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DESIGN REPORT

SPOOK HILL F.R.S.

PHASE III - FINAL DESIGN

SOIL CONSERVATION SERVICE

DEC. 22, 1976

A300.604

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ARIZONA STATE OFFICE
PHOENIX, ARIZONA
DECEMBER 22, 1976

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DESIGN REPORT

Job: Spook Hill Floodwater Retarding Structure
Project: Buckhorn-Mesa WPP
Location: Maricopa County, Arizona
Authority: PL 566
Phase: III - Final Design

Summary: The design is in accordance with the supplemented work plan or the exceptions noted in the Preliminary Design Report submitted June 4, 1975 except that a reinforced concrete structure is designed to pass the emergency spillway and freeboard hydrographs.

The embankment is a routed fill using material from the Floodway excavation, the principal spillway inlet channel excavation and the Salt-Gila Aqueduct borrow area. The slopes are designed 2 1/2 to 1.

The reinforced concrete appurtenances are designed in accordance with NEH sections 6 and 11 and TR's 5 and 20 excluding the computer design for the conduit which was requested from the Design Unit, Washington, D.C.

The landscape features were designed by A. Wayne Smith.

Description of Job

The job consists of 25' high earth dam approximately 4 miles long with a Type C reinforced concrete drop emergency spillway, 260 feet wide and 12' high; a 7' x 7.5' concrete box conduit with a drop inlet and SAF outlet as the principal spillway and 3 earth road ramp crossings.

Layout

a. The horizontal alinement of the centerline of the dam is referenced to a baseline by stationing on the baseline and offset distances from it. This procedure is used to simplify the layout of the dam in a meandering pattern for aesthetic purposes. The meandering pattern is as recommended in page 4 Design Assumptions and Philosophy prepared as a part of Contract for Landscape Visual Resource Plan Contract Number AG04SCS-00045 by A. Wayne Smith and Associates, Tempe, Arizona

The storage is unaffected by the meandering embankment. Loss in storage due to offseting the dam is made up in steepening the upstream slope and in the excavation of the principal spillway inlet channel.

b. The profile and cross sections for earthwork is taken on the baseline of the dam. Error incurred should be within tolerable limits. The exception to the above practice will be at the beginning and end of the dam where the centerline of the dam is on the baseline. Cross sections for quantities in the area of McKellips and McDowell Road ramps should be taken perpendicular to the dam since the alinement departs radically from the baseline.

c. The emergency and principal spillway layouts are generally as given in the Preliminary Design Report.

d. A permanent barbed wire fence placed as part of the contract at the rights-of-way line upstream from the reservoir. It will connect with a temporary barbed wire fence and on the Bureau of Reclamation's west rights-of-way limit also being placed as part of the construction contract. Upon completion of the Salt-Gila Aqueduct downstream access to the dam will be interrupted by the Bureau's permanent fencing.

Hydrology

The basic hydrology and flood routing for the principal spillway, emergency spillway and freeboard hydrographs has been reviewed by the E&WP Unit. The review comments are contained in the letter to Paul Monville from Wendell Styner dated May 9, 1975. The only significant change made since the Preliminary Design was to flood route the 260-foot wide reinforced concrete drop emergency spillway used in place of a concrete drop combined with an earth auxilliary spillway.

Hydraulic Design

a. The reinforce concrete emergency spillway has been designed for the freeboard discharge. The outlet channel converges in order to provide sufficient tailwater for the operation of the Type C drop spillway. Channel capacity at the emergency spillway outlet channel protection is designed for the emergency spillway hydrograph discharge.

b. No anti-vortex device or trash rack is being used on the principal spillway inlet. The riser proportions are such that flow during the design discharge will not cause a vortex. The riser has an open top and will pass the maximum sized trash anticipated from the watershed.

c. The flow over the road ramp and crossings were checked in accordance with a hydrologic procedure developed by Robin McArther, hydraulic engineer, Arizona Watershed Planning Staff. Calculations are included in the Appendix.

A 24-inch by 24-inch slide gate is being used to draw down the sediment pool. A slotted CMP section is designed to protect the gate from sediment encroachment. The gate is to remain in a closed position except during storms. The gate is to be opened upon drawdown of the reservoir to the crest of the principal spillway.

Structure Design

a. The emergency spillway apron buttress and longitudinal still is designed in accordance with NEH Section 11. Because the apron section of the spillway is articulated from the sidewalls, the toe wall was incapable of resisting the total upward force the longitudinal sill had placed upon it. To resist the upward force and design in accordance with Section 11, an anchor was provided at the intersection of each longitudinal sill and the toe wall. This anchor consists of an 18-foot, 6-inch deep cast in place reinforced concrete anchor 18 inches in diameter for 16 feet 6 inches and belled to 36 inches for the remaining 2 feet.

b. The emergency spillway sidewalls were designed as a cantilever retaining wall.

c. The principal spillway inlet was designed in accordance with R 29 and NEH Section 6.

d. The conduit section is a computer design requested from the Design Unit, Design Branch, Engineering Division, Washington, D.C., dated August 13, 1976.

e. The transition section is designed in accordance with NEH Section 6.

f. The SAF basin outlet is designed in accordance with NEH Section 6.

Foundation and Embankment Design

a. The preliminary design called for a zoned fill. Re-examination of the borrow material has revised the embankment geometry to a homogeneous fill as far as construction is concerned. However, the embankment materials will be routed as follows.

   (1) Silty and clayey sand and silts to the upstream part of the embankment.

   (2) Caliches downstream from the center line.

   (3) Sands, decomposed granite and granites to the downstream toe of the embankment.

b. The upstream side slope of the embankment has been reanalyzed for a condition less critical than a rapid draw down condition for a water surface at the crest of the emergency spillway. A time-draw down analysis was performed and a water surface elevation established at which the phreatic line is considered fully developed. It was determined that the phreatic line could not develop at any level other than the crest of the principal spillway. The Swedish Circle analysis for the downstream slope for steady seepage condition with the water surface at the crest of the emergency spillway was run at a slope of 2:1. The minimum safety factor calculated was 1.24. This

result is used in justifying a 2½ to 1 slope on either side of the dam.

Landscape Treatment

a. Landscape treatment was designed by A. Wayne Smith & Associates of Phoenix, Arizona. The principal ingredients of the design are the following:

(1) Seed the dam slopes and sustain the plant life with a permanent irrigation system.

(2) Plant container stock in the reservoir and at the upstream and downstream toes of the dam for quick growth for screening purposes. A temporary irrigation system will be used to establish the plants.

(3) Seed other bare or disturbed areas within the rights-of-way limits. No irrigation will be provided for these areas.

(4) The irrigation system will contain two pumping stations and receive municipal water from the City of Mesa.

(5) A planting road will be laid out in the reservoir as a meandering line. This road will be available as a trail for possible future development in the reservoir area.

Appendix

a. Cost estimates for the construction of the dam and the landscape treatment for the dam and floodway are included in the Appendix.

b. Design calculations for the significant components of the dam are included in the Appendix.

Paul Monville
Design Engineer

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill FRS.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	18 Aug 76			2005
SUBJECT				SHEET 1 OF 5
Brown Road Ramp Alignment of Dam and Prin. Spwy Channel				

Brown Road is located on Curve No. 3.

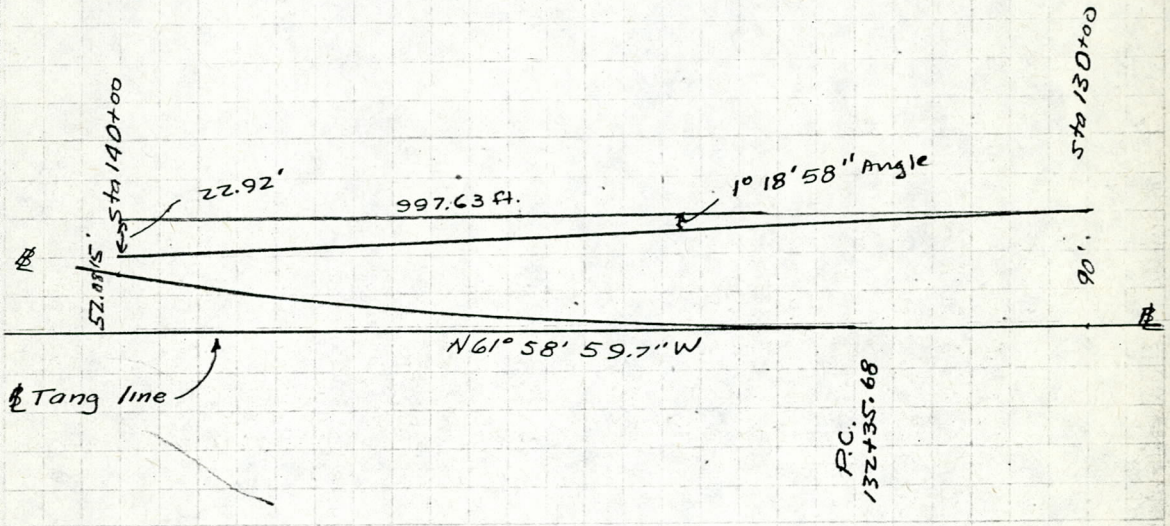
the curve data is Δ 16° 26' 47"
R 5599.61 ft.
D 1° 01' 24"
T 809.23 ft.
L 1607.33 ft.

P.C. Sta. 132+35.68

Find bearing of ℄ dam
℄ Bearing N 61° 58' 59.7" W

Angle point Sta 130+00, ℄ Dam 90ft. Right

Angle point Sta. 140+00 (on curve #3) 15 ft. Right



use Monroe 1880 program
Compute Arc length 140+00 - 132+35.68 = 764.32

Machine Computes tang. line dist 761.95'
off set dist. 52.08'
add the dist Rt. 15.
67.08 ft.

Arc length 764.32
tang length 761.95 A
offset 52.08 — A

90' - 67.08' = 22.92 ft. opp. side

13235.68 - 13000.00 + 761.95 = 997.63 ft. adj side

STATE		PROJECT		
Arizona		Buckhorn Mesa WRP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	18 Aug 76			2005
SUBJECT				SHEET 2 OF
Brown Road Ramp Alignment of dam and princ spwy. Channel				

$\tan = \frac{\text{opp } 22.92}{\text{adj } 997.63} = 0.022974 = 1°\,18'\,58''$

℄ Bearing = N 61° 58' 59.7" W
add 1° 18' 58"
℄ Bearing = N 63° 17' 57.7" W (between sta 130+00 & 140+00)

Find the bearing of a perpendicular line to Brown Road

℄ Brown Road — S 89° 59' 55.3" E

90°

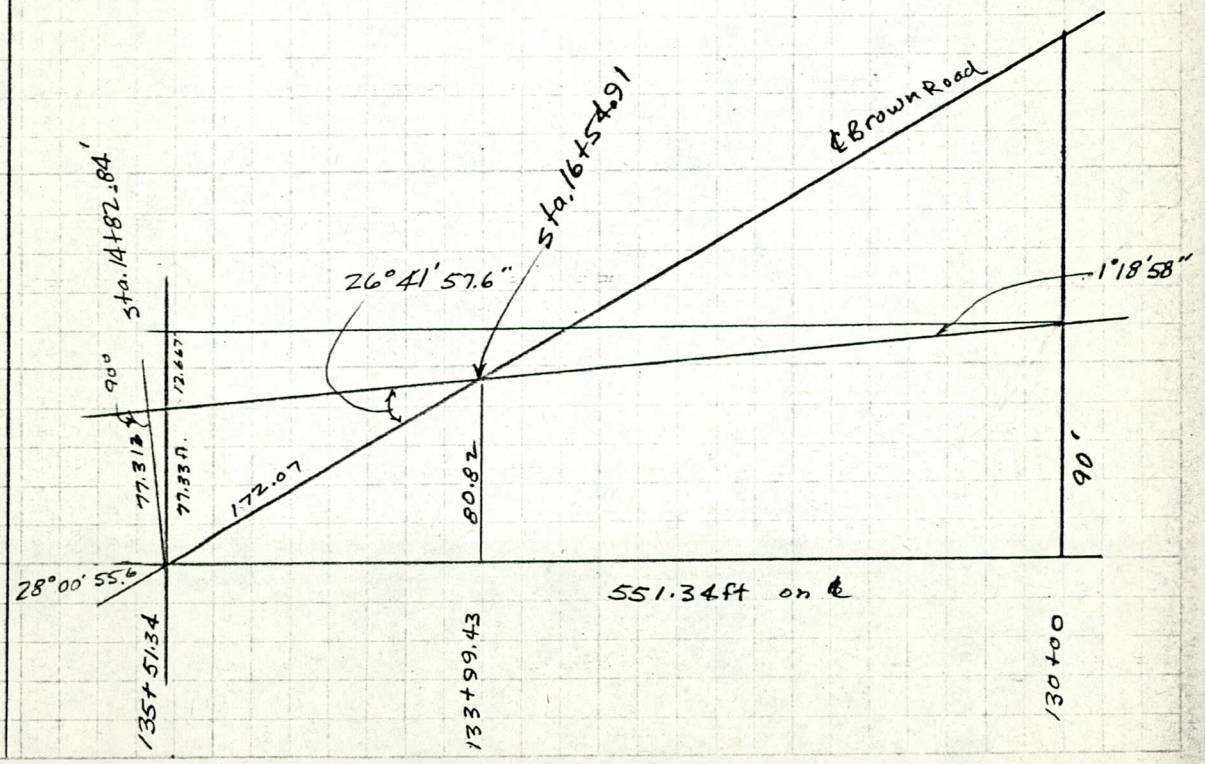
89 59 60.0
−89 59 55.3
S 0° 00' 04.7" W

or N 0° 00' 04.7" E

Find the angle between bearings

S 89° 59' 55.3" E ℄ Brown Road
S 61° 58' 59.7" E ℄ F.R.S.

28° 00' 55.6"



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY J.E.B.	DATE 18 Aug 76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Brown Road Ramp Alignment of dam and prime spwy chan				SHEET 3 OF

Find dist. ℄ is right of ℄ at sta. 135+51.34

angle = 1° 18' 58", adj. side 551.34 ft.

opp. side, = (tan)(551.34 ft) = 12.667 ft.

90 ft − 12.667 = 77.333 ft.

Find dist. to ℄ perpendicular to ℄ using 77.333 ft as hypot.

(77.333)(cos 1°18'58") = 77.313 ft.

Find Angle between ℄ dam and ℄ Brown Road

Bearing ℄ Brown Road	89° 59' 55.3"
less Bearing ℄ dam	63 17 57.7
	26° 41' 57.6"

Solve triangle for hypotenuse

angle 26° 41' 57.6", opp side 77.313

$$\text{hypot.} = \frac{77.313}{\sin 26°41.58} = 172.07 \text{ ft.}$$

Sta on sec. line. 14+82.84 + 172.07 = sta. 16+54.91

Sta on ℄ Brown Road intersection with ℄ dam is 16+54.91

plotted as 16+55 O.K.

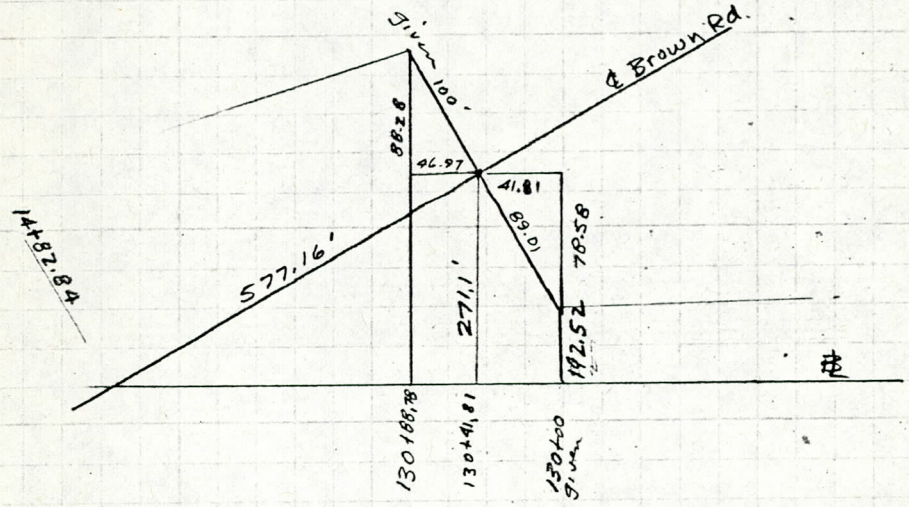
Establish ℄ sta. and dist. right

dist right = (172.07)(sin 28°00' 55.6") = 80.82'

Sta = 135+51.34 − ((172.07)(cos)) = sta. 133+99.43

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	19 Aug 76			2005
SUBJECT				SHEET 4 OF
Brown Road Ramp Alignment of dam and princ. spwy. Channel				

Find the ℄ sta. and distances right of base line for the angle points on the channel.



Given intersection channel on Brown Road Sta 20+60

Angle 28° 00' 55.6"

side (hypot) = 2060 − 1482.84 = 577.16 ft

(577.16)(sin 28°+) = 271.0976 ft. Rt.

(577.16)(cos 28°+) = 509.529 ft.

℄ sta. 135+51.34 − 509.529 = 130+41.81

Sta. 130+41.81, 271.1 ft. right = intersect. road & channel

Find ℄ sta. and dist. right for angle point 100' left of ℄ Brown Road.

hypot. = 100 ft., angle 28° 00' 55.6"

solve triangle, opp. side = (sin)(100) = 46.971 ft.
adj. side = (cos)(100) = 88.282 ft.

℄ sta = 130+41.81 + 46.971 = 130+88.78
dist. right ℄ 271.1 + 88.28 = 359.38 ft.

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B	19 Aug 76			2005

SUBJECT
Brown Road Ramp Alignment of dom and princ. Spwy. Channel

SHEET 5 OF

Solve triangle ~~south~~ of road

Given ℄ sta. 130+00

intersection of Channel & Brown Road is perpendicular to sta. 130+41.81.

130+41.81 − 130+00 = 41.81 ft. side opp. angle 28°00'55.6"

$\frac{41.81}{\tan 28°}$ = 78.58 ft. adj side

$\frac{41.81}{\sin 28°}$ = 89.01 ft. hypot.

271.1 ft − 78.58 = 192.52 ft.

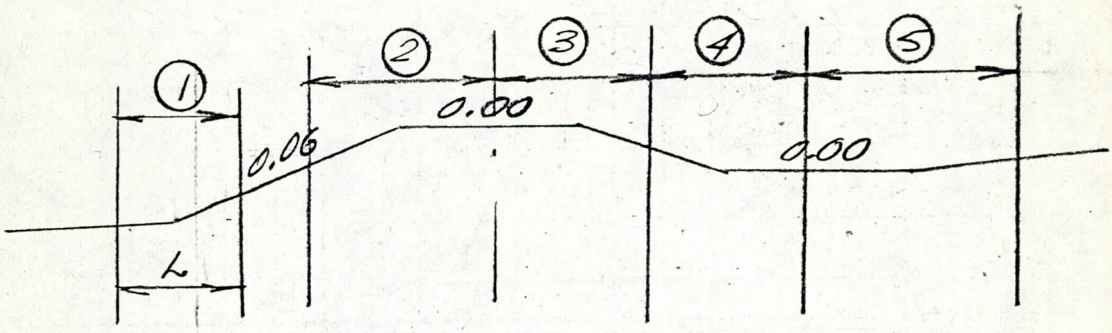
Sta. 130+00.00 Right 192.52 ft. to angle point

STATE		PROJECT Birthorn Mesa WDP Spook Hill ERS		
BY PJM	DATE 11/29/16	CHECKED BY	DATE	JOB NO.

SUBJECT Brown Road

SHEET 1 OF 1

Curve Data



Ref: Highway Engineering (Ritter & Paquette) p146

$q_1(+)$ $q_2(-)$ sign convention

$E = qL/8$

$q = q_2 - q_1$

$y = \left(\frac{x}{e}\right)^2 E$

Elev@x = Elev@PVC + $q_1 X + y$

x = Sta@x − Sta@PVC

Monroe 1880

Enter Sta@PVC, L, q_1, q_2 & Sta@x

Ans Elev@x

STATE	PROJECT			
Ariz	Buckhorn Mesa W/P Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	11/29/76			

SUBJECT Vertical Curve Data
Monroe 1880

SHEET 1 OF 2

0000	117	
1	002	2
2	056	Sta @ PVC
3	060	
4	110	↓
5	000	0
6	056	Elev @ PVC
7	060	
8	110	↓
9	010	8
0010	056	L. F't
1	060	
2	024	÷
3	001	1
4	000	0
5	000	0
6	020	=
7	110	↓
8	001	1
9	023	X
0020	001	1
1	000	0
2	000	0
3	024	÷
4	002	2
5	020	=
6	110	↓
7	002	2
8	117	(91)
9	005	5
		↓
0030	056	
1	060	
2	023	X
3	001	1
4	000	0
5	000	0
6	020	=
7	110	↓
8	003	3
9	056	92
0040	060	

1	023	X
2	001	1
3	000	0
4	000	0
5	020	=
6	110	↓
7	004	4
8	066	
9	001	1 > 066
0050	117	
1	002	2
2	056	Sta x
3	060	
4	~~065~~ 377	
5	110	↓
6	005	5
7	111	↑
8	022	-
9	000	0
0060	110	↓
1	006	6
2	023	X
3	020	=
4	110	↓
5	007	7
6	111	↑
7	004	4
8	111	↑
9	022	-
0070	003	3
1	023	X
2	111	↑
3	001	1
4	024	÷
5	010	8
6	024	÷
7	026	(
8	111	↑
9	002	2
0080	023	X

STATE	PROJECT			
AR	Buckhorn Mtn Spook Hill FPS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	11/29/76			

SUBJECT Vertical Curve Data

SHEET 2 OF 2

1	020	=
2	027	)
3	023	X
4	111	↑
5	007	7
6	021	+
7	026	(
8	111	↑
9	003	3
0090	024	÷
1	001	1
2	000	0
3	000	0
4	023	X
5	111	↑
6	006	6
7	027	)
8	021	+
9	111	↑
0100	010	8
1	020	=
2	061	A Elev
3	~~065~~	377 @ Sta X
4	127	Br
5	067	
6	001	1

Reset Br (0X0) Resume
Enter Sta @ PVC
Elev @ PVC
L in ft
g_1 in ft/ft
g_2 in ft/ft
Sta @ X_1
Read Elev @ X_1
Enter Sta @ x_2
Read Elev @ x_2

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	11/29/76			

SUBJECT ~~Mc~~ Brown Rd

SHEET 8 OF

Brown Rd Vertical Curve Data

1

993.00 Sta@PVC
1,565.60 El@PVC
200.00 L
0.01200 g1
0.06000 g2

1,043.00 Sta X
1,566.50 El X
A

1,093.00
1,568.00 A

1,143.00
1,570.10 A

1,193.00
1,572.80 A

1,572.80	+
1,572.80	(
1,355.00	−
1,193.00	X
0.06	)
9.72	*
9.72	=
1,582.52	*

2

1,355.00
1,582.52
300.00
0.06000
0.00000

1,430.00
1,586.46 A

1,505.00
1,589.27 A

1,580.00
1,590.96 A

1,655.00
1,591.52 A

3

1,655.00
1,591.52
250.00
0.00000
−0.04500

1,720.00
1,591.14 A

1,780.00
1,590.11 A

1,840.00
1,588.44 A

1,905.00
1,585.90 A

STATE		PROJECT		
Ariz		Buckhorn Mesa NP Rock Hillers		
BY	DATE	CHECKED BY	DATE	JOB NO.
RM	11/29/75			

SUBJECT Brown Rd

SHEET 12 OF 2

4

1,905.00
1,585.90
250.00
-0.04500
0.00000

1,970.00
1,583.36 A

2,030.00
1,581.68 A

2,090.00
1,580.66 A

2,155.00
1,580.28 A

5

2,155.00
1,580.28
200.00
0.00000
0.01300

2,205.00
1,580.36 A

2,255.00
1,580.61 A

2,305.00
1,581.01 A

2,355.00
1,581.58 A

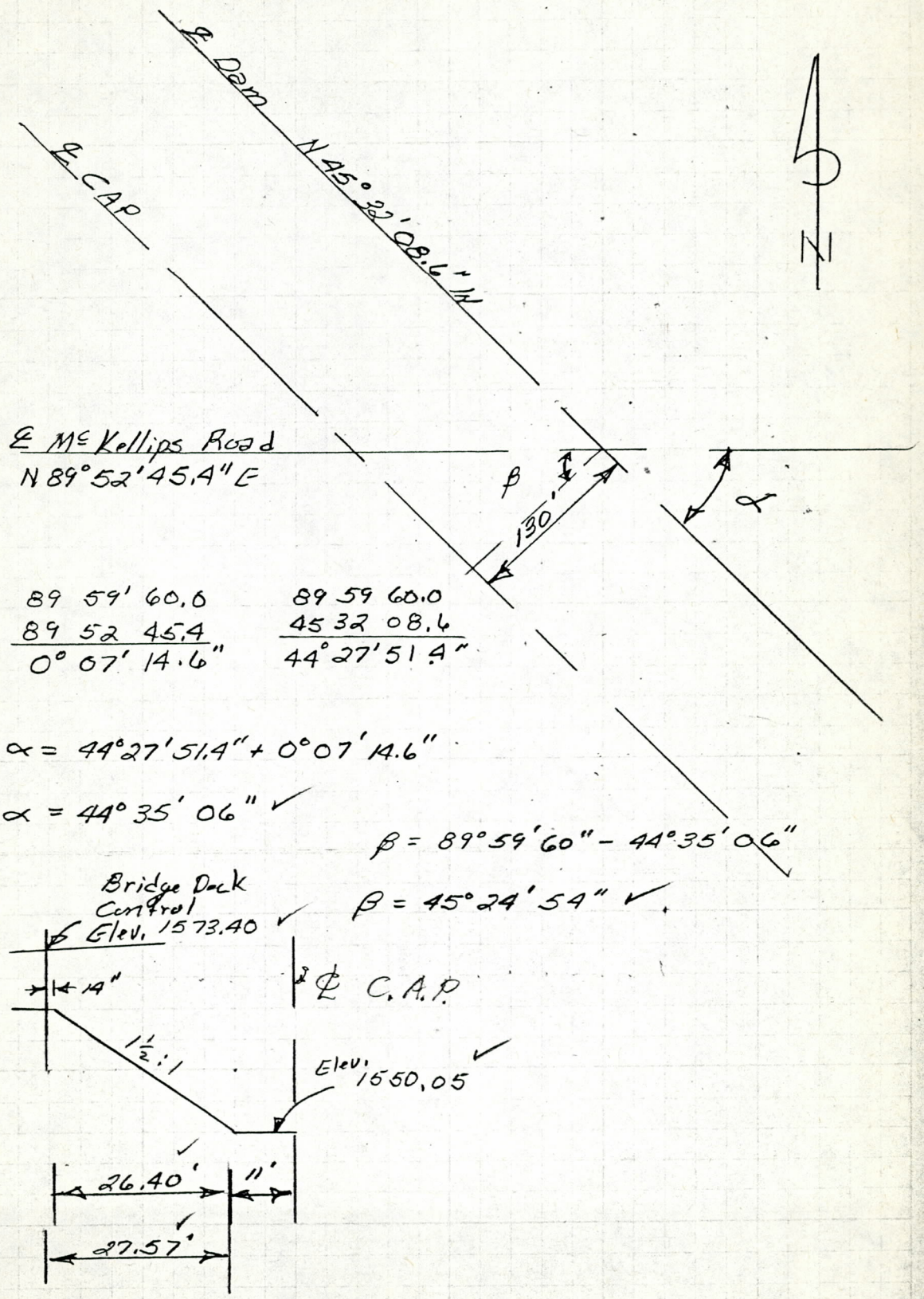
COMPUTATION SHEET

SCS–ENG–523 Rev. 8–69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE 11 of 429

☆ GPO : 1969—O–357–545

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-8-76	D Riddle	4-16-76	2005
SUBJECT				SHEET 11 OF
McKellips Road Ramp				



89 59' 60.0
89 52 45.4
0° 07' 14.6"

89 59 60.0
45 32 08.6
44° 27' 51.4"

$\alpha = 44°27'51.4" + 0°07'14.6"$

$\alpha = 44°35'06"$ ✓

$\beta = 89°59'60" - 44°35'06"$

$\beta = 45°24'54"$ ✓

CAP Canal

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-8-76	D Riddle	4-15-76	2005
SUBJECT				SHEET 12 OF
McKellips Road Ramp				

Skewed Distances from E Dem

Control Pt. = $\frac{168.57}{\cos\beta}$ = 240.14'

West Edge of canal = $\frac{167.40}{\cos\beta}$ = 238.47

West side of bottom = $\frac{141.00}{\cos\beta}$ = 200.86

E of CAP = $\frac{130.00}{\cos\beta}$ = 185.19

East side of bottom = $\frac{119.00}{\cos\beta}$ = 169.52

East edge of canal = $\frac{92.60}{\cos\beta}$ = 131.92'

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-16-76			2005
SUBJECT				SHEET 13 OF
Mc Kellips Road Ramp				

1500.00
240.14
1259.86
1225.00
34.86

1573.40
2.04
1571.31
6.00
1565.31

$g_1 = 0.014$

Curve No. 1

End curve no. 1 @ Sta. 12+25

Elev. = 1573.40 − (34.86)(0.06) = 1571.31

$g_1 = 1.4\%$ $g_2 = 6\%$

Min. length of curve = (6 − 1.40)(50) = 230'

Use 200' (will be good for between (35-40 mph)

$r = (6 - 1.4) \div 2.00 = 2.3$; $\frac{1}{2} r = 1.15$

PVC - Sta. 10+25 ≈ Elev. = 1563.91

P.I - Sta. 11+25 ≈ Elev. 1565.31

PVT - Sta. 12+25 ≈ Elev. 1571.31

Sta.		Y.	Elev.
10+25			1563.9
10+75	1564 [61]	0.29	1564.9
11+25	1565 [31]	1.15	1566.5
11+75	1568 [31]	0.29	1568.6
12+25		-	1571.3

Superseded 11/26/76

20 / 1500 = .0133 = 1% slope

88.1
82.1
6

Curve No. 2

$g_1 = 6\%$ $g_2 = 0$

The bridge deck controls the placement of the ramp.

STATE	PROJECT		JOB NO.
Arizona	Buckhorn Mesa WPP, Spook Hill FRS		
BY / DATE	CHECKED BY / DATE		
J.L. Sullivan / 4-16-76			2005
SUBJECT			SHEET 4 OF
McKellips Road Ramp			

Use the same elev. ±0.25' for the PVC

∴ PVC Elev. = 1582.25

Distance to PVC = (1582.25 - 1573.40) ÷ 0.06

= 147.50 feet

New Sta. of PVC = 15+00 - 240.14 + 147.50

= 14+07^{36} Use 14+07

Elev. of PVC = 1573.40 + (147.14)(0.06) = 1582.23

Min length of curve = 50 x 6 = 300 ok

r = 6/3 = 2 ; ½ r = 1

Sta.		y	Elev.
14+07		-	1582.2
14+57	1585^{23}	0.25	1585.0
15+07	1588.^{23}	1.00	1587.2
15+57	1591^{25}	2.25	1589.0
16+07		1.00	1590.3
16+57		0.25	1591.0
17+07		-	1591.25

STATE	PROJECT		JOB NO.
Arizona	Buckhorn Mesa WPP, Spook Hill FRS		2005
BY J.L. Sullivan	DATE 4-16-76	CHECKED BY	DATE
SUBJECT McKellips Road Ramp			SHEET 15 OF

Curve No. 3

$g_1 = 0$ $g_2 = 4.45$ (0.45)

Length of curve = 200' (4.45)

PRVC – Sta. 17+07 Elev. 1591.25

P.I. Sta. 18+07 Elev. = 1591.25

PVT – Sta. 19+07 Elev. = 1586.80

$r = 4.45/2. = 2.23$; $\frac{1}{2} r = 1.1125$

	Sta.		y	Elev.
	17+07		–	1591.3
	17+57		0.28	1591.0
P.I.	18+07		1.11	1590.1
	18+57	1589.03	0.28	1588.7
	19+07		–	1586.8

Curve No. 4

$g_1 = 4.45\%$ $g_2 = 6.00$

Distance to go from 1591^{25} to 1582.10 using a 4.45% grade

$(1591^{25} - 1582^{10}) \div 0.0445 = 205.62$ ft.

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	9-16-76			2005
SUBJECT				SHEET 6 OF
McKellips Road Ramp				

Used 100' for curve no. 3

∴ Length of curve = (205.62 − 100) × 2

= 211.24 use 211 ft.

PRVC - Sta. 19+07 - Elev. 1586.80

P.I. - Sta. 20+12.5 - Elev. 1582.10

PVT - Sta. 21+18 - Elev. 1582.10

$r = 4.45/2.11 = 2.109$; $\frac{1}{2} r = 1.0545$

Sta.		y	Elev.
19+07		—	1586.80
19+57	1584^{58}	0.26	1584.8
20+07	1582^{35}	1.05	1583.4
20+12.5		1.17	1583.3
20+57		0.39	1582.5
21+07		0.01	1582.1
21+18		—	1582.1

N.G.L. 1.4%

2860
171
2689
85
2601

82.1
6
88.1

Curve No. 5

Set P.I. @ Sta. 26+89 $g_1 = 0$ $g_2 =$

Grade = 6/(2860 − 2689) = 3.51% use 3.5% g_2

Min. Length of curve = 50 × 3.5 = 175'

use 178

PVC =

PVC - Sta. 26+89 − 89 = 26+00 Elev. 1582.1

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP; Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	9-16-76			2005
SUBJECT				SHEET 17 OF
McKellips Road Ramp				

PVT - Sta. 27+78 - Elev. 1585.22

$r = 3.5/1.78 = 1.9663$; $\frac{1}{2} r = 0.9831$

	Sta.		y	Elev.
	26+00		-	1582.1
	26+50		0.25	1582.4
P.I.	26+89		0.78	1582.9
	27+28	1583^{47}	0.25	1583.7
	27+78			1585.2

Curve No. 6

$g_1 = 3.5\%$ $g_2 = 1.4$

Min Length of curve = 50 x 2.1 = 105
Use 110

Available Length = 171 - 89 = 82

P.I - Sta 28+60 Elev. 1588.1

PRVC - Sta. 28+05 Elev. = 1586.15

PVT - Sta. 29+15 Elev. = 1588.87

$r = 2.1/1.1 = 1.9091$; $\frac{1}{2} r = 0.9545$

	Sta.	y	Elev.
	28+05	-	1586.1
P.I.	28+60	0.29	1587.8

COMPUTATION SHEET

SCS–ENG–523 Rev. 8–69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE 18 of 429

☆ GPO : 1969—O–357–545

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-16-76			2005
SUBJECT				SHEET 18 OF
McKellips Road Ramp				

Sta.	y	Elev.
29+15		1588.9

STATE		PROJECT		
AZ		BUCKHORN MESA WPP - SPOOK HILL F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-28-76			2005
SUBJECT				SHEET 19 OF
McKellips Road Ramp				

Changes on McKellips Road Ramp

Sta 17+07, Elev 1591.25, $g = 0.0$

would like to achieve 45 MPH in curve No 3 and No 4

to go from 1591.25 to ≈1579 = 12.25'

*Values from curve developed from AASHO Standards See McDowell Road Ramp changes (Also for equation)

*45MPH, $K_s = 59$, $K_c = 61$

*$A = \sqrt{2y/(591.61)} = 4.52$ use $g = 4.5$ (or less)

Curve No. 3 Sta 17+07 Elev. 1591.25

$g_1 = 0\%$ $g_2 = -4.5\%$ $K = 61$ $A = -4.2$

$L = KA = 256.2$ use $L = 300$ $r = \frac{-4.2}{3.0} = 1.4$ $\frac{1}{2}r = -0.7$

$y = \frac{1}{2}rx^2$ PI = 18+67

Sta		y	Elev	
17+07		—	1591.25	
17+82		-.394	1590.86	1590.
18+67	1591.25	-1.575	1589.68	
19+32	1588.10	-.394	1587.71	
20+07		—	1584.95	

STATE		PROJECT		
Az		Buckhorn Mesa WPP – Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
AC.	7-28-76			
SUBJECT				SHEET 10 OF
McKellips Road Romp				

Curve No 4 Sta 20+07 Elev 1584.50

$g_1 = -4.5\%$ $g_2 = 0.0\%$ $K = 59$ $A = 4.2$

$L = KA = 247.8$ use 250' $r = \frac{4.2}{2.5} = 1.68$ $\frac{1}{2}r = 0.84$

Sta		y	Elev.
20+07		—	1584.95
20+82	1581.80	+.473	1582.27
21+32	1579.70	+1.313	1581.01
21+82		+.473	1580.17
22+57		—	1579.70

to get from 1579.70 to 1589 ± $y = 9.3'$

$A = \sqrt{2y/(.59+.61)} = 3.94$

$L_c = 59(3.94) = 232'$ $L_s = 61(3.94) = 240'$

try 250' curves (g of road is 1.4%)

$1.4(1.25) + (A_c+1.4)(2.5) = 9.3$ $A_c = 1.62$ $L_c = 99'$
$A_s = 3.02$ $L_s = 178'$

try 150' curves

$1.4(.75) + (A_c+1.4)(1.5) = 9.3$ $A_c = 4.1$ $L_c = 250'$
$A_s = 5.5$ $L_s = 325$

try 200' curves

$1.4(1) + (A_c+1.4)(2) = 9.3$ $A_c = 2.55$ $L_c = 156$
$(A_s = 3.95)$ $L_s = 233$

try 250' on curve 5 200' on curve 6

$1.4(1) + (A_c+1.4)(2.25) = 9.3$ $A_c = 2.11$ $L_c = 129' < 200'$
$A_s = 3.51$ $L_s = 207' < 250'$

STATE		PROJECT		
Az		Buckhorn Mesa WPP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-28-76			2005
SUBJECT				SHEET 21 OF
McKellips Road Ramp				

Curve No. 5 Sta 24+70 Elev. 1579.7

$g_1 = 0.0$ $g_2 = 3.51$ $A = 3.51$

$L = 59(3.51) = 207'$ use 250' $r = \frac{3.51}{2.5} = 1.404$ $\frac{1}{2}r = 0.702$

$y = \frac{1}{2} r x^2$ PI = 25+95

Sta		y	Elev.
24+70		—	1579.70
25+40		+ .34	1580.04
25+95	1579.70	+ 1.10	1580.80
26+50	1581.63	+ .34	1581.97
27+20	1584.09	-	1584.09

Curve No. 6 Sta 27+20 Elev. 1584.09

$g_1 = 3.51$ $g_2 = 1.4$ $A = -2.11$

$L = 129'$ use $L = 200'$ $r = \frac{-2.11}{2.0} = 1.055$ $\frac{1}{2}r = -0.528$

$y = \frac{1}{2} r x^2$ PI = 28+20

Sta		y	Elev
27+20		—	1584.09
27+70	1585.845	-.132	1585.71
28+20	1587.60	- .528	1587.03
28+70	1588.30	-.132	1588.17
29+20		—	1589.00

STATE Ariz | PROJECT Buckhorn Mesa WPP Spook Hill FRS

BY RM | DATE 11/26 | CHECKED BY | DATE | JOB NO.

SUBJECT McKellips Rd | SHEET 1 OF 1

Curve No 1

$E = gL/8$

$y = \left(\frac{x}{L}\right)^2 E$

$g = g_2 - g_1 = 6.0 - 1.7 = 4.3$

$L = 2$

$\therefore E = (4.3)(2)/8 = 1.075$

$y = (x/100)^2 (1.075)_2$

$= 0.0001075x^2$

$Elev = 1503.6 + 0.017x + 0.0001075x^2$

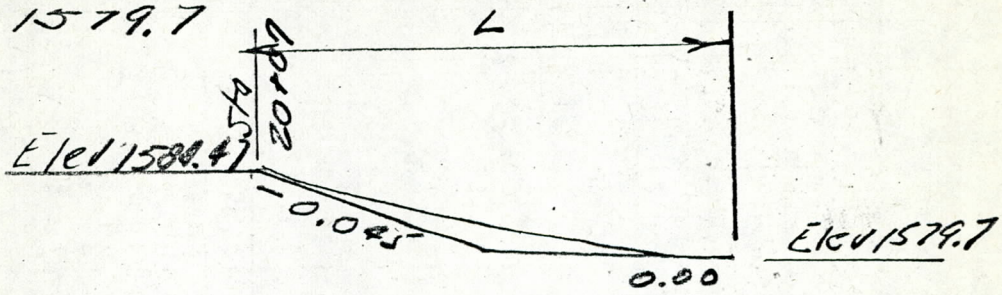
Sta	x	Elev	
10+25	0	1563.6	±
10+75	50	1564.72	
11+25	100	1566.38	
11+75	150	1568.57	
12+25	200	1571.30	

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY PJM	DATE 11/29/76	CHECKED BY	DATE	JOB NO.

SUBJECT Alignment

SHEET 1 OF 1

Adjust Curve No. 4 to end @ Elev 1579.7



$L = 2[(1584.47 - 1579.7)/(0.045)]$

$= 212'$ USE $L = 210'$

STATE		PROJECT		
Ariz		Buckhorn-Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	11/29/76	QAB	11-30-76	

SUBJECT McKellips Road

SHEET 21 OF

1

1,025.00	
1,563.60	
200.00	
0.01700	
0.06000	
1,075.00	
1,564.72	A
1,125.00	
1,566.38	A
1,175.00	
1,568.57	A
1,225.00	
1,571.30	A

1,571.30	+
1,571.30	(
1,407.00	−
1,225.00	X
0.06	)
10.92	*
10.92	=
1,582.22	*

2

1,407.00	
1,582.22	
300.00	
0.06000	
0.00000	

1,457.00	
1,584.97	A
1,507.00	
1,587.22	A
1,557.00	
1,588.97	A
1,607.00	
1,590.22	A
1,657.00	
1,590.97	A
1,707.00	
1,591.22	A

3

1,707.00	
1,591.22	
300.00	
0.00000	
−0.04500	
1,782.00	
1,590.80	A
1,857.00	
1,589.53	A
1,932.00	
1,587.42	A

STATE		PROJECT		
Ariz		Buckhorn-Mesa WPA Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJH	11/29/76	CAB	11-30-76	

SUBJECT McKellips Road

SHEET 2 OF

2,007.00
1,584.47 A

4

2,007.00
1,584.47
210.00
-0.04500
0.00000

2,057.00
1,582.49 82.37 A

2,112.00
1,580.93 80.98 A

2,167.00
1,580.01 80.7 A

2,217.00
1,579.75 79.745 A

5

2,470.00
1,579.75
250.00
0.00000
0.03500

2,540.00
1,580.09 A

2,595.00
1,580.84 A

2,650.00
1,582.02 A

2,720.00
1,584.13 A

6

2,720.00
1,584.13
200.00
0.03500
0.01400

2,770.00
1,585.75 A

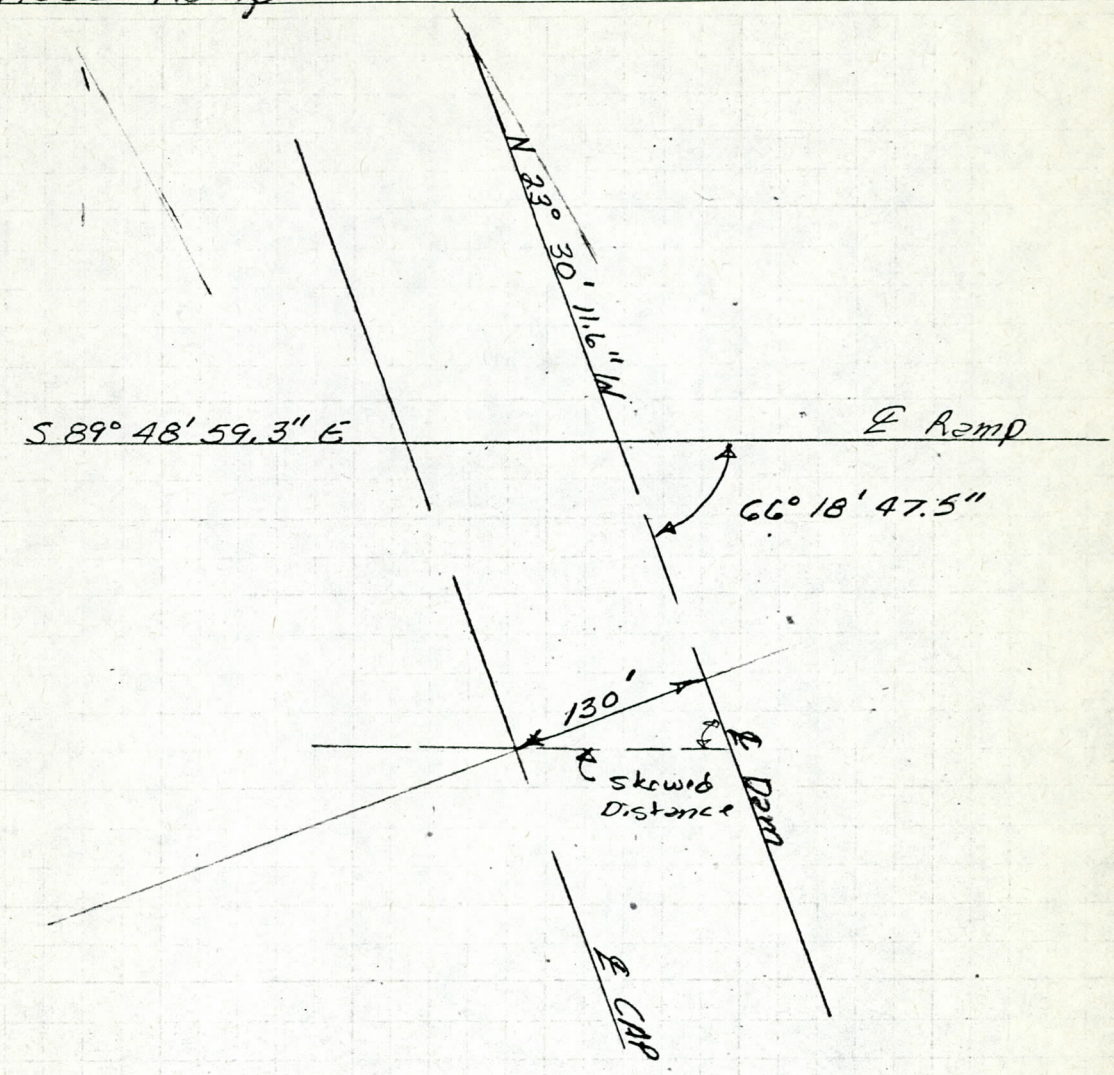
2,820.00
1,587.11 A

2,870.00
1,588.20 A

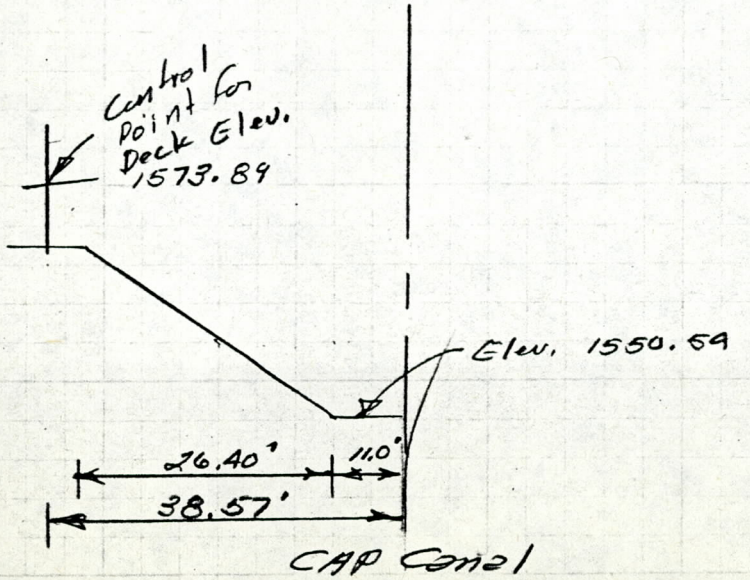
2,920.00
1,589.03 A

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-5-76			2005

SUBJECT: McDowell Road Ramp — SHEET 1 OF



Note: Elev. obtained from L. Heaton U.S.B.R. See Letter dated 4-9-76



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-5-76			2005
SUBJECT				SHEET 27 OF
McDowell Road Ramp				

89 59 60.0
66 18 47.7
23°41' 12.3

Skewed dist to CAP ℄ = $\frac{130.00}{\cos 23°41'12.3''}$ = 141.96'

Skewed dist. to Control Pt. = $\frac{168.57}{\cos 23°41'12.3''}$ = 184.08'

Difference in elev. between Bridge deck & top of dam = 1591.00 − 1573.89 = 17.11 ft.

Dist. req'd. @ 6% Slope for the difference in elev.

17.11 / 0.06 = 285.17

Skewed dist. to west edge of CAP = $\frac{167.40}{\cos 23°41'12.3''}$ = 182.80' ~~170.74'~~

Skewed dist. to east edge of CAP = $\frac{92.60}{\cos 23°41'12.3}$ = 101.12' ~~99.98'~~

Skewed dist. to West side of bottom = $\frac{141.00}{\cos \alpha}$ = 153.97'

Skewed dist. to east side of bottom $\frac{119}{\cos d}$ = 129.95'

Assumptions

1. Curve No. 2, 3 & 4 will remain the same except will allow enough room for the asphalt ∴ will go over the dam 0.25' higher. or finished asphalt elev. will be 1591.25

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
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J.L. Sullivan	4-9-76			2005
SUBJECT				SHEET 3 OF
Mc Dowell Road Ramp				

2. Keep the ramp inside the rights-of-way see water surface profile

3. Control Pt. of ll bridge deck will govern the position of the ramp

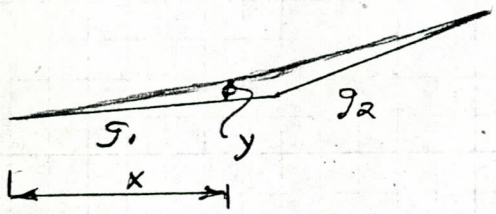
4. Max grade will not exceed 6%

Curve No. 1

P.I. Elev. = 1563.0 Sta. 11+34

PVC Elev. = 1561.6 Sta. 10+64

PVT Elev. = 1567.2 Sta. 12+04



Min. Length of curve required for 30 mph speed

$g_1 = +2\%$ $g_2 = +6\%$

Route Location and design P. 156

$(6-2) \times 35 = 140'$

$r = (g_2 - g_1) \div L = 4 \div 1.40 =$

$\frac{1}{2} r = 1.4286$

$y = \frac{1}{2} r x^2$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-12-76			2005
SUBJECT				SHEET 4 OF
Mc Dowell Road Ramp				

Sta		y	Elev.
10+64		-	1561.6
10+99	1562.3	0.18	1562.5
11+34	1563.0	0.70	1563.7
11+69	1565.10	0.18	1565.3
12+04		-	1567.2

91.25
3.75
87.50

Curve No. 2

Need to shift the curve & use the same elev. as before + 0.25' for the PVC

Elev. PVC = 1583.50 + 0.25 = 1583.75

Dist. req'd. to reach elev. 1583.75 from elev. of control point 1573.89

(1583.75 - 1573.89) ÷ 0.06 = 164.33 ft.

See Sht. 2

Sta. of PVC = 15+00 - 184.08 + 164.33

= 14+80.25 Use 14+80

13+15.92

Check Elev. 1573.89 + (0.06 x 164.08) = 1583.73 ok.

Use same L = 250 ft. g_1 = 6% g_2 = 0%

Sta. of P.I = 14+80 + 125 = 16+05

r = 6 ÷ 2.5 = 2.40 ft ½ r = 1.20

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-12-76			2005
SUBJECT				SHEET 5 OF
McDowell Road Ramp				

Sta.		y	Elev.
14+80		-	1583.7
15+17	1586^{95}	0.16	1585.8
15+67	1588^{95}	0.91	1588.0
16+05	1591^{25}	1.88	1589.4
16+17		1.53	1589.7
16+67		0.48	1590.8
17+17			1591.25

1730
1667
63

Curve No. 3

Begin curve at same dist forward as curve No. 2 14+80 − 12+13 = 267'

PVC = 15+00 + 267 = 17+67 Elev. 1591^{25}

$g_1 = 0\%$ $g_2 = 6\%$ $L = 130'$

$r = 6/1.30 = 4.62$ PVT Elev. = $1591^{25} - (.06)(65) = 1587^{35}$

P.I. = 17+67 + 65'
= 18+32

$\frac{1}{2} r = 2.3077$

Sta.		y	Elev.
17+67		-	1591.25
18+32	1591^{35}	0.98	1590.30
18+67	1589^{15}	0.21	1588.9
18+97		—	1587.35

STATE		PROJECT		
Arizona		Buckhorn Mesa NPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-15-76			2005
SUBJECT				SHEET 6 OF
Mc Dowell Road Ramp				

Curve No. 5

Beginning Elev. 1580.7

Use 6% grade to intersect the N.G.L.

Elev. @ Point of intersection - 1592.7

Distance = 1592.7 - 1580.7 ÷ 0.06 = 200'

Length of vertical curve = 400'

$g_1 = 0$ $g_2 = 6$

$r = 6 \div 4 = 1.50$

$\frac{1}{2} r = 0.75$

PVC Sta. 21+65 elev. 1580.7

PI Sta. 23+65 elev. 1580.7

PVT Sta. 25+65 elev. 1592.7

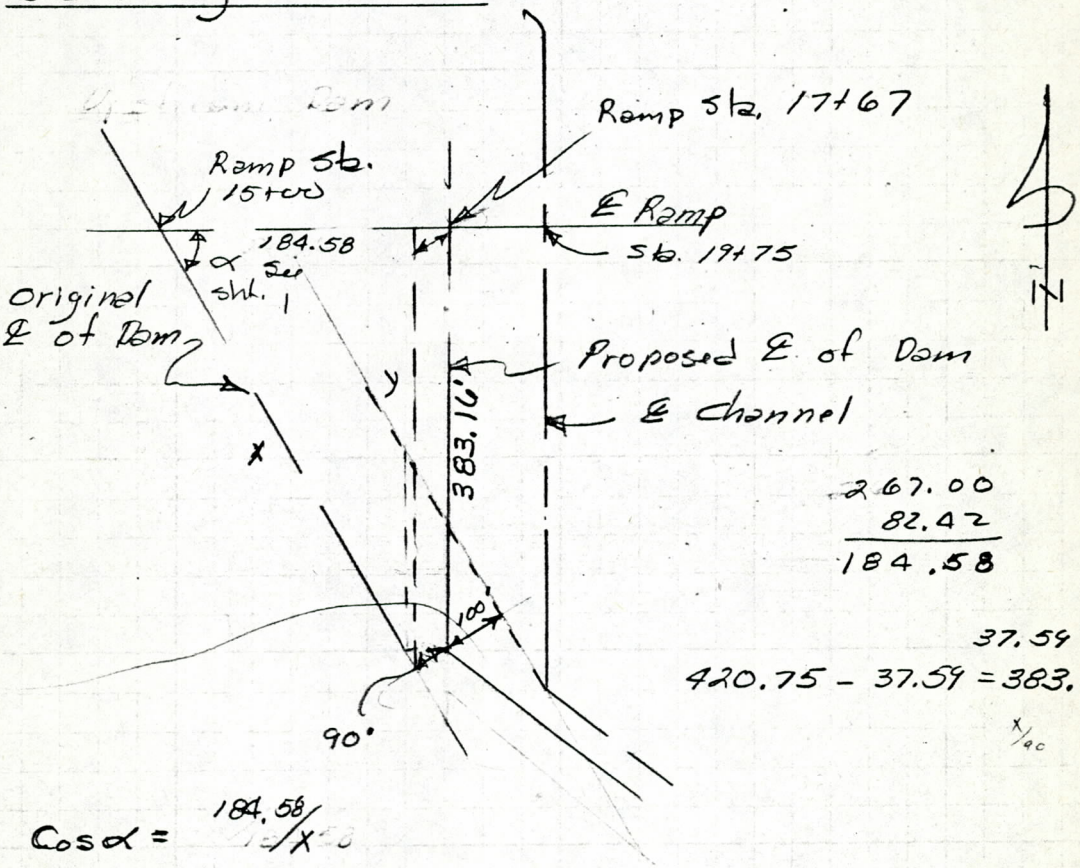
Sta.		y	Elev.
21+65		-	1580.7
22+15	1580.7	0.19	1580.9
22+65		0.75	1581.5
23+15		1.69	1582.4
23+65		3.00	1583.7
24+15	1583.70	1.69	1585.4

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-15-76			2005
SUBJECT				SHEET 7 OF
McDowell Road Ramp				

Sta.		y	Elev.
24+65	1586.20	0.75	1587.5
25+15	1589.20	0.19	1589.9
25+65	1591.20	—	1591.7

See Sht. 9 & 10

Stationing of P.I.'s



267.00
82.42
184.58

37.59'
420.75 - 37.59 = 383.16'

X/90

$\cos\alpha = 184.58/X$

$X = 459.46'$

Sta. = 273+80.87 − 459.46 = 269+21.41

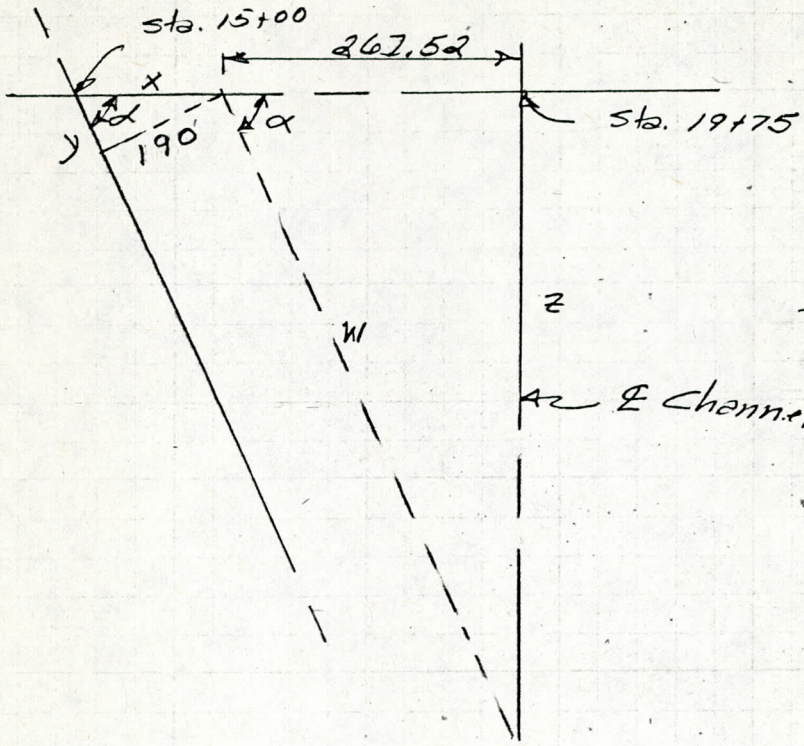
$\tan\alpha = y/184.58$

$y = 420.75$

b. 54 60
23 30 11.6
N 66° 29' 48.4" E

89 59 60
89 48 59.3
0° 11' 00.7"
23 30 11.6
23° 41' 12.3"

STATE	PROJECT			
Arizona	Buckhorn Mesa WPP, Spook Hill FRS			
BY / DATE		CHECKED BY / DATE		JOB NO.
J.L. Sullivan / 9-15-76				2005
SUBJECT				SHEET 8 OF
McDowell Road Ramp				



$\alpha = 66° 18' 47.5''$

1975
1500
475.00
207.48
267.52

$\sin \alpha = 190/x$

$x = 207.48$

$\tan \alpha = 190/y$

$\cos \alpha = 267.52/W$

$y = 83.35$

$W = 665.91$

$\tan \alpha = z/267.52$

$z = 609.81'$

Station of Channel P.I.

$273+80.87 - 83.35 - 665.91 = 264+31.61$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-16-76			2005
SUBJECT				SHEET 39 OF
McDowell Road Ramp				

Curve No. 5

See sht. 6 for original calculations.

Grade of N.G.L. ≈ 2.2 %

Design Speed - 40 mph

move P.I. back 50' to Sta. 23+15

Distance to N.G.L - 250'

Grade 12/250 = 4.8 %

Length of curve required = 50 x 4.8 = 240'
Use 300'

$g_1 = 0$ $g_2 = 4.8$ $r = 4.8/3 = 1.6$

$\frac{1}{2} r = 0.80$

PVC - Sta. 21+65 Elev. 1580.7

P.I. - Sta. 23+15 Elev. 1580.7

PVT - Sta. 24+65 Elev. 1587.9

	Sta.		y	Elev.
	21+65		–	1580.7
	22+15		0.20	1580.9
	22+65		0.80	1581.5
P.I.	23+15		1.80	1582.5
	23+65	1583 Lo	0.80	1583.9
	24+15	1585 Co	0.20	1585.7
	24+65		–	1587.9

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	4-16-76			2005
SUBJECT				SHEET 10 OF
McDowell Road Ramp				

Curve No. 6

$g_1 = 4.8\%$ $g_2 = 2.2\%$

Min. Length of Curve = $50 \times 2.6 = 130'$
$r = 2.6/1.3 = 2.0$ $\frac{1}{2} r = 1.0$

P.I. - Sta. 25+65 Elev. ≈ 1592.7

PVRC - Sta. 25+00 Elev. = 1589.6

PVT - Sta. 26+30 Elev. = 1594.1

2500
2315
185

Sta.		y	Elev.
25+00		-	1589.6
25+50	1592^{00}	0.25	1592.3
25+65	1592^{7}	0.42	1593.1
25+80	1593^{00}	0.25	1593.3
26+30			1594.1

STATE Az		PROJECT Buckhorn Mesa WPP – Spook Hill FRS		
BY A.C.	DATE 7-26-76	CHECKED BY	DATE	JOB NO.
SUBJECT Road Ramp Design – McDowell				SHEET 3/3 OF

(A7)

Changes on McDowell Road Ramp

Curves 1 and 2 are satisfactory. Curves 3 and 4 shall be changes. We have been requested to try to increase our allowable speed limits. In order to get a 35 M.P.H. speed limit on curves 3 and 4, a grade other than 6% will be required. From the chart on the following page K_c (for Crest Vertical Curve) is 38, while K_s (sag Vert. Curve) is 41.

$L = KA$ in feet, $r = \frac{g_2 - g_1}{L}$, $y = \frac{1}{2} r x^2$

for g in percent, L is in stations.

$$y = \frac{1}{2} r x^2 = \frac{1}{2} \left(\frac{g_2 - g_1}{L}\right) L^2 = \frac{1}{2} A L = \frac{1}{2} A K A$$

for curves 3 and 4

$$y = \frac{1}{2} A^2 (.38 + .41)$$

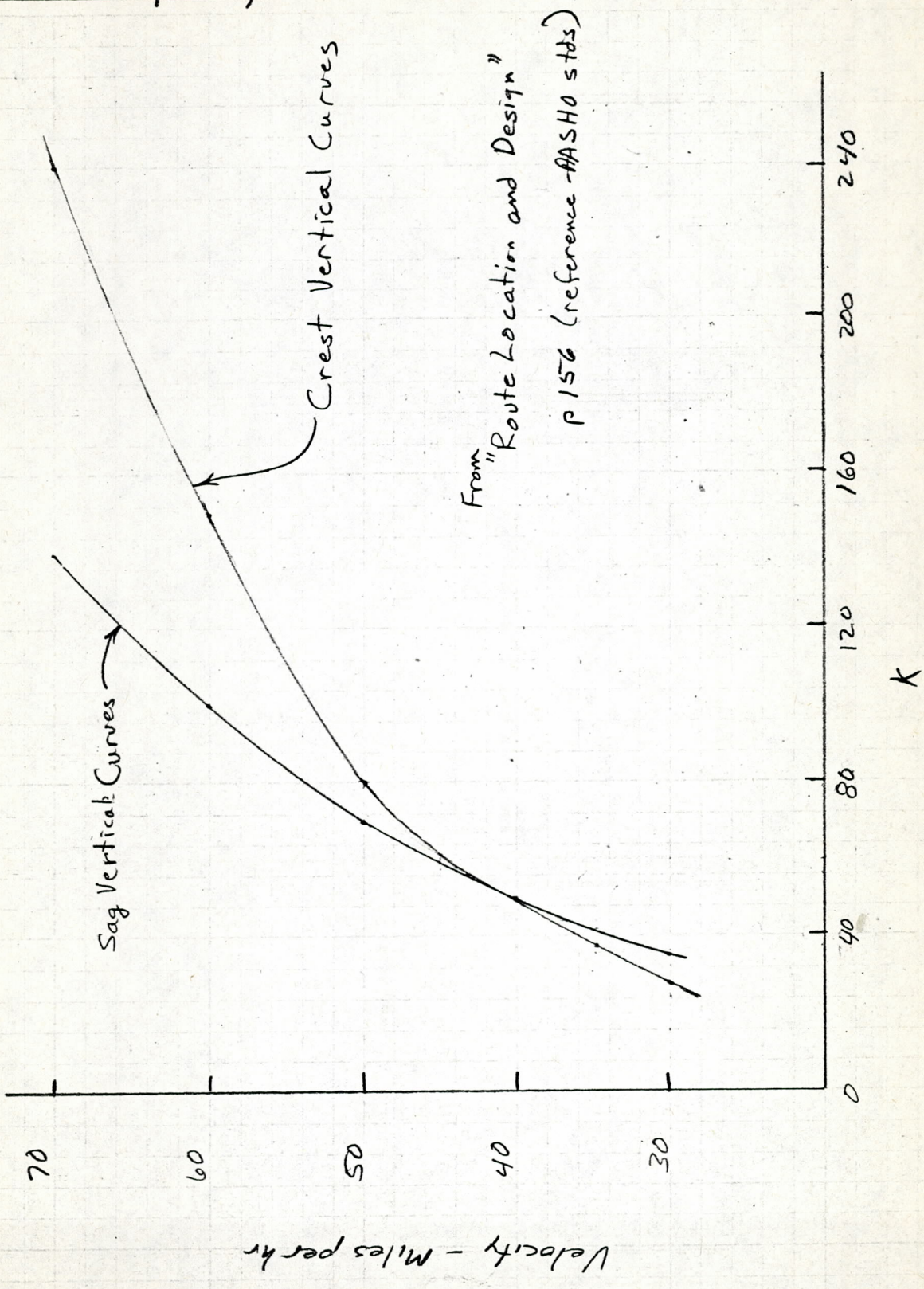
to get from 1591.25 to 1578.7 at 35 MPH, (12.55')

$$A < \sqrt{2y/(.38+.41)}$$

$$A < 5.637\%$$

use $A = 5.5\%$

STATE Az		PROJECT Buckhorn Mesa WPP - Spook Hill FRS		
BY A.C.	DATE 7-26-76	CHECKED BY	DATE	JOB NO. 200
SUBJECT Road Ramp Design		McDowell		SHEET 32 OF



STATE		PROJECT		
Az		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-27-76			2005
SUBJECT				SHEET 33 OF
Road Ramp Design McDowell				

Curve No 3 Sta 17+30, Elev. 1591.25

$g_1 = 0\%$ $g_2 = -5.5\%$, $K = 38$ $A = -5.5$

$L = KA = 38(5.5) = 209'$ use $L = 210'$

$r = \frac{-5.5}{2.1} = -2.619$ $\frac{1}{2}r = -1.310$

$y = \frac{1}{2} r x^2$ PI = 18+35

Sta.		y	Elev.
17+30		—	1591.25
17+85	1591.25	-.396	1590.85
18+35	1591.25	-1.444	1589.81
18+85	1588.50	-.396	1588.10
19+40		-	1585.48

Curve No 4 Sta 19+40, Elev. 1585.48

$g_1 = -5.5$ $g_2 = 0$ $K = 41$ $A = 5.5$

$L = KA = 5.5(41) = 225.5$ use $L = 230$

$r = \frac{5.5}{2.3} = 2.391$ $\frac{1}{2}r = 1.196$ $y = \frac{1}{2} r x^2$ PI = 20+55

Sta		y	Elev
19+40	—	—	1585.48
20+00	1582.18	+0.431	1582.61
20+55	1579.16	1.375	1580.54
21+10	-	+0.431	1579.59
21+70	-		1579.16

STATE		PROJECT		
Az.		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-27-76			2005
SUBJECT				SHEET 4 OF
Road Ramp Design - McDowell				

Curve No. 5 design for 40 MPH $K_s = 50$

$g_1 = 0$, $g_2 = 5.5$ $A = 5.5$ $L = 275$ use 300

$r = 5.5/3.0 = 1.833$ $\frac{1}{2} r = .917$ PI = 23+20

Sta		y	Elev.
21+70		-	1579.16
22+45		.516	1579.68
23+20	1579.16	2.063	1581.22
23+95	1583.285	.516	1583.80
24+70	1587.410	-	1587.41

Curve No. 6 - 40 MPH $K_c = 50$

$g_1 = 5.5$ $g_2 = 2.2$ $A = -2.3$ $L = 115$ use 180'

$r = -2.3/1.8 = -1.278$ $\frac{1}{2} r = -.639$ PI = 25+60

Sta		y	Elev.
24+70		—	1587.41
25+10	1589.610	- .102	1589.51
25+60	1592.360	- .518	1591.84
26+10	1593.460	- .102	1593.36
26+50	1594.34	—	1594.34

STATE		PROJECT		
AZ12		Buckhorn Mesa & Dook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	11/29/76			

SUBJECT McDowell Rd — SHEET 1 OF 2

McDowell Rd Curve Data (Corrected)

1

1,064.00	
1,561.60	
140.00	
0.02000	
0.06000	
1,099.00	
1,562.47	A
1,134.00	
1,563.70	A
1,169.00	
1,565.28	A
1,204.00	
1,567.20	A
~~1,561.20~~	
~~1,567.20~~	)

1,567.20	+
1,567.20	(
1,480.00	-
1,204.00	X
0.06	)
16.56	*
16.56	=
1,583.76	*

2

1,480.00	
1,583.76	
250.00	
0.06000	
0.00000	
1,517.00	
1,585.82	A
1,567.00	
1,588.07	A
1,605.00	
1,589.39	A
1,617.00	
1,589.73	A
1,667.00	
1,590.78	A
1,717.00	
1,591.24	A
1,730.00	
1,591.26	A

STATE		PROJECT		
Ariz		Buckhorn-Mesa WDP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RSM	11/29/76			

SUBJECT McDowell Rd

SHEET 42 OF 2

3

1,730.00
1,591.26
210.00
0.00000
-0.05500

1,785.00
1,590.86 A

1,835.00
1,589.82 A

1,885.00
1,588.11 A

1,940.00
1,585.49 A

4

1,940.00
1,585.49
230.00
-0.05500
0.00000

2,000.00
1,582.62 A

2,055.00
1,580.75 A

2,110.00
1,579.60 A

2,170.00
1,579.17 A

5

2,170.00
1,579.17
300.00
0.00000
0.05500

2,245.00
1,579.69 A

2,320.00
1,581.23 A

2,395.00
1,583.81 A

2,470.00
1,587.42 A

6

2,470.00
1,587.42
180.00
0.05500
0.02200

2,510.00
1,589.47 A

2,560.00
1,591.63 A

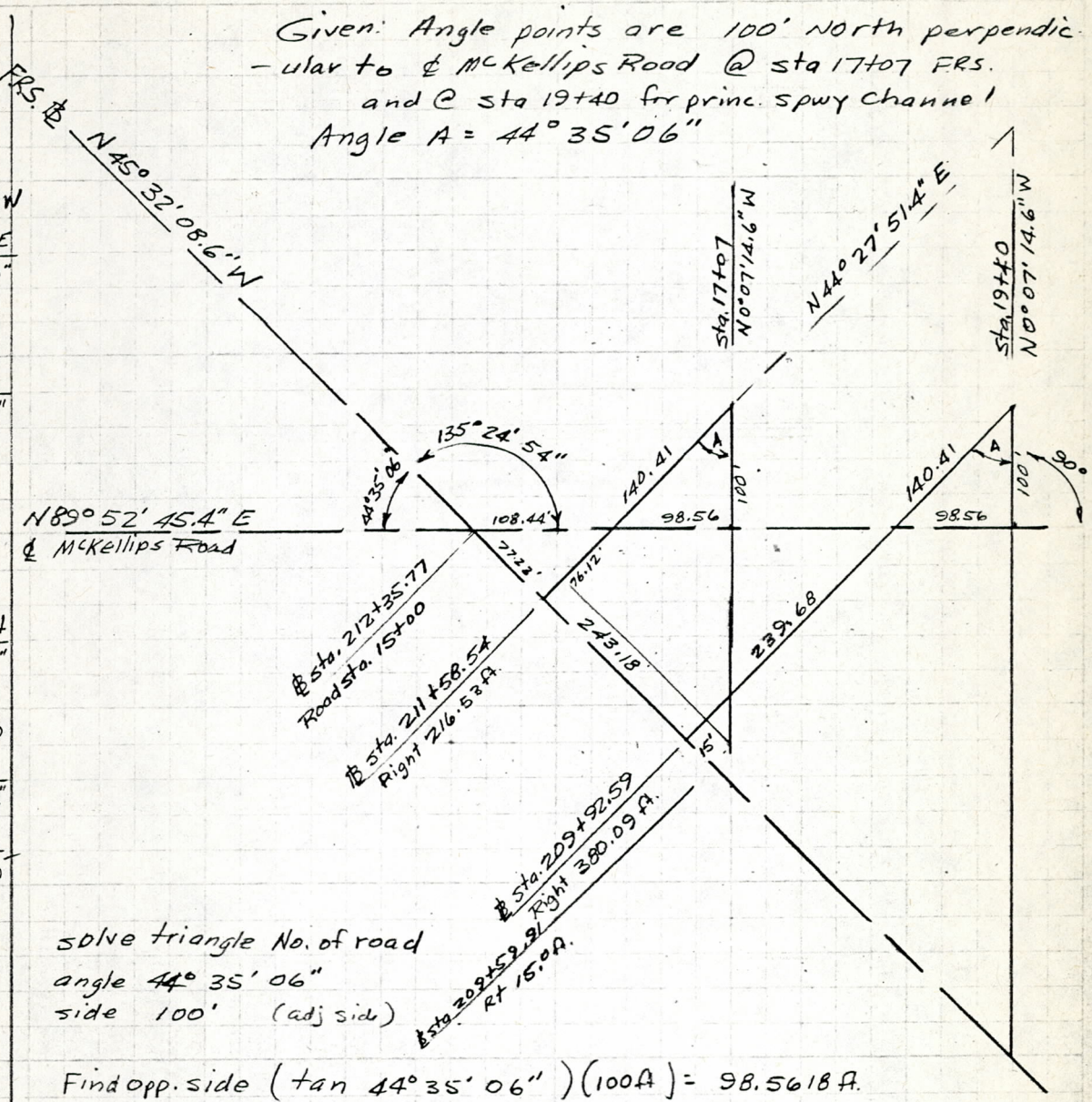
2,610.00
1,593.32 A

2,650.00
1,594.35 A

STATE		PROJECT		
Arizona		Buckhorn Mesa WRP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	17 Aug 76			2005
SUBJECT				SHEET 41 OF
McKellips Road Ramp Alignment of dom & princ. spwy. channel				

Given: Angle points are 100' North perpendicular to ℄ McKellips Road @ sta 17+07 FRS. and @ sta 19+40 for princ. spwy Channel

Angle A = 44° 35' 06"



N 45° 32' 0.86" W
+ N 89° 52' 45.4" E
135° 24' 54.0"

179 59 60
− 135 24 54
44° 35' 06"

89 59 60
89 52 45.4
0° 07' 14.6"

89 59 60.0
45 32 08.6
44° 27' 51.4"
+ 0° 07' 14.6
44° 35 06.0

solve triangle No. of road
angle 44° 35' 06"
side 100' (adj side)

Find opp. side $(\tan 44° 35' 06")(100 ft) = 98.5618$ ft.

Find hypot. $\dfrac{100}{\cos 44° 35' 06"} = 140.408$ ft.

Find sta. on ℄ and dist Rt. to angle point ℄ F.R.S. 100' No. Rd

solve triangle so. of road sta 17+07 − 15+00 = 207 ft.

207 ft − 98.5618 = 108.4382 ft. hypot. side

STATE. Arizona		PROJECT Buckhorn Mesa W.P.P. - Spook Hill F.R.S.		
BY J.E.B.	DATE 17 Aug 76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Mc Kellips Road Ramp Alignment of dam & princ. spwy. Channel				SHEET 42 OF

Find opp. side (sin 44° 35' 06")(108.4382) = 76.12 ft.

Find adj. side (Cos 44° 35' 06")(108.4382) = 77.2308 ft.

Sta. on ℄ = 212+35.77 − 77.23 = Sta. 211+58.54

Dist. Right 76.12 + 140.41 = 216.53 ft.

Sta. 211+58.54 rt. 216.53 ft.

Find sta. on ℄ and dist rt. to angle point ℄ Channel 100' No.

Solve triangle so. of road sta. 19+40 − 15+00 = 440 ft.

440 ft. − 98.5618 = 341.4382 ft. hypot. side

Find opp. side (Sin 44° 35' 06")(341.4382) = 239.6782 ft.

Find adj side (Cos 44° 35' 06")(341.4382) = 243.1756 ft.

Sta. on ℄ = 212+35.77 − 243.18 = 209+92.59

Dist Right = 239.68' + 140.41' = 380.09 ft.

Sta. 209+92.59 rt. 380.09 ft.

Find angle point perpendicular to ℄ road and 15' perpendicular from ℄ to locate ℄ F.R.S.

Dist. Right 216.53 ft − 15 ft. offset = 201.53 ft.

adj. side = 201.53 ft, angle 44° 35' 06"

find opp. side (201.53 ft.)(tan 44° 35' 06") = 198.63 ft.

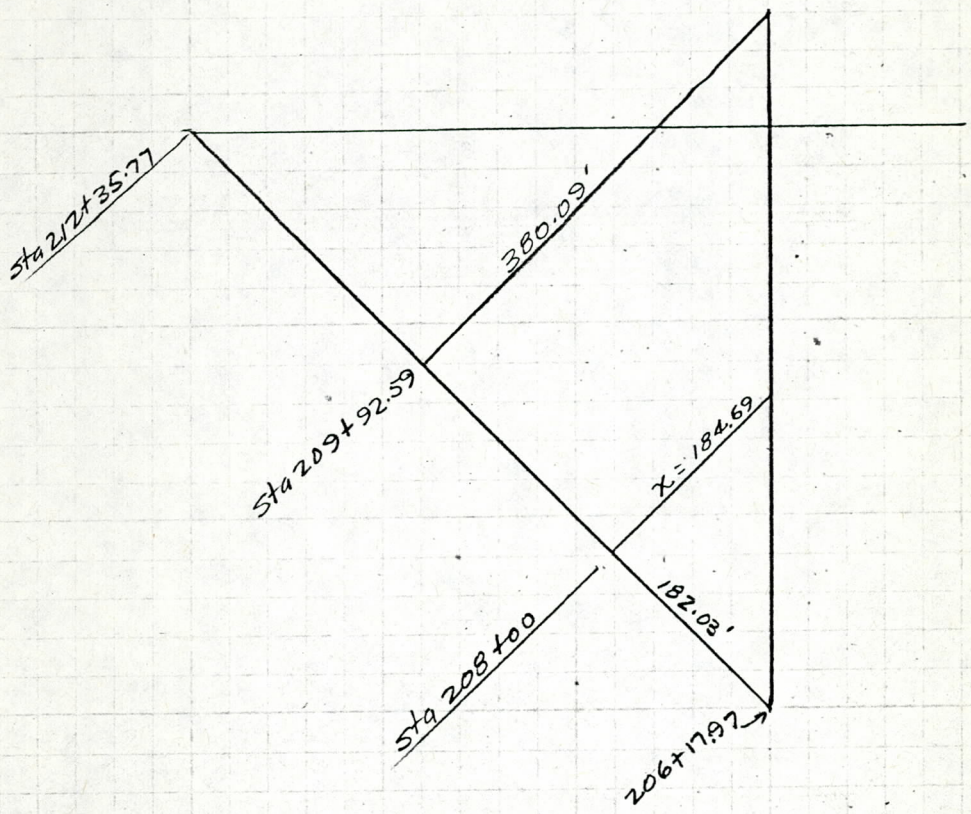
Sta. 211+58.54 − 198.63 = 209+59.91

Sta. 209+59.91 15 ft. Right to angle pt. ℄ F.R.S.

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	17 Aug 76			2005
SUBJECT				SHEET 3 OF
McKellips Road Ramp Alignment of dam and Princ. Spwy channel				

Find angle point perpendicular to ℄ road and perpendicular to sta. 208+00 ℄, Compute dist. Right of ℄

Find sta. on ℄ that line perpendicular to ℄ road intersects ℄



adj. side 380.09', angle 44°35'06"

find opp side, (380.09)(tan) = 374.62 ft

sta. at intersection 209+92.59 - 374.62 = 206+17.97

opp. side triangle formed from sta 208+00 to 206+17.97

20800 - 20617.97 = 182.03 ft

find adj. side $\frac{182.03}{\tan}$ = 184.69 ft.

sta 208+00 184.69 ft. Right

STATE		PROJECT		
Arizona		Buckhorn Mesa WRP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	15 Aug 76			2005

SUBJECT: McDowell Road Ramp Alignment of damand Prin. Spwy channel — SHEET 45 OF

McDowell perp.

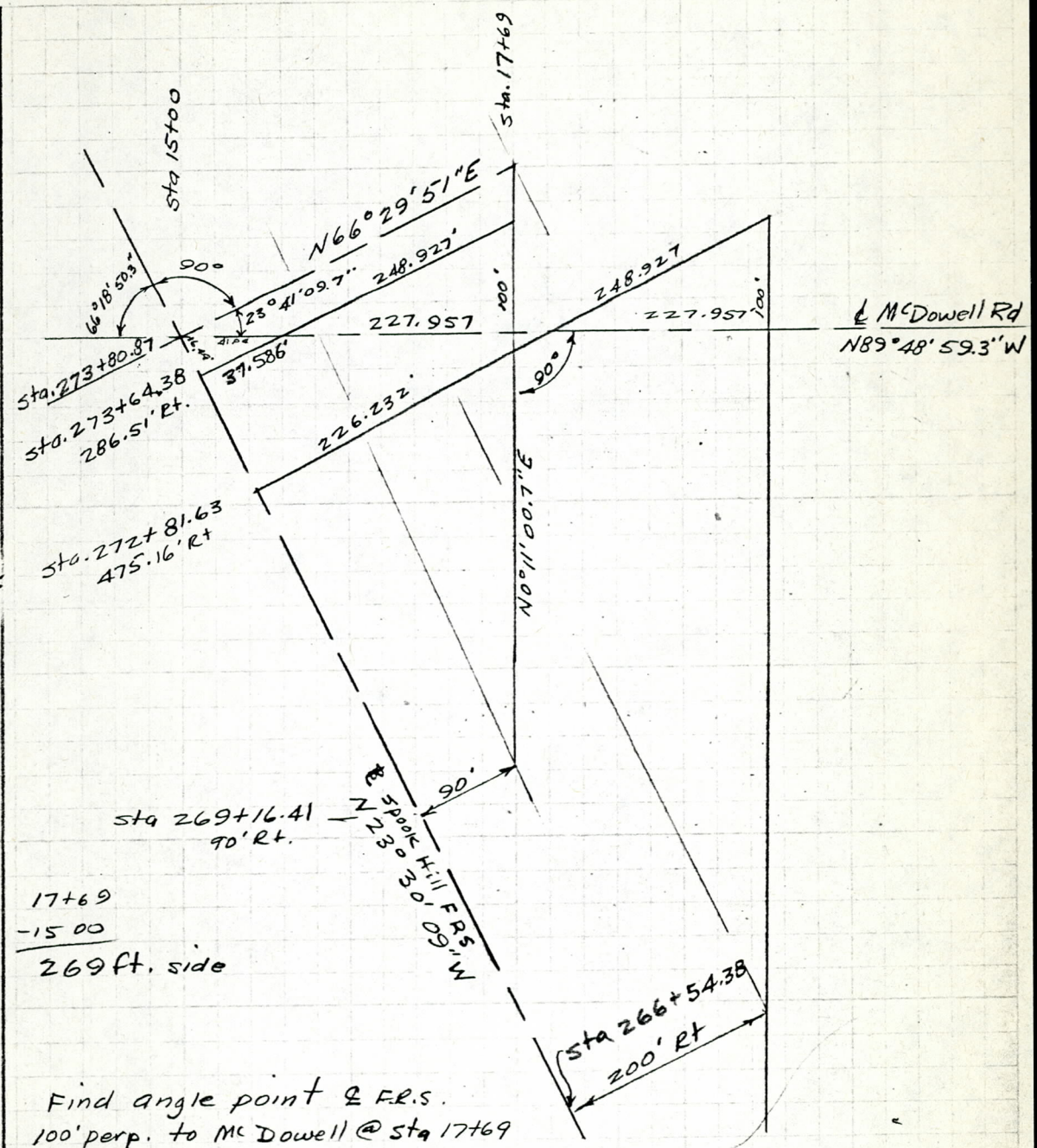
89 59 60
89 48 59.3
0° 11' 00.7"

℄ perpendic.

89 59 60
23 30 09
66 29 51

66 29 51
- 0 11 00.7
66° 18' 50.3"

89 59 60
66 18 50.3
23° 41' 09.7"



17+69
-15 00
269 ft. side

Find angle point ℄ F.R.S.
100' perp. to Mc Dowell @ sta 17+69

Solve triangle, 23° 41' 09.7" angle
adj. side 269 ft.

find opp. side $(\tan 23° 41' 09.7")(269 \text{ ft}) = 118.005$ ft.

118.005 ft - 100 ft = 18.005 ft.

Hypot. side $\dfrac{118.005}{\sin 23° 41' 09.7"} = 293.745$ ft.

STATE. Arizona		PROJECT Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY J.E.B.	DATE 16 Aug 76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Mc Dowell Road Ramp Alignment of dam and Prin. Spwy Channel				SHEET 45 OF

Solve similar triangle with opp. side of 100 ft.

$\frac{100 \text{ ft.}}{\sin 23°41'09.7''} = 248.927 \text{ ft. hypot.}$

$\frac{100 \text{ ft.}}{\tan 23°41'09.7''} = 227.957 \text{ ft. adj. (℄ Road)}$

$269 - 227.957 = 41.043 \text{ ft.}$

Solve triangle with hypot. 41.043 ft

$(\sin 23°41'09.7'')(41.043) = 16.488 \text{ ft}$

$(\cos 23°41'09.7'')(41.043) = 37.586 \text{ ft.}$

$16.488^2 + 37.586^2 = 1684.527 \quad \sqrt{1684.5} = 41.043$

$248.927 + 37.586 = 286.513 \text{ ft.}$

$(\tan 23°41'09.7'')(16.488) = 7.233 \text{ ft}$

$286.513 + 7.233 = 293.746 = 293.745$

Find ℄ sta., sta $273+80.87 - 16.49 = 273+64.38$

sta. 273+64.38 286.51 ft. Rt. Angle point ℄ F.R.S.

