INSPECTION REPORT

Sedimentation Structure

WW-9

Black Mesa Mine

Navajo County, Arizona

for

PEABODY COAL COMPANY

Dames & Moore
10139-011-22

TABLE OF CONTENTS

INTRODUCTION

Sedimentation Structure WW-9 is 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 WW-9 is shown on Plate 1, Site Plan.

This inspection report contains information specific to Structure WW-9. 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 WW-9 was inspected on August 29, 1985 by an inter-disciplinary 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 WW-9 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 WW-9 has a 346.0-acre tributary drainage area and is located near Yucca Flats Wash at the Black Mesa Mine. The watershed is classified as 99% Sagebrush/grass and 1% disturbed for Pond 1, 90% Sagebrush/grass and 10% disturbed for Pond 2.

EMBANKMENT

Structure WW-9 is a homogeneous earthen embankment classified as a cross-valley embankment. Physical characteristics of the embankment are listed in the following table:

Structure WW-9

Embankment	Residual Shale Soils
Foundation	Sandstone
Right Abutment	Residual Sandstone/Shale Soils
Left Abutment	Residual Sandstone/Shale Soils
Height	20.6 ft
Crest Width	23 ft
Upstream Slope	2 H : 1 V
Downstream Slope	6 H : 1 V

A cross-section of the embankment is shown on Plate 2, Existing Maximum Cross Section WW-9, A-A'. Grass provides erosion protection on the upstream and downstream slopes of the embankment.

ANALYSES

STABILITY

Structure WW-9 is a category A-5 embankment. A standard category A-5 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 = 30 ft
2. Maximum upstream slope = 2.0 H : 1 V
3. Maximum downstream slope = 4.25 H : 1 V
4. Normal pool with steady seepage saturation conditions

The WW-9 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 WW-9 is divided into two ponds with a roadway embankment separating them and a corrugated metal pipe spillway allowing flow between them. The combined storage capacity of the two ponds exceeds 20 acre-feet. Therefore, the upstream pond was analyzed using the 25-year, 6-hour storm and the downstream pond was analyzed using the 100-year, 6-hour storm. The storage capacity of Structure WW-9 was analyzed using the 10-year, 24-hour storm.

The hydrologic analysis was completed for two subbasins tributary to Structure WW-9. The drainage area west of the access road located about 800 feet upstream from the structure was designated Area 1 (and corresponding Pond 1). The drainage area east of the road was designated Area 2 (and corresponding Pond 2). Separating the drainage area facilitated the hydraulic analysis of temporary water retention at the culvert passing beneath the roadway embankment.

The following parameters were used in the hydrologic analysis for the 10-year, 24-hour storm:

		Pond 1	Pond 2	
1.	Water Course length, L	1.63	—	mi
2.	Elevation Difference, H	320	--	ft
3.	Time of Concentration, T_c	0.495	0.031*	h
4.	Lag time, $0.6T_c$	0.297	0.018	h
5.	SCS Curve Number	80	81	
6.	Rainfall Depth, 10-year, 24-hour storm	2.1	2.1	in.
	25-year, 6-hour storm.	1.9	1.9	in.
7.	Drainage Area	333.4	12.6	acres

*There is no water course for Pond 2. Therefore, time of concentration was calculated based on slope and length of side hills draining into Pond 2. (Slope = 17%, Length = 500 feet, assumed flow velocity = 4.5 ft per sec.)

The following parameters were used in the hydrologic analysis for the 25-year, 6-hour storm and 100-year, 6-hour storm:

		Pond 1 25-Year, 6-hour Storm	Pond 2 100-year, 6-hour Storm	
1.	Water Course length, L	1.63	1.63	mi
2.	Elevation Difference, H	320	320	ft
3.	Time of Concentration, T_c	0.495	0.495	h
4.	Lag time, $0.6T_c$	0.297	0.297	h
5.	SCS Curve Number	80	80	
6.	Rainfall Depth	1.9	2.4	in.
7.	Drainage Area	333.4	346.0	acres

Parameters such as water course length etc. were effectively the same for both ponds because the ponds are immediately adjacent to each other with no water course between them (see Plate 4).

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.

WW-9 HYDRAULICS

	Units	10-year 24-hour Storm		25-year 6-hour Storm	100-year 6-hour Storm
Initial Reservoir Volume Condition		Empty		Full to the spillway elevation	
		Pond 1	Pond 2	Pond 1	Pond 2
Inflow					
Peak Flow	cfs	190	109	206	377
Volume	acre-ft	16.95	0.89*	13.89	23.64
Storage					
Peak Stage	ft	6370.70	6344.55	—	--
Spillway Elevation . .	ft	6366.20	6348.10	--	--
Peak Storage	acre-ft			--	--
Storage Capacity . . .	acre-ft	2.1	21.7	--	--
Outflow					
Peak Flow	cfs	108	0	133	360
Embankment Crest Elevation	ft	--	--	6380.00	6351.60
Peak Stage	ft	--	--	6371.58	6350.22
Freeboard	ft	--	--	8.42	1.38

*Inflow volume for the tributary drainage area between Structure WW-9 and the roadway located about 800 feet upstream.

