
| **7. SPILLWAY/EMERGENCY** | | | |
| a. Location: | | | NA |
| 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? | | | |

| ITEM | YES | NO | REMARKS |
|---|---|---|---|
| **8. IMPOUNDMENT** | | | |
| a. Sinkholes? | | X | (Elev.) feet |
| b. Water present? | | X | (Elev.) feet |
| c. Siltation? | | X | |
| d. Watershed matches soil map? | | X | |

**9. GENERAL COMMENTS**

# APPENDIX B

# HYDROLOGY AND HYDRAULIC CALCULATIONS

FILE PEABODY COAL CO 10139-011-22
SUBJECT SEDIMENT POND HYDROLOGY
J16-G Revised SHEET ___ OF ___
due to J16-G1

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

## TIME OF CONCENTRATION

ELEVATION DIFFERENCE = 6683 − 6576 = 107 ft.

WATER COURSE LENGTH = 1.4 (40c) = 560 ft. = 0.106 mi.

$$T_c = \left(\frac{11.9\,(0.106)^3}{107}\right)^{0.385} = 0.032 \text{ hr.}$$

LAG TIME = $0.6\,T_c$ = 0.019 hr.

LAG FROM G1 TO G ≈ .009 hr 10-22-5

## SCS CURVE NUMBER

| DRAINAGE AREA (ac) | COVER TYPE | HYDROLOGIC CONDITION | SOIL TYPE | WEIGHTED CURVE NUMBER |
|---|---|---|---|---|
| 8.78 | DIST | — | D | 94 (.79) |
| 2.38 | S-G | mean | D | 79 (.21) |
| | | | | 90.95 |
| | | | use | 91 |

5.82 ac "27" S-G
2.34 ac #36 DIST

BY ____ DATE ____
CHECKED BY ____
COPY TO EO ____

## DRAINAGE BASIN AREA

11.16 ACRE 0.017 SQ MILE

FILE KEABOY COAL CO 1039-011-22
SUBJECT SEDIMENT INFLOW
J16-G SHEET ___ OF ___

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

BY ___ CHECKED BY BHM DATE 10/24/85 COPY TO EO ___

# UNIVERSAL SOIL LOSS EQUATION

## RAINFALL FACTOR

R = 40

## SOIL ERODIBILITY FACTOR

| SOIL TYPE = | | |
|---|---|---|
| | 80% EH #22 | .8(.22) |
| | 16% EH #36 | .16(.33) |
| | 4% EH #35 | .04(.42) |
| | | .246 |

K = .246

## SLOPE FACTOR

| LENGTH (ft.) | ΔELEV (ft.) | SLOPE (%) | LS |
|---|---|---|---|
| 2200 | 110 | 5% | 1.65(.7) |
| 700 | 80 | 11.4 | 4.43(.1) |
| 500 | 80 | 16.0 | 6.35(.2) |
| | | | = 2.87 |

## COVER FACTOR

| AREA (ac) | COVER TYPE | % COVER | CANOPY (%) | WEIGHTED C |
|---|---|---|---|---|
| 16% | S-G | 40 | 25 | .16(.13) |
| 4% | reclaimed | — | — | .04(.15) |
| 80% | disturbed | — | — | .80(1.0) |
| | | | | C = .827 |

## EROSION CONTROL FACTOR

P = 1.0

## SEDIMENT INFLOW

$A = 40(.246)(2.87)(.827)(1.0) = 23.36$ ton/acre/year

$A = (23.36)\left(\frac{1}{20}\right)(272.0)\left(\frac{.95}{2.95}\right) =$ ~~279~~ acre-feet/year

Dames & Moore

FILE PEABODY COAL CO 10139-011-22
SUBJECT SEDIMENT POND HYDROLOGY
J16G SHEET ___ OF ___

100 yr storm excluding J16G1 to watershed dam

## TIME OF CONCENTRATION

ELEVATION DIFFERENCE = 6720 - 6576 = 144'

WATER COURSE LENGTH = 2520 ft = .477 mi

$T_c$ = .163 hr.

LAG TIME = $0.6 T_c$ = 0.098 hr.

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

## SCS CURVE NUMBER

| DRAINAGE AREA (ac) | COVER TYPE | HYDROLOGIC CONDITION | SOIL TYPE | WEIGHTED CURVE NUMBER |
|---|---|---|---|---|

weighted ave of J16G1 and J16G curve #'s

$$89.49\left(\frac{260.84}{272}\right) + 90.85\left(\frac{11.1}{272}\right) = 89.5$$

use 90

## DRAINAGE BASIN AREA

272. ACRE .425 SQ MILE

85.8

BY ____ DATE ____
CHECKED BY ____
COPY TO EO ____

Dames & Moore

945 1 (3-72) PRINTED IN U.S.A.

Revised Due to G-1 Upstream

FILE Peabody Coal Co 1039-011-22
SUBJECT Sediment Inflow J16-G
SHEET ___ OF ___

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

## Universal Soil Loss Equation

### Rainfall Factor

R = 40

### Soil Erodibility Factor

| | | | |
|---|---|---|---|
| Soil Type = | 52% | EH #22 | .52 (0.22) |
| | 48% | EH #36 | .48 (0.33) |
| | | | 0.273 |

K = 0.273

### Slope Factor

| Length (ft.) | Δ Elev (ft.) | Slope (%) | LS |
|---|---|---|---|
| 500 | 125 | 0.25 | 13.9 |

### Cover Factor

| Area (ac) | Cover Type | % Cover | Canopy (%) | Weighted C |
|---|---|---|---|---|
| 79% | Disturbed | — | | 1.0 (.79) |
| 21% | S-G | 40 | 25 | .13 (.21) |
| | | | | C = 0.817 |

### Erosion Control Factor

P = 1.0

### Sediment Inflow

$A = 40(0.273)(13.9)(0.517)(1.0) = 124.0$ ton/acre/year

$A = 124.0\left(\frac{1}{2047}\right)(11.16)(.95) = 0.642$ acre-feet/year

DATE ___ CHECKED BY ___ COPY TO EO ___ BY ___

Dames & Moore