Find Channel Angle point 100 ft. perpendicular to ℄ Mc Dowell Road at sta 19+75

Given angle 23°41'09.7"
Find adj. side 1975 - 1500 = 475 ft.

solve for opp. side $(\tan 23°41'09.7'')(475') = 208.372'$

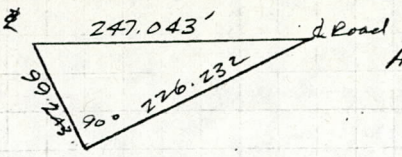
solve for hypot. $\frac{208.372}{\sin 23°41'09.7''} = 518.695 \text{ ft}$

use F.R.S. comp for triangle 100' perpendicular to ℄ road

Find hypot. side remaining triangle $475' - 227.957 = 247.043$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	16 Aug 76			2005

SUBJECT: McDowell Road Ramp Alignment of dam and Rin. spwy channel — SHEET 46 OF



solve triangle Angle 23°41'09.7"

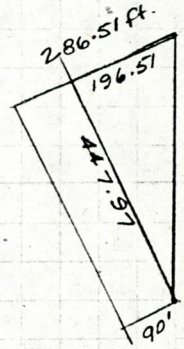
(sin. 23°41'09.7") (247.043') = 99.243

(cos. 23°41'09.7") (247.043') = 226.232

Find ℄ sta., sta. 273+80.87 - 99.243 = sta 272+81.627

sta. 272+81.63, 475.16 ft. Rt. Angle point princ. spwy. Chan.

Find Angle point for F.R.S. perpendicular to Road ℄ and 90 ft. perpendicular to ℄



Angle = 23°41'09.7"

Find opp side

286.513 - 90 = 196.513

Find adj. side

$$\frac{196.513}{\text{Tan } 23°41'09.7"} = 447.966 \text{ ft.}$$

sta. 27364.38 - 447.97 = 269+16.41

sta. 269+16.41 90 ft Rt.

Find Angle point for pr. spwy. channel perpendicular to ℄ Road and 200ft perpendicular from ℄

Find opp side 475.16' - 200 = 275.16 ft.

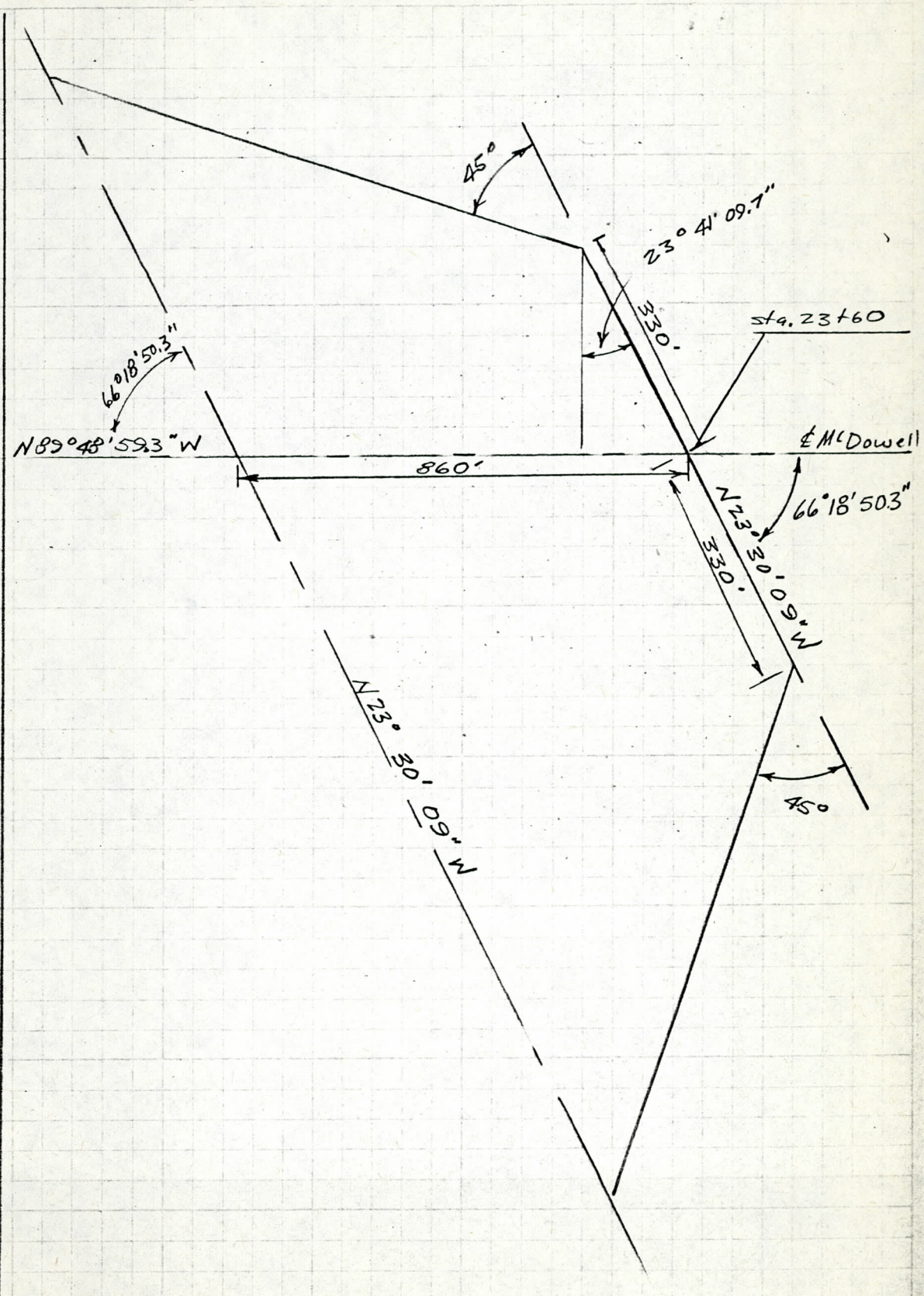
Find adj side

$$\frac{275.16}{\text{Tan } 23°41'09.7"} = 627.25'$$

272 81.63 - 627.25 = 266+54.38

sta. 266+54.38 200ft. Rt.

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	16 Aug 76			2005
SUBJECT				SHEET 47 OF
McDowell Road Ramp Alignment for excavation				

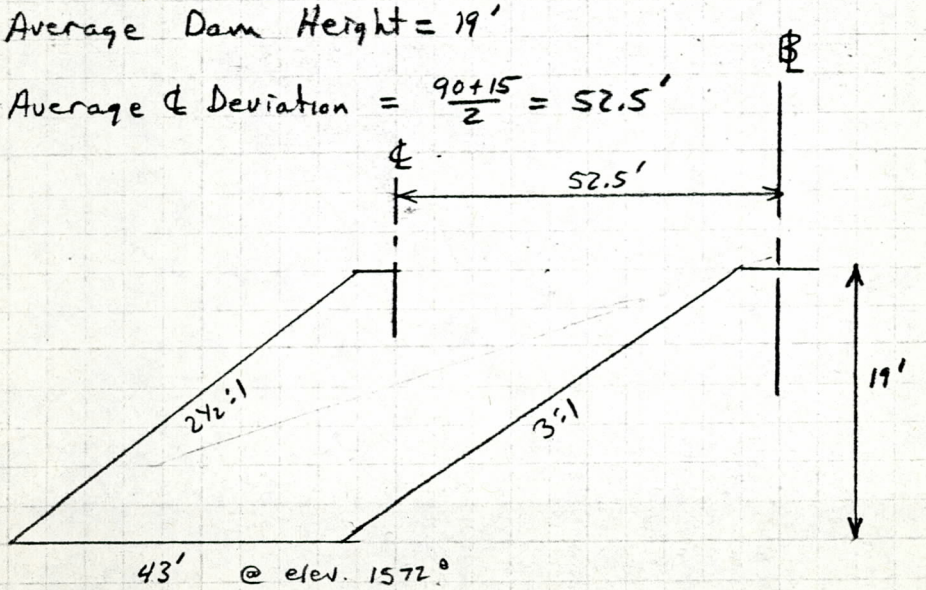


STATE ARIZONA		PROJECT BUCKHORN MESA WPP – SPOOK HILL FRS		
BY A.C.	DATE 4-15-76	CHECKED BY JCS	DATE 4-16-76	JOB NO.
SUBJECT Effect of Alignment on Reservior Storage				SHEET 49 OF

For landscaping purposes, it was requested that the dam meander and weave away from its straight alignment. It has been proposed that the centerline of the dam be offset from the base line (present centerline) distances of 15' and 90'. The dam is to weave away from the CAP canal to allow areas on natural vegetation. Here we are attempting to justify the use of the freeboard routing maximum water surface. Our final storage figures will include; the change in the alignment (Average offset 52.5'), the change in side slopes (2½:1), the low flow channel excavation, the excavation around the road ramps and a replanimeter of the reservior surface areas based on the old centerline with 3:1 side slopes.

Average Dam Height = 19'

Average ℄ Deviation = $\frac{90+15}{2} = 52.5'$



for El 1591

$$\Delta S = 19\left(\frac{52.5+43}{2}\right) L$$ where L = length of dam

STATE: Arizona | PROJECT: Buckhorn Mesa WPP - Spook Hill F.R.S.

BY: J.E.B. | DATE: 26 Apr 76 | CHECKED BY: | DATE: | JOB NO.: 2005

SUBJECT: F.R.S. Surface Area in Acres @ on ½ 3:1 Z Slope | SHEET 50 OF

Taken from 10 sheets of planimeter readings

Elev.	1567	1568	1570	1572	1574
sheet 1	–	–	–	0.51	1.64
2	–	–	–	0.00	0.52
3	–	–	0.00	1.13	4.60
4	–	–	0.00	0.84	4.14
5	–	–	0.00	0.25	3.57
6		0.00	0.00	0.50	4.58
7		0.00	0.45	3.75	10.11
8	0	0.25	1.50	4.60	10.52
9		0.00	0.00	0.00	1.00
10		0.00	0.10	1.28	5.50
Total Acres		0.25	2.05	12.86	46.18

Elev.	1576	1578	1580	1582	1584
sheet 1	3.99	6.39	8.25	12.96	17.02
2	4.70	10.73	16.24	21.34	26.40
3	8.72	12.46	16.18	19.92	23.12
4	8.33	12.31	16.45	20.62	24.91
5	7.90	12.10	16.08	20.68	24.50
6	10.57	16.53	23.35	30.50	37.07
7	15.54	21.10	26.84	32.86	38.47
8	17.44	24.65	31.23	38.14	45.09
9	6.33	11.75	16.92	22.25	27.50
10	11.83	18.63	25.77	33.25	41.25
Total Acres	95.35	146.65	197.31	252.52	305.33

Elev.	1586	1588	1590	1591	1592
sheet 1	21.53	26.22	31.22	33.77	36.32
2	31.83	37.05	42.90	45.23	47.55
3	26.84	29.70	33.14	34.56	35.97
4	28.97	32.75	36.65	38.72	40.79
5	28.70	32.40	36.00	38.06	40.12
6	43.36	49.69	55.54	59.02	62.50
7	43.83	49.51	55.18	57.99	60.70
8	51.56	58.02	64.20	67.49	70.78
9	32.63	37.29	43.75	46.56	49.37
10	48.46	56.35	64.12	68.27	72.42
Total Acres	357.71	408.98	462.70	489.67	516.52

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP – Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	3-May-76			2005

SUBJECT: F.R.S. storage in Ac.Ft. ℄ on ℄ with 3:1 Z slope — SHEET 52 OF

Taken from 10 sheets of planimeter readings

Elev.		1567	1568	1570	1572	1574
Sheet	1	–	–	–	0.26	2.41
	2				–	0.52
	3				1.13	6.86
	4				0.42	5.40
	5				0.25	4.07
	6				0.50	5.58
	7			0.45	4.65	18.51
	8		0.25	2.00	8.10	23.22
	9			–	–	0.50
	10			0.05	1.43	8.21
Total				2.50	16.74	75.28

Elev.		1576	1578	1580	1582	1584
Sheet	1	8.04	18.42	33.06	54.27	84.25
	2	5.74	21.17	48.14	85.72	133.46
	3	20.18	41.36	70.00	106.10	149.14
	4	17.87	38.51	67.27	104.34	149.87
	5	15.54	35.54	63.72	100.48	145.66
	6	20.73	47.83	87.71	141.56	209.13
	7	44.16	80.80	128.74	188.44	259.77
	8	51.18	93.27	149.15	218.52	301.75
	9	7.83	25.91	54.58	93.75	143.50
	10	25.54	56.00	100.40	159.42	233.92
Total		216.81	458.81	802.77	1252.60	1810.45

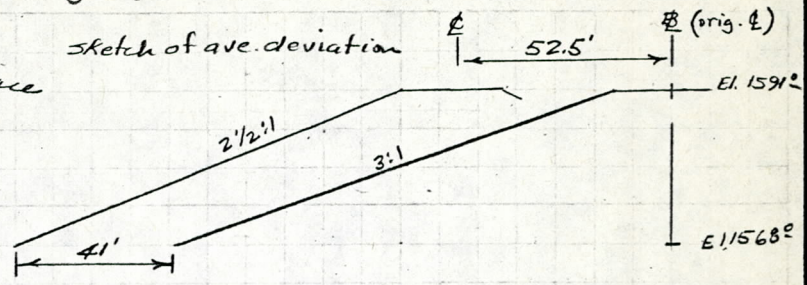
Elev.		1586	1588	1590	1591	1592
Sheet	1	122.80	170.55	227.99	260.49	
	2	191.69	260.57	340.52	384.59	
	3	199.10	255.64	318.48	386.18	
	4	203.75	265.47	334.87	372.56	
	5	198.86	259.96	328.36	365.39	
	6	289.56	382.61	487.84	545.12	
	7	342.07	435.41	540.10	596.69	
	8	398.40	507.98	630.20	696.05	
	9	203.63	273.55	354.59	399.75	
	10	323.63	428.44	548.91	615.11	
Total		2473.49	3240.18	4111.86	4621.93	

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J. E. B.	3-May 76			2005

SUBJECT: Surface Area correction for landscaping alignment of dam. SHEET 3 OF

Compute change in surface areas for ℄ realignment. lengths were taken from plan profile sheets.

Sketch of ave. deviation



Elev	original alignment surface Acres	− (ave width change)(length) / 43560 = − Acres	Revised Surf. Area
1568	0.25	(41')(170') / 43560 = − 0.16 Ac.	0.09 Ac
1570	2.05	(42')(1270') / 43560 = − 1.22 Ac.	0.83 Ac.
1572	12.86	(43')(6010') / 43560 = − 5.93 Ac	6.93 Ac
1574	46.18	(44')(15500) / 43560 = − 15.66 Ac.	30.52 Ac.
1576	95.35	(45')(18,200) / 43,560 = − 18.80 Ac	76.55 Ac.
1578	146.65	(46')(18460) / 43,560 = − 19.49 Ac.	127.16 Ac.
1580	197.31	(47')(18,560) / 43,560 = − 20.03 Ac.	177.28 Ac.
1582	252.52	(48')(18,680) / 43,560 = − 20.58 Ac	231.94 Ac.
1584	305.33	(49')(18,820) / 43,560' = − 21.17 Ac.	284.16 Ac.
1586	357.71	(50')(19,100) / 43.560 = − 21.92 Ac.	335.79 Ac.
1588	408.98	(51')(19,140) / 43,560 = − 22.41 Ac.	386.57 Ac.
1590	462.70	(52')(19270) / 43,560 = − 23.00 Ac.	439.70 Ac
1591	489.67	(52.5')(19300) / 43,560 = − 23.26 Ac.	466.41 Ac

Capacity computed on following page

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B	3-May-76			2005

SUBJECT: Ac. Ft. Storage correction for landscaping alignment — SHEET 1 OF

Elev	Revised surf. Area	Ac. Ft. storage (per contour)	cumulative Ac. Ft. storage
1568.0	0.09		
		0.92	
1570.0	0.83		0.92
		7.76	
1572.0	6.93		8.68
		37.45	
1574.0	30.52		46.13
		107.07	
1576.0	76.55		153.20
		203.71	
1578.0	127.16		356.91
		304.44	
1580.0	177.28		661.35
		409.22	
1582.0	231.94		1,070.57
		516.10	
1584.0	284.16		1,586.67
		619.95	
1586.0	335.79		2,206.62
		722.36	
1588.0	386.57		2,928.98
		826.27	
1590.0	439.70		3,755.25
		453.06	
1591.0	466.41		4,208.31

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	28-Apr-76			2005
SUBJECT				SHEET 54 OF
planimeter Comp. of cut at roadramps				

From Plan of McKellips Road, Planimeter the excavation areas. for additional storage

	Elev	sq. feet	surf. Acres	Ac. Ft.		
	1580.0	379,700	8.72			
				13.61		
	1582.0	213,200	4.89			13.61
				7.48		
	1584.0	112,800	2.59			21.09
				3.16		
	1586.0	25,000	0.57			24.25
				0.29		
	1587.0	0	0.00			24.54
				24.54	Total	

From plan of McDowell Road, Planimeter the excavation area for additional storage

approx.	1578.5	398,000	9.14			
				12.55		
	1580.0	330,500	7.59			12.55
				12.38		
	1582.0	208,700	4.79			24.93
				7.54		
	1584.0	119,800	2.75			32.47
				3.99		
	1586.0	54,200	1.24			36.46
				1.47		
	1588.0	10,000	0.23			37.93
				.12		
	1589.0	0	.00			38.05
				38.05	Total	

STATE		PROJECT		
ARIZONA		BUCKHORN MESA WPP SPOOK HILL F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	April 15, 1976	JEB	4-16-76	
SUBJECT				SHEET 65 OF 6
Quantities				

Channel Excavations - McKellips Road

(1050 x 350 x 7/2) ÷ 27 = 47,639 cu yds

(300 x 350 x 7/4) ÷ 27 = 6,806 cu. yds

Total Excavation 54,445 cu. yds

ROADWAY - McKellips Road

(500 x 100 x 2) ÷ 27 = 3704 cu yds

Total Storage 50741 cu yds (Above El 1580)

Channel Excavations - McDowell Road

(500 x 1300 x 8/2) ÷ 27 = 96,296 cu yds

(500 x 400 x 8/4) ÷ 27 = 14,814 cu yds

Total Excavation 111,110 cu yds (Above El 1579)

Roadway - McDowell Road

(600 x 150 x 3) ÷ 27 10,000 cu yds

Total Storage 101,110 cu yds

Storage for two channels = 151,851 cu yds

= 94.1 Ac ft

Exceeds planimeter by a considerable amount
JEB

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	3 May 76			2005
SUBJECT				SHEET 56 OF
Spook Hill F.R.S. storage capacity in Acre Ft.				

Elev.	Landscaping revised storage in. Ac. Feet	add principal spillway low Flow inlet Channel Ac. Ft of excavation	add McDowell and McKellips Road Ramp spillway Ac. Ft. excavation	Less Sediment storage Required	Total Available Storage in Acre Feet
1568	0.00	+ 63.5		- 271	- 207.5
1570	0.92	+ 63.5		- 271	- 206.58
1572	8.68	+ 63.5		- 271	- 198.82
1574	46.13	+ 63.5		- 271	- 161.37
1576	153.20	+ 63.5		- 271	- 54.30
1578	356.91	+ 63.5		- 271	149.41
1580	661.35	+ 63.5	+ 12.55	- 271	466.40
1582	1,070.57	+ 63.5	+ 38.54	- 271	901.61
1584	1,586.67	+ 63.5	+ 53.56	- 271	1432.73
1586	2,206.62	+ 63.5	+ 60.71	- 271	2059.83
1588	2,928.98	+ 63.5	+ 62.47	- 271	2783.95
1590	3,755.25	+ 63.5	+ 62.59	- 271	3610.34
1591	4,208.31	+ 63.5	+ 62.59	- 271	4063.40

Total storage of 4,063 Ac.Ft = 4054 Ac.Ft. on original Storage computations.

Therefore we can assume the Elevations from the Freeboard Routing for the previous storage curve will be acceptable for this storage curve.

STATE		PROJECT		
Arizona		Buckhorn Meso WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	31 Mar 76	A.C.	4-16-76	2005
SUBJECT				SHEET 527 OF
Quantities				

1. Core trench and Foundation excavation to be used in embankment fill - This will cancel additional cu.yds from outside source as fill

2. Embankment 14' Top W. ⧖ 2½:1 each side

969,000 cu.yds Fill

3. Blanket of granite 1ft. thick over embankment surface

82,000 cuyds Fill

Principal Spillway inlet channel excavation

102,500 cu.yds. = (63.53 Ac-ft)

Floodway channel excavation

403,000 cu.yds.

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. - Spook Hill F.R.S.		
BY J.E.B.	DATE 6 April 76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Planimeter Contours to Compute Capacity of dam				SHEET 58 OF 10

Compute Area from Sta. 87+00 to 107+50 on original ℄ with 14' top W. and 3:1 up ⇄ slope

Elev.	Surface Acre	Storage Ac. Ft.	Cumulative Ac. Ft.
1571	0.0		
		0.26	0.26
1572	0.51		
		2.15	2.41
1574	1.64		
		5.63	8.04
1576	3.99		
		10.38	18.42
1578	6.39		
		14.64	33.06
1580	8.25		
		21.21	54.27
1582	12.96		
		29.98	84.25
1584	17.02		
		38.55	122.80
1586	21.53		
		47.75	170.55
1588	26.22		
		57.44	227.99
1590	31.22		
		32.50	260.49
1591	33.77		
1592	36.32		

*1591 Area is considered to be ave of 1590 and 1592 areas —

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP-Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	6Apr 76			2005
SUBJECT				SHEET 59 OF 10
Planimeter Comp. for capacity of dam				

Compute Area from Sta 107+50 to 130+00

Elev.	Surface Area in Acres	Storage in Acre Feet	Cumulative Acre Feet
1572	0.0		
		0.52	
1574	0.52		0.52
		5.22	
1576	4.70		5.74
		15.43	
1578	10.73		21.17
		26.97	
1580	16.24		48.14
		37.58	
1582	21.34		85.72
		47.74	
1584	26.40		133.46
		58.23	
1586	31.83		191.69
		68.88	
1588	37.05		260.57
		79.95	
1590	42.90		340.52
		44.07	
1591	45.23		384.59
1592	47.55		

* 1591 Area ave of 1590 + 1592 areas

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP. - Spook Hill F.R.S		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	6 Apr 76			2005
SUBJECT				SHEET 60 OF 70
Planimeter computation for capacity of dam				

Compute Area from sta 130+00 to 145+00

Elev.	surface Area in Acres	storage in Ac. Feet	Cumulative Acre Feet
1570	0.00		
		1.13	
1572	1.13		1.13
		5.73	
1574	4.60		6.86
		13.32	
1576	8.72		20.18
		21.18	
1578	12.46		41.36
		28.64	
1580	16.18		70.00
		36.10	
1582	19.92		106.10
		43.04	
1584	23.12		149.14
		49.96	
1586	26.84		199.10
		56.54	
1588	29.70		255.64
		62.84	
1590	33.14		318.48
		67.70	
1591	34.56		386.18
1592	35.97		

* 1591 Area is ave of 1590 and 1592 areas

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. - Spook Hill F.R.S.		
BY J.E.B.	DATE 6 Apr 76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Planimeter Computation for Capacity of dam				SHEET 61 OF

Compute Areas from sta. 145+00 to 160+00

Elev.	Surface Area in Acres	Storage in Ac. Ft.	Cumulative Acre Feet
1571	0		
		0.42	
1572	0.84		0.42
		4.98	
1574	4.14		5.40
		12.47	
1576	8.33		17.87
		20.64	
1578	12.31		38.51
		28.76	
1580	16.45		67.27
		37.07	
1582	20.62		104.34
		45.53	
1584	24.91		149.87
		53.88	
1586	28.97		203.75
		61.72	
1588	32.75		265.47
		69.40	
1590	36.65		334.87
		37.69	
1591	38.72		372.56
1592	40.79		

* 1591 Area is ave. of 1590 & 1592 Areas

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	6 Apr 76			2005
SUBJECT				SHEET 63 OF 10
Planimeter Computation for Capacity of dam				

Compute Areas from Sta 160+00 to 175+00

Elev.	surface Acres	storage Acre feet	cumulative Acre Ft. Storage
1570	0		
		0.25	
1572	0.25		0.25
		3.82	
1574	3.57		4.07
		11.47	
1576	7.90		15.54
		20.00	
1578	12.10		35.54
		28.18	
1580	16.08		63.72
		36.76	
1582	20.68		100.48
		45.18	
1584	24.50		145.66
		53.20	
1586	28.70		198.86
		61.10	
1588	32.40		259.96
		68.40	
1590	36.00		328.36
		37.03	
1591	38.06		365.39
1592	40.12		

* Ave of 1590 and 1592 is use for 1591 Area

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY J.E.B.	DATE 20 Apr 76	CHECKED BY	DATE	JOB NO. 2005

SUBJECT Planimeter Computation for Capacity of dam — SHEET 63 OF 10

Compute Areas from sta 175+00 to 199+50

Elev.	surface Acres	storage in Ac. Ft.	cumulative storage in A.C. Ft.
1570.0	0		
		0.50	
1572	0.50		0.50
		5.08	
1574	4.58		5.58
		15.15	
1576	10.57		20.73
		27.10	
1578	16.53		47.83
		39.88	
1580	23.35		87.71
		53.85	
1582	30.50		141.56
		67.57	
1584	37.07		209.13
		80.43	
1586	43.36		289.56
		93.05	
1588	49.69		382.61
		105.23	
1590	55.54		487.84
		57.28	
* 1591 *	59.02		545.12
1592	62.50		

* 1591.0 Area is the Ave of 1590 and 1592 Areas

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	20 Apr. 76			2005

SUBJECT: Planimeter computation for capacity of dam — SHEET 64 OF 10

Compute Areas from Sta. 199+50 to 220+00

Elev.	Surface Acres	Storage in Ac. Ft.	Cumulative Storage in Acre Feet
1568.0	0.00		
		0.45	
1570.0	0.45		0.45
		4.20	
1572.0	3.75		4.65
		13.86	
1574.0	10.11		18.51
		25.65	
1576.0	15.54		44.16
		36.64	
1578.0	21.10		80.80
		47.94	
1580.0	26.84		128.74
		59.70	
1582.0	32.86		188.44
		71.33	
1584.0	38.47		259.77
		82.30	
1586.0	43.83		342.07
		93.34	
1588.0	49.51		435.41
		104.69	
1590.0	55.18		540.10
		56.59	
1591.0	57.99		596.69
1592.0	60.70		

* 1591.0 Area is the Ave. of 1590 and 1592 Areas.

STATE Arizona | PROJECT Buckhorn Mesa WPP-Spook Hill FRS

BY J.E.B. | DATE 20 Apr. 76 | CHECKED BY | DATE | JOB NO. 2005

SUBJECT Planimeter computation for capacity of dam | SHEET 6F OF 10

Compute Areas from Sta. 220+00 to 245+00

Elev.	Surface Acres	Storage in Ac. Ft.	Cumulative storage in Acre Feet
1567.0	0		
		0.25	
1568.0	0.25		0.25
		1.75	
1570.0	1.50		2.00
		6.10	
1572.	4.60		8.10
		15.12	
1574	10.52		23.22
		27.96	
1576	17.44		51.18
		42.09	
1578	24.65		93.27
		55.88	
1580	31.23		149.15
		69.37	
1582	38.14		218.52
		83.23	
1584	45.09		301.75
		96.65	
1586	51.56		398.40
		109.58	
1588	58.02		507.98
		122.22	
1590	64.20		630.20
		65.85	
1591	67.49		696.05
1592	70.78		

* Ave of 1590 and 1592 area used for 1591 area.

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY J.E.B.	DATE 20 Apr 76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Planimeter computation for capacity of dam				SHEET 66 OF 10

Compute Areas from sta 245+00 to 265+00

Elev.	surface Acres	storage in Acre Feet	cumulative storage in Acre Feet
1572	0.0		
		0.50	
1574	1.00		0.50
		7.33	
1576	6.33		7.83
		18.08	
1578	11.75		25.91
		28.67	
1580	16.92		54.58
		39.17	
1582	22.25		93.75
		49.75	
1584	27.50		143.50
		60.13	
1586	32.63		203.63
		69.92	
1588	37.29		273.55
		81.04	
1590	43.75		354.59
		45.16	
1591	46.56*		399.75
1592	49.37		

* Area of 1591 is the ave of 1590 and 1592 Areas

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	20 Apr 76			2005

SUBJECT: Planimeter Computation for Capacity of dam — SHEET 67 OF

Compute Areas from Sta 265+00 to 303+75±

Elev.	surface in Acres	storage in Ac. Ft.	cumulative storage in Acre Feet
1569.0	0		
		0.05	
1570	0.10		0.05
		1.38	
1572	1.28		1.43
		6.78	
1574	5.50		8.21
		17.33	
1576	11.83		25.54
		30.46	
1578	18.63		56.00
		44.40	
1580	25.77		100.40
		59.02	
1582	33.25		159.42
		74.50	
1584	41.25		233.92
		89.71	
1586	48.46		323.63
		104.81	
1588	56.35		428.44
		120.47	
1590	64.12		548.91
		66.20	
1591*	68.27		615.11
1592	72.42		

* Area at 1591 is the ave. area of 1590 and 1592 areas.

STATE		PROJECT		
AZ		BUCKHORN MESA WPP SPOOK HILL F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	4-5-76			

SUBJECT Surface Area - Planimeter Check (Sheet 5) SHEET 68 OF

Station 175+00 to 220+00

ELEV (ft)	S.A. 175 to 199 (Ac)	S.A. 199 to 220 (Ac)	Total S.A. (Ac)	Storage (Ac ft)	Cummulative Storage (Ac-ft)	
1592	62.1	60.1	122.2	233.0	1274.7	
1591			116.5	116.5	1158.2	= 1141.81 Fair check
1590	55.6	55.2	110.8 (113.6)	210.3	1041.7	
1588	49.9	49.6	99.5	187.1	831.4	
1586	43.5	44.1	87.6	163.2	644.3	
1584	37.0	38.6	75.6	139.5	481.1	
1582	30.7	33.2	63.9	115.1	341.6	
1580	23.8	27.4	51.2	90.2	226.5	
1578	17.2	21.8	39.0	65.8	136.3	
1576	10.7	16.1	26.8	43.3	70.5	
1574	5.8	10.7	16.5	21.4	27.2	
1572	0.4	4.5	4.9	5.5	5.8	
1570	0.0	0.6	0.6	0.3	0.3	

STATE		PROJECT		
Az		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	4-5-76			
SUBJECT Surface Area - Planimeter Check (Sheet 6)				SHEET 69 OF

Station 220+00 to 265+00

ELEV (ft)	S.A. 220 to 245+50	S.A. 245+50 to 265	Total S.A.	Total Storage	Cummulative Storage	
1592	69.6	48.8	118.4	225.8	1216.4	check
1591			112.9	1129	1103.5	= 1095.8
1590	63.8	43.6	107.4 (110.8)	202.4	990.6	
1588	57.8	37.2	95.0	178.7	788.2	
1586	51.2	32.5	83.7	156.3	609.5	
1584	45.0	27.6	72.6	133.4	453.2	
1582	38.2	22.6	60.8	109.4	319.8	
1580	31.5	17.1	48.6	85.6	210.4	
1578	24.7	12.3	37.0	61.9	124.8	
1576	18.0	6.9	24.9	37.6	62.9	
1574	11.1	1.6	12.7	17.8	25.3	
1572	5.0	0.1	5.1	6.7	7.5	
1570	1.6	0.0	1.6	0.8	0.8	

STATE Az		PROJECT Buckhorn Mesa WPP Spook Hill FRS		
BY A. C.	DATE 4-5-76	CHECKED BY	DATE	JOB NO.
SUBJECT Surface Area Planimeter Check -(Sheet 7)				SHEET 70 OF

STATION 265+00 to 303+75

ELEV (ft)	Surface Area (Ac)	Storage (Ac-ft)	Cummulative Storage Ac-ft	
1592	72.2	137.0	695.2	
1591	68.5	68.5	626.7	= 615.11
1590	64.8 (67.6)	121.5	558.2	
1588	56.7	105.7	436.7	
1586	49.0	90.7	331.0	
1584	41.7	75.5	240.3	
1582	33.8	60.3	164.8	
1580	26.5	45.9	104.5	
1578	19.4	31.7	58.6	
1576	12.3	18.3	26.9	
1574	6.0	7.2	8.6	
1572	1.2	1.3	1.4	
1570	0.1	0.1	0.1	

check computations by Burgin seem to be consistantly lower since the computation by Burgin corresponds with original curve we will use these figures for the revised curve

SUMMARY - RESERVOIR ROUTING PROGRAM

SPOOK HILL F.R.S.
BUCKHORN MESA W.P.P. STRUCTURE CLASS C 08-13-75

TYPE	BO	L	ELEV.	HP	STORAGE	Q-TOTAL	Q-EM.SP	V/C	D/C	S/C	S/C.25 DJR-HR	DE/B
ESH	220.	0.	1584.83	2.83	1627.0	4203.5	3378.5	7.88	1.93	1.87	2.54*********	0.00
	240.	0.	1584.73	2.73	1602.0	4334.9	3509.9	7.75	1.87	1.89	2.57*********	0.00
	260.	0.	1584.65	2.65	1580.1	4461.0	3636.0	7.64	1.81	1.90	2.59*********	0.00
FBH	220.	0.	1590.14	8.14	3671.2	16997.3	16172.3	13.21	5.42	1.32	1.80*********	0.00
	240.	0.	1589.91	7.91	3570.5	17692.1	16867.1	13.02	5.27	1.33	1.82*********	0.00
	260.	0.	1589.69	7.69	3482.6	18338.3	17513.3	12.85	5.13	1.35	1.83*********	0.00

NOTE - IN ABOVE SUMMARY VC, DC, AND SC WERE COMPUTED FROM (Q-EM.SP) PER FOOT USING FORMULAS IN T.R.-2 AND T.R.-39.

TITLE1 SPOOK HILL F.R.S.

TITLE2 BUCKHORN MESA W.P.P. STRUCTURE CLASS C 08-13-75

	CN	Tc	hr Storm	Emi, Spillway Areal Rainfall	Freeboard	Drainage Area
HYDRO	79.	1.18	6.	5.66	13.	13.56
	Crest el	Case No	Full Print	rain table		
SPILLWAY	1582.	0.	0.	1.		
	Bo1	L1	Bo2	L2	Bo3	L3
SPW.SIZE	220.		240.		260.	
	elev	Storage AF	Q for Bo1	Bo2	Bo3	
STAGE-CFS	1577.5	238.4	0.	0.	0.	
STAGE-CFS	1579.01	238.5	240.	240.	240.	
STAGE-CFS	1580.	408.9	515.	515.	515.	
STAGE-CFS	1581.	632.6	780.	780.	780.	
STAGE-CFS	1582.	856.3	825.	825.	825.	
STAGE-CFS	1582.5	992.9	1086.1	1108.	1130.	
STAGE-CFS	1583.	1129.5	1547.	1609.	1671.	
STAGE-CFS	1583.5	1223.	2137.9	2251.8	2365.7	
STAGE-CFS	1584.	1402.7	2834.	3009.3	3184.7	
STAGE-CFS	1585.	1673.	4483.8	4805.9	5128.1	
STAGE-CFS	1586.	2045.1	6434.	6930.	7426.	
STAGE-CFS	1587.	2404.	8637.	9330.2	10023.	
STAGE-CFS	1588.	2779.	11069.3	11980.5	12891.7	
STAGE-CFS	1589.	3204.	13710.8	14859.1	16007.3	
STAGE-CFS	1590.	3604.	16545.9	17948.8	19351.7	
STAGE-CFS	1591.	4054.	19560.	21234.	22908.	

END TABLE

SPOOK HILL F.R.S.

BUCKHORN MESA W.P.P. STRUCTURE CLASS C 08-13-75

EMER. SPW. UNCONTROLLED AREA HYDROGRAPH.

RUNOFF = 3.37 IN., VOL. = 2442. AC.FT.

TIME	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75
0.00	0.00	0.00	0.00	0.00	0.00	2.74	35.95	176.88
2.00	595.31	1921.44	4938.35	8893.89	11697.28	12014.54	10705.89	9231.26
4.00	7994.67	6963.65	6119.10	5485.08	4988.28	4562.82	4201.27	3848.31
6.00	3525.59	3240.82	2792.44	2103.20	1415.27	897.42	565.25	357.42
8.00	221.99	135.89	80.57	47.48	26.89	13.83	5.10	0.90
10.00	0.00							

SPOOK HILL F.R.S. PAGE NO. 5
BUCKHORN MESA W.P.P. STRUCTURE CLASS C 08-13-75

EMER.SPW. ROUTING BOTTOM WIDTH= 260.0 ENTRANCE LENGTH= 0.0

TIME	INFLOW	AVE INFLOW	OUTFLOW	STORAGE	ELEVATION
0.25	0.00	0.00	0.00	238.40	1577.50
0.50	0.00	0.00	0.00	238.40	1577.50
0.75	0.00	0.00	0.00	238.40	1577.50
1.00	0.00	0.00	0.00	238.40	1577.50
1.25	2.74	1.37	2.64	238.40	1577.51
1.50	35.95	19.35	34.76	238.41	1577.71
1.75	176.88	106.42	172.51	238.47	1578.58
2.00	595.31	386.09	245.85	242.12	1579.03
2.25	1921.44	1258.38	279.06	262.70	1579.15
2.50	4938.35	3429.89	382.40	326.73	1579.52
2.75	8893.89	6916.12	575.22	459.72	1580.22
3.00	11697.28	10295.59	785.19	658.38	1581.11
3.25	12014.54	11855.91	891.40	886.00	1582.10
3.50	10705.89	11360.21	1537.01	1095.62	1582.87
3.75	9231.26	9968.57	2532.46	1259.53	1583.60
4.00	7994.67	8612.96	3079.29	1379.50	1583.93
4.25	6963.65	7479.16	3631.03	1464.70	1584.22
4.50	6119.10	6541.37	4033.47	1520.67	1584.43
4.75	5485.08	5802.09	4278.03	1554.69	1584.56
5.00	4988.28	5236.68	4410.59	1573.12	1584.63
5.25	4562.82	4775.55	4461.05	1580.14	1584.65
5.50	4201.27	4382.05	4450.12	1578.62	1584.65

PEAK → USE

VOLUME CHECK AT HP= 0.06. COMPUTED HP= 2.65 AT ELEV.1584.65 (STORAGE IS 1580.1 AC.FT.= 2.18 IN.)
TIME= 5.25 HOURS CRITICAL VELOCITY= 7.64 CRITICAL DEPTH= 1.81 CRITICAL SLOPE= 1.90.
EXIT CHANNEL VELOCITY = 32.52

SPOOK HILL F.R.S. PAGE NO. 6
BUCKHORN MESA W.P.P. STRUCTURE CLASS C 08-13-75

FREEBOARD UNCONTROLLED AREA HYDROGRAPH.

RUNOFF =10.27 IN., VOL. = 7432. AC.FT.

TIME	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75
0.00	0.00	0.00	0.00	10.84	94.10	485.01	1393.67	2884.80
2.00	5232.43	10269.74	19926.11	31262.30	38045.78	37210.87	32052.72	26866.91
4.00	22685.90	19328.90	16690.30	14728.13	13214.93	11955.02	10909.87	9916.94
6.00	9026.41	8257.56	7095.91	5337.80	3589.77	2275.49	1432.75	905.66
8.00	562.28	344.02	203.88	120.07	67.95	34.94	12.87	2.27
10.00	0.00							

SPOOK HILL F.R.S.
BUCKHORN MESA W.P.P. STRUCTURE CLASS C 08-13-75

FREEBOARD ROUTING BOTTOM WIDTH= 260.0 ENTRANCE LENGTH= 0.0

TIME	INFLOW	AVE INFLOW	OUTFLOW	STORAGE	ELEVATION
0.25	0.00	0.00	0.00	238.40	1577.50
0.50	0.00	0.00	0.00	238.40	1577.50
0.75	10.84	5.42	10.42	238.40	1577.56
1.00	94.10	52.47	91.26	238.43	1578.07
1.25	485.01	289.56	243.96	240.95	1579.02
1.50	1393.67	939.34	266.77	255.08	1579.10
1.75	2884.80	2139.24	328.18	293.13	1579.32
2.00	5232.43	4058.61	450.53	368.94	1579.76
2.25	10269.74	7751.08	643.99	517.77	1580.48
2.50	19926.11	15097.92	816.62	814.61	1581.81
2.75	31262.30	25594.20	2746.88	1306.57	1583.73
3.00	38045.78	34654.04	6685.48	1925.09	1585.67
3.25	37210.87	37628.32	10916.45	2520.66	1587.31
3.50	32052.72	34631.79	14332.16	2975.34	1588.46
3.75	26866.91	29459.81	16520.97	3265.26	1589.15
4.00	22685.90	24776.40	17833.69	3422.26	1589.54
4.25	19328.90	21007.40	18338.35	3482.61	1589.69
4.50	16690.30	18009.60	18286.07	3476.36	1589.68

PEAK → USE

VOLUME CHECK AT HP= 0.29. COMPUTED HP= 7.69 AT ELEV.1589.69 (STORAGE IS 3482.6 AC.FT.= 4.81 IN.)
TIME= 4.25 HOURS CRITICAL VELOCITY= 12.85 CRITICAL DEPTH= 5.13 CRITICAL SLOPE= 1.35.
EXIT CHANNEL VELOCITY = 60.69

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.				
SUBJECT				SHEET ____ OF ____
Road Ramp Hydrology				

Design criteria was requested from the flood control district of Maricopa County for the design of a road ramp at McDowell Road over structure #3 of the Buckeye Watershed. Robin McCarthur developed a method for determining the road elevation and it's effect on the dam safety. We feel that it is acceptable for that situation. We tried to apply it to the multi-reservior system of the Spook Hill F.R.S. The following is an attempt to evaluate this proceedure

PROPOSED McDOWELL ROAD CROSSING OVER STRUCTURE #3, BUCKEYE WATERSHED

HYDROLOGIC STUDIES

A. To Determine the Minimum Elevation of the Top of the Road Crossing Within the Reservoir.

1. Determine the drainage area contributing to the reservoir (a) between the proposed road location and the principal spillway and (b) between the proposed road location and the emergency spillway.

2. Develop elevation-storage relationships for the reservoir area for the two ponded areas separated by the proposed road crossing. Extend top of dam 2 feet to ensure adequate data for flood routing

3. Develop principal spillway hydrographs (PSH) for the two drainage areas determined under item 1. above using SCS, NEH sec. 4 Chap 21. Use all applicable input data originally developed for the PSH in sizing the storage capacity. Use the 1-day and 10-day for rainfall values for the desired frequency (10 percent chance).

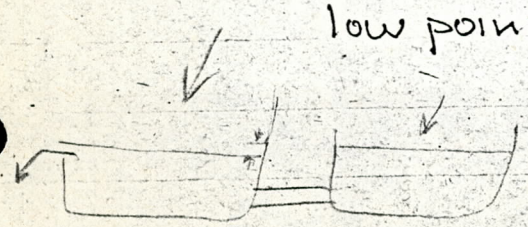
4. Flood route the PSH developed for the drainage area between the proposed road

and the principal spillway using the elevation-discharge relationship for the existing principal spillway and the elevation-storage relationship determined in item 2. Use the Storage-Indication Method SCS, NEH Sec. 4, Chap. 17.

5. Use the maximum water surface elevation attained from routing under 4. as the tailwater conditions for the proposed culvert or bridge structure in the road crossing. Develop elevation-discharge relationship(s) for the proposed culvert or bridge (alternatives)

6. Flood route the PSH developed for the area between the proposed road crossing and the emergency spillway using the elevation-storage relationship derived in 2. above and the elevation-discharge relationship derived in 5. above. Use the Storage-Indication Method

7. Use the maximum water surface elevation attained in the flood routing as the low point on the proposed road crossing.



B. Check the Effect of the Proposed Road Crossing Upon the Safety of the Dam; that is, the Freeboard.

1. Starting with the hydraulic characteristics of the emergency spillway & the elevation-discharge relationship, develop water surface profiles to a location immediately upstream of the proposed road ramp. Use as a maximum discharge the peak flow from previous routings, ~~20,670 cfs~~. Use cross-sections including an additional 2 feet of dam (vertically on top of dam).

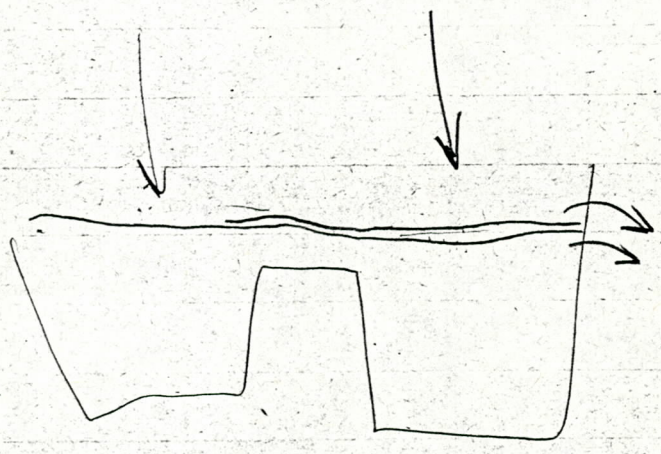
2. Develop a freeboard hydrograph (F.H.) for the two areas as separated by the proposed road crossing (see Item A.1.). Use the procedures described in SCS, NEH Sec. 4, Chap. 21. Use all applicable input derived in original computations related to determining the freeboard.

3. Using the elevation-discharge relationship derived for the road crossing (1. above) and the elevation-storage relation derived in A.2 perform the flood routing using the Storage Indication Method. Check maximum water surface against top of dam elevation

4. Add the freeboard hydrograph for the area between the emergency spillway and the road crossing to the outflow hydrograph

derived from 3. above.

5. Using the elevation - discharge relationship for the emergency spillway and the elevation - storage relationship for this part of the reservoir flood route using the Storage - Indication Method. Check maximum water-surface elevation against existing top of dam.



STATE		PROJECT		
ARIZONA		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	6-21-76			2005
SUBJECT				SHEET 1 OF
ROAD RAMP Hydrology				

(A1) Reservior is divided into 4 areas - see map.

Above McDowell Road area ①, 1.06 sq mi

Between McDowell & McKellips area ②, 2.64 sq mi = 13.57

Between Brown & McKellips area ③, 5.36 sq mi

Below Brown road area ④ 4.51 sq mi

Elev	Actual	Storage Volume (Acft) ①	②	③	④	
1591	4063.4	475.42	1459.61	1900.22	786.68	=4621.93
1590	3610.34	424.25	1312.31	1690.01	685.29	4111.86
1588	2783.95	331.14	1042.39	1341.81	524.85	3240.18
1586	2059.83	250.13	804.01	1031.85	387.49	2473.49
1584	1432.73	180.8	595.94	761.31	272.39	1810.45
1582	901.61	123.22	419.25	531.24	178.89	1252.60
1580	466.40	77.60	274.89	343.42	106.87	802.77
1578	149.41	43.28	162.25	198.53	54.76	458.81
1576	-54.30	19.74	81.39	94.49	21.18	
1574	-161.37	6.35	37.54	30.95	10.67	
1572	-198.82	1.11	10.17	4.79	1.19	

No Storage below 1576.5 (This is sediment Storage)

STATE		PROJECT		
ARIZONA		BUCKHORN MESA WPP - SPOOK HILL FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	6-22-76			2005
SUBJECT				SHEET 2 OF
Road Ramp Hydrology				

Storage volume adjusted by percent

	S (Ac ft)				
Elev	①	②	③	④	
1591	418	1283	1670	692	4063
1590	372	1152	1484	602	
1588	284	896	1153	451	
1586	208	670	859	323	
1584	143	472	602	216	
1582	89	302	382	129	
1580	45	160	200	62	467
1578	14	53	65	18	150
1576.5	0	0	0	0	

(A2)

Since the flow between reservoirs is dependent on the levels of each, discharges for changes in head are given

assume 108" pipes 225' long

p 31, C.S.P. manual

ΔH	Q
.4	170
.7	230
1.0	270
1.2	300
1.5	330

Principle Spillway

Elev	Discharge ($Q = 130.2 H^{3/2}$)
1577.5	0
1578.0	46
1579.0	239
1580.0	515
1582.0	1243

STATE		PROJECT		
ARIZONA		BUCKHORN MESA WPP - SPOOK HILL FRS.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-6-76			
SUBJECT				SHEET 3 OF

(A3) Principal Spillway Hydrograph

design for 10 year event (10% chance) in 1-day and 10-days
2.33" 3.73"

100 yr - 1 day	3.90"	Principle Spillway
100 yr - 10 day	6.10"	
Freeboard	13.0"	

To be compatible with work done previously, the drainage areas will be factored since the total drainage area is > 10 sq mi

1 day rainfall factor = .978
10 day rainfall factor = .991

from Lew Burton 2/18/75

Area #	Drainage Area	Area (sq mi)	Adjusted RCN	RCN	RCN (10 day)
	14	.25	75		
	15	.68	75		
(4)	16	1.22	75	75	58
	17	1.44	75		
	18	0.92	75		
	19	4.08	76	76	
(3)	20	1.28	75		
	21	1.91	76	77	
(2)	22	.73	79		
(1)	22	1.06	79	79	

$$C_i = \frac{100\,P_a}{(T_a)^2} = \frac{100\,(8.06)}{(68.1)^2} = .174 < 1.0$$

C_i is obviously less than one, therefore channel losses may be included

Channel loss factor = 0.7 (Lew Burton 2/19/75)

STATE		PROJECT		
ARIZONA		BUCKHORN MESA WPP - SPOOK HILL FRS.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-6-76			
SUBJECT				SHEET 3 OF

(A3) Principal Spillway Hydrograph

design for 10 year event (10% chance) in 1-day and 10-days
2.33" 3.73"

100 yr - 1 day	3.90"	Principle Spillway
100 yr - 10 day	6.10"	
Freeboard	13.0"	

To be compatible with work done previously, the drainage areas will be factored since the total drainage area is > 10 sq mi

1 day rainfall factor = .978
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from Lew Burton 2/18/75

Area #	Drainage Area	Area (sq mi)	Adjusted RCN	RCN	RCN (10 day)
	14	.25	75		
	15	.68	75		
(4)	16	1.22	75	75	58
	17	1.44	75		
	18	0.92	75		
(3)	19	4.08	76	76	60
	20	1.28	75		
(2)	21	1.91	76	77	61
	22	.73	79		
(1)	22	1.06	79	79	64

$$C_i = \frac{100\,P_a}{(T_a)^2} = \frac{100\,(8.04)}{(68.1)^2} = .174 < 1.0$$

C_i is obviously less than one, therefore channel losses may be included

Channel loss factor = 0.7 (Lew Burton 2/19/75)

STATE Arizona | PROJECT Buckhorn Mesa W.P.P. - Spook Hill FRS.
BY Burton | DATE 2/20/75 | CHECKED BY | DATE | JOB NO. 2005
SUBJECT Hydrology - Time of Concentration | SHEET 4 OF

	Drainage Area No.	Drainage Length (ft.)	Slope (%)	Velocity (fps)	Tc (hrs)	Reach Routing Coefficient "C"
	11	14000.	5.0	6.0	0.65	0.80
	12	11000.	5.0	6.0	0.51	0.80
	13	14500.	6.0	6.0	0.67	0.80
	14	5500.	1.3	4.0	0.38	0.70
	15	5500.	1.0	4.0	0.38	0.70
(4)	16	12200.	2.0	6.0	0.56	0.80
	17	14300	2.4	6.0	0.66	0.80
	18	13000	2.1	6.0	0.60	0.80
	19	25800.	3.6	6.0	1.19	0.80
(3)	20	15800	2.8	6.0	0.73	0.80
	21	18000	3.8	6.0	0.83	0.80
(2)	~~22~~	~~14500.~~	~~3.0~~	~~6.0~~	~~0.67~~	~~0.80~~
(1)	23	14000.	4.4	6.0	0.65	0.80
	24	14300.	6.4	6.0	0.66	0.80
	25	10800.	5.8	6.0	0.50	0.80
	26	12900.	7.1	6.0	0.60	0.80

Calculations for Time of Concentration based on 1974 calculations by Bob Barlels on RWCD Floodway.

Velocities used in these calculations were as follows:

2% + Above slopes Use v = 6.0 fps

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U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Sheet 5 of ___

State ARIZONA Watershed BUCKHORN MESA Site No. (1)

PRINCIPAL SPILLWAY HYDROGRAPH

By A.C. Date 6-7-76 Ck'd ___ Date ___

		Source of Data
DA	1.06 Sq. Mi.	
T_c	0.6 Hrs.	
Structure Class		
Design Storm Freq.	10 %	
Pa	8.06 in.	
Ta	68.1 °F	
Pm	in.	
Tm	°F	
Ci	0.174	

		1 Day	10 Day	
(1)	Point P	2.33"	3.73"	
(2)	Areal Corr.	x .978	x .991	
(3)	Areal P	2.28"	3.70"	
(4)	CN	79	64	
(5)	Gross Q	.70"	.80"	
(6)	Channel Loss Factor	x .70	x .70	when Ci<1
(7)	Net Q	.49"	.56"	
(8)	Q_1/Q_{10}	.49" / .56" =	.88	
(9)	Hydrograph Serial No.		8	
(10)	1" Q	56.53 ac. ft.		
(11)	DA x Q_{10}	1.06 x .56 =	.59	
(12)	Q_{10} x ac. ft./in.	.56 x 56.53 =	31.66	

(13)	Baseflow	csm.	
(14)		in./da.	(13) ÷ 26.89
(15)		cfs	(13) x DA
(16)		ac. ft./da.	(15) x 2
(17)	Minimum	csm.	
(18)		in./da.	(17) ÷ 26.89

(19)	Snowmelt	csm.	
(20)		in./da.	(19) ÷ 26.89
(21)		cfs	(19) x DA
(22)		ac. ft./da.	(21) x 2

1/ Mark out items not applicable.

① Time (Days)	② PSMC OR PSH 1/ Prelim. PSMC ~~PSH~~ (Acre Ft.) Table 21.10 x (12) or Q_{10} or (11)	③ PSMC OR PSH 1/ Base flow Snowmelt ( ) ① x (16) or (22) (14) or (20) (15) or (21)	④ PSMC OR PSH 1/ Upstream Releases ( )	⑤ PSMC OR PSH 1/ Total PSMC PSH ( ) ②+③+④
0				
.1	.01			
.5	.06			
1.0	.15			
2.0	.36			
3.0	.64			
3.5	.85			
4.0	1.14			
4.2	1.36			
4.4	1.52			
4.6	1.76			
4.7	1.92			
4.8	2.15			
4.9	2.50			
5.0	~~14.66~~	12.86		
5.1	25.60			
5.2	28.83			
5.3	29.65			
5.4	29.94			
5.5	30.11			
5.6	30.24			
5.8	30.41			
6.0	30.56			
6.5	30.82			
7.0	31.01			
8.0	31.30			
9.0	31.51			
10.0	31.65			
10.1	31.66			

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U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Sheet 6 of ____

State ARIZONA Watershed BUCKHORN MESA Site No. (1)

PRINCIPAL SPILLWAY HYDROGRAPH

By A.C. Date 6-7-76 Ck'd ____ Date ____

			Source of Data
DA 1.06 Sq. Mi.			
T_c 0.6 Hrs.			
Structure Class ____			
Design Storm Freq. 10%			
Pa		in.	
Ta		°F	
Pm		in.	
Tm		°F	
Ci			

		1 Day	10 Day	
(1)	Point P	"	"	
(2)	Areal Corr.	x ____	x ____	
(3)	Areal P	"	"	
(4)	CN			
(5)	Gross Q	"	"	
(6)	Channel Loss Factor	x ____	x ____	when Ci < 1
(7)	Net Q	"	"	
(8)	Q_1/Q_{10} ____ " / " =			
(9)	Hydrograph Serial No.			
(10)	1" Q		ac. ft.	
(11)	DA x Q_{10} ____ x ____ =			.59
(12)	Q_{10} x ac. ft./in. ____ x ____ =			

(13)	Baseflow		csm.	
(14)			in./da.	(13) ÷ 26.89
(15)			cfs	(13) x DA
(16)			ac. ft./da.	(15) x 2
(17)	Minimum		csm.	
(18)			in./da.	(17) ÷ 26.89

(19)	Snowmelt		csm.	
(20)			in./da.	(19) ÷ 26.89
(21)			cfs	(19) x DA
(22)			ac. ft./da.	(21) x 2

1/ Mark out items not applicable.

① Time (Days)	② PSMC OR PSH 1/ Prelim. ~~PSMC~~ PSH (cfs)	③ PSMC OR PSH 1/ Base flow Snowmelt ( )	④ PSMC OR PSH 1/ Upstream Releases ( )	⑤ PSMC OR PSH 1/ Total PSMC PSH ( )
	Table 21.10 (12) x or Q10 or (11)	① x (16) or (22) (14) or (20) (15) or (21)		②+③+④
0	0			
.1	.05			
.5	.08			
1.0	.10			
2.0	.13			
3.0	.18			
3.5	.23			
4.0	.31			
4.2	.49			
4.4	.57			
4.6	.75			
4.7	.98			
4.8	1.37			
4.9	2.33			
5.0	105.62			
5.1	27.08			
5.2	6.54			
5.3	2.02			
5.4	1.01			
5.5	.77			
5.6	.54			
5.8	.47			
6.0	.34			
6.5	.25			
7.0	.19			
8.0	.13			
9.0	.10			
10.0	.07			
10.1	.00			

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Sheet 7 of ____

State ARIZONA Watershed BUCKHORN MESA Site No. 2

PRINCIPAL SPILLWAY HYDROGRAPH

By A.C. Date 6-7-76 Ck'd ____ Date ____

		Source of Data
DA	2.64 Sq. Mi.	
T_c	1.0 Hrs.	
Structure Class		
Design Storm Freq.	10%	
Pa	8.06 in.	
Ta	68.1 °F	
Pm	in.	
Tm	°F	
Ci	0.174	

		1 Day	10 Day	
(1)	Point P	2.33"	3.73"	
(2)	Areal Corr.	x .978	x .991	
(3)	Areal P	2.28"	3.70"	
(4)	CN	77	61	
(5)	Gross Q	.62"	.67"	
(6)	Channel Loss Factor	x .70	x .70	when Ci<1
(7)	Net Q	.43"	.47"	
(8)	Q_1/Q_{10}	.43" / .47" =	.93	
(9)	Hydrograph Serial No.		8	

(10)	1" Q	140.80	ac. ft.
(11)	DA x Q_{10}	2.64 x .47 =	1.24
(12)	Q_{10} x ac. ft./in.	.47 x 140.8 =	66.18

(13)	Baseflow		csm.	
(14)			in./da.	(13) ÷ 26.89
(15)			cfs	(13) x DA
(16)			ac. ft./da.	(15) x 2
(17)	Minimum		csm.	
(18)			in./da.	(17) ÷ 26.89

(19)	Snowmelt		csm.	
(20)			in./da.	(19) ÷ 26.89
(21)			cfs	(19) x DA
(22)			ac. ft./da.	(21) x 2

1/ Mark out items not applicable.

① Time (Days)	② PSMC OR PSH 1/ Prelim. PSMC ~~PSH~~ (Ins)	③ PSMC OR PSH 1/ Base flow Snowmelt ( )*	④ PSMC OR PSH 1/ Upstream Releases ( )	⑤ PSMC OR PSH 1/ Total PSMC PSH ( )
	Table 21.10 x (12) or Q 10 or (11)	① x (16) or (22) (14) or (20) (15) or (21)		②+③+④
0				
.1	.01			
.5	.13			
1.0	.31			
2.0	.75			
3.0	1.34			
3.5	1.77			
4.0	2.38			
4.2	2.73			
4.4	3.17			
4.6	3.67			
4.7	4.02			
4.8	4.49			
4.9	5.23			
5.0	26.89			
5.1	53.51			
5.2	60.26			
5.3	61.97			
5.4	62.58			
5.5	62.94			
5.6	63.23			
5.8	63.57			
6.0	63.88			
6.5	64.42			
7.0	64.83			
8.0	65.43			
9.0	65.87			
10.0	66.16			
10.1	66.18			

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SOIL CONSERVATION SERVICE

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State ARIZONA Watershed BUCKHORN MESA Site No. (2)

PRINCIPAL SPILLWAY HYDROGRAPH

By A.C. Date 6-7-76 Ck'd ____ Date ____

			Source of Data
DA	2.64	Sq. Mi.	
T_c	1.0	Hrs.	
Structure Class			
Design Storm Freq.	10 %		
Pa		in.	
Ta		°F	
Pm		in.	
Tm		°F	
Ci			

		1 Day	10 Day	
(1)	Point P	"	"	
(2)	Areal Corr.	x ____	x ____	
(3)	Areal P	"	"	
(4)	CN			
(5)	Gross Q	"	"	
(6)	Channel Loss Factor	x ____	x ____	when Ci<1
(7)	Net Q	"	"	
(8)	Q_{1}/Q_{10} ____ =			
(9)	Hydrograph Serial No.			

(10)	1" Q	ac. ft.	
(11)	DA x Q_{10} ____ x ____ =		1.24
(12)	Q_{10} x ac. ft./in. ____ x ____ =		

(13)	Baseflow	csm.	
(14)		in./da.	(13) ÷ 26.89
(15)		cfs	(13) x DA
(16)		ac. ft./da.	(15) x 2
(17)	Minimum	csm.	
(18)		in./da.	(17) ÷ 26.89

(19)	Snowmelt	csm.	
(20)		in./da.	(19) ÷ 26.89
(21)		cfs	(19) x DA
(22)		ac. ft./da.	(21) x 2

1/ Mark out items not applicable.

① Time (Days)	② PSMC OR PSH 1/ Prelim. ~~PSMC~~ PSH (cfs)	③ PSMC OR PSH 1/ Base flow Snowmelt ( )	④ PSMC OR PSH 1/ Upstream Releases ( )	⑤ PSMC OR PSH 1/ Total PSMC PSH ( )
	Table 21.10 (12) x or Q_{10} or (11)	① x (16) or (22) (14) or (20) (15) or (21)		②+③+④
0	0			
.1	.11			
.5	.17			
1.0	.21			
2.0	.27			
3.0	.37			
3.5	.48			
4.0	.66			
4.2	1.04			
4.4	1.21			
4.6	1.57			
4.7	2.06			
4.8	2.87			
4.9	4.91			
5.0	221.98			
5.1	56.91			
5.2	13.75			
5.3	4.25			
5.4	2.11			
5.5	1.61			
5.6	1.13			
5.8	1.80			
6.0	.71			
6.5	.53			
7.0	.39			
8.0	.28			
9.0	.21			
10.0	.15			
10.1	0			

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SOIL CONSERVATION SERVICE

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State ARIZONA Watershed BUCKHORN MESA Site No. (3)

PRINCIPAL SPILLWAY HYDROGRAPH

By A.C. Date 6-7-76 Ck'd ___ Date ___

			Source of Data
DA 5.36 Sq. Mi.			
T_c .8 Hrs.			
Structure Class ___			
Design Storm Freq. 10%			
Pa 8.06		in.	
Ta 68.1		°F	
Pm		in.	
Tm		°F	
Ci	0.174		

		1 Day	10 Day	
(1)	Point P	2.33"	3.73"	
(2)	Areal Corr.	x .978	x .991	
(3)	Areal P	2.28"	3.70"	
(4)	CN	76	60	
(5)	Gross Q	.60"	.62"	
(6)	Channel Loss Factor	x .70	x .70	when Ci<1
(7)	Net Q	.42"	.43"	
(8)	Q_1/Q_{10} .42" / .43" =		.97	
(9)	Hydrograph Serial No.		8	

(10)	1" Q	285.87	ac. ft.
(11)	DA x Q_{10}	5.36 x .43 =	2.30
(12)	Q_{10} x ac. ft./in.	.43 x 285.87 =	122.92

(13)	Baseflow		csm.	
(14)			in./da.	(13) ÷ 26.89
(15)			cfs	(13) x DA
(16)			ac. ft./da.	(15) x 2
(17)	Minimum		csm.	
(18)			in./da.	(17) ÷ 26.89

(19)	Snowmelt		csm.	
(20)			in./da.	(19) ÷ 26.89
(21)			cfs	(19) x DA
(22)			ac. ft./da.	(21) x 2

1/ Mark out items not applicable.

① Time (Days)	② PSMC OR PSH 1/ Prelim. PSMC ~~PSH~~ (Ac-ft)	③ PSMC OR PSH 1/ Base flow Snowmelt ( )	④ PSMC OR PSH 1/ Upstream Releases ( )	⑤ PSMC OR PSH 1/ Total PSMC PSH ( )
	Table 21.10 (12) x or Q10 or (11)	① x (16) or (22) (14) or (20) (15) or (21)		②+③+④
0				
.1	.02			
.5	.23			
1.0	.58			
2.0	1.39			
3.0	2.50			
3.5	3.29			
4.0	4.41			
4.2	5.06			
4.4	5.89			
4.6	6.82			
4.7	7.46			
4.8	8.33			
4.9	9.71			
5.0	49.94			
5.1	99.39			
5.2	111.92			
5.3	115.10			
5.4	116.23			
5.5	116.90			
5.6	117.45			
5.8	118.06			
6.0	118.64			
6.5	119.65			
7.0	120.41			
8.0	121.53			
9.0	122.34			
10.0	122.88			
10.1	122.92			

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SOIL CONSERVATION SERVICE

Sheet 10 of ___

State ARIZONA Watershed BUCKHORN MESA Site No. (3)

PRINCIPAL SPILLWAY HYDROGRAPH

By A.C. Date 6-7-76 Ck'd ___ Date ___

			Source of Data
DA	5.36	Sq. Mi.	
T_c	.8	Hrs.	
Structure Class			
Design Storm Freq.	10%		
Pa		in.	
Ta		°F	
Pm		in.	
Tm		°F	
Ci			

		1 Day	10 Day	
(1)	Point P	"	"	
(2)	Areal Corr.	x ___	x ___	
(3)	Areal P	"	"	
(4)	CN			
(5)	Gross Q	"	"	
(6)	Channel Loss Factor	x ___	x ___	when Ci<1
(7)	Net Q	"	"	
(8)	Q_1/Q_{10} ___ " / " =			
(9)	Hydrograph Serial No.			
(10)	1" Q		ac. ft.	
(11)	DA x Q_{10} ___ x ___ =			2.3
(12)	Q_{10} x ac. ft./in. ___ x ___ =			

(13)	Baseflow		csm.	
(14)			in./da.	(13) ÷ 26.89
(15)			cfs	(13) x DA
(16)			ac. ft./da.	(15) x 2
(17)	Minimum		csm.	
(18)			in./da.	(17) ÷ 26.89

(19)	Snowmelt		csm.	
(20)			in./da.	(19) ÷ 26.89
(21)			cfs	(19) x DA
(22)			ac. ft./da.	(21) x 2

1/ Mark out items not applicable.

① Time (Days)	② PSMC OR PSH 1/ Prelim. ~~PSMC~~ PSH (cfs)	③ Base flow Snowmelt ( )*	④ Upstream Releases ( )	⑤ Total PSMC PSH ( )
	Table 21.10 x (12) or Q_{10} or (11)	① x (16) or (22) (14) or (20) (15) or (21)		②+③+④
0	0			
.1	.20			
.5	.32			
1.0	.39			
2.0	.50			
3.0	.69			
3.5	.90			
4.0	1.22			
4.2	1.93			
4.4	2.24			
4.6	2.92			
4.7	3.82			
4.8	5.33			
4.9	9.10			
5.0	411.74			
5.1	105.57			
5.2	25.50			
5.3	7.89			
5.4	3.92			
5.5	2.99			
5.6	2.09			
5.8	1.85			
6.0	1.31			
6.5	.98			
7.0	.72			
8.0	.52			
9.0	.39			
10.0	.27			
10.1	.01			

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SOIL CONSERVATION SERVICE

Sheet 11 of ____

State ARIZONA Watershed BUCKHORN MESA Site No. 4

PRINCIPAL SPILLWAY HYDROGRAPH

By A.C. Date 6-7-76 Ck'd ____ Date ____

			Source of Data
DA	4.51	Sq. Mi.	
T_c	.7	Hrs.	
Structure Class			
Design Storm Freq.	10%		
Pa	8.06	in.	
Ta	68.1	°F	
Pm		in.	
Tm		°F	
Ci	0.174		

		1 Day	10 Day	
(1)	Point P	2.33"	3.73"	
(2)	Areal Corr.	x .978	x .991	
(3)	Areal P	2.28"	3.70"	
(4)	CN	75	58	
(5)	Gross Q	.53"	.54"	
(6)	Channel Loss Factor	x .70	x .70	when Ci<1
(7)	Net Q	.37"	.38"	
(8)	Q_1/Q_{10}	.37" / .38" =	.97	
(9)	Hydrograph Serial No.		8	
(10)	1" Q	240.53	ac. ft.	
(11)	DA x Q_{10}	4.51 x .38	= 1.71	cfs
(12)	Q_{10} x ac. ft./in.	.38 x 240.53	= 91.40	in

(13)	Baseflow		csm.	
(14)			in./da.	(13) ÷ 26.89
(15)			cfs	(13) x DA
(16)			ac. ft./da.	(15) x 2
(17)	Minimum		csm.	
(18)			in./da.	(17) ÷ 26.89

(19)	Snowmelt		csm.	
(20)			in./da.	(19) ÷ 26.89
(21)			cfs	(19) x DA
(22)			ac. ft./da.	(21) x 2

1/ Mark out items not applicable.

① Time (Days)	② ← PSMC OR PSH 1/ → Prelim. PSMC ~~PSH~~ (Ac ft)	③ Base flow Snowmelt ( )*	④ Upstream Releases ( )	⑤ Total PSMC PSH ( )
	Table 21.10 (12) x or Q10 or (11)	① x (16) or (22) (14) or (20) (15) or (21)		②+③+④
0	0			
.1	.02			
.5	.17			
1.0	.43			
2.0	1.03			
3.0	1.86			
3.5	2.45			
4.0	3.28			
4.2	3.77			
4.4	4.38			
4.6	5.07			
4.7	5.55			
4.8	6.20			
4.9	7.22			
5.0	37.14			
5.1	73.91			
5.2	83.22			
5.3	85.59			
5.4	86.43			
5.5	86.92			
5.6	87.29			
5.8	87.79			
6.0	88.22			
6.5	88.97			
7.0	89.54			
8.0	90.37			
9.0	90.97			
10.0	91.37			
10.1	91.40			

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U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Sheet 12 of ____

State ARIZONA Watershed Buckhorn Mesa Site No. (4)

PRINCIPAL SPILLWAY HYDROGRAPH

By A-C. Date 6-7-76 Ck'd ____ Date ____

		Source of Data
DA 4.51 Sq. Mi.		
T_c .7 Hrs.		
Structure Class ____		
Design Storm Freq. 10%		
Pa	in.	
Ta	°F	
Pm	in.	
Tm	°F	
Ci		

		1 Day	10 Day	
(1)	Point P	"	"	
(2)	Areal Corr.	x ____	x ____	
(3)	Areal P	"	"	
(4)	CN			
(5)	Gross Q	"	"	
(6)	Channel Loss Factor	x ____	x ____	when Ci < 1
(7)	Net Q	"	"	

(8)	Q_1/Q_{10} ____ " / " =		
(9)	Hydrograph Serial No.		

(10)	1" Q	____	ac. ft.
(11)	DA x Q_{10} ____	x ____	= 1.71
(12)	Q_{10} x ac. ft./in. ____	x ____	=

(13)	Baseflow		csm.	
(14)			in./da.	(13) ÷ 26.89
(15)		____	cfs	(13) x DA
(16)		____	ac. ft./da.	(15) x 2
(17)	Minimum		csm.	
(18)			in./da.	(17) ÷ 26.89

(19)	Snowmelt		csm.	
(20)			in./da.	(19) ÷ 26.89
(21)		____	cfs	(19) x DA
(22)		____	ac. ft./da.	(21) x 2

1/ Mark out items not applicable.

① Time (Days)	② ← PSMC OR PSH 1/ → Prelim. ~~PSMC~~ PSH (cfs)	③ Base flow Snowmelt ( )	④ Upstream Releases ( )	⑤ Total PSMC PSH ( )
	Table 21.10 x (12) or Q_{10} or (11)	① x (16) or (22) (14) or (20) (15) or (21)		②+③+④
0				
.1	.15			
.5	.24			
1.0	.29			
2.0	.37			
3.0	.52			
3.5	.67			
4.0	.91			
4.2	1.43			
4.4	1.67			
4.6	2.17			
4.7	2.84			
4.8	3.96			
4.9	6.76			
5.0	306.12			
5.1	78.49			
5.2	18.96			
5.3	5.87			
5.4	2.91			
5.5	2.22			
5.6	1.55			
5.8	1.38			
6.0	.97			
6.5	.73			
7.0	.54			
8.0	.38			
9.0	.29			
10.0	.20			
10.1	.01			

STATE		PROJECT		
ARIZONA		BUCKHORN MESA WPP - SPOOK HILL FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-7-76			
SUBJECT				SHEET 13 OF
Road Ramp Hydrology				

(Quick look at situation before continueing with Robin's Proceedure)

Several Variables still exist in this problem
1. The location of Signal Butte Floodway
2. Brown Road Ramp Design

Present Design -

McDowell Road - min. elev. 1580.7, invert 1566.5 (Top of pipe 1575.5)
McKilleps Road - min. elev. 1582.1, invert 1567.4 1576.4
Brown Road - (not yet designed), invert 1569.4 1578.4

For the 10 yr flow, this is a comparisome of total flow and reservior area

Location	Area #	Storage below 1580 (Ac-ft)	storage below 1582 (Ac-ft)	total flow (Ac-ft)
north of McDowell	①	45	89	32
between McD. and McK	②	160	302	66
between Brown and McK.	③	200	382	123
south of Brown	④	62	129	92

(flow is from ④ → ①)

This has assumed that Signal Butte Floodway adds flow to area ④ If the floodway came in above Brown road (area ③), then all flow from the 10 yr storm could be stored in the four reserviors below elevation 1580. (plus 1' freeboard) Then Brown Road would not be at all critical. As it stands, Brown Road would have to be set at about 1582. This may have an effect of the Freeboard Routing although the 100 year storm is all that will be contributed from Signal Butte Floodway. It also appears that McKilleps Road could be lowered.