Spillway Channel

The existing spillway for WW-9 has a trapezoidal channel with the following dimensions:

Channel depth	3 ft
Channel width	65 ft
Channel length	40 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 WW-9 has a trapezoidal channel with the following dimensions:

Channel width	55 ft
Channel length	150 ft
Side slopes (horizontal to vertical)	2:1
Average exit slope	17 percent

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, WW-9.

The calculations for the sediment load entering Structure WW-9 were made utilizing the Universal Soil Loss Equation with the following parameters:

1. Rainfall Factor, R 40
2. Soil Erodibility Factor, K 0.18
3. Slope Factor, LS 2.98
4. Cover Factor, C 0.14
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 WW-9 and the results of the sediment inflow analysis are summarized in the following table.

WW-9 STORAGE

Total Storage Capacity	23.8*	acre-ft
10-year, 24-hour Storm Inflow	17.84	acre-ft
Available Sediment Storage Capacity . .	5.96	acre-ft
Sediment Inflow Rate	0.457	acre-ft/yr
Sediment Storage Life	13	yrs

*Pond 1 = 2.1 acre-ft and Pond 2 = 21.7 acre-ft.

Excess storage capacity in Structure WW-9 can be used for storing water produced during maintenance of the nearby water well.

REMEDIAL COMPLIANCE PLAN

GEOTECHNICS

The inspection of Structure WW-9 indicated that the only geotechnical problems are rills on the downstream slopes and the right and left abutments. Correction of erosion is considered a periodic maintenance task and does not require remedial action.

HYDRAULICS

The storage capacity and spillway capacity of Structure WW-9 are adequate but the storage capacity exceeds 20 acre-feet. The bottom elevation of the existing spillway channel should be lowered to elevation 6347.10 feet while maintaining the bottom width of 65 feet. The spillway and outflow channel profiles are shown in Plates 4A and 4B. The spillway and outflow channel do not require any modifications.

Lowering the spillway elevation to 6347.10 feet decreases the storage capacity and increases the freeboard. The analysis of these conditions is summarized in the following table. A trashrack should be installed on the inlet of the CMP to prevent clogging of the spillway.

WW-9 HYDRAULICS FOR REDESIGNED SPILLWAY

	Units	10-year 24-hour Storm		25-year 6-hour Storm	100-year 6-hour Storm
Initial Reservoir Volume Condition		Empty		Full to the spillway elevation	
		Pond 1	Pond 2	Pond 1	Pond 2
Inflow					
Peak Flow	cfs	190	109	206	377
Volume	acre-ft	16.95	0.89*	13.89	23.64
Storage					
Peak Stage	ft	6370.70	6344.55	6371.58	6349.23
Spillway Elevation . .	ft	6366.20	6347.10	--	—
Peak Storage	acre-ft			--	—
Storage Capacity . . .	acre-ft	2.1	20.0	--	--
		Combined			
Available Sediment Storage Capacity . .	acre-ft	4.26		—	--
Sediment Inflow Rate .	acre-ft/yr	0.457		--	--
Sediment Storage Life.	yrs	9		--	--
Outflow					
Peak Flow	cfs	108	0	133	363
Embankment Crest Elevation	ft	--	--	6380.00	6351.60
Peak Stage	ft	--	—	6371.58	6349.23
Freeboard	ft	--	—	8.42	2.37
Spillway Channel					
Flow Depth	ft	--	--	--	2.13
Critical Velocity. . .	fps	--	--	--	5.5
Manning's "n"		--	--	--	0.040
Outflow Channel					
Slope	%	--	--	--	20
Normal Velocity. . . .	fps	--	--	--	11.2
Normal Depth	ft	--	--	--	0.57
Manning's "n"		--	--	--	0.040

*Inflow volume for the tributary drainage area between Structure WW-9 and the roadway located about 800 feet upstream.