STATE		PROJECT		
ARIZONA		BUCKHORN MESA WPP - SPOOK HILL F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-7-76			
SUBJECT				SHEET 14 OF
Road Ramp Hydrology				

The hydrograph seems to route like a flash flood, with a tremendous increase in storage and discharge (from watershed) after 5 days.

at 4.9 days, the storage is as follows:

Area	Storage (Acft)	Elev.
①	2.5	1576.5
②	5.2	1576.5
③	9.7	1576.5
④	7.2	1576.5

No discharge through the principle spillway, and no flow in a set direction

(Principle Spillway El. 1577.5)
McDowell 108" CMP (270* cfs)
McKellips 108" CMP (225' long)

at 5.0 days,

Area	storage	discharge	Elev.	ΔE	Q	
①	14.7	106 cfs (IN)	1578	+.5	46 ↑	Spillway
②	26.9	272 cfs (IN)	1577.3	−.7	230 ↘	McDowell Rd
③	49.9	472 cfs (IN)	1577.7	+.4	170 ↗	McKellips Rd
④	37.2	306 cfs (IN)	1578.9	+1.2	300 ↗	Brown

$(X\ cfs)(.1\ day)\ \frac{3600\ sec}{hr}\ \frac{24\ hr}{day}\ \frac{1\ Ac}{43{,}560\ ft^2} = (.1983)(X^{cfs})\ Acft$

↖ discharges from CSP Publication

at 5.1 days

Area	Storage	Discharge	added storage (from above discharges)	E (collum 2)	Equalibrium Elev.	Storage
①	25.6	27	−54.7	1578.75	1578.65	25.1
②	53.5	57	+79.3	1578.0	1578.65	87.6
③	99.4	106	+19.8	1578.5	1578.65	108.6
④	73.9	78	−53.5	1580.4	1578.65	32.2
	252.4 (−9.12 in discharge)					

Area	ΔStor. from 5.0 to 5.1 Equilibrium	Ave Q	Q spillway	Ave Q
①	−.5	2.5 out	$\frac{200\ cfs + 40\ cfs}{2}$ = 120 out	120 out
②	+34.1	1.72 in		52 out
③	+9.2	46 in		74 out
④	−41.7	210 out		330 out

reservior below Brown Road will back up considerably
the other three reserviors will go to about the same level

discharges into the reserviors decrease past this point with more flow through the culverts - note that after 5.1 days the reservior is draining faster than the flow is coming in. Flow through the culverts becomes important in determining water levels. Reservior ④ will continue to be considerably above the other three. (Est. levels 1579, 1579.5, 1580, 1581)

STATE		PROJECT		
BY	DATE	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 15 OF

(A4) Storage Indication Method – (A4 to A7 will be repeated 3 times)

$$\bar{I} + \frac{S_1}{\Delta t} - \frac{O_1}{2} = \frac{S_2}{\Delta t} + \frac{O_2}{2}$$

where $\bar{I} = \frac{I_1 + I_2}{2}$ I = inflow, O = outflow, S = storage volume

check time lag $T_t = \frac{L A}{3600 q}$ L = length = 5,000' A = end area 1,500 ac q = 200 cfs

$$T_t = \frac{5000 \times 1500}{3600 \times 200} = 20.8 \text{ hrs}$$

$T_p = 5 \text{ days} \times 24 = 120 \text{ hrs}$

$T_t / T_p = .18 < \frac{1}{2}$ travel times should not be serious (check later)

The first run will be the routing of reservior ①, with no flow between reservoirs $\Delta t = .1$ days

Elev	S	$S/\Delta t$	O_2	$S/\Delta t + O_2/2$
1577	4	20.17	0	20.17
1577.3	7	35.30	0	35.30
1577.5	9	45.39	0	49.39
1577.8	11	55.47	24	67.47
1578	14	70.60	46	93.60
1579	29	146.24	239	265.74
1580	45	226.93	515	484.43 ← if this elevation were reached, Δt will have to be changed

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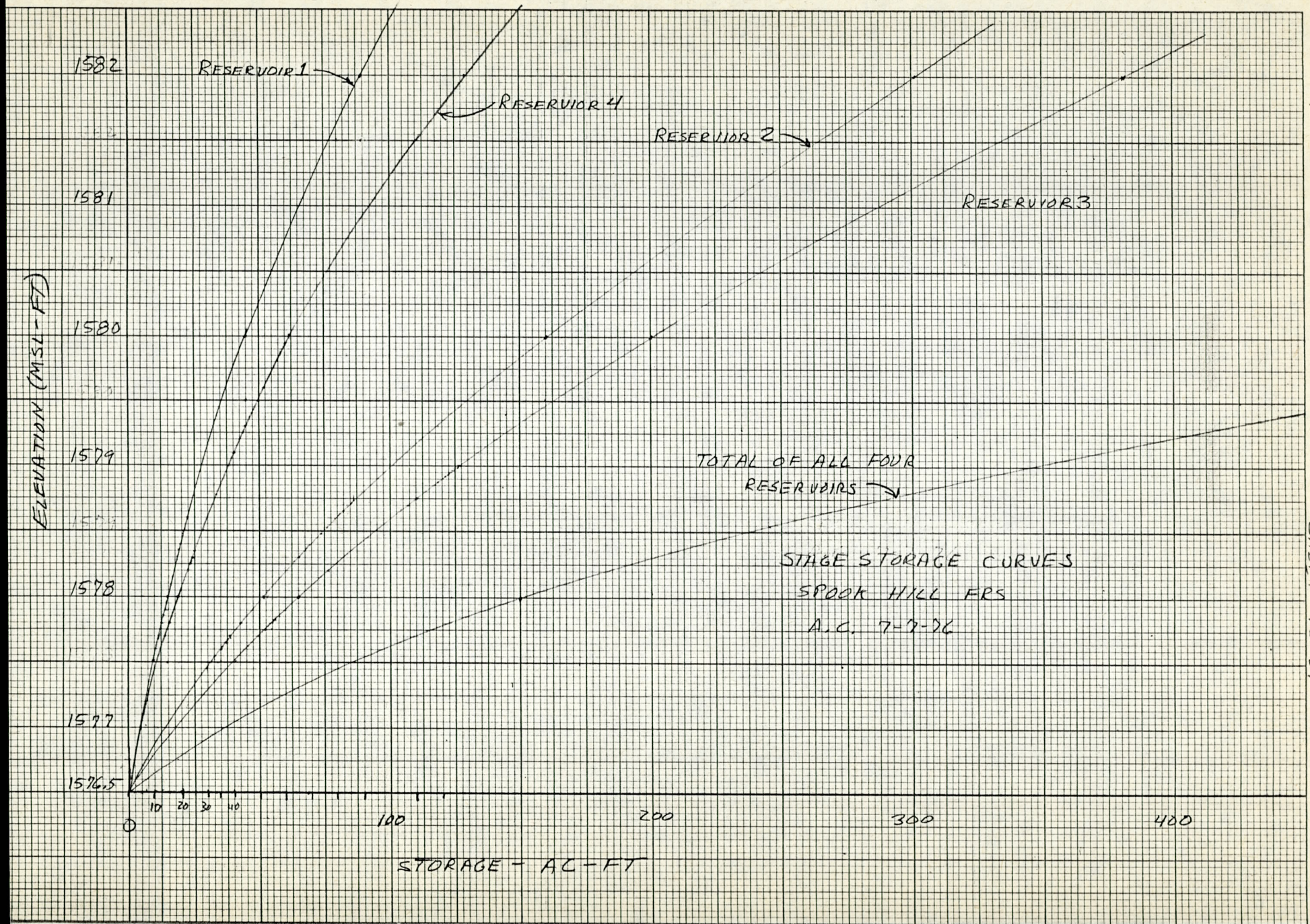
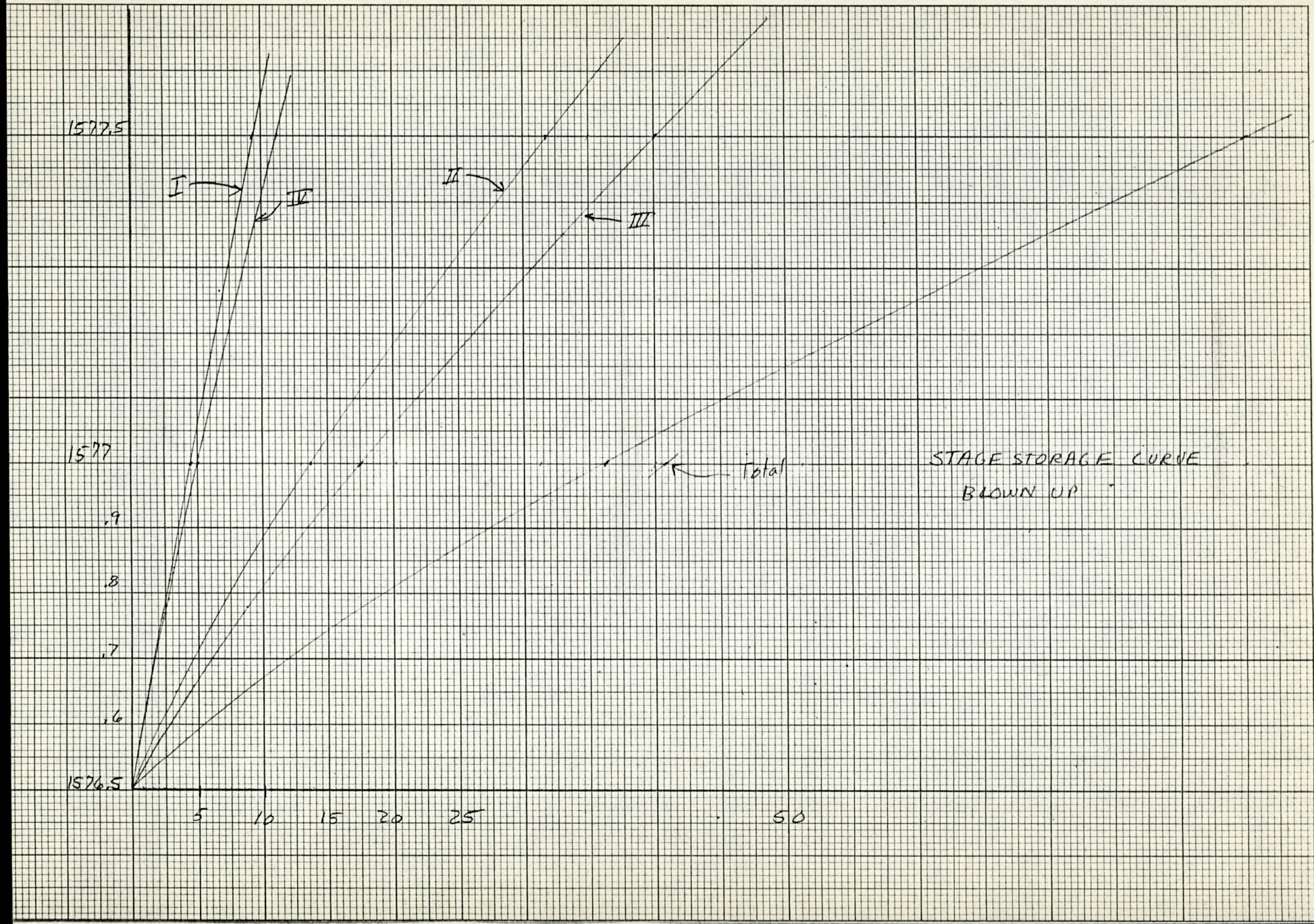


SHEET 16 of

77 4 29

K+E 20 X 20 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



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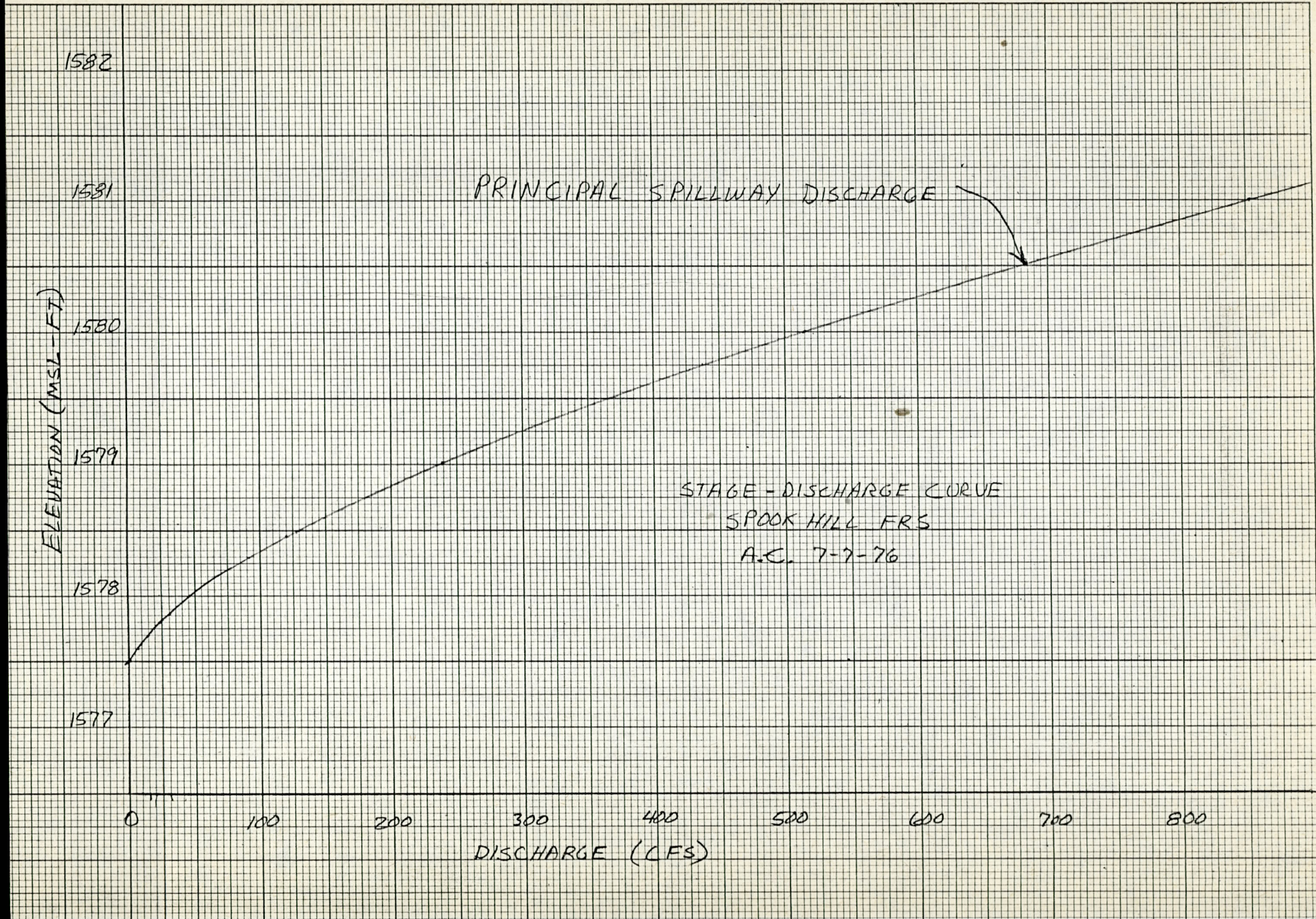

K+E 20 X 20 TO THE INCH • 7 X 10 INCHES
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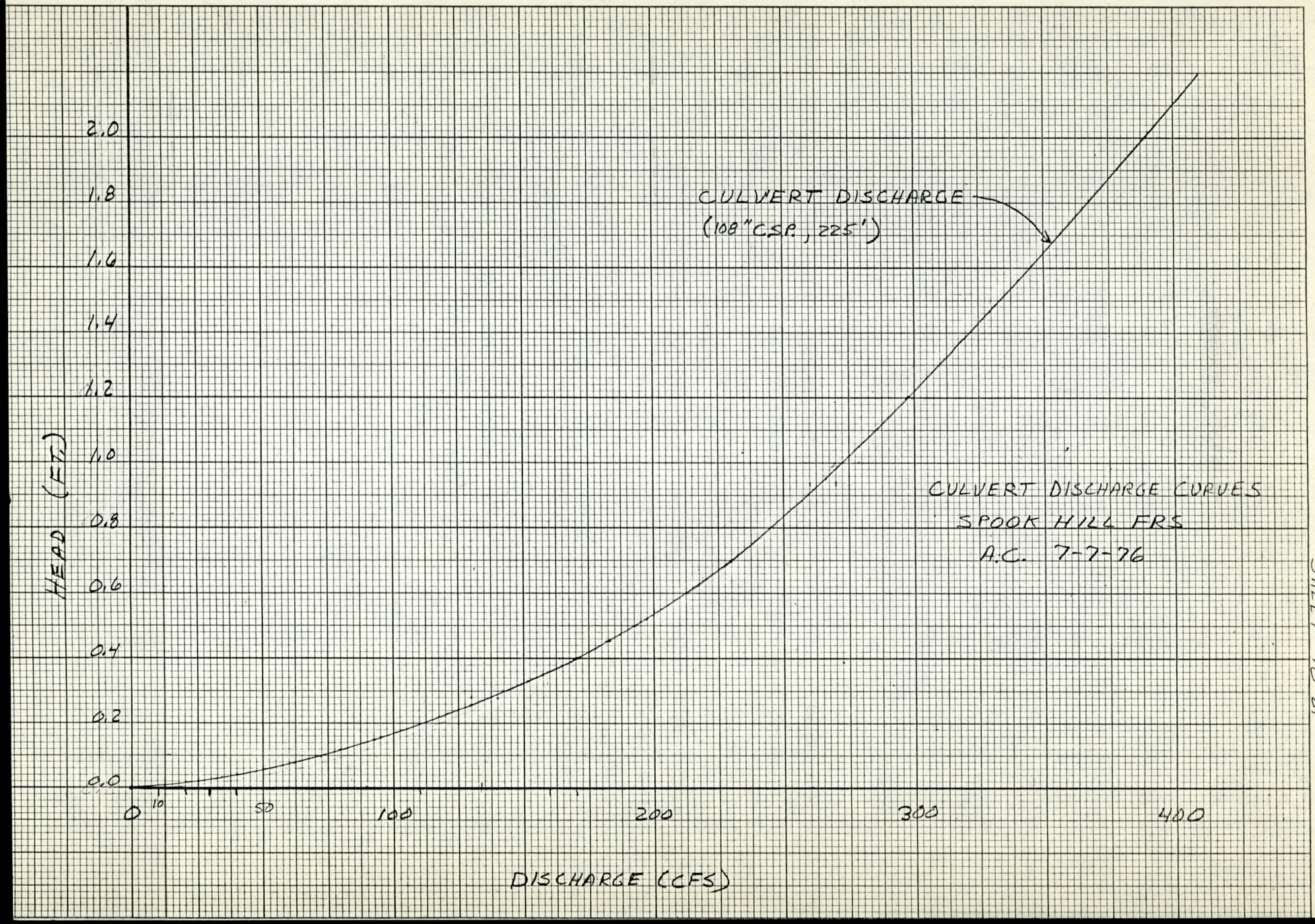
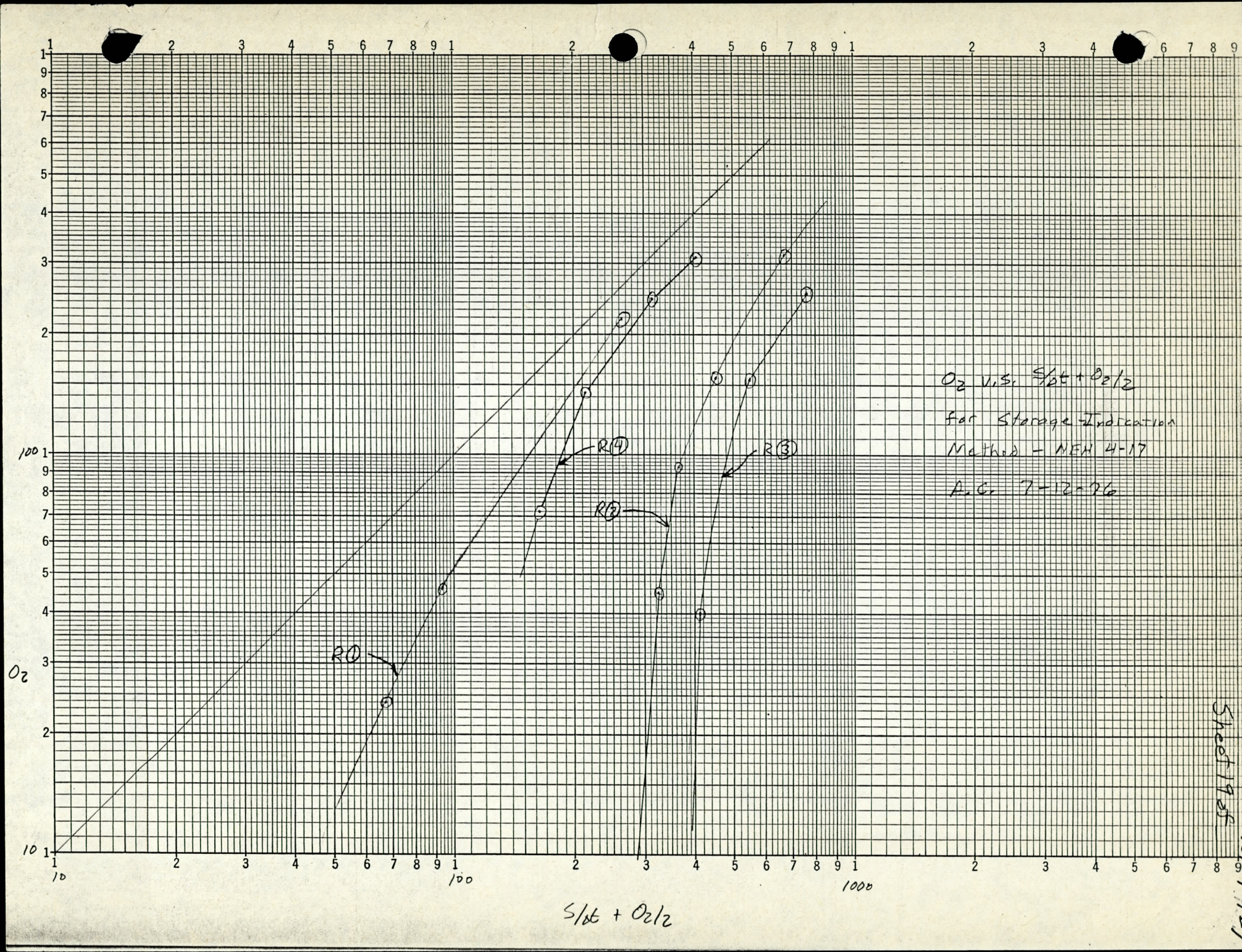


SHEET 18 of


O_2 vs. $S/\Delta t + O_2/2$
for Storage Indication
Method – MEM 4-17
A.C. 7-12-76
R①
R②
R③
R④
O_2
$S/\Delta t + O_2/2$
Sheet 1 of

STATE		PROJECT		
AZ		BUCKHORN MESA WPP - SPOOK HILL F.R.S		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-12-76			
SUBJECT				SHEET 20 OF
Road Ramp Hydrology				

Time (days)	I (cfs)	$S_2/\Delta t + O_2/2$ (cfs)	O_2 (cfs)	S (Ac-ft)	Elev. (MSL-ft)
				Begin with Known storage value	
4.9	2.33	12.61	0	2.5	1576.79 with no O_2
5.0	105.62	118.23	66	(not needed)	1578.15 (from Sheet 17)
5.1	27.08	79.31	33.5		1577.88

Maximum elevation 1578.15 of Reservior 1

(A5) This is now the tailwater condition on the outflow from reservior 2

Elev.	S	$S/\Delta t$	O_2	$S/\Delta t + O_2/2$
1577	13.8	69.6	0	69.6
1578	53.0	267.3	0	267.3
1578.3	65.0	327.8	93	374.3
1578.5	75.0	378.2	157	456.7
1578.2	60.5	305.1	45	327.6
1579	102.0	514.4	316	672.4
1580	160	806.9	too high	

(A6)

Time (days)	I (cfs)	$S_2/\Delta t + O_2/2$ (cfs)	O_2 (cfs)	Elev (MSL ft)	S (Ac-ft)
4.9	4.91	26.37	0	1576.72	5.23
5.0	221.98	248.35	0	?	
5.1	56.91	305.26	20	*(extrapolated) 1578.17	
5.2	13.75	299.01	15	1578.16	

Max. elevation 1578.16 of Reservior 2

This is now the tailwater condition on the outflow from reservior 3

STATE Az		PROJECT Buckhorn MESA WPP Spook Hill FRS		
BY A.C.	DATE 7-12-76	CHECKED BY	DATE	JOB NO.
SUBJECT Road Ramp Hydrology				SHEET 21 OF

Reservior 3

Elev.	S	S/Δt	O_2	S/Δt + O_2/2
1577	17.5	88.3	0	88.3
1578	65	327.8	0	327.8
1578.2	78	393.3	40	413.3
1578.5	94	474.0	155	551.5
1579	129	650.5	252	776.5

Time (days)	I (cfs)	S_2/Δt + O_2/2 (cfs)	O_2 (cfs)	Elev. (MSL - ft)	S (Ac-ft)
4.9	-	48.97	0	1577.70	9.71
5.0	411.74	460.7	42	1578.20	-
5.1	105.57	524.28	43	1578.20	
5.2	25.50	506.78	42.5	1578.20	

Max. elevation of Reservior 3 is 1578.20

Reservior 4

Elev.	S	S/Δt	O_2	S/Δt + O_2/2
1578	18.5	93.3	0	
1578.2	22.0	110.9	0	
1578.3	25.0	126.1	72	162.1
1578.5	28.0	141.2	143	212.7
1579.	38.5	194.2	245	316.7
1579.5	50.0	252.1	310	407.1
1580.0				

STATE		PROJECT		
Az.		Buckhorn Mesa WPP - Spook Hill FRS		
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SUBJECT				SHEET 22 OF
Road Ramp Hydrology				

Reservior 4

Time	I	$S_2/\Delta t + O_2/2$	O_2	Elev.	S
4.9	—	36.41	0	1577.20	7.22
5.0	306.12	342.53	262	1579.12	—
5.1	78.49	159.02	64	1578.28	—

Max. elevation of reservior 4 is 1579.12

		Reservior	
Maximum elevation	1578.15	①	
	1578.16	②	McDowell Road (now at 1580.7)
	1578.20	③	McKellips Road (now at 1582.1)
	1579.12	④	Brown Road

STATE Az		PROJECT Buckhorn Mesa -WPP- Spook Hill FRS		
BY A.C.	DATE 7-7-76	CHECKED BY	DATE	JOB NO.
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(A4) Storage-Indication Method

$$\bar{I} + \frac{S_1}{\Delta t} - \frac{O_1}{2} = \frac{S_2}{\Delta t} + \frac{O_2}{2}$$

$\bar{I} = \frac{I_1 + I_2}{2}$ I = inflow rate O = outflow rate S = storage volume

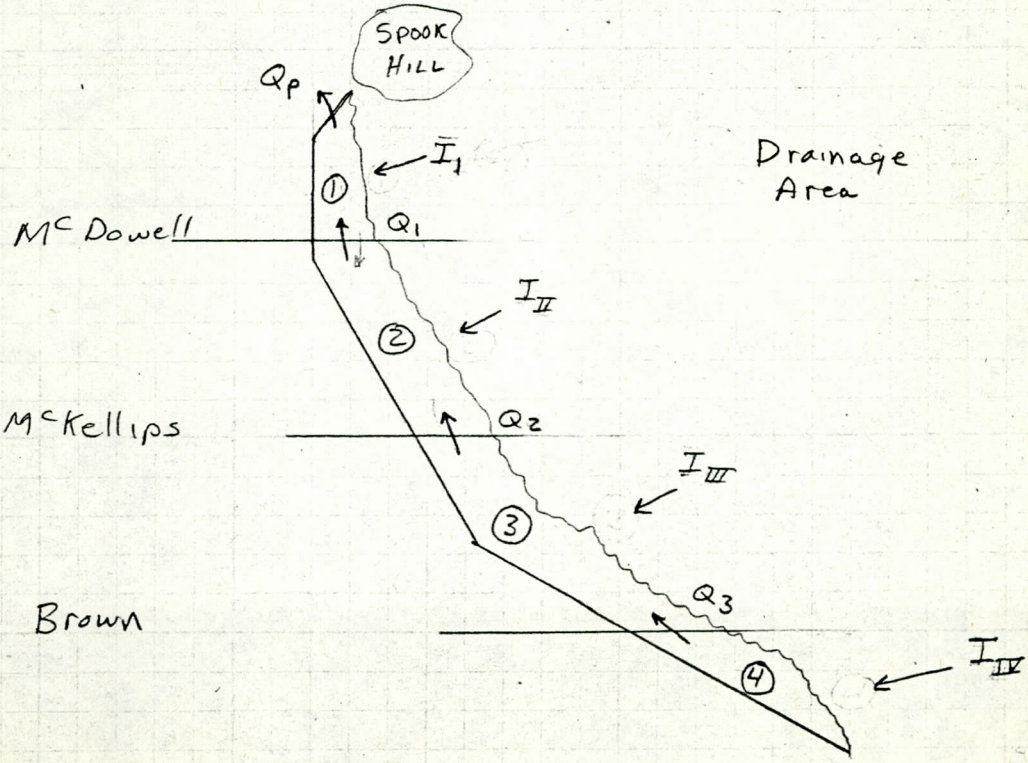
check time lag $T_t = \frac{LA}{3600q}$ L = length ≃ 5,000' A = end Area 1,500
q = 200

$$T_t = \frac{(5000)(1500)}{3600\ 200} = 20.8 \text{ hrs}$$

T_p = 5 days x 12 = 60

$T_t/T_p = .35 < 1/2$ – travel time delays are not serious (although a look at the routing would seem to show more like .1 to .2 days for T_p)

Because of the interrelationship of the four reservoirs, the storage-Indrcation Method will require modification



COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE ARIZONA | PROJECT BUCKHORN-MESA WPP - SPOOK HILL FRS
BY A.C. | DATE 7-26-76 | CHECKED BY | DATE | JOB NO. 2005
SUBJECT Road Ramp Hydrology | SHEET 25 OF

1,983 Ac ft = 1 cfs day

Time (Days)	$I_1 \Delta t$ (Ac-ft)	S_I (Ac-ft)	Elev. (MSL-ft)	Q_p (cfs) ($Q_{p\Delta t}$)	$O_I \Delta t$ (Ac ft)	$I_{II} \Delta t$ (Ac-ft)	S_{II} (Ac-ft)	Elev. (ft)	Q_1 ($Q_1 \Delta t$) cfs (Ac-ft)	$O_{II} \Delta t$ (Ac-ft)	$I_{III} \Delta t$ (Ac-ft)	S_{III} (Ac-ft)	Elev. (ft)	Q_2 ($Q_2 \Delta t$) cfs (Ac-ft)	$O_{III} \Delta t$ (Ac-ft)	$I_{IV} \Delta t$ (Ac-ft)	S_{IV} (Ac-ft)	Elev. (ft)	Q cfs	$Q_3 \Delta t$ (Ac-ft)	$O_{IV} \Delta t$ (Ac-ft)
0	0	0	1576.5	0	0	0	0	1576.5	0	0	0	0	1576.5	0	0	0	0	1576.5	0	0	
2.0	.36	.36	1576.5	0	0	.75	.75	1576.5	0	0	1.39	1.39	1576.55	0	0	1.03	1.03	1576.55	← unimportant at this point		
3.0	.28	.64	1576.55	0	0	.59	1.34	1576.55	0	X	1.11	2.50	1576.59	.40 (79.32)	X	.83	1.86	1576.70	77 (152.69)	X	
3.0	.28	.59	1576.59	0	.05	.59	2.24	1576.59	0.03 (.05)	-.90	1.11	2.75	1576.59	.43 (.85)	-.25	.83	.76	1576.59	.55 (1.10)	1.10	
3.5	.21	.80	1576.60	0	X	.43	2.65	1576.62	24 (23.8)	X	.79	3.29	1576.62	0 (0)	X	.59	1.35	1576.63	12 (11.9)	X	
3.5	.21	.94	1576.62	0	-.14	.43	2.65	1576.62	.14 (.14)	0	.79	3.29	1576.62	.14 (.14)	0	.59	1.21	1576.62	.14 (.14)	.14	
4.0	.29	1.13	1576.63	0	X	.61	3.26	1576.65	24 (23.8)	X	1.12	4.41	1576.65	0 (0)	X	.83	2.04	1576.72	57 (56.5)	X	
4.0	.29	1.35	1576.66	0	-.22	.61	3.43	1576.66	.22 (.22)	-.17	1.12	4.68	1576.66	.39 (.39)	-.27	.83	1.38	1576.66	.67 (.66)	.66	
4.4	.38	1.73	1576.70	0	X	.79	4.21	1576.68	24 (19.04)	X	1.48	6.16	1576.70	24 (19.04)	X	1.10	2.48	1576.76	52 (41.25)	X	
4.4	.38	1.82	1576.70	0	-.09	.79	4.72	1576.70	.11 (.09)	-.51	1.48	6.12	1576.70	.76 (.60)	.04	1.10	1.92	1576.70	.71 (.56)	.56	
4.8	.63	2.45	1576.78	0	X	1.32	6.04	1576.75	33 (26.18)	X	2.44	8.56	1576.77	24 (19.04)	X	1.82	3.74	1576.88	92 (72.97)	X	
4.8	.63	2.51	1576.78	0	-.06	1.32	6.83	1576.78	.08 (.06)	-.79	2.44	8.83	1576.78	1.07 (.85)	-.27	1.82	2.67	1576.78	1.41 (1.12)	1.12	
4.9	.35	2.86	1576.83	0	X	.74	7.57	1576.80	33 (6.54)	X	1.38	10.21	1576.82	24 (4.76)	X	1.02	3.64	1576.88	52 (10.31)	X	
4.9	.35	2.80	1576.82	0	.06	.74	8.02	1576.82	.30 (.06)	-.45	1.38	10.44	1576.82	1.97 (.39)	-.23	1.02	3.02	1576.82	3.13 (.62)	+.62	
126.45 5.0	10.36	13.16	1577.86	25 (4.96)	X	21.66	29.68	1577.46	40 (7.93)	X	40.23	50.67	1577.72	130 (25.78)	X	29.92	32.94	1578.77	278 (55.13)	X	
X	10.36	12.60	1577.80	24 (4.76)	0.56	21.66	39.53	1577.72	(4.20)	-9.85	40.23	52.63	1577.76	(4.05)	-1.96	29.92	16.73	1577.8	(16.21)	16.21	
	10.36	11.80	1577.70	15 (2.97)	1.36	21.66	38.73	1577.71	8.12 (1.61) (OK)	-9.05	40.23	55.25	1577.80	53.76 (10.66) (67) too much head	-4.58	29.92	17.70	1577.95	76.85 (15.24) (92) too much head	15.24	
5.0	10.36	12.10	1577.71	16 (3.17)	1.06	21.66	39.53	1577.72	10.6 (2.11) (12) OK	-9.85	40.23	54.45	1577.79	60 (11.94) (58) OK	-3.78	29.92	17.20	1577.92	79 (15.74) (73) OK	15.74	
248.86 5.1	12.74	24.84	1578.51 (76)	132 (26.18)	X	26.62	66.15	1578.32	-108 (21.42)	X	49.45	103.90	1578.65	152 (30.14)	X	36.77	53.97	1579.68	272 (53.94)	X	
		24.70	1578.50	130 (25.78)			80.00	1578.60				113.00	1578.80				38.00	1579.00			
		19.40	1578.40	111 (22.01)	5.44		73.65	1578.50	84 (16.57) 73 (not enough head)	-7.50		99.00	1578.70	121 (24.07) 111 (not enough head)	4.9		34.80	1578.85	97 (19.11) (93) (not enough head)	19.17	
5.1	12.74	19.30	1578.39	108 (21.42)	5.54	26.62	73.65	1578.50	80 (15.88) (78)	-7.50	49.45	99.39	1578.71*	117 (23.38) (115)	4.51	36.77	35.10	1578.87*	95 (18.87) (97)	18.87	
257.26 5.2	3.23	22.53	1578.63	152 (30.14)	X	6.75	80.40	1578.62	X	X	12.53	111.92	1578.76	X	X	9.31	44.41	1579.27	X	X	
		20.33	1578.45	120 (23.80)	2.20		77.40	1578.55	109 (21.60) 72 not enough head	3.0		104.43	1578.65	94 (18.60) 72 not enough head	7.49		33.30	1578.75	56 (11.11) 72 too much head	11.11	
		20.00	1578.44	119 (23.60)	2.53		77.90	1578.55	(21.07) 78 not enough	2.5		104.96	1578.66	94 (18.57) (78) not enough	6.96		32.70	1578.74	59 (11.61) (62) too much	11.61	
5.2	3.23	19.50	1578.40*	112 (22.21)	3.03	6.75	77.90	1578.55*	97 (19.18) (93)	2.5	12.53	106.85	1578.68	84 (16.68) (85)	5.07	9.31	37.70	1578.74	59 (11.61) (62)	11.61	
5.3	.82	20.32				1.71	79.61				3.18	110.03				2.37	35.07				

COMPUTATION SHEET
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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA | PROJECT: BUCKHORN-MESA WPP - SPOOK HILL FRS
BY: A.C. | DATE | CHECKED BY: 7-26-76 | DATE | JOB NO.: 2005
SUBJECT: Road Ramp Hydrology | SHEET 26 OF

Time (Days)	I_1 at (Ac-ft)	S_I (Ac-ft)	Elev. (MSL-ft)	Q_p (Q_p at) (cfs) (Ac-ft)	O_I at (Ac-ft)	I_{II} at (Ac-ft)	S_{II} (Ac-ft)	Elev (ft)	Q_1 (Q_1 at) cfs (Ac-ft)	O_{II} at (Ac-ft)	I_{III} at (Ac-ft)	S_{III} (Ac-ft)	Elev. (ft)	Q_2 (Q_2 at) cfs (Ac-ft)	O_{III} at (Ac-ft)	I_{IV} at (Ac-ft)	S_{IV} (Ac-ft)	Elev. (ft)	Q_3 Q_3 at cfs (Ac-ft)	O_{IV} at (Ac-ft)
246.03 5.3	.82	20.32	1578.44	119 (23.60)	X	1.71	79.61	1578.59			3.18	110.63	1578.75			2.37	35.07	1578.80		
5.3	.82	18.81	1578.38	107 (21.22)	1.51	1.71	75.50	1578.53	99 (19.71) (93) not enough	4.11	3.18	99.50	1578.60	79 (15.60) (63) not enough head	10.53	2.37	30.00	1578.65	26 (5.07) (42) too much head	5.07

Although the reservoirs are not quite balance for the lost time interval, it is obvious that all reservoirs have reached their maximum levels as follows (10yr storm)

Max level	reservoir	Road elevations
1578.40	(1)	
1578.55	(2)	McDowell (now at 1580.7)
1578.71	(3)	McKellips (now at 1582.1)
1578.87	(4)	Brown Road

STATE		PROJECT		
AZ		BUCKHORN MESA WPP - SPOOK HILL F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-7-76			
SUBJECT				SHEET 24 OF
Road Ramp Hydrology				

Roman Numeral Subscripts will be used to identify the reservoirs

$$\bar{I}_I + \frac{S_{1I}}{\Delta t} - \frac{O_{1I}}{2} = \frac{S_{2I}}{\Delta t} + \frac{O_{2I}}{2}$$ and similarly for II, III, IV

$O_2 = Q_1 - Q_2$

$O_I = Q_p - Q_1 \quad O_{II} = Q_1 - Q_2 \quad O_{III} = Q_2 - Q_3 \quad O_{IV} = Q_3$

$\Sigma \bar{O} = Q_p \quad Q_p = f(E_I \text{ (elevation)}), E_I = f(S_I), Q_1 = f(E_{II} - E_I), Q_2 = f(E_{III} - E_{II})$

$Q_3 = f(E_{III} - E_{III})$

Because of the nature of the hydrograph (flash flood), and the complexity of the problem, the following equation will be used

$$\bar{I}\Delta t + S_1 - \frac{Q_1}{2}\Delta t = S_2 + \frac{Q_2}{2}\Delta t$$

$\bar{I}\Delta t$ = the change in storage from the mass curves (sheets 5, 7, 9, 11)
S = total storage at some time
O = average outflow over the time period Δt

All four mass curves will be run simultaneously

all values from previous time to ending time i.e. @ T = .1 use values for change from 0 to .1

Steps

1) at time = 0, all values = 0, take values from PSMC to get $\bar{I}\Delta t$ and S_1 (for all four reservoirs), first trial S should correspond to value on mass curve, value of $\bar{I}\Delta t$ is difference in PSMC values
2) determine reservoir elevation from sheet 16
3) determine Q_p from sheet 17 ($Elev_{II} - Elev_I$)
4) determine Q_1, Q_2, Q_3 from change in elev. and sheet 18 (cfs)
5) use average Q values to determine $O\Delta t$, $O\Delta t = \Sigma Q_s \times \Delta t / 1.983 = Ac\,ft$
6) adjust S value and repeat steps 2-5, (values may oscillate because of large unrealistic discharges), except: step 4 determine total outflow, step 5 determine Q and check against step 4.

In step 5, make sure that the average value is taken of your trial and the final value of the last time period, not averages of your trials

- note: a guess of elevations must be tried in some cases, make sure that the sum of the 4 storages $S_I + S_{II} + S_{III} + S_{III}^{+Qp}$ = constant. = Σ values from PSMC

R-7-E
R-8-E
T-2-N
T-1-N
NATIONAL FOREST
MARICOPA CO
PINAL CO.
℄ CAP Canal
℄ Spookhill Dam
HIGHWAY
PUSH
FLOODWAY
SIGNAL BUTTE
SIGNAL BUTTE FLWY
BULL DOG DIVERSION
APACHE JCT. FLWY
APACHE JUNCTION
APACHE TRAIL

	Sq. Mi.
4	4.51
3	5.36
2	2.64
1	1.06
	13.57

BUCKHORN MESA
Scale: 1" = 2000'
8/7/73
Revised 5/14/74
Rerevised 2/19/75

STATE AZ		PROJECT Buckhorn Mesa WPP - Spook Hill FRS		
BY A.C.	DATE 7-26-76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Road Ramp Hydrology				SHEET 27 OF

Comparison of two methods

reservior	Robin's short cut	Reservior Balancing	Difference
①	1578.15	1578.40	-.35
②	1578.16	1578.55	-.39
③	1578.20	1578.71	-.51
④	1579.12	1578.87	+.25

Several conditions effect the relative results.

1. There is continual flow between reservoirs
2. flow can be in either direction
3. Storage volume v.s. drainage area for set elevations vary
4. a flash flood condition exists.

The short cut method has usable applications. It would seem that it would give conservative results for a two reservior system (one road ramp). If a realistic base flow figure could be added to simulate flow between reservoirs, then the method may be useable for a series of reservoirs.

The following road elevations will be used

McDowell Road. - 1578.7

McKellips Road - 1578.8

Brown Road - 1579.0

STATE		PROJECT		
AZ		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	8-2-76			2005
SUBJECT				SHEET 1 OF
Freeboard Design - Road Ramps				

The road ramps have been designed. The next step is determining the maximum elevation of the top of the dam. It is hoped that the road ramps will not cause headlosses that will cause overtopping up stream.

Cross sections at Road Ramps (⊥ to dam, not along road) from ℄

Brown Road

Natural Ground		Road Ramp	
offset	Elev.	offset	Elev.
0	1575	0	1591
100	1576	150	1590
210	1578	250	1582
300	1580	290	1580.25
520	1582	440	1580.25
610	1584	520	1582
680	1586	610	1584
770	1588	680	1586
860	1590	770	1588
950	1592	860	1590
		950	1592

McKellips Road

offset	Elev.
0	(1592)
140	1591
240	1589.7
390	1582.3
510	1579.7
670	1579.7
755	1580.8
1000	1589.0
1080	1590.0
1300	1592.0

McDowell Road

offset	Elev.
200	1591.25
300	1589.8
450	1582.6
550	1579.6
670	1579.6
790	1582.8
815	1589.8
915	1592

STATE Az		PROJECT Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY A.C.	DATE 8-2-76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Freeboard Design - Road Ramps				SHEET 2 OF

INFORMATION FROM TR-20 ROUTING - see map.

Drainage Area #	Total water	Peak discharge	Peak time	Res. discharge
14	129.64 Ac-Ft	1590	3.03 hrs	-
(52)	129.47	-	3.09	1495
15	353 Ac Ft	4325	3.03	-
(53)	482	-	3.04	5804
(54)	481	-	3.12	5533
16	631	6913	3.14	-
(55)	1113	-	3.13	12,440
(56)	1112	-	3.20	11,866
17	745	7610	3.18	
(57)	1857	-	3.19	19,474
(58)	1857	-	3.26	18,621
(59)				
Output into reservior				
18	477	5125	3.16	-
(60)	1210	-	3.16	8013 Brow Road
19	2142	15,674	3.47	-
(61)	3348	-	3.36	22,272
20	662	6,492	3.22	-
(62)	4,011	-	3.30	28,412 McKellips Rd
21	1,002	9124	3.27	-

STATE		PROJECT		
Az		Buckhorn Mesa W.P.P. Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	8-2-76			2005
SUBJECT				SHEET 3 OF
Freeboard Design - Road Romps				

(63)	5014	-	3.29	37,699 McDowell Rd.
22	980	9945	3.18	—
(64)	5994	-	3.26	47,315 E.S.

Estimate of discharges

At Brown Road - At peak discharge, 8013 cfs, the total Volume of inflow is 1210 Ac-ft - reservior capacity is 692 Ac-ft

Ave discharge $\frac{6268 \text{ cfs hrs}}{3.16 \text{ hrs}} = 1,984$ cfs max ≈ 4000 cfs

difference between 8000 and 4000 cfs figures is storage

At McKellips Road - At peak discharge, 28,412 cfs, the total Volume of inflow is 4,011 Ac-ft - reservior capacity is 1670+692 or 2362 Ac-ft (diff = 1649 Ac ft = 19,953 cfs hrs)

Ave Q = $\frac{19,953 \text{ cfs-hrs}}{3.30 \text{ hrs}} = 6,046$ cfs max ≈ 12,000 cfs

At McDowell Road - At peak discharge, 37,699 cfs, the total Volume of inflow is 5014 Ac-ft - reservior capacity = 1283+1670+692 or 3,645 Ac-ft (diff = 1369 Ac-ft = 16,565 cfs-hrs)

Ave Q = $\frac{16,565 \text{ cfs-hr}}{3.29 \text{ hrs}} = 5,035$ cfs max ≈ 11,000 cfs

At Emergency Spillway - peak discharge, 47,315, total vol. = 5994

res: capacity = 4063 diff = 1931 Ac-ft = 23,365 cfs-hrs

$\frac{23,365}{3.26} = 7,167$ max ≈ 15,000 cfs

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	8-2-76			2005
SUBJECT				SHEET 4 OF
Freeboard Design - Road Ramps				

The estimates on the previous page were gross estimates The timing of the inflows will greatly effect outflows. Another method for estimating the discharges across the roads is to proportion the discharges across the road and through the spillway to the maximum discharges of the reaches.

Max. Q	→ proper. Q	est. Q	→ prop. Q	ΔS (cfs hrs)	→ prop. Q
47,315	18,338	15,000	18,338	23,365	18,338
37,699	14,611	11,000	13,448	16,565	13,001
28,412	11,012	12,000	14,670	19,953	15,660
8,013	3,105	4,000	4,890	6,268	4,919

Max. Q's are unreasonable, if this Q were to pass McDowell Road, the w.s. downstream would soon be much higher than the upstream w.s. and the routed elevation at the E.S. It would be feasible for the discharge across McDowell Road to be greater that the E.S. discharge, but this would be a very small difference at these elevation (near top of dam). It would be reasonable to use the following discharges

Sta 293+00 (E.S.) to Sta 175+00 – 18,338 cfs

Sta 175+00 to Sta 220+00 – 17,000 cfs McDowell Sta 273+00 ±

Sta 220+00 to Sta 140+00 – 15,000 cfs McKellips Sta 210+00 ±

Sta 140+00 to Sta 110+00 – 5,000 cfs Brown Road Sta 131+00 ±

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	8-2-76			2005
SUBJECT				SHEET 5 OF
Freeboard Design - Road Ramps				

Backwater curves were run from Sta 293+00 to 115+00 carrying 18,338 cfs all the way. Both McDowell and McKellips Road Ramps were included, Brown Road was not. The road ramp designs have been changed. The area of the openings (at the ramps) are slightly greater and have been lowered several feet. The water surface elevation at 115+00 was 1591.023. One can easily see that with the modified discharges and the new road ramp designs that the addition of the ramp at Brown Road should not cause overtopping of the dam.

It should be noted that there will be an overflow section on the Signal Butte Floodway so that only the 100 yr discharge will reach the dam. This is why the inflow into the area below Brown Road is so much lower than the other reserviors.

It was felt by both Robin and I that his approach would not give reasonable results in this case. (while it would be ok on the Buckeye structure).

EXECUTIVE CONTROL CARD 119 OPERATION INCREM, MAIN TIME INCREMENT= 0.20
EXECUTIVE CONTROL CARD 120 OPERATION COMPUT, FROM XSECTN/STRUCT 14/ 0 TO XSECTN/STRUCT 66/ 0
STARTING TIME= 0.00 RAIN DEPTH= 13.00 RAIN DURATION= 6.00 RAIN TABLE NO.= 2 SOIL CONDITION= 2
ALTERNATE NO.= 1 STORM NO.= 3

SUBROUTINE RUNOFF CROSS SECTION 14
AREA= 0.25 INPUT RUNOFF CURVE= 75.0 TIME OF CONCENTRATION= 0.38
COMPUTED CURVE NO. = 75.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.03	1589.938	(RUNOFF)
5.81	52.419	(RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7234 CFS-HRS= 1568.80 ACRE-FT= 129.64

SUBROUTINE REACH CROSS SECTION 52
LENGTH= 2450.00 INPUT COEFFICIENT= 0.8700 INPUT ROUTINGS= 0.00

AVERAGE WATER VELOCITY= 9.399 ROUTING COEFF= 0.8700 MODIFIED COEFFICIENT= 0.9984

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.09	1495.269	(NULL)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7106 CFS-HRS= 1566.74 ACRE-FT= 129.47

SUBROUTINE RUNOFF CROSS SECTION 15
AREA= 0.68 INPUT RUNOFF CURVE= 75.0 TIME OF CONCENTRATION= 0.38
COMPUTED CURVE NO. = 75.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.03	4324.633	(RUNOFF)
5.81	142.600	(RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7234 CFS-HRS= 4267.13 ACRE-FT= 352.63

SUBROUTINE ADDHYD CROSS SECTION 53
INPUT HYDROGRAPHS= 5,6 OUTPUT HYDROGRAPH= 7

DUE TO STORAGE OVERFLOW, THE SUM OF HYDROGRAPHS 5 AND 6 WAS TRUNCATED HERE TO 100 VALUES.

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.04	5803.946	(NULL)
5.74	194.762	(NULL)

HYDROGRAPH, TZERO= 1.40 DELTA T= 0.20 DRAINAGE AREA= 0.93

TIME											
1.40	DISCHG	0.00	12.92	57.78	140.78	527.50	1506.56	2748.84	4202.30	5752.02	5149.05
3.40	DISCHG	2594.54	1360.15	907.26	702.55	575.91	498.25	425.49	364.72	320.71	256.32
5.40	DISCHG	225.21	193.91	194.67	192.38	138.02	50.90	14.90	4.13	1.00	0.11
7.40	DISCHG	0.00	0.00								

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7199 CFS-HRS= 5833.87 ACRE-FT= 482.11

SUBROUTINE REACH CROSS SECTION 54
LENGTH= 3600.00 INPUT COEFFICIENT= 0.9000 INPUT ROUTINGS= 0.00

AVERAGE WATER VELOCITY= 11.800 ROUTING COEFF= 0.9000 MODIFIED COEFFICIENT= 0.9976

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.12	5533.182	(NULL)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7071 CFS-HRS= 5826.17 ACRE-FT= 481.47

SUBROUTINE RUNOFF CROSS SECTION 16
AREA= 1.22 INPUT RUNOFF CURVE= 75.0 TIME OF CONCENTRATION= 0.56
COMPUTED CURVE NO. = 75.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.14	6913.367	(RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7050 CFS-HRS= 7641.28 ACRE-FT= 631.47

SUBROUTINE ADDHYD CROSS SECTION 55
INPUT HYDROGRAPHS= 5,6 OUTPUT HYDROGRAPH= 7

DUE TO STORAGE OVERFLOW, THE SUM OF HYDROGRAPHS 5 AND 6 WAS TRUNCATED HERE TO 100 VALUES.

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.13	12440.226	(NULL)

HYDROGRAPH, TZERO= 1.40 DELTA T= 0.20 DRAINAGE AREA= 2.15

TIME											
1.40	DISCHG	0.00	17.08	87.42	235.28	812.18	2448.67	4969.16	8055.57	11435.77	12192.02
3.40	DISCHG	8445.10	4657.55	2858.78	2033.08	1578.86	1298.36	1090.93	921.49	799.98	669.95
5.40	DISCHG	563.61	490.94	457.21	449.27	374.70	211.14	84.37	31.76	11.98	4.45
7.40	DISCHG	1.59	0.46	0.04	0.00						

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7059 CFS-HRS= 13467.45 ACRE-FT= 1112.95

SUBROUTINE REACH CROSS SECTION 56
LENGTH= 5200.00 INPUT COEFFICIENT= 0.9500 INPUT ROUTINGS= 0.00

AVERAGE WATER VELOCITY= 16.000 ROUTING COEFF= 0.9500 MODIFIED COEFFICIENT= 0.9990

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.20	11865.933	(NULL)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.6999 CFS-HRS= 13459.13 ACRE-FT= 1112.26

SUBROUTINE RUNOFF CROSS SECTION 17
AREA= 1.44 INPUT RUNOFF CURVE= 75.0 TIME OF CONCENTRATION= 0.66
COMPUTED CURVE NO. = 75.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS

3.18 7609.617 (RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7030 CFS-HRS= 9017.35 ACRE-FT= 745.19

SUBROUTINE ADDHYD CROSS SECTION 57
INPUT HYDROGRAPHS= 5,6 OUTPUT HYDROGRAPH= 7

DUE TO STORAGE OVERFLOW, THE SUM OF HYDROGRAPHS 5 AND 6 WAS TRUNCATED HERE TO 100 VALUES.

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.19	19473.527	(NULL)

TIME		HYDROGRAPH, TZERO= 1.40			DELTA T= 0.20			DRAINAGE AREA= 3.58			
1.40	DISCHG	0.00	17.46	98.31	293.03	975.10	2978.31	6529.35	11233.41	16544.84	19472.73
3.40	DISCHG	16380.42	10387.87	6251.63	4202.98	3114.67	2468.81	2031.79	1697.78	1442.17	1221.18
5.40	DISCHG	1026.24	881.73	796.56	763.10	681.41	466.39	236.05	100.22	42.64	18.34
7.40	DISCHG	7.81	3.18	1.09	0.24	0.00	0.00				

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7012 CFS-HRS= 22476.49 ACRE-FT= 1857.45

SUBROUTINE REACH CROSS SECTION 58
LENGTH= 2500.00 INPUT COEFFICIENT= 0.8500 INPUT ROUTINGS= 0.00

AVERAGE WATER VELOCITY= 8.200 ROUTING COEFF= 0.8500 MODIFIED COEFFICIENT= 0.9948

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.26	18621.230	(NULL)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7002 CFS-HRS= 22474.23 ACRE-FT= 1857.27

SUBROUTINE DIVERT CROSS SECTION 59
INPUT HYDROGRAPH= 6 OUTPUT HYDROGRAPHS= 2,1

SUBROUTINE RUNOFF CROSS SECTION 18
AREA= 0.92 INPUT RUNOFF CURVE= 75.0 TIME OF CONCENTRATION= 0.60
COMPUTED CURVE NO. = 75.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.16	5125.133	(RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7130 CFS-HRS= 5767.04 ACRE-FT= 476.58

SUBROUTINE ADDHYD CROSS SECTION 60
INPUT HYDROGRAPHS= 7,2 OUTPUT HYDROGRAPH= 6

DUE TO STORAGE OVERFLOW, THE SUM OF HYDROGRAPHS 7 AND 2 WAS TRUNCATED HERE TO 100 VALUES.

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.16	8012.993	(NULL)

TIME	HYDROGRAPH, TZERO= 1.40	DELTA T= 0.20	DRAINAGE AREA= 4.50

1.40	DISCHG	0.00	17.28	100.61	313.77	1029.87	3157.19	4787.21	6026.90	7406.59	7982.30
3.40	DISCHG	6736.19	5183.49	4346.93	3908.57	3656.98	3319.59	2696.24	2239.29	1893.58	1604.68
5.40	DISCHG	1351.18	1154.80	1029.66	970.11	879.10	649.86	369.86	172.14	73.66	31.57
7.40	DISCHG	13.53	5.58	2.03	0.56	0.09	0.00	0.00			

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 5.0320 CFS-HRS= 14646.50 ACRE-FT= 1210.38

SUBROUTINE RUNOFF CROSS SECTION 19
AREA= 4.08 INPUT RUNOFF CURVE= 76.0 TIME OF CONCENTRATION= 1.19
COMPUTED CURVE NO. = 76.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.47	15674.419	(RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.8426 CFS-HRS= 25916.78 ACRE-FT= 2141.76

SUBROUTINE ADDHYD CROSS SECTION 61
INPUT HYDROGRAPHS= 5,6 OUTPUT HYDROGRAPH= 7

DUE TO STORAGE OVERFLOW, THE SUM OF HYDROGRAPHS 5 AND 6 WAS TRUNCATED HERE TO 100 VALUES.

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.36	22271.828	(NULL)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 7.3082 CFS-HRS= 40514.69 ACRE-FT= 3348.13

SUBROUTINE RUNOFF CROSS SECTION 20
AREA= 1.28 INPUT RUNOFF CURVE= 75.0 TIME OF CONCENTRATION= 0.73
COMPUTED CURVE NO. = 75.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.22	6492.154	(RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.7006 CFS-HRS= 8013.40 ACRE-FT= 662.22

SUBROUTINE ADDHYD CROSS SECTION 62
INPUT HYDROGRAPHS= 7,6 OUTPUT HYDROGRAPH= 5

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.30	28412.089	(NULL)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 7.6190 CFS-HRS= 48531.55 ACRE-FT= 4010.64

SUBROUTINE RUNOFF CROSS SECTION 21
AREA= 1.91 INPUT RUNOFF CURVE= 76.0 TIME OF CONCENTRATION= 0.83
COMPUTED CURVE NO. = 76.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.27	9123.519	(RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 9.8402 CFS-HRS= 12129.66 ACRE-FT= 1002.39

SUBROUTINE ADDHYD CROSS SECTION 63
INPUT HYDROGRAPHS= 5,6 OUTPUT HYDROGRAPH= 7

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.29	37698.968	(NULL)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 7.9805 CFS-HRS= 60671.92 ACRE-FT= 5013.92

SUBROUTINE RUNOFF CROSS SECTION 22
AREA= 1.79 INPUT RUNOFF CURVE= 79.0 TIME OF CONCENTRATION= 0.67
COMPUTED CURVE NO. = 79.0

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.18	9945.316	(RUNOFF)

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 10.2663 CFS-HRS= 11859.84 ACRE-FT= 980.09

SUBROUTINE ADDHYD CROSS SECTION 64
INPUT HYDROGRAPHS= 7,6 OUTPUT HYDROGRAPH= 5

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
3.26	47314.890	(NULL)

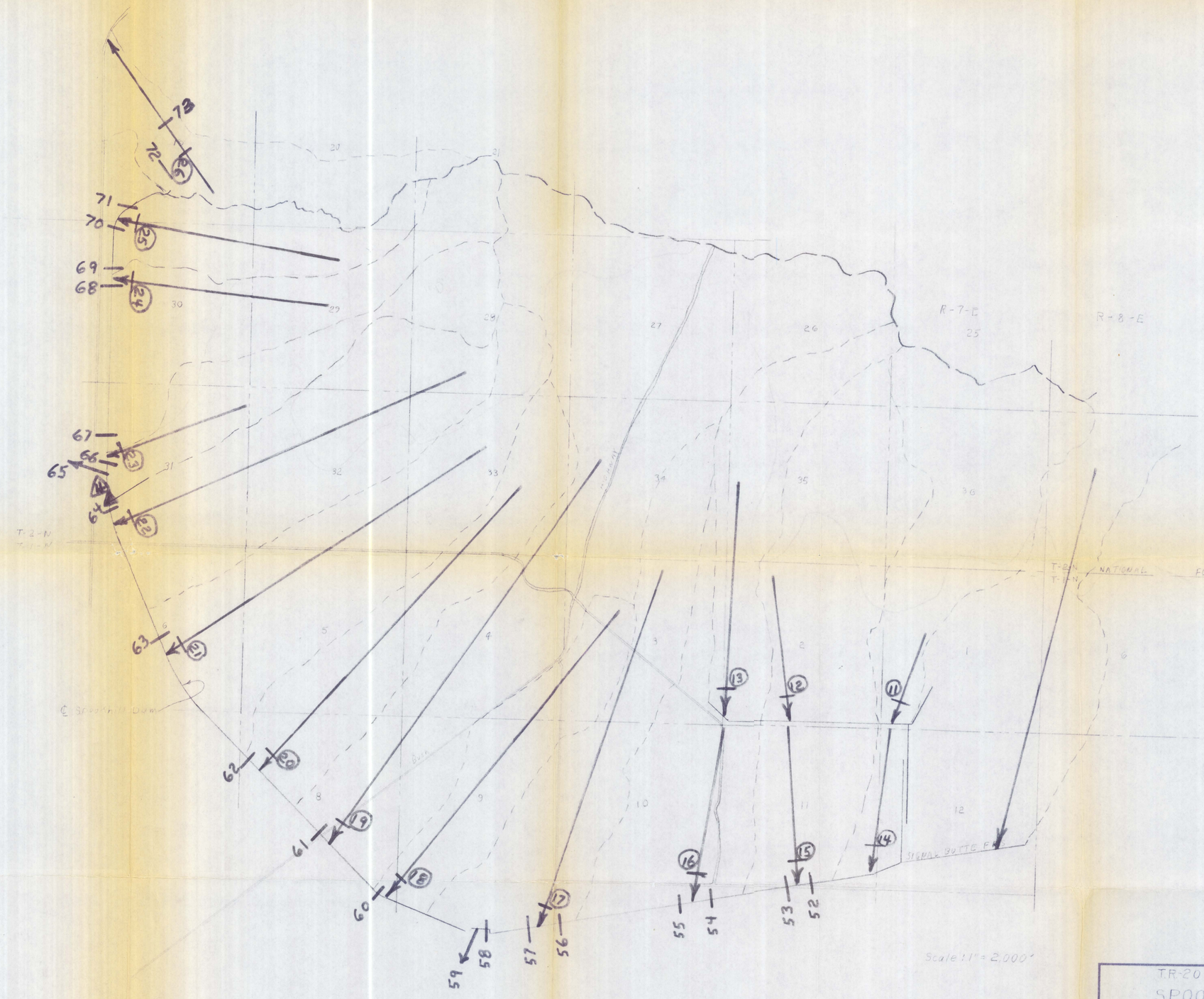
TIME		HYDROGRAPH, TZERO= 1.20				DELTA T= 0.20			DRAINAGE AREA= 13.56		
1.20	DISCHG	0.00	7.07	83.21	345.31	954.64	2963.57	8493.17	16380.25	26426.15	38401.95
3.20	DISCHG	46796.50	44920.62	36567.94	28266.30	21922.87	17277.19	13812.85	11024.56	8960.26	7385.24
5.20	DISCHG	6126.78	5087.38	4287.12	3721.64	3364.81	2975.65	2305.26	1535.77	937.56	562.69
7.20	DISCHG	341.34	208.77	130.55	81.86	51.24	32.20	20.28	12.76	7.95	4.93
9.20	DISCHG	2.93	1.61	0.66	0.15	0.00					

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 8.2820 CFS-HRS= 72531.78 ACRE-FT= 5994.02

SUBROUTINE RESVOR STRUCTURE 4
SURFACE ELEVATION= 1579.01 **Freeboard Routing**

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
1.49	174.212	1579.10
4.04	21285.835	1589.38 ← Use

TIME		HYDROGRAPH, TZERO= 1.20				DELTA T= 0.20			DRAINAGE AREA= 13.56		
1.20	DISCHG	0.00	155.24	154.06	154.71	162.09	191.38	281.61	485.22	832.89	2404.06
3.20	DISCHG	5677.48	13221.08	17894.94	20447.59	21256.12	20967.98	20024.44	18688.78	17149.31	15560.24
5.20	DISCHG	14084.88	12760.72	11499.72	9796.48	7039.33	6697.43	6338.94	5948.50	5532.14	5109.57
7.20	DISCHG	4698.01	4307.17	3941.56	3687.15	3540.57	3398.92	3168.33	2781.23	2440.92	2264.02
9.20	DISCHG	2142.83	2028.06	1919.37	1816.48	1719.09	1552.86	1275.20	1062.98	1045.03	1027.39
11.20	DISCHG	1010.05	993.00	976.24	959.76	943.55	927.62	911.97	896.57	881.44	866.56
13.20	DISCHG	854.74	846.39	838.11	829.91	821.80	813.76	803.57	789.47	775.62	762.01
15.20	DISCHG	748.65	735.51	722.61	709.94	697.48	685.25	673.23	661.42	649.81	638.42
17.20	DISCHG	627.22	616.21	605.40	594.78	584.35	574.10	564.03	554.14	544.41	534.86
19.20	DISCHG	525.48	516.26	507.21	498.31	489.57	480.98	472.54	464.25	456.11	448.11



TR-20 LINE DIAGRAM
SPOOK HILL F.R.S.
BUCKHORN MESA W.P.P.
MARICOPA COUNTY, ARIZONA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by	
Drawn DAT	2-75	Title	
Traced		Title	
Checked		Sheet No. of	Drawing No.

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SCS-ENG-313 Rev. 8-72

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
Burton	6/11/75			2005
SUBJECT				SHEET 1 OF 2
Hydraulics - Low Flow Channel				

Design Criteria:

Q = 808 cfs.

n = 0.035

S = 0.00020

Max. allowable flow depth = 12.0 ft.

Assume side slopes 2:1 & 3:1 (This is conservative in that the upper part of the flow depth will run out of the design channel and spread over the natural reservoir area.)

Determine:

Minimum design bottom width

Try: b = 20 ft.

20.000000	b
-2.500000	z
0.000200	S
0.035000	n
808.000000	Q
9.000000	
723.808786	
9.503998	
810.889285	
9.487812	
808.002636	
9.487798	d
807.999999	Q
1.947918	V
414.801742	A

"d" is less than 12.0 ft.

∴ try narrower "b".

STATE Arizona		PROJECT Buckhorn Mesa WPP - Spook Hill FRS.		
BY Burton	DATE 6/11/75	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Hydraulics - Low Flow Channel				SHEET 2 OF 2

Try: b = 10.0 ft.

```
 10.000000 b
  2.500000 z
  0.000200 S
  0.035000 n
808.000000 Q
 10.000000
653.962300
 11.026392
819.335173
 10.960614
808.046678
 10.960340 d
807.999994 Q
  1.971086 V
409.926096 A
```

d ≈ 11 ft < 12.0 minimum ∴ O.K.

For construction ease a 12.0 ft bottom width may be better.

Try: b = 12.0 ft

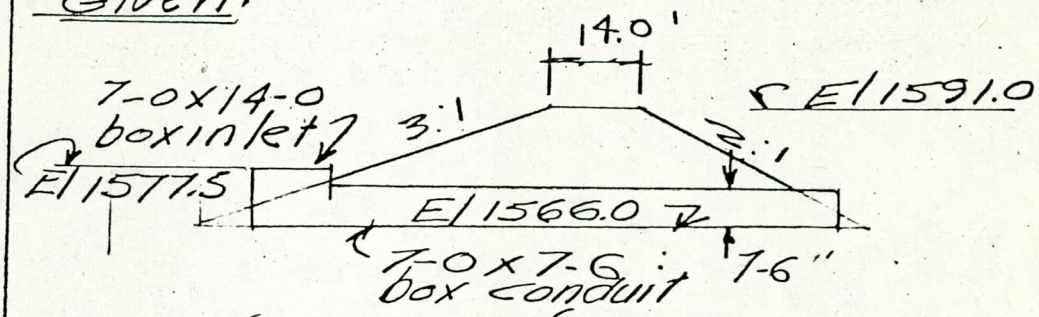
```
 12.000000 b
  2.500000 z
  0.000200 S
  0.035000 n
808.000000 Q
 10.500000
784.544638
 10.638870
808.217082
 10.637607 d
807.999990 Q
  1.968100 V
410.548045 A
```

Use: b = 12.0 ft.

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	10-22-75			

SUBJECT Principal Spillway Outlet — SHEET 1 OF 2

Given:



Q = 808 cfs

Find: Most desireable outlet

Solution Set up and solve a matrix of alternates vs considerations

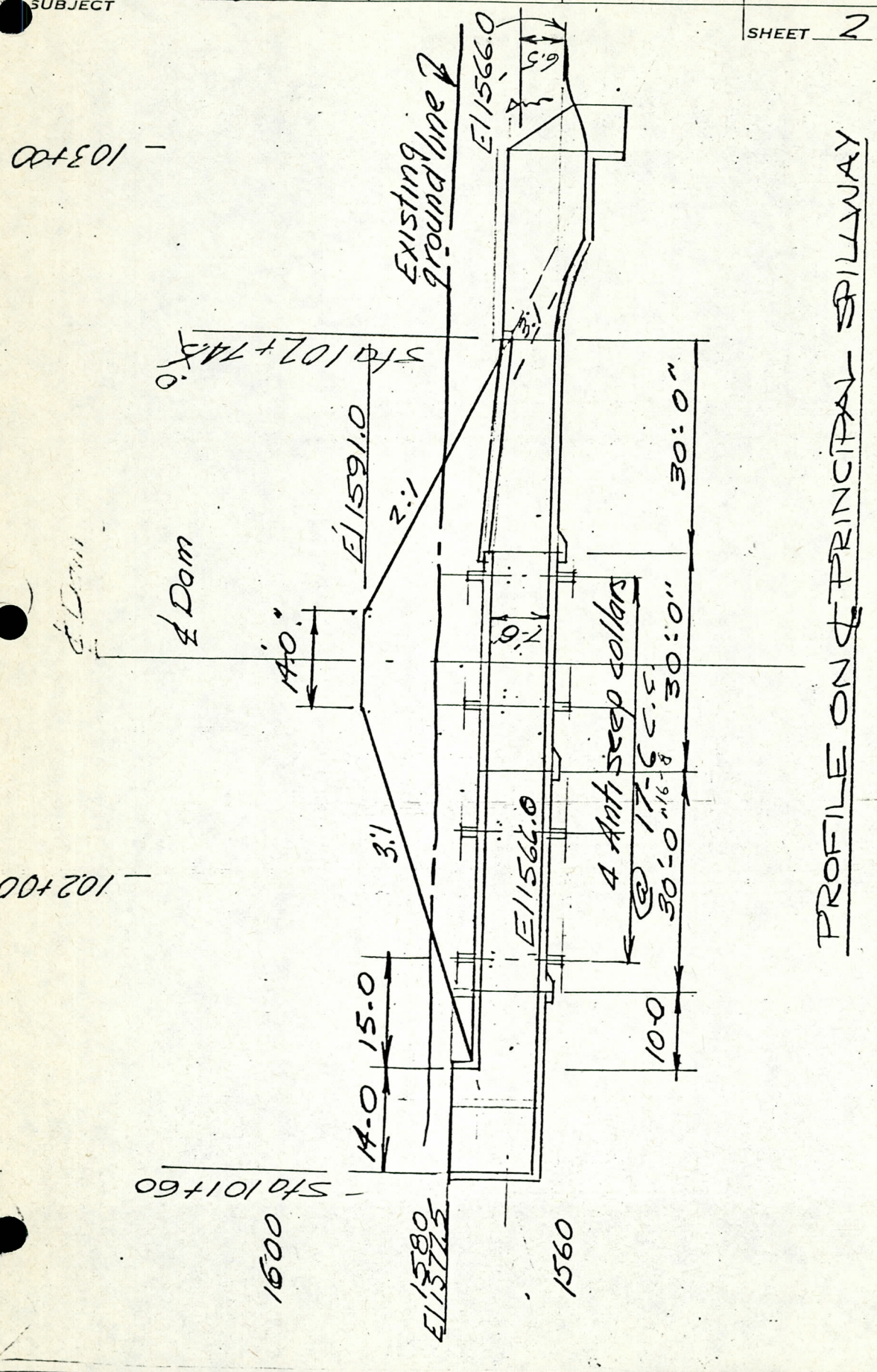
	.20 Hydraulics Design	.13 Alignment	.20 Structural Design	.13 Aesthetics	.14 Simplicity	.20 Cost	
1. SAF Basin	8	6	9	6	3	4	6.18
2. Cantilever	4	5	6	4	10	7	5.97
3 30° Wingwalls	3	4	5	5	8	6	5.09
4 45° Wingwalls	2	4	5	5	8	6	4.89
5 PWP Basin	4	6	9	6	4	5	5.72

Proportion the principal spillway w/ SAF outlet.

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	10-12-75			

SUBJECT

SHEET 2 OF 3



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B	11-7-75			2005
SUBJECT				SHEET 3 OF
Principal Spillway outlet				

Consider side walls to diverge at 10:1
Begin diverging at sta 102+44.00
with full conduit flow of 7.5'

Q = 808 c.f.s. — n = 0.014 - S = 0.00
Eddy factor 0.2 - alpha 1.15

sta. 102+44.0, Elev. 1566.0 b = 7.0'
z = 0.00 — D, 7.5'

	Si	sta.	b	z
	0.0	102+44.0	7.0	0.0
		102+49.0	8.0	
		102+54.0	9.0	
		102+59.0	10.0	
		102+64.0	11.0	
		102+69.0	12.0	
		102+74.0	13.0	
start vert. curve.	0.0278	102+75.0	13.20	
	0.0833	102+76.0	13.40	
	0.1389	102+77.0	13.60	
	0.1940	102+78.0	13.80	
	0.2500	102+79.0	14.00	
	0.306	102+80.0	14.20	
	0.333	102+82.0	14.60	
		102+84.0	15.00	
		102+86.0	15.40	
		102+88.0	15.80	
		102+90.0	16.20	
		102+92.0	16.60	
		102+94.0	17.00	

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	11-10-75			2005
SUBJECT				SHEET 4 OF
Principal Spillway outlet				

use 10:1 diverging walls
Froude number 3.030n Monroe 1880 print out occurs at sta 102+87
For an even bottom width for the basin use sta 102+88 - Flow depth 2.032' (call 2ft.)

Design Criteria For SAF STILLING Basin
page 2.197 NEH #14 ES 73

Details of layout for floor and chute blocks

1. Height of floor and chute blocks is d_1 = 2.0 ft.

2. Width and spacing of floor and chute blocks approx.

$$\frac{3d_1}{4} = \frac{(3)(2.0\text{ft.})}{4} = 1.5 \text{ ft. or } 1 \text{ ft. } 6 \text{ in.}$$

3. No Floor block should be placed closer to side wall than $\frac{3d_1}{8} = \frac{(3)(2\text{ ft})}{8} = 0.75$ ft. or 9 inches

4. Floor blocks occupy between 40 and 55 percent of stilling basin width of blocks

5. Chute blocks to be staggered with Floor blocks

6. A Portion of a chute block or a whole chute block may be adjacent to a sidewall.

7. Space between sidewall and First chute block is not to be greater than Approx. $\frac{3d_1}{4}$ or 1.5' or 1' 6"

8. Blocks are to be symmetrical about stilling basin center line,

Q = 808 c.f.s. Sta. 102+44.00 outlet conduit

Elev. outlet 1566.0 ft., bottom width 7ft.

sta 102+74.00 begin chute with vertical curve 6' long drop in elev. 1 ft. to elev of 1565.0 at sta 102+80.00

bottom width 102+74.00 is 13.0ft.

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	11-10-75			2005
SUBJECT. Principal Spillway Outlet				SHEET 5 OF

start floor blocks at sta. 102+88.00
elev. 1562.33
bottom width 15.80 ft.

F_1 = Froude's number = 3.11

V_1 = 25.16 f.p.s. entrance vel. to SAF

d_1 = 2.0' entrance depth of water

L_B = length of SAF stilling basin in feet

$$L_B = \frac{4.5\, d_2}{F_1^{0.38}}$$

$$d_2 = \frac{d_1}{2}\left(-1+\sqrt{8F_1+1}\right) = \frac{2.032'}{2}\left(-1+\sqrt{24.88+1}\right)$$

$$d_2 = (1.016)(4.08723) = 4.1526 \text{ ft.}$$

$$L_B = \frac{(4.5)(4.1526)}{3.11^{0.38}} = 12.1419 \text{ ft}$$

d_2'

$$d_2' = 1.4\, d_1 F_1^{0.45} = (1.4)(2.032')(3.11^{0.45}) = 4.74 \text{ ft.}$$

J = height of sidewalls of SAF stilling basin in Feet

$$J = \frac{d_2}{3} + d_2' = \frac{4.1526}{3} + 4.74 = 6.1244 \text{ ft.}$$

S = height of Transverse end sill of SAF basin in feet

$$S = 0.07\, d_2 = (0.07)(4.1526) = 0.2907 \text{ ft.}$$

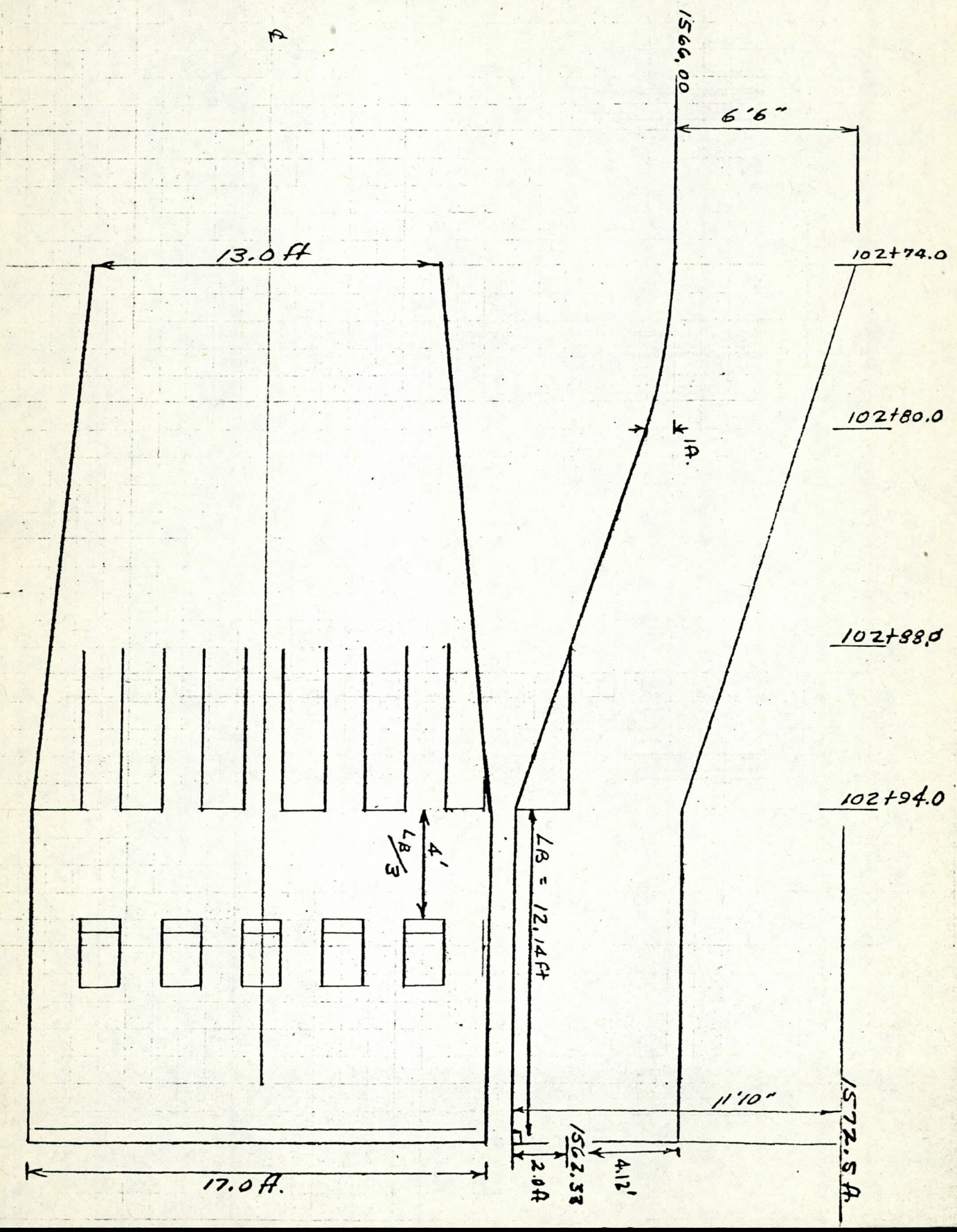
M = height of wall at start of vert. curve

$$M = 4/3\, dc = (1.333)(5.16) = 6.878 \text{ ft. or } 6'10.54''$$

Sta 102+74 dc from manual 1880 print out

b_0 = 4.25 from ES-86 for J of 6' or 6.5'

STATE		PROJECT		
Arizona		Buckhorn Mesa NPP - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	11-10-75			2005
SUBJECT				SHEET 6 OF
Principal spillway outlet				



STATE Arizona		PROJECT Buckhorn Mesa - Spook Hill		
BY Burton	DATE 4/7/75	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Stability Analysis - Basic Assumptions				SHEET 2 OF 20

Use Test Hole #7 @ Station 223+00 ± as being critical.

ML Material will be removed down to caliche layer.

A cutoff trench will extend to the sandstone.

As per Soil Mechanics report by Jim Talbot, March 6, 1975 — The stability can be checked using infinite slope procedures.

Use the following ϕ values:

SC : $\phi = 32°$

SM : $\phi = 33°$ > Use 33° for design

$\gamma_D = 120$ pcf

$C = 0$

$m = 10\%$

$\gamma_m = 120(1.10) = 132.0$ pcf

$m_s = 18\%$

$\gamma_s = 120(1.18) = 141.6$ p.c.f.

STATE Arizona | PROJECT Buckhorn Mesa - Spook Hill Dam

BY D Riddle | DATE 4/10/75 | CHECKED BY | DATE | JOB NO. 2005

SUBJECT Stability Analysis R=60 Downstream slop | SHEET 5 OF 20

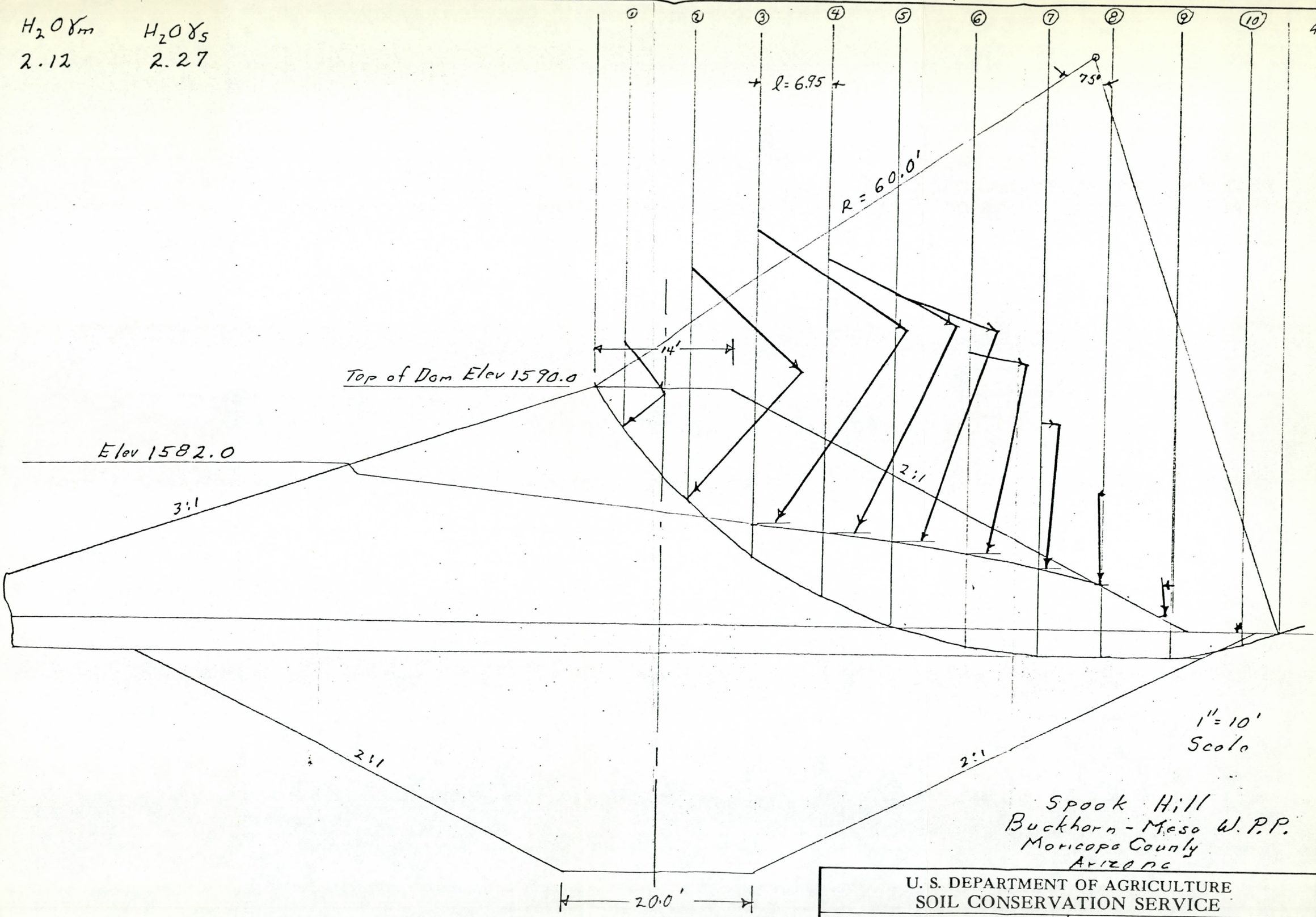
Slice	Depth	Sub Total Wt. of Slice H_2O Equiv	Total Wt. of Slice H_2O Equiv	T	N
1	4.0	8.48	8.48	6.8	5.2
2	11.0	23.32	23.32	15.5	17.5
3	12.0 3.2	25.44 7.26	32.70	18.0	23.5
4	9.2 6.3	19.50 14.30	33.80	15.0	23.5
5	6.5 8.5	13.78 19.30	33.08	11.0	22.5
6	3.6 9.6	7.63 21.79	29.42	6.0	19.0
7	1.5 9.0	3.18 20.43	23.61	2.0	14.5
8	7.2	16.34	16.34	-0.5	9.0
9	3.2	7.26	7.26	-1.1	2.9
10	0.8	1.82	1.82	-0.5	0.5
				72.7	138.1

Tan 33° = 0.64941

$$F.S. = \frac{(138.1)(0.64941)}{(72.7} = 1.23$$

$H_2O\ \gamma_m$ 2.12

$H_2O\ \gamma_s$ 2.27



1" = 10' Scale

Spook Hill
Buckhorn-Mesa W.P.P.
Maricopa County
Arizona

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	
DESIGNED BY D Riddle	APPROVED BY
CHECKED BY	DRAWING NO.
DATE: 4/10/75	SHEET 6 OF 20

U.S. GOVERNMENT PRINTING OFFICE : 1970 O—401-772

STATE Az		PROJECT Buckhorn Mesa WPP - Spook Hill FRS		
BY A.C.	DATE 3-24-76	CHECKED BY	DATE	JOB NO.
SUBJECT Line of Seepage for slope stability				SHEET 1 OF 8

Permeability from Buckeye Site I, Sta 805+00 ℄ Dam, is typical

SM-SP, $K = .003$ ft³/ft²/day $= .43$ ft/day (156 ft/yr)

Permeability from Bureau of Reclamation Geology Laboratory Permeability test

$K \simeq 1$ to 100 ft/yr (with 600 ft/yr max.)
100 ft/yr = .27 ft/day (1.64 ft/day max)

$K = .43$ ft/day is certainly justifiable

Darcy's Law

$V = Ki$ the actual water velocity $V_a = V/n$, n = porosity
for fine grained material, $n = .3$ to $.5$ use $.3$ (gives higher V)

$V_a = Ki/n$ $\quad i = h/L$

The average gradient for i will be used since no flow net has been drawn. This is conservative for gradients at the upstream face of the dam. The difference in elevation of the phreatic surface at the upstream and downstream end of the dam is about 12' (Measured from phreatic line drawn on profile). The length, scaled, is about 76 feet.

$$V_a = \frac{.43}{.3}(12/76) = .227 \text{ ft/day}$$

After 17 days, the flood pool is below elev 1577.5,

the distance traveled by the water is $.227 \times 17 = 3.8$ ft

This penetration is negligable when the Swedish circle method is used for Slope stability.

Assumptions – Permeability value - appears reasonable
Porosity – guessed conservatively
Gradient – averaged conservatively
Pool level – change in gradient not considered from drawdown

Penetration distance for absolute worst case – (unrealistic)

$$V_a = \frac{1.64}{.3}(15/80) = 1.0 \text{ ft/day}$$

penetration length $= (1.0)(20) = 20$ ft This is unrealistic

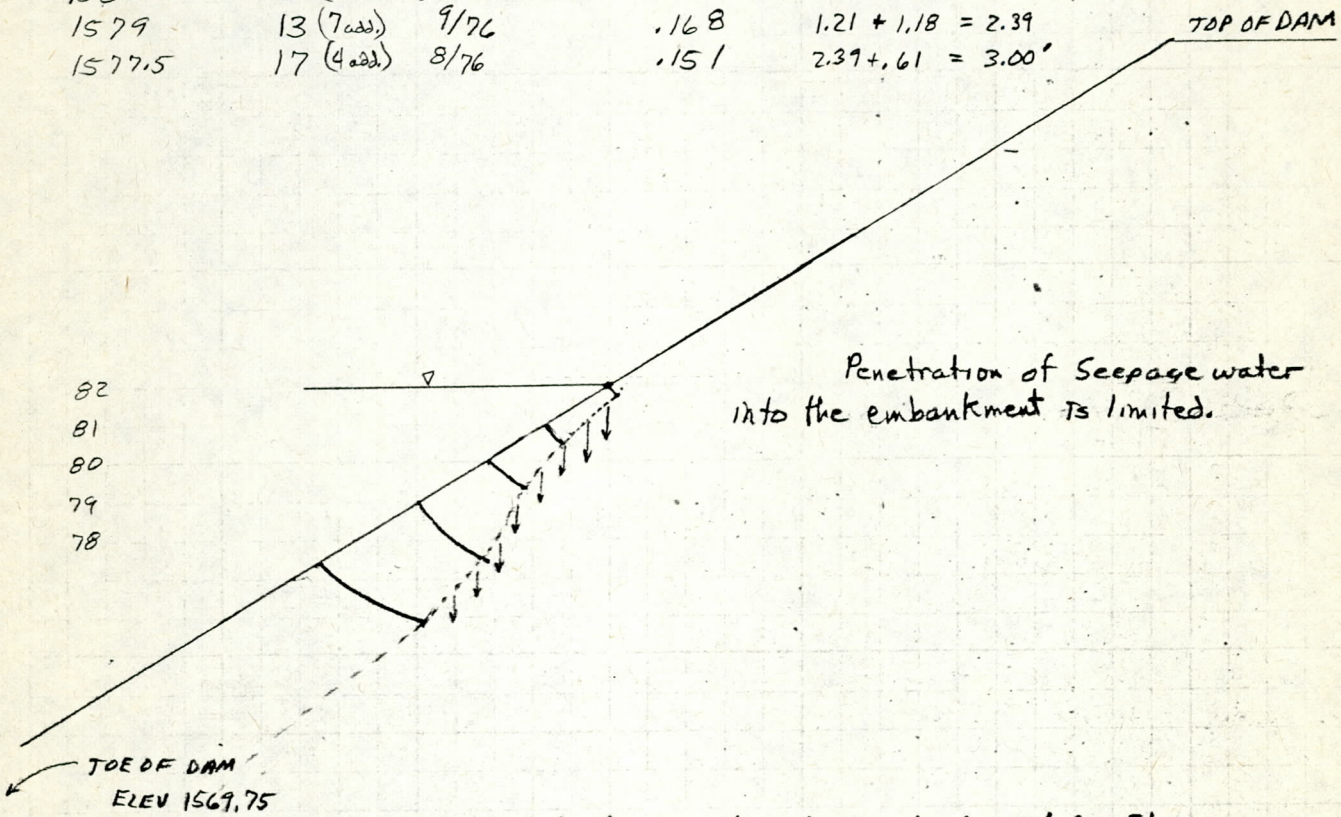
STATE		PROJECT		
AZ		BUCKHORN MESA WPP - SPOOK HILL FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	3-25-76			
SUBJECT			SHEET	OF
Penetration of water into embankment			2	8

Actual water penetration for $k = .43$ ft/day and $n = .3$

$v_n = ki/n$

$k/n = 1.43$

ELEV	Duration (Total)	i	seepage velocity (ft/day)	distance of Penetration
1582	1	12/76	.226	.226
1581	3 (2 additional)	11/76	.207	.226 + .414 = .640
1580	6 (3 additional)	10/76	.189	.640 + .567 = 1.207
1579	13 (7 add.)	9/76	.168	1.21 + 1.18 = 2.39
1577.5	17 (4 add.)	8/76	.151	2.39 + .61 = 3.00'



Penetration of Seepage water into the embankment is limited.

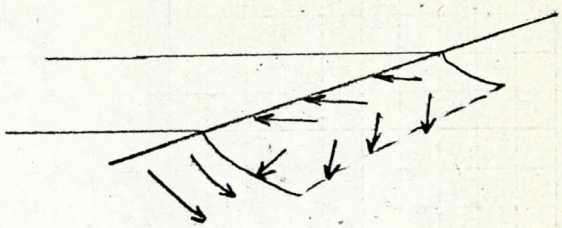
This penetration is based on steady state flow

Seepage will progress much faster toward the toe of the dam

STATE Az		PROJECT Buckhorn Mesa WPP Spook Hill FRS		
BY A.C.	DATE 3-25-76	CHECKED BY	DATE	JOB NO.
SUBJECT Drainage of embankment upon drawdown of reservior				SHEET 3 OF 8

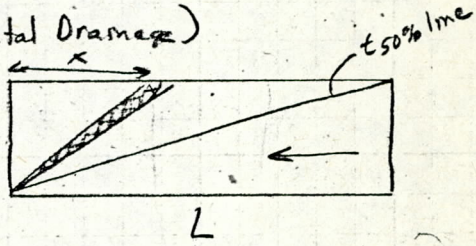
To investigate the drainage in the embankment material, a step drop is considered in the reservoir

Average drop is 6"/day



An Estimate of this situation will give at least a relative time scale for drainage

Example: Base Course Drainage (Horizontal Drainage)



From Casagrande Trans. ASCE 1952

$t = \frac{n_e C x^2}{4KH}$ at $t = 50°$ $x = L$ n_e = porosity (estimate high)
C = model study variable
= 2.4 if L/H > 5

$L = 3'$ $H = .5'$ $L/H = 6$

$t_{50} = \frac{(.4)(2.4)(3)^2}{4(.43)(.5)}$ days = 10 days - reservior drops this amount in one day

$t = 1\text{ day} = \frac{(.4)(2.4)(x)^2}{4(.43)(.5)}$ $x = .94$ ft about 1/6 the area is drained in the direction of the reservior

Vertical Drainage also takes place. Attempt is made to estimate lag between reservior level and drainage in soil.

$V_a = Ki/n$ $K = .43$, $n = .4$

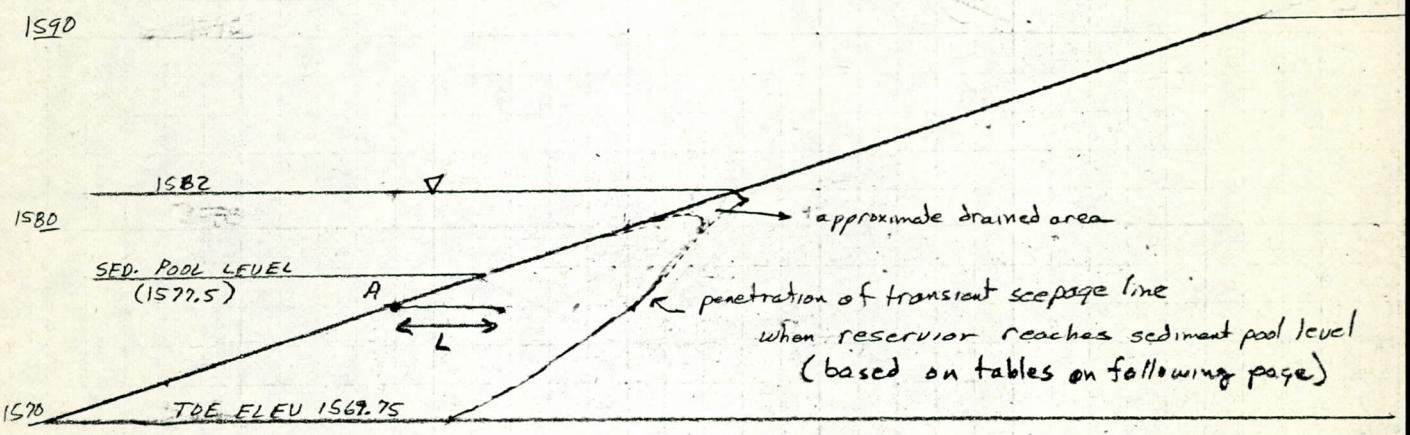
Verticle permeability could be as low as .1 ft/day

$V_a = \frac{(.1)(i)}{.4}$ if V_a = rate at which reservior drains ($V_a = .5$)

then $i = \frac{(.5)(.4)}{(.1)} = 2$ this will not develope in our case

It must be assumed that the embankment will not drain effectively in the drawdown period of the reservior. However, partial drainage will occur.

STATE Az		PROJECT BUCKHORN MESA WPP - SPOOK HILL FRS		
BY A.C.	DATE 3-25-75	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 4 OF 8



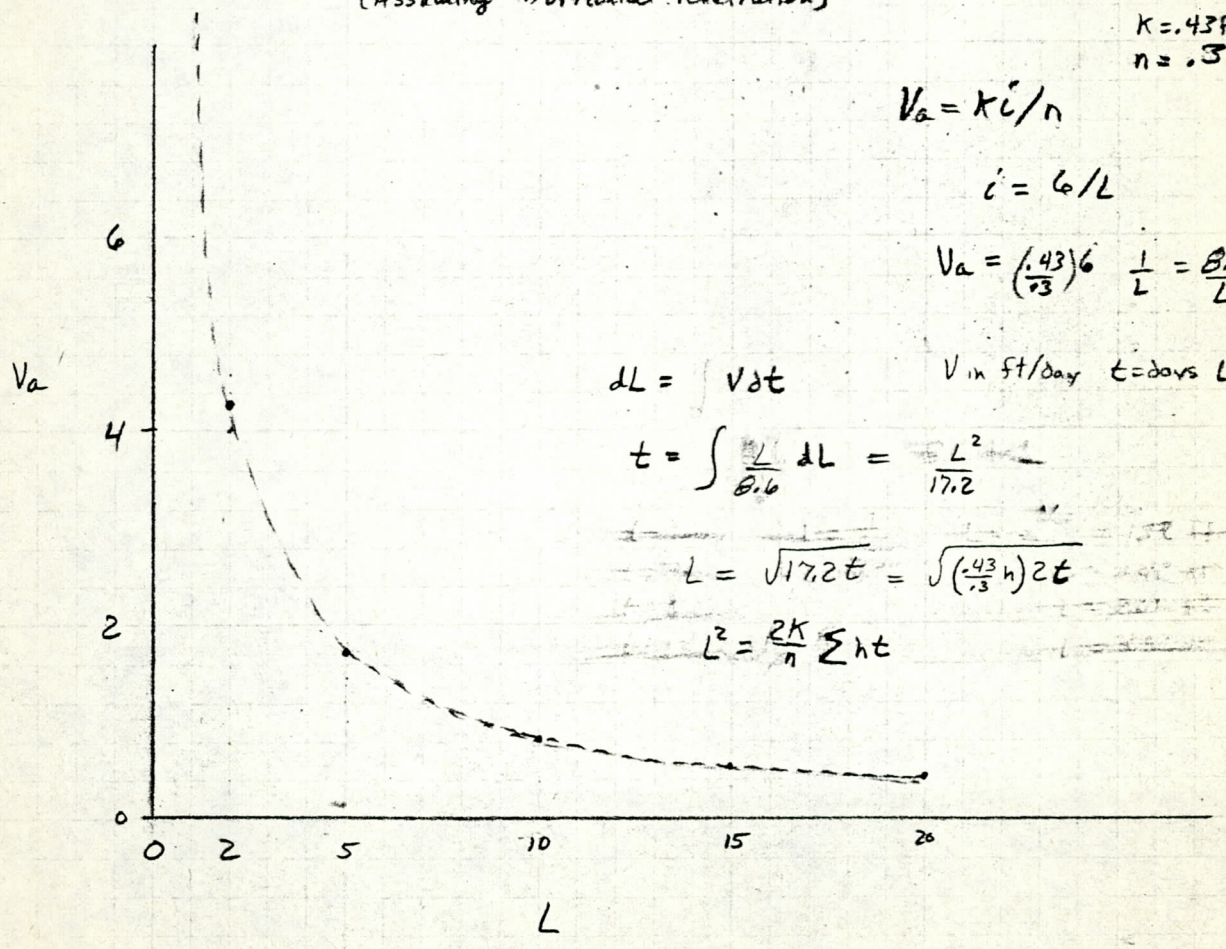
Point A is 6 ft below the maximum water surface.
(Assuming Horizontal Penetration)

$K = .43$ ft/day
$n = .3$

$V_a = Ki/n$

$i = 6/L$

$V_a = \left(\frac{.43}{.3}\right)6 \quad \frac{1}{L} = \frac{8.6}{L}$



$dL = V dt$ V in ft/day t=days L=ft

$t = \int \frac{L}{8.6} dL = \frac{L^2}{17.2}$

$L = \sqrt{17.2t} = \sqrt{\left(\frac{.43}{.3}h\right)2t}$

$L^2 = \frac{2K}{n} \sum ht$

STATE		PROJECT		
AZ		Buckhorn Mesa WPA Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	3-25-75			
SUBJECT				SHEET 5 OF 8

t	h	L^2	L
1 day	6 ft	17.2	4.15
3 days	5 ft	$17.2(1) + \left(\frac{.43}{.3}s\right)(2)(2)$	6.77
6 days	4 ft	$17.2 + 28.6 + \left(\frac{.43}{.3}\right)(4)(3)(2)$	8.96
13 days	3 ft	$17.2 + 28.6 + 34.4 + \left(\frac{.43}{.3}\right)(3)(7)(2)$	11.85
17 days	1.5 ft	$17.2 + 28.6 + 34.4 + 60.2 + \left(\frac{.43}{.3}\right)(1.5)(4)(2)$	12.55

Base of dam

t	h	L_2	L
1 day	12 ft	$\left(\frac{.43}{.3}\right)(12)(1)(2)$	5.87
3 days	11 ft	$34.4 + \left(\frac{.43}{.3}\right)(11)(2)(2)$	9.87
6 days	10 ft	$34.4 + 63.1 + \left(\frac{.43}{.3}\right)(10)(3)(2)$	13.55
13 days	9 ft	$34.4 + 63.1 + 86.0 + \left(\frac{.43}{.3}\right)(9)(7)(2)$	19.08
17 days	7.5 ft	$34.4 + 63.1 + 86.0 + 180.6 + \left(\frac{.43}{.3}\right)(7.5)(4)(2)$	20.70

The effect of this new seepage line on the stability analysis will have to be investigated. See diagram on previous page

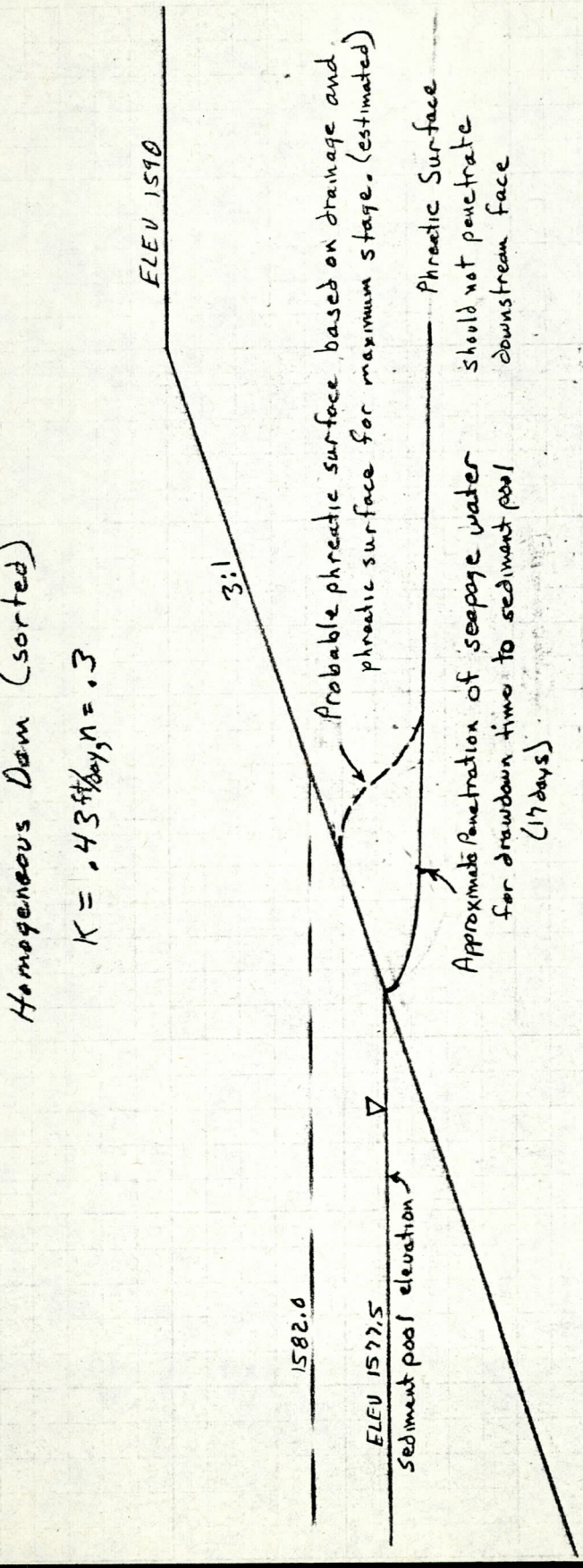
Conclusions - A rapid drawdown condition need not be considered. The volume of submerged soil above the reservoir level is small compared to the volume within the failure plane.

The phreatic line will not reach the downstream toe of the dam unless the sediment pool is not drained. The phreatic line, if it developes, will form from the sediment pool elevation.

A steady seepage condition need not be considered since it applys only to the downstream slope. The seepage line should not effect the downstream slope stability. (SM-10, 17-5)

A slope stability analysis should be made with the water surface and phreatic line at the sediment pool elevation

STATE Az		PROJECT Buckhorn Mesa WPP Spook Hill F.R.S.		
BY A.C.	DATE 3-25-76	CHECKED BY	DATE	JOB NO.
SUBJECT Conditions for Upstream Slope Stability				SHEET 6 OF 8



Homogeneous Dam (sorted)

$K = .43 \frac{ft}{day}, n = .3$

STATE Az		PROJECT Buckhorn Mesa WPP - Spook Hill FRS		
BY A.C.	DATE 3-24-76	CHECKED BY	DATE	JOB NO.
SUBJECT Upstream Side Slopes				SHEET 7 OF 8

One conclusion that can be drawn from this analysis is that the upstream stability conditions will be no worse than the down side slope stability conditions when the phreatic line has developed. This downstream condition was checked by the "Swedish Circle" Method 2:1 side slopes were acceptable with $F_s = 1.23$

* 2½:1 side slopes are easily justifiable under these conditions on the upstream side of the dam and will be used.

Since the ϕ angle for the course material was used in

* this analysis, either a zoned dam or a homogeneous dam is acceptable (as far as slope stability).

* GPO: 1972 —460-109

STATE		PROJECT		
AZ		BUCKHORN MESA WPP SPOOK HILL FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	3-25-76			

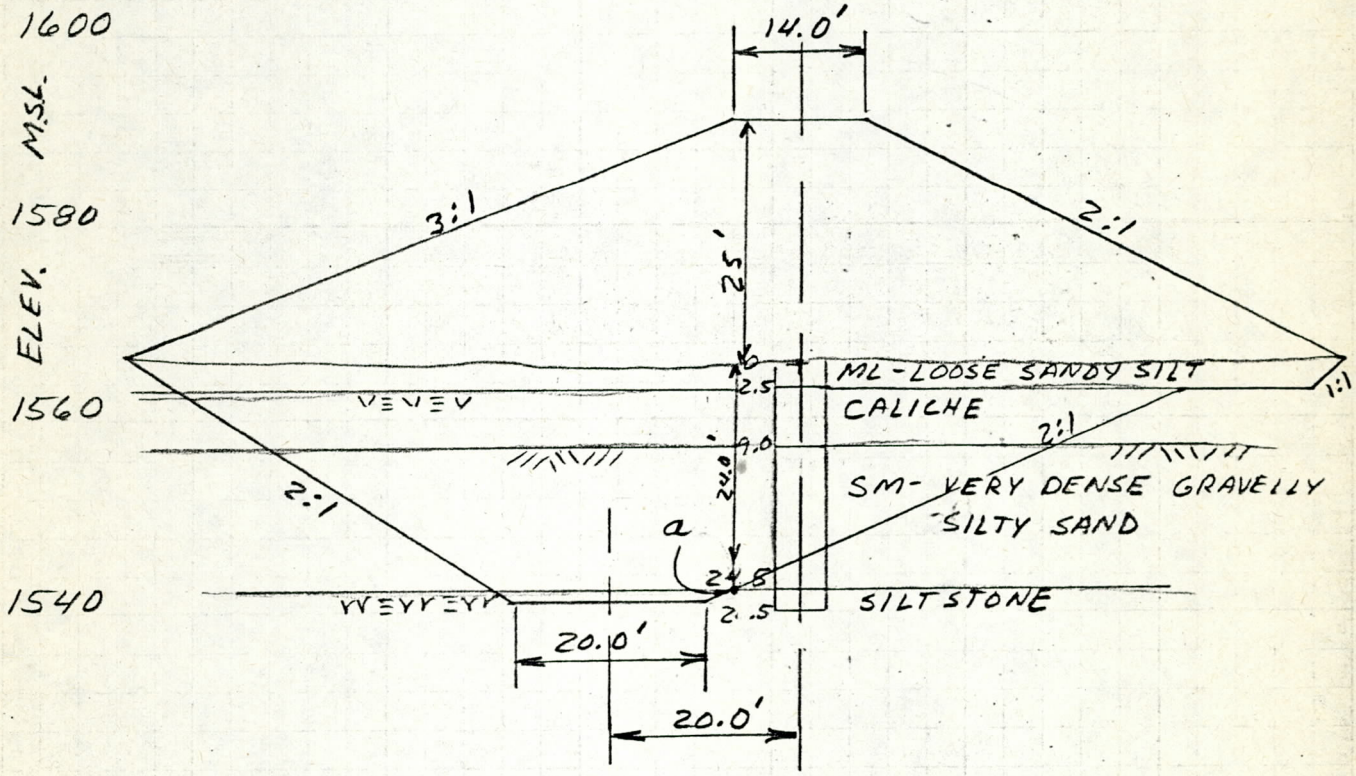
SUBJECT Use of Caliche as Embankment Material — SHEET 8 OF 8

The soils in the Spook Hill area are very calcareous. They react to HCL. In many areas layers of Caliche have developed. these layers are poorly indurated. They are easily broken down to less than sand size particles. If this material is mixed with the other embankment material, it can be used. It has been suggested that this material be used on the downstream side of dam. The permeability of the soil is increased by the presence of the caliche. Tests have been made by the Bureau of Reclamation and they found these materials usable.

Based on discussions with Mr De Groot of the Bureau of Rec. and Jim Talbot of the SCS.

STATE ARIZONA	PROJECT BUCKHORN MESA WPP SPOOK HILL FRS		
BY A.C. DATE 7-31-75	CHECKED BY	DATE	JOB NO.
SUBJECT EMBANKMENT AND FOUNDATION DESIGN			SHEET 1 OF 2

SETTLEMENT - STATION 222+35



MAXIMUM SETTLEMENT WILL OCCUR @ U.S. EDGE OF DAM

BASIC SOIL MECHANICS SM(10) Vol. 2 FIG 14.3

$d = \frac{1566 - 1542}{2} = 12'$ $\quad b = (1591-1566)3 = 75.0'$

$d/b = 12/75 = 0.16$

$\Delta p = 0.89\,p$ @ pt a

$\gamma_m = .95(128.2) + (0.088)(62.4) = 127.3$ pcf

$p = 25'(127.3) = 3182.5$ psf

$\Delta p = 2832$ psf

FROM TABLE 14-2 - SM SOIL TYPE

@ 2880 psf	@ 7200 psf
1.2 %	3.0 %

STATE		PROJECT		
ARIZONA		BUCKHORN MESA WPP SPOOK HILL FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
A.C.	7-31-75			
SUBJECT				SHEET 2 OF 2
EMBANKMENT AND FOUNDATION DESIGN				

SETTLEMENT OF FOUNDATION
@ 2832 psf ⟶ USE 1.2%

$\delta = 0.012 (24') = 0.29$ FT

SETTLEMENT OF EMBANKMENT

CONSIDER THE SETTLEMENT ON THE LOWER HALF

$d = \frac{25'}{4}$ $b = \frac{3(75)}{2}$ $d/b = .08$ $\Delta p = .94p$

$p = 3182.5/2 = 1591.25$

$\Delta p = 1495.8$ USE 0.6% SETTLEMENT

$\delta = 0.006 (12.5) = 0.08$ FT

SETTLEMENT IN THE UPPER EMBANKMENT
WILL BE SMALL

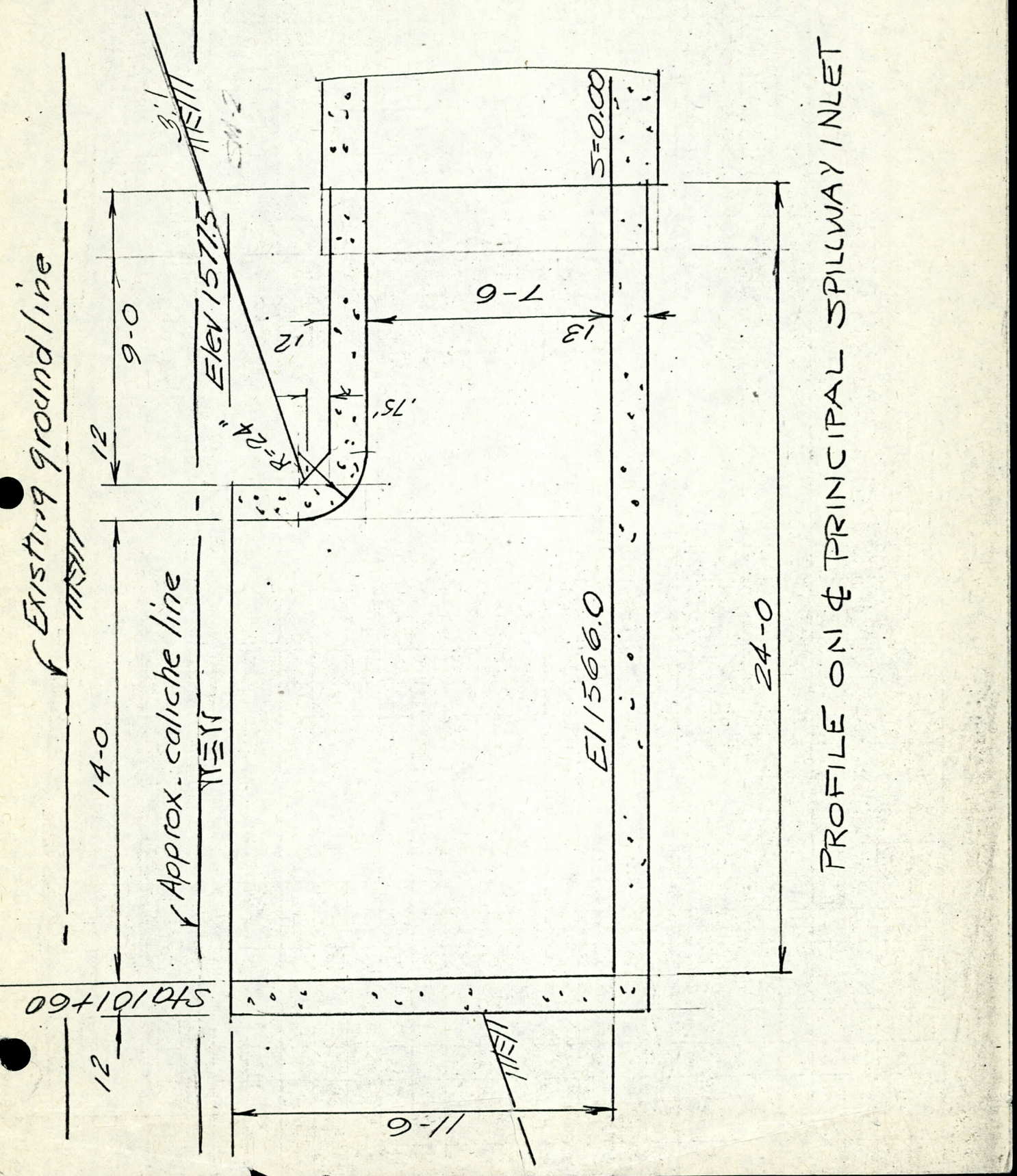
0.29 FT + 0.08 FT = 0.37 FT USE 0.4 FT

TOP OF DAM ELEV = 1590.4 + 0.4
= 1590.8

STATE		PROJECT		
Ariz		Buckhorn Mesa WAA Sook Hillers		
BY	DATE	CHECKED BY	DATE	JOB NO.
RM	11-11-75	SA	11-24-75	2005

SUBJECT Structural Design

SHEET 1 OF ~~25~~ 49



STATE Ariz | PROJECT Buckhorn Mesa WPP Spook Hill FRS

BY RJM | DATE 11-11-75 | CHECKED BY JL | DATE 11-21-75 | JOB NO. 2005

SUBJECT Structural Design | SHEET 2 OF 549

Loads

Embankment Materials

Station *	Sample Field	Sample Lab	Symbol	γ_{dmax}	w_{opt}	ϕ **
20+00-200'rt	2113.1	750304	SC	127.1	9.1	—
228+00-400'rt	2116.1	750305	SC	122.2	10.9	32.0°
263+00-200'rt	2120.1	750306	SM-2	129.1	9.1	—
295+00-200'rt	2134.1	750307	GM	109.5	17.9	—
Sta 18+00 ES *** -250'rt	221.1	750295	SP-SM	126.8	10.7	33.0°

USE Sample 2116.1

95% γ_{max}

$\gamma_m = \gamma_d(1+w)$

$\gamma_d = .95(122.2) = 116.1$ pcf

$\gamma_m = 116.1(1+0.109) = \underline{128.8 \text{ pcf}}$

$\phi = 32.0°$

Geology Rept

$\frac{G+Se}{1+e}\gamma_w$

$G = 2.75$

$\gamma_{sat} = (62.4)(2.75+0.23)/(1+0.23) = \underline{151.2 \text{ pcf}}$

$\gamma_b = 151.2 - 62.4 = \underline{88.8 \text{ pcf}}$

* ℄ dam Sta @ PS = 299+16.00

** ℄ CAP Sta ≈ @ PS = 125+00±

** C = 0

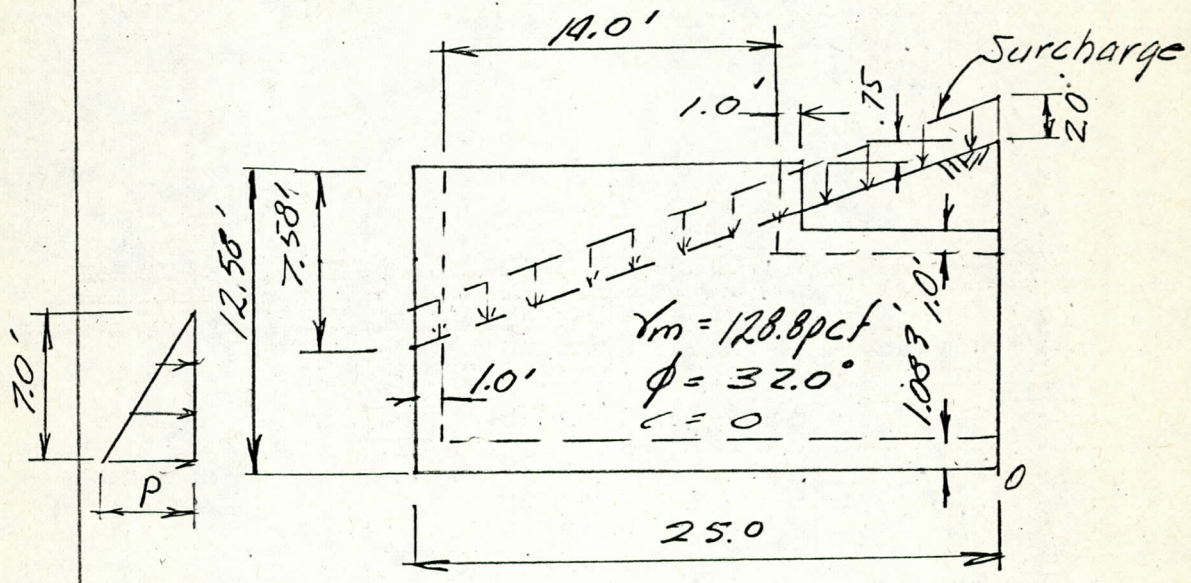
*** ES in area of PS

STATE		PROJECT		
Ariz		Buckhorn Mesa WRP Sook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RSM	11-11-75	[illegible]	11-21-75	2005

SUBJECT Structural Design

SHEET 3 OF 2849

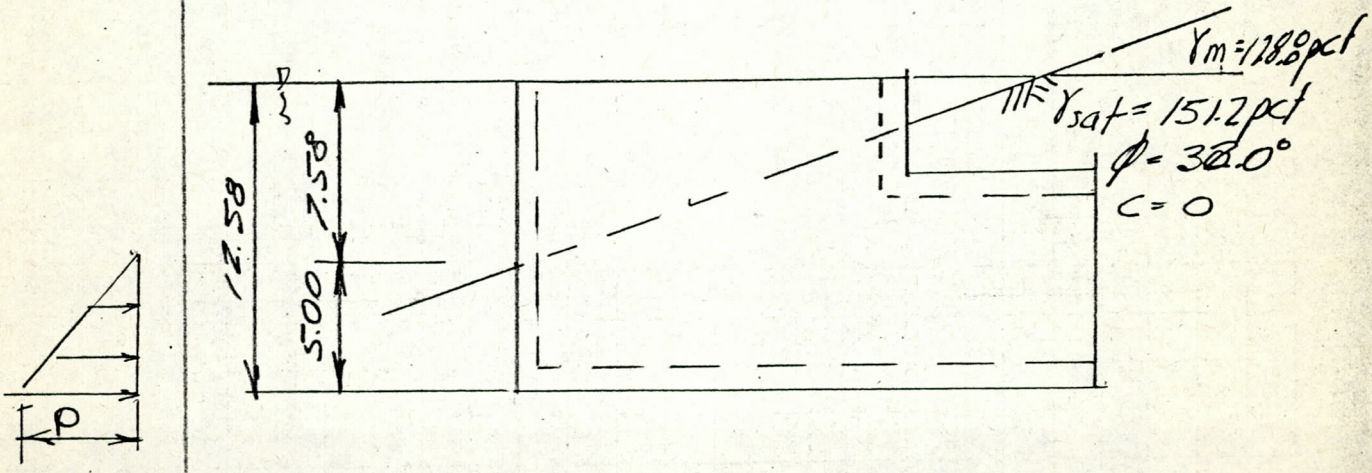
As-Built Condition



w = 7.0'

t_w = 12"

No Flow Condition



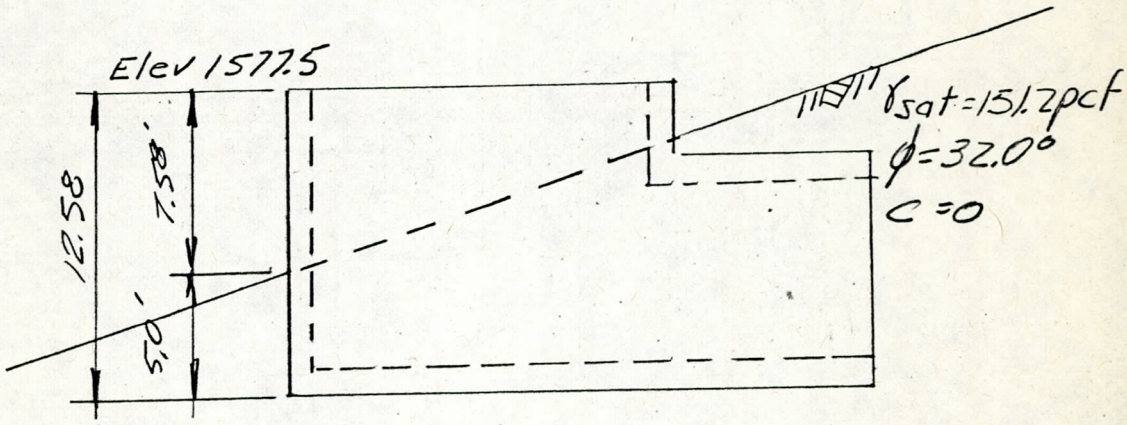
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	11-11-75	JR	11-21-75	2005

SUBJECT Structural Design

SHEET 4 OF 2549

Full-Flow Condition

El 1582.0



By observation the full flow condition will will not be the most critical case since the water pressure on either side of the structure will be equal. Therefore the full-flow condition will not be analyzed

Stability Analysis

As-Built Condition

Lateral earth pressures

$K_A = 0.725$ EDS FWS Fig 2.1

$p = 128.8(0.725)(7) = 654$ psf

Revised earth pressures from Supplement
$K_A = 0.575$
A.C. 8-76

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Before fill

Part		Wt	Arm	Moment
Endwall	(12.58)(9)(1)(150) =	16,980	24.5	416,000
Inlet section	[(12.04)(2) + 8](1)(150) + (9)(.0833)(150) =	68,900	17.0	1,171,000
Pipe section	[(9.58)(9) − (7.5)(7)](1500)	50,600	5.0	253,000
US endwall	(3)(9)(1)(150)	4050	9.5	38,500
		140,500		1,878000

$z = 1878000 / 140,500 = 13.37'$

$e = 13.37 - 12.5 = 0.87'$

$V/A = 140,500 / (25)(9) = 624$ psf

1.209

$p_d = 624[1 + (6)(0.87)/25] = 754$ psf

$p_u = 624(1 - .209) = 494$ psf

After fill (as built)

Part		Wt	Arm	Moment
Structure		140,500	13.37	1,878,000
Earth fill ▭	(2.75)(9)(9)(128.8)	28,700	4.50	129,100
Earth fill △	(3)(9)(9)(128.8)/2	15,650	3.00	46,900
Horiz Force —	assume balanced by resisting force of conduit		2.33	
			2.33	−49000
		184,800		2,050,000

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$Z = 2,050,000/184800 = 11.093'$

$e = 11.093 - 12.50 = -1.407'$

$p = 184800[1 \pm (6)(1.407)/25](25)(9)$

$= 821(1 \pm 0.338)$

$p_d = 821(1-0.338) = 544 \text{ psf}$

$p_u = 821(1+0.338) = 1098 \text{ psf}$

No Flow Condition

Part		Wt	Arm	Moment
Structure		140,500	13.37	1,878,000
Earthfill □	(0.75)(9)(9)(88.8)	5390	4.50	24,300
" △	(3)(9)(9)(88.8)/2	10,790	3.00	32,400
Horizontal Force	-Assumed balanced by resisting force of conduit			
		156,700		1,935,000
Uplift* □		-123,800	12.50	-1,548,000
		32900		387,000

$Z = 387,000/32,900 = 11.763$

$e = 11.763 - 12.50 = -0.737$

$p = 32,900[1 \pm (6)(-0.737)/25](9)(25)$

$= 146.2(1 \pm 0.177)$

$p_d = 146.2(1-0.177) = 120.3 \text{ psf}$

$p_u = 146.2(1+0.177) = 172.1 \text{ psf}$

Structure o.k. in over turning, uplift and sliding (by inspection)

Weight/Uplift = 156,700/123,800

$= 1.266 < 1.5$ NG

Add req'd footing during steel analysis

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*Uplift

Opinion of D Clark Geologist RB WP Staff Arizona is that the uplift pressures in the caliches in the Emergency Spillway Principal Spillway area may be reduced up to 30% because of the impermeability of the material

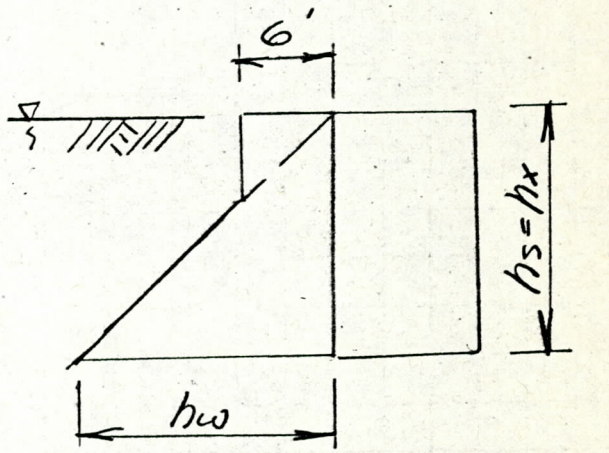
pressure @ base = 12.58 (62.4)(.7)
= 550 psf

Total Uplift = 550 (25)(9) =
= 123,800 lbs

Steel Design

Load Diagram

TR30 p 1-5



PRESSURE DIAGRAM

$h_x = h_s = 12.58'$

$h_w = h_x + \frac{K_w w_2}{w} s h_s = (0.72)(12.58)$
$= 21.7'$

$= 12.58 + \frac{(0.725)(88.8)}{62.4}(12.58) = 25.6'$

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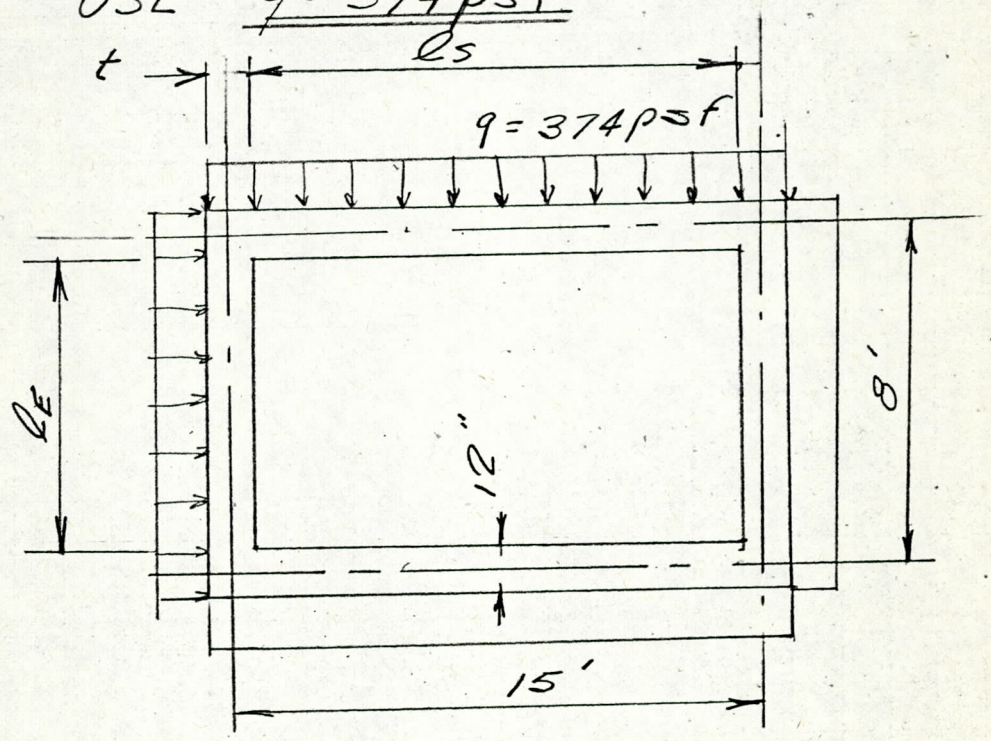
Top 4' - Horizontal Moments

$q = 6(62.4) = 374$ psf

$q = 4(25.6)(62.4)/12.58)(2) = 254$ psf

USE $q = 374$ psf



LOAD DIAGRAM

$\ell_s = 14.0'$ $\ell_E = 7.0'$

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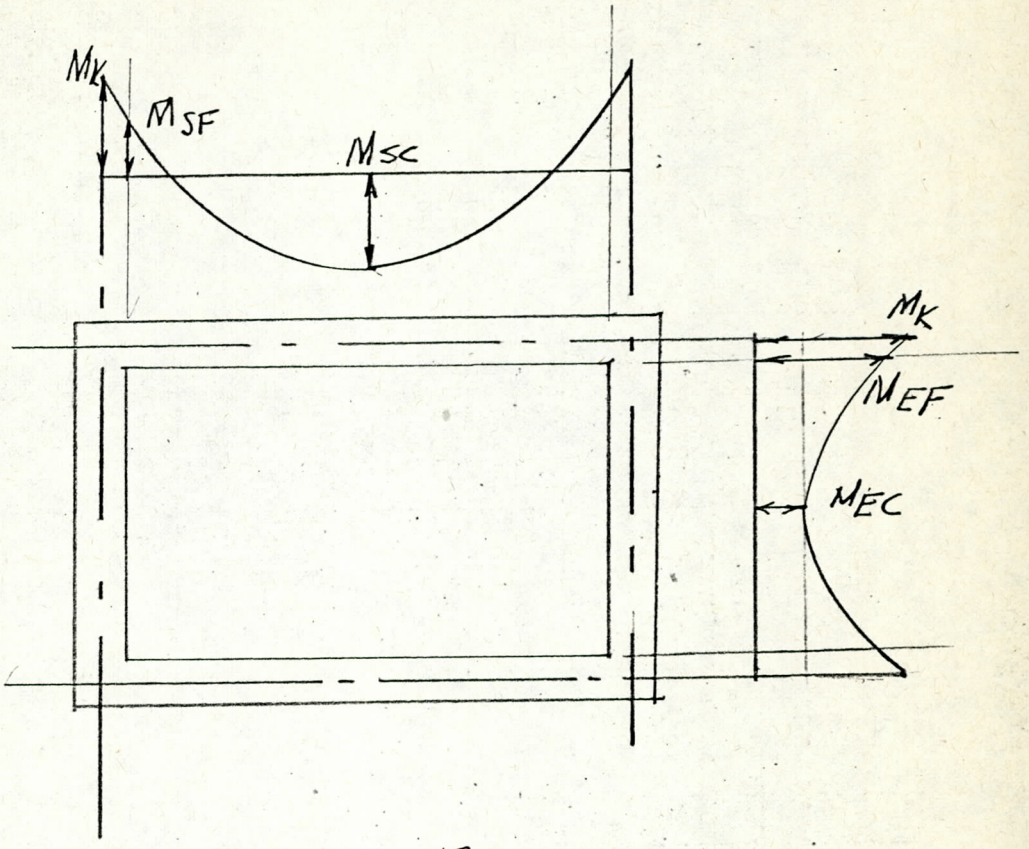
TR30
Chap 2



$$M_{SC} = \frac{1}{8} q (\ell_s + t)^2 - M_K$$

$$M_{SF} = \frac{1}{8} q (\ell_s)^2 - M_{SC}$$

$$M_{EC} = M_K - \frac{1}{8} q (\ell_E + t)^2$$

$$M_{EF} = M_{EC} + \frac{1}{8} q (\ell_E)^2$$

$$M_K = M_S^F - \lambda_S (M_S^F - M_E^F)$$

or $$M_K = M_E^F + \lambda_E (M_S^F - M_E^F)$$

$$\lambda_S = \frac{S_S}{S_S + S_E} \qquad \lambda_E = \frac{S_E}{S_S + S_E}$$

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$$S \simeq \frac{1}{L}$$

$S_S = 1/(l_s + t) = 1/(15) = 0.0667$

$S_E = 1/8 = 0.125$

$\lambda_S = 0.0667/(0.0667+0.125) = 0.348$

$\lambda_E = 0.125/(0.0667+0.125) = 0.652$

$M_S^F = q l_s^2/12 = 374(15)^2/12 = 7010^{\#}$

$M_E^F = q l_E^2/12 = 374(8)^2/12 = 1995^{\#}$

$M_K = 7010 - 0.348(7010-1995) = 5260^{\#}$

check: $M_K = 1995 + 0.652(7010-1995) = 5260^{\#}$ OK

$M_{SC} = 374(15)^2/8 - 5260 = \underline{5260}^{\#}$

$M_{SF} = 374(14)^2/8 - 5260 = 3900^{\#}$

$M_{EC} = 5260 - 374(8)^2/8 = \underline{2270}^{\#}$

$M_{EF} = 2270 + 374(7)^2/8 = 4560^{\#}$

Moment Correction

$S(\Delta M) = V_A(t/6)$

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Sidewalls

$V_A = q(\ell_s + t)/2 = 374(15)/2 = 2810^{\#}$

$M'_{SF} = 3900 + 2800/6 = 4370^{'\#}$

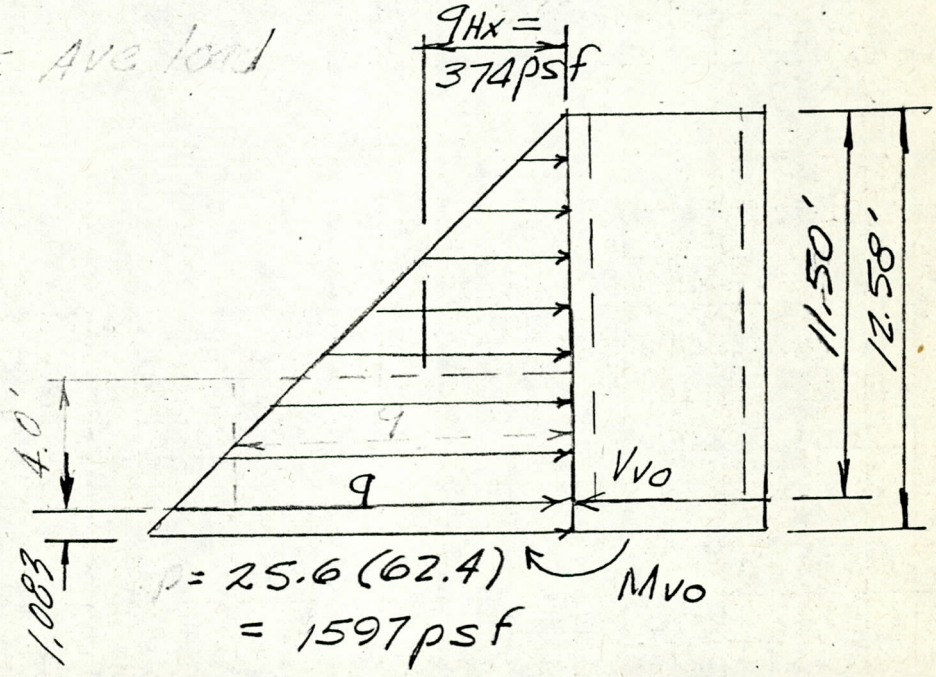
Endwalls

$V_A = q(\ell_E + t)/2 = 374(8)/2 = 1496^{\#}$

$M'_{EF} = 4560 + 1496/6 = 4810^{'\#}$

Riser Walls Vertical Bending

USE Ave load



$= 25.6(62.4)$

$= 1597 psf$

$q = 11.50(1597)/12.58 = 1460 psf$

$= 1206 psf$

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p 2-20

$$M_{Vo} = \frac{q}{2B^2}\left(1 - \frac{0.1074}{qB}\right)$$

$$V_{Vo} = \frac{q}{B}\left(1 - \frac{0.1074}{2qB}\right)$$

$$M_{Vx} = -\frac{V_{Vo}}{B}e^{-Bx}\sin Bx + M_{Vo}e^{-Bx}(\cos Bx + \sin Bx)$$

$$V_{Vx} = -V_{Vo}e^{-Bx}(\cos Bx - \sin Bx) - 2M_{Vo}Be^{-Bx}\sin Bx$$

$$B = \left(\frac{1}{4K_y D^4}\right)^{\frac{1}{4}}$$

$$K_y = \frac{EI}{qD^4}Y$$

For sidewall (Y = deflection)

$D = Q_E$

$$Y = \frac{5}{384}\frac{qD^4}{EI}(2 + t/D)^4 - \frac{1}{16}\frac{M_K D^2}{EI}(2 + t/D)^2$$

For endwall

$$Y = \frac{1}{8}\frac{M_K D^2}{EI}(1 + t/D)^2 - \frac{5}{384}\frac{qD^4}{EI}(1 + t/D)^4$$

$$M_K = \frac{q}{2}(2D + t)^2 - R(2D + t)$$

$$= 1460[2(7) + 1]^2/2 - R(2D + t)$$

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0	0	+18.67
+0.66		−0.62
−0.66	+0.56	
+1.11	−1.31	
−1.11	+1.70	
+3.41	−2.22	
−3.41	0.	
0	+.682	
0	+27.38	

FIXED END MOMENTS

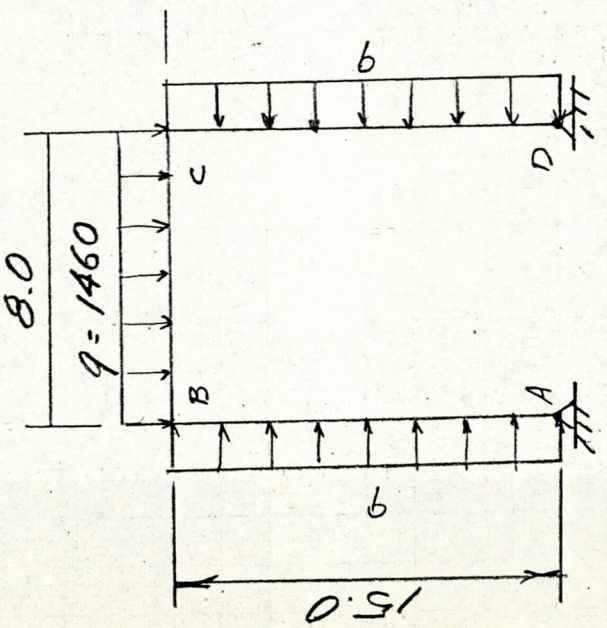
$M^F_{BC} = 1460(8)^2/12 = 7,790$ #

$M^F_{DC} = 1460(15)^2/12 = 27380$ #

− 7.79	K
−12.77	
+ 6.38	
− 4.16	
+ 2.08	
− 2.46	
+ 1.23	
− 1.17	
−18.66	

,348 ,652

FEM



DFCB&C

$DF_{BA} = \frac{\frac{1}{15}}{\frac{1}{15}+\frac{1}{8}} = 0.348$

$DF_{BC} = \frac{\frac{1}{8}}{\frac{1}{15}+\frac{1}{8}} = 0.652$

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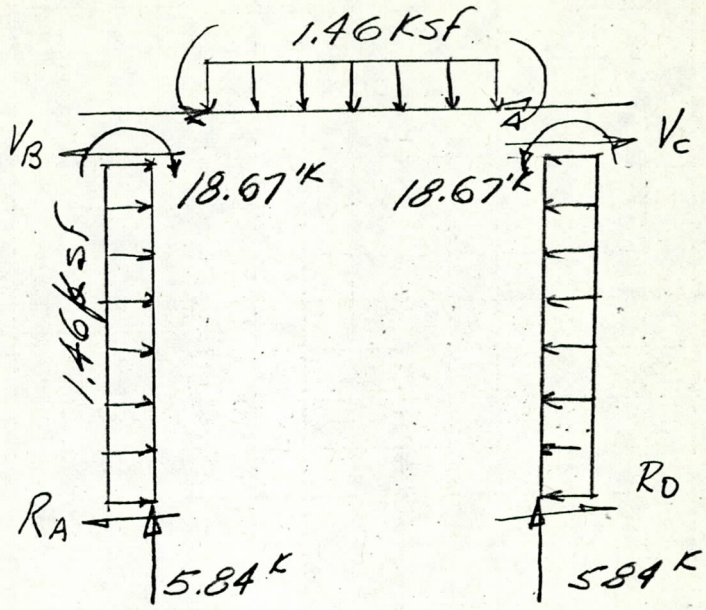

$$R_A = \frac{1.46(15)^2/2 - 18.67}{15} = \underline{9.71^K}$$

$$V_B = 1.46.(15)^2/2 + 18.67 = \underline{12.19^K}$$

Check:

$$R_A + V_B = 1.46(15) = 21.9^K$$

$$9.71 + 12.19 = 21.9^K \text{ OK}$$

$$\text{Ç } M_K = 1.46\,[2(7) + 7]^2/2 - 9.71[2(7) + 1]$$
$$= 18.600^{IK} \simeq 18.67^{IK} \text{ OK}$$

USE $M_K = \underline{18.67^{IK}}$

STATE	PROJECT			
Arizona	Firehorn Mesa WPP Spook Hill FRS			
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Sidewalls

Deflection:

$$Y = 5(1460)(7)^4[2+1/7)^4/384EI - 18670(7)^2[2+1/7)^2/16EI$$

$$= 963{,}000/EI - 263{,}000/EI$$

$$= \underline{700{,}000/EI}$$

$$K_y = [EI/(1460)(7)^4](700{,}000/EI)$$

$$= \underline{0.1997}$$

$$B = [1/(4)(0.1997)(7)^4]^{0.25}$$

$$= \underline{0.1511}$$

Bending

$$M_{VO} = 1.46[1-0.1074/(1.46)(0.1511)](2)(0.1511)^2$$

$$= \underline{16.41}\ ^{1K}$$

$$V_{VO} = 1.46[1.0-0.1074/(2)(1.46)(0.1511)]/0.1511$$

$$= \underline{7.31}\ ^{K}$$

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$$M_{Vx} = -(7.31)e^{-0.1511x}\sin 0.1511x/0.1511 + 16.41e^{-0.1511x}(\cos 0.1511x + \sin 0.1511x)$$

$$= e^{-0.1511x}[-48.4\sin 0.1511x + 16.41(\cos 0.1511x + \sin 0.1511x)]$$

$$V_{Vx} = -7.31e^{-0.1511x}(\cos 0.1511x - \sin 0.1511x) - 2(16.41)e^{-0.1511x}(0.1511)\sin 0.1511x$$

$$= e^{-0.1511x}[-7.31(\cos 0.1511x - \sin 0.1511x) - 4.96\sin 0.1511x]$$

check: @ $x=0$

$$M_{Vx} = -(7.31)e^{0}\sin 0°/0.1511 + 16.41e^{0}(\cos 0° + \sin 0°)$$

$$= 0 + 16.41 \quad \text{OK}$$

$$V_{Vx} = e^{0}[-7.31(\cos 0° - \sin 0°) - 4.96\sin 0]$$

$$= -7.31 \quad \text{(sign change but ok)}$$

@ $x = 2$

$$M_{Vx} = e^{-0.1511(2)}[-48.4\sin 0.1511(2) + 16.41(\cos 0.1511(2) + \sin 0.1511(2)]$$

$$= 0.7392[-14.40 + 20.55]$$

$$= 4.55 \text{ 'K}$$

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@ $x = 4$

$$M_{vx} = e^{-0.1511(4)}[-48.4 \sin 0.1511(4) + 16.41(\cos 0.1511(4) + \sin 0.1511(4)]$$

$$= 0.5464[-27.50 + 22.83]$$

$$= -2.56^{1K}$$

@ $x = 6$

$$M_{vx} = e^{-0.1511(6)}[-48.4 \sin 0.1511(6) + 16.41(\cos 0.1511(6) + \sin 0.1511(6)]$$

$$= 0.4039[-15.07]$$

$$= -6.08^{1K}$$

@ $x = 8$

$$M_{vx} = e^{-0.1511(8)}[-48.4 \sin 0.1511(8) + 16.41(\cos 0.1511(8) + \sin 0.1511(8)]$$

$$= 0.2986[-24.1]$$

$$= -7.20^{1K}$$

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@ X = 10

$$M_{VX} = e^{-0.1511(10)}\left[48.4 \sin 86.6° + 16.41(\cos 86.6° + \sin 86.6°)\right]$$

$$= 0.2207(-34.0)$$

$$= -6.83$$

@ X = 11.5

$$M_{VX} = e^{-0.1511(11.5)}\left[-48.4 \sin 0.1511(11.5) + 16.41(\cos 0.1511(11.5) + \sin 0.1511(11.5)\right]$$

$$= 0.1759(-34.3)$$

$$= -6.02$$

Endwalk

Deflection

$$Y = 18670(7)^2(1+1/7)^2/8EI - 5(1460)(7)^4(1+1/7)^4/384EI$$

$$= \underline{171,500/EI}$$

$$K_y = [EI/(1460)(7)^4](71,500/EI)$$

$$= \underline{0.0204}$$

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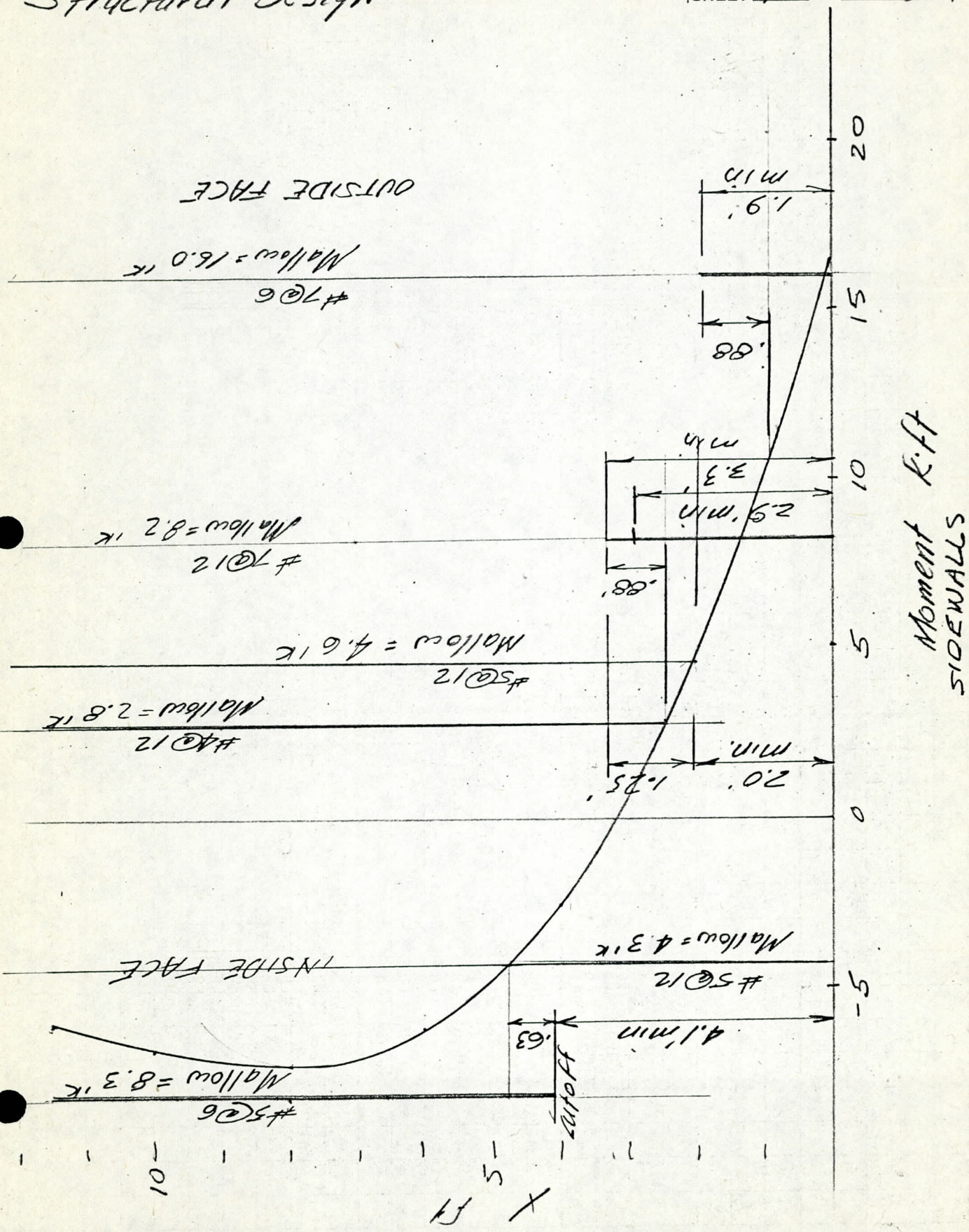

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$$\beta = [1/(4)(0.0204)(7)^4]^{1/4}$$

$$= 0.267$$

Bending:

$$M_{VO} = 1.46\,[1 - 0.1074/(1.46)(0.267)]/2(0.267)^2$$

$$= 7.42\ ^{1K}$$

$$V_{VO} = 1.46\,[1 - 0.1074/(2)(1.46)(0.267)]/0.267$$

$$= 4.72\ ^{1K}$$

Check Shear @ d above floor (Sidewalls)

$$d = 12 - 2.5 = 9.5"$$

$$\beta X = 0.1511(9.5/12) = 0.1196$$

$$e^{-\beta X}(\cos \beta X - \sin \beta X) = 0.775$$

$$e^{-\beta X}(\sin \beta X) = 0.1059$$

-6.19 (11/26 PJM)

$$V_{VX} = -7.31(0.775) - 4.96(0.1059) = \text{-}5.72^{K}$$

$$v = V_{VX}/bd = 5720/(12)(9.5) = 50 < 70 \text{ psi OK}$$

STILL OK

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Check: Vertical Steel @ wall to footing connection - sidewall

Direct compressive force:

Wt of riser above footing

$\approx 140,500 - 1.083(9.0)(25.0)(150)$
$= 103,900^{\#} = 103.9^{K}$

Pressure $= 1039/(225-168)$
$= 1.823$ KSF

$No = 1.823(1) = 1.823$ kips/ft

Analysis for required steel

$d'' = 13/2 - 3.5 = 3.0''$

$Ms = 16.41 + 1.823(3.0)/12 = 16.87$ ft k/ft

$A_s = 1.20$ sq in/ft #7@6 = 1.20 sq/ft
$A_s = 1.20 - 1.823/20 = 1.10$ OK
$\Sigma_o = 5.50$ in/ft

$\Sigma_o = (Vvo/u)d$

$= (7.31)(8)/(.350)(7)(9.5) = 2.51$ in/ft
OK

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Check: Vertical Steel @ wall to floor connection - sidewall

$M_S = 7.42 + 1.823(3)/12 = 7.87$ ^k

$A = 0.54$ sq in

$A_S = 0.54 - 1.823/20 = 0.44$ sq in

USE #5@6 $A_S = 0.61$ sq in

Check: for temp stl 2.0' above floor

$$M_{VX} = -4.72e^{-0.1511(2)}\sin 0.1511(2)/0.1511 + 7.42e^{-0.1511(2)}[\cos 0.1511(2) + \sin 0.1511(2)]$$

$= -6.87 + 6.87$

$= 0.93$ ^k

@ x - 4'

$$M_{VX} = -4.72e^{-0.1511(4)}\sin 0.1511(4)/0.1511 + 7.42e^{-0.1511(4)}[\cos 0.1511(4) + \sin 0.1511(4)]$$

$= -9.70 + 5.64$

$= -4.06$ ^k

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@ X = 6

$$M_{vx} = -4.72e^{-0.1511(6)}\sin 0.1511(6)/0.1511 + 7.42e^{0.1511(6)}[\cos 0.1511(6) + \sin 0.1511(6)]$$

$$= -9.93 + 4.16$$
$$= -5.77$$

@ X = 8

$$M_{vx} = -4.72e^{-0.1511(8)}\sin 0.1511(8)/0.1511 + 7.42e^{-0.1511(8)}[\cos 0.1511(8) + \sin 0.1511(8)]$$

$$= -8.72 + 2.86$$
$$= -5.86^{1K}$$

@ X = 10

$$M_{vx} = -4.72e^{-0.1511(10)}\sin 0.1511(10)/0.1511 + 7.42e^{-0.1511(10)}[\cos 0.1511(10) + \sin 0.1511(10)]$$

$$= -6.88 + 1.73$$
$$= -5.14$$

@ X = 11.5

$$M_{vx} = -4.72e^{-0.1511(11.5)}\sin 0.1511(11.5)/0.1511 + 7.42e^{-0.1511(11.5)}[\cos 0.1511(11.5) + \sin 0.1511(11.5)]$$

1.07 (11/26 Rm)

$$= -5.42 + \cancel{0.81}$$
$$= -\cancel{4.61} + 4.35$$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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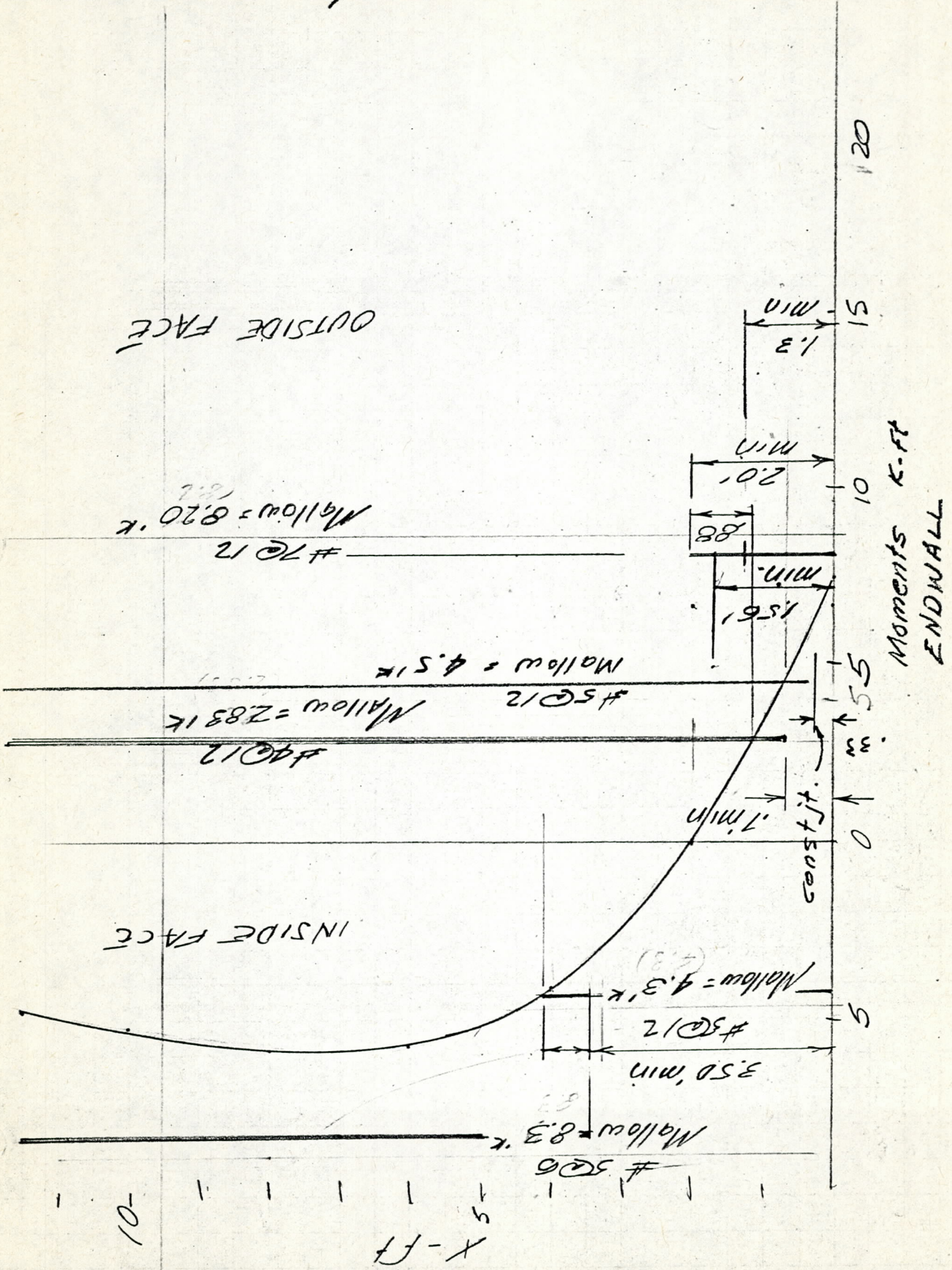
SUBJECT Structural Design

SHEET 24 OF 549



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJH	11-18-75	D Riddle	11-24-75	2005

SUBJECT Structural Analysis

SHEET 25 OF 25 49

Add Concrete to floor to increase weight for Uplift ratio to 1.5

Uplift = 123,800 # (Sheet 6)
Inlet wt = 156,700 # " "

Increased wt req'd

= 1.5(123,800) − 156,700
= 29,000 #

wt / inch of base

= (9)(25)(150)/12
= 2810 lb/in

Additional thickness req'd

= 29,000/2810
= 10.3

Total Floor thickness req'd

= 13 + 10.3
= 23.3

USE 24"

USE temp steel

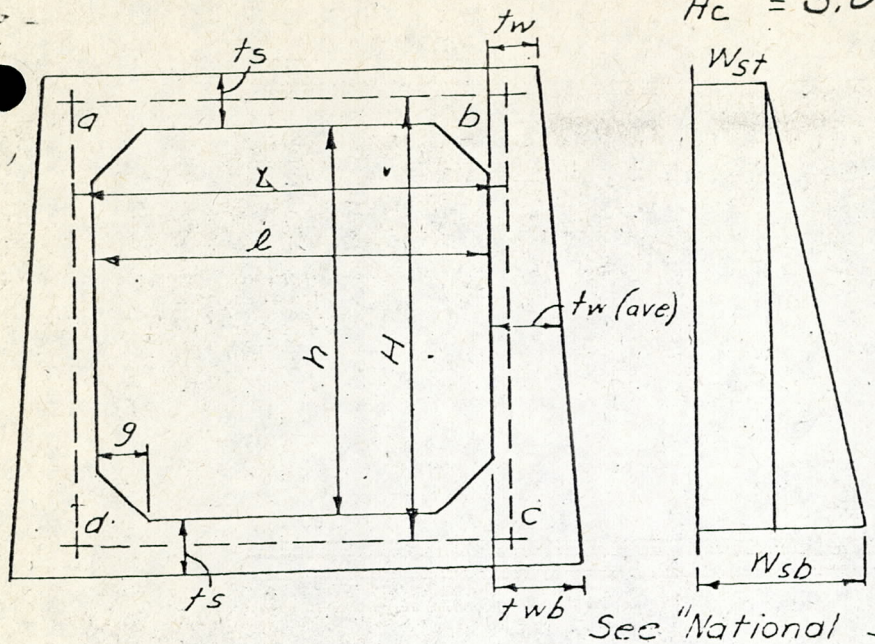
Top A_s = 0.002 (16)(12) = 0.38 #6@12
0.19 (#5@12)

Bottom A_s = 0.001 (16)(12) = ~~0.19~~ #4@12

DESIGN OF As Built Condition X R/C DROP INLET

Sheet 1 of
Date 12-1-75
Comp by P.J.M.-J.B

H_c = 5.0 Ft.



Hc=(Fill Over Box)= 5.0 ft.
H= 8.5 ft.; h= 7.5 ft.
L= 8.0 ft.; ℓ= 7.0 ft.
t_w= 12 in.; t_{wb}= 12 in.
$t_{w(ave.)}$ = 12 in
t_s= 12 in.; g= 0 in.

$$C = \left(\frac{t_s}{t_{w(ave.)}}\right)^3 \frac{H}{L}$$

$$C = \left(\frac{12}{12}\right)^3 \frac{8.5}{8.0} = 1.0625$$

See "National Structural Design Handbook." Section 6 - para. 2.2.4.

UNIT LOAD ON TOP SLAB:

$$W_t = \left(150 \times \frac{T_s}{12}\right) + \left(W_c = C_c \gamma DC^2\right) = \left(150 \times \frac{12}{12}\right) + (0.56)(128.8)(9^2) = 799 \text{ lbs/ft}^2$$

UNIT LOAD ON BOTTOM SLAB

Concrete Weight:

2 Sidewalls $(2 \times 150) \times \frac{T_{w(ave.)}}{12} \times h = 300 \times 7.5$ = 2250 lbs.

W_w = Distributed weight = $\frac{\text{Sidewall weight}}{\left(\ell + \frac{2\, t_{wb}}{12}\right)} = \frac{2250}{\left(7.0 + \frac{2 \times 12}{12}\right)}$ = 250 lbs/ft²

Concrete plus Fill:

W_b = Unit load on bottom slab = $W_t + W_w$ = 799 + 250 = 1049 lbs/ft²

UNIT SIDEWALL LOAD (See "Structure Design Handbook" Section 6)

At ℄ Top Slab $W_{st} = \left(H_c + \frac{t_s}{2}\right)\left(\frac{88.8}{\text{cu ft}}\right)(.725) + \left(H_c + \frac{t_s}{2}\right)(40.0)_{\text{Hydrostatic}} = 574$ lbs/ft²

At ℄ Bottom Slab: $W_{sb} = W_{st} + \left(H_c + \frac{t_s}{2} + H\right)\left(\frac{88.8 \text{ lbs}}{\text{cu ft}}\right)(.725) + \left(H_c + \frac{t_s}{2} + H\right)\left(\frac{40.0 \text{ lbs}}{\text{cu ft}}\right) = 1461$ lbs/ft²

$(W_{sb} - W_{st})$ = 1461 − 574 = 887 lbs/ft²

CHECK BOTTOM SLAB THICKNESS FOR SHEAR

V_{ts} = Shear at thickness $t_s = W_b\left(\frac{\ell}{2} - \frac{g}{12}\right) = 1049\left(\frac{7.0}{2} - \frac{0}{12}\right)$ = (~~0.5~~) = 3672 lbs.

d_s = Thickness req'd. for shear = $\frac{V_{ts}}{v\, j\, b} = \frac{V_{ts} \text{ of } 3672}{70 \times 7/8 \times 12}$ = 5.0 in.

(d_s cannot exceed $t_s - 2\frac{1}{2}$); $(t_s - 2\frac{1}{2})$ = 12 − 2½ = 9½ in.

Check thickness req'd. at end of Fillet (at max. depth of fillet)

$V_\ell = W_b\left(\frac{\ell}{2}\right)$ = = lbs.

in. (d_s cannot exceed $t_s - 2\frac{1}{2} + \frac{g}{2}$)

ES 160

As Built

DESIGN OF 7.0 x R/C DROP INLET H_c = 5 Ft.

Sheet 2 of
Date 12-3-75
Comp. by PJM-JB

L 8.0 Ft L^2 = 64
H 8.5 Ft H^2 = 72.25

CULATE FIXED-ENDED MOMENTS:

$M^F_{cd} = \frac{1}{12} W_b L^2 = \frac{(1049)(64)}{12} = 5595$ ft.-lbs.; $M^F_{ab} = \frac{1}{12} W_t L^2 = \frac{(799)(64)}{12} = 4261$ ft.-lbs

$M^F_{ad} = \frac{1}{12} W_{st} H^2 + \frac{1}{30}(W_{sb} - W_{st}) H^2 = \frac{(574)(72.25)}{12} + \frac{(887)(72.25}{30} = 5592$

$M^F_{cb} = \frac{1}{12} W_{st} H^2 + \frac{1}{20}(W_{sb} - W_{st}) H^2 = \frac{(574)(72.25)}{12} + \frac{(887)(72.25)}{20} = 6660$

$M^F_{ab} = -$ 4261 ft.-lbs. $\quad M^F_{ad} = +$ 5592 ft.-lbs.

$M^F_{cd} = -$ 5595 ft.-lbs. $\quad M^F_{cb} = +$ 6660 ft.-lbs.

$M^F_{dc} = +$ 5595 ft.-lbs.

CALCULATE DISTRIBUTED END MOMENTS:

$$M_{ab} = M^F_{ab} - \frac{C}{(C+2)^2 - 1}\left[(C+2)(M^F_{ab} + M^F_{ad}) + (M^F_{cd} + M^F_{cb})\right]$$

$$M_{dc} = M^F_{cd} + \frac{C}{(C+2)^2 - 1}\left[(C+2)(M^F_{cd} + M^F_{cb}) + (M^F_{ab} + M^F_{ad})\right]$$

$M_{dc} + M_{da} = 0$ $\qquad$ $M_{ab} + M_{ad} = 0$

	Calculate Mab:		Calculate M dc		
	From page 1 C	1.0625			
	$(C+2)$	3.0625			
	$(C+2)^2$	9.379			
	$(C+2)^2 - 1$	8.379			
(A)	$-\frac{C}{(C+2)^2-1}$	-0.1268	$+\frac{C}{(C+2)^2-1}$	+0.1268	(G)
	$(M^F_{ab} + M^F_{ad})$	1331	$(M^F_{cd} + M^F_{cb})$	1065	
(B)	$(C+2)(M^F_{ab} + M^F_{ad})$	4076	$(C+2)(M^F_{cd} + M^F_{cb})$	3262	(H)
(C)	$(M^F_{cd} + M^F_{cb})$	1065	$(M^F_{ab} + M^F_{ad})$	1331	(I)
(D)	Total (B) + (C)	5141	Total (H) + (I)	4593	(J)
(E)	Product (A) x (D)	-652	Product (G) X (J)	582	(K)
(F)	M^F_{ab}	-4261	M^F_{dc}	5595	(L)
	$M_{ab} = (F) + (E)$	-4913	$M_{dc} = (L) + (K)$	6177	
	M_{ad}	+4913	M_{da}	-6177	
	M_{ba}	+4913	M_{cb}	-6177	

DESIGN OF 7.0 x 7.5 R/C DROP INLET Hc = 5 Ft. Sheet 30 of 429
Date 12-3-75
Comp. By PJM-JB

COMPUTE SIMPLE BEAM MOMENTS (AT 1/10 POINTS)

For Bottom Slab: $M = mW_b L^2$; Let $A = W_b L^2 = 1049 \times 64 = 67{,}136$ ft. lb.

Location	M = Moment at 1/10 Points	Moment	Location	M = Moment at 1/10 Points	Moment
Point d	0	0	0.3 dc	.105 A	7049
0.1 dc	.045 A	3021	0.4 dc	.120 A	8056
0.2 dc	.080 A	5371	℄ 0.5 dc	.125 A	8392

FOR SIDE WALLS: M = Uniform M + Trianglar M

$M = mW_{st}H^2 + m\text{Ⅳ}H$; Let $W_{st}H^2 = B = 574 \times 64$ = 36,736 ft. lb.

$\text{Ⅳ} = (W_{sb} - W_{st})\frac{H}{2} = 887 \times \frac{8.5}{2} = 3770$ lbs

Let $C = \left[(W_{sb} - W_{st})\frac{H}{2}\right] \times H = 3770 \times 8.5 = 32{,}043$ ft. lb.

For Uniform Load			For Triangular Load			
Location	m x B	Moment	Location	m x C	Moment	Total Moment
Point a	0	0	Point a	0	0	0
0.1 ad	0.045 B	1653	0.1 ad	0.033 C	1057	2710
0.2 ad	0.080 B	2939	0.2 ad	0.064 C	2051	4990
0.3 ad	0.105 B	3857	0.3 ad	0.091 C	2916	6773
0.4 ad	0.120 B	4408	0.4 ad	0.112 C	3589	7997
0.5 ad	0.125 B	4592	0.5 ad	0.125 C	4005	8597
0.6 ad	0.120 B	4408	0.6 ad	0.128 C	4101	8509
0.7 ad	0.105 B	3857	0.7 ad	0.119 C	3813	7670
0.8 ad	0.080 B	2939	0.8 ad	0.096 C	3076	6015
0.9 ad	0.045 B	1653	0.9 ad	0.057 C	1826	3479
Point d	0	0	Point d	0	0	0

PLOT THE MOMENT DIAGRAMS ON THE FOLLOWING SHEET

CHECK SIDEWALL THICKNESS (For following computations, refer to tables in "Reinf. Concrete Design Handbook" by Amer. Concrete Institute)

Revised M at Face of Top Slab = 4.91 ft. kips

$F = \frac{M}{K} = \frac{4.913}{272} = 0.018$ From Table 4 with b = 12 in,

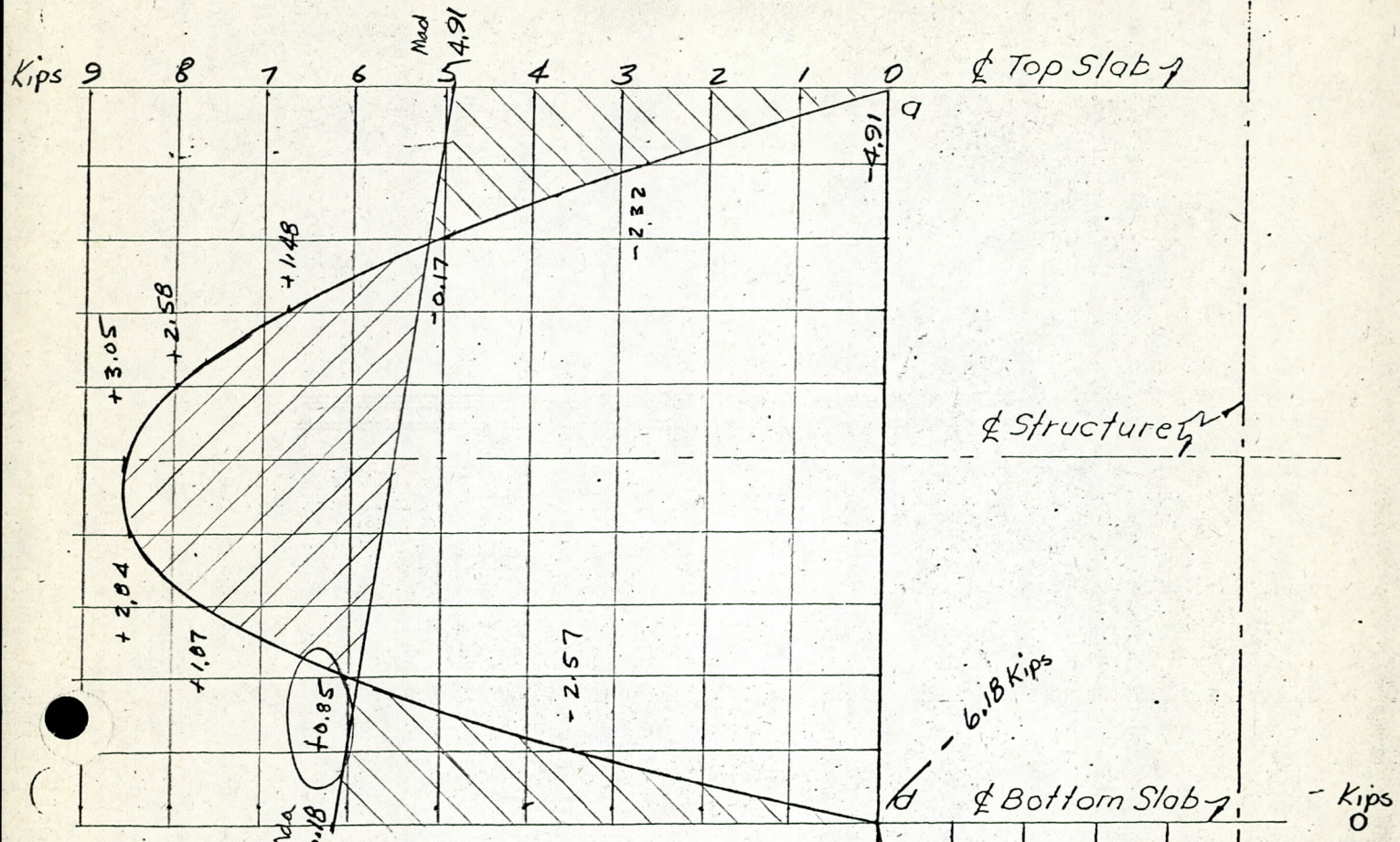
and F = 0.018, then d = < 5 in. $(t_w - 2\frac{1}{2}) = 9\frac{1}{2}$ in.

Revised M at ℄ of Sidewall = 3.05 ft. kips

$F = \frac{M}{K} = \frac{3.05}{272} = 0.011$ From Table 4 with b = 12 in.,

and F = 0.011, then d = < 5 in. $(t_{w\,ave.}) - 2\frac{1}{2}) = 9\frac{1}{2}$ in.

Plot the Moment Diagrams for the Bottom Slab and Sidewall



Moments to be corrected for the effect of width of end supports:

Thickness of sidewall = $t_{w(ave.)}$ = 12 in.

Thickness of bottom slab = t_s = 12 in.

CORRECTED MOMENTS, BOTTOM SLAB:

At Point (d): $M_c = M_{dc} - \frac{1}{6} V_L \frac{t_{w(ave.)}}{12}$

Let $A = V_L \frac{t_{w(ave.)}}{12} = w_b \times \frac{L}{2} \times \frac{t_{w(ave.)}}{12} = (1049)\left(\frac{8}{2}\right)\left(\frac{12}{12}\right)$

$A = 4{,}196$, $M_c = M_{dc} - \frac{A}{6} = -6177 - \frac{4196}{6} = -6{,}876$ Kip

At Face of Support $M_c = M_{dc} - \frac{A}{3} = -7.576$ Kips

At ℄ of Span: $M_c = M_{℄} - \frac{A}{9} = 1{,}744$ Kips

CORRECTED MOMENTS, SIDEWALL:

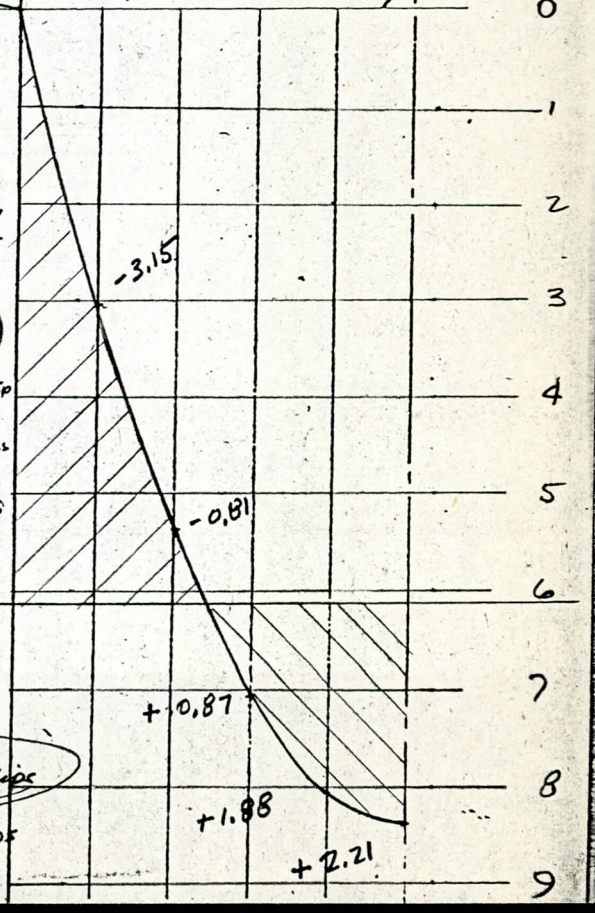
At Point (d): $M_c = M_{da} - \frac{1}{6} V_H \frac{t_s}{12}$

Let $B = V_H \frac{t_s}{12} = \left(\frac{w_{st} + w_{sb}}{2}\right) \frac{H}{2} \times \frac{t_s}{12} = \left(\frac{574 + 1461}{2}\right)\left(\frac{8.5}{2}\right)\left(\frac{12}{12}\right)$

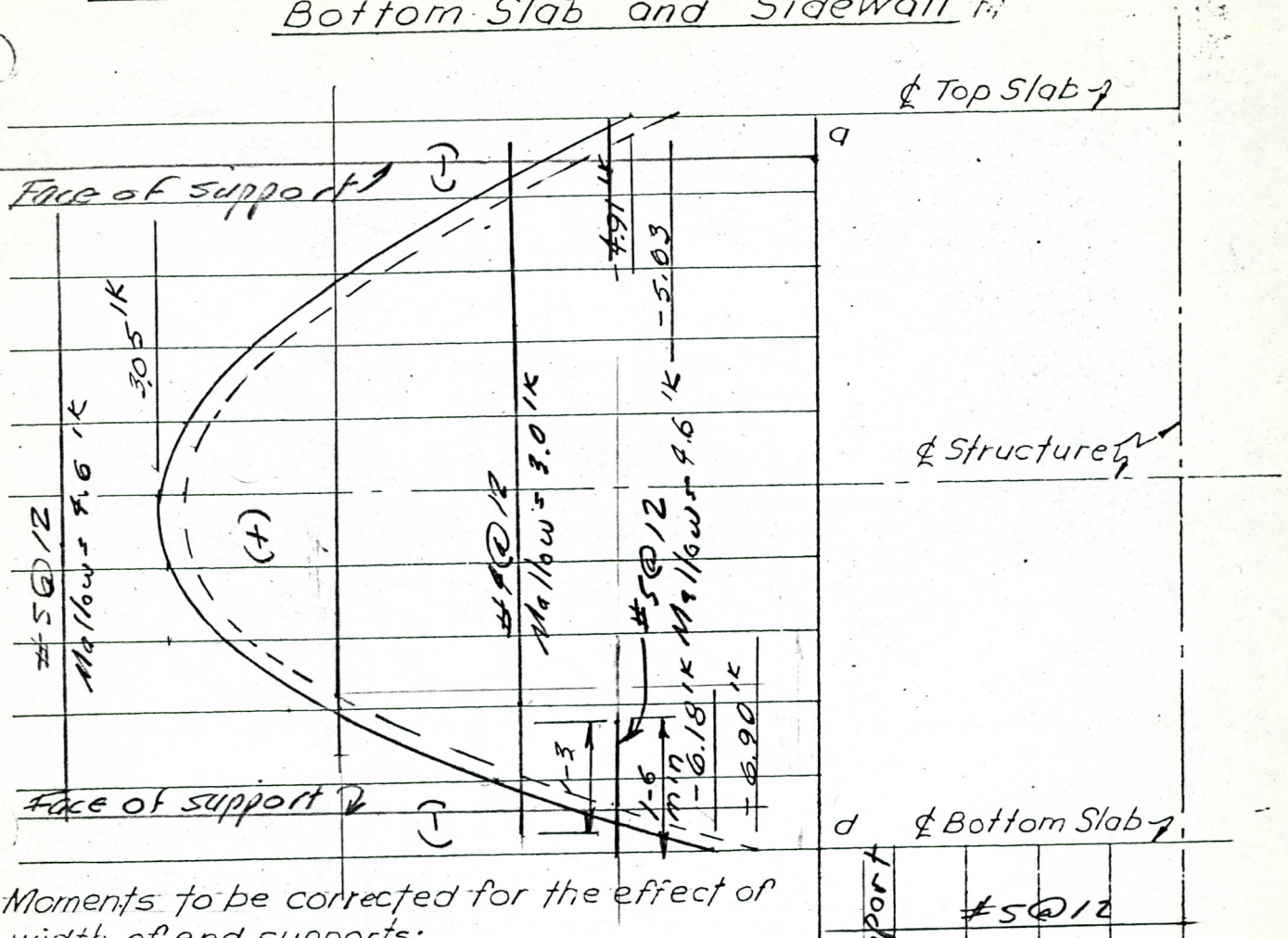
$B = 4324$, $M_c = M_{da} - \frac{B}{6} = -6180 - \frac{4324}{6} = -6.9$ Kips

At Face of Support: $M_c = M_{da} - \frac{B}{3} = -7.621$ Kips (5.46)

At ℄ of Span: $M_c = M_{℄} - \frac{B}{9} = 3.05 - \frac{4.32}{9} = 2.57$ Kips



Plot the Moment Diagrams for the Bottom Slab and Sidewall



Moments to be corrected for the effect of width of end supports:

Thickness of sidewall = $t_{w(ave.)}$ = in.

Thickness of bottom slab = t_s = in.