* * *

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

Plate 1 - Site Plan WW-9

Plate 2 - Existing Maximum Cross Section WW-9, A-A'

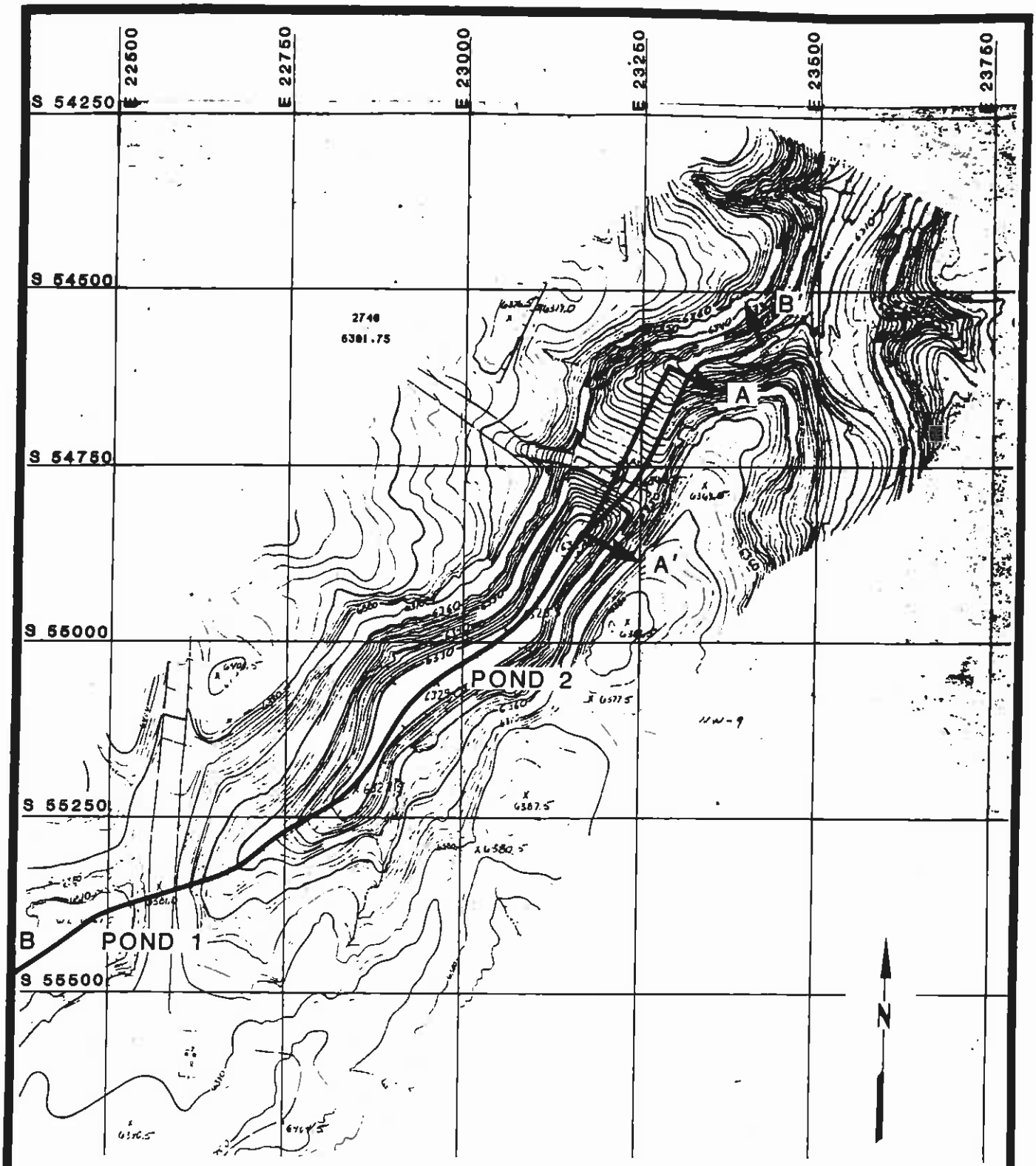
Plate 3 - Volume-Elevation Curve WW-9

Plate 4A - Channel Profile WW-9, B-B'

Plate 4B - Channel Profile WW-9, C-C'