CORRECTED MOMENTS, BOTTOM SLAB:

At Point (d): $M_c = M_{dc} - \frac{1}{6} V_L \frac{t_{w(ave.)}}{12}$

Let $A = V_L \frac{t_{w(ave.)}}{12} = w_b \times \frac{L}{2} \times \frac{t_{w(ave.)}}{12} =$

$A =$, $M_c = M_{dc} - \frac{A}{6} =$

At Face of Support $M_c = M_{dc} - \frac{A}{3} =$

At ℄ of Span: $M_c = M_{℄} - \frac{A}{9} =$

CORRECTED MOMENTS, SIDEWALL:

At Point (d): $M_c = M_{da} - \frac{1}{6} V_H \frac{t_s}{12}$

Let $B = V_H \frac{t_s}{12} = \left(\frac{W_{st} + W_{sb}}{2}\right) \frac{H}{2} \times \frac{t_s}{12} =$

$B =$, $M_c = M_{da} - \frac{B}{6} =$

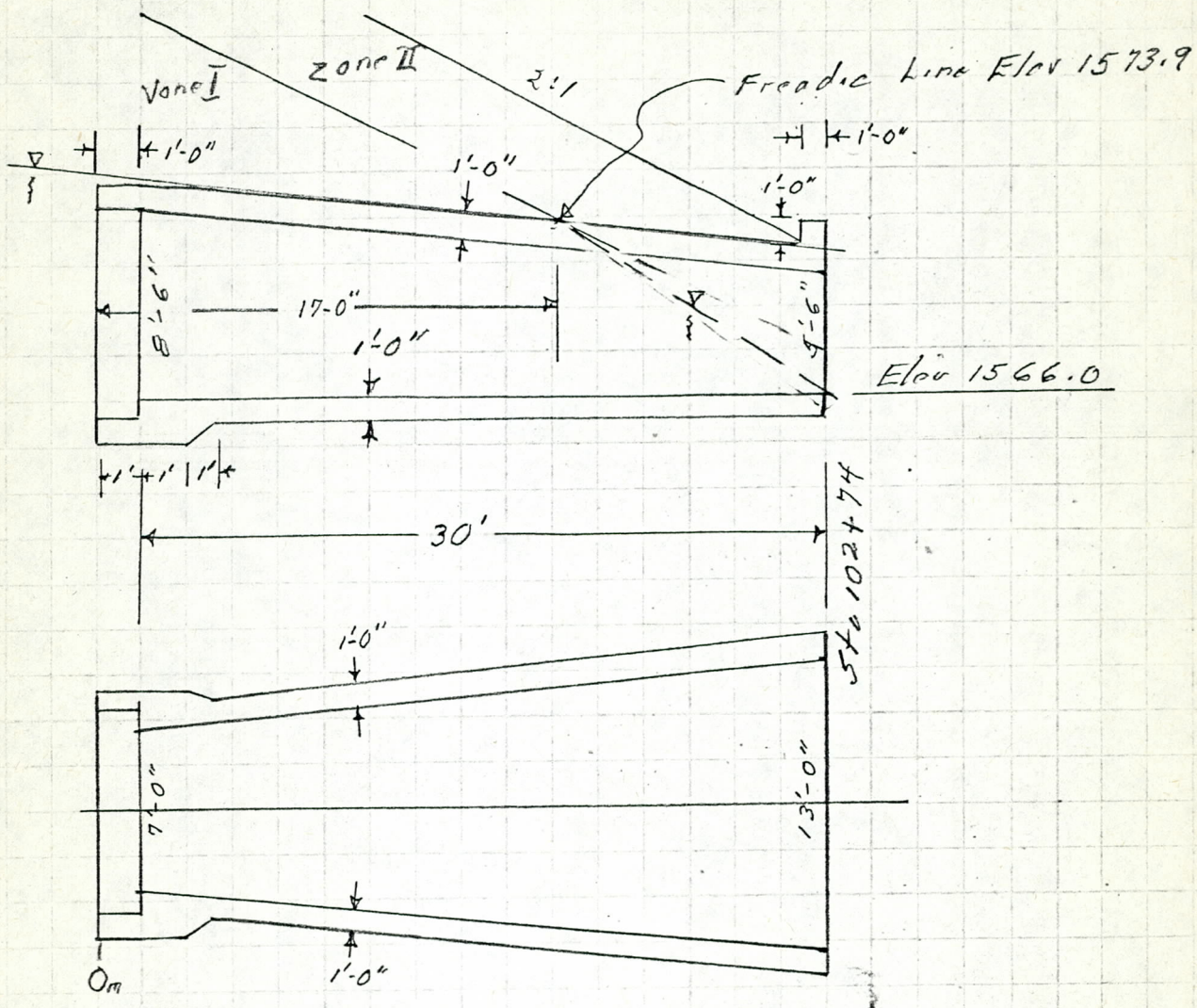
At Face of Support: $M_c = M_{da} - \frac{B}{3} =$

℄ of Span: $M_c = M_{℄} - \frac{B}{9} =$

(For discussion of moment correction, refer to "Continuity of Concrete Building Frames" by Portland Cement Association.)

STATE	PROJECT			
Arizona	Buckhorn Mesa WPP Spook Hill Dam			
BY	DATE	CHECKED BY	DATE	JOB NO.
D Riddle	12-4-75			2005

SUBJECT Transition Prin Spwy Outlet Culvert — SHEET 1 OF



Zone II

$\phi = 32.0°$

$\gamma_m = 128.8$ pcf

$\gamma_d = 116.1$ pcf

$\gamma_s = 151.2$ pcf

$\gamma_b = 88.8$

STATE	PROJECT			
Arizona	Buckhorn Mesa WPP Spack Hill Dam			
BY	DATE	CHECKED BY	DATE	JOB NO.
D Riddle	12-4-75			2065

SUBJECT: Transition Prin Spwy Outlet — SHEET 2 OF

Structural Design

Before fill

	Dem	W	Arm	M
floor	(30)(10)(1.0)(150)	45,000	17.00	765,000
Walls	2 (30)(9)(1.0)(150)	81,000	14.67	1,188,270
Top	(31)(10)(1.0)(150)	46,500	17.00	790,500
DS Curb	(15)(1.0)(1.0)(150)	2,250	30.50	68,625
ups sill	(2.5)(1.0)(32)(150)	12,000	1.25	15,000
		186,750		2,827,395

$\bar{x} = 2,827,395 \div 186,750 = 15.14$

$e = 15.50 - 15.14 = 0.36'$

$V/A = 186,750/(31)(12)+(1)(5) = 495$ psf

$p_d = 495[1+(6)(0.36)/31] = 531$ psf

$p_u = 495[1-(6)(0.36)/31] = 460$ psf

Affter Fill (as built)

Structur	186,750		2,827,395
Earth Fill (31)(7.75)(12)(128.8)	371,330	10.33'	3,835,843
Neglect Horiz Force			
	558,080		6,663,238

$6,663,238 \div 558,080 = 11.94$

$e = 15.50 - 11.94 = 3.56$

$P = 558,080[1 \pm 6(3.56)/31](31)(12)+5$

$P_d = 2,500$ psf

$P_u = 460$ psf

STATE	PROJECT			
Arizona	Backhorn Mesc W/PP. Speak Hill Dam			
BY D Riddle	DATE 12-4-75	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Transition Prin. Spwy. Outlet				SHEET 3 OF

Structural Design

No Flow Condition

uplift @ 30%

$s = \frac{3}{30} = 0.1$ Top Slop $\frac{1.4}{0.1} = 14.0' \& 17'$

		Wate	Arm	Moment
uplift	(12.0)(62.4)(8.3)(.7)(17)	-73,960	8.5	-628,650
	(14)(12)(3.05)(62.4)(.7)	-22,380	21.67	-485,010
Force from SAB Baser		-31,000	.31	-961,006
Total Neg		-127,340		2,074,660
Same of Cas built		558,080		6,663,238
		430,740		4,588,578

$z = 4,588,578 \div 430,740 = 10.65$

$e = 15.50 - 10.64 = 4.87$

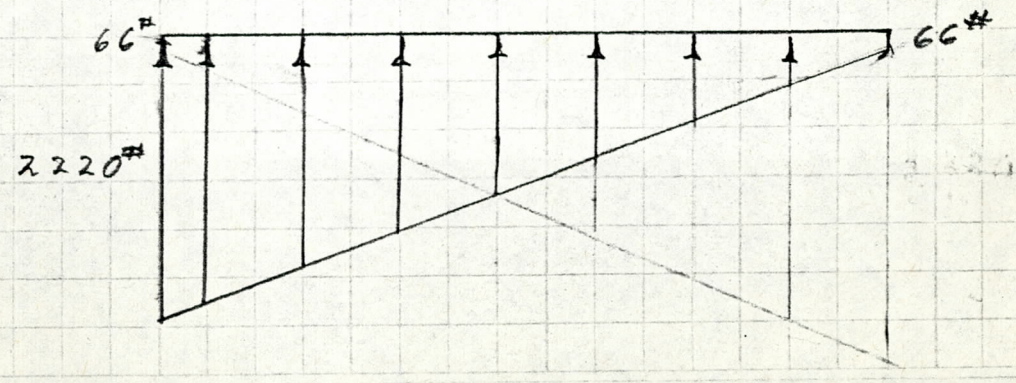
$V/A = 430,740/(31)(12)+(1)(5) = 1,143$

$P = 1,143\left[1 \pm (6)(4.87)/31\right]$

$P_d = 2,220$ PSF

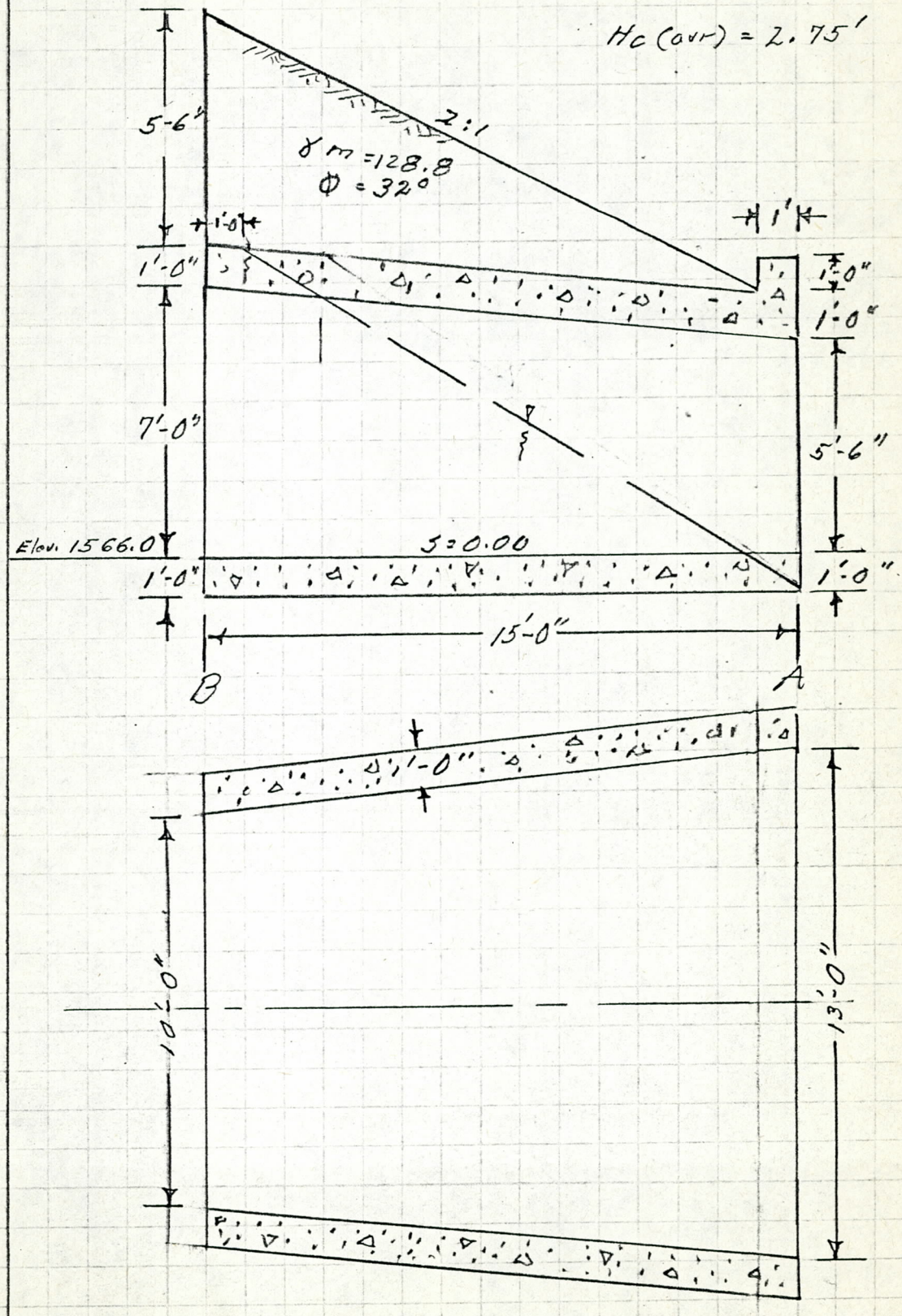
$P_u = 66$ PSF

Weight uplift = 558,080/127,340 = 4.38



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP Spookhill Dam		
BY	DATE	CHECKED BY	DATE	JOB NO.
D. Riddle	12-11-75			2005

SUBJECT Structural Design Prim Spwy Transition — SHEET ____ OF ____



STATE	PROJECT			
Arizona	Buckhorn Mesa WPP Spook Hill Dam			
BY	DATE	CHECKED BY	DATE	JOB NO.
D Riddle	12-11-75			2005

SUBJECT Str. Design P-in. Spwy. Transition Section (B) SHEET ____ OF ____

@ 15' u s

$$P = \frac{13.5}{13.5} = 1.07407$$

$$\delta P = (1)(1.07407) = 1.07407$$

$$K_4 = 0.17$$

$$\frac{H_c}{b_c} = \frac{5.5}{13.5} = 0.407407$$

$$C_c = 0.41$$

$$W_c = \frac{(.41)(128.8)(13.5)^2}{13.5} = 718. \frac{lbs}{ft^2}$$

$$K = 0.725$$

$$W_{st} = (6.0)(88.8)(0.725) + (6.0)(40) = 626.23$$

$$W_{bs} = (14.0)(88.8)(0.725) + (14.0)(40) = 1,461.32$$

STATE		PROJECT		
Arizona		Buckhorn-Mesa WPP Spookhill Dam		
BY	DATE	CHECKED BY	DATE	JOB NO.
D Riddle	12-16-75			2005

SUBJECT
Steel Design Transition Prin. Spwy ©

SHEET 7 OF

7'×8.5' Hc = 14.5

$P = \frac{10.5}{9.0} = 1.1667$

$K_u = 0.17$

$\frac{H_c}{b_c} = \frac{14.5}{9.0} = 1.611$

$\delta_p = 0.4$ from ES 22

$C_c = 2.3$

$W_c = (2.3)(128.8)(9)^2 = 23,995.44$

$Load = \frac{23,995.44}{9} = 2,666.16$ lbs

$W_d = 150 + 2,666.16 = 2,816.16$

Check Bottom Slab Thickness for Shear

$V_d = 9298(48 - 14.5) \div 48 = 6,489.23$

$d_s = \frac{6,489.23}{70 \times 12} = 7.73$ in

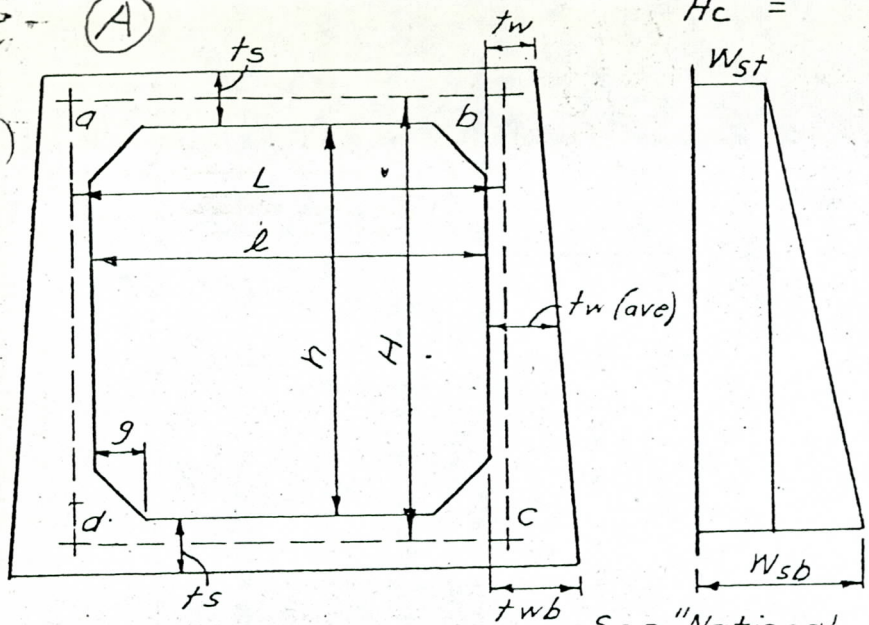
$12 - 2\frac{1}{2} = 9\frac{1}{2} > 7.73$ ok

Date 12-15-75
Comp by D R. dalla

DESIGN OF 5.5' x 13' R/C DROP INLET

Hc = Ft.

(A)



Hc=(Fill Over Box)= 0 ft.

H= 6.5 ft.; h= 5.5 ft.

L= 14 ft.; ℓ = 13 ft.

tw= 12 in.; twb= 12 in.

tw (ave) = 12 in

ts= 12 in.; g= 0. in.

$C = \left(\frac{ts}{tw(ave.)}\right)^3 \frac{H}{L}$

$C = \left(\frac{12}{12}\right)^3 \frac{6.5}{14} = 0.46429$

See "National Structural Design Handbook."

UNIT LOAD ON TOP SLAB: Section 6 para. 2.2.4.

$W_t = \left(150 \times \frac{Ts}{12}\right) + (\ 0\ ) = 150$ = 150 lbs/ft²

UNIT LOAD ON BOTTOM SLAB

Concrete Weight:

2 Sidewalls $= 2 \times 150 \times \frac{Tw(ave.)}{12} \times h = 300 \times \frac{12}{12} \times 5.5 = 1{,}650$ lbs.

W_w = Distributed weight $= \frac{\text{Sidewall weight}}{\left(\ell + \frac{2\,twb}{12}\right)} = \frac{1{,}650}{13+2} = 110$ lbs/ft²

Concrete plus Fill:

W_b = Unit load on bottom slab = $W_t + W_w = 150 + 110$ 260 lbs/ft²

UNIT SIDEWALL LOAD (See "Structure Design Handbook" Section 6)

At ℄ Top Slab: $W_{st} = (\ 0\ ) = 0$ lbs/ft²

At ℄ Bottom Slab: $W_{sb} = W_{st} + (150)(6.5)\left[\frac{12}{12}\right] = 707$ lbs/ft²

$(W_{sb} - W_{st}) = 707$ lbs/ft²

CHECK BOTTOM SLAB THICKNESS FOR SHEAR

V_{ts} = Shear at thickness $ts = W_b\left(\frac{\ell}{2} - \frac{g}{12}\right) = 260\ (6.5 - 0.5) = 1{,}560$ lbs.

d_s = Thickness req'd. for shear $= \frac{V_{ts}}{v\,j\,b} = \frac{V_{ts}\ 1560}{70 \times 7/8 \times 12}$ = 2.12 in.

(ds cannot exceed $ts - 2\frac{1}{2}$); $(ts - 2\frac{1}{2}) = 12 - 2\frac{1}{2} = 9.5$ in.

Check thickness req'd. at end of Fillet (at max. depth of fillet)

$V_e = W_b\left(\frac{\ell}{2}\right) =$ = lbs.

$d_s = \frac{Ve}{\quad} =$ = in. (ds cannot exceed $ts - 2\frac{1}{2} + \frac{g}{2}$)

$\left(ts - 2\frac{1}{2} + \frac{g}{2}\right) =$ $-2\frac{1}{2} + 3 =$ in.

DESIGN OF 13' x 5.5' R/C DROP INLET H_c = 0 FT.

Date 12-15-75
Comp. by D Riddle
180 of 429

(A)

L 14 Ft L^2 = 196
H 6.5 Ft H^2 = 42.25

CALCULATE FIXED-ENDED MOMENTS:

$M^F_{cd} = \frac{1}{12} W_b L^2 = \frac{260(196)}{12} = 4,247$ ft.-lbs.; $M^F_{ab} = \frac{1}{12} W_t L^2 = \frac{150(196)}{12} = 2,450$ ft.-lbs.

$M^F_{ad} = \frac{1}{12} W_{st} H^2 + \frac{1}{30}(W_{sb} - W_{st}) H^2 = \frac{0}{12} + \frac{707(42.25)}{30} = 996$

$M^F_{cb} = \frac{1}{12} W_{st} H^2 + \frac{1}{20}(W_{sb} - W_{st}) H^2 = \frac{0}{12} + \frac{707(42.25)}{20} = 1,494$

$M^F_{ab} = -2,450$ ft.-lbs. $\quad M^F_{ad} = +996$ ft.-lbs.

$M^F_{cd} = -4247$ ft.-lbs. $\quad M^F_{cb} = +1,494$ ft.-lbs.

$M^F_{dc} = +4,247$ ft.-lbs.

CALCULATE DISTRIBUTED END MOMENTS:

$$M_{ab} = M^F_{ab} - \frac{C}{(C+2)^2 - 1}\left[(C+2)(M^F_{ab} + M^F_{ad}) + (M^F_{cd} + M^F_{cb})\right]$$

$$M_{dc} = M^F_{cd} + \frac{C}{(C+2)^2 - 1}\left[(C+2)(M^F_{cd} + M^F_{cb}) + (M^F_{ab} + M^F_{ad})\right]$$

$M_{dc} + M_{da} = 0$ $\qquad$ $M_{ab} + M_{ad} = 0$

	Calculate M_{ab}:		Calculate M_{dc}		
	C	0.464			
	$(C+2)$	2.464			
	$(C+2)^2$	6.07			
	$(C+2)^2 - 1$	5.07			
(A)	$-\frac{C}{(C+2)^2-1}$	-0.0915	$+\frac{C}{(C+2)^2-1}$	+0.0915	(G)
	$(M^F_{ab} + M^F_{ad})$	-1,452	$(M^F_{cd} + M^F_{cb})$	-2,753	
(B)	$(C+2)(M^F_{ab} + M^F_{ad})$	-3583	$(C+2)(M^F_{cd} + M^F_{cb})$	-6,783	(H)
(C)	$(M^F_{cd} + M^F_{cb})$	-2,753	$(M^F_{ab} + M^F_{ad})$	-1,452	(I)
(D)	Total (B) + (C)	-6,336	Total (H) + (I)	-8,235	(J)
(E)	Product (A) x (D)	+580	Product (G) x (J)	-754	(K)
(F)	M^F_{ab}	-2450	M^F_{dc}	-4,247	(L)
	$M_{ab} = (F) + (E)$	-1,870	$M_{dc} = (L) + (K)$	-5001	
	M_{ad}	-1,870	M_{da}	-5001	
	M_{ba}	+1,870	M_{cb}	+5001	
	M_{bc}	1,870	M_{cd}	+5001	

DESIGN OF 13 x 5.5 R/C DROP INLET HC 0 Ft.

Sheet 3 of 18 19 425
Date 12-15-25
Comp. By D Riddl

(A)

COMPUTE SIMPLE BEAM MOMENTS (AT 1/10 POINTS)

For Bottom Slab: $M = m W_b L^2$; Let $A = W_b L^2 = 260 \times 196 = 50,960$ ft. lb.

Location	M = Moment at 1/10 Points	Moment	Location	M = Moment at 1/10 Points	Moment
Point d	0	0	0.3 dc	.105 A	5351
0.1 dc	.045 A	2293	0.4 dc	.120 A	6115
0.2 dc	.080 A	4077	℄ 0.5 dc	.125 A	6370

FOR SIDE WALLS: M = Uniform M + Trianglar M

$M = m W_{st} H^2 + m \mathbb{W} H$; Let $W_{st} H^2 = B =$. x = 0 ft. lb.

$\mathbb{W} = (W_{sb} - W_{st}) \frac{H}{2} = 7.07 \times \frac{6.5}{2} = 2298$ lbs

Let $C = \left[(W_{sb} - W_{st}) \frac{H}{2}\right] \times H = 2298 \times 6.5 = 14,935.38$ ft. lb.

For Uniform Load			For Triangular Load			
Location	m x B	Moment	Location	m x C	Moment	Total Moment
Point a	0	0	Point a	0	0	0
0.1 ad	0.045 B	0	0.1 ad	0.033 C	493	493
0.2 ad	0.080 B	0	0.2 ad	0.064 C	956	956
0.3 ad	0.105 B	0	0.3 ad	0.091 C	1,359	1,359
0.4 ad	0.120 B	0	0.4 ad	0.112 C	1,673	1,673
0.5 ad	0.125 B	0	0.5 ad	0.125 C	1,867	1,867
0.6 ad	0.120 B	0	0.6 ad	0.128 C	1,912	1,912
0.7 ad	0.105 B	0	0.7 ad	0.119 C	1,777	1,777
0.8 ad	0.080 B	0	0.8 ad	0.096 C	1,434	1,434
0.9 ad	0.045 B	0	0.9 ad	0.057 C	851	851
Point d	0	0	Point d	0	0	0

PLOT THE MOMENT DIAGRAMS ON THE FOLLOWING SHEET

CHECK SIDEWALL THICKNESS

(For following computations, refer to tables in "Reinf. Concrete Design Handbook" by Amer. Concrete Institute)

Revised M at Face of top Slab = ft. kips

$F = \frac{M}{K} = \frac{5.0}{277} = 0.018$ From Table 4 with b = 12 in,

and $F = 0.25$, then d = 5 in. $(t_w - 2\frac{1}{2}) = 9\frac{1}{2}$ in.

Revised M at ℄ of Sidewall = ft. kips

$F = \frac{M}{K} = \frac{6.40}{277} = 0.00147$ From Table 4 with b = 12 in.,

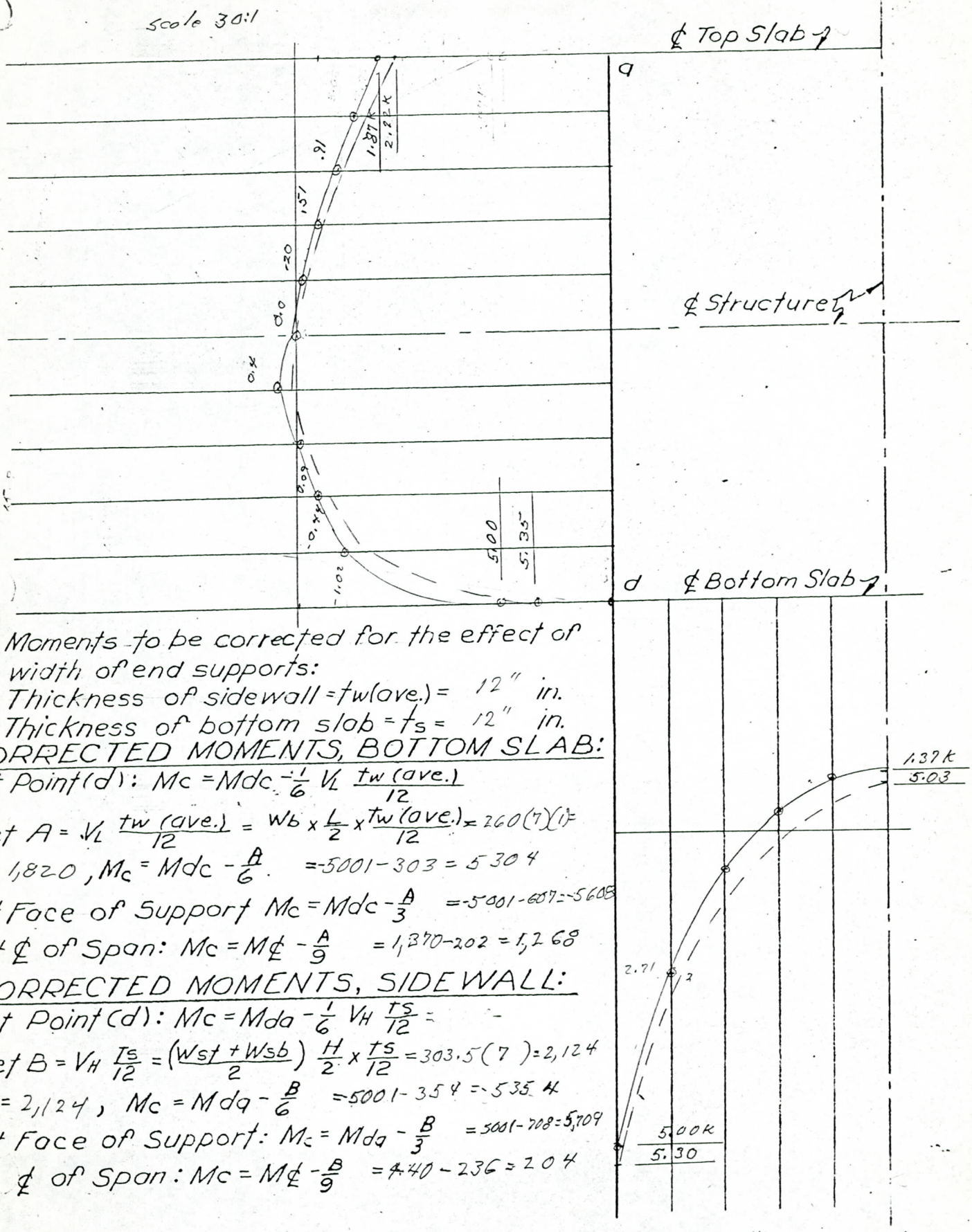
and $F = 0.25$, then d = 5 in. $(t_{w\,ave.}) - 2\frac{1}{2}) = 9\frac{1}{2}$ in.

(The minimum sidewall thickness assumed will always be adequate for shear, even up to 30 ft. fill over the barrel.)

DESIGN OF 13' x 5.5' R/C DROP INLET Hc 0 Ft.

(A)

Plot the Moment Diagrams for the Bottom Slab and Sidewall



Moments to be corrected for the effect of width of end supports:

Thickness of sidewall = $t_{w(ave.)}$ = 12" in.

Thickness of bottom slab = t_s = 12" in.

CORRECTED MOMENTS, BOTTOM SLAB:

At Point(d): $M_c = M_{dc} - \frac{1}{6} V_L \frac{t_{w(ave.)}}{12}$

Let $A = V_L \frac{t_{w(ave.)}}{12} = W_b \times \frac{L}{2} \times \frac{t_{w(ave.)}}{12} = 260(7)(1) =$

$A = 1,820$, $M_c = M_{dc} - \frac{A}{6}$ $= -5001 - 303 = 5304$

At Face of Support $M_c = M_{dc} - \frac{A}{3}$ $= -5001 - 607 = -5608$

At ℄ of Span: $M_c = M_{℄} - \frac{A}{9}$ $= 1,370 - 202 = 1,168$

CORRECTED MOMENTS, SIDEWALL:

At Point(d): $M_c = M_{da} - \frac{1}{6} V_H \frac{t_s}{12} =$

Let $B = V_H \frac{t_s}{12} = \left(\frac{W_{st} + W_{sb}}{2}\right) \frac{H}{2} \times \frac{t_s}{12} = 303.5(7) = 2,124$

$B = 2,124$, $M_c = M_{da} - \frac{B}{6}$ $= -5001 - 354 = -5354$

At Face of Support: $M_c = M_{da} - \frac{B}{3}$ $= 5001 - 708 = 5,709$

℄ of Span: $M_c = M_{℄} - \frac{B}{9}$ $= 440 - 236 = 204$

(For discussion of moment correction, refer to "Continuity of Concrete Building Frames" by Portland Cement Association.)

DESIGN OF 13 x 5.5 R/C DROP INLET-Hc=0 FT.

(A)

DESIGN OF BOTTOM SLAB: (Make Top Slab similar)

Corrected Neg. M at Face of Sidewall = 5608 ft.-lbs.

Corrected Net M at ℄ Slab = 1268 ft.-lbs (indicate sign)

$F = \frac{(M \text{ in kips})}{K}$ (Use the largest of the two Moments above)

K = 272 (Taken from Table 1 "Reinforced Concrete Design Handbook" of the American Concrete Institute.)

$F = \frac{5.608}{272} = 0.02$

From Table 4 (Reinf. Concrete Design Handbook)

with b = 12 in., and F = 0.02, then d = 5 in. (for moment)

Use t_s = 9½ in. slab (d + 2½") for top and bottom. (d = 12 in. for shear)

STEEL DETERMINATION FOR BOTTOM SLAB

$A_{s\,Neg} = \frac{\text{Corrected } M_{Neg} \text{ (in kips) (At face of sidewall)}}{ad}$

a = (From Table 1, "Reinforced Concrete Design Handbook")

d = (t_s − 2½") = −2½" = . in.

$A_{s\,Neg} = \frac{\quad}{x} =$ sq. in.

$\Sigma_{o\,Neg} = \frac{V_s}{u\,j\,d} = \frac{\quad}{x \quad x} =$ in.

The negative steel is determined by _____ (Moment or Bond)

USE _____ bars spaced _____ in. c to c. (Neg. Steel)

$A_{s\,Pos} = \frac{\text{Corrected } M_{pos} \text{ (in kips) (at ℄ span)}}{ad}$

$= \frac{\quad}{x} =$ sq. in.

$\Sigma_{o\,pos} = \frac{V \text{ at Zero M}}{u\,j\,d}$

$V_{at\ zero\ M} = W_b \times$ (Distance in feet from ℄ to point of inflection, as determined from revised moment diagram.)

= x = lbs.

$\Sigma_{o\,pos} = \frac{\quad}{x \quad x} =$ in.

The positive steel is determined by _____ (Moment or Bond)

USE _____ bars spaced _____ in. c. to c. (Pos. Steel)

DESIGN OF SIDEWALL:

Steel Required at ℄ Sidewall (for a net +M)

$A_s = \frac{\text{Corrected M.℄ (kips)}}{9d(a+℄)} = \frac{\quad}{x} =$ sq. in.

$℄_o = \frac{V \text{ at zero } M}{4 j d_i}$ $d_i =$ in. effective depth at point of inflection, near top slab

$= \frac{\quad}{x \quad x} =$ in.

Use bars spaced in. c. to c. (Sidewall Positive Steel)

(Note: Separate calculations should be made to check actual stresses in concrete and steel at the top, the ℄, and the bottom of the sidewall for the condition of combined bending and axial loading which exists. Calculations for a 6 x 6 with a 30 ft. fill showed that the allowable stresses were not exceeded (axial load = 15, 150 #), however further checks should be made for other fill heights and structure sizes.)

TEMPERATURE REINFORCING:

See "Engineering Handbook Structural Design"- Section 6 Dwg E.S. 47

For a ____ in. top and bottom slab

Use bars spaced in. c. to c. (For exposed face)

Use bars spaced in. c. to c. (For unexposed face)

For a ____ in sidewall (ave. thickness)

Use bars spaced in. c. to c. (For exposed face)

Use bars spaced in. c to c. (For unexposed face)

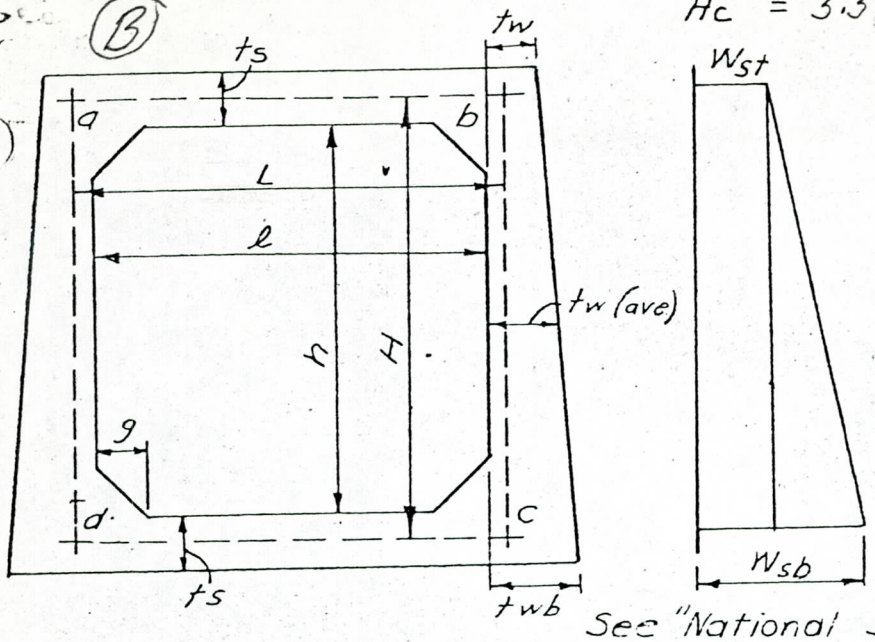
(It is recommended that the temperature steel required for maximum fill depth be used throughout barrel length, unless it is practical to vary the amount.

DESIGN OF ? X 10 R/C DROP INLET

Sheet 1 of [illegible]
Date 12-8-75
Comp by D Riddle

H_c = 5.5 Ft.

(B)



Hc=(Fill Over Box)= 5.5 ft.

H= 8.0 ft.; h= 7.0 ft.

L = 11.0 ft.; ℓ = 10.0 ft.

t_w = 1.2" in.; t_{wb} = 12 in.

$t_{w(ave)}$ = 1.2 in

ts= 12 in.; g = 0. in.

$$C = \left(\frac{t_s}{t_{w(ave.)}}\right)^3 \frac{H}{L}$$

$$C = \left(\frac{12}{12}\right)^3 \frac{8}{11} = 0.7273$$

See "National Structural Design Handbook." Section 6 para. 2.2.4. (See back sheet)

UNIT LOAD ON TOP SLAB:

$$W_t = \left(150 \times \frac{T_s}{12}\right) + (\omega_c) = (150)\left(\frac{12}{12}\right) + 713 = \underline{863} \text{ lbs/ft}^2$$

UNIT LOAD ON BOTTOM SLAB

Concrete Weight:

2 Sidewalls $= 2 \times 150 \times \frac{T_{w(ave)}}{12} \times h = 300 \times \frac{12}{12} \times 7.0 = 2{,}100$ lbs.

W_w = Distributed weight $= \frac{\text{Sidewall weight}}{\left(\ell + \frac{2\, t_{wb}}{12}\right)} = \frac{2{,}100}{(10)+2} = 105$ lbs/ft²

Concrete plus Fill:

W_b = Unit load on bottom slab = $W_t + W_w$ = 863 + 105 = 968 lbs/ft²

UNIT SIDEWALL LOAD (See "Structure Design Handbook" Section 6)

At ℄ Top Slab $W_{st} = (6)(88.8)(.725) + (6)40 = 626.23$ lbs/ft²

At ℄ Bottom Slab: $W_{sb} = W_{st} + \left(\frac{(14)(88.8)(.725) + 14(40)}{}\right) = 1{,}461.32$ lbs/ft²

$(W_{sb} - W_{st}) = 1461.32 - 626.23 = 835.09$ lbs/ft²

CHECK BOTTOM SLAB THICKNESS FOR SHEAR

V_{ts} = Shear at thickness $t_s = W_b\left(\frac{\ell}{2} - \frac{g}{12}\right) = 968\ (5 - 0.5) = 4{,}356$ lbs.

d_s = Thickness req'd. for shear $= \frac{V_{ts}}{v\, j\, b} = \frac{V_{ts}\ 4{,}356.0}{70 \times 7/8 \times 12} = 5.93$ in.

(d_s cannot exceed $t_s - 2\frac{1}{2}$); $(t_s - 2\frac{1}{2}) = 12.0 - 2\frac{1}{2} = 9.5$ in.

Check thickness req'd. at end of Fillet (at max. depth of fillet)

$V_\ell = W_b\left(\frac{\ell}{2}\right) =$ = lbs.

$d_s = \frac{V_\ell}{} =$ = in. (ds cannot exceed $t_s - 2\frac{1}{2} + \frac{g}{2}$)

$\left(t_s - 2\frac{1}{2} + \frac{g}{2}\right) =$ $-2\frac{1}{2} + 3 =$ in.

DESIGN OF 7' x 10 R/C-DROP INLET $H_C = 5.5$ FT.

(B)

L 11 Ft $L^2 =$ 121
H 8 Ft $H^2 =$ 64

CALCULATE FIXED-ENDED MOMENTS:

$M^F_{cd} = \frac{1}{12} W_b L^2 = \frac{(968)(11)^2}{12} = 9{,}761$ ft.-lbs.; $M^F_{ab} = \frac{1}{12} W_t L^2 = \frac{863(11)^2}{12} = 8{,}702$ ft.-lbs.

$$M^F_{ad} = \frac{1}{12} W_{st} H^2 + \frac{1}{30}(W_{sb} - W_{st}) H^2 = \frac{626.23(8)^2}{12} + \frac{(835.09)(8)^2}{30} = 5{,}121.42$$

$$M^F_{cb} = \frac{1}{12} W_{st} H^2 + \frac{1}{20}(W_{sb} - W_{st}) H^2 = \frac{626.23(8)^2}{12} + \frac{(835.09)(8)^2}{20} = 6{,}012.18$$

$M^F_{ab} = -8702$ ft.-lbs. $\quad M^F_{ad} = +5{,}121$ ft.-lbs.

$M^F_{cd} = -9{,}761$ ft.-lbs. $\quad M^F_{cb} = +6{,}012$ ft.-lbs.

$M^F_{dc} = +9{,}761$ ft.-lbs.

CALCULATE DISTRIBUTED END MOMENTS:

$$M_{ab} = M^F_{ab} - \frac{C}{(C+2)^2-1}\left[(C+2)(M^F_{ab} + M^F_{ad}) + (M^F_{cd} + M^F_{cb})\right]$$

$$M_{dc} = M^F_{cd} + \frac{C}{(C+2)^2-1}\left[(C+2)(M^F_{cd} + M^F_{cb}) + (M^F_{ab} + M^F_{ad})\right]$$

$M_{dc} + M_{da} = 0 \qquad M_{ab} + M_{ad} = 0$

	Calculate M_{ab}:		Calculate M_{dc}		
	C	0.7273			
	$(C+2)$	2.7273			
	$(C+2)^2$	7.438			
	$(C+2)^2-1$	6.438			
(A)	$-\frac{C}{(C+2)^2-1}$	-0.1127	$+\frac{C}{(C+2)^2-1}$	+0.1127	(G)
	$(M^F_{ab} + M^F_{ad})$	-3,581	$(M^F_{cd} + M^F_{cb})$	-3,749	
(B)	$(C+2)(M^F_{ab} + M^F_{ad})$	-9,766	$(C+2)(M^F_{cd} + M^F_{cb})$	-10,224	(H)
(C)	$(M^F_{cd} + M^F_{cb})$	-3,749	$(M^F_{ab} + M^F_{ad})$	-3,581	(I)
(D)	Total (B) + (C)	-13,515	Total (H) + (I)	-13,806	(J)
(E)	Product (A) x (D)	+1,523	Product (G) x (J)	-1,555	(K)
(F)	M^F_{ab}	-8,702	M^F_{dc}	9,761	(L)
	$M_{ab} = (F) + (E)$	-7,179	$M_{dc} = (L) + (K)$	+8206	
	M_{ad}	+7,179	M_{dc}	8206	
	M_{ba}	-[illegible]	M_{cb}	[illegible]	
	M_{bc}	-[illegible]	M_{cd}	[illegible]	

DESIGN OF 7' x 10' R/C DROP INLET Hc 5.5 Ft. Sheet 3 of
Date 12-7-35
Comp. By O.R.dlb.

(B)

COMPUTE SIMPLE BEAM MOMENTS (AT 1/10 POINTS)

For Bottom Slab: $M = m W_b L^2$; Let $A = W_b L^2 = 968 \times (11)^2 = 117{,}128$ ft. lb.

Location	M = Moment at 1/10 Points	Moment	Location	M = Moment at 1/10 Points	Moment
Point d	0	0	0.3 dc	.105 A	12,298
0.1 dc	.045 A	5,271	0.4 dc	.120 A	14,055
0.2 dc	.080 A	9,370	℄ 0.5 dc	.125 A	14,641

FOR SIDE WALLS: M = Uniform M + Trianglar M

$M = m W_{st} H^2 + m \text{Ⅳ} H$; Let $W_{st} H^2 = B = 626.23 \times (8)^2 = 40{,}079$ ft. lb.

$\text{Ⅳ} = (W_{sb} - W_{st}) \frac{H}{2} = 835.09 \times \frac{8}{2} = 3{,}340$ lbs

Let $C = [(W_{sb} - W_{st}) \frac{H}{2}] \times H = 3{,}340 \times 8 = 26{,}723$ ft. lb.

For Uniform Load			For Triangular Load			
Location	m x B	Moment	location	m x C	Moment	Total Moment
Point a	0	0	Point a	0	0	0
0.1 ad	0.045 B	1,803	0.1 ad	0.033 C	882	2,685
0.2 ad	0.080 B	3,238	0.2 ad	0.064 C	1,710	4,948
0.3 ad	0.105 B	4,208	0.3 ad	0.091 C	2,432	6,640
0.4 ad	0.120 B	4,809	0.4 ad	0.112 C	2,993	7,802
0.5 ad	0.125 B	5,010	0.5 ad	0.125 C	3,340	8,350
0.6 ad	0.120 B	4,809	0.6 ad	0.128 C	3,421	8,230
0.7 ad	0.105 B	4,208	0.7 ad	0.119 C	3,180	7,388
0.8 ad	0.080 B	3,238	0.8 ad	0.096 C	2,565	5,803
0.9 ad	0.045 B	1,803	0.9 ad	0.057 C	1,523	3,326
Point d	0	0	Point d	0	0	0

PLOT THE MOMENT DIAGRAMS ON THE FOLLOWING SHEET

CHECK SIDEWALL THICKNESS (For following computations, refer to tables in "Reinf. Concrete Design Handbook" by Amer. Concrete Institute)

Revised M at Face of top Slab = [illegible] ft. kips

$F = \frac{M}{K} = \frac{6.07_u}{272} = 0.022316$ From Table 4 with b = 12 in,

and $F = 0.022316$, then d = 6" in. $(t_w - 2\frac{1}{2}) = 9\frac{1}{2}$ in.

Revised M at ℄ of Sidewall = ft. kips

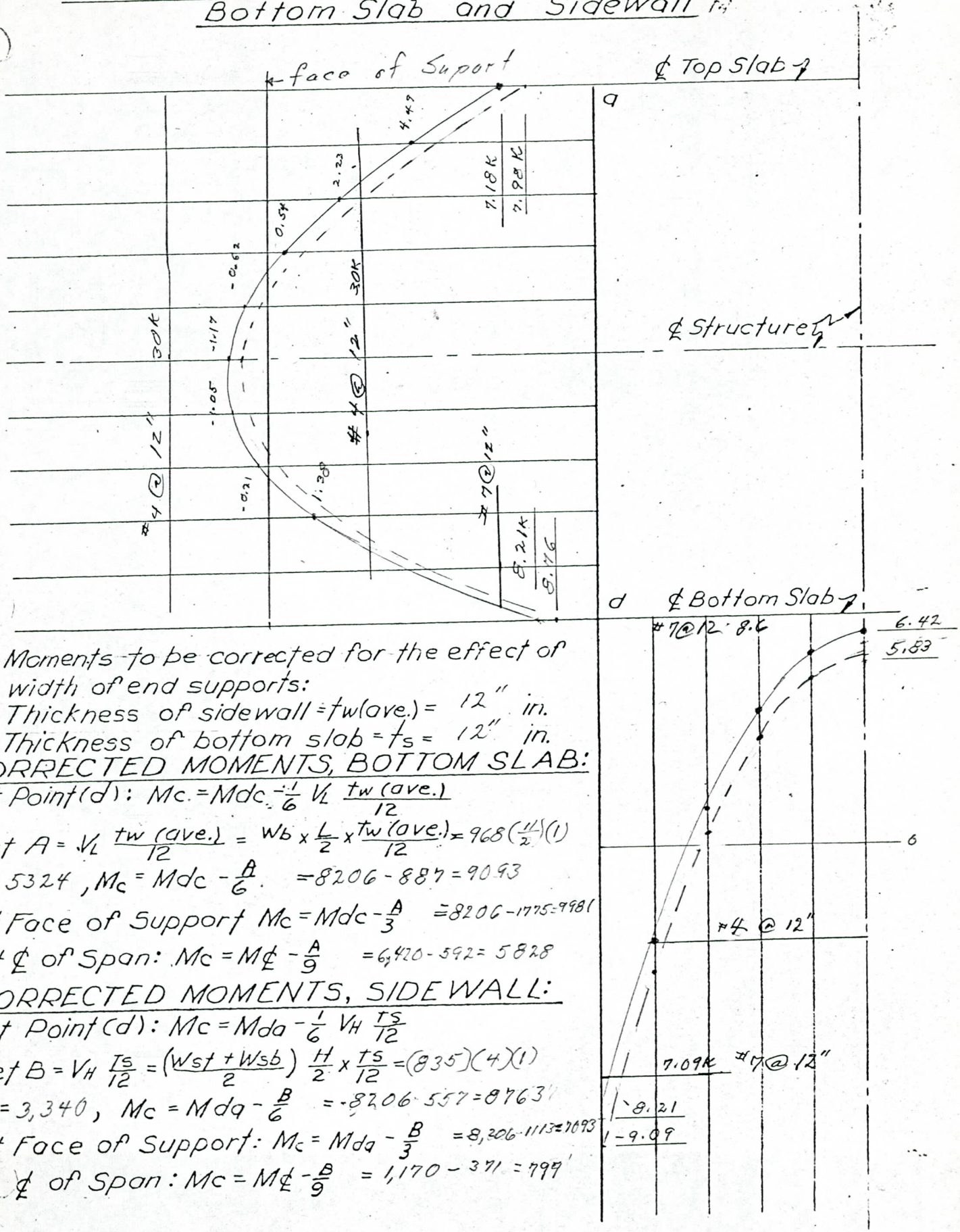
$F = \frac{M}{K} = \frac{1.17}{272} = 0.00430$ From Table 4 with b = 12 in.,

and $F = 0.00430$, then d = 12 in. $(t_{w\,ave.}) - 2\frac{1}{2}) =$ in.

(The minimum sidewall thickness assumed will always be adequate for shear, even up to 30 ft. fill over the barrel.)

(B)

Plot the Moment Diagrams for the Bottom Slab and Sidewall



Moments to be corrected for the effect of width of end supports:
Thickness of sidewall = $t_{w(ave.)}$ = 12" in.
Thickness of bottom slab = t_s = 12" in.

CORRECTED MOMENTS, BOTTOM SLAB:

At Point (d): $M_c = M_{dc} - \frac{1}{6} V_L \frac{t_{w(ave.)}}{12}$

Let $A = V_L \frac{t_{w(ave.)}}{12} = W_b \times \frac{L}{2} \times \frac{t_{w(ave.)}}{12} = 968\left(\frac{11}{2}\right)(1)$

$A = 5324$, $M_c = M_{dc} - \frac{A}{6} = -8206 - 887 = 9093$

At Face of Support $M_c = M_{dc} - \frac{A}{3} = 8206 - 1775 = 9981$

At ℄ of Span: $M_c = M_{℄} - \frac{A}{9} = 6{,}420 - 592 = 5828$

CORRECTED MOMENTS, SIDEWALL:

At Point (d): $M_c = M_{da} - \frac{1}{6} V_H \frac{t_s}{12}$

Let $B = V_H \frac{t_s}{12} = \left(\frac{W_{st} + W_{sb}}{2}\right) \frac{H}{2} \times \frac{t_s}{12} = (835)(4)(1)$

$B = 3{,}340$, $M_c = M_{da} - \frac{B}{6} = -8206 - 557 = 8763$

At Face of Support: $M_c = M_{da} - \frac{B}{3} = 8{,}206 - 1113 = 7093$

℄ of Span: $M_c = M_{℄} - \frac{B}{9} = 1{,}170 - 371 = 799$

(For discussion of moment correction, refer to "Continuity of Concrete Building Frames" by Portland Cement Association.)

DESIGN OF 7 x 10 R/C DROP INLET-Hc=5.5Ft.

(B)

DESIGN OF BOTTOM SLAB: (Make Top Slab similar)

Corrected Neg M at Face of Sidewall = -9981 ft.-lbs.

Corrected Net M at ℄ Slab = ± 5828 ft.-lbs (indicate sign)

$F = \frac{\text{(M in kips) (Use the largest of the two Moments above)}}{K} = 9,981$

K = 272 (Taken from Table 1 "Reinforced Concrete Design Handbook" of the American Concrete Institute.)

$F = \frac{9981}{272} = 0.037$

From Table 4 (Reinf. Concrete Design Handbook)

with b = 12 in., and F = 0.036, then d = 6 in. (for moment)

Use t_s = 12 in. slab ($d + 2\frac{1}{2}$") for top and bottom. ($d = 8\frac{1}{2}$ in. for shear)

STEEL DETERMINATION FOR BOTTOM SLAB

$A_{s\,Neg} = \frac{\text{Corrected } M_{Neg} \text{ (in kips) (At face of sidewall)}}{ad}$

a = (From Table 1, "Reinforced Concrete Design Handbook")

$d = (t_s - 2\frac{1}{2}") = \quad -2\frac{1}{2}" = \quad$ in.

$A_{s\,Neg} = \frac{\quad}{x} = \quad$ sq. in.

$\ell_{o\,Neg} = \frac{V_{\ell}}{ujd} = \frac{\quad}{x \quad x} = \quad$ in.

The negative steel is determined by _____ (Moment or Bond)

USE _____ bars spaced _____ in. c to c. (Neg. Steel)

$A_{s\,Pos} = \frac{\text{Corrected } M_{pos} \text{ (in kips) (at ℄ span)}}{ad}$

$= \frac{\quad}{x} = \quad$ sq. in.

$\ell_{o\,pos} = \frac{V \text{ at Zero M}}{ujd}$

$V_{at\ zero\ M} = W_b \times$ (Distance in feet from ℄ to point of inflection, as determined from revised moment diagram.)

$= \quad x \quad = \quad$ lbs.

$\ell_{o\,pos} = \frac{\quad}{x \quad x} = \quad$ in.

The positive steel is determined by _____ (Moment or Bond)

USE _____ bars spaced _____ in. c. to c. (Pos. Steel)

DESIGN OF SIDEWALL:

Steel Required at ℄ Sidewall (for a net +M)

$A_s = \frac{\text{Corrected M.E(kips)}}{9d(\text{at ℄})} = \frac{\quad}{x} =$ sq. in.

$\Sigma_o = \frac{V \text{ at zero M}}{4 j d_i}$ $d_1 =$ in. effective depth at point of inflection, near top slab

$= \frac{\quad}{x \quad x} =$ in.

Use bars spaced in. c. to c. (Sidewall Positive Steel)

(Note: Separate calculations should be made to check actual stresses in concrete and steel at the top, the ℄, and the bottom of the sidewall for the condition of combined bending and axial loading which exists. Calculations for a 6 x 6 with a 30 ft. fill showed that the allowable stresses were not exceeded (axial load = 15, 150#), however further checks should be made for other fill heights and structure sizes.)

TEMPERATURE REINFORCING:

See "Engineering Handbook Structural Design"- Section 6
For a ____ in. top and bottom slab Dwg E.S. 47

Use bars spaced in. c. to c. (For exposed face)

Use bars spaced in. c. to c. (For unexposed face)

For a ____ in sidewall (ave. thickness)

Use bars spaced in. c. to c. (For exposed face)

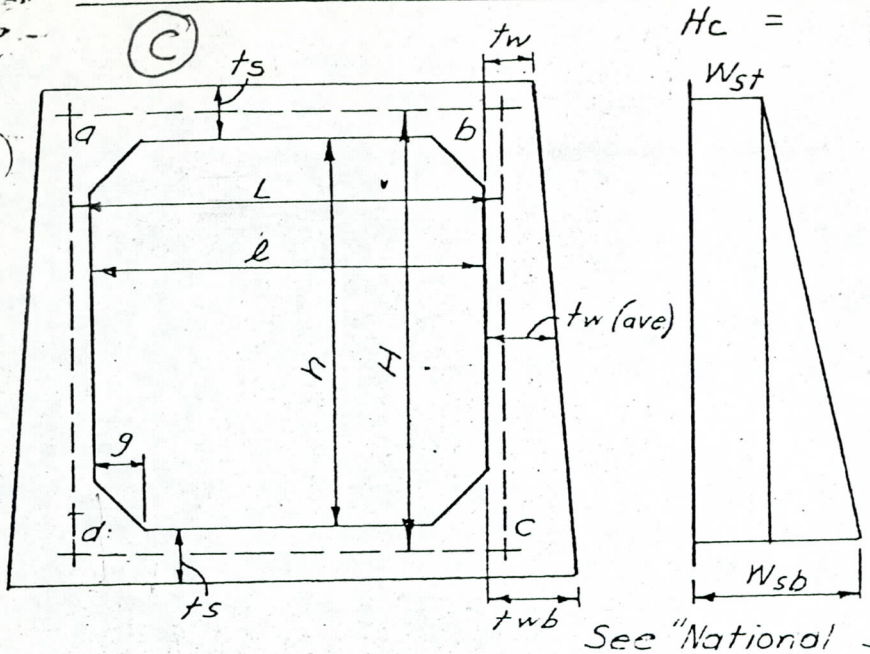
Use bars spaced in. c. to c. (For unexposed face)

(It is recommended that the temperature steel required for maximum fill depth be used throughout barrel length, unless it is practical to vary the amount.

DESIGN OF 8.5' x 7' R/C DROP INLET

Sheet 1 of
Date 12-16-75
Comp by D Ridella

Hc = Ft.



Hc = (Fill Over Box) = 14.5 ft.
H = 9.5 ft.; h = 8.5 ft.
L = 8.0' ft.; ℓ = 7.0 ft.
tw = 12 in.; twb = 12 in.
tw (ave.) = 12 in
ts = 12 in.; g = 0. in.

$$C = \left(\frac{ts}{tw(ave.)}\right)^3 \frac{H}{L}$$

$$C = \left(\frac{12}{12}\right)^3 \frac{9.5}{8} = 1.1875$$

See "National Structural Design Handbook." Section 6 – para. 2.2.4 (see Sheet No 7)

UNIT LOAD ON TOP SLAB:

$$W_t = \left(150 \times \frac{Ts}{12}\right) + (1,666.16) =$$

$$= \underline{2,816.16} \text{ lbs/ft}^2$$

UNIT LOAD ON BOTTOM SLAB

Concrete Weight:

2 Sidewalls $= 2 \times 150 \times \frac{Tw(ave.)}{12} \times h = 300 \times \frac{12}{12} \times 8.5 = 2,550$ lbs.

$$W_w = \text{Distributed weight} = \frac{\text{Sidewall weight}}{\left(\ell + \frac{2\,twb}{12}\right)} = \frac{2,550}{7+2} = 283.33 \text{ lbs/ft}^2$$

Concrete plus Fill

W_b = Unit load on bottom slab = $W_t + W_w = 2,816.16 + 283.33 = \underline{3,099.49}$ lbs/ft²

UNIT SIDEWALL LOAD (See "Structure Design Handbook" Section 6)

At ℄ Top Slab: $W_{st} = (15.5)(88.8)(.725) + (15.5)(40) = 1,619.89$ lbs/ft²

At ℄ Bottom Slab: $W_{sb} = W_{st} + (24)(88.8)(.725) + (24)(40) = 2,505.12$ lbs/ft²

$(W_{sb} - W_{st}) = 2,505.12 - 1,619.89 = 887.23$ lbs/ft²

CHECK BOTTOM SLAB THICKNESS FOR SHEAR

V_{ts} = Shear at thickness $ts = W_b\left(\frac{\ell}{2} - \frac{g}{12}\right) = 3,099.49(3.5 - 0.5) = 9,298$ lbs.

See Sheet #7

ds = Thickness req'd. for shear $= \frac{V_{ts}}{vjb} = \frac{9,298}{70 \times (7/8) \times 12} = 12.65$ in.

(ds cannot exceed $ts - 2\frac{1}{2}$); $(ts - 2\frac{1}{2}) = 12 - 2\frac{1}{2} = 9\frac{1}{2}$ in.

Check thickness req'd. at end of Fillet (at max. depth of fillet)

$V_\ell = W_b\left(\frac{\ell}{2}\right) =$ = lbs.

$ds = \frac{V_\ell}{} =$ = in. (ds cannot exceed $ts - 2\frac{1}{2} + \frac{g}{2}$)

$\left(ts - 2\frac{1}{2} + \frac{g}{2}\right) = -2\frac{1}{2} + 3 =$ in.

DESIGN OF 8'-5" x 7' R/C DROP INLET Hc = 14.5 Ft.

Date 12-16-75 Comp. by D Riddle

(C) L 8 Ft L^2 = 64
H 9.5 Ft H^2 = 90.25

CALCULATE FIXED-ENDED MOMENTS:

$M^F_{cd} = \frac{1}{12} W_b L^2 = \frac{3,099(64)}{12} = 16,528$ ft.-lbs.; $M^F_{ab} = \frac{1}{12} W_t L^2 = \frac{2,816(64)}{12} = 15,020$ ft.-lbs.

$M^F_{ad} = \frac{1}{12} W_{st} H^2 + \frac{1}{30}(W_{sb} - W_{st}) H^2 = \frac{1,617.89(90.25)}{12} + \frac{887.23(90.25)}{30} = 14,836$

$M^F_{cb} = \frac{1}{12} W_{st} H^2 + \frac{1}{20}(W_{sb} - W_{st}) H^2 = \frac{1,617.89(90.25)}{12} + \frac{887.23(90.25)}{20} = 16,172$

$M^F_{ab} = -15,020$ ft.-lbs. $M^F_{ad} = +14,836$ ft.-lbs.

$M^F_{cd} = -16,528$ ft.-lbs. $M^F_{cb} = +16,172$ ft.-lbs.

$M^F_{dc} = +16,528$ ft.-lbs.

CALCULATE DISTRIBUTED END MOMENTS:

$$M_{ab} = M^F_{ab} - \frac{C}{(C+2)^2 - 1}\left[(C+2)(M^F_{ab} + M^F_{ad}) + (M^F_{cd} + M^F_{cb})\right]$$

$$M_{dc} = M^F_{cd} + \frac{C}{(C+2)^2 - 1}\left[(C+2)(M^F_{cd} + M^F_{cb}) + (M^F_{ab} + M^F_{ad})\right]$$

$M_{dc} + M_{da} = 0$ $\qquad$ $M_{ab} + M_{ad} = 0$

	Calculate M_{ab}:		Calculate M_{dc}		
	C	1.1875			
	$(C+2)$	3.1875			
	$(C+2)^2$	10.160			
	$(C+2)^2 - 1$	9.160			
(A)	$-\frac{C}{(C+2)^2-1}$	-0.1296	$+\frac{C}{(C+2)^2-1}$	+0.1296	(G)
	$(M^F_{ab} + M^F_{ad})$	-.184	$(M^F_{cd} + M^F_{cb})$	-356	
(B)	$(C+2)(M^F_{ab} + M^F_{ad})$	-586.5	$(C+2)(M^F_{cd} + M^F_{cb})$	-1,135	(H)
(C)	$(M^F_{cd} + M^F_{cb})$	-356.0	$(M^F_{ab} + M^F_{ad})$	-184	(I)
(D)	Total (B) + (C)	-942.5	Total (H) + (I)	-1,319	(J)
(E)	Product (A) x (D)	+122	Product (G) x (J)	-171	(K)
(F)	M^F_{ab}	15,020	M^F_{dc}	+16,528	(L)
	$M_{ab} = (F) + (E)$	-14,898	$M_{dc} = (L) + (K)$	16,357	
	M_{ad}	-14,898	M_{dc}	-16,357	
	M_{ba}	+14,898	M_{cb}	+16,357	
	M_{bc}	14,898	M_{cd}	16,357	

DESIGN OF 7' x 8.5' R/C DROP INLET Hc 14.5 Ft. Sheet 3 of
Date 12-16-75
Comp. By D Riddle

(C)

COMPUTE SIMPLE BEAM MOMENTS (AT 1/10 POINTS)

For Bottom Slab: $M = m W_b L^2$; Let $A = W_b L^2 = 3,099 \times 64 = 198,336$ ft. lb.

Location	M=Moment at 1/10 Points	Moment	Location	M=Moment at 1/10 Points	Moment
Point d	0	0	0.3 dc	.105 A	20,825
0.1 dc	.045 A	8,925	0.4 dc	.120 A	23,800
0.2 dc	.080 A	15,867	℄ 0.5 dc	.125 A	24,792

FOR SIDE WALLS: M = Uniform M + Trianglar M

$M = m W_{st} H^2 + m \text{Ⅲ} H$; Let $W_{st} H^2 = B = 1,61789 \times 90.25 = 146,015$ ft. lb.

$\text{Ⅲ} = (W_{sb} - W_{st}) \frac{H}{2} = 887.23 \times \frac{9.5}{2} = 4,214$ lbs

Let $C = \left[(W_{sb} - W_{st}) \frac{H}{2}\right] \times H = 4,214.34 \times 9.5 = 40,036$ ft. lb.

For Uniform Load			For Triangular Load			
Location	m x B	Moment	Location	m x C	Moment	Total Moment
Point a	0	0	Point a	0	0	0
0.1 ad	0.045 B	6,571	0.1 ad	0.033 C	1,321	7,892
0.2 ad	0.080 B	11,681	0.2 ad	0.064 C	2,562	14,243
0.3 ad	0.105 B	15,332	0.3 ad	0.091 C	3,643	18,975
0.4 ad	0.120 B	17,522	0.4 ad	0.112 C	4,484	22,006
0.5 ad	0.125 B	18,252	0.5 ad	0.125 C	5,004	23,256
0.6 ad	0.120 B	17,522	0.6 ad	0.128 C	5,125	22,647
0.7 ad	0.105 B	15,332	0.7 ad	0.119 C	4,764	20,096
0.8 ad	0.080 B	11,681	0.8 ad	0.096 C	3,843	15,524
0.9 ad	0.045 B	6,571	0.9 ad	0.057 C	2,282	8,853
Point d	0	0	Point d	0	0	0

PLOT THE MOMENT DIAGRAMS ON THE FOLLOWING SHEET

CHECK SIDEWALL THICKNESS (For following computations, refer to tables in "Reinf. Concrete Design Handbook" by Amer. Concrete Institute)

Revised M at Face of Top Slab = ft. Kips

$F = \frac{M}{K} = \frac{14.90}{2.72} = 0.055$ From Table 4 with b = 12 in,

and $F = 0.056$, then d = 7½ in. $(t_w - 2\frac{1}{2}) = 9$ in.

Revised M at ℄ of Sidewall = ft. Kips

$F = \frac{M}{K} = \frac{8.36}{2.72} = 0.031$ From Table 4 with b = 12 in.,

and $F = 0.036$, then d = 6 in. $(t_{w\,ave.}) - 2\frac{1}{2} = 8\frac{1}{2}$ in.

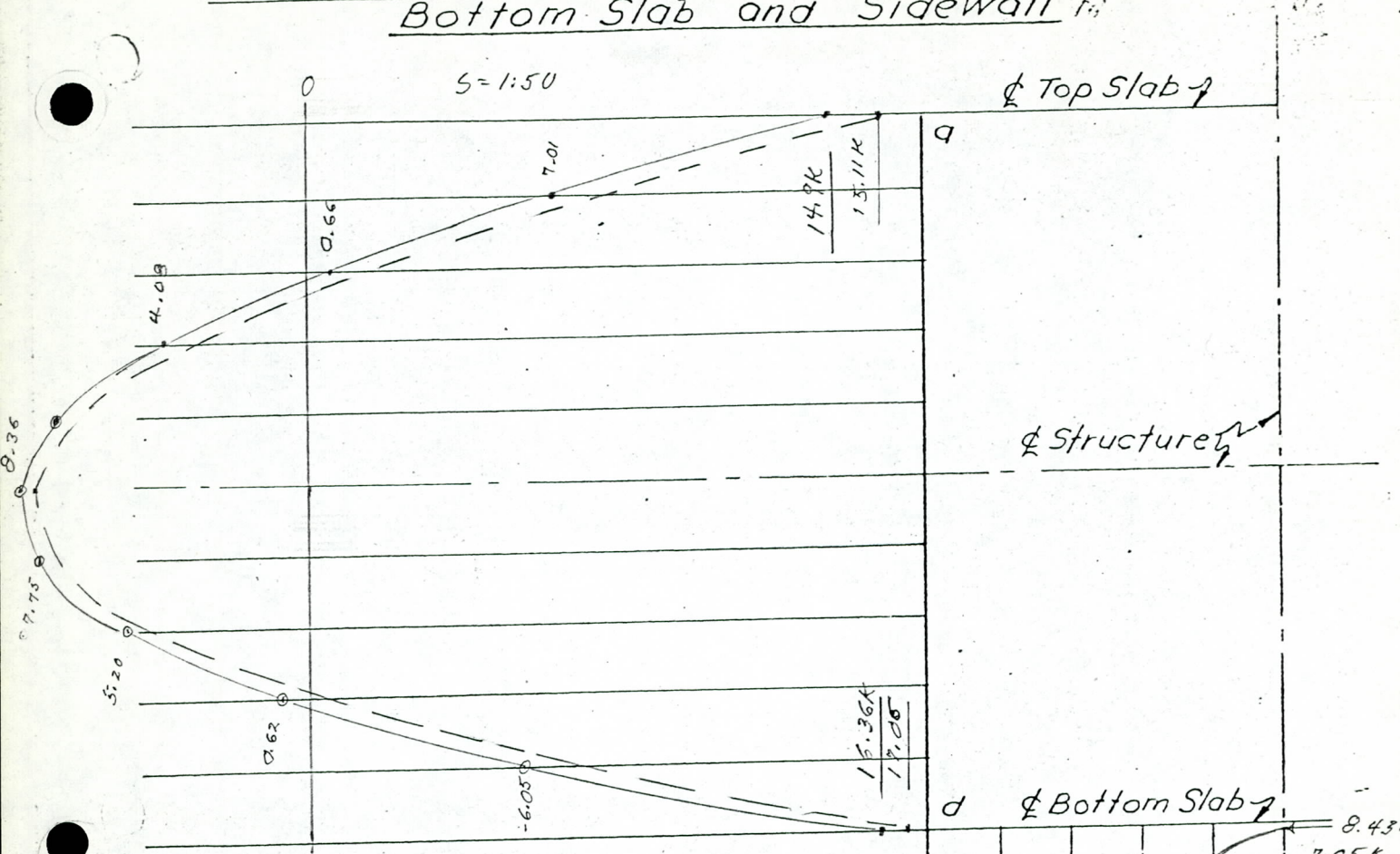
(The minimum sidewall thickness assumed will always be adequate for shear, even up to 30 ft. fill over the barrel.)

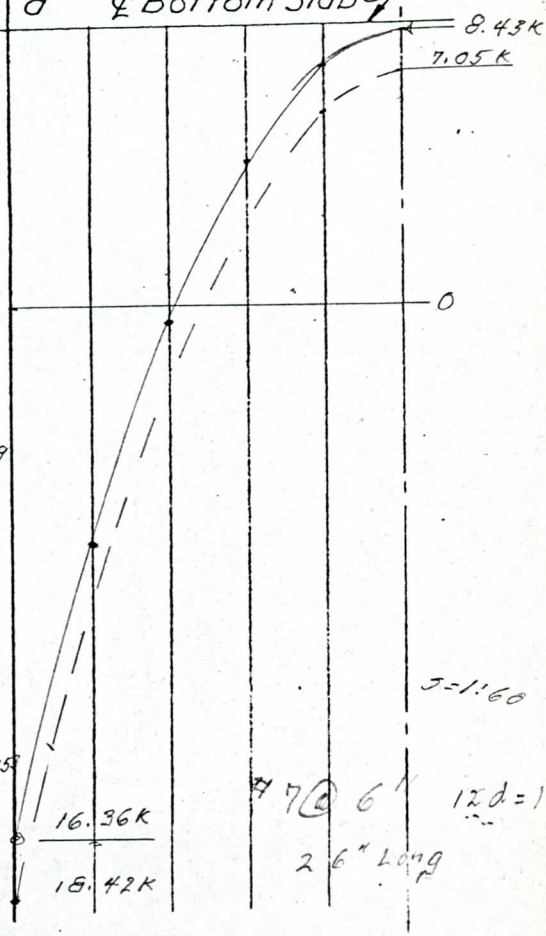
DESIGN OF 7' x 8.5' R/C DROP INLET Hc 14.5 Ft.

Date 12-16-75
Comp. by D. Riddle

(C)

Plot the Moment Diagrams for the Bottom Slab and Sidewall





Moments to be corrected for the effect of width of end supports:

Thickness of sidewall = $t_{w(ave.)}$ = 12 in.

Thickness of bottom slab = t_s = 12 in.

CORRECTED MOMENTS, BOTTOM SLAB:

At Point (d): $M_c = M_{dc} - \frac{1}{6} V_L \frac{t_{w(ave.)}}{12}$

Let $A = V_L \frac{t_{w(ave.)}}{12} = W_b \times \frac{L}{2} \times \frac{t_{w(ave.)}}{12} = 3,099(4)(1)$

$A = 12,396$, $M_c = M_{dc} - \frac{A}{6} = -16,357 - 2,066 = 18,423$

At Face of Support $M_c = M_{dc} - \frac{A}{3} = -16,357 - 4132 = 20,489$

At ℄ of Span: $M_c = M_{℄} - \frac{A}{9} = 8,430 - 1,377 = 7,053$

CORRECTED MOMENTS, SIDEWALL:

At Point (d): $M_c = M_{da} - \frac{1}{6} V_H \frac{t_s}{12}$

Let $B = V_H \frac{t_s}{12} = \left(\frac{W_{st} + W_{sb}}{2}\right) \frac{H}{2} \times \frac{t_s}{12} = 889(4.75) = 4,213$

$B = 4,213$, $M_c = M_{da} - \frac{B}{6} = 16,359 - 702. = 17,059$

At Face of Support: $M_c = M_{da} - \frac{B}{3} = 16,357 - 1,404 = 14,953$

℄ of Span: $M_c = M_{℄} - \frac{B}{9} = 8,360 - 468 = 7,892$

(For discussion of moment correction, refer to "Continuity of Concrete Building Frames" by Portland Cement Association.)

DESIGN OF 7 x 8.5 R/C DROP INLET-Hc=14.5 Ft.

(C)

DESIGN OF BOTTOM SLAB: (Make Top Slab similar)

Corrected Neg M at Face of Sidewall = 18,423 ft.-lbs.

Corrected Net M at ℄ Slab = 7,053 ft.-lbs (indicate sign)

$F = \frac{\text{(M in Kips) (Use the largest of the two Moments above)}}{K}$

K = 272 (Taken from Table 1 "Reinforced Concrete Design Handbook" of the American Concrete Institute.)

$F = \frac{18.423^{K}}{272} \quad 0.068$

From Table 4 (Reinf. Concrete Design Handbook)

with b = 12 in., and F = 0.772, then d = 8½ in. (for moment)

Use t_s = 8½ in. slab (d + 2½") for top and bottom. (d = 11 in. for shear)

STEEL DETERMINATION FOR BOTTOM SLAB

$A_{s\,Neg} = \frac{\text{Corrected } M_{Neg} \text{ (in kips) (At face of sidewall)}}{ad}$

a = (From Table 1, "Reinforced Concrete Design Handbook")

d = (t_s - 2½") = -2½" = . in.

$A_{s\,Neg} = \frac{\quad}{x} =$ sq. in.

$\ell_{o\,Neg} = \frac{V_x}{u\,j\,d} = \frac{\quad}{x \quad x} =$ in.

The negative steel is determined by _____ (Moment or Bond)

USE bars spaced in. c to c. (Neg. Steel)

$A_{s\,Pos} = \frac{\text{Corrected } M_{pos} \text{ (in kips) (at ℄ span)}}{ad}$

$= \frac{\quad}{x} =$ sq. in.

$\ell_{o\,pos} = \frac{V \text{ at Zero } M}{u\,j\,d}$

$V_{at\ zero\ M} = W_b \times$ (Distance in feet from ℄ to point of inflection, as determined from revised moment diagram.)

= x = lbs.

$\ell_{o\,Pos} = \frac{\quad}{x \quad x} =$ in.

The positive steel is determined by _____ (Moment or Bond)

USE bars spaced in. c. to c. (Pos. Steel)

DESIGN OF SIDEWALL:

Steel Required at ℄ Sidewall (for a net +M)

$A_s = \frac{\text{Corrected M.℄ (kips)}}{9d(\text{at ℄})} = \frac{\quad}{x} =$ ___ sq. in.

$\Sigma_o = \frac{V \text{ at zero M}}{4 j d_i}$ $d_i =$ ___ in. effective depth at point of inflection, near top slab

$= \frac{\quad}{x \quad x} =$ ___ in.

Use ___ bars spaced ___ in. c. to c. (Sidewall Positive Steel)

(Note: Separate calculations should be made to check actual stresses in concrete and steel at the top, the ℄, and the bottom of the sidewall for the condition of combined bending and axial loading which exists. Calculations for a 6 x 6 with a 30 ft. fill showed that the allowable stresses were not exceeded (axial load = 15, 150 #), however further checks should be made for other fill heights and structure sizes.)

TEMPERATURE REINFORCING:

See "Engineering Handbook Structural Design" - Section 6
For a ___ in. top and bottom slab Dwg E.S. 47

Use ___ bars spaced ___ in. c. to c. (For exposed face)

Use ___ bars spaced ___ in. c. to c. (For unexposed face)

For a ___ in sidewall (ave. thickness)

Use ___ bars spaced ___ in. c. to c. (For exposed face)

Use ___ bars spaced ___ in. c. to c. (For unexposed face)

(It is recommended that the temperature steel required for maximum fill depth be used throughout barrel length, unless it is practical to vary the amount.

See EB 163 Sec 6

DESIGN OF SIDEWALL:

Steel Required at ℄ Sidewall (for a net +M) 0.43

$A_s = \frac{\text{Corrected M.E (kips)}}{9d(\text{at }℄)} = \frac{\quad}{x} =$ sq. in.

$\Sigma_o = \frac{V \text{ at zero M}}{4 j d_i}$ $d_i =$ in. effective depth at point of inflection, near top slab

$= \frac{\quad}{x \quad x} =$ 0 in.

See ES 46 Sec 6

Use 4 bars spaced 12 in. c. to c. (Sidewall Positive Steel)

(Note: Separate calculations should be made to check actual stresses in concrete and steel at the top, the ℄, and the bottom of the sidewall for the condition of combined bending and axial loading which exists. Calculations for a 6 x 6 with a 30 ft. fill showed that the allowable stresses were not exceeded (axial load = 15,150 #), however further checks should be made for other fill heights and structure sizes.)

TEMPERATURE REINFORCING:

See "Engineering Handbook Structural Design" - Section 6
Dwg E.S. 47

For a ____ in. top and bottom slab

Use ____ bars spaced ____ in. c. to c. (For exposed face)

Use ____ bars spaced ____ in. c. to c. (For unexposed face)

For a ____ in sidewall (ave. thickness)

Use ____ bars spaced ____ in. c. to c. (For exposed face)

Use ____ bars spaced ____ in. c. to c. (For unexposed face)

(It is recommended that the temperature steel required for maximum fill depth be used throughout barrel length, unless it is practical to vary the amount.

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. - Spook Hill F.R.S.		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	12-1-75			2005

SUBJECT R/C Drop inlet structure as built condition SHEET 1 OF

N.E.H. Sec. 6 Para - 2.2.4 page 6-2-16

unit load on top slab

Find weight of concrete
Find weight of earthfill over Concrete

Concrete 1 ft. thick = 150 lbs/sq. ft.

Weight of earth (H_c = 5.0 ft.)

Projecting conduit condition

P = projection ratio = distance between the natural ground surface and the top of the conduit. h = 7.5' + 1.0' + 1.0' = 9.5 ft divided by conduit width. ℓ = 7.0' + 1.0' + 1.0' = 9.0 ft.

NEH 6
See E.S. 22

(1) $\frac{9.5}{9.0} = 1.0556 = P$, δ for unyielding material = 1

$\delta P = (1.0556)(1.0) = 1.0556$

(2) K_u for sandy, clayey silt = 0.17

from chart $\frac{He}{bc} = 2.175$

(3) $\frac{Hc}{bc} = \frac{5.0}{9.0} = 0.55556$

(4) $\frac{He}{bc}$ of 2.175 > $\frac{Hc}{bc}$ of 0.556, complete project

As built condit
no water table
2' surcharge
H_c = 5.0'
γ_m = 128.8 lbs
K = 0.725

(5) From curve on sheet 2 of ES 22
coeff C_c = 0.56

(6) Compute W_c (load per lin. ft.)

$W_c = C_c \gamma b_c^2$

$= (0.56)(128.8)(9^2) = 5842.37$

STATE. Arizona		PROJECT Buckhorn Mesa WPP - Spook Hill F.R.S.		
BY J.E.B.	DATE 12-2-75	CHECKED BY	DATE	JOB NO. 2005
SUBJECT R/C Drop inlet structure as built condition				SHEET 2 OF

load in lbs. per sq. ft. $= \frac{W_c}{bc} = \frac{5842.37}{9} = \underline{649.15}$ lbs

ratio $\frac{649}{(124)(5)} = 1.006$

Concrete + earth = 150 + 649.15 = 799.15 lbs/sq.ft.

γ_m 128 8
Soil 88.8
water 40.0 lbs

Unit sidewall load
At ℄ top slab $W_{st} = (5.5)\left(\frac{88.8 \text{ lbs}}{\text{cu.ft.}}\right)(.725) + (5.5)\left(\frac{40.0}{\text{cu ft}}\right)$

$W_{st} = \frac{354 \text{ lbs}}{\text{sq.ft.}} + \frac{220 \text{ lbs}}{\text{sq ft}} = \underline{\frac{574 \text{ lbs.}}{\text{sq. ft.}}}$

At ℄ bottom slab $W_{sb} = (14.0')\left(\frac{88.8 \text{ lbs}}{\text{cu.ft.}}\right)(.725) + (14.0')\left(\frac{40.0 \text{ lbs}}{\text{cu ft}}\right)$

$W_{sb} = \frac{901 \text{ lbs}}{\text{sq.ft.}} + \frac{560 \text{ lbs}}{\text{sq ft.}} = \underline{\frac{1461 \text{ lbs}}{\text{sq. ft.}}}$

$W_{sb} - W_{st} = 1461 - 574 = 887$ lbs/sq. ft.

Check bottom thickness for shear

V_{ts} = Shear at ts = $W_b\left(\frac{\ell}{2}\right)$ =

From ES 160
Class conc
4000
shear
$V_c = 70$

$V_{ts} = (1049)\left(\frac{7.0}{2}\right) = 3671.5$ lbs

d_s = thickness req'd for shear $\frac{V_{ts}}{V_j b}$

V = 70
J = 7/8
b = 12"

$\frac{V_{ts}}{V_j b} = \frac{3671.5}{(70)(7/8)(12)} = 5.0$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP - Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.E.B.	12-3-75			2005

SUBJECT R/C Drop inlet structure (as built condition) SHEET 3 OF

Check side wall thickness
From printed sheet #2
Mab = − 4.913 Kips , Mad = + 4.913 Kips

Revised M = 4.9 ft. Kips

From Book Reinforced Concrete Fundamentals
Table D-5 page 686
R from table is K in formula = 272

$$F = \frac{M}{K} = \frac{4.913 \text{ Kip}}{272} = 0.018$$

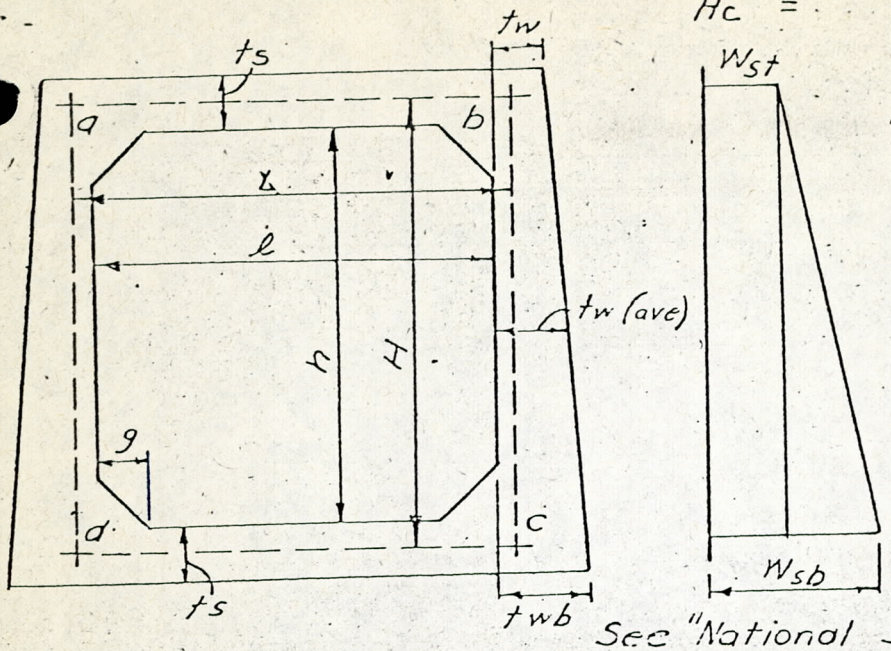
From table 4 Reinforced concrete Design Handbook

No Flow Condition

DESIGN OF X R/C DROP INLET

Sheet 31 of 49
Date 11-25-75
Comp by PJM - JEB

H_c = Ft.



H_c = (Fill Over Box) = 3.0 ft.

H = 8.5 ft.; h = 7.5 ft.

L = 8.0 ft.; ℓ = 7.0 ft.

t_w = 12 in.; t_{wb} = 12 in.

$t_{w(ave)}$ = 12 in

t_s = 12 in.; g = 0 in.

$$C = \left(\frac{t_s}{t_{w(a.e.)}}\right)^3 \frac{H}{L}$$

$$C = \left(\frac{12}{12}\right)^3 \frac{8.5}{8.0} = 1.06$$

See "National Structural Design Handbook" Section 6 - para. 2.2.4.