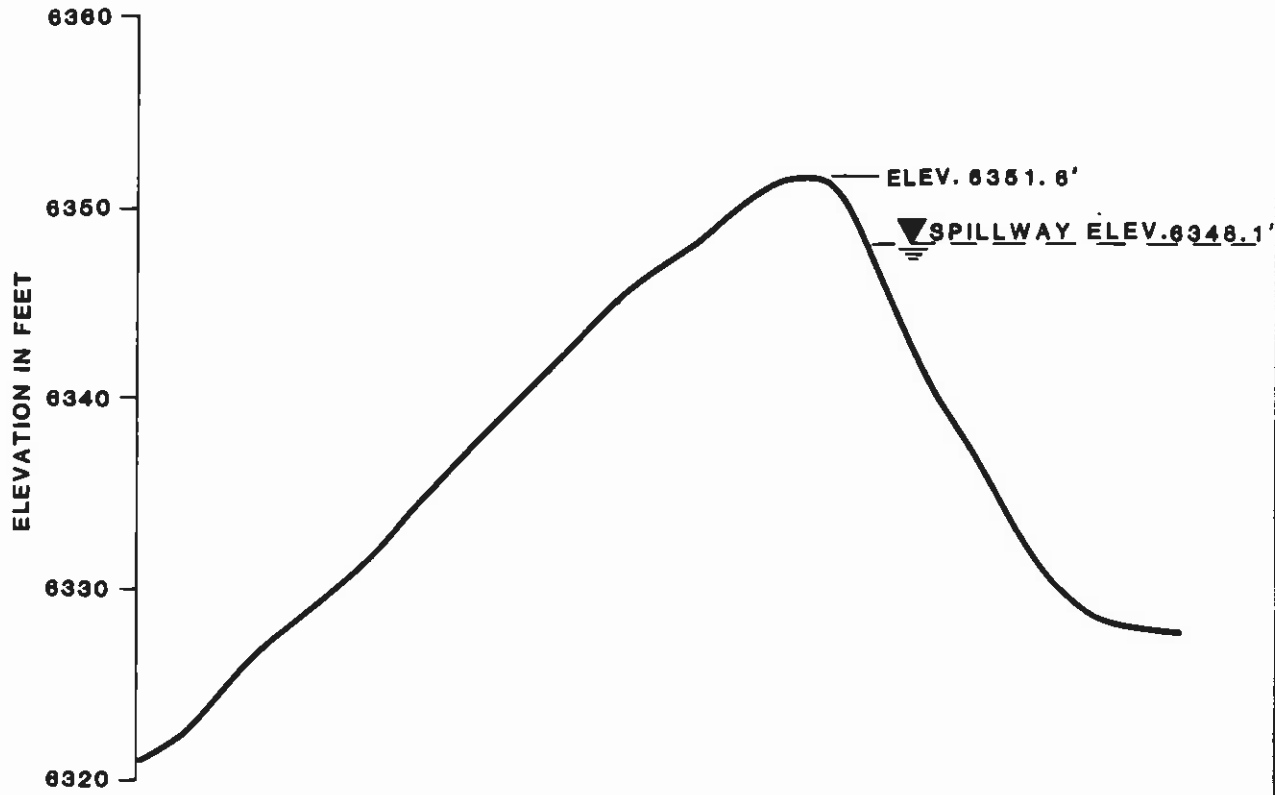
Appendix A - Inspection Check List

Appendix B - Hydrology and Hydraulic Calculations



SITE PLAN
WW-9

BY **Dames & Moore** Plate 1



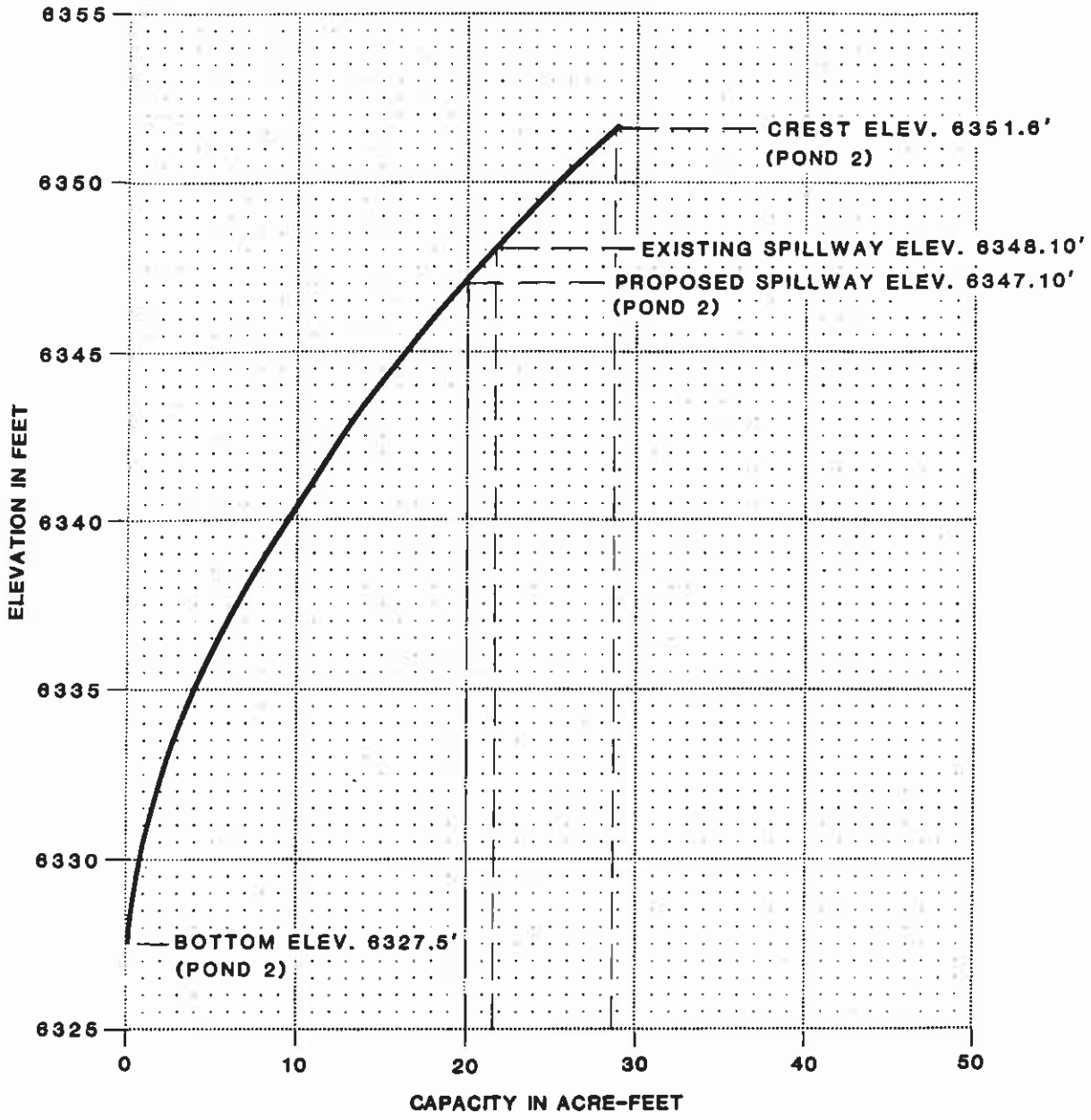
SCALE
0 50 100
FEET

EXISTING MAXIMUM CROSS-SECTION A-A' WW9

FOR LOCATION SEE PLATE 1

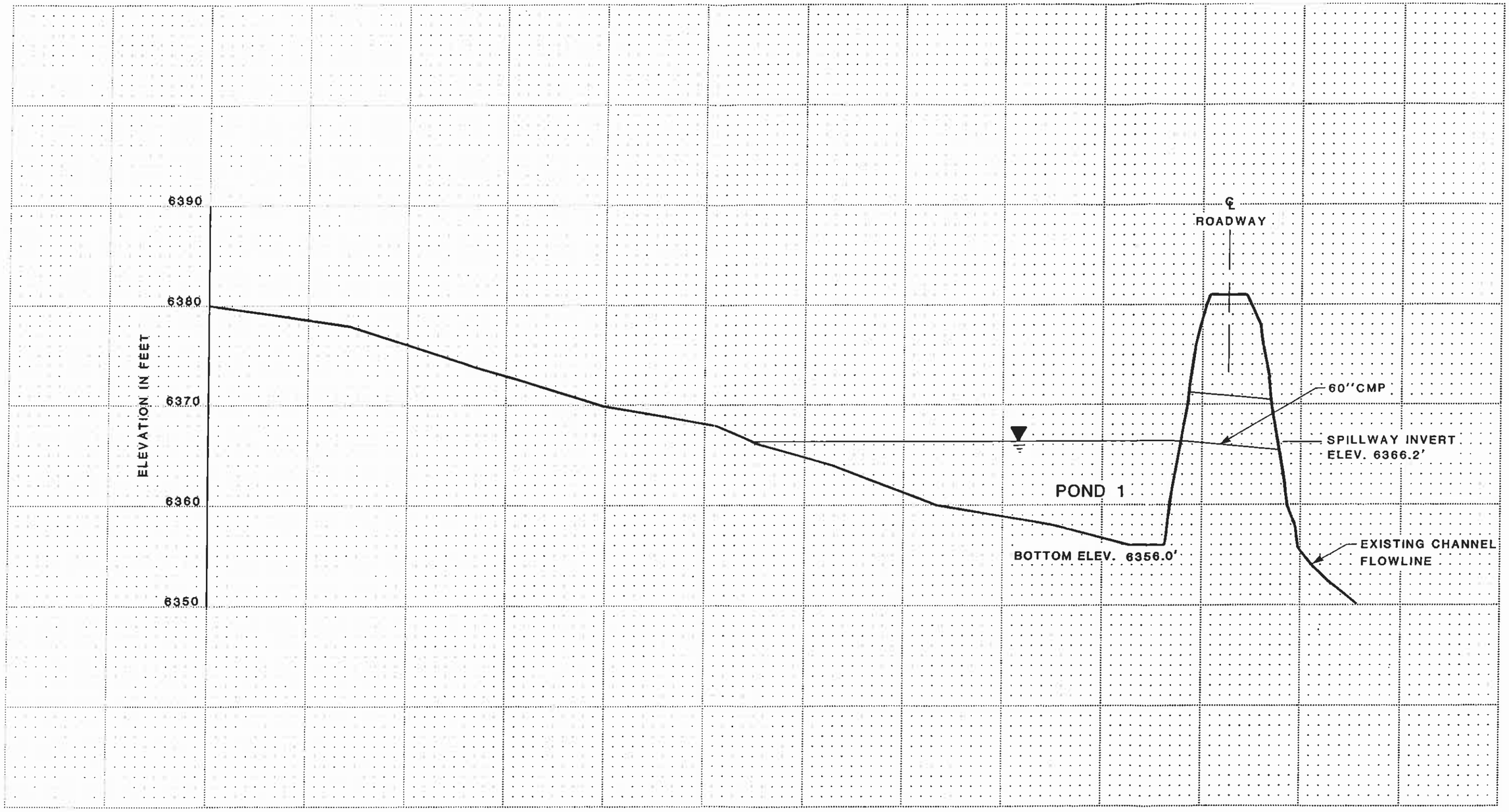
BY **Dames & Moore**

Plate 2



VOLUME-ELEVATION CURVE WW-9

BY **Dames & Moore** Plate 3