UNIT LOAD ON TOP SLAB:

$$W_t = \left(150 \times \frac{T_s}{12}\right) + \left(W_c = \Sigma \gamma b c^2\right) = \left(150 \times \frac{12}{12}\right) + (0.35)(151.2)(9^2) = 626 \text{ lbs/ft}^2$$

UNIT LOAD ON BOTTOM SLAB

Concrete Weight:

2 Sidewalls $= 2 \times 150 \times \frac{T_{w(ave)}}{12} \times h = 300 \times 7.5 = 2250$ lbs.

W_w = Distributed weight $= \frac{\text{Sidewall weight}}{\left(\ell + \frac{2\, t_{wb}}{12}\right)} = \frac{2250}{\left(7.0 + \frac{2 \times 12}{12}\right)} = 250 \text{ lbs/ft}^2$

Concrete plus Fill:

W_b = Unit load on bottom slab = $W_t + W_w$ = 626 + 250 = 876 lbs/ft.^{2}

UNIT SIDEWALL LOAD (See "Structure Design Handbook" Section 6)

At ℄ Top Slab: $W_{st} = \left(H_c + \frac{t_s}{2}\right)\left(\frac{88.8 \text{ lbs}}{\text{cu. ft}}\right)(.725) + H_c + \frac{t_s}{2}(62.4) = 443.73 \text{ lbs/ft}^2$

At ℄ Bottom Slab: $W_{sb} = W_{st} + \left(H_c + \frac{t_s}{2} + H \text{ (} \leq 12.0 \text{ ft)}\right)\left(\frac{88.8 \text{ lbs}}{\text{cu. ft}}\right)(.725) + (12)(62.4 \text{ lbs}) = 1521 \text{ lbs/ft}^2$

$(W_{sb} - W_{st})$ = 1521 − 443 = 1078 lbs/ft.^{2}

CHECK BOTTOM SLAB THICKNESS FOR SHEAR

V_{ts} = Shear at thickness $t_s = W_b\left(\frac{\ell}{2} - \frac{t_s}{12}\right) = 3066\left(\frac{7}{8} - 0.5\right) = 3066$ lbs.

d_s = Thickness req'd. for shear $= \frac{V_{ts}}{v_j b} = \frac{V_{ts}}{70 \times 7/8 \times 12} = \frac{3066}{(70)(12)} = \frac{(3066)(8)}{(70)(12)} = 4.17$ in.

(d_s cannot exceed $t_s - 2\frac{1}{2}$); $(t_s - 2\frac{1}{2}) = 12 - 2\frac{1}{2} = 9\frac{1}{2}$ in.

Check thickness req'd. at end of Fillet (at max. depth of fillet)

$V_\ell = W_b\left(\frac{\ell}{2}\right) =$ = lbs.

(cannot exceed $t_s - 2\frac{1}{2} + 2$)

Form ES-160

DESIGN OF 7.0 x 7.5 R/C DROP INLET H_c = 3 Ft.

Date 11-25-75
Comp. by PJM-JB
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L 8.0 Ft L^2 = 64
H 8.5 Ft H^2 = 72.25

CULATE FIXED-ENDED MOMENTS:

$M^F_{cd} = \frac{1}{12} W_b L^2 = \frac{(876)(64)}{12} = 4672$ ft.-lbs.; $M^F_{ab} = \frac{1}{12} W_t L^2 = \frac{(626)(64)}{12} = 3339$ ft.-lb

$M^F_{ad} = \frac{1}{12} W_{st} H^2 + \frac{1}{30}(W_{sb} - W_{st}) H^2 = \frac{(444)(72.25)}{12} + \frac{(1078)(72.25)}{30} = 5269$

$M^F_{cb} = \frac{1}{12} W_{st} H^2 + \frac{1}{20}(W_{sb} - W_{st}) H^2 = \frac{(444)(72.25}{12} + \frac{(1078)(72.25}{20} = 6567$

$M^F_{ab} = -3339$ ft.-lbs. $M^F_{ad} = +5269$ ft.-lbs.

$M^F_{cd} = -4672$ ft.-lbs. $M^F_{cb} = +6567$ ft.-lbs.

$M^F_{dc} = +4672$ ft.-lbs.

CALCULATE DISTRIBUTED END MOMENTS:

$$M_{ab} = M^F_{ab} - \frac{C}{(C+2)^2 - 1}\left[(C+2)(M^F_{ab} + M^F_{ad}) + (M^F_{cd} + M^F_{cb})\right]$$

$$M_{dc} = M^F_{cd} + \frac{C}{(C+2)^2 - 1}\left[(C+2)(M^F_{cd} + M^F_{cb}) + (M^F_{ab} + M^F_{ad})\right]$$

$M_{dc} + M_{da} = 0$ $M_{ab} + M_{ad} = 0$

	Calculate M_{ab}:		Calculate M_{dc}		
	C	1.06			
	$(C+2)$	3.06			
	$(C+2)^2$	9.36			
	$(C+2)^2 - 1$	8.36			
(A)	$-\frac{C}{(C+2)^2-1}$	-.1268	$+\frac{C}{(C+2)^2-1}$	+.1268.	(G)
	$(M^F_{ab} + M^F_{ad})$	1930	$(M^F_{cd} + M^F_{cb})$	-1895	
(B)	$(C+2)(M^F_{ab} + M^F_{ad})$	5906	$(C+2)(M^F_{cd} + M^F_{cb})$	5799	(H)
(C)	$(M^F_{cd} + M^F_{cb})$	1895	$(M^F_{ab} + M^F_{ad})$	1930	(I)
(D)	Total (B) + (C)	7801	Total (H) + (I)	7729	(J)
(E)	Product (A) x (D)	-989	Product (G) X (J)	980	(K)
(F)	M^F_{ab}	-3339	M^F_{dc}	4672	(L)
	M_{ab} = (F) + (E)	-4328	M_{dc} = (L) + (K)	5652	
	M_{ad}	+4328	M_{da}	-5652	
	M_{ba}	+4328	M_{cb}	-5652	

NO FLOW

DESIGN OF 7.0 x 7.5 R/C DROP INLET Hc 3.0 Ft.

COMPUTE SIMPLE BEAM MOMENTS (AT 1/10 POINTS)

For Bottom Slab: $M = mW_b L^2$; Let $A = W_b L^2 = 876 \times 8^2 = 56064$ ft. lb.

Location	M = Moment at 1/10 Points	Moment	Location	M = Moment at 1/10 Points	Moment
Point d	0	0	0.3 dc	.105 A	5887
0.1 dc	.045 A	2523	0.4 dc	.120 A	6728
0.2 dc	.080 A	4485	℄ 0.5 dc	.125 A	7008

FOR SIDE WALLS: M = Uniform M + Triangular M

$M = m_1 W_{st} H^2 + m_2 W H$; Let $W_{st} H^2 = B = 444 \times 8.5^2 = 32{,}079$ ft. lb.

$W = (W_{sb} - W_{st}) \frac{H}{2} = 1078 \times \frac{8.5}{2} = 4582$ lbs

Let $C = \left[(W_{sb} - W_{st}) \frac{H}{2}\right] \times H = 4582 \times 8.5 = 38{,}947$ ft. lb.

For Uniform Load			For Triangular Load			
Location	m x B	Moment	Location	m x C	Moment	Total Moment
Point a	0	0	Point a	0	0	0
0.1 ad	0.045 B	1444	0.1 ad	0.033 C	1285	2729
0.2 ad	0.080 B	2566	0.2 ad	0.064 C	2493	5059
0.3 ad	0.105 B	3368	0.3 ad	0.091 C	3544	6912
0.4 ad	0.120 B	3849	0.4 ad	0.112 C	4362	8211
0.5 ad	0.125 B	4010	0.5 ad	0.125 C	4868	8878
0.6 ad	0.120 B	3849	0.6 ad	0.128 C	4985	8834
0.7 ad	0.105 B	3368	0.7 ad	0.119 C	4635	8003
0.8 ad	0.080 B	2566	0.8 ad	0.096 C	3739	6305
0.9 ad	0.045 B	1444	0.9 ad	0.057 C	2220	3664
Point d	0	0	Point d	0	0	0

PLOT THE MOMENT DIAGRAMS ON THE FOLLOWING SHEET

CHECK SIDEWALL THICKNESS

(For following computations, refer to tables in "Reinf. Concrete Design Handbook" by Amer. Concrete Institute)

Revised M at Face of top Slab = 4.3 ft. kips

$F = \frac{M}{K} = \frac{4.3}{272} = 0.016$ From Table 4 with b = 12 in,

and $F = .016$, then $d \leq 5$ in. $(t_w - 2\frac{1}{2}) = 9\frac{1}{2}$ in.

Revised M at ℄ of Sidewall = 3.9 ft. kips

$F = \frac{M}{K} = \frac{3.9}{272} = 0.014$ From Table 4 with b = 12 in.,

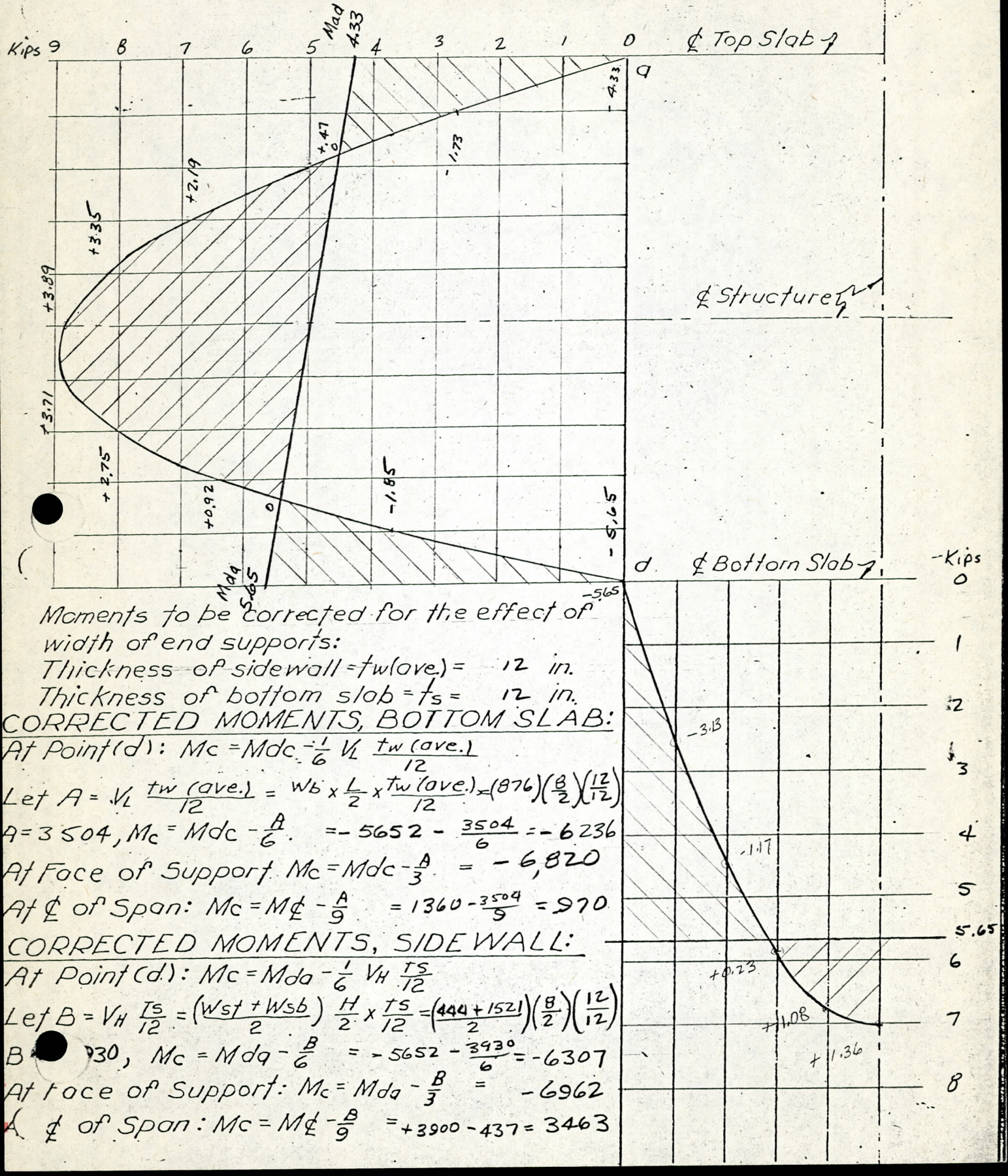
and $F = 0.014$, then $d = < 5$ in. $(t_{w\,ave.}) - 2\frac{1}{2} = 9\frac{1}{2}$ in.

From Table D.5 Reinf. Conc. Fund.

DESIGN OF 7.0 x .75 R/C DROP INLET Hc 3 Ft.

Sheet 37 of 46
Date 12-1-75
Comp. by PJM JB

Plot the Moment Diagrams for the Bottom Slab and Sidewall



Moments to be corrected for the effect of width of end supports:

Thickness of sidewall = $t_{w(ave.)}$ = 12 in.

Thickness of bottom slab = t_s = 12 in.

CORRECTED MOMENTS, BOTTOM SLAB:

At Point (d): $M_c = M_{dc} - \frac{1}{6} V_L \frac{t_{w(ave.)}}{12}$

Let $A = V_L \frac{t_{w(ave.)}}{12} = W_b \times \frac{L}{2} \times \frac{t_{w(ave.)}}{12} = (876)\left(\frac{8}{2}\right)\left(\frac{12}{12}\right)$

$A = 3504$, $M_c = M_{dc} - \frac{A}{6} = -5652 - \frac{3504}{6} = -6236$

At Face of Support $M_c = M_{dc} - \frac{A}{3} = -6{,}820$

At ℄ of Span: $M_c = M_{℄} - \frac{A}{9} = 1360 - \frac{3504}{9} = 970$

CORRECTED MOMENTS, SIDEWALL:

At Point (d): $M_c = M_{da} - \frac{1}{6} V_H \frac{t_s}{12}$

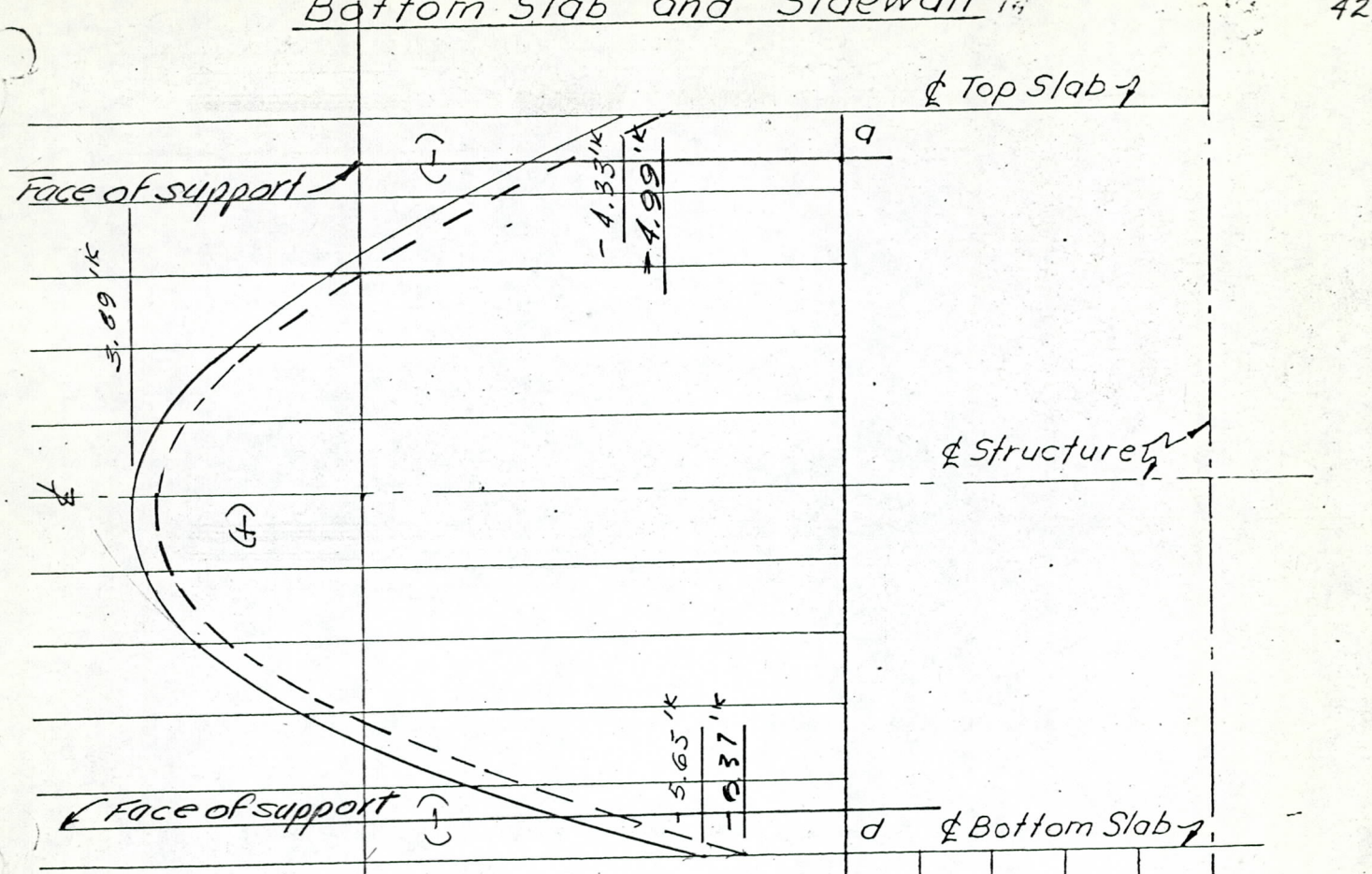
Let $B = V_H \frac{t_s}{12} = \left(\frac{W_{st} + W_{sb}}{2}\right) \frac{H}{2} \times \frac{t_s}{12} = \left(\frac{444 + 1521}{2}\right)\left(\frac{8}{2}\right)\left(\frac{12}{12}\right)$

$B = 3930$, $M_c = M_{da} - \frac{B}{6} = -5652 - \frac{3930}{6} = -6307$

At Face of Support: $M_c = M_{da} - \frac{B}{3} = -6962$

At ℄ of Span: $M_c = M_{℄} - \frac{B}{9} = +3900 - 437 = 3463$

Plot the Moment Diagrams for the Bottom Slab and Sidewall



Moments to be corrected for the effect of width of end supports:
Thickness of sidewall = tw(ave.) = in.
Thickness of bottom slab = t_s = in.

CORRECTED MOMENTS, BOTTOM SLAB:

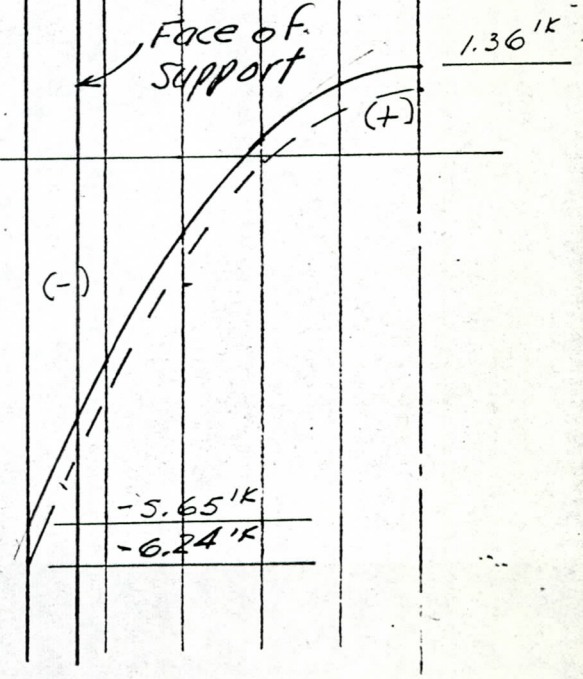
At Point(d): $Mc = Mdc - \frac{1}{6} V_L \frac{tw\ (ave.)}{12}$

Let $A = V_L \frac{tw\ (ave.)}{12} = Wb \times \frac{L}{2} \times \frac{tw\ (ave.)}{12} =$

$A =$, $Mc = Mdc - \frac{A}{6} =$

At Face of Support $Mc = Mdc - \frac{A}{3} =$

At ℄ of Span: $Mc = M℄ - \frac{A}{9} =$



CORRECTED MOMENTS, SIDEWALL:

At Point(d): $Mc = Mda - \frac{1}{6} V_H \frac{ts}{12}$

Let $B = V_H \frac{ts}{12} = \left(\frac{Wst + Wsb}{2}\right) \frac{H}{2} \times \frac{ts}{12} =$

$B =$, $Mc = Mda - \frac{B}{6} =$

At Face of Support: $Mc = Mda - \frac{B}{3} =$

℄ of Span: $Mc = M℄ - \frac{B}{9} =$

(For discussion of moment correction, refer to "Continuity of Concrete Building Frames" by Portland Cement Association.)

DESIGN OF 7.0 x 7.5 R/C DROP INLET-Hc=3 FT. Comp. by PJM-JB

DESIGN OF BOTTOM SLAB: (Make Top Slab similar)

Corrected Neg. M at face of Sidewall = -6820 ft.-lbs.

Corrected Net M at ℄ Slab = +970 ft.-lbs (indicate sign)

$F = \frac{(M \text{ in kips}) \text{ (Use the largest of the two Moments above)}}{K} = \frac{-6.820}{}$

K = 272 (Taken from Table 1 "Reinforced Concrete Design Handbook" of the American Concrete Institute.)

$F = \frac{-6,820}{272} = -0.025$

From Table 4 (Reinf. Concrete Design Handbook)

with b = 12 in., and F = 0.025, then d = 5 in. (for moment)

Use t_s = 12 in. slab ($d + 2\frac{1}{2}$") for top and bottom. (d= in. for shear)

STEEL DETERMINATION FOR BOTTOM SLAB

$A_{s\,Neg} = \frac{\text{Corrected } M_{Neg} \text{ (in kips) (At face of sidewall)}}{ad}$

a = 1.44 (From Table 1, "Reinforced Concrete Design Handbook")

$d = (t_s - 2\frac{1}{2}") = \quad -2\frac{1}{2}" = \quad 9.5$ in.

$A_{s\,Neg} = \frac{\quad}{x} =$ sq. in.

$\ell_{o\,Neg} = \frac{V_A}{ujd} = \frac{\quad}{x \quad x} =$ in.

The negative steel is determined by _____ (Moment or Bond)

USE _____ bars spaced _____ in. c to c. (Neg. Steel)

$A_{s\,Pos} = \frac{\text{Corrected } M_{pos} \text{ (in kips) (at ℄ span)}}{ad}$

$= \frac{\quad}{x} =$ sq. in.

$\ell_{o\,pos} = \frac{V \text{ at Zero } M}{ujd}$

$V_{at\ zero\ M} = W_b \times$ (Distance in feet from ℄ to point of inflection, as determined from revised moment diagram.)

$= \quad x \quad =$ lbs.

$\ell_{o\,pos} = \frac{\quad}{x \quad x} =$ in.

The positive steel is determined by _____ (Moment or Bond)

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N.E.H. Sec. 6 Para 2-2.4 page 6.2-16

Unit load on Top Slab

Find weight of concrete
Find weight of earth over the concrete

Concrete 1 ft thick = 150 lbs/sq ft.

weight of earth fill (3.0 ft of fill) = Hc

Projecting conduit condition

P = projection ratio = distance between the natural ground surface and the top of the conduit. h = 7.5 ft + 1 ft + 1 ft = 9.5 ft. divided by width of the conduit ℓ = 70 + 1 ft + 1 ft = 9 ft.

see ES-22 (1) $\frac{9.5}{9.0} = 1.055 = P$, δ for unyielding material = 1

$\delta P = (1.055)(1.0) = 1.055$

(2) K_μ for sandy, clayey silt 0.17

from chart $\frac{He}{bc}$ = 2.175

$He = bc\ 2.175 = (9.0)(2.175) = 19.6$

(3) $\frac{Hc}{bc} = \frac{3.0}{9.0} = .333+$

(4) $\frac{He}{bc}$ of 2.175 > $\frac{Hc}{bc}$ of .333 so complete projection exists.

(5) From curve on sheet 2 of ES-22
coefficient C_c = 0.35

(6) Compute Wc (load per linear ft)

$W_c = C_c \gamma b_c^2$

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(6) compute Wc (load per linear ft.) continued

$C_c = 0.35$, $\gamma = 151.2$, $b_c^2 = 9^2 = 81$

$W_c = (0.35)(151.2)(81) = 4286.52$

load in lbs per sq ft $= \frac{W_c}{b_c} = \frac{4286.52}{9} = 476$

concrete + earth $= 150 + 476 = 626$ lbs/sq ft

ratio $\frac{476}{(151)(3)} = 1.05$

wt $\gamma_s = 151.2$ lbs
wt. $H_2O = 62.4$ lbs
wt. Soil 88.8 lbs

Unit sidewall load

At ℄ top slab $W_{st} = (3.5')\left(\frac{88.8 \text{ lbs}}{\text{cu. ft.}}\right)(.725) + (3.5')(62.4 \text{ lbs})$

$s_t = H_c + \frac{t_s}{2}$

$3.0 + \frac{1}{2} = 3.5$

$W_{st} = \frac{225.33 \text{ lbs}}{\text{sq. ft.}} + \frac{218.4 \text{ lbs}}{\text{sq. ft.}} = \frac{443.73 \text{ lbs}}{\text{sq. ft.}}$

At ℄ bottom slab $W_{sb} = (12.0')\left(\frac{88.8 \text{ lbs}}{\text{cu. ft.}}\right)(.725) + (12.0')(62.4 \text{ lbs})$

$s_b = s_t + H$

$3.5 + 8.5 = 12.0$

$W_{sb} = \frac{772.56 \text{ lbs}}{\text{sq. ft}} + \frac{748.8 \text{ lbs}}{\text{sq. ft.}} = \frac{1521.36 \text{ lbs.}}{\text{sq. ft.}}$

$W_{sb} - W_{st} = 1521.36 - 443.73 = 1078$

Check bottom slab thickness for shear

V_{ts} = shear at $t_s = W_b\left(\frac{\ell}{2}\right) = (876)\left(\frac{7}{2}\right) = 3066$ lbs

d_s = thickness req'd for shear $\frac{V_{ts}}{v_{jb}}$

$v = 70$
$j = 7/8$
$b = 12''$

$\frac{V_{ts}}{v_{jb}} = \frac{3066}{(70)(7/8)(12)} = 4.17$

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SUBJECT				SHEET 3 OF
R/C Drop inlet structure				

$$M^F_{ad} = 1/12\ W_{st} H^2 + 1/30 (W_{sb} - W_{st}) H^2$$

$$= \frac{(444)(72.25)}{12} + \frac{(1078)(72.25)}{30}$$

$$2673 + 2596 = 5269$$

$$M^F_{cb} = 1/12\ W_{st} H^2 + 1/20 (W_{sb} - W_{st}) H^2$$

$$\frac{(444)(72.25)}{12} + \frac{(1078)(72.25)}{20}$$

$$2673 + 3894 = 6567$$

Calculate distributed end moments

$$M_{ab} = M^F_{ab} - \frac{C}{(C+2)^2 - 1} \left[(C+2)(M^F_{ab} + M^F_{ad}) + (M^F_{cd} + M^F_{cb})\right]$$

C from page 1
C = 1.0625

$M^F_{ab} + M^F_{ad} = -3339 + 5269 = 1930$

(B) $(C+2)(1930) = (3.06)(1930) = 5906$

(C) $M^F_{cd} + M^F_{cb} = -4672 + 6567 = 1895$

(D) $5906 + 1895 = 7801$

(E) $(-.1268)(7801) = -989$

(F) M^F_{ab} -3339 from page 2 print out

(G) $\frac{C}{(C+2)^2 - 1} = +.1268$

(H) $(C+2)(M^F_{cd} + M^F_{cb})$

$(3.06)(-4672 + 6567) = 5799$

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(I) $(M^F_{ab} + M^F_{ad}) = (-3339 + 5269) = 1930$

(J) $5799 + 1930 = 7729$

(K) $G \times J = (7729)(.1268) = 980$

(L) $M^F_{dc} = 4672$

$Mdc = (L) + (K) = 4672 + 980 = +5652$

$Mdc + Mda = 0$

$5652 + (-5652) = 0$ or $Mda = -5652$

$Mab + Mad = 0$

$-4328 + 4328 = 0$ or $Mad = +4328$

Check sidewall thickness
from sheet 2 $Mab = -4.33$ Kips $= Mad = +4.33$

Note: use Reinf Conc. Fundamen Table D.5 page 686 R in this table = K in formula

$F = \frac{M}{K}$, $M = +4.33$ (Mad)

$K = 272$

f_c' 4000 lb concrete
$n = 8$

$f_c = (4000)(0.4^{\text{SCS factor}}) = 1600$

$f_s = 20000$ $a = 1.44$

$K = R = 272$

$\frac{4.33}{272} = 0.0159$

$b = 12''$, $d = 5 = 0.025$ so d in problem is less than 5

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SUBJECT R/c Drop inlet structure				SHEET 5 OF

(longitudanal stresses were considered negligable, Temp. Steel was used) A.C. 8-76

Corrected Moments, Bottom slab at point (d)

$$M_c = M_{dc} - 1/6\ V_L \frac{t_{w(ave)}}{12}$$

let $A = V_L \frac{T_{w(ave)}}{12} = (W_b)\left(\frac{L}{2}\right)\left(\frac{12}{12}\right)$

$= (876)\left(\frac{8}{2}\right)(1) = 3{,}504$

$M_{dc} = +5652$ page 2, from diagram -5.65 Kips

$M_c = M_{dc} - \frac{A}{6} = -5{,}652 - \left(\frac{3504}{6}\right) = 6236$

at point d 6236 lbs or 6.24 kips

at Face of support $-5652 - \left(\frac{3504}{3}\right) = 6.82$ Kips

at ℄ span $M_c = M_{℄} - \frac{A}{9}$

$= 1360 - \left(\frac{3504}{9}\right) = 970$ lbs or 0.97 Kip

Corrected Moments, side wall at point (d)

$M_c = M_{da} - 1/6\ V_H \frac{T_s}{12}$, $M_{da} = -5652$

$V_H \frac{T_s}{12} = \frac{(W_{st} + W_{sb})}{2}\left(\frac{H}{2}\right)\left(\frac{T_s}{12}\right)$

$= \left(\frac{444 + 1521}{2}\right)\left(\frac{8}{2}\right)\left(\frac{12}{12}\right) = 3930$

$\frac{3930}{6} = 655$

$-5652 - \left(\frac{3930}{6}\right) = -6307$

$\frac{3930}{3} = 1310$

$-5652 - \left(\frac{3930}{3}\right) = -6962$

$\frac{3930}{9} = 437$

$+3900 - \left(\frac{3930}{9}\right) = 3463$

STATE: Ariz | PROJECT: Buckhorn Mesa WPP Spook Hill FRS
RJM | DATE: 12-10-75 | CHECKED BY | DATE | JOB NO.
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Horizontal steel Inside Face

Sidewalls

$M_{SC} = 5260$ #/ft — sheet 10

$A_s = 0.43$ sq in — $d = 8.5$"

USE #6@12 — $A_s = 0.44$ sq in

Endwalls

$M_{EC} = 2270$ #/ft

$A_s = 0.18$ sq in — $d = 8.5$

TEMP STL GOVERNS

USE #5@12 — $A_s = 0.31$ sq in

Floor Steel

TRANSVERSE — $d = 24 - 3.5 = 20.5$"

$M_{max} = -16.4$ k/ft (sidewall moments)

$A_s = 0.52$ sq in

USE # @12 — $A_s = 0.60$ sq in
Bottom

Temp St'l Governs

$A_T = (0.002)(12)(16)$ — Top
$= 0.38$ sq in
USE #6@12 — Both faces

STATE Ariz | PROJECT Buckhorn Mesa WPP Spook Hill FRS

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Horizontal Steel Outside Face

Sidewalls

$V_A = 2810^{\#}$ sheet 11

$M'_{SF} = 4370^{\#}$ "

$A_s = 0.33$ sq in $d = 12 - 3.5 = 8.5$

Endwalls

$V_A = 1496^{\#}$ sheet 11

$M'_{EF} = 4810^{\#}$ "

$A_s = 0.375$ sq in $d = 8.5$

Temperature Steel

Both faces exposed

$A_T = 0.002(12)(12) = 0.29$ sq in

#5@12 $A_s = 0.31$ sq in

Outside steel

USE #5@6 at corners
#5@12 away from corners

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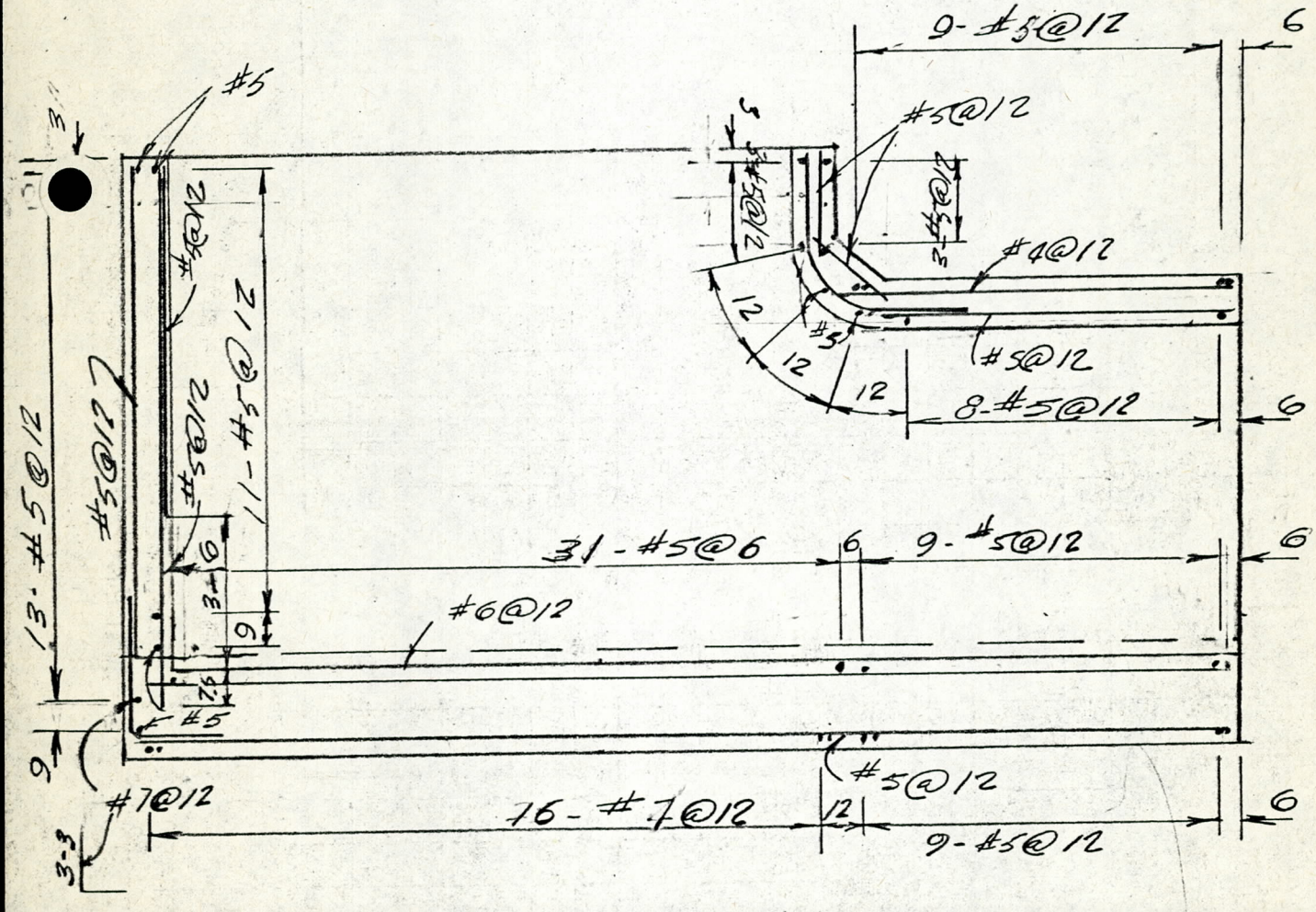
LONGITUDINAL $d = 24 - 4.5 = 19.5''$

$M_{max} = -7.5^{1K}$ (Endwall)

$A_s = 0.24$ sq in

USE #5@12 $A_s = 0.31$ sq in.



PROFILE ON ℄

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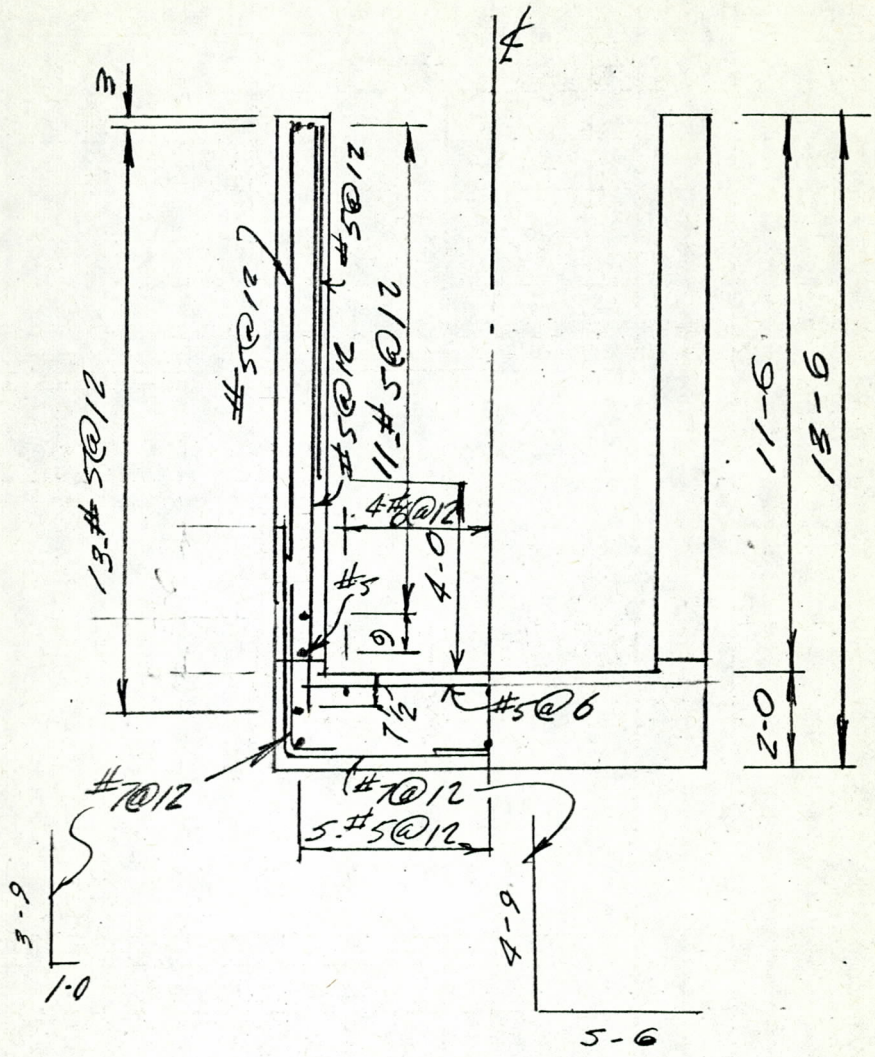
STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY: RJM	DATE: 12/10/75	CHECKED BY	DATE	JOB NO.

SUBJECT: Structural Design

SHEET ____ OF ____



CROSS SECTION THRU RISER

STATE	PROJECT		
Ariz	Buckhorn Mesa WPP Spook Hill FRS		
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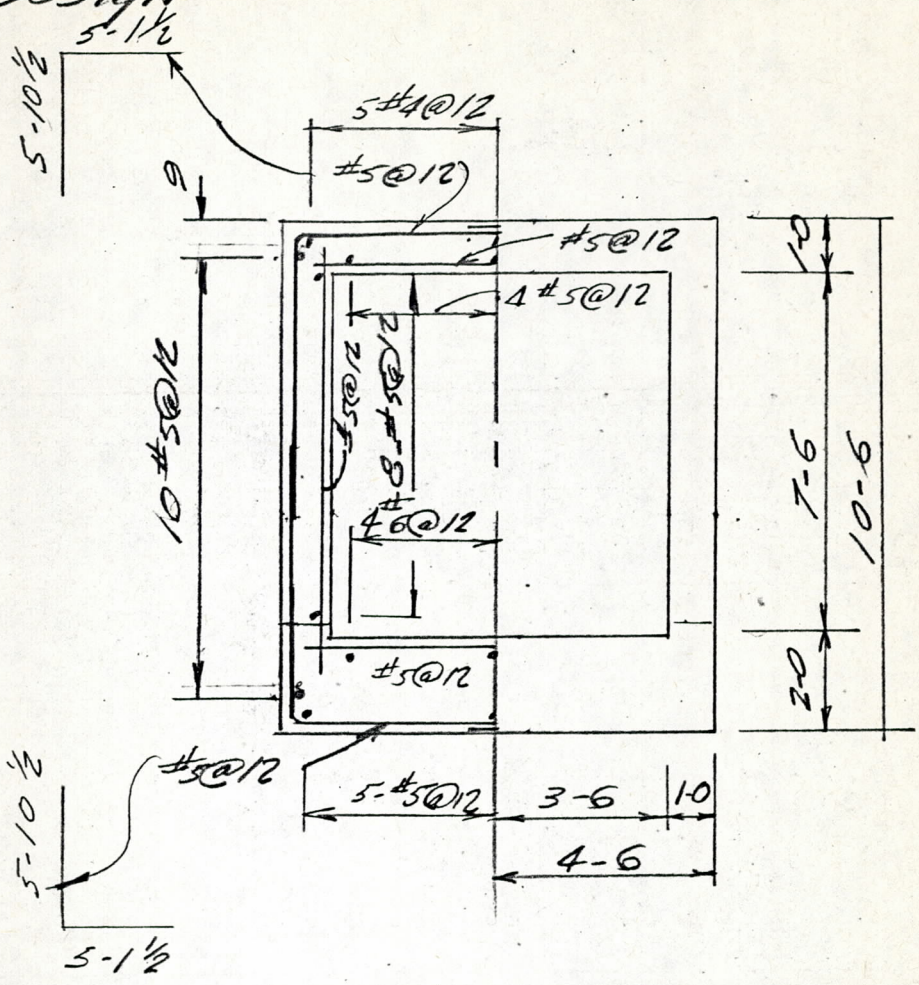
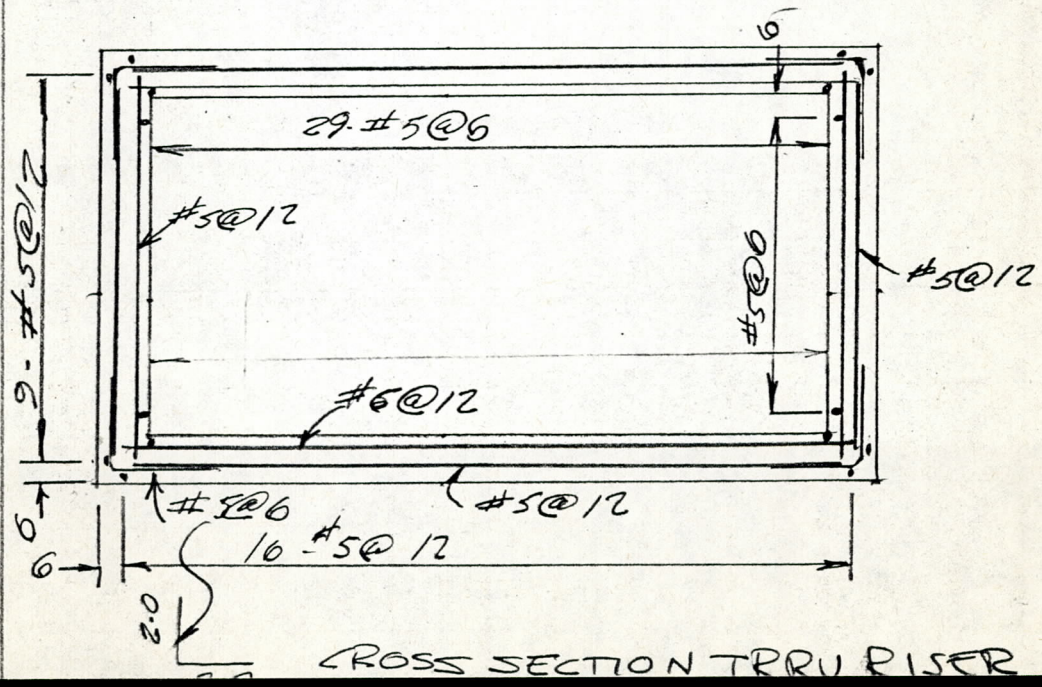
SHEET ____ OF ____



CROSS SECTION THRU CONDUIT



CROSS SECTION THRU RISER

COPY FOR: Ralph Arrington

ENG - Special Design, Spook Hill Principal Spillway Conduit, Buckhorn Mesa Watershed, Arizona

August 13, 1975

Mr. Paul Tilker, Head,
Engineering and Watershed Planning Unit
Soil Conservation Service
Federal Building
511 N. W. Broadway
Portland, Oregon

Attention: Mr. Harry Firman

The special single cell conduit design you requested by phone today is enclosed.

Setting this conduit on rock makes more difference than I would have guesses -- compare to standard design 7312.

Edwin S. Alling

Edwin S. Alling, Head,
Design Unit, Design Branch
Engineering Division.

1 enclosure

cc: Ralph Arrington, State Conservation Engineer, Phoenix, Arizona

SINGLE CELL RECTANGULAR CONDUIT
CROSS SECTION DESIGN
ELASTIC ANALYSIS AND WORKING STRESS DESIGN ARE USED

SPECIAL DESIGN PREPARED BY THE DESIGN UNIT AT HYATTSVILLE, MD
FOR

SPOOK HILL PRINC. SPILLWAY, BUCKHORN MESA WATERSHED, ARIZONA, 8/13/
ENGINEERING AND WATERSHED PLANNING UNIT, PORTLAND, OREGON

SPECIAL DESIGN NO. 215-SG DESIGN MODE=11

CLEAR SPANS ARE 7.50 HIGH AND 7.00 WIDE

LOAD PARAMETERS ARE
PV1= 4000. PH1= 1600. PV2= 2000. PH2= 2400.

NUMBER OF CYCLES REQUIRED FOR CONVERGENCE= 3
NUMBER OF TRIAL DESIGNS MADE = 1

REQUIRED SLAB THICKNESSES ARE
TTOP= 15.00 TSTOP= 13.00 TSBOT= 17.00 TBOT= 17.00

CONDUIT QUANTITY = 1.6327 CU.YDS.PER FT.

	REQUIRED STEEL AREA	MAXIMUM STEEL SPACING
A(1)=	0.78	S(1)= 10.42
A(2)=	0.18	S(2)= 18.00
A(3)=	0.36	S(3)= 18.00
A(4)=	0.50	S(4)= 6.05
A(5)=	0.32	S(5)= 18.00
A(6)=	0.56	S(6)= 9.79
A(7)=	0.36	S(7)= 16.13
A(8)=	0.18	S(8)= 18.00
A(9)=	0.40	S(9)= 18.00
A(10)=	0.30	S(10)= 14.91
A(11)=	0.41	S(11)= 18.00
A(12)=	0.21	S(12)= 8.54
A(13)=	0.79	S(13)= 7.34
A(14)=	0.20	S(14)= 18.00

POINTS OF INFLECTION ARE
PI(01)= 2.37 PI(07)= 2.52 PI(13)= 3.10

POSITIVE ANCHORAGE REQUIREMENT= 0004

**** END OF DESIGN ****

RJM 1/20/76

in Figure 1 would be followed.

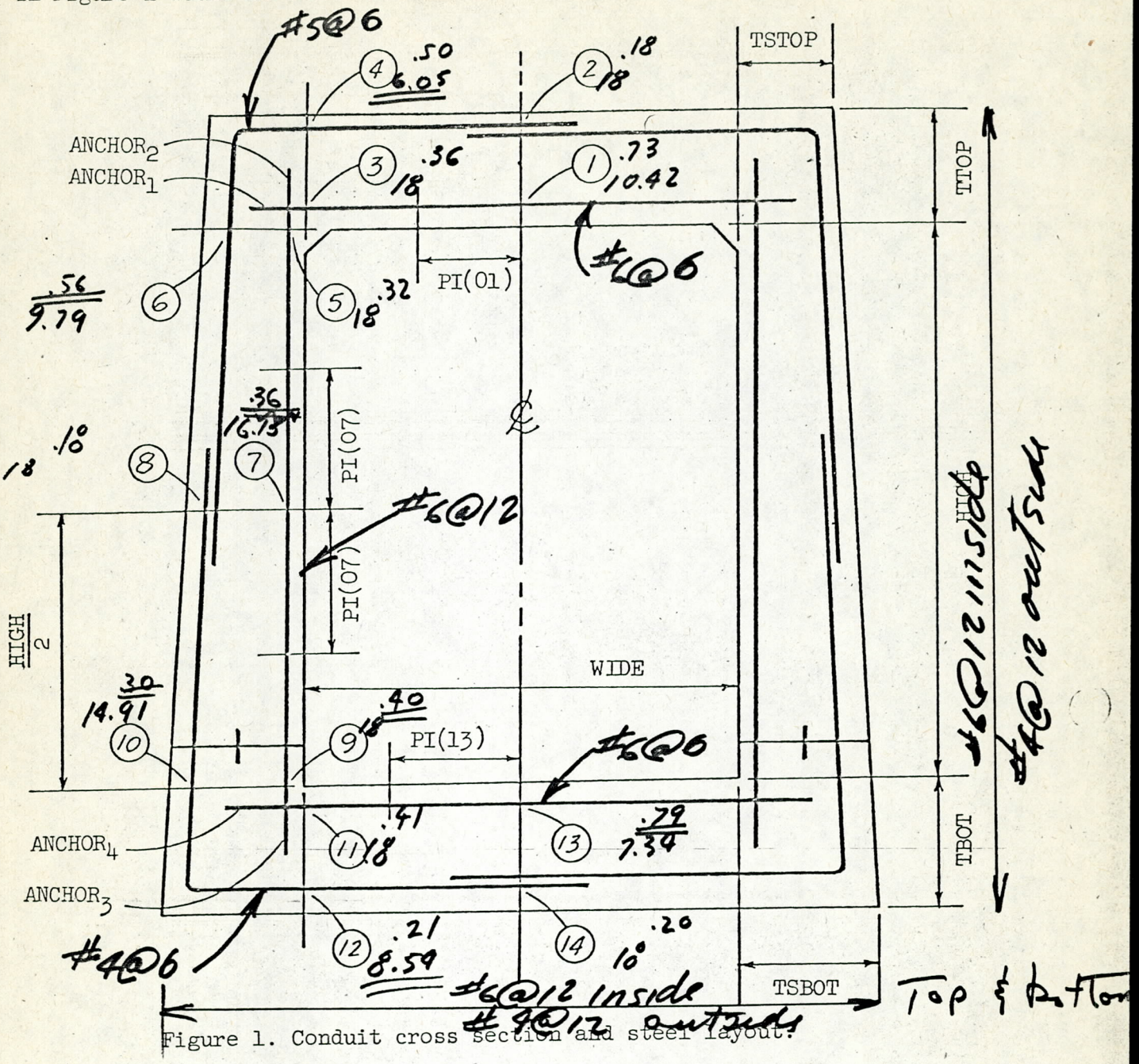


Figure 1. Conduit cross section and steel layout.

While it is theoretically possible to determine the minimum acceptable bar size at a location when required steel area and spacing is known, this has not been done. The designer is free to exercise his judgement in the selection of actual bar sizes and spacings. Often the designer will be able to select actual steel somewhat as follows. Positive steel held constant throughout the span, area determined by that required at the center of the span, spacing determined by that required at the point of inflection or face of the support, whichever is smaller. Negative steel area and spacing determined by requirements at the faces of the support, often with different steel used at top and bottom corners of the conduit.

STATE		PROJECT		
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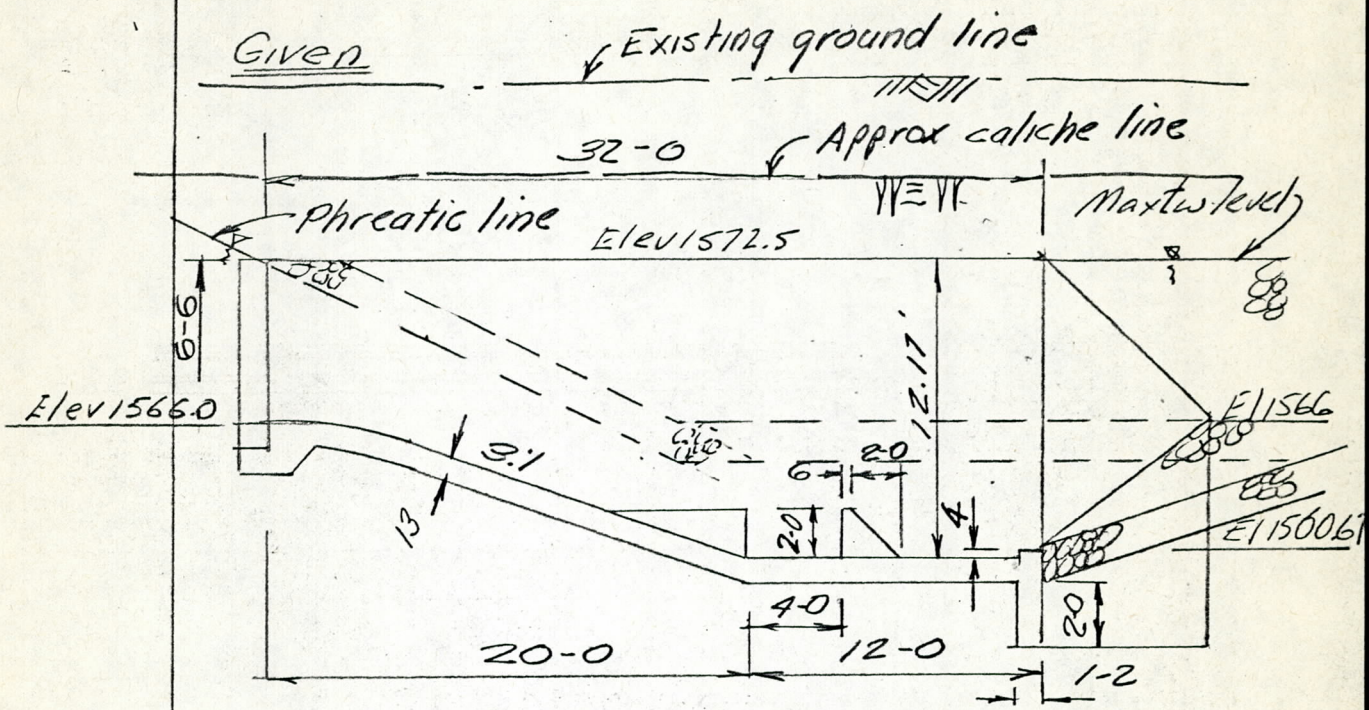
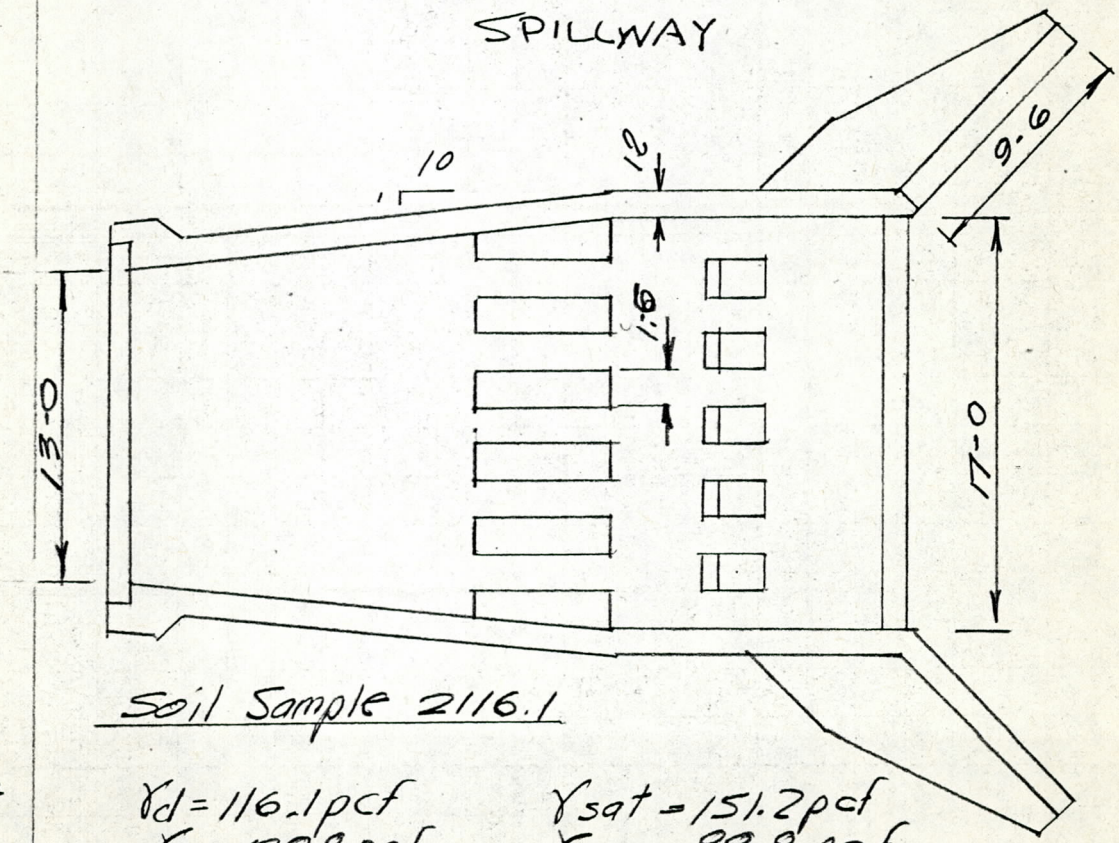
SUBJECT Structural Design

SHEET 1 OF 25

Given



PROFILE ON ℄ PRINCIPAL SPILLWAY



Soil Sample 2116.1

See Inlet design

$\gamma_d = 116.1$ pcf
$\gamma_m = 128.8$ pcf
$\phi = 32.0°$
$c = 0$

$\gamma_{sat} = 151.2$ pcf
$\gamma_b = 88.8$ pcf
$K = 0.725$

STATE Ariz | PROJECT Buckhorn Mesa WPA Spook Hill FRS

BY RLM | DATE 11-19-75 | CHECKED BY | DATE | JOB NO.

SUBJECT Structural Design | SHEET 2 OF 25

Design the concrete thicknesses & steel sizes

Solution:

1. Stability

Before Fill (No Uplift) - neglect jt blocks
- neglect wingwalls & vert. curve

Part		Wt	Arm	Moment
Apron □	(17.00)(12)(1.083)(150)	33,100	6.00	198,800
" □	(13.00)(20)(1.142)(150)	44,500	16.00	713,000
" ◁	(2.00)(20)(1.142)(150)	6,850	12.67	86,800
Walls □	(13.25)(12)(1)(150)(2)	47,700	6.00	286,000
" □	(7.58)(20)(1)(150)(2)	45,500	16.00	728,000
" ◁	(5.67)(20)(1)(150)(2)/2	17,010	12.67	216,000
chuteBlocks	(6)(2)(6)(1.5)(150)/2	8,100	14.00	113,400
FloorBlocks ▯	(5)(2)(.5)(1.5)(150)	1,125	7.75	8,720
" ▷	(5)(2)(2)(1.5)(150)/2	2,250	6.17	13,880
Toewall	(2)(17)(1.167)(150)	5,950	0.583	3,470
Endsill	(.333)(17)(1)(150)	849	0.500	425
		213,000		2,350,000

$z = 2,350,000/213,000 = 11.03'$

$e = 16.0 - 11.03 = 4.97'$

Area of base $= (19)(12) + (20)(19+15)/2 = 568\ sf$

$p = (213,000/568)[1 \pm (6)(4.97)/32] = 375(1 \pm 0.932)$

$p_u = 375(1-0.932) = 25.5\ psf$

$p_d = 375(1+0.932) = 724\ psf$

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Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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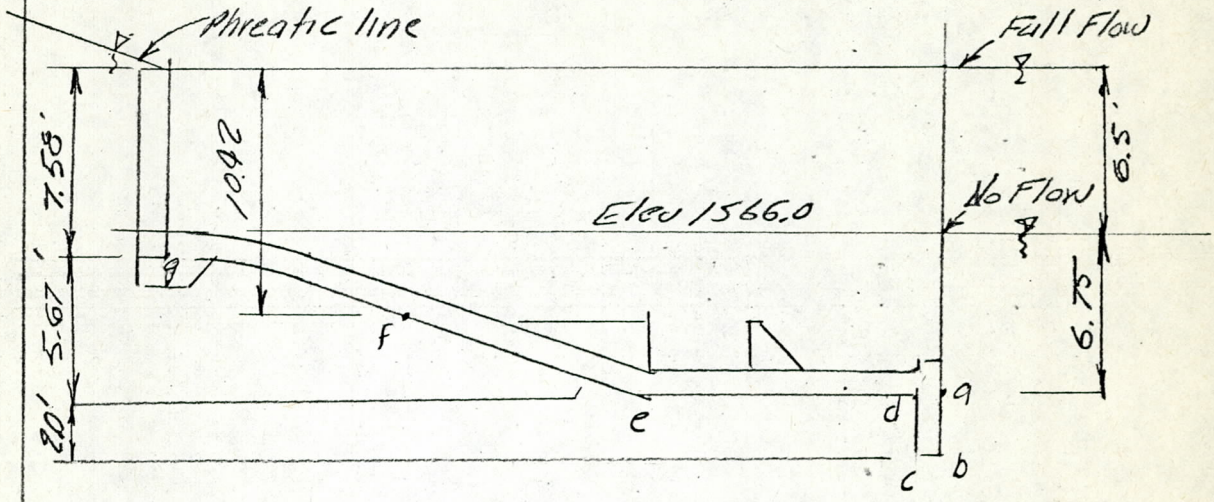
SUBJECT

SHEET 3 OF 25

Uplift



Full Flow

Full flow condition should not be any problem since the water level inside and outside of the basin should be approximately equal

No Flow

pressure @ pt a = .7(6.75)(62.4) = 295 psf
pressure @ pt g = .7(7.58)(62.4) = 331 psf
assumed pressure @ pt f = .7(13.25)(62.4) = 579 psf
corrected pressure @ pt f = .7(10.42)(62.4) = 455 psf
Assumptions

1. WS in basin @ Elev 1566.0 when full phreatic line exists
2. Uplift reduced 30% in caliche. See sheet 7 Inlet design

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SUBJECT Structural Design

SHEET 4 OF 25

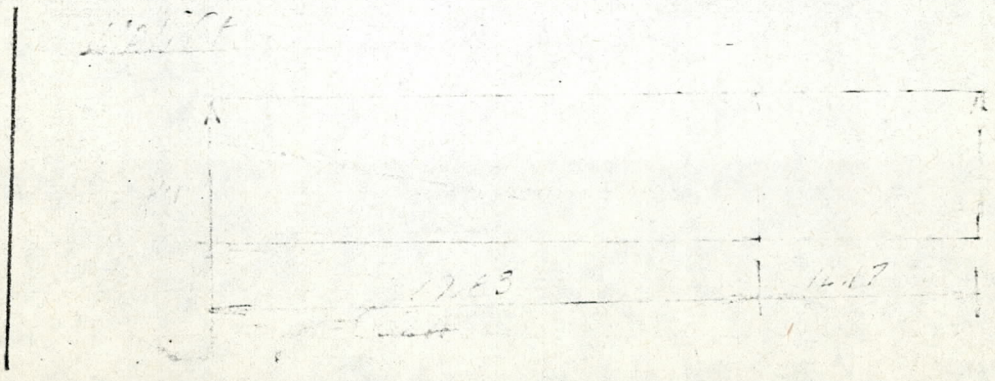
Point	Wt Creep Dist ft	Inc. of Pres psf/ft	Pres. @ Pt. psf/ft	Ave Pres betw Pts. psf/ft	Base length ft	Uplift/ ft width lbs	Base Width ft	Total Uplift lbs
a			295					
	2.0	28						
b			323					
	.39	5		326	1.167	380	19.0	7220
c			328					
	2.0	28						
d			356					
	3.67	51		382	11.00	4202	19.0	79,800
e			407					
	12.33	172	331 / ~~579~~	369	20.00	7380	17.0	125,500
f								
g								

212,520

Wt creep dist. $= 2 + \frac{1.17}{3} + \frac{11}{3} + \frac{20}{3} + 5.67 + 2$

$= 20.40'$

inc. of pres. p s f/ft $= (579 - 295)/20.4 = 13.92$



STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill F.R.S.		
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SUBJECT Structural Design

SHEET 5 OF 25

Resolve Uplift into Trapezoidal Diagram

Rate of change per ft of horiz contact
$= 13.92/3 = 4.64$

Let x = unit uplift @ ds edge
y = unit uplift @ us edge

then $y = x + 4.64(32)$
$= x + 148$

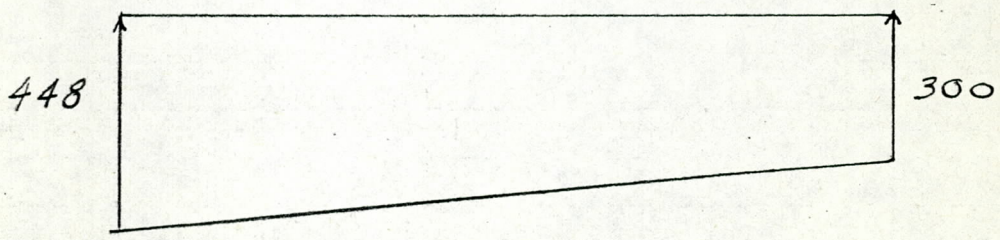
Total uplift per ft width
$= (212{,}520/568)(32) = 11{,}970$

$[(x+y)/2](32) = 11{,}970$

$(x + x + 148)/2 = 11{,}970/32$

$x = (748 - 148)/2$
$= 300$ psf

$y = 300 + 148$
$= 448$ psf



STATE		PROJECT		
Ariz		Buckhorn Mesa WAP Spook Hill FRS		
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SUBJECT Structural Design

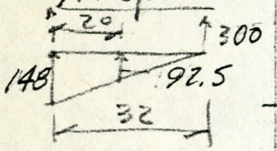
SHEET 6 OF 25

No Flow

Part		Wt	Arm	Moment
Concrete		213,000	11.03	2,350,000
Water □	(5.67)(12)(62.4)(17) =	72,200	6.0	433,000
" ▽	(5.67)(20)(62.4)(15)/2 =	53,100	9.33	495,000
Horiz Force	(6.5)(62.4)(5.67)(15)=34,500		2.83	- 97,600
		338,000		3,180,000
Uplift ▭	(19)(300)(32)	- 182,400	16.00	- 2,918,000
-" ▽	(19)(148)(32)(2)	- 45,000	10.67	- 480,000
" -□	-(2)(300+120)(20)	+ 16,800	22.0	+ 369,600
		-210,600		-3028,400
		127,400		151,600

$z = 151,600/127,400 = 1.19'$ NG outside the middle 1/3 ∴ Neg. contact pressures

*Avepres.

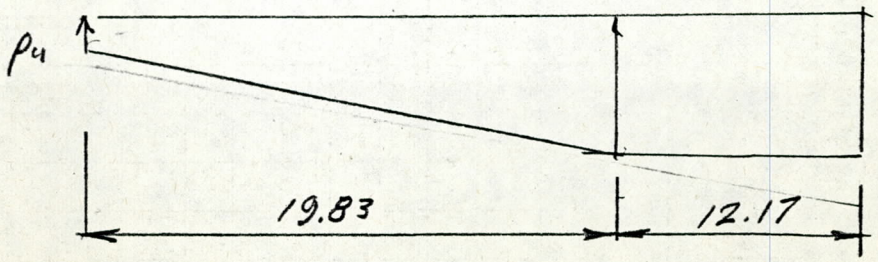


$\frac{148+92.5}{2} = 120$

Revise design:

1. Backfill with drainfill - A
∴ Assume W.S. inside & outside structure @ Elev 1560.0 - No Flow condition.

Uplift



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SUBJECT Structural Design — SHEET 7 OF 25

$p_u = (0.7)(62.4)(1.083) = 47.3$

$p_d = (0.7)(62.4)(6.75) = 295$

No Flow

Part		Wt	Arm	Moment
Strw/o uplift	See sheet 6	338,000	9.41	3,~~180~~,209,000
Uplift □	(19)(295)(12.71)	-711,200	6.36	- 453,000
▭	(19+15)(47.3)(19.83)/2	- 15,950	22.1	- 352,000
◁	(19+15)(248)(19.83)/(2)(2)	- 41,800	19.32	- 808,000
		-128,950		-1,613,000
		209,050		1,5~~67~~,000

$z = 1,5\overset{8}{6}7,000/209,000 = 7.5\overset{9}{0}$ ft NG-outside middle 1/3

TRY 2' footing at level section

Assume:

1. γ_b (backfill-granular) = 75.0 pcf
2. γ_b (rock) = γ_b (backfill)

Part		Wt	Arm	Moment
Str w/o uplift	See Sheet 6	338,000	9.41	3,180,000
Footing	(1.083)(2)(5)(150)	4140	6.38	26,400
		342,140		3206,400
Uplift	See above	-128,950		-1,615,000
Uplift Ftg				

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SUBJECT Structural Design

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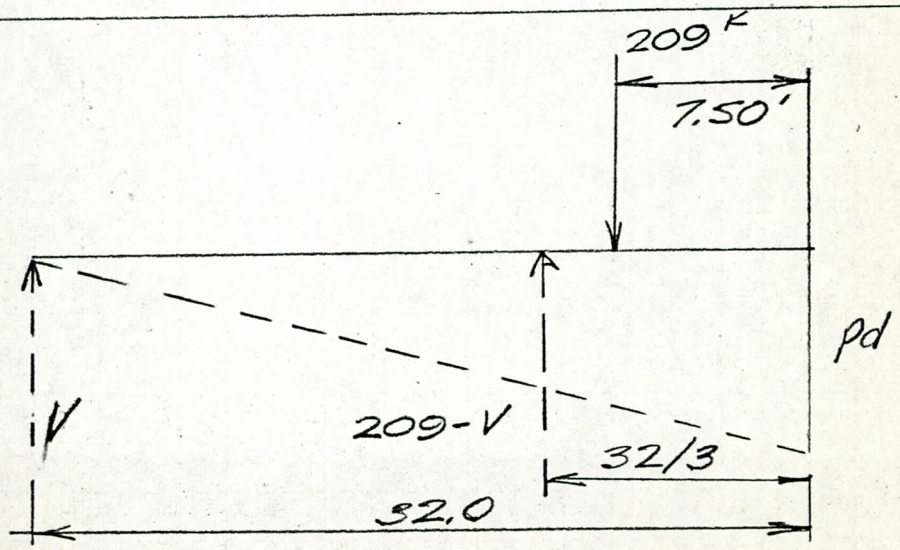
Part		Wt	Arm	Moment
Str w/o uplift	See Sheet 6	338,000	9.41	3,180,000
Footing	(1.083)(4)(12.75)(150)	8,280	6.38	52,800
Earth Fill	(5.67)(4)(75)(12.75)	21,700	6.38	138,400
		367,980		3,371,200
Uplift	See above	-128,950		-1,613,000
Uplift Ftg	(4)(295)(12.75)	- 15,040	6.38	- 96,000
		-143990		-1,709,000
		224,000		1,662,200

$e = 1{,}662{,}200 / 224{,}000 = 7.42$ NG

ADDING FOOTING DOES NOT APPEAR TO SOLVE THE OVERTURNING PROBLEM.

DO NOT CONSIDER FOOTING · TRY USING THE CONDUIT SECTION TO RESIST OVERTURNING



STATE		PROJECT		
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PJM	12-1-75			

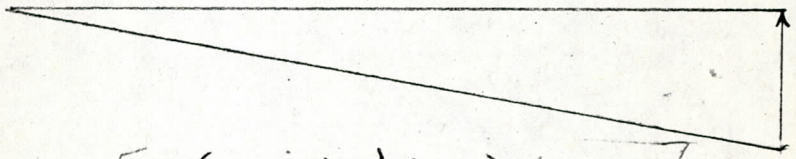
SUBJECT Structural Design

SHEET 9 OF 25

$$32V + (32)(209 - V)/3 - 209(7.5) = 0$$
$$32V + \frac{6690}{3} - 10.67V - 1568 = 0$$
$$V = -31.0^{k}$$

$$d = V/vb$$
$$= 31000/(170)(12)(17)$$
$$= 2.17" < d = 9.5" \quad OK$$

PRESSURE DIAGRAM (CONTACT)



$$Pd = \left[\frac{V}{A}\left(1 \pm \frac{6e}{d}\right)\right]/1000$$

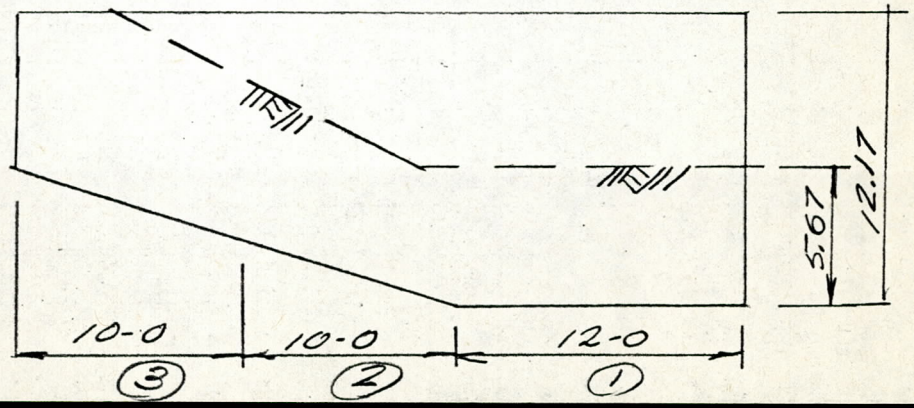
627 psf

$$= \frac{(209{,}000 + 31{,}000)(2)}{568}$$

$$= 845 \text{ psf}$$

SIDEWALLS

Design for Construction After Backfill condition. Check 3 sections



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Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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RJM	12-2-75			

SUBJECT Structural Design

SHEET 10 OF 25

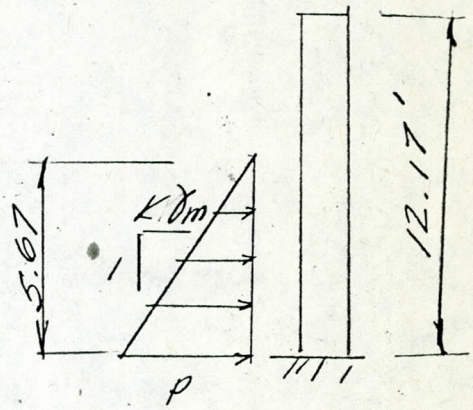
For clean gravel backfill

EDS FWS
TABLE 2.1

$\gamma_m = 120$ pcf $\gamma_{sub} =$
$\phi = 36°$

SECTION ①

$K = 0.26$
$p = 0.26(120)(5.67)$
$= 176.9$ psf



$V_{max} = 176.9(5.67)/2$
$= 502^{\#}$

$M_{max} = 176.9(5.67)^2/6$
$= 948^{\#}$

$v = V_d/bd$ $V_d = \frac{(5.67 - 0.79)^2(176.9)(\quad)}{(5.67)(2)}$
$= 371/(12)(9.5)$
$= 3.3$ psi $= 371^{\#}$

$A_s = 12M/f_s b j d$
$= 12(12)(948)/(20{,}000)(12)(7)(9.5)$
$= 0.0057$ sq in

TEMP STL

$A_T = 0.002\,bt$
$= 0.002(12)(12)$
$= 0.29$ sq in

exposed face
Vertical

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SUBJECT Structural Design

SHEET 11 OF 25

$A_T = 0.003\,bt$
$= 0.003(12)(12)$
$= 0.435 \text{ sq in}$

exposed face horizontal

USE

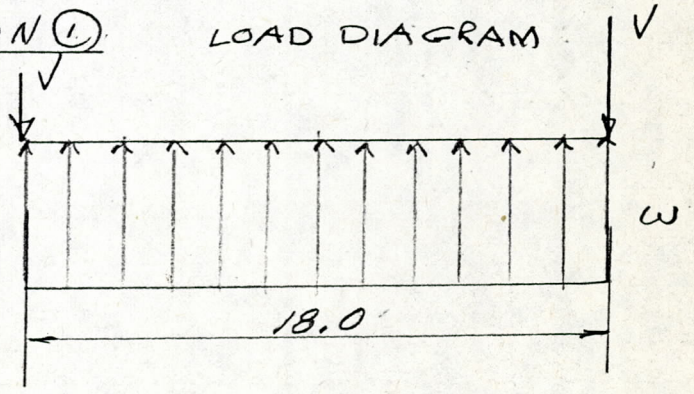
#5@12 vertical steel both faces
#6@12 horizontal steel both faces.

SECTION ② – SECTION ① GOVERNS.

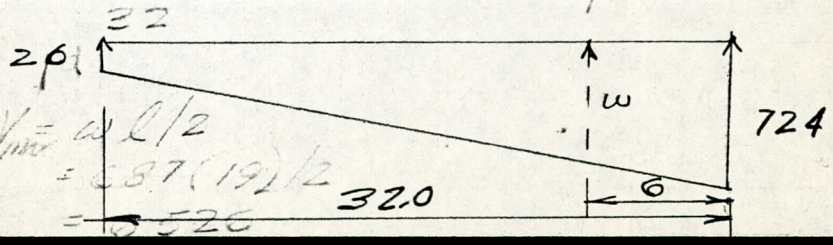
SECTION ③ – ONLY SLIGHTLY GREATER THAN SECTION ① USE SECTION ① STEEL

FLOOR

SECTION ① LOAD DIAGRAM



w = CONTACT PRESSURE DIAGRAM



sheet 2

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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RJM	12-2-75			

SUBJECT Structural Design

SHEET 12 OF 25

$w = 26 + (26/32)(724-26)$
$= 593$ plf

$V_{max} = wl/2$
$= 593(18)/2$
$= 5340$ #

$V_d = 593[18 - (0.992)(2)]/2$
$= 4870$ #

$v = V_d/bd$
$= 4870/(12)(9.5)$
$= 43$ psi $<$ $v_{allow} = 70$ psi OK

$M_{max_s} = wl^2/8$
$= 593(18)^2/8$
$= 24{,}000$ #

$-M_{max} = 948$ #

$+M_{max} = 24{,}000 - 948 = 23{,}100$ #

$d_{req'd} = 9.3" < d_{eff} = 10.5"$ OK

ES1
NEH 6

SIMPLE MOMENTS $M = C w l^2 = 192{,}100C$

x/l	C	M
0	0.0000	0
0.1	0.0450	8,640
0.2	0.0800	15,370
0.3	0.1050	20,200
0.4	0.1200	23,100
0.5	0.1250	24,000

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Ariz		Buckhorn Mesa WPO Spook Hill FRS		
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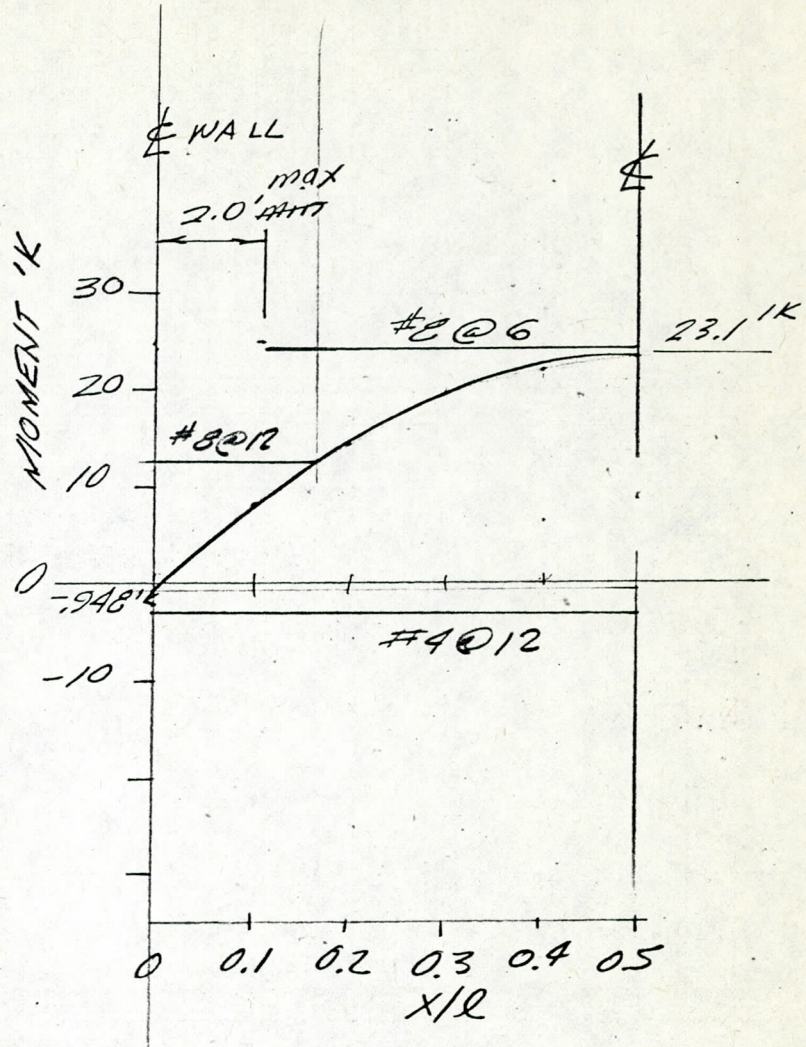
SUBJECT Structural Design

SHEET 13 OF 25

.17ℓ = 3.06



d: 10.5" A_s = 1.559 in

USE #8@6 A_s = 1.575 sq in Σ_o = 6.28 in

#8@12 A_s = 0.795 sq in Σ_o = 3.14 in

@ support $\Sigma_{o,req'd}$ 2.71 in OK

A_T = 0.001(12)(13) = 0.156 sq in

USE #4@12 A_s = 0.20 sq in

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Ariz		Buck Horn Mesa WPP Spook Hill FRS		
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RJM	12-4-75	DKT	12-9-75	

SUBJECT Structural Design

SHEET 14 OF 25

SECTION (2), @ 15' from us end

$w = 26 + (15/32)(724-26)$

$= 353$ plf

$M_{max_s} = wl^2/8$

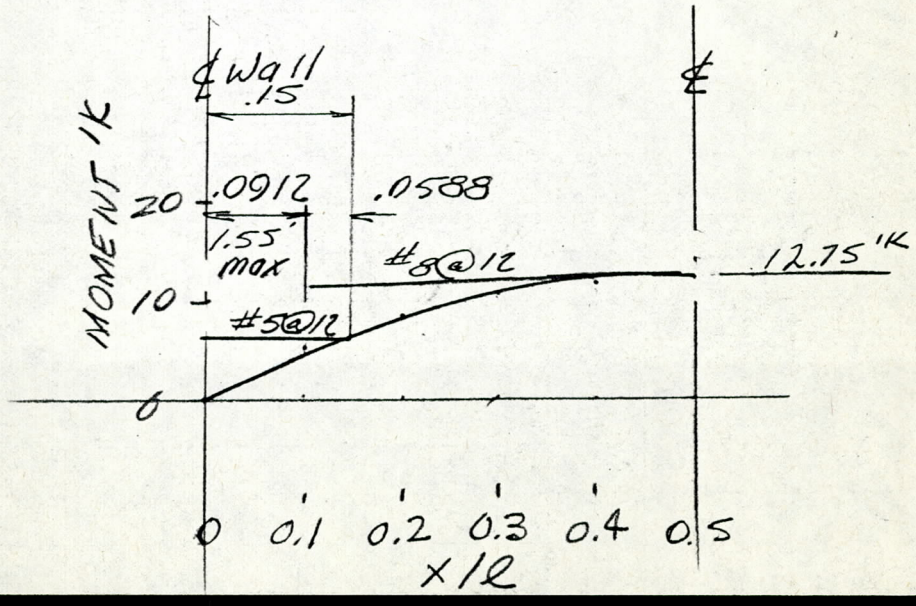
where $l = 14 + 2(15)/10 = 17.0'$

$M_{max_s} = 353(17)^2/8 = 12,750$ '#

$-M_{max} < 1000$ '# NEGLECT

SIMPLE MOMENTS $M = CwL^2 = 102,000\ C$

x/l	C	M
0	0.0000	0
0.1	0.0450	4590
0.2	0.0800	8160
0.3	0.1050	10,710
0.4	0.1200	12,240
0.5	0.1250	12,750



STATE Ariz | PROJECT Buckhorn Mesa WPP Spook Hill FRS

BY PJM | DATE 12-4-75 | CHECKED BY DKT | DATE 12-9-75 | JOB NO.

SUBJECT Structural Design | SHEET 15 OF 25

$d = 10.5''$ $A_s = 0.79$ sq. in

USE #8@12 $A_s = 0.795$ sq in $\Sigma_o = 3.14$
Mallow = 12,750 #

A_T (top) $= 0.002(12)(13) = 0.31$ sq in

USE #5@12 $A_s = 0.31$ sq in
Mallow = 6.1 K

SECTION 3 @ 5' from us. end

$w = 20\#(5/32)(724-26) = 135.1$ plf

$\ell = 14 + 2(5)/10 = 15.0$

$-M_{max} < 1000$ # NEGLECT

$M = cw\ell^2 = (135.1)(15)^2 = 30400$ #

$M_{max} = 0.1250(30,400) = 3800$ #

$A_s = 0.23$ sq in $d = 10.5''$

USE TEMP STL #5@12

$A_T = 0.31$ sq in

Bottom stl - transverse

$A_T = 0.001(12)(13) = 0.16$ sq in

USE #4@12

STATE		PROJECT		
Ariz		Buckhorn Mesa WSA Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-4-75	DRT	12-9-75	

SUBJECT

SHEET 16 OF 25

Temp St'l Longitudinal

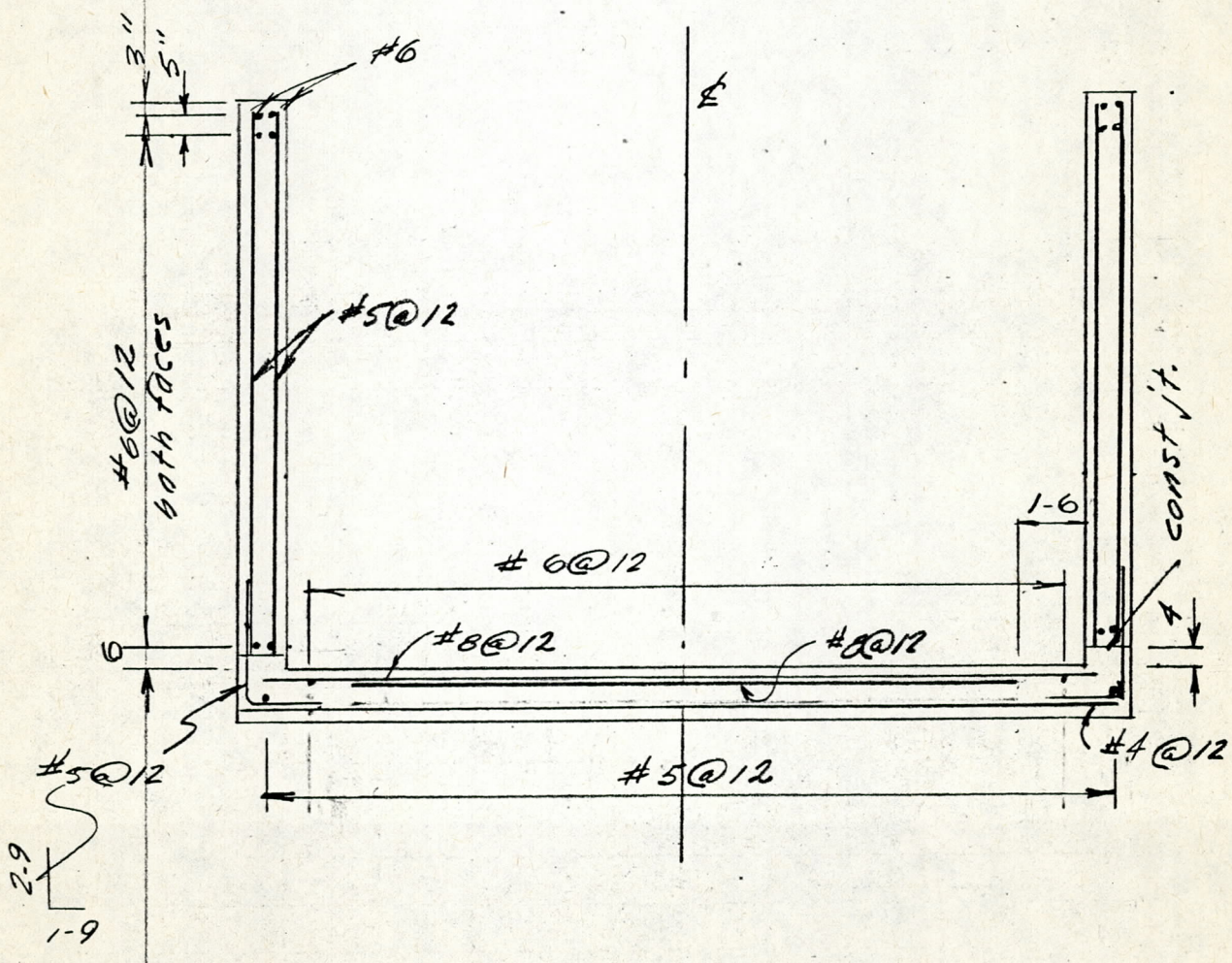
Top $A_T = 0.003(12)(13) = 0.47$ sq in

#6@12 $A_S = 0.44$ sq in

Bottom $A_T = 0.002(12)(13) = 0.315$ sq in

#5@12 $A_S = 0.31$ sq in.

SECTION (1) 0-12' from d.s. end

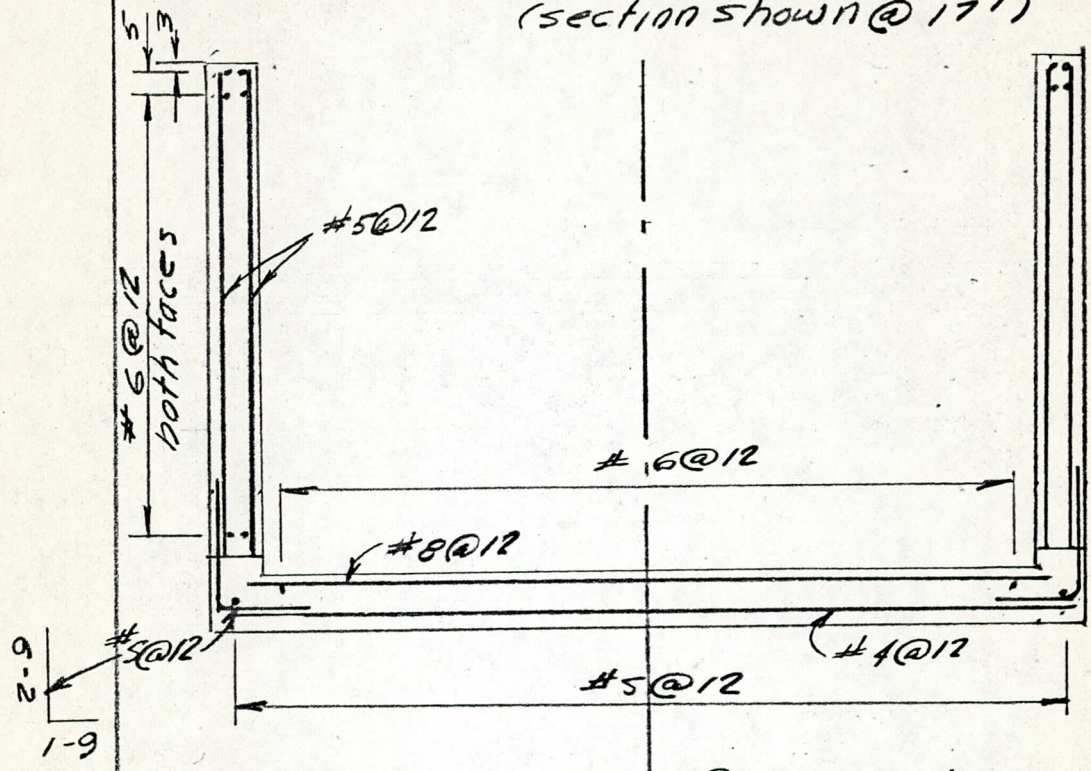


STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	12-4-75	BRT	12-9-75	

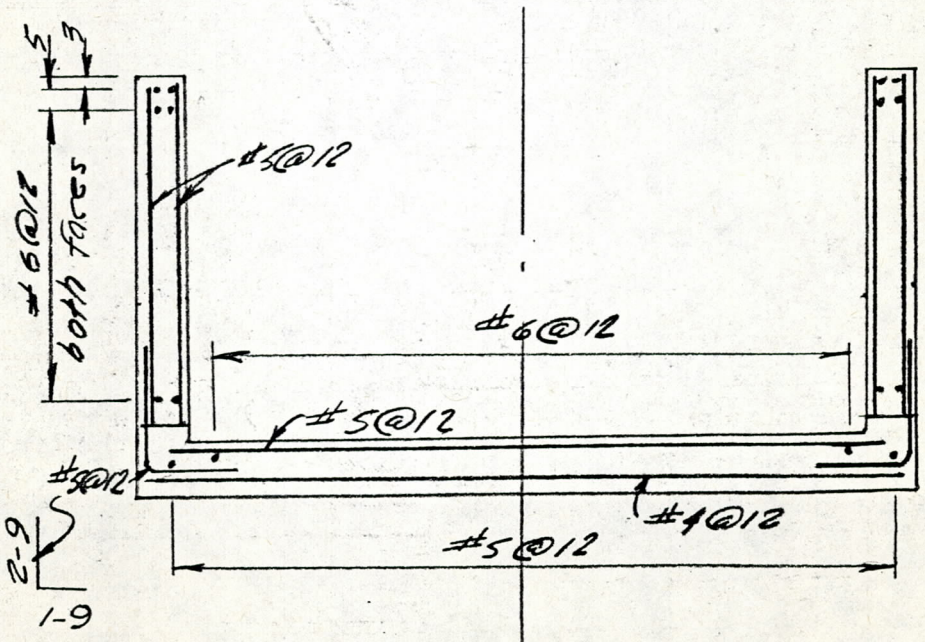
SUBJECT Structural Design

SHEET 17 OF 25

SECTION (2) 12'-22' from d.s. end
(section shown @ 17')



SECTION (3) 22'-32' from ds end



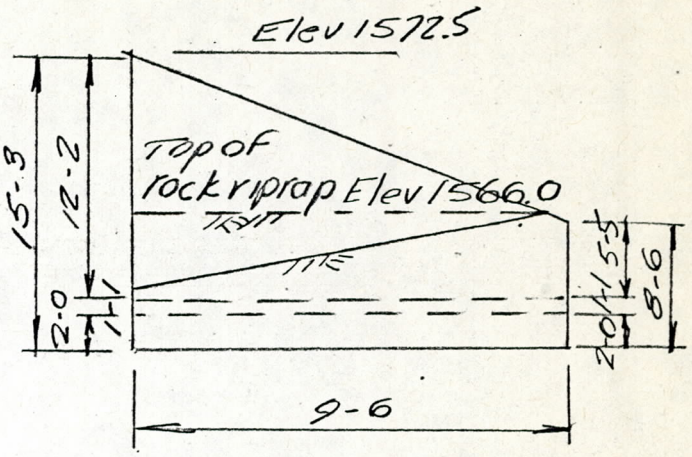
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-3-75	DKT	12-9-75	

SUBJECT Structural Design

SHEET 18 OF 25

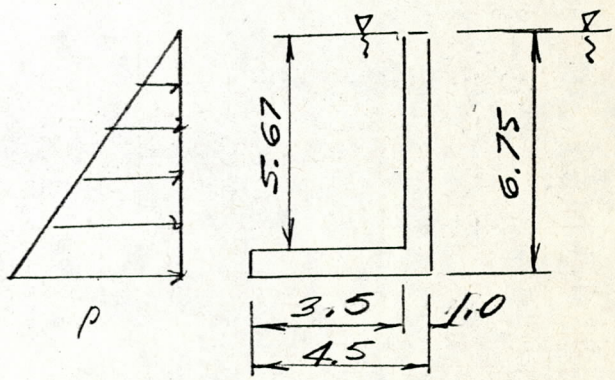
WINGWALL

$\gamma_m = 120 pcf$
$\gamma_{sat} = 137.5 pcf$
$\phi = 36°$
$K = 0.26$



Stability

The worst condition occurs where top of wall is at top of back fill. Assume no passive resistance. Neglect uplift forces.



$p = 6.75(75.0)(0.26) = 131.6 psf$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-3-75	DKT	12-9-75	

SUBJECT Structural Design

SHEET 19 OF 25

Part		Wt	arm	Moment
Conc wall	(1)(5.67)(150)	850	0.5	425
" ftg	(1.167)(4)(150)	700	2.0	1,400
Earth	(3.5)(5.67)(75)	1488	2.75	4,092
Horiz Force	(131.6)(6.75)/2 = -444		2.25	- 999
		3038		4918

$$z = 4918/3038 = 1.619'$$

$$e = 4.5/2 - 1.619 = 0.631'$$

$$p = \frac{3038}{4.5}\left[1 \pm \frac{6(0.631)}{4.5}\right]$$

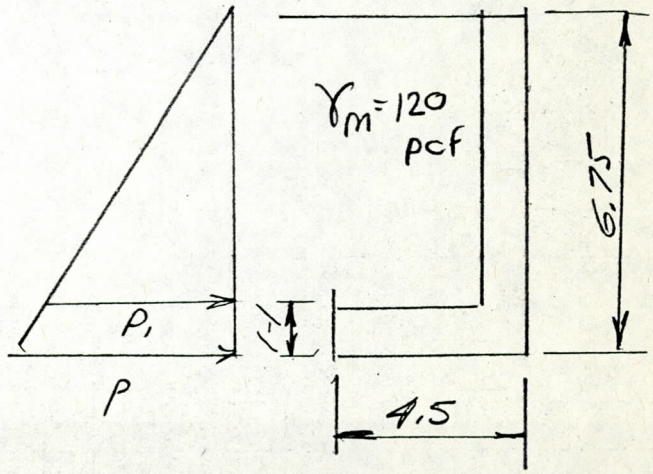
$p_d = 1243$ psf

$p_u = 1047$ psf

USE 3'-6" footing

WINGWALL STEEL

Design for Construction condition



$$p_1 = (5.67)(120)(0.26) = 176.9 \text{ psf}$$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	12-3-75	DKT	12-9-75	

SUBJECT Structural Design

SHEET 20 OF 25

$f_c' = 4000$ psi

$V_{max} = (176.9)(5.67)/2 = 502$ #

$V_d = (5.67 - 0.792)(502)/5.67 = \cancel{334}\ 432$ #

$v = V_d/bd = \cancel{334}\ 432/(12)(9.5) = 4$ psi OK

$M_{max} = (176.9)(5.67)^2/6 = 950$ #

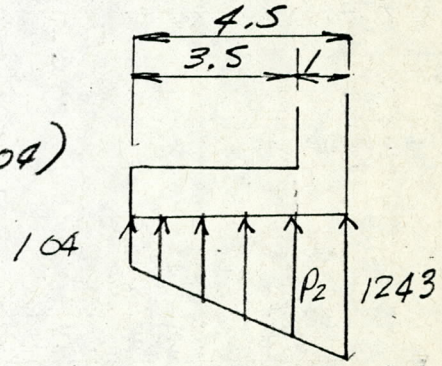
$d_{req'd} < 3$" OK

TEMP STL GOVERNS

$A_s = 0.002(12)(12) = 0.2885$ sq in

USE #5@12 Horizontally & vertically

FOOTING



$p_2 = 104 + (3.5/4.5)(1243 - 104)$
$= 990$

$V_{max} = 104(3.5) + (886)(3.5)/2 - (5.67)(120)(3.5)$
$= 1914 - 2381 = -467$

$V_d = (104)(2.71) + (2.71/4.5)(1139) - (5.67)(120)(2.71)$
$= 968 - 1844 = -876$

$v = 876/(12)(9.5) = 8$ psi OK

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Sook Hill FRS		
BY PJM	DATE 12-3-75	CHECKED BY DKT	DATE 12-9-75	JOB NO.

SUBJECT Structural Design

SHEET 21 OF 25

$M_{max} = (686)(3.5)^2/6 - (680-104)(3.5)^2/2$

$= -1719$ #

dreq'd < 3" OK

$A_s = 0.12$ sq in

TEMP STL GOVERNS

TOP $A_T = 0.002(12)(12) = 0.29$ sq in

BOTTOM $A_T = 0.001(12)(12) = 0.14$ sq in

USE #5@12 TOP
#4@12 BOTTOM

BLOCK STEEL

Ref: CEHB Urquhart p 4-100 (4th ed)

Dynamic Load:

$$F = \frac{Q w}{g}(v - v_o)$$

where: Q = discharge cfs
w = unit wt fluid = 62.4 pcf
g = 32.2 fps/s
v = velocity of jet@end
v_o = velocity of jet@beginning

STATE		PROJECT		
Ariz		Buckhorn Mesa WPA Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-4-75	DKT	12-9-75	

SUBJECT Structural Design

SHEET 22 OF 25

Assumptions:

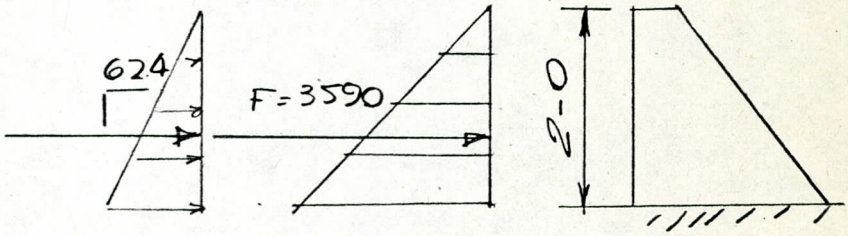
1. Q is evenly distributed on all blocks
2. $V_0 = V_1 = 25.2$ fps
3. $V = 0$

For 11 blocks

$Q = 808/11 = 73.5$ cfs/block

$$F = \frac{73.5(62.4)(25.2)}{32.2}$$

$$= 3590\#$$



STATIC FORCE DYNAMIC FORCE

Static Force

$F = 62.4(2)/2 = 62.4$

TOTAL FORCE

$F_T = 3590 + 62.4 = 3652.4$

say 3650#

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-4-75	DRT	12-9-75	

SUBJECT Structural Design

SHEET 23 OF 25

Approx.

$V = F_T = 3650^{\#}$

$d = 2.5(12) - 2.5 = 27.5"$

$v = 3650/(18)(27.5)$
$= 7$ psi < 70 psi. OK.

$M_{max} = (2)(3650)(3)(1.5) = 1620^{\#}/'$

$d_{req'd} < 3"$ OK

$A_s <$ 0.10 sq in TEMP STL GOVERNS

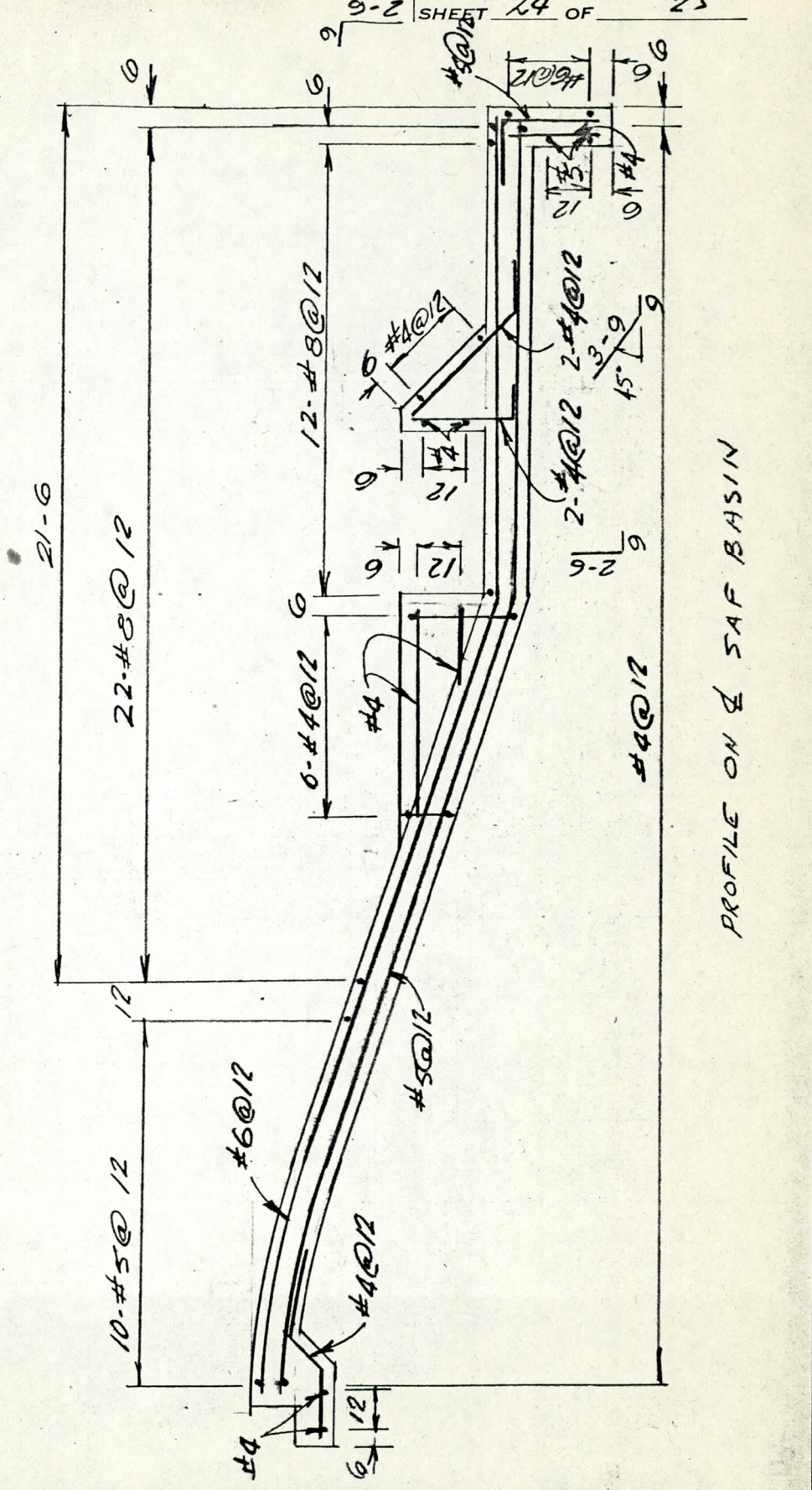
$A_T = 0.002(12)(16)$
$= 0.38$ sq in

USE #6@12 $A_s = 0.44^{"}\Sigma_o = 2.36"$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-5-75	DKT	12-9-75	

SUBJECT
Structural Design

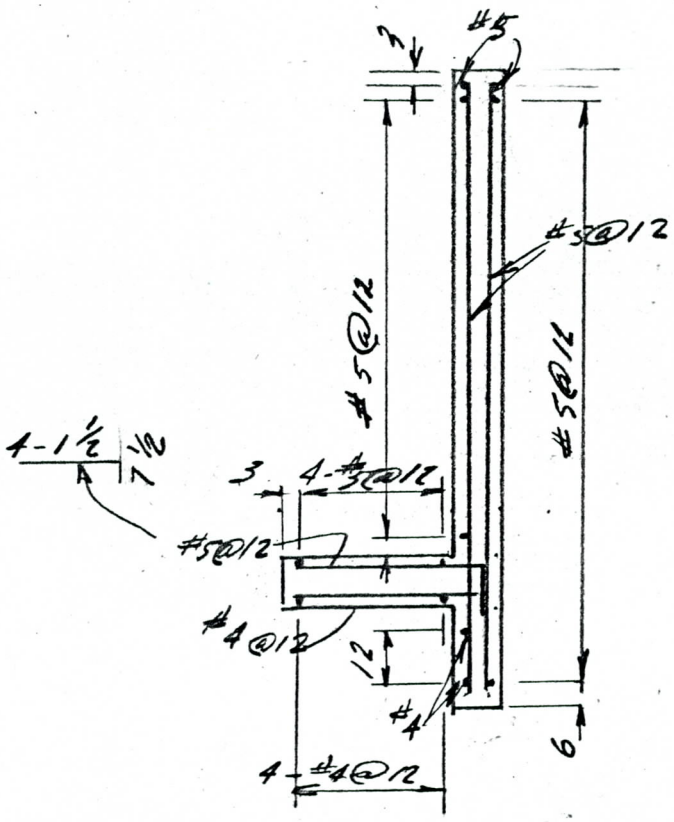
SHEET 24 OF 25



STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	12-5-75	DRT	12-9-75	

SUBJECT Structural Design

SHEET 25 OF 25



WINGWALL
CROSS SECTION

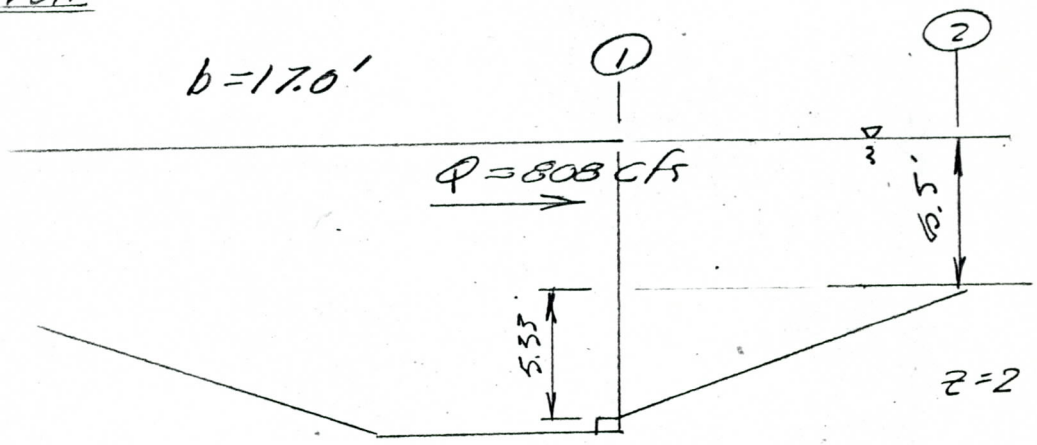
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RLM	11-19-75			

SUBJECT Hydraulics

SHEET 1 OF 2

Rock Riprap - Principal Spillway outlet

Given



Velocity @ SAF Exit pt (1)

$V = Q/A$
$= 808/(17)(6.5+5.33)$
$= 4.02$ fps

Velocity in channel pt (2)

$V = Q/A$
$= 808/[(30)(6.5) + 2(6.5)^2]$
$= 2.89$ fps

Find: Rock riprap size req'd @ pt (1)

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY PJM	DATE 11-19-75	CHECKED BY	DATE	JOB NO.

SUBJECT Hydraulics

SHEET 2 OF 2

Solution:

Ref: Blaisdell comments on NCHR Report 108 p37

$$D_{50} = 0.00116 V^3/\sqrt{d}$$

where:

D_{50} = riprap size in feet of which 50% is finer by wt.
V = average velocity fps
d = depth of flow = hydraulic radius in wide channels *

* The equations were developed for the assumption that $d = R$. Since the channel section used in this problem is not infinitely wide R will be used.

$$\therefore D_{50} = 0.00116 V^3/\sqrt{R}$$

where $R = A/P$

$A = (6.5 + 5.33)(17) = 201$

$P = 17 + 2(6.5 + 5.33) = 40.7$

$R = 201/40.7 = 4.95$

$$\therefore D_{50} = 0.00116(4.02)^3/\sqrt{4.95} = \underline{0.17'} \simeq 2"$$

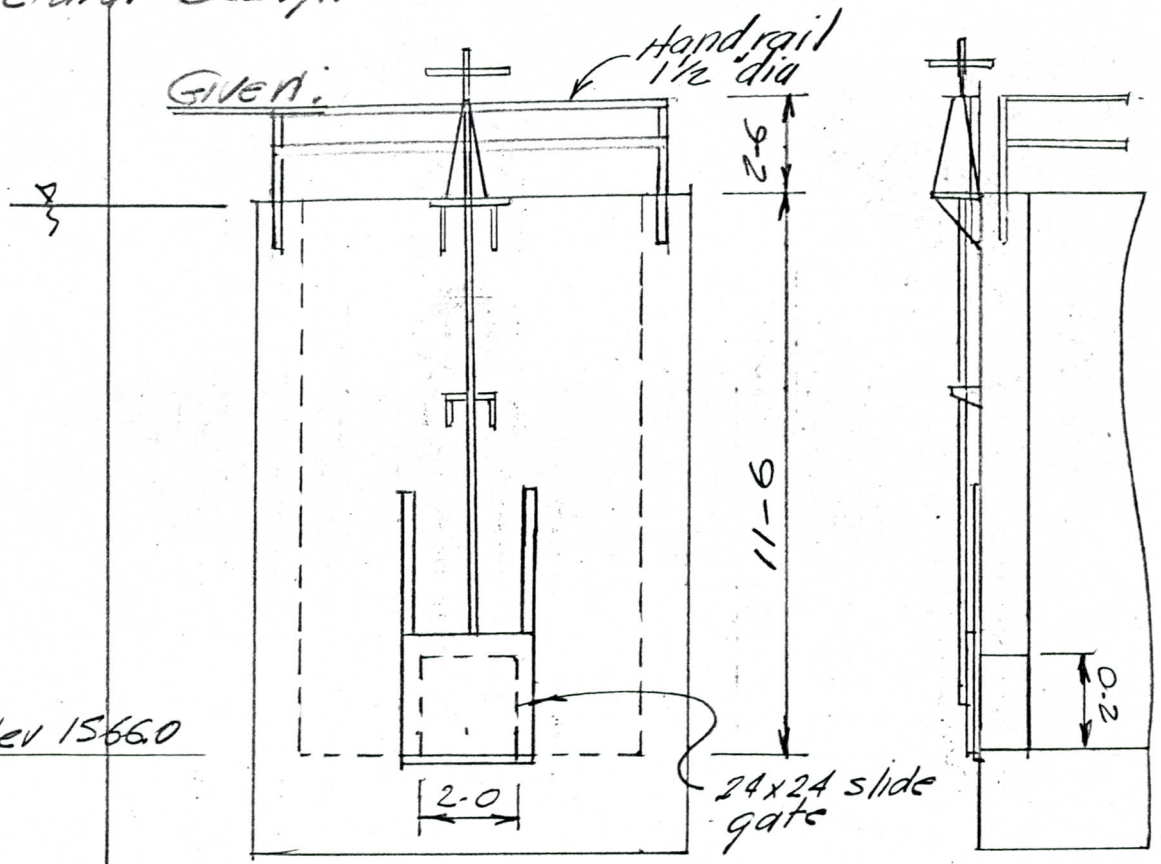
USE $D_{50} = 6"$ USE No Bedding

STATE	PROJECT			
Ariz	Buckman Mesa WPP Spook Hill FRS			
BY RJM	DATE 12-22-75	CHECKED BY	DATE	JOB NO.

SUBJECT Structural Design

SHEET 1 OF 3

Given:



Find:
a) Gate type
b) Stem type & dia
c) Frame type
d) Thimble size & type if necessary
e) Handwheel dia & pull
f) Stem guides – No, Type & spacing
g) Handwheel mounting
h) Front & side elevations

STATE		PROJECT		
AVIZ		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-22-15			

SUBJECT Structural Design

SHEET 2 OF 3

Solution

a) Gate type

Head = H = 11.5 - 1.5 = 10.0

ARMCO WATER CONTROL GATES
p4 sec 4

USE Model 10-00 Fabricated slide gate

b) Stem — 1½" dia coldrolled steel stainless

c) Frame - spigot back

d) Thimble - unnessary -

e) Handwheel 24" dia lift capacity 1900 lbs 25 lb pull

f) Stem guides -

$l/r \leq 200$ - ?

$r = d/4 = 1.5/4 = 0.375$ "

$l_{MAX} = 200(0.375) = 75$"
$= 6\text{-}3$"

USE 1 stem guide 5'-0" from top of wall

g) Handwheel mounting USE Type HPB 24 Lift

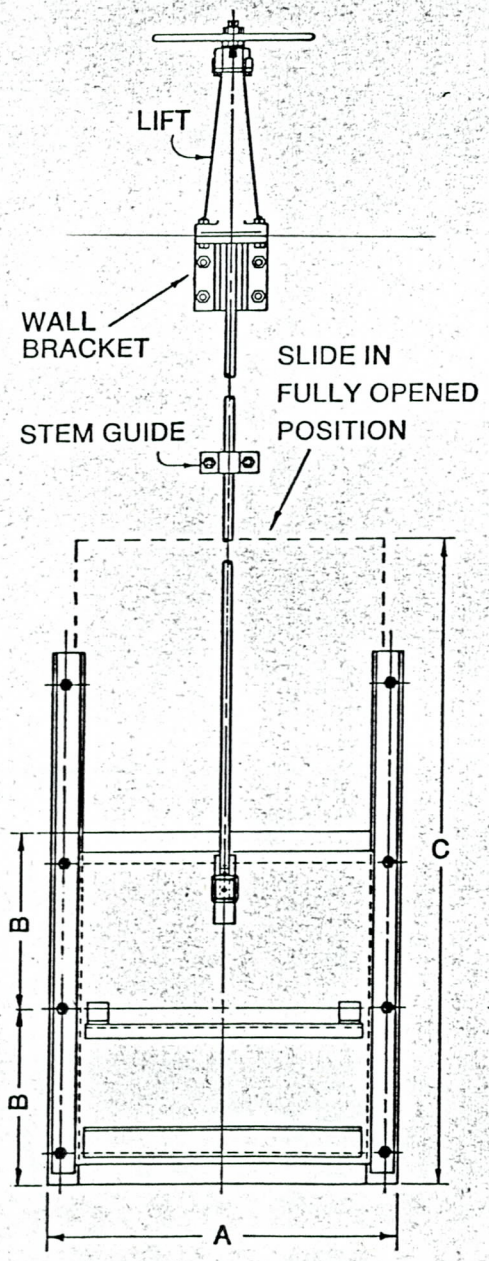
p 6/10 ARMCO

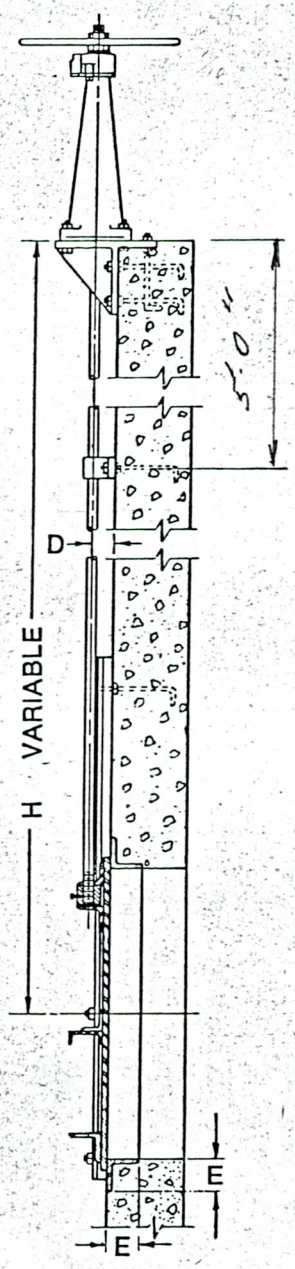
FABRICATED SLIDE GATES MODEL 10-00

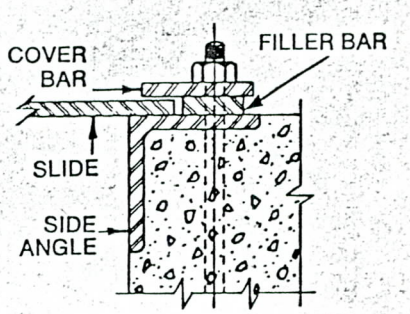
Sheet 3 of 3

10-Foot Seating Heads
No Unseating Heads

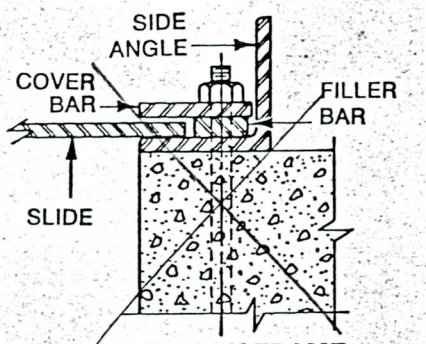
- Square or Rectangular Opening
- Rising Stem
- Pedestal Lift
- Flat or Spigot Back
- No Wedges



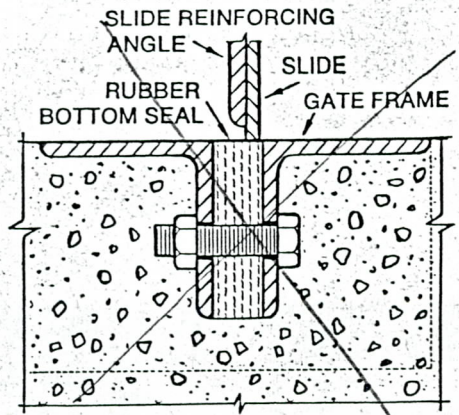




SPIGOT BACK FRAME



FLAT BACK FRAME



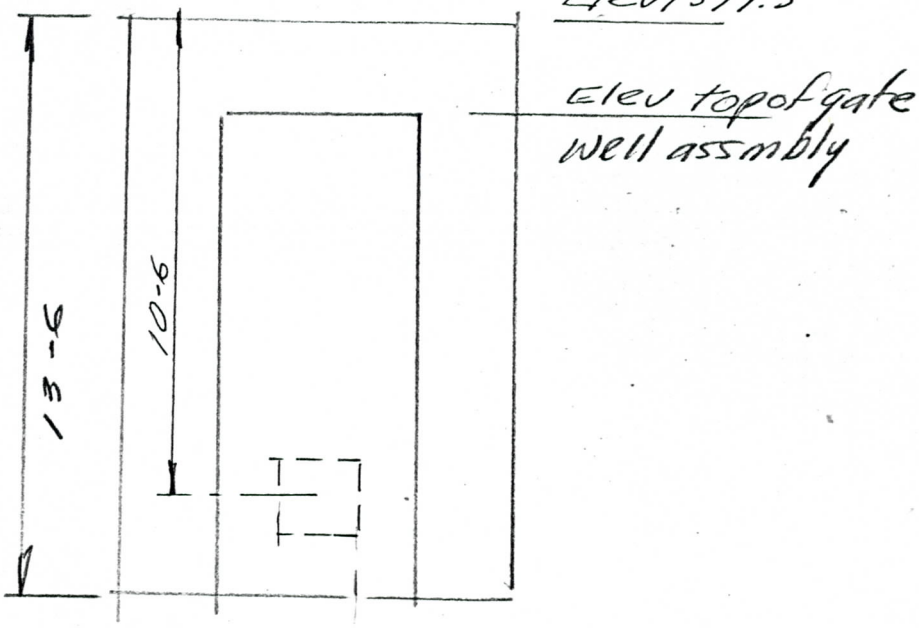
SECTION THRU FLUSH BOTTOM OPENING

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	12-23-75	DR	1/8/76	

SUBJECT Structural Details

SHEET 1 OF 3

Given



Find: a) Elev top of gate assembly
b) No of holes, size & spacing

Solution:

a) Set top @ Elev 80% Sed storage

Work Plan Suppl. Table 3

S = 254 + 63 = 317 af

From Stage-storage curve

Elev top = 1575.4 say 1575.5

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-29-75			

SUBJECT Structural Details

SHEET 2 OF 3

b) Design holes for Q = 48 cfs h = 2'

$$A = \frac{48}{.6\sqrt{(64.4)(2)}} = 7.05 \text{ sq ft}$$

Try 3/8" holes

$$A = \frac{(3/8)^2 \pi}{4(144)} = 0.000767 \text{ sq ft}$$

$$N = 7.05/0.000767 = 9,190$$

For 60" dia CMP w/ 3-12" coupling bands the available area =

$$A = (11.5)(5\pi/12) = 90.3 \text{ sq ft}$$

Holes/sq.ft = 9190/90.3 = 102 /sq.ft

would be approximately on 12/10 = 1.2" c.c.

Too close - NG

Try 3/8" slots 6" wide

$$A = (3/8)(6)/144 = 0.01563 \text{ sq ft}$$

$$N_T = 7.05/0.01563 = 451$$

$$N/\text{sq ft} = 451/90.3 = 5$$

stagger slots

Row spacing = 12/5 = 2.4" c.c. could use 2½" c.c.

IF 899 pipe is used the slots shall be OK

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-29-75			

SUBJECT Structural Details

SHEET 3 OF 3

Check time of drawdown

Assume: $Q_1 = .8\,Q_{max}$ for the 1st 2 feet
& $Q_2 = .5\,Q_{max}$ for the remainder

$\therefore T = 63/2\,Q_1 + 254/2\,Q_2$

$Q_{1\,max} = 3.1L(2)^{3/2} = 8.77L$

$L = \pi D/2 = 2.5\pi = 7.85'$

$\therefore Q_{1\,max} = 8.77(7.85) = 68.9$ cfs

For gate

$Q_{max} = .6a\sqrt{2gh}$
$= .6(2)(2)\sqrt{(64.4)(10.5)}$
$= 62.4$ cfs USE

$Q_1 = .8(62.4) = 49.9$ cfs

$Q_{2\,max} = .67a\sqrt{2gh}$

$a = 7.05^{D'}$ $h = 11.5/2 = 6.75'$

$Q_{2\,max} = .67(7.05)\sqrt{(64.4)(6.75)}$
$= 98.48$ cfs

$Q_2 = .5(98.5) = 49.2$ cfs

$T = 63/(2)(49.9) + 254/(2)(49.2) = 3.21$ days OK

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-29-75			

SUBJECT Structural Details

SHEET 1 OF 9

Handrail & walkway details

Alternatives

1. No walkway, no handrails
2. No walkway, handrail on outside edge of riser
3. No walkway, handrail on inside edge of riser
4. 3' walkway inside riser, hand rail in top of riser walls
5. 3' walkway inside riser, handrails on walkway
6. 3' walkway on one side & u.s. end of riser walls, hand rail in wall
7. 3' walkway on one side & u.s. end of riser walls, hand rail on both sides of walkway

Considerations

1. Design
2. Maintenance
3. Safety
4. Function of riser
5. Operation of gate

Assume above are of equal importance

STATE: Ariz | PROJECT: Buckhorn Mesa WPP Spook Hill FRS

BY: RJM | DATE: 12-29-75 | CHECKED BY: | DATE: | JOB NO.:

SUBJECT: Structural Details consideration

Alternative No	Design	Maintenance	Safety	Function of riser	Operation of gate	Total
1. No walk, No rails	10	10	0	10	0	30
2. No walk, rail on outside	8	8	3	8	3	30
3 No walk, rail on inside	8	8	4	8	3	31
4 3' walk inside rail in wall	6	6	10	4	10	36
5 3' walk inside ctr rails on walk	6	6	10	6	10	38
6 3' walk outside rail in wall	6	6	8	8	10	38
7 3' walk outside rails either side	6	6	10	7	10	39
8 2' walk inside ctr rails on walk	7	6	10	7	10	40

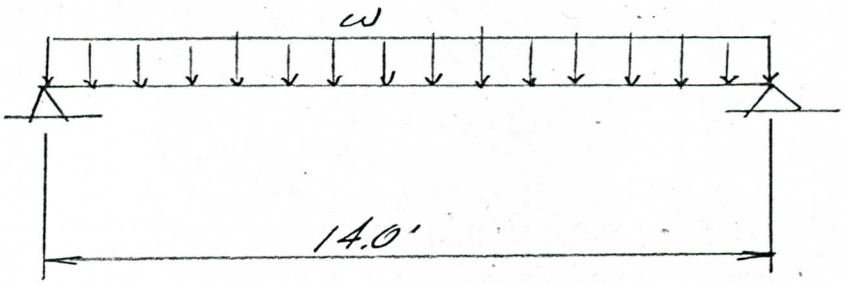
USE No 8 2' walk inside riser on ℄ w/ handrails on walk.

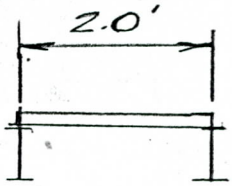
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-29-75			

SUBJECT Structural Details

SHEET 3 OF 9

Walkway





width = 2.0'

loading = 100 psf

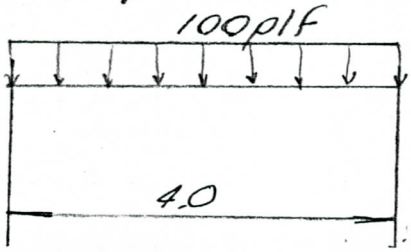
$w = (2)(100)(2) = 100$ plf

$M_{max} = wL^2/8$
$= (100)(14)^2/8$
$= 2450$ '#

$f_s = 24{,}000$ psi

$S = 12(2450)/24{,}000 = 1.23\ in^3$

For overhanging section



$M_{max} = wL^2/2$
$= (100)(4)^2/2$
$= 800$ '# simply supported governs

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-29-75			

SUBJECT Structural Details

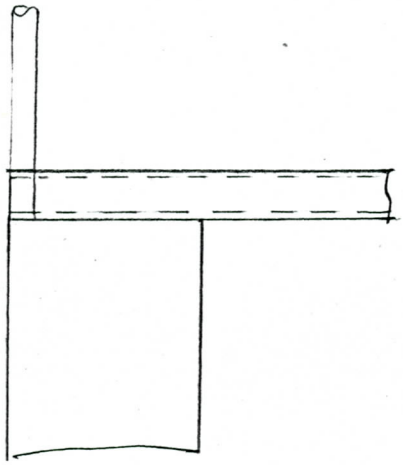
SHEET 4 OF 9

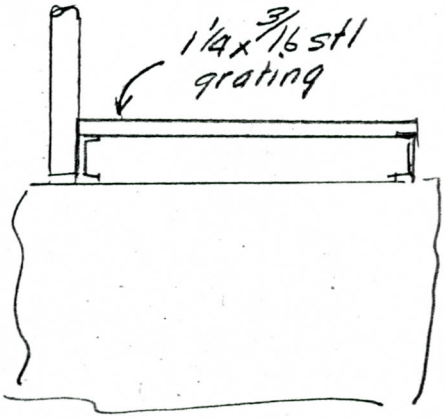
USE 3x1½ channel 6.0 lbs/ft 3C 6.0
S = 1.4

Extend cantilever to limit of channel or 6'

$M_{max} = (100)(6)^2/2$
$= 1800$ '# OK

Anchor details



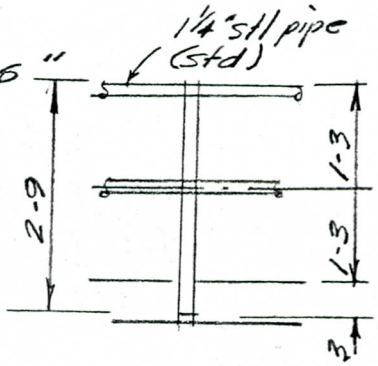


C3 cannot be drilled for fastener

USE C4=7.25 g=1" ⅝ anchor bolt

space handrail posts @ 5-6"
5 posts / side

44
13.75=5(2.75)
57.75



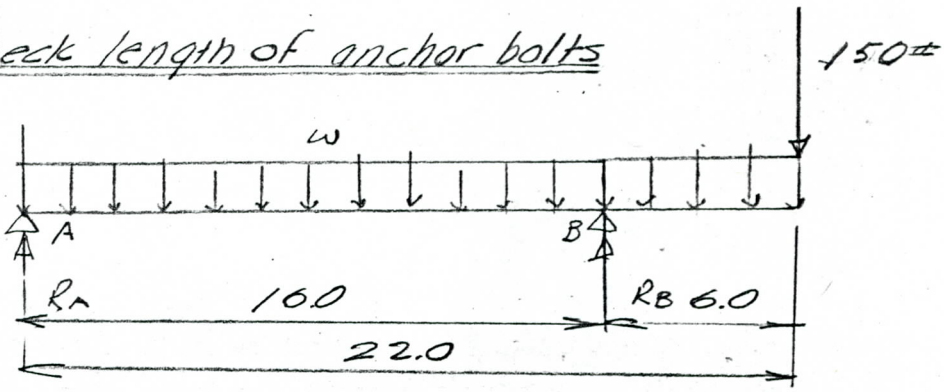
Wt of channel + rail
$= (22)(7.25) + (57.75)(2.272)$
$= 159.5 + 131.2$
$= 291$ lbs

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	12-29-75			

SUBJECT Structural Details

SHEET 5 OF 9

Check length of anchor bolts



$$w = [2(291) + (22)(2)(9.2)]/22$$
$$= (582 + 405)/(22)(2)$$
$$= 987/(22)(2)$$
$$= 22.4 \text{ plf}$$

$$\Sigma M_A = (22.4)(22.0)^2/2 - 16R_B + 22(150) = 0$$
$$5420 - 16R_B + 3300 = 0$$
$$16R_B = 8720$$
$$R_B = 545\#$$

$$\Sigma F_y = R_A + R_B - 22w - 150 = 0$$
$$R_A + 545 - (22)(22.4) - 150 = 0$$
$$R_A = 97.8\#$$

No tension @ pt A 1- 5/8 x 8" anchor bolt w/ flat & lock washer @ ℄ wall for each channel all that's necessary.

weld bearing bars @ 1'-0" c.c.

paint all metal w/ prime coat & 2 coats aluminium paste.

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-29-75			

SUBJECT
Structural Details

SHEET 6 OF 9

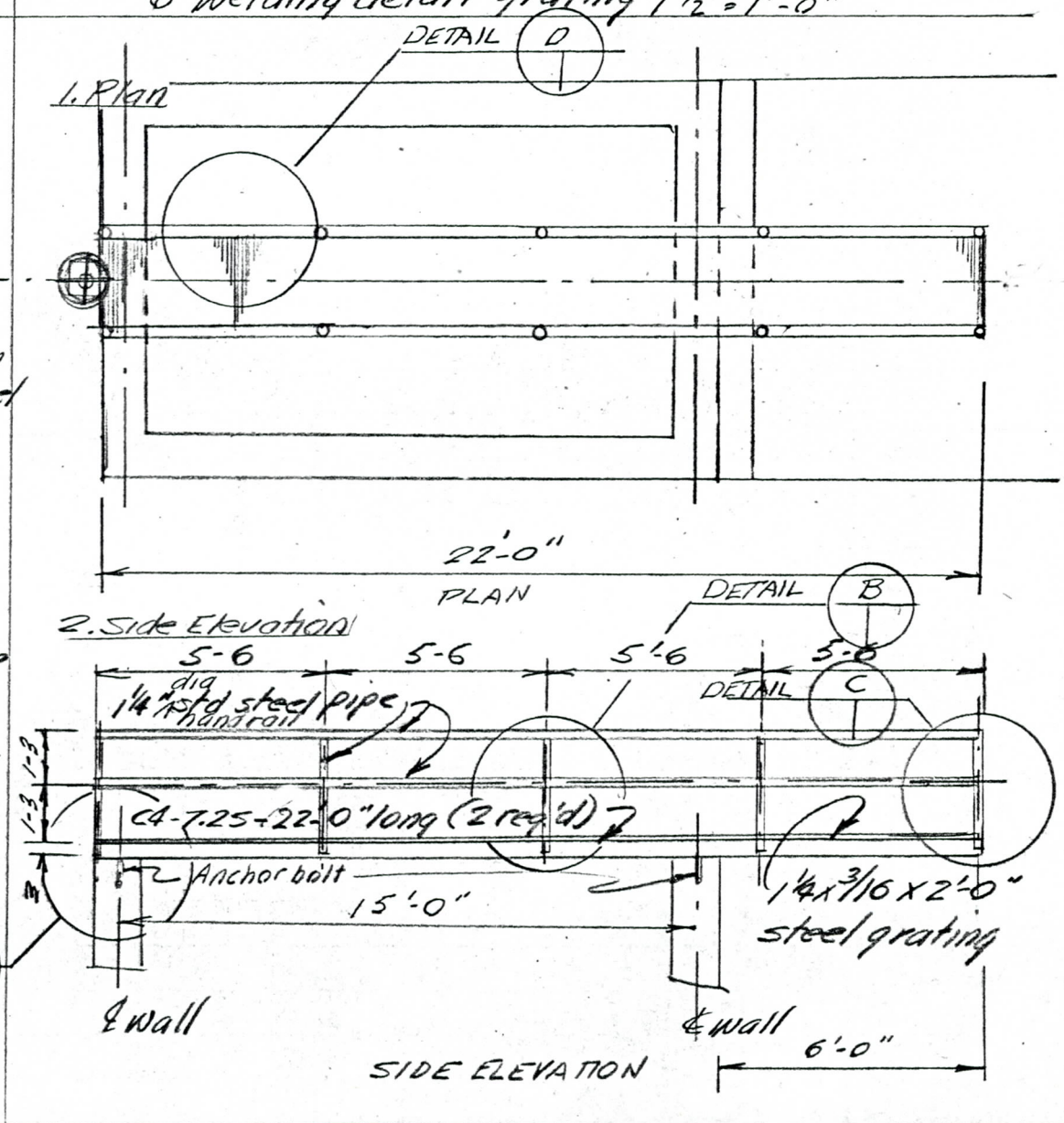
Views Required

1. Plan of walkway 3/4" = 1'-0"
2. Side Elevation of walkway 3/4" = 1'-0"
3. End Elevation of walkway 3/4" = 1'-0"
4. Anchor bolt detail 3" = 1'-0"
5. Hand rail details
   a) Center post welds 1½" = 1'-0"
   b) End post welds 1½" = 1'-0"
6. Welding detail grating 1½ = 1'-0"

℄ Principal Spillway

C4-7.25 American Standard channel Manual of Str Design etc p2060

¼ std steel pipe handrail Standard pipe sections Manual of Str Design etc p2086 Standard



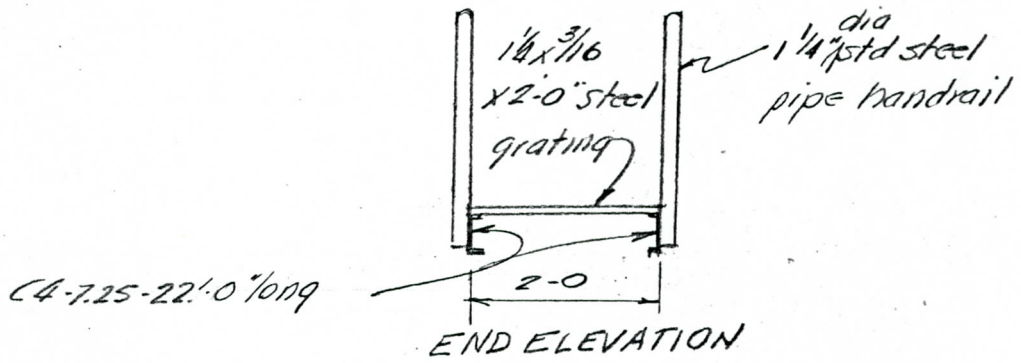
STATE		PROJECT		
AriZ		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	12-30-75			

SUBJECT Structural Details

SHEET 7 OF 9

1¼ x 3/16 x 2'-0" steel grating
McMasters p555A standard spacing type

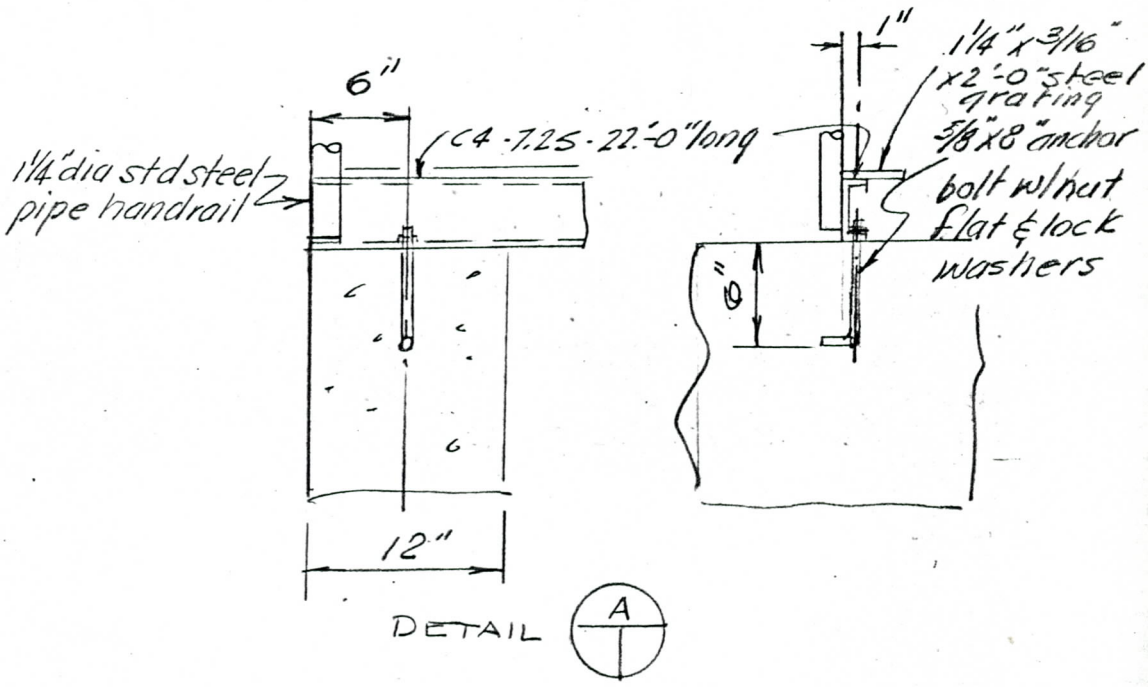
3. End Elevation



END ELEVATION

4. Anchor Bolt Detail

Anchor bolts p1413A McMasters No 91581D
Nuts p1415D Steel full nuts No 90490A coarse thread
Lock washer p1421C Kant-link Spring Lock washers Medium type
Flat washer p1419C Standard wrought iron washers No 91081A



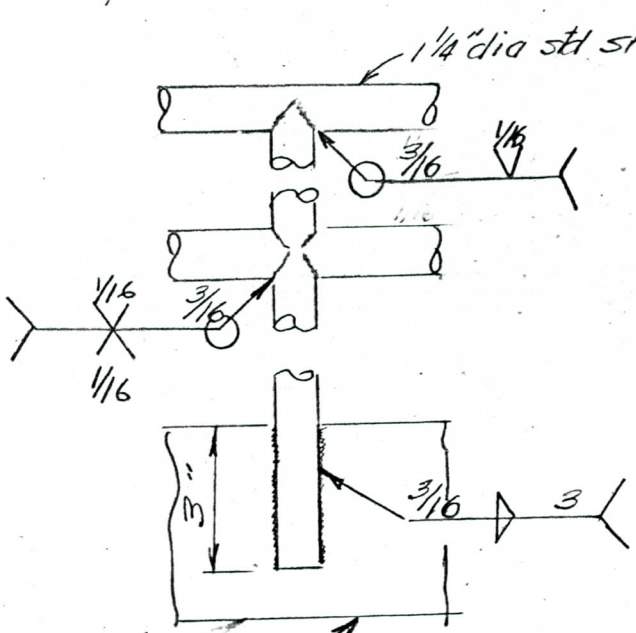
DETAIL A

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJW	12-30-75			

SUBJECT Structural Details

SHEET 8 OF 9

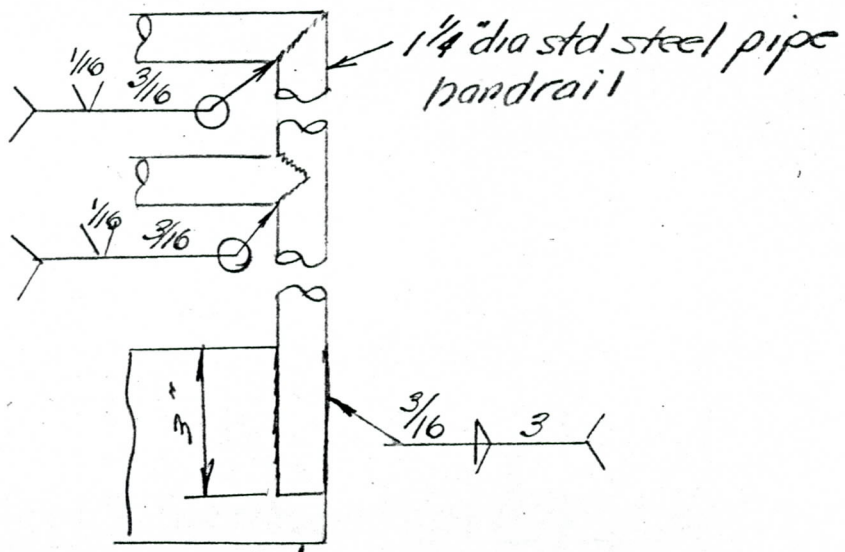
5a) Center post welds



C4-7.25-22'-0" long

DETAIL B

5b) End post welds



C4-7.25-22'-0" long

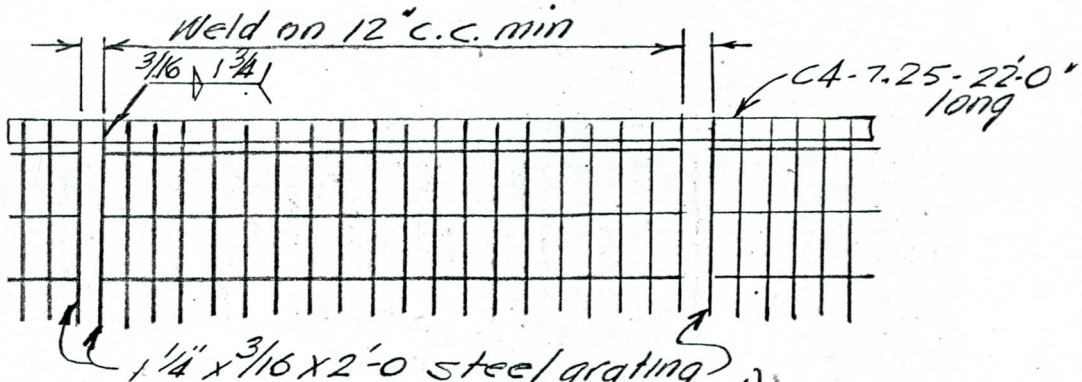
DETAIL C

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	12-30-75			

SUBJECT
Structural Design

SHEET 9 OF 9

6 Welding detail grating



Note: Weld end bars on each section

DETAIL D

STATE ARIZONA		PROJECT Buckhorn Mesa WPP - Spook Hill FRS		
BY A.C.	DATE 8-12-76	CHECKED BY	DATE	JOB NO. 2005
SUBJECT Principal Spillway outlet Vertical Curve				SHEET 1 OF 1

See road ramp designs for methods

$l = 6'$ $g_1 = 0$ $g_2 = 33.3\%$ $A = 33.3$

$r = \frac{33.3}{.06}$ $\frac{1}{2} r = 277.5$

$y = \frac{1}{2} r x^2$ PI = 102 + 78.28

Station		y	Elev.
102+75.28		—	1566.0
102+76.28		- 0.03	1565.97
102+77.28		- 0.11	1565.89
102+78.28	1566.0	- 0.25	1565.75
102+79.28	1565.67	- 0.11	1565.56
102+80.28	1565.33	- 0.03	1565.30
102+81.28		—	1565.0

STATE		PROJECT		
BY A.C.	DATE 8-26-76	CHECKED BY	DATE	JOB NO.
SUBJECT Corrugated Metal Pipe				SHEET 1 OF 4

CSP Technical Manual

108" Dia. pitch = 3" depth = 1"

available in 14, 12, 10 and 8 gage

height of cover — McDowell Road 8'; McKellips Road 11'; Brown Road 4'

H20 loading

D.L. = 11'(108")(130 lb/ft³) = 12,870 L.L. = 900

total load = 13,770 lb/ft

8' cover DL = 9,360 LL = 900

total load = 10,260 lb/ft

4' cover DL = 4,680 LL = 3600

total load = 8,280 lb/ft

use load factor = 1.0

$P_v = 13{,}770 \times 1.0 = 13{,}770$ lb/ft actually $P_u = 1530$ lb/ft²

$C = P \times \frac{S}{2} = 1530 \times \frac{108/12}{2} = 6885$ lb/ft

$f_c = 16$ ksi

$A = C/f_c = .43$ in²/ft any gage will do use 14 ga.

Handling Stiffness

$$\frac{D^2}{EI} = \frac{(108)^2}{(30\times10^6)(.1306)} = 2.98 \times 10^{-3} = .003 < .0433$$

care must be taken in handling!

STATE		PROJECT		
BY A.C.	DATE 8-26-76	CHECKED BY	DATE	JOB NO.
SUBJECT Asbestos-Cement Pipe				SHEET 1 OF 1

John's Manville

4" drain - perforated

13' earth load plus 1' concrete ≈ 15' earth load

$W_c = C_c w (B_c)^2$ = $C_c = 15'/4" = 45 - .96$
$w = 130$
$B_c = 4"$

$W_c = 636$ lb/ft

D.L. = 636 lb/ft LL = 201b/ft @ 15' 656 lb/ft

D.L = 72 lb/ft LL = 498 lb/ft @ 2' 570 lb/ft

(this TS for 6" drain - 4" is not in manual)

T-40 is lowest grade 6" pipe at a 2500 lb/ft

O.D. = 6.89" wall thickness .445"

certain-teed

4" class 100 irrigation pipe looks good

ID = 4.0" O.D = 5.08" wall thickness = .504"

checked ASTM C 296 and C 508 - looks ok.

---

try 6" pipe - 22' head plus surcharge

DL = 1430 lb/ft LL = 5 lb/ft 1435 lb/ft

T-40 - still O.K. 460psi

6" class 100 will hold 4,000 lb (crushing) - 225' head
(2100 lb Flexural)

Use 6" class 100

COMPUTATION SHEET
SCS–ENG–523 Rev. 8–69

U. S. DEPARTMENT OF AGR.
SOIL CONSERVATION SERVICE

2650 1

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	8-27-75	A.C.	3-29-76	2005

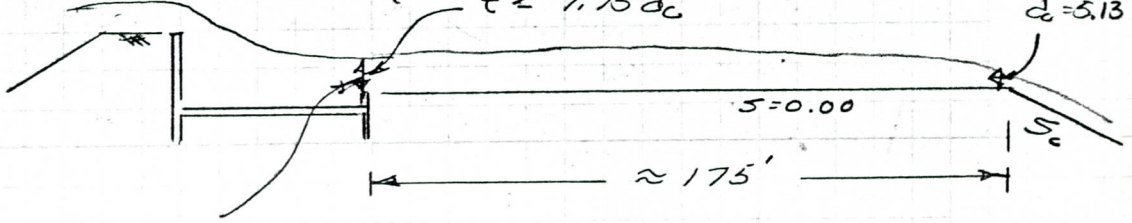
SUBJECT Emergency Spillway (Type C - Drop Str.) SHEET 1 OF

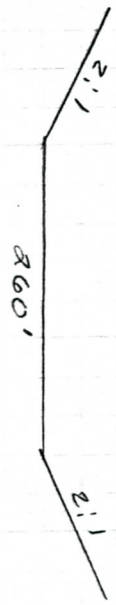
From ADP Print Out Sheet

$Q^{F.B.}_{Total} = 18,338.3$ cfs $\quad Q^{F.B}_{Em.\,Sp.} = 17,513.3$ cfs

$L = 260$ ft. $\quad HP = 7.69$ ft. $\quad d_c = 5.13$ ft.

Tailwater Depth



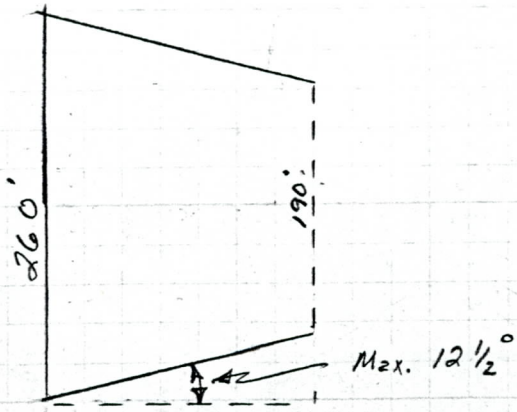


Using the 1880 t = 7.05' < 8.98' ∴ have to try something else

Could lower the basin 2.0', but would require a reverse grade on the outlet channel

---

Use transition to increase the tailwater depth



35'
40
38.8
2600/190
M
9.75

STATE	PROJECT		
Arizona	Buckhorn Mesa W.P.P., Spook Hill FRS		
BY J.L. Sullivan	DATE 8-29-75	CHECKED BY A.C.	DATE 3-29-76
JOB NO. 2005			
SUBJECT Emergency Spillway (Type C - Drop Str.)		SHEET 2 OF	

Free Board

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16•2706 dfQ

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W e

16•2706

1•

39•3204 A

14•0214 P

2•8042 r

K 4,303•5082

2•

1,191•4140 A

190•0000 P

6•2705 r

K222,975•4982

3•

39•3204 A

14•0214 P

2•8042 r

K 4,303•5082

• • • • • • • • • • • • • • • • • • • t

1,270•0548 A

K231,582•5147

1•0277 α

V

13•7894

VE

3•0344

E O

19•3050

0•0057 SF

COMPUTATION SHEET
SCS–ENG–523 Rev. 8–69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE Arizona		PROJECT Buckhorn Mesa W.P.P., Spook Hill FRS		
BY J.L. Sullivan	DATE 8-29-75	CHECKED BY A.C.	DATE 3-29-76	JOB NO. 2005
SUBJECT Emergency Spillway - Type C Drop Str				SHEET 3 OF

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....
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15.1344 dfCL

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W e

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W e

19.0000

E 0

19.7828

E 1

19.8852

....

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W e

19.2000

E 0

19.9474

E 1

19.8794

....

....

W e

19.1000

E 0

19.8648

E 1

19.8823

....

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P., Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	8-29-75	A.C.	3-29-76	2005
SUBJECT				SHEET 4 OF
Emergency Spillway - Type C Drop Str.				

```
. . . . . .
      W          e
   19.1500
E 0
   19.9060
E 1
   19.8808
. . . . . .

. . . . . .
      W          e
   19.1200
E 0
   19.8813
E 1
   19.8817
. . . . . .

. . . . . .
      W          e
   19.1200 ✓
-------------------
1.
   83.1744        A
   20.3929        P
    4.0785        r
K 11,685.6070

2.
 2,371.2000       A
  260.0000        P
    9.1199        r
K569,665.3319

3.
   83.1744        A
   20.3929        P
    4.0785        r
K 11,685.6070
```

```
. . . . . .                t
 2,537.5488        A
K593,036.5460
    1.0293         α
 V
    6.9016
 VE
    0.7613
E 0
   19.8813
    0.0008        SF
    0.0032        SF
 FL
    0.5767
    0.0000         e
E 1
   19.8817
. . . . . .
```

Note: See design of Channel for other trials.

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	9-15-75	A.C.	3-29-76	2005

SUBJECT: Emergency Spillway (Type C Drop Structure — SHEET 5 OF

17, 513.3

Hydraulic Design

$0.1 \leq h/F \leq 1.43$ Where h = design head over crest

$L \geq 1.5\ d_c \geq (1.5)(5.13) = 7.695$

90
85

$t \geq 1.75\ d_c \geq (1.75)(5.13) = 8.9775$

$h/F = 7.69/12 = 0.6408$ ok

$t = 9.12$ ok > 8.98

ES-111
P. 5-21

Basin Length – L_B

$h/t = 7.69/9.12 = 0.8432$

$L_B/F = 2.75$

$L_B = (12)(2.75) =$ 33.00 ft.

ES-111
P. 5-22

Location of Floor Blocks L_f

$L_f/F = 1.95$

(Es11)
(P 5-13)

$L_f = (12)(1.95) = 23.4$ ft.

$L_B - L_f$ min $= 1.75 d_c = 8.98$

Use 23.5 ft.

$L_B - L_f = 33 - 23.5 = 9.5$ ok

Height of Floor Blocks $0.8 d_c$

$(0.8)(5.13) = 4.104$ ft.

Use 4.0 ft.

Floor Block Width & Length $(0.4\ d_c \pm .15 d_c)$

$(0.4)(5.13) = 2.052$ ft.

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	9-15-75	AC.	3-29-76	2005

SUBJECT: Emergency Spillway – Type C Drop Structure — SHEET 6 OF

$0.15\,d_c = (0.15)(5.13) = 0.7695$

Use 2.0'

Floor Block Spacing

Have 1' spacing between walls & block & 2' in between the blocks

Longitudinal Sills

Width ≥ Block Width

height – Structural Requirements

Not to be spaced between floor blocks

13 - 20' apart

Transverse Sill Height

$S_{min} = 0.4\,d_c = 2.052$ ft.

Use 2'-0"

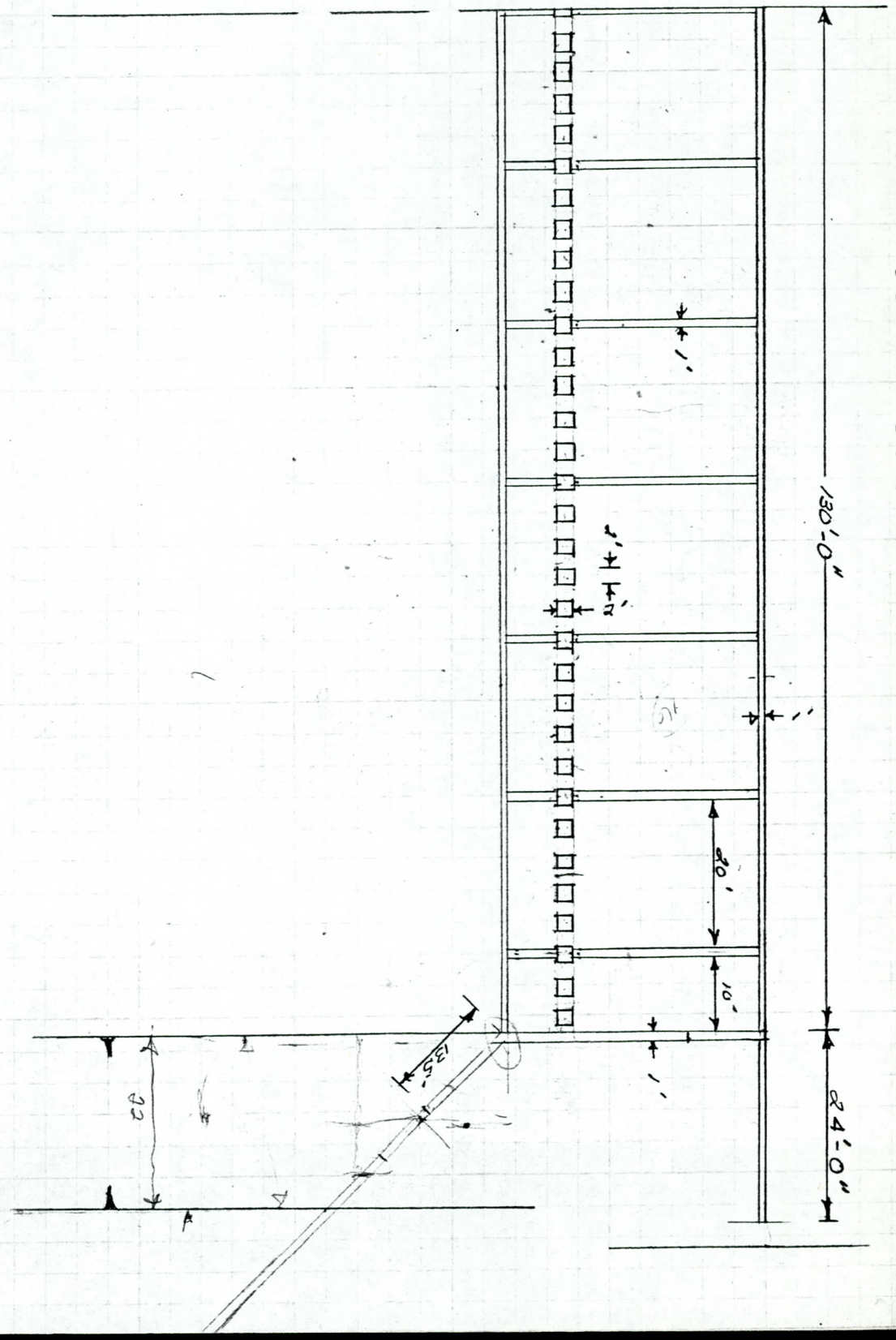
Sidewall Height

$f + 0.85\,d_c = 9.12 + (0.85)(5.13) = 13.4805'$

Use 13.50 ft.

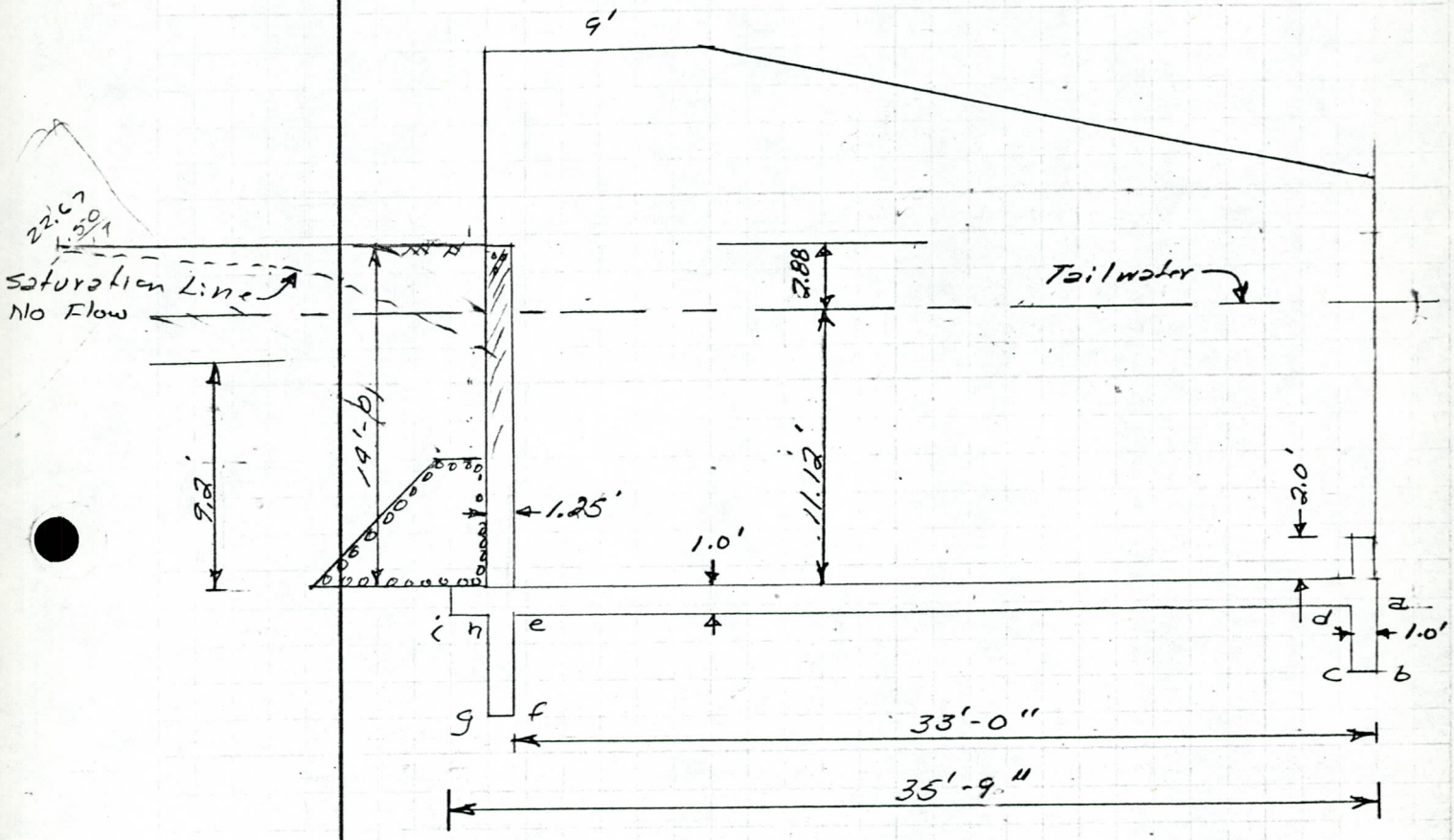
STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	9-29-75	A.C.	3-29-76	2005

SUBJECT Emergency Spillway - Type C Drop Structure SHEET 1 OF



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	9-30-75	A.C.	3-29-76	2005
SUBJECT				SHEET 8 OF
Emergency Spillway - Type C Drop Str.				

Reged Cutoff Wall & Toe Wall



SM - Silty Sand
ML - Sandy Silt
SC -

Foundation Material - Caliche

Backfill - SM & SC

Dry Wt. ≈ 128 lbs/ft^3

Moist Wt. ≈ 139 lbs/ft^3

e = Void ratio = 0.40

% Voids = $\left(\frac{e}{1+e}\right) \times 100$ = 28.6 use 29

ϕ = 33° 30' $\left(\frac{1-\sin\phi}{1+\sin\phi}\right)$ = 0.2887

Eff. submerged Wt. = [128 - (1 - .29)(62.4)] = 84 lbs/ft

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-1-75	A.C.	3-29-76	2005
SUBJECT				SHEET 9 OF
Emergency Spillway - Type C Drop Str.				

$\frac{\Sigma L_H + 3\Sigma L_V}{3H}$

0.13

8/1/3a

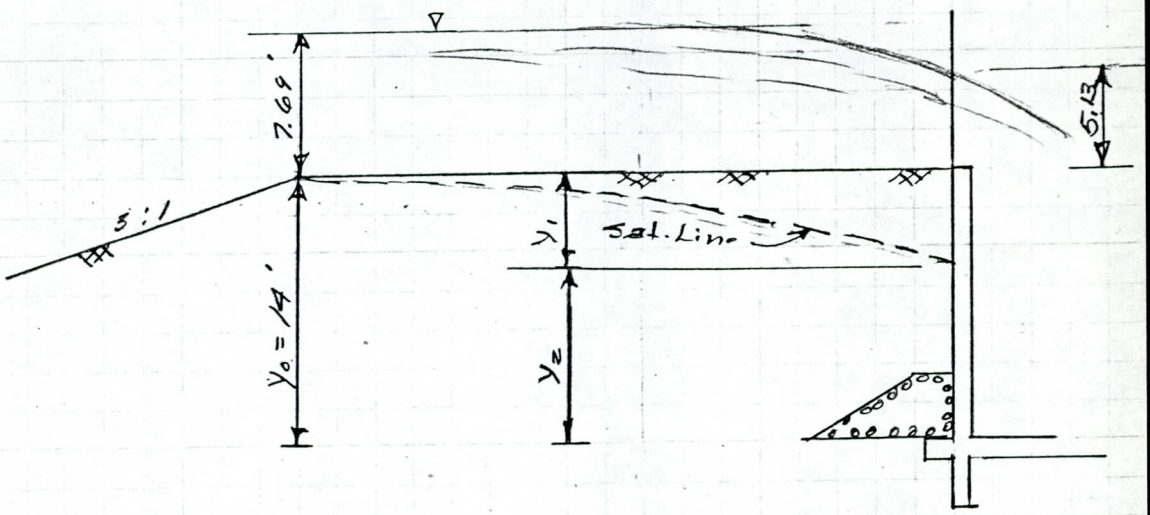
6a/1

$3H C_w = \Sigma$

$H C_w = \frac{\Sigma L_H}{3} + \Sigma L_V$

Saturated Wt. = 128 + (.29)(62.4) = 146 lbs/ft.^{3}

Use C_w = 2.0 = (For Foundation Material - Not embankment)



Sec. 11
P. 4.4

No Flow Conditions

$y_2 = S + 0.6F$ where $S = 2.0'$ $F = 12'$

$y_2 = 2.00 + (0.6)(12.00) = 9.20'$

Full Flow Conditions

$y_2 = t + S + 0.6F$ where $t = 9.12'$

$y_2 = 9.20 + 9.12 = 18.32$ ∴ consider backfill saturated to crest.

$C_w H = \frac{\Sigma L_H}{3} + \Sigma L_V$.

$(2.00)(9.20) = 4t + 35.5/3$

$18.4 - 11.8 = 4t$

$t = 1.65$ Use ~~2.00'~~ 3'-0"

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan.	10-1-75	A.C. ✓	3-29-76	2005
SUBJECT				SHEET 10 OF
Emergency Spillway				

Uplift with Flow

Point a = 12.12 x 62.4 = 756.23 lbs/ft²

Point i = 15 x 62.4 = 936.00 lbs/ft²

Weighted Creep Distance = (1 + 32 + 125 + 1.5)/3 + 12 = 23.92

& 180 ÷ 23.92 = 7.53 lbs/ft²

Point	Weighted creep Dist ft.	Increase in Press. between Points psf	Pressure @ point psf	Ave. Press between pts. psf	Base Area between points ft²	Uplift between pts. per ft of width lbs
a			756			
	3.00	22.6				
b			779			
	0.33	2.5		780	1.0	780
c			781			
	3.00	22.6				
d			804			
	10.67	80.3		844	32.0	27,008
e			884			
	3.00	22.6				
f			906			
	0.42	3.2		908	1.25	1,135
g			910			
	3.00	22.6				
h			932			
	0.50	3.8		934	1.5	1,401
i			936			
	23.92	180.2			35.5	30,324

Total uplift per bay = 20 x 30,324 = 606,480 lbs

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-1-75	A.C ✓	3-29-76	2005
SUBJECT				SHEET 11 OF
Emergency Spillway				

Uplift Without Flow

Point a - 0

Point i = 10.2 x 62.4 = 636.5 lbs.

Change in press. per ft. of wtd. creep distance

= 636.5 ÷ 23.92 = 26.6 lbs / ft²

Pt.	Weighted Creep Distance ft.	Increase In Press. between Points psf	Press @ pt. psf	Ave. Press. between Points psf	Base Area between points ft²	Uplift between Points per foot of width lbs.
a			0			
	3.00	79.8				
b			79.8			
	0.33	8.8		84.20	1.0	84
c			88.6			
	3.0	79.8				
d			168.4			
	10.67	283.8		310.3	32.0	9,930
e			452.2			
	3.00	79.8				
f			532.0			
	0.42	11.2		537.6	1.25	672
g			543.2			
	3.00	79.8				
h			623.0			
	0.50	13.3		629.7	1.5	945
i			636.3			
		636.3			35.75	11,631

Total uplift per bay = 11,631 x 20 = 232,620

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P., Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-1-75	AC ✓	3-29-76	2005
SUBJECT				SHEET 12 OF
Emergency Spillway				

Contact Pressure No Backfill (20' Section)

	Wt	Arm	Mom.
Apron = 20 x 35.75 x 1.0 x 150	= 107,250	x 17.88	= 1,917,094
Head Wall = 20 x 14 x 1.25 x 150	= 52,500	x 33.63	= 1,765,575
C.O. Wall = 20 x 3.0 x 1.25 x 150	= 11,250	x 33.63	= 378,338
Toe Wall = 20 x 3.0 x 1.0 x 150	= 9,000	x 0.5	= 4,500
Trans. Sill = 20 x 2 x 1 x 150	= 6,000	x 0.5	= 3,000
Long. Sill = 32 x 1 x 1 x 150	= 4,800	x 16.5	= 79,200
Blocks = 5 x 2 x 2 x 4 x 150	= 12,000	x 8.5	= 102,000
Buttress = 6.5 x 1 x 13 ÷ 2 x 150	= 6,338	x 30.83	195,400
	209,138		4,445,107

$z = 4,445,107 \div 209,138 = 21.25$ ft.