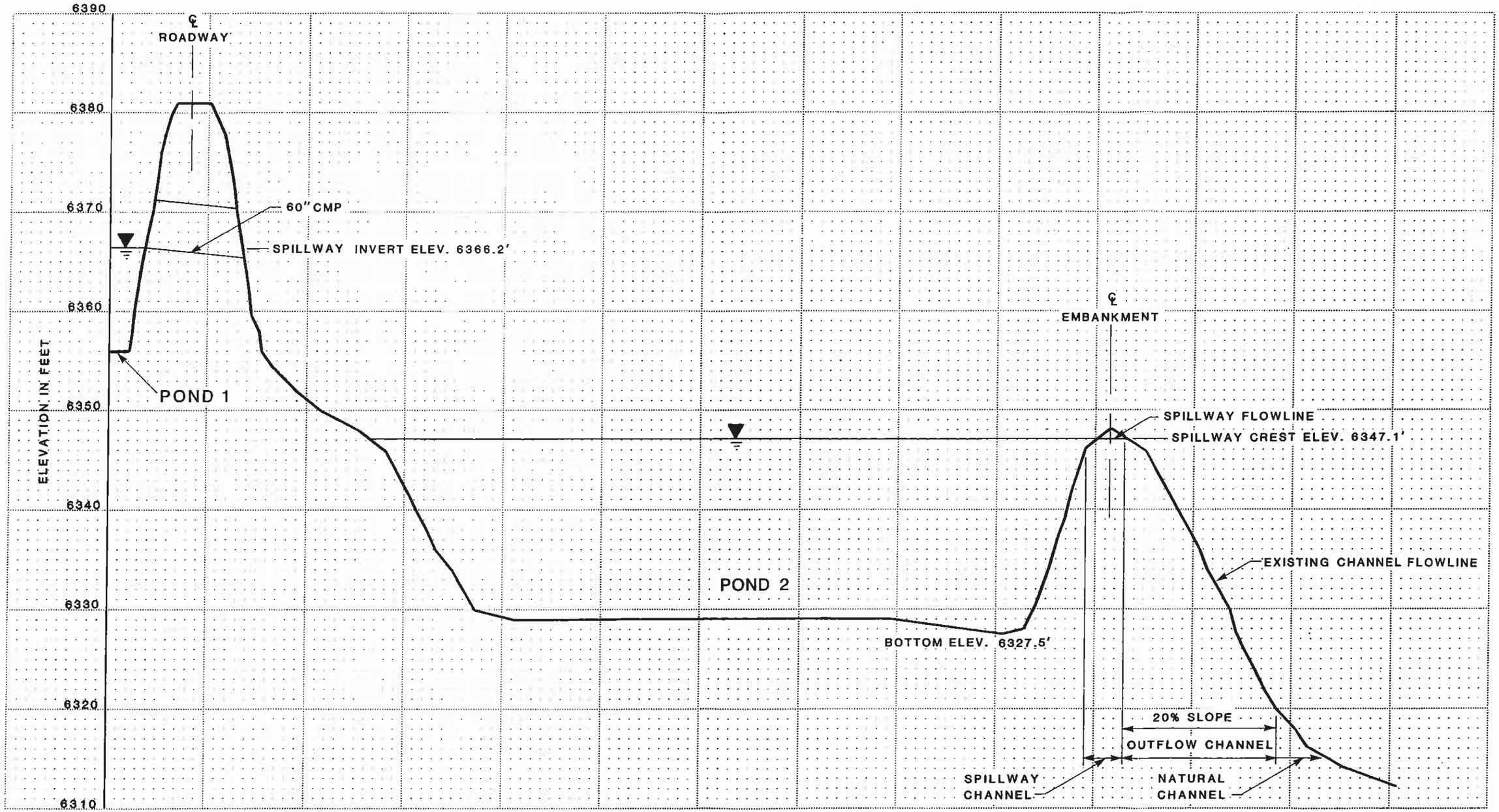


SCALE
0 100 200
FEET

CHANNEL PROFILE B-B'
WW-9

FOR LOCATION SEE PLATE 1

BY **Dames & Moore** Plate 4 A



SCALE
0 100 200
FEET

CHANNEL PROFILE B-B'
WW-9 cont.

FOR LOCATION SEE PLATE 1

BY **Dames & Moore** Plate 4B

APPENDIX A

INSPECTION CHECK LIST

Sediment Impoundment Name: WW 9
Page: 4

INSPECTION CHECK LIST

ITEM	YES	NO	REMARKS
1. CREST			
a. Any visual settlements?		X	
b. Misalignment?		X	
c. Cracking?		X	
2. UPSTREAM SLOPE			
a. Adequate grass cover?			NA
b. Any erosion?	X		slight
c. Are trees growing on slope?		X	
d. Longitudinal cracks?		X	
e. Transverse cracks?		X	
f. Adequate riprap protection?			NA
g. Any stone deterioration?			NA
h. Visual depressions or bulges?		X	irregular due to construction
i. Visual settlements?		X	
j. Animal burrows?		X	
3. DOWNSTREAM SLOPE			
a. Adequate grass cover?			NA
b. Any erosion?	X		numerous small 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?			N.A.
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		some where disturbed by construction
b. Visual differential movement?		X	
c. Any cracks noted?		X	
d. Is seepage present?		X	
e. Type of Material?			Bedrock - sst over shale
5. ABUTMENT CONTACT. LEFT			
a. Any erosion?	X		some where disturbed by construction
b. Visual differential movement?		X	
c. Any cracks noted?		X	
d. Is seepage present?		X	
e. Type of Material?			Bedrock - sst over shale

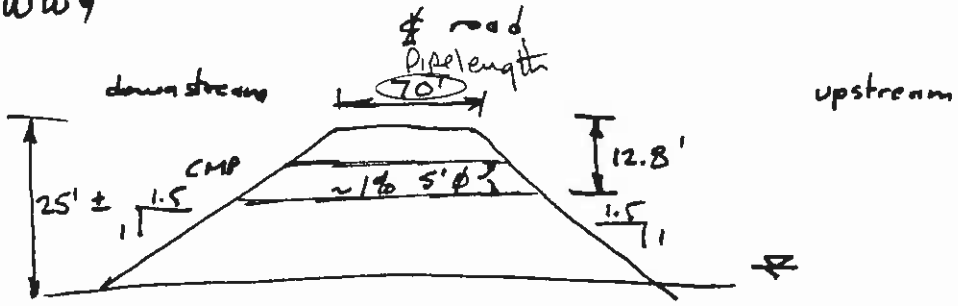
ITEM	YES	NO	REMARKS
6. SPILLWAY/NORMAL			
a. Location:			
Left abutment?			
Right abutment?			
Crest of Embankments?	X		occupies ½ of crest length
b. Approach Channel:		X	
Are side slopes eroding?			
Are side slopes sloughing?			
Bottom of channel eroding?			
Obstructed?			
Erosion protection?			
c. Spillway Channel:	X		
Are side slopes eroding?		X	
Are side slopes sloughing?		X	
Bottom of channel eroding?		X	
Obstructed?		X	
Erosion protection?	X		riprap - about 5% deteriorated
d. Outflow Channel:	X		
Are side slopes eroding?		X	
Are side slopes sloughing?		X	
Bottom of channel eroding?		X	
Obstructed?		X	
Erosion protection?	X		riprap
e. Weir:		X	
Condition?			
7. SPILLWAY/EMERGENCY			
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

Present water level about 7' below spillway invert
-high water mark about 3' below spillway invert
Immediate watershed - 40% coverage with sagebrush - grass

Additional Structure

Road embankment crossing wash about 600' U/S from WW 9



- moderate gully erosion on both slopes

- potential flood hazard due to blocking of culvert, overtopping/breaching of embankment and flood surge entering WW 9
- does pipeline from well follow road bed? is pipeline susceptible to failure if road washes out
- embankment material highly susceptible to erosion
  - no slope protection present