$e = 21.25 - 17.88 = 3.37$

Area of Base = $35.75 \times 20 = 715$ ft²

$P = (V \div A)[1 \pm (6e \div d)] = \left(\frac{209,138}{715}\right)[1 \pm (6 \times 3.37 \div 35.75)]$

$= 292.50 \times [1 \pm 0.566]$

$P_u = (292.50)(1.566) = 458$ lbs/ft²

$P_d = (292.50)(.434) = 127$ lbs/ft²

$\frac{35.5}{2} =$

$L_f = 23.5$
24.5

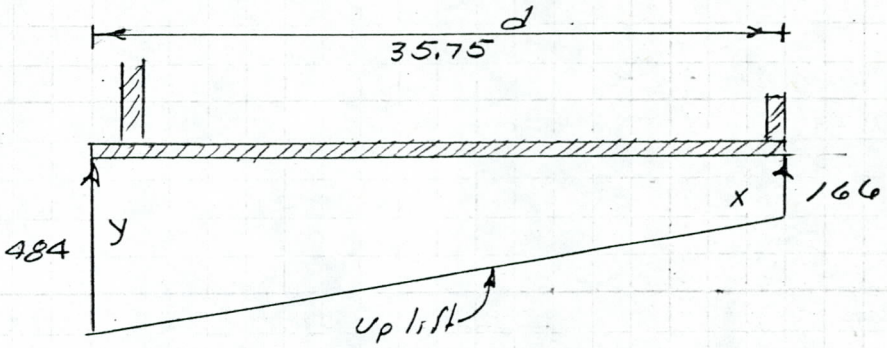
$L_f = 23.5$
$\frac{1.0}{24.5}$

2.17

$\frac{17.75}{2\overline{)35.5}}$
$\frac{2}{15}$
$\frac{14}{15}$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-2-75	D.R. Riddle (AC) 3-29-76	11-4-75	2005
SUBJECT				SHEET 13 OF
Emergency Spillway				

Uplift Without Flow Diagram



Rate of change per ft. of hoiz. contact. = 26.6 ÷ 3

= 8.9

$y = x + (8.9 \times 35.75) = x + 318$

Uplift per ft. of width = 11,631 lbs

$[(x+y) \div 2]\, d = 11,631$

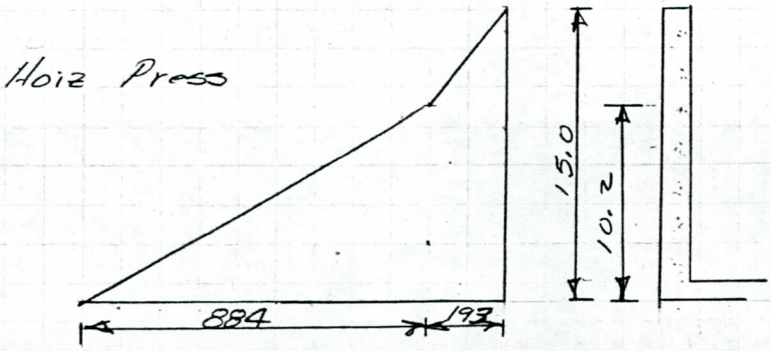
$[(x + x + 318) \div 2]\, 35.75 = 11,631$

$x + 159 = \frac{11,631}{35.75} = 325$

$x = 325 - 159 = 166$ lbs

$y = 166 + 318 = 484$ lbs

Press. After Backfill No Flow



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan		O Riddle (AC 3-29-76)	11-4-75	2005
SUBJECT				SHEET 14 OF
Emergency Spillway				

At 4.80' below crest

Vert. Wt. = 4.80 x 139 = 667 lbs.

Equiv. fluid press. P = 667 x 0.2887 = 193 lbs/ft²

At 15.00' below the crest

Vert. Wt. = 667 + (10.2 x 84) = 667 + 857 = 1524 lbs

Eq fluid press. P = (1524)(0.2887) = 440

Water press. = (10.2)(62.4) = 637

P_{Total} = 1077 lbs / ft²

		Wt.	Arm	Moment
Concrete		209,138	21.25	4,445,107
Moist Earth	20 x 4.8 x 1.5 x 139	20,016	35.00	700,560
146				
Satur. Earth	20 x 9.2 x 1.5 x 146	40,296	35.00	1,410,360
Hor. Press.	20 x 0.5 x 193 x 4.8 = -9,264		11.80	-109,315
Hor. Press.	20 x 193 x 10.2 = -39,372		5.10	-200,797
Hor. Press.	20 x 0.5 x 884 x 10.2 = -90,168		3.40	-306,571
		-138,804	269,450	5,939,344
Up lift ▭	20 x 166 x 35.75	-118,690	17.88	-2,121,584
Up lift ◺	20 x 0.5 x 318 x 35.75	-113,685	23.83	-2,709,114
		-232,375		-4,830,698
		-37,075		-1,108646

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-2-75	D Riddle	11-4-75	2005
SUBJECT				SHEET 15 OF
Emergency Spillway				

35.75 ÷ 2
17.88

22.68

$z = 1,108,646 \div 37,075 = 29.90'$

$e = 29.89 - 17.88 = 12.02$

Contact Press.

$P_u = [37,075 \div 715][1 + (6 \times 12.02 \div 35.75)]$

$P_u = (51.85)(1 + 2.02) = 156$

$P_d = (51.85)(1 - 2.02) = -52.9$. Neg. Press No good

Assume that the caliche is impermeable & there is a positive cutoff resulting in a low water table

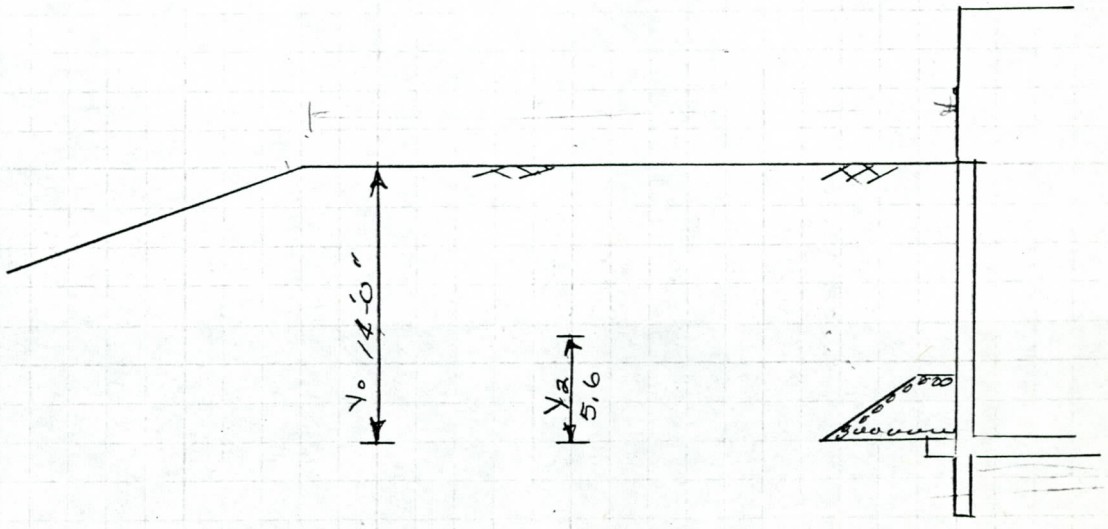
Permeability test run on TH-14 Sta. 280+00

A.C. 3-29-76

(Lab tests by Bu. of Rec. show K = .3 ft/day)

results are at 8.0' which is into the caliche 0.5' using 8.0' of head $K = 9.3$ ft³/ft²/day & test ~~was~~ at 16.0' with 15.0' of Head $K = 3.3$ ft³/ft²/day

1/2



STATE		PROJECT		
Arizona		Buckhorn Mesa W.S.A., Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-3-75	OR	11-4-75	2005
SUBJECT				SHEET 16 OF
Emergency Spillway				

No Flow Conditions

$y_2 = 5 + 0.3F = 2.00 + (0.3)(12)$

$y_2 = 5.6$ ft.

Full Flow Conditions

$y_2 = t + 5 + 0.3F$

$y_2 = 9.12 + 5.6 = 14.72$ ∴ Consider back-fill saturated to the crest.

Uplift Without Flow

Point a = 0

Point i = 6.6 x 62.4 = 412 lbs.

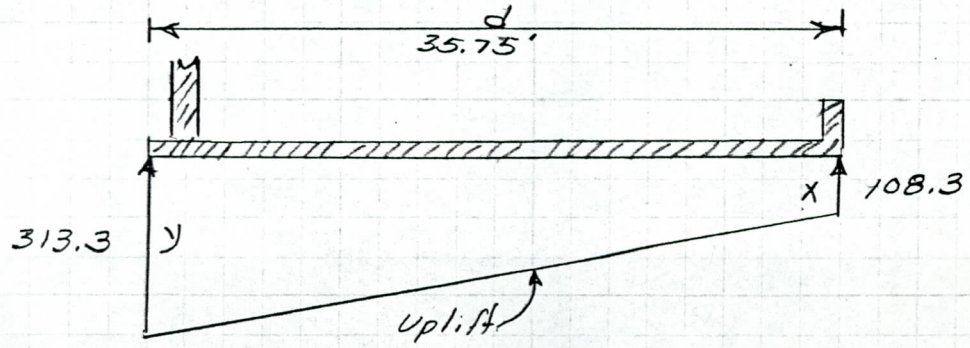
Change in press. per ft. of weighted creep dist.
= 412 ÷ 23.92 = 17.2 lbs/ft^2

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P. Spook Hill FR		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-6-75	DR	11-4-75	2005
SUBJECT				SHEET 12 OF
Emergency Spillway				

Pt.	Weighted Creep dist. feet	Increase In Press. Between Points. psf.	Press. @ Pt. psf	Ave. Press. Between Points psf	Base Area Between Points ft²	Uplift Between Points foot of W lbs.
a			0.0			
	3.00	51.7				
b			51.7			
	0.33	5.7		54.6	1.0	55.
c			57.4			
	3.00	51.7				
d			109.1			
	10.67	183.8		201.0	32.0	6,432
e			292.9			
	3.00	51.7				
f			344.6			
	0.42	7.2		348.2	1.25	435
g			351.8			
	3.00	51.7				
h			403.5			
	0.50	8.6		407.8	1.50	612
i			412.1			
-						7,534

Total uplift per bay = 7,534 x 20 = 150,680

Uplift Without Flow Diagram



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-6-75	11-4-75	[illegible]	2005
SUBJECT				SHEET 18 OF
Emergency Spillway				

Rate of change in the uplift per foot of horiz. contact = 17.2 lbs ÷ 3 = 5.73

$y = x + (5.73 \times 35.75) = x + 205$

Uplift per ft. of width = 7,536 lbs.

$[(x+y) \div 2]\, d = 7{,}536$

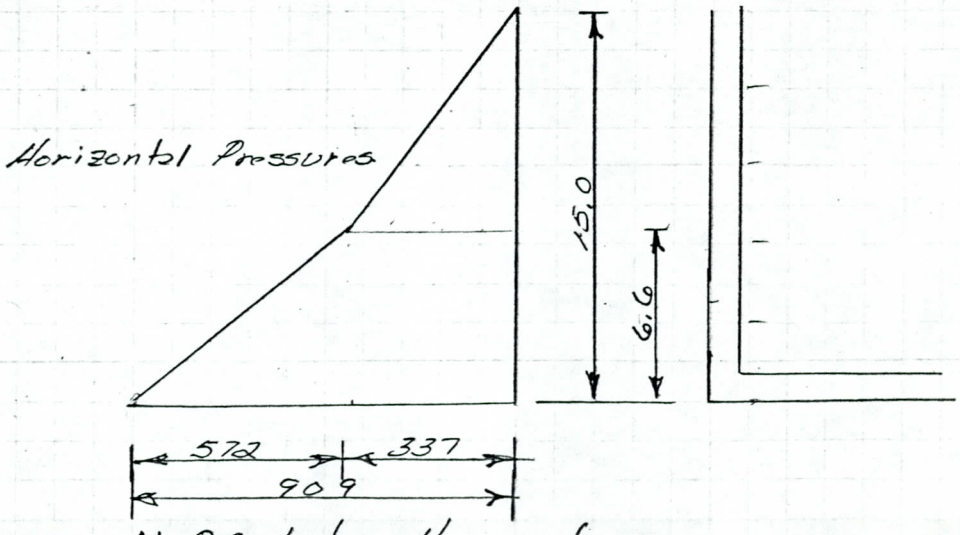
$[(x+y) \div 2] = \frac{7{,}536}{35.75} = 210.8$

$[(x + x + 205) \div 2] = 210.8$

$x = 210.8 - 102.5 = 108.3$ lbs.

$y = 108.3 + 205 = 313.3$ lbs.

Press. After Backfill No Flow



At 8.4 below the crest

Vert. Wt. = (8.4)(139) = 1167.6

Equiv. fluid Press. P = (1167.6)(0.2887) = 337

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P., Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-6-75	D Riddle	11-5-75	2005

SUBJECT: Emergency Spillway — SHEET 19 OF

At. 15.0 A below the crest

Vert Ht. = 1167.6 + (6.6 x 84) = 1167.6 + 554.4 = 1722

Eq. fluid press. P = (1722)(0.2887) = 497 lbs / ft²

Water Press. = (6.6)(62.4) = 412

P_{Total} = 909 lbs / ft.²

Item		Weight	Arm	Moment
Concrete		209,138	21.25	4,445,107
Moist Earth	20 x 8.4 x 1.5 x 139	35,028	35.00	1,225,980
Sat. Earth.	20 x 5.6 x 1.5 x 146	24,528	35.00	858,480
Horiz Press	20 x 0.5 x 337 x 8.4 = -28,308		9.4	-266,095
Horiz. Press	20 x 337 x 6.6 = -44,484		3.3	-146,797
Horiz. Press	20 x 0.5 x 572 x 6.6 = -37,752		2.2	-83,054
		-110,544	268,694	6,033,621
Uplift. ▭	20 x 108.3 x 35.75	-77,434	17.88	-1,384,529
Uplift. △	20 x 0.5 x 205 x 35.75	-73,288	23.83	-1,746,441
			117,972	2,902,651

$\bar{x}$ = 2,902,651 ÷ 117,972 = 24.60

e = 24.60 - 17.88 = 6.72

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-6-75	[illegible]	11-5-75	2005
SUBJECT				SHEET 20 OF
Emergency Spillway				

Contact Pressure

$$P = [117,972 \div 715]\,[1 \pm (6 \times 6.72 \div 35.75)]$$

$$P_u = (165)(1 + 1.13) = 351$$

$$P_d = (165)(1 - 1.13) = -21.09 \text{ ~~-21.45~~}$$

Use Type 6 Drain with a positive Cut off

From Far West States Table 9.1 & SM-10

For drain use

Saturated Wt. = 138 pcf

Dry Weight = 120 pcf

Moist Weight = 134 pcf

Submerged Weight = 75 pcf

$\phi = 36°$ ~~$\frac{(1 - \sin\phi)}{(1 + \sin\phi)} = \frac{0.4122}{1.5818} = 0.2596$~~

$$K = \frac{\sigma h}{\sigma v} = 1 - \sin\phi = 0.4122$$

Draft Supplement to P2.2 FMS - EDS

No Flow Conditions

$y_2 = 5 + 0.1F$

$y_2 = 3.2$ ft.

Full Flow Conditions

$y_2 = t + 5 + 0.1F$

$y_2 = 9.12 + 3.20 = 12.30$ Consider backfill saturated to crest

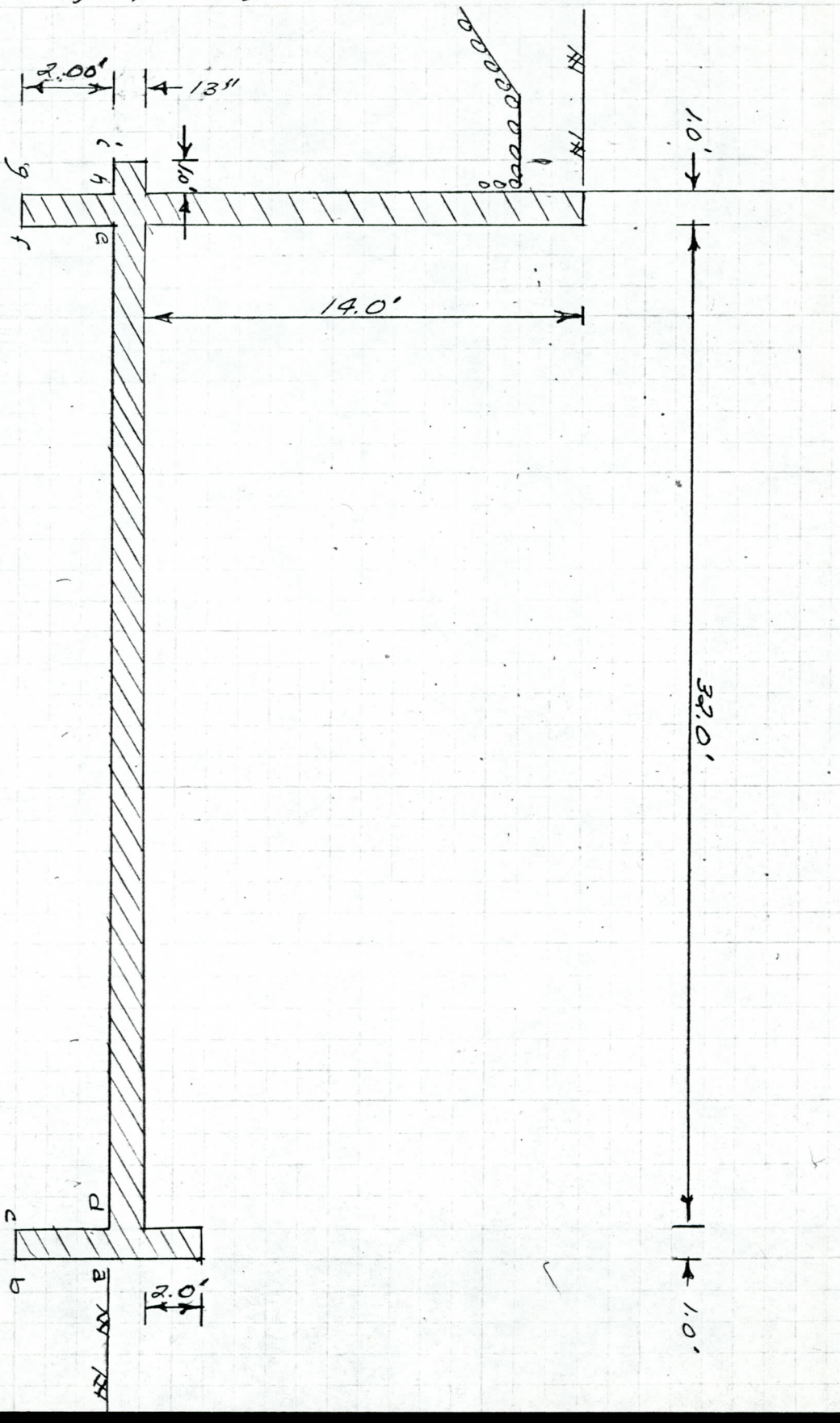
COMPUTATION SHEET

SCS–ENG–523 Rev. 8–69

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-7-75	[illegible]	11-5-75	2005
SUBJECT				SHEET 21 OF
Emergency Spillway				



STATE Arizona | PROJECT Buckhorn Mesa WPP, Spook Hill FRS

BY J.L. Sullivan | DATE 10-6-75 | CHECKED BY (2) | DATE 11-5-75 | JOB NO.

SUBJECT Emergency Spillway | SHEET 22 OF

Uplift Without Flow

Point a = 0

Point i = 4.28 x 62.4 = 267 lbs

Change in pressure per ft. of weighted creep distance = 267 ÷ 19.67 = 13.58 psf

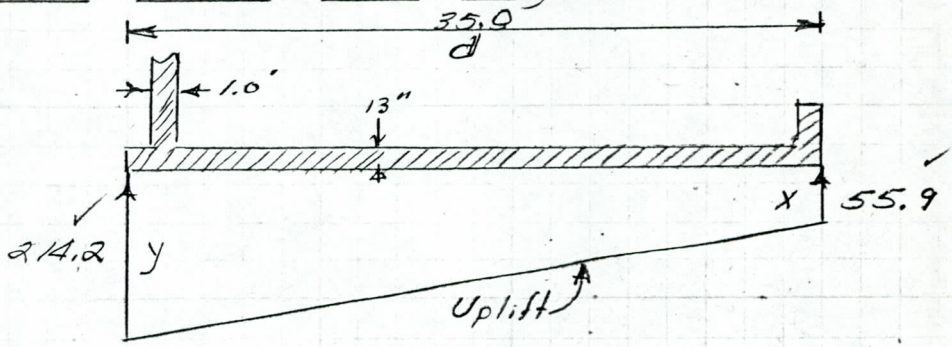
Point	Weighted Creep Dist. feet	Increase In Press. Betwn Points psf	Pressure at Point psf	Ave. Press. Between Points psf	Base Area Between Points ft²	Uplift Between Points per Foot of Width lbs
a			0.0			
	2.00	27.2				
b			27.2			
	0.33	4.5		29.5	1.0	30
c			31.7			
	2.00	27.2				
d			58.9			
	10.67	144.8		131.3	32.0	4202
e			203.7			
	2.00	27.2				
f			230.9			
	0.33	4.5		233.2	1.0	233
g			235.4			
	2.00	27.2				
h			262.6			
	0.33	4.5		264.9	1.0	265
i			267.1			
Total	19.66	237.1			35.0	4730

Total uplift per bay = 4730 x 20 = 94,600

Ratio of Weight to uplift = $\frac{197287}{94,600}$ = 2.09

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-7-75	(2) [illegible]	11-5-75	2005
SUBJECT				SHEET 23 OF
Emergency Spillway				

Uplift Without Flow Diagram



Rate of change in the uplift per foot of horiz. Contact = 13.57 ÷ 3 = 4.52 ✓

$y = x + (4.52 \times 35.0) = x + 158.3$ ✓

See Sht. 22 Uplift per ft. of width = 4730 ✓

(79.2)

$[(x+y) \div 2]\, d = 4730$

$\frac{x+y}{2} = \frac{4730}{35.0} = 135.1$ ✓

$x + 79.2 = 135.1$

$x = 55.9$ lbs ✓

$y = 55.9 + 158.3 = 214.2$ ✓ lbs.

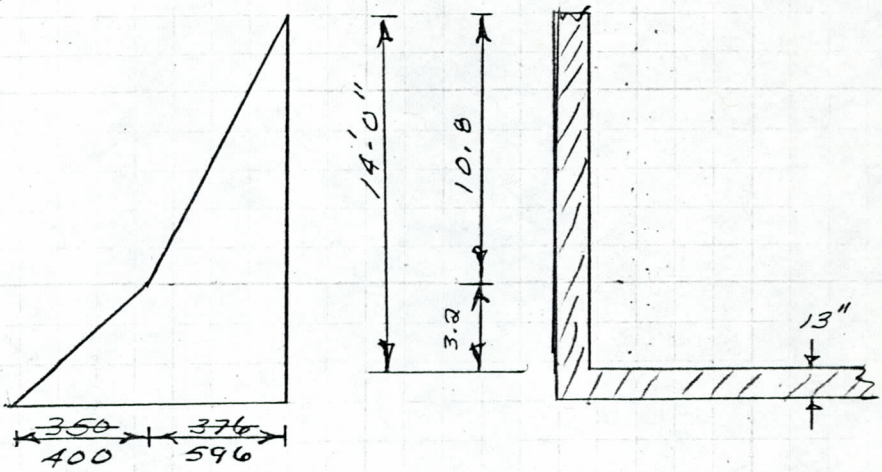
Pressure After Backfill No Flow

Horizontal Pressures

5 ft 11 4.12

Assume that the backfill is Drainage material for the entire height of the sidewall

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-7-75	[illegible]	11-5-75	2005
SUBJECT				SHEET 24 OF
Emergency Spillway				



3.2

At 10.8 ft. below the Crest

Vert Weight = (10.8)(134) = 1447 ✓

$P = (1447)(0.2596) = 376$ lbs/ft² → $P = (1447)(0.4122) = 596.5$ ✓

At 15.08 ft. Below The Crest

Vert Weight = 1447 + (4.28)(75) = 1768 lbs ✓

$P = (1768)(0.2596) = 459$ psf → $P = (1768)(0.4122) = 729$ ✓ psf

$P_{water} = (4.28)(62.4) = 267$ ✓ psf

$P_{Total} = 726$ psf → 996 ✓ psf

Contact Pressure No Backfill

Item	Weight	Arm	Moment
Apron 20x35 x1.08x150	113,400 ✓	17.50 ✓	1,984,500 ✓
Headwall 20x14x1.0x150	42,000 ✓	33.50	1,407,000 ✓
C.O. Wall 20x2.0x1.0x150	6000 +3 ✓	33.50	201[illegible]

STATE	PROJECT			
Arizona	Buckhorn Mesa WPP, Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-7-75	[illegible]	11-5-75	2005
SUBJECT				SHEET 25 OF
Emergency Spillway				

Item	Weight	Arm	Moment
T. Wall 20x2.0x1.0 x 150	16,000	0.50	3,000
T. Sill 20x2.0x1.0 x 150	6,000	0.50	3,000
L. Sill 32x1.5x1.0x150	7,200	17.00	122,400
Blocks 5x2x2x4x150	12,000	8.5	102,000
Buttress 5.0' x 12.5x1.0x.5x150	4,687.5	31.33	~~59~~ 146,844
	197,287 ✓		3,969,744 ✓

14.00 / 1.50 / 12.50 ≈

12.5 / 5.0

33.00 / 7.25 / 25.75

OK

3.5/2 = 17.5

$$z = \frac{3,969,744}{197,287} = 20.12 \checkmark$$

$$e = 20.12 - 17.50 = 2.63 \checkmark \quad \text{(eccentricity)}$$

Contact Pressure After Backfill No. Flow

Item	Weight	Arm	Moment
Concrete	197,287 ✓	20.12	3,969,744 ✓
Moist Earth 20x10.8x1.0x134	28,944 ✓	34.50	998,568 ✓
Saturated Earth 20x4.28x1.0x138	11,813 ✓	34.50	407,542 ✓
Horizontal Press. 20x0.5x ~~376~~ 596 x 10.8 = ~~-40,608~~ -64,368 ✓		7.88	507,220 ✓ - ~~319,991~~
Horizontal Pressure 20x ~~376~~ 596 x4.28 = ~~-32,186~~ 51,018 ✓		2.14	109,178 ✓ - ~~68,877~~
Horizontal Pressure 20x ~~350~~ 400 x.5 x 4.28 = ~~-14,980~~ 17,120 ✓		1.43	24,482 ✓ - ~~21,421~~
~~132,506~~ 87,774 ✓	238,044 ✓		4,734,974 ✓ ~~5,230,573~~

STATE	PROJECT			
Arizona	Buckhorn Mesa WPP. Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-7-75	[illegible]	11-5-75	2005
SUBJECT				SHEET 26 OF
Emergency Spillway				

Talked with Don Clarke, Geologist Planning Party, he estimated that the uplift could be decreased 30% because of the Caliche.
∴ The uplift will be decreased 20% to be on the safe side

		238,044 ✓		4,734,974 ✓
Uplift ▭	20 x 35 x 55.9 x 0.8	-31,304 ✓	17.5	-547,820 ✓
Uplift ◺	20 x 35 x 0.5 x 158.3 x 0.8	-44,324 ✓	23.33	-1,034,079 ✓
		162,416 ✓		3,153,075 ✓

17.5

$$z = \frac{3,153,075}{162,416} = 19.41 \checkmark > 17.5$$

$$e = 19.41 - 17.50 = 1.91 \checkmark$$

.328

$$P_u = \left(\frac{162,416}{700}\right)\left(1 + \frac{6 \times 1.91}{35}\right) = 308 \text{ psf} \checkmark$$

$$P_d = \left(\frac{162,416}{700}\right)\left(1 - \frac{6 \times 1.91}{35}\right) = 156 \text{ psf} \checkmark$$

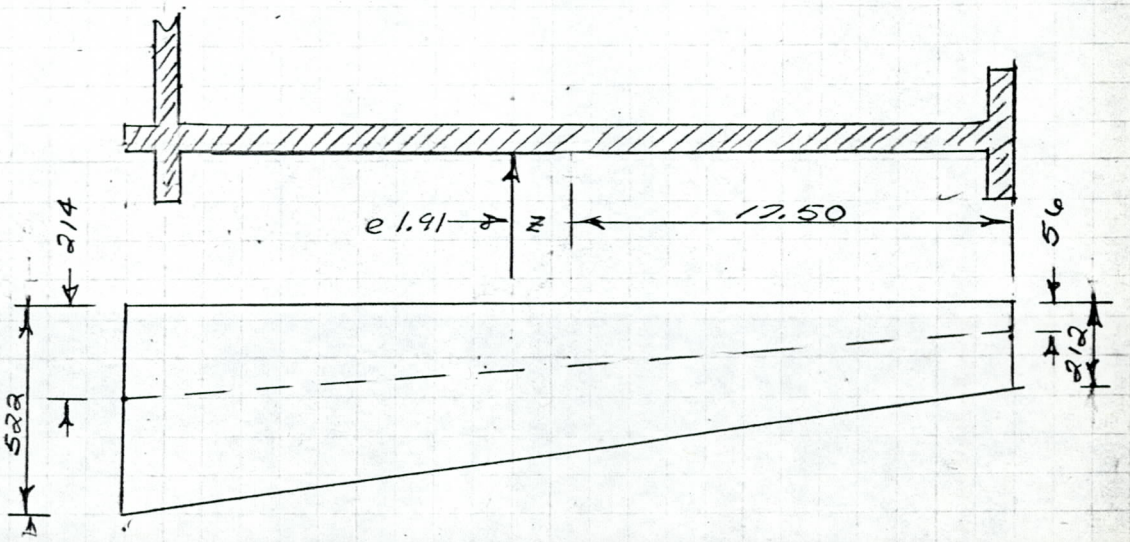
Total Press. After Backfill - No Flow

$$P_{TU} = 214 + 308 = 522 \text{ psf} \checkmark$$

$$P_{Td} = 56 + 156 = 212 \text{ psf} \checkmark$$

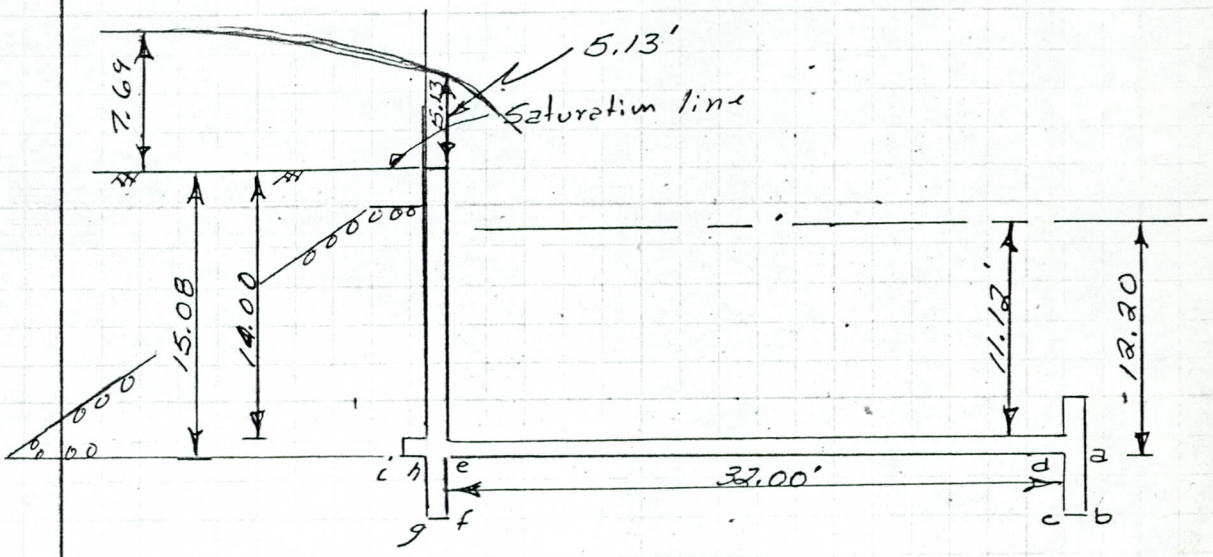
(7.5)

4.67



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-7-75	[illegible]	11-5-75	2005
SUBJECT				SHEET 27 OF
Emergency Spillway				

After Backfill Full Flow



Pressure at Point a = 12.20 x 62.5 = 763 lbs ✓

Pressure at point i = 15.08 x 62.5 = 943 lbs ✓

Weighted Creep dist. = $\frac{1+32+1+1}{3} + 4 \times 2$ ✓

$= \frac{35}{3} + 8 = 19.67'$

Change in press. /ft. of Wtd. Creep dist. = $\frac{943-763}{19.67} = 9.15$ ✓

Rate of change in the uplift per ft. of horiz. contact = 9.15 ÷ 3 = 3.05 ✓

$y = x + (3.05 \times 35) = x + 106.8$ ✓

$\frac{x+y}{2} = \frac{29,889}{35}$

$x + 53.4 = 854$ ✓

$x = 800.6$

$y = 800.6 + 106.8 = 907.4$ ✓

STATE	PROJECT			
Arizona	Buckhorn Mesa WPP, Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-8-75	[illegible]	11-5-75	2005
SUBJECT				SHEET 28 OF
Emergency Spillway				

Point	Weighted Creep dist. Between Points Ft.	Increase In Pressure Between Points psf	Pressure @ Point psf	Average Pressure Between Points psf	Base Area Between Points per Foot of Width Ft²	Uplift Between points lbs.
a			763			
	2.00	18.3				
b			781.3			
	0.33	3.0		782.8	1.0	783
c			784.3			
	2.00	18.3				
d			802.6			
	10.67	97.6		851.4	32.0	27,245
e			900.2			
	2.00	18.3				
f			918.5			
	0.33	3.0		920.0	1.0	920
g			921.5			
	2.00	18.3				
h			939.8			
	0.33	3.0		941.3	1.0	941
i			942.8			
						29,889

see 11 p 4.11

Total uplift per bay = 29,889 x 20 = 597,780

Horizontal Pressures

At The Crest

Vertical Weight = 7.69 x 62.5 = 480.6 lbs

$P = 480.6 \times \frac{0.4122}{0.2596} = \frac{198}{125}$ psf

At 15.08 Depth

Vertical Weight = 480 + (15.08 x 75) = 1611 lbs.

P = 1611 x 0.2596 = 418 psf

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-8-75	(2)	11-5-75	2005
SUBJECT				SHEET 29 OF
Emergency Spillway				

15.08
2.88
12.20

At 2.88' Down From Crest

Vertical Weight = 481 + (2.88 x 75) = 697

Water Press. = 2.88 x 62.5 = 180

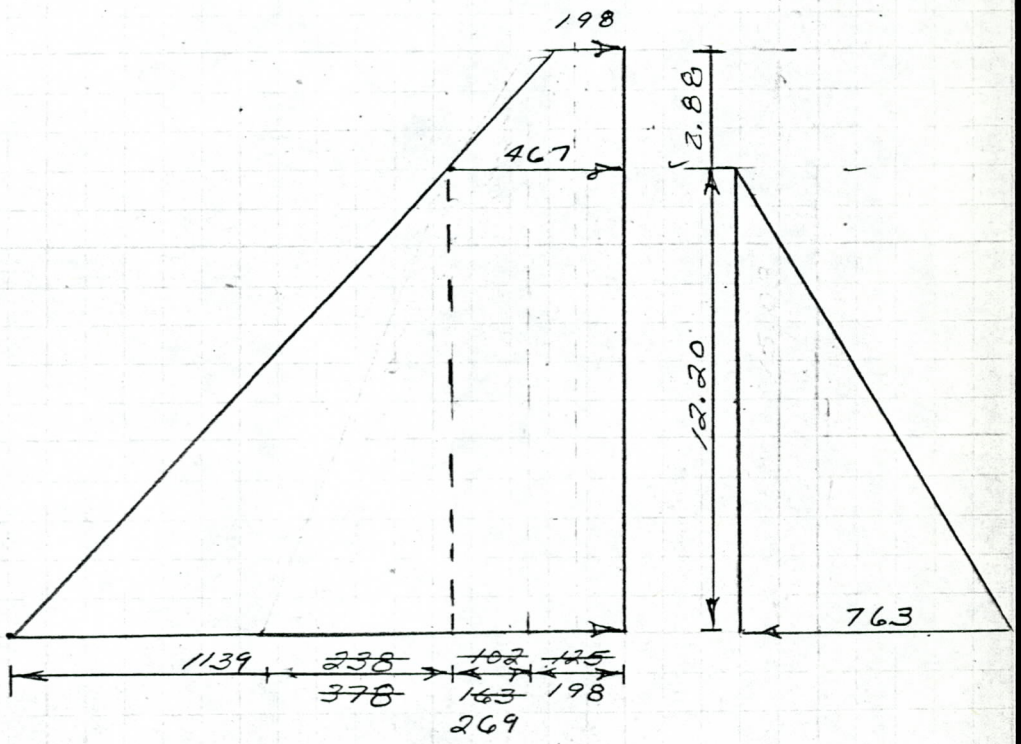
$P = 180 + [697\ (0.4122)] = 467$ psf.

At 15.08' Down From Crest

Vertical Weight = 697 + (12.2 x 75) = 1612 lbs.

Water Press. = 15.08 x 62.5 = 942

$P = 1612 \times 0.4122 = 739 + 942 = 1606$ psf.



Tailwater Press. = 12.20 x 62.5 = 763 psf

STATE Arizona | PROJECT Buckhorn Mesa WPP, Spook Hill FRS

BY J.L. Sullivan | DATE 10-8-75 | CHECKED BY [illegible] | DATE 11-5-75 | JOB NO. 2005

SUBJECT Emergency Spillway | SHEET 30 OF

Item		Weight	Arm	Moment
Concrete		197,287 ✓	20.12	3,969,744 ✓
Sgt, Drain Material	20 x 1.5 x 1.0 x 138	41,400 ✓	34.50	1,428,300 ✓
H_2O on Footing	20 x 7.69 x 1.0 x 62.5	9,613 ✓	34.50	331,648 ✓
H_2O on Apron	19 x 11.12 x 32 x 62.5	422,560 ✓	17.00	7,183,520 ✓
H_2O on L.Sill	20 x 9.12 x 1.0 x 62.5	11,400 ✓	0.50	5,700 ✓
H_2O on Buttress	3.85 x 9.62 x 1.0 x 0.5 x 62.5	1,157 ✓	29.28	33,877 ✓
H_2O on L.Sill	27 x 1.0 x 9.62 x 62.5	16,234 ✓	14.50	235,393 ✓
Horiz press.	20 x 198 x 15.08 = -59,717 ✓		7.54	-450,265 ✓
Horiz Press.	20 x 1408 x 0.5 x 15.08 = -212,326 ✓		5.03	-1,068,002 ✓
Horiz T.W	20 x 763 x 0.5 x 12.2 = 93,086 ✓		4.07	378,860 ~~550~~
			[illegible]	[illegible] 775
		699,651 ✓		12,048,465 ~~12,245,838~~
Note: Uplift Decrease by 20%				
Uplift ▭	20 x 35 x 800.6 x 0.80	-448,336 ✓	17.50	-7,845,880 ✓
Uplift ◺	20 x 35 x 0.5 x 106.8 x 0.80	-29,904 ✓	23.33	-697,660 ✓ 235
		221,411 ✓		3,504,925 ~~3,702,298~~

$12.5/5 = 9.62/x$; $x = 3.85$

$$z = \frac{15.83}{\cancel{16.72}} \checkmark$$

$$e = \frac{15.83}{\cancel{16.72}} - 17.50 = \frac{-1.67}{\cancel{-0.78}} \checkmark$$

0.714
0.867

$$P_u = \left(\frac{221,411}{700}\right)\left(1 + \frac{6 \times \overset{-1.67}{(-0.78)}}{35}\right) = \frac{226}{\cancel{274}} \text{ psf.} \checkmark$$

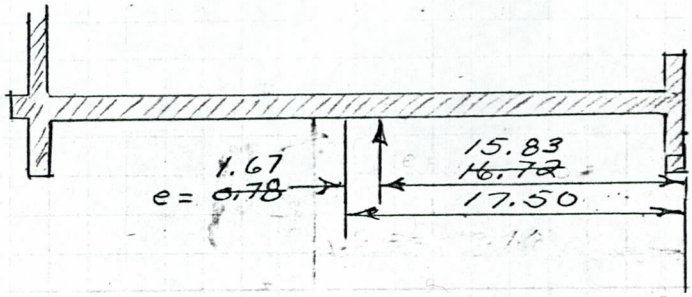
1.134

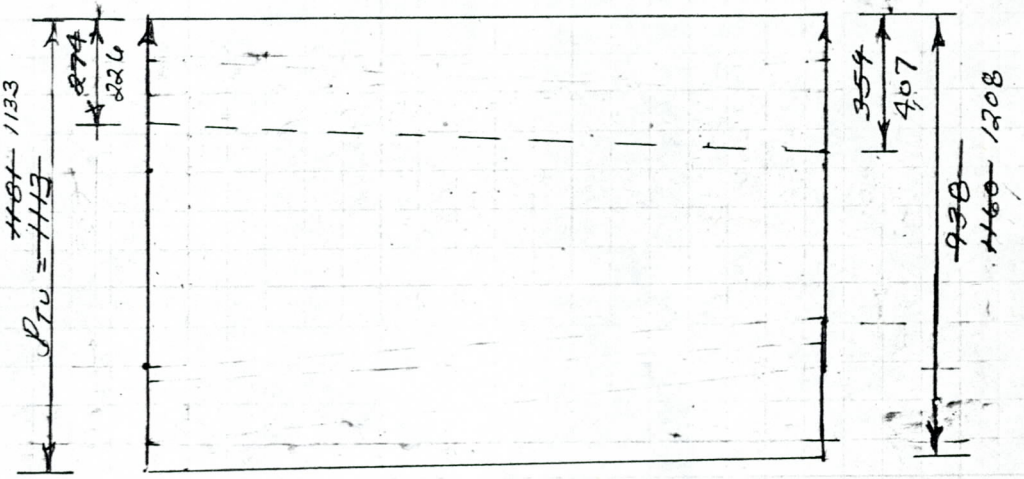
$$P_d = \left(\frac{221,411}{700}\right)\left(1 - \frac{6 \times \overset{-1.67}{(-0.78)}}{35}\right) = \frac{407}{\cancel{359}} \text{ psf.} \checkmark$$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-8-75	[illegible]	11-6-75	2005
SUBJECT				SHEET 31 OF
Emergency Spillway				

$$P_{TU} = \frac{226}{\cancel{274}} + \frac{\cancel{222}}{407} + 907 = \frac{1133}{\cancel{1181}} \text{ psf}$$

$$P_{TD} = \frac{\cancel{359}}{\cancel{323}} + 801 = \frac{1208}{\cancel{1160}} \text{ psf}$$





STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-8-75	[illegible]	11-6-75	2005
SUBJECT				SHEET 32 OF
Emergency Spillway				

Sliding

See Geology Report

Sample No. 2112.1
Depth 1.0' to 3.0' at Sta. 187+00

γ_d = 128.5 ✓
Opt. Moisture 9.2% ✓
G_s = 2.67 ✓
Void Ratio = 0.37 ✓
ϕ = 33°30' ✓

Classification - SM-1
LL. = N.P. PI = N.P.

Sample No. 2116.1 - Depth 1.0-3.0 ft. - Sta. 228+00

γ_d = 122.1 ✓
Opt. moisture = 10.9% ✓
G_s = 2.75 ✓
Void Ratio 0.479 ✓
ϕ = 32°00' ✓

Classification - SC
LL = 36 PI = 16

Sample No. 2108 - Depth 1.0 to 2.0 ft. - Sta. 146+00

γ_d = 127.7 ✓
Opt. moisture = 8.5% ✓
G_s = 2.74 ✓
Void ratio = 0.412 ✓
ϕ = 35°00' ✓

Classification. SM-1
LL = N.P. PI = N.P.

Use → Is Caliche & Close to the New location of Spillway

Sample No. 221.1 - Depth 3.5 to 25.0 ft. - Em Sp. Sta. 18+00

γ_d = 126.8 ✓
Opt. moisture = 10.7 ✓
G_s = 2.70 ✓
Void ratio = 0.399 ✓
ϕ = 33°00' ✓

Classification - SP-SM
LL = N.P. PI = NP

Sample No. 2107.1 - 1.5' to 5.0' - Borrow Sta. 298+70 C.A.P.
γ_d = 130.6 ✓
Opt. moist. 8.9 ✓
G_s = 2.71 ✓
Void ratio = 0.362 ✓
ϕ = 32°25' ✓

Classification - SC-SM
LL = 23 PI = 7

STATE Arizona | PROJECT Buckhorn Mesa W.P.P., Spook Hill FRS

BY J.L. Sullivan | DATE 10-28-75 | CHECKED BY [illegible] | DATE 11-6-75 | JOB NO. 2005

SUBJECT Emergency Spillway | SHEET 33 OF

$\phi = 38°$ ✓ $\quad 1 - \sin\phi = 0.4554$ ✓

$f = \tan\phi = 0.6494$ ✓

Void Ratio $= 0.399$ ✓

Effective Submerged Wt. $= [126.8 - (1.0 - 0.285)(62.5)]$
$= 82.1$ ✓

e/1+e

$\%$ Voids $= 28.5$ ✓

Moist Wt. = 140.4

Cohesion ? ✓ - Cementation will be a factor, the following values were obtained from Don Clarke, Geologist.

Caliche

	Estimated Compressive Strength (Air dry)
Logged V/po. indurated	< 150 psi
Logged po. indurated	150 - 750 psi
Logged mod. indurated, hd. 1	750 - 3000 psi

Use → See Geology Report
T.H. 301
T.H 302
T.H 201
T.H 202
These T.H.'s are all in this area & are Mod. indurated hd. 1

Shear values will be similar to Concrete

$\therefore V = \sqrt{750} = 27.4$ ✓ psi use 25

then $25 \times 144 \times 700 = 2,520,000$ ✓ lbs.

No Flow Conditions

Effective Wt. of Soil $20 \times 35 \times 2.0 \times 82.1 = 114,940$ ✓

Weight of Bay minus uplift $\quad 221,411$ ✓

$\Sigma W \quad 336,351$

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P., Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-28-75	[illegible]	11-6-75	2005
SUBJECT				SHEET 34 OF
Emergency Spillway				

At 15.08 feet

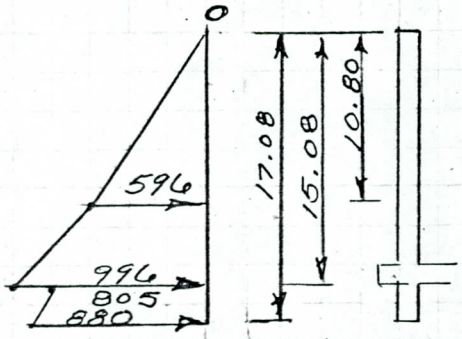
Vert. Weight = 1768 lbs.

$P = 1768 \times 0.4554 = 805$

At 17.08 feet,

Vert Wt. = $1768 + (2.0 \times 82.1) = 1932$ ✓

$P = 1932 \times 0.4554 = 880$ ✓



$F = 20[(596 \times 0.5 \times 10.8) + (1592 \times 0.5 \times 4.28) + (1685 \times 0.5 \times 2.0)]$

$= 20[3218 + 3407 + 1685] = (20)(8310) = 166,200$ ✓

For a Saftey Factor of 1.5 use

$1.5 \times 166,200 = 249,300$ ✓

Sliding Resistance

$f \Sigma N$ + cementation effect

$(0.6494)(336,351) + 2,520,000 = 2,738,426$ lbs ✓ ok

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P.P., Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-29-75	CJ Rudd	11-6-75	2005
SUBJECT				SHEET 35 OF
Emergency Spillway				

Effective Wt. of Soil = 114,940

Wt. of Bay minus Uplift 221,411

$\Sigma M = 336,351$ ✓

Horz. Pressures

At 15.08 feet

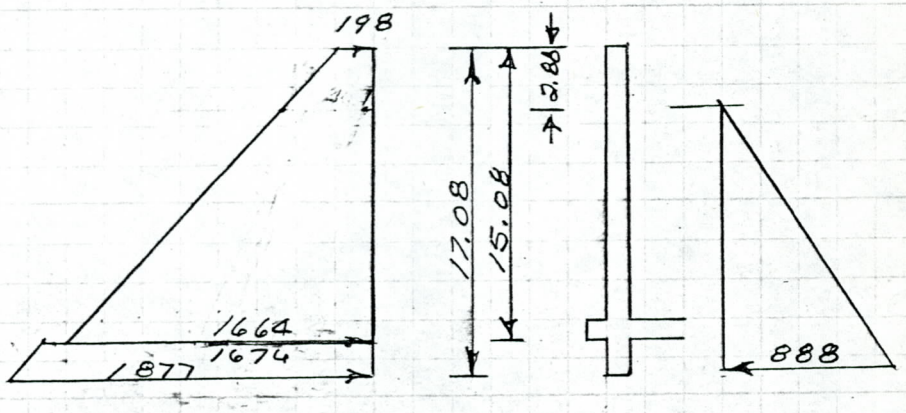
Vert. Wt. = ~~1792~~ 1612 lbs

$P = \frac{1612}{\cancel{1792}} \times 0.4554 = \frac{734}{\cancel{816}}$ lbs + 942 = 1675 ✓

At 17.08 feet

Vert. Wt. = $\frac{1612}{\cancel{1792}}$ + (2.0 x 82.1) = $\frac{1776}{\cancel{1956}}$ lbs. ✓

B09 $P = \frac{1776}{\cancel{1956}} \times 0.4554 + (17.08 \times 62.5) = 1877$ ✓



805 6710 Tail water Press = 14.2 x 62.5 = 888 ✓

$F = 20[(862 \times 0.5 \times 15.08) + (3553 \times 0.5 \times 2.0) - (888 \times 0.5 \times 14.20)]$

$= 20[14,090 + 3553 - 6,305] = 225,760$ ✓

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-29-75	[illegible]	11-6-75	2005
SUBJECT				SHEET 36 OF
Emergency Spillway				

Sliding Resistance

$f \Sigma hl$ + Cementation effect. ✓ ok

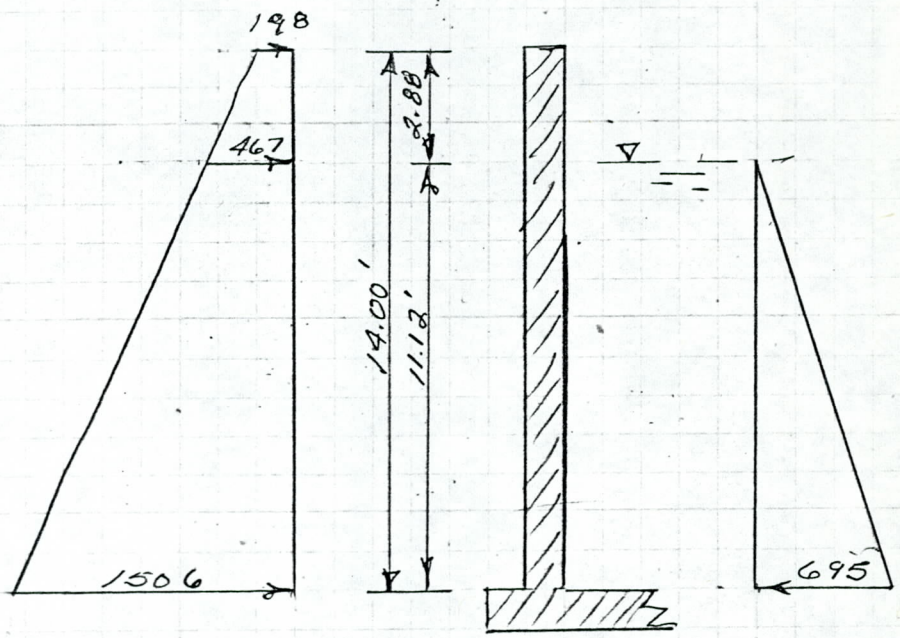
$(0.6494)(336,351) + 2,520,000 = 2,738,426$ lbs

$S.F = \frac{2,738,426}{225,760} = 12.13$ ✓

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	11-3-75	[illegible]	11-6-75	2005
SUBJECT				SHEET 37 OF
Emergency Spillway (Headwall				

Headwall Analysis

Loading With Flow



See Sht. 29

At the crest = 198 At 2.88' = 467

$\frac{269}{2.88} = 93.4$

4

$\frac{1308}{14} = 93.43$

At 14.00'

Vert weight = 697 + (11.12 x 75) = 1531 ✓ (834)

Water Press. = 14.0 x 62.5 = 875 ✓

P = 875 + (0.4122 x 1531) = 1506 ✓ (631)

Tailwater Press = 11.12 x 62.5 = 695 ✓

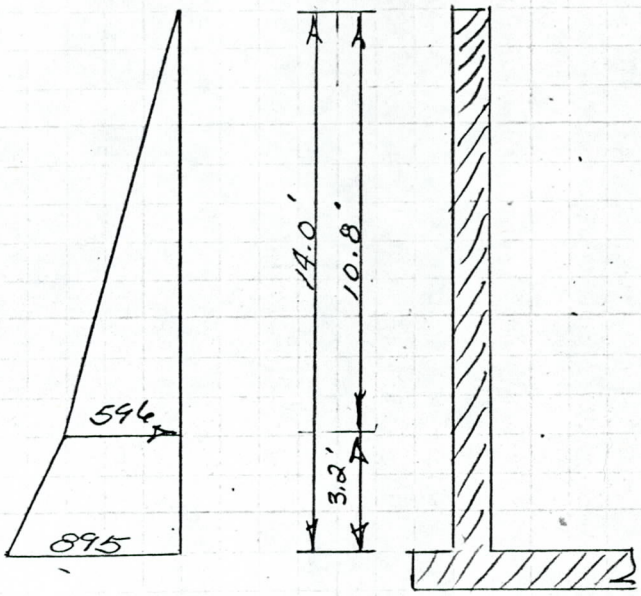
Eq. Fluid Press w = 104.6 lbs/ft³

Loading Without Flow

STATE		PROJECT		
Arizona		Buckhorn Mesa W.P., Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	11-3-75	[illegible]	11-6-75	2005

SUBJECT: Emergency Spillway (Headwall)

SHEET 38 OF



At. 10.8 feet

See sht 24

Vert Weight = 1447

P = 596

At. 14.0'

Vert Weight = 1447 + (3.2 x 75) = 1687 ✓

Water Press. = 3.2 x 62.5 = 200 ✓

P = 200 + (1687 x 0.4122) = 895 ✓ (645)

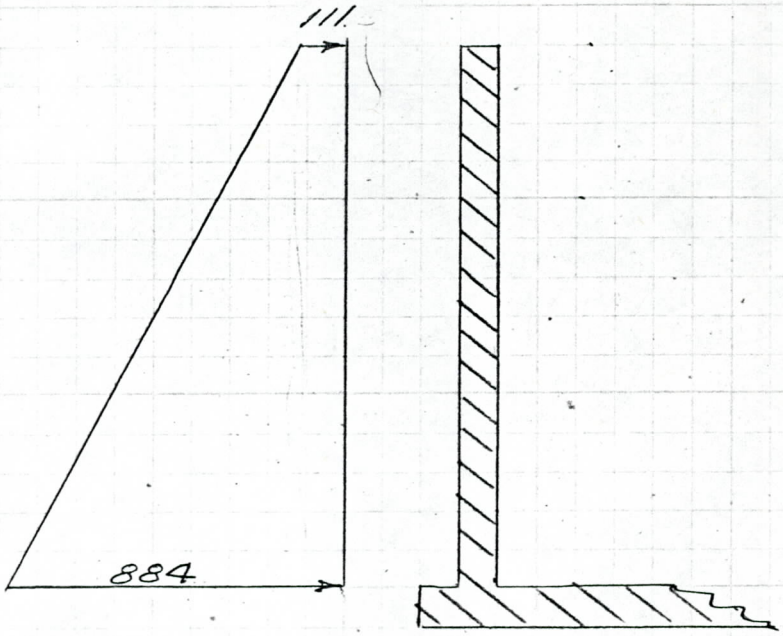
$$W = \frac{6}{2744}[(596 \times 0.5 \times 10.8 \times 6.80) + (596 \times 3.2 \times 1.6) + (244 \times 0.5 \times 3.2 \times 1.6$$

$$= \frac{6}{2744}[21,885 + 3051 + 512] = 53.65 \text{ lbs / ft}^3. \checkmark$$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	11-10-75	A.C.	3-29-76	2005
SUBJECT				SHEET 39 OF
Emergency Spillway Headwall				

Loading During Construction

Use 2.0' of surcharge



At the crest.

Vert Weight = 2 x 134 = 268

$P = 268 \times 0.4122 = 110.5$ lbs / ft^2

At 14.0 ft.

Vert. Weight = 268 + (14)(134) = 2144 lbs/ft^2

$P = (2144)(0.4122) = 883.8$

Eq. Fluid Press.

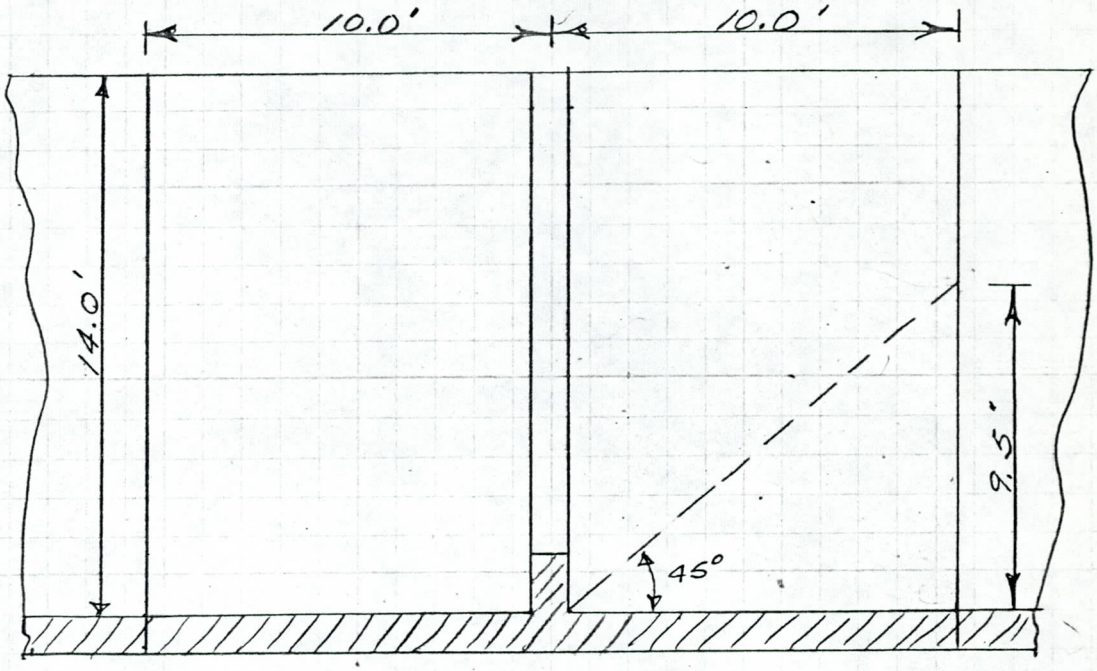
$$w = \frac{6}{2744}\left[(111 \times 14 \times 7) + (773 \times 7 \times 4.67)\right]$$

$w = 79$ lbs / ft^3

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	11-3-75	[illegible]	11-6-75	2005

SUBJECT
Emergency Spillway Headwall

SHEET 40 OF



STATE		PROJECT			
Arizona		Buckhorn Mesa WPP, Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.	
J.L. Sullivan	11-10-75	AJ	11-26-75	2005	
SUBJECT				SHEET 41 OF	
Emergency Spillway (Headwall)					

Vertical Steel (Unexposed Face)

ES-4
Section 6

Spillway Flowing

(Figure p43)

$M_1 = 198 \times 14 \times 7 = +19,404$ ✓

$M_2 = 1308 \times 7.0 \times 4.67 = +42,758$ ✓

$M_3 = 695 \times 5.56 \times 3.7^{*} = -14,323$ ✓

*Note: Rounded off from 3.7066

$+47,839$ ✓

$W L^3$

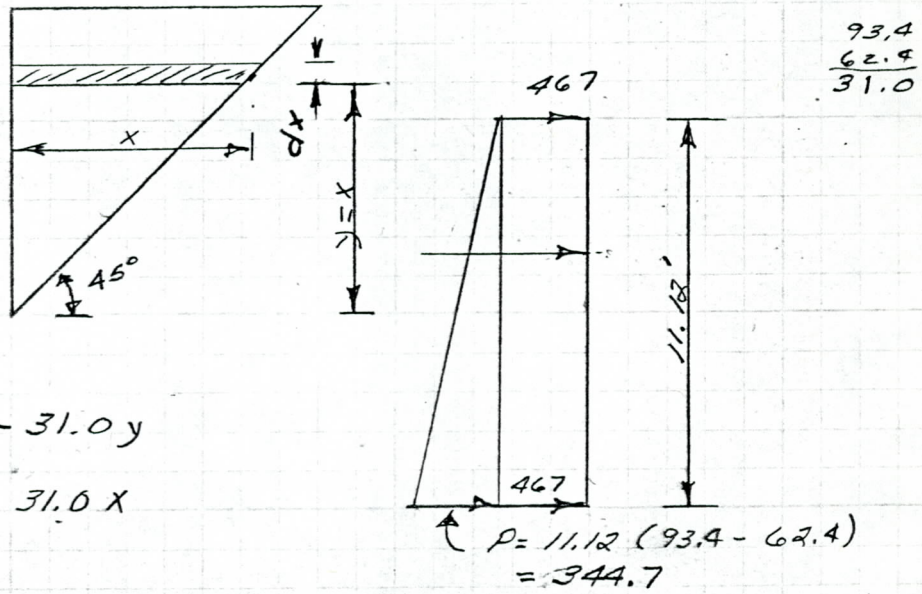
1308

ES-164
$f'_c = 4000$ psi

Min $d = 13.5''$ $A_s = 2.50$

(NEH11, 6.20)

Horizontal Steel



$w_y = P - 31.0\,y$

$w_x = P - 31.0\,x$

$P = 11.12\,(93.4 - 62.4)$
$= 344.7$

$dM = w x^2 dx \div 2$

$\frac{dM}{dx} = w x^2/2 = 0$ ✓

$(344.7 - 31.0x)\,x^2/2 = 0$

STATE		PROJECT			
Arizona		Buckhorn Mesa WPP, Spook Hill FRS			
BY	DATE	CHECKED BY		DATE	JOB NO.
J.L. Sullivan	11-10-75	[illegible] A.C.		11-26-75	2005
SUBJECT					SHEET 42 OF
Emergency Spillway (Headwall)					

$172.4 X^2 - 15.5X^3 = 0$

Max. Moment where $V = 0$

$X^2 = 7.41X$

$(2)(172.4)X - (3)(15.5)X^2 = 0$

$344.7 X - 46.5 X^2 = 0$

11.12
7.41
3.71

$X = 344.7 / 46.5 = 7.41'$ ✓

7.41³

$N = 344.7 - (31.0)(7.41) = 115$ ✓

$115 + 467 = 582$

229.7
334.7
50

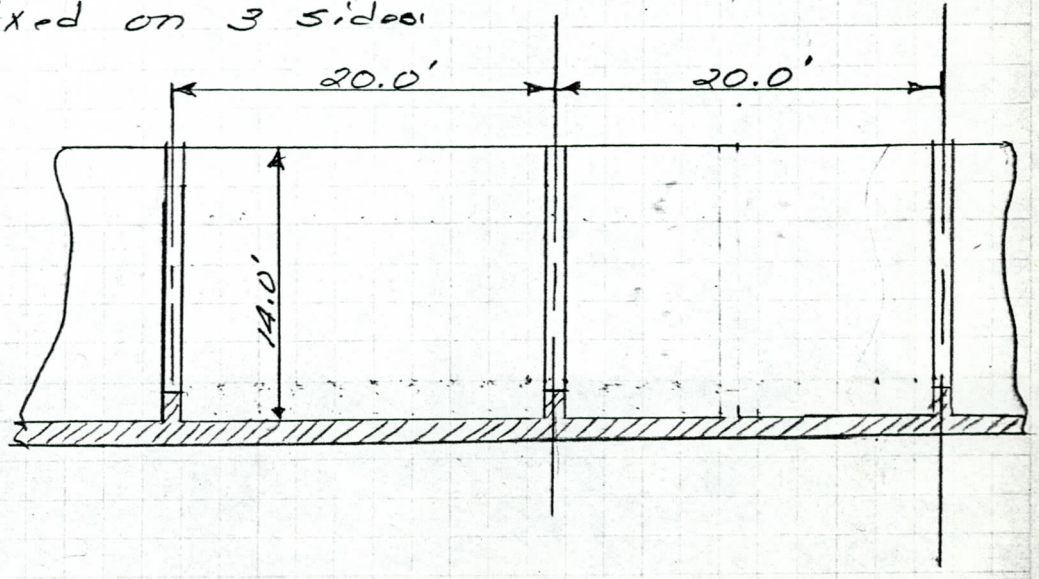
$M = (582)(7.41)^3/6 = 39,466$ ✓

Es 164
(NEH 6)

Min $d = 12^{1/2}$ $A_s = 2.2$

Use $d = 13.5$ $A_s = 1.95$

It would be cheaper to use more steel than to increase the thickness of the Conc. ∴ use continous steel & a slab fixed on 3 sides

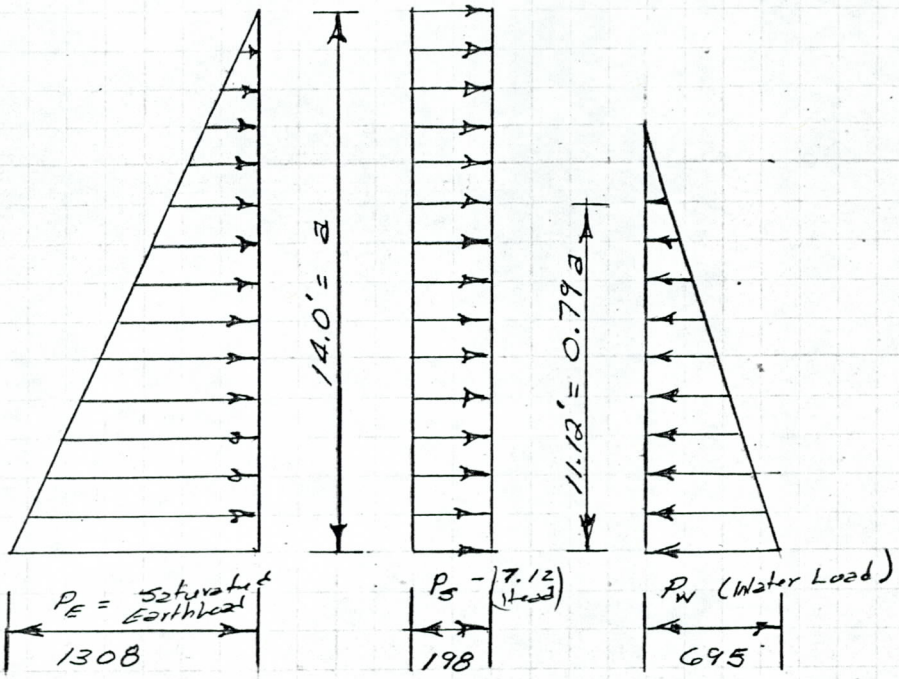


STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-11-75	[illegible]	7-26-76	2005
SUBJECT				SHEET 43 OF
Emergency Spillway Headwall				

1302

$b = 20.0'$ $\quad d = 14.0'$

$b/d = 1.43$



$P_E d^2 = 1.308 \times 14^2 = 256.4$ ft. Kips / ft.

$P_S d^2 = 0.198 \times 14^2 = 38.8$ ft. Kips / ft.

$P_W d^2 = 0.695 \times 14^2 = 136.2$ ft. Kips / ft.

$P_E d = 1.308 \times 14 =$ ~~13.81~~ 18.31 Kips / ft.

$P_S d = 0.198 \times 14 = 2.77$ Kips / ft.

$P_W d = 0.695 \times 14 = 9.73$ Kips / ft.

STATE: Arizona | PROJECT: Buckhorn Mesa WPP, Spook Hill FRS

BY: J.L. Sullivan | DATE: 10-11-75 | CHECKED BY: [illegible] | DATE: 12-1-75 | JOB NO. 2005

SUBJECT: Emergency Spillway (Headwall) | SHEET 44 OF

Vertical Moments (M_x) $b/a = 1.43$

.0012

Note: Coeff. for P_W is gotten by taking 12/33 times the difference between 2/3 H.L. & full H.L.

pa^2 →		Moment Coefficients			Moments (ft. kips)			Total Moments (ft. kips)
		256.4	38.8	-136.2				
$\pm y/b$	x/a	P_E	P_S	P_W	M_E	M_S	M_W	
0	0	0	0	0	0	0	0	0
0	0.2	0.006	0.018	0.0031	1.54	0.70	-0.42	1.82
0	0.4	0.013	0.023	0.0085	3.33	0.89	-1.16	3.06
0	0.6	0.014	0.015	0.0113	3.59	0.58	-1.54	2.63
0	0.8	-0.002	-0.020	~~-0.0001~~ +0.00813	-0.51	-0.78	~~0.07~~ -0.18	~~-1.22~~ -1.47
0	1.0	-0.055	-0.011	-0.0416	-14.10	-0.43	5.67	-8.86
0.1	0	0	0	0	0	0	0	0
0.1	0.2	0.0055	0.016	0.0028	1.41	0.62	-0.38	1.65
0.1	0.4	0.012	0.022	0.0080	3.08	0.85	-1.09	2.64
0.1	0.6	0.0136	0.014	0.0114	3.49	0.54	-1.55	2.48
0.1	0.8	-0.0015	-0.018	~~0.0003~~ 0.0015	-0.38	-0.70	~~-0.04~~ -0.22	~~-1.12~~ -1.39
0.1	1.0	-0.0515	-0.103	-0.0397	-13.20	-4.00	5.41	-11.79
0.2	0	0	0	0	0	0	0	0
0.2	0.2	0.0035	0.010	0.0017	0.90	0.39	-0.23	1.06
0.2	0.4	0.0095	0.015	0.0062	2.44	0.58	-0.84	2.18
0.2	0.6	0.011	0.010	0.0095	2.82	0.39	-1.29	1.92
0.2	0.8	0.00	-0.015	~~0.0072~~ 0.0051	0.00	-0.58	~~-0.16~~ -0.29	~~-0.74~~ -0.87
0.2	1.0	-0.0435	-0.082	-0.0340	-11.15	-3.18	4.63	-9.70
0.3	0	0	0	0	0	0	0	0
0.3	0.2	0.001	0.002	0.0002	0.26	0.08	-0.03	0.31
0.3	0.4	0.005	0.0062	0.0031	1.28	0.24	-0.42	1.10
0.3	0.6	0.0075	0.0060	0.0065	~~1.92~~ 1.93	0.23	-0.89	~~1.26~~ 1.27
0.3	0.8	0.0005	-0.0082	0.0022	0.13	-0.32	-0.30	-0.49
0.3	1.0	-0.0295	-0.053	-0.0240	-7.56	-2.06	3.27	-6.35
0.4	0.0	0	0	0	0	0	0	0
0.4	0.2	-0.003	-0.0108	-0.00195	-0.77	-0.42	0.27	-0.92
0.4	0.4	-0.0011	-0.0069	-0.00076	-0.28	-0.27	0.10	-0.45
0.4	0.6	0.0009	-0.0031	0.00119	0.23	-0.12	-0.16	-0.05
0.4	0.8	0.000	-0.0050	~~0.00055~~ 0.001	0.00	-0.19	~~-0.07~~ -0.14	~~-0.26~~ -0.33
0.4	1.0	-0.01275	-0.0193	-0.01090	-3.27	-0.75	1.48	-2.54
0.5	0	0	0	0	0	0	0	0
0.5	0.2	-0.0081	-0.0289	-0.00466	-2.08	-1.12	0.63	-2.57
0.5	0.4	-0.008	-0.0228	-0.0051	-2.05	-0.88	0.69	-2.24
0.5	0.6	-0.0069	-0.0151	-0.00491	-1.77	-0.59	0.67	-1.69
0.5	0.8	-0.0033	-0.0057	-0.00262	-0.85	-0.22	0.36	-0.71
0.5	1.0	0	0	0	0.00	0.00	0	0

STATE Arizona | PROJECT Buckhorn Mesa WPP, Spook Hill FRS

BY J.L. Sullivan | DATE 11-12-75 | CHECKED BY JW | DATE 12-2-75 | JOB NO. 2005

SUBJECT Emergency Spillway (Headwall) | SHEET 45 OF

Horizontal Moments (M_y) $b/a = 1.43$

Pa^2 →		Moment Coefficients			Moments (ft. kips)			Total Moments
		256.4	38.8	-136.2				
X/a	$\pm Y/b$	P_E	P_S	P_W	M_E	M_S	M_W	(ft. kips)
0	0	0.0198	.0770	.0112	5.08	2.99	- 1.53	6.54
0	0.1	.0178	.0680	.0100	4.56	2.64	- 1.36	5.84
0	0.2	.0105	.0440	.0058	2.69	1.71	- 0.79	3.61
0	0.3	-.0016	.0010	-.0012	- 0.41	.04	0.16	- 0.21
0	0.4	-.0180	-.0670	-.0103	-4.62	-2.60	1.40	- 5.82
0	0.5	-.0368	-.1630	-.0193	- 9.44	-6.32	2.63	- 13.13
0.2	0	.0196	.0670	.0115	5.03	2.60	- 1.57	6.06
0.2	0.1	.0175	.0590	.0102	4.49	2.29	- 1.39	5.39
0.2	0.2	.0112	.0390	.0064	2.87	1.51	- 0.87	3.51
0.2	0.3	.0000	.0000	-.0003	0.00	.00	- 0.04	0.04
0.2	0.4	-.0166	-.0580	-.0099	- 4.26	- 2.25	1.35	- 5.16
0.2	0.5	-.0400	-.1440	-.0230	-10.26	-5.59	3.13	- 12.72
0.4	0	.0185	.0535	.0116	4.74	2.08	- 1.58	5.24
0.4	0.1	.0170	.0480	.0106	4.36	1.85	- 1.44	4.77
0.4	0.2	.0119	.0315	.0076	3.05	1.22	- 1.04	3.23
0.4	0.3	.0022	.0035	.0015	0.56	0.14	- 0.20	0.50
0.4	0.4	-.0141	-.0440	-.0089	- 3.62	- 1.71	1.21	- 4.12
0.4	0.5	-.0410	-.1140	-.0258	-10.51	-4.42	3.51	- 11.42
0.6	0	.0139	.03320	.0096	3.56	1.29	- 1.31	3.54
0.6	0.1	.0130	.0302	.0092	3.33	1.17	- 1.25	3.25
0.6	0.2	.0101	.0210	.0074	2.59	0.81	- 1.01	2.39
0.6	0.3	.0038	.0028	.0032	0.97	0.11	- 0.44	0.64
0.6	0.4	-.0092	-.0274	-.0058	- 2.36	- 1.06	0.79	- 2.63
0.6	0.5	-.0340	-.0760	-.0244	- 8.72	- 2.95	3.32	- 8.35
0.8	0	.0038	.0064	.0030	0.97	0.25	- 0.41	0.81
0.8	0.1	.0037	.0058	.0031	0.95	0.23	- 0.42	0.76
0.8	0.2	.0034	.0042	.0030	0.87	0.16	- 0.41	0.62
0.8	0.3	.0018	~~.0050~~ .0030	.0020	0.46	~~0.17~~ 0.07	- 0.27	~~0.67~~ 0.00
0.8	0.4	-.0032	-.0106	~~-.0077~~ -.0006	- 0.82	- 0.41	~~0.23~~ 0.08	~~- 1.15~~ 0.00
0.8	0.5	-.0165	-.0286	-.0132	- 4.23	- 1.11	1.80	- 3.54
1.0	0	-.0109	-.0220	-.0083	- 2.79	- 0.85	1.13	- 2.51
1.0	0.1	-.0103	-.0207	-.0079	- 2.64	- 0.80	1.08	- 2.36
1.0	0.2	-.0087	-.0163	-.0068	- 2.23	- 0.63	0.93	- 1.93
1.0	0.3	-.0060	-.0104	-.0048	- 1.54	- 0.40	0.65	- 1.29
1.0	0.4	-.0026	-.0038	-.0021	- 0.67	- 0.15	0.29	- 0.53
1.0	0.5	.0000	.0000	.0000	0.00	0.00	0.00	0.00

STATE Arizona | PROJECT Buckhorn Mesa WPP

BY J.L. Sullivan | DATE 10-12-75 | CHECKED BY [illegible] | DATE 12-2-75 | JOB NO. 2005

SUBJECT Emergency Spillway | SHEET 46 OF

Shear

$\frac{b}{a} = 1.43$

$P_a \rightarrow$		Shear Coefficients 8.33 ~~13.31~~	2.77	-9.73	Shear (Kips/ft)			Total Shear Kips/ft
x/a	$\pm y/b$	P_E	P_S	P_W	S_E	S_S	S_W	
0	0.5	.094	.804	.0316	~~1.25~~	2.23	- .31	~~3.17~~
0.2	0.5	.197	.756	.1041	~~2.62~~	~~2.09~~	- 1.01	~~3.70~~
0.4	0.5	.238	.690	.1470	~~3.17~~	~~1.91~~	- 1.43	~~3.65~~
0.6	0.5	.254	.440	.1961	3.38	1.22	- 1.91	~~2.69~~
0.8	0.5	.138	.130	.1329	1.84	.36	- 1.29	~~0.91~~
1.0	0.5	-.018	-.065	-.0065	- .24	- .18	.06	- ~~0.36~~
1.0	0.4	.119	.0775	.1241	1.58	.21	- 1.21	~~0.58~~
1.0	0.3	.256	.320	.2350	~~3.41~~	.89	- 2.29	~~2.01~~
1.0	0.2	.340	.502	.2942	4.53	1.39	- 2.86	~~3.06~~
1.0	0.1	.383	.610	.3238	5.10	1.69	- 3.15	~~3.64~~
1.0	0	.397	.645	.3334	5.28	1.79	- 3.24	~~3.83~~

See below

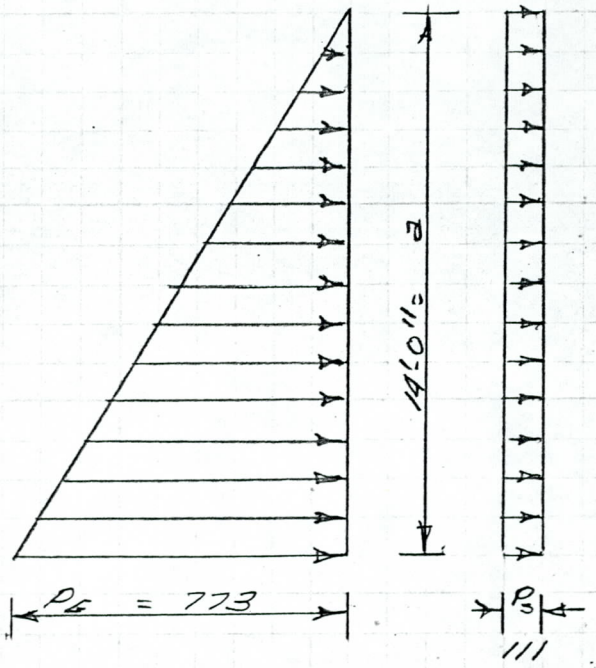
0	0.5		1.72	3.64
0.2	0.5		3.61	4.69
0.4	0.5		4.36	~~4.56~~ ~~4.84~~
0.6	0.5		4.65	3.96
0.8	0.5		2.53	1.60
1.0	0.5		-0.33	-.45
1.0	0.4		2.18	1.18
1.0	0.3		4.69	3.29
1.0	0.2		6.23	4.76
1.0	0.1		7.01	5.55
1.0	0		7.27	5.82

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	11-12-75	[illegible]	11-26-75	2005

SUBJECT: Emergency Spillway — Headwall — SHEET 42 OF

Check For Conditions During Const.

See Sht. 39 for Loading diagram



$P_E a = 0.773 \times 14 = 10.8$ Kips / ft.

$P_S a = 0.111 \times 14 = 1.6$ Kips / ft.

$P_E a^2 = 0.773 \times 14^2 = 151.5$ Kips

$P_S a^2 = 0.111 \times 14^2 = 21.8$ Kips

STATE Arizona | PROJECT Buckhorn Mesa WPP, Spook Hill FRS

BY J.L. Sullivan | DATE 11-12-75 | CHECKED BY JMJ | DATE 12-2-75 | JOB NO. 2005

SUBJECT Emergency Spillway Headwall | SHEET 48 OF

Vertical Moments (M_x) $b/a = 1.43$

Pa^2 →		Moment Coefficient 151.5	Moment Coefficient 21.8	Moments (ft. Kips)		Total Moments (ft. Kips)
± y/b	x/a	P_E	P_S	M_E	M_S	
0	0	0.000	0.000	0.00	0.00	0.00
"	0.2	0.006	0.018	0.91	0.39	1.30
"	0.4	0.013	0.023	1.97	0.50	2.47
"	0.6	0.014	0.015	2.12	0.33	2.45
"	0.8	-0.002	-0.020	- 0.30	- 0.44	- 0.74
"	1.0	-0.055	-0.011	- 8.33	- 0.24	- 8.57
0.1	0	0.000	0.000	0.00	0.00	0.00
"	0.2	0.0055	0.016	0.83	0.35	1.18
"	0.4	0.012	0.022	1.82	0.48	2.30
"	0.6	0.0136	0.014	2.06	0.31	2.37
"	0.8	-0.0015	-0.018	- 0.23	- 0.39	- 0.62
"	1.0	-0.0515	-0.103	- 7.80	- 2.25	- 10.05
0.2	0	0.000	0.000	0.00	0.00	0.00
"	0.2	0.0035	0.010	0.53	0.22	0.75
"	0.4	0.0095	0.015	1.44	0.33	1.77
"	0.6	0.011	0.010	1.67	0.22	1.89
"	0.8	0.000	-0.015	0.00	- 0.33	- 0.33
"	1.0	-0.0435	-0.082	- 6.59	- 1.79	- 8.38
0.3	0	0.000	0.000	0.00	0.00	0.00
"	0.2	0.001	0.002	0.15	0.04	0.19
"	0.4	0.005	0.0062	0.76	0.14	0.90
"	0.6	0.0075	0.006	1.14	0.13	1.27
"	0.8	0.0005	-0.0082	0.08	- 0.18	- 0.10
"	1.0	-0.0295	-0.053	- 4.47	- 1.16	- 5.63
0.4	0	0.000	0.000	0.00	0.00	0.00
"	0.2	-0.003	-0.0108	- 0.45	- 0.24	- 0.69
"	0.4	-0.0011	-0.0069	- 0.17	- 0.15	- 0.32
"	0.6	0.0009	-0.0031	0.14	- 0.07	0.07
"	0.8	0.0000	-0.005	0.00	- 0.11	- 0.11
"	1.0	-0.01275	-0.0193	- 1.993	- 0.42	- 2.435
0.5	0	0.000	0.000	0.00	0.00	0.00
"	0.2	-0.0081	-0.0289	- 1.23	- 0.63	- 1.86
"	0.4	-0.008	-0.0228	- 1.21	- 0.50	- 1.71
"	0.6	-0.0069	-0.0151	- 1.05	- 0.33	- 1.38
"	0.8	-0.0033	-0.0057	- 0.50	- 0.12	- 0.62
"	1.0	0.000	0.000	0.00	0.00	0.00

STATE Arizona | PROJECT Buckhorn Mesa WPA, Spook Hill FRS

BY J.L. Sullivan | DATE 11-13-75 | CHECKED BY [illegible] | DATE 12-2-74 | JOB NO. 2005

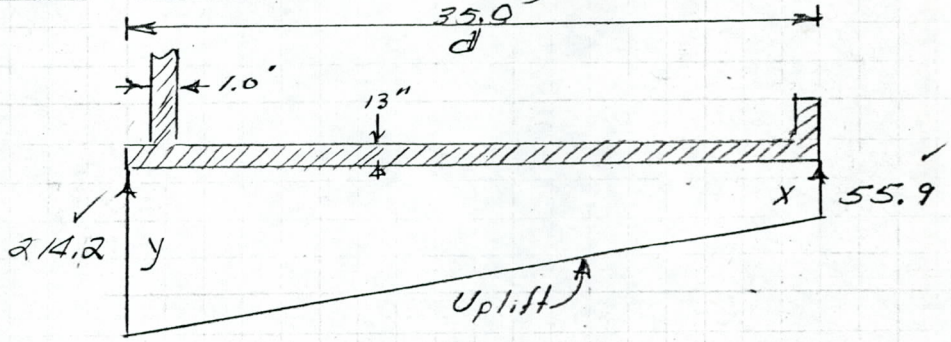
SUBJECT Emergency Spillway (Headwall) | SHEET 49 OF

Horizontal Moments (M_y) $b/a = 1.43$

$Pa^2 \rightarrow$		Moment Coefficients 151.5	Moment Coefficients 21.8	Moments (ft. kips)		Total Moments (ft. Kips)
x/a	± y/b	P_E	P_S	M_E	M_S	
0	0.0	0.0198	0.0770	3.00	1.68	4.68
"	0.1	0.0178	0.0680	2.70	1.48	4.18
"	0.2	0.0105	0.0440	1.59	0.96	2.55
"	0.3	-0.0016	0.0010	- 0.24	0.02	- 0.22
"	0.4	-0.0180	-0.0670	- 2.73	- 1.46	- 4.19
"	0.5	-0.0368	-0.1630	- 5.58	- 3.55	- 9.13
0.2	0.0	0.0196	0.0670	2.97	1.46	4.43
"	0.1	0.0175	0.0590	2.65	1.29	3.94
"	0.2	0.0112	0.0390	1.70	0.85	2.55
"	0.3	0.0000	0.0000	0.00	0.00	0.00
"	0.4	-0.0166	-0.0580	- 2.51	- 1.26	- 3.77
"	0.5	-0.0400	-0.1440	- 6.06	- 3.14	- 9.20
0.4	0.0	0.0185	0.0535	2.80	1.17	3.97
"	0.1	0.0170	0.0480	2.58	1.05	3.63
"	0.2	0.0119	0.0315	1.80	0.69	2.49
"	0.3	0.0022	0.0035	0.33	0.08	0.41
"	0.4	-0.0141	-0.0440	- 2.14	- 0.96	- 3.10
"	0.5	-0.0410	-0.1140	- 6.21	- 2.49	- 8.70
0.6	0.0	0.0139	0.0332	2.11	0.72	2.83
"	0.1	0.0130	0.0302	1.97	0.66	2.63
"	0.2	0.0101	0.0210	1.53	0.46	1.99
"	0.3	0.0038	0.0028	0.58	0.06	0.64
"	0.4	-0.0092	-0.0274	- 1.39	- 0.60	- 1.99
"	0.5	-0.0340	-0.0760	- 5.15	- 1.66	- 6.81
0.8	0.0	0.0038	0.0064	0.58	0.14	0.72
"	0.1	0.0037	0.0058	0.56	0.13	0.69
"	0.2	0.0034	0.0042	0.52	0.09	0.61
"	0.3	0.0018	-0.0050 → -0.0005	0.27	- 0.01	0.26 ~~0.16~~
"	0.4	-0.0032	-0.0106	- 0.48	- 0.23	- 0.71
"	0.5	-0.0165	-0.0286	- 2.50	- 0.62	- 3.12
1.0	0.0	-0.0109	-0.0220	~~-1.65~~ -2.88	- 0.48	~~-2.13~~ -3.36
"	0.1	-0.0103	-0.0207	- 1.56	- 0.45	- 2.01
"	0.2	-0.0087	-0.0163	- 1.32	- 0.36	- 1.68
"	0.3	-0.0060	-0.0104	- 0.91	- 0.23	- 1.14
"	0.4	-0.0026	-0.0038	- 0.39	- 0.08	- 0