APPENDIX B

HYDROLOGY AND HYDRAULIC CALCULATIONS

FILE PEABODY COAL CO 10139-011-22
SUBJECT HYDROLOGY
WW-9 SHEET ___ OF ___

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

BY [illegible] DATE 9/7/85
CHECKED BY ___
COPY TO EO ___

TIME CONCENTRATION (FOR AREA EAST OF ROADWAY

THERE IS NO DEFINED WATER COURSE. SIDE HILLS SLOPE DIRECTLY INTO RESERVOIR

AVERAGE SIDE HILL SLOPE = 17%

ASSUME AVERAGE VELOCITY OF 4.5 ft/sec

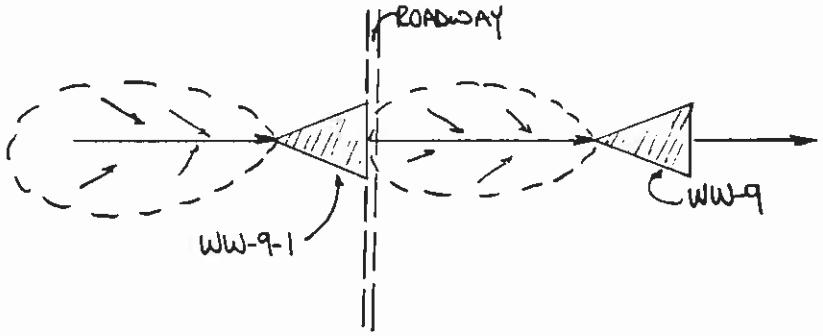
MAXIMUM DISTANCE ≈ 500'

$T_c = \frac{500 \text{ ft}}{4.5 \text{ ft/s}} = 111 \text{ sec} = 1.85 \text{ min} = 0.02 \text{ hr.}$

LAG TIME = $0.6\, T_c$ = 1.11 min =

HEC-1 COMPUTER MODEL

SET UP THE MODEL WITH TWO RESERVOIRS AND TWO WATERSHEDS.



NOTE: PONDING AREA WEST OF ROAD CALLED WW-9-1

1. CALCULATE INFLOW HYDROGRAPH TO WW-9-1
2. ROUTE INFLOW THROUGH WW9-1
3. CALCULATE INFLOW TO WW-9 FROM DRAINAGE BASIN
4. COMBINE OUTFLOW FROM WW-9-1 AND INFLOW FROM DRAINAGE BASIN TO GET COMBINED INFLOW TO WW-9.
5. ROUTE COMBINED INFLOW THROUGH WW-9 TO GET SPILLWAY FLOW AND MAX WATER LEVEL.

Dames & Moore

FILE PEABODY COAL CO. 10139-011-
SUBJECT SEDIMENT POND HYDROLOGY
WW.9 SHEET 0

REVISIONS BY DATE TO EO BY DATE TO EO

TIME OF CONCENTRATION (TO IMPOUNDMENT AT UPSTREAM ROADWAY)

ELEVATION DIFFERENCE = 6680 - 6360 = 320'

WATER COURSE LENGTH = 8600' = 1.63 mi

$T_c = \left(\frac{11.9\ (1.63)^3}{320}\right)^{0.385} = 0.495$ hr. ME

LAG TIME = $0.6\ T_c$ = 0.297 hr. ME — FOR AREA WEST OF ROADWAY

SCS CURVE NUMBER

	DRAINAGE AREA (ac)	COVER TYPE	HYDROLOGIC CONDITION	SOIL TYPE	WEIGHTED CURVE NUMBER
WEST OF ROADWAY	3.3 (1%)	Dist	—	D	0.01(94) = 0.9
	330.1 (99%)	S-G	ave.	D	0.99(79) = 78.2
					79.1
				EH #23	
				EH #43	
					USE 80
EAST OF ROADWAY	1.3	(10%) Dist	—	D	0.10(94) = 9.4
	11.3	(90%) S-G	ave.	D	0.90(79) = 71.1
					80.5
					USE 81

DRAINAGE AREA

WEST (UPSTREAM) FROM ROADWAY 333.4 AC. = 0.521 mi²

EAST (DOWNSTREAM) " " 12.6 AC. = 0.020 mi²

346

BY ADM DATE 9/6/86 CHECKED BY COPY TO EO

UNIVERSAL SOIL LOSS EQUATION

RAINFALL FACTOR

R = 40

SOIL ERODIBILITY FACTOR

SOIL TYPE = EH #23

K = 0.18

SLOPE FACTOR

LENGTH (ft.)	Δ ELEV (ft.)	SLOPE (%)	LS
800	60	8	2.81
900	70	8	2.98

Use 2.98

COVER FACTOR

AREA (ac.)	COVER TYPE	% COVER	CANOPY (%)	WEIGHTED C
99%	S-G	40	25	.99(.13)
1%	DISTURBED			.01 (1.0)
				C = .14

EROSION CONTROL FACTOR

P = 1.0

SEDIMENT INFLOW

$A = 40(0.18)(2.98)(0.14)(1.0) = 3.00$ ton/acre/year

$A = 3.00\left(\frac{1}{2047}\right)(346)(0.90) = 0.457$ acre-feet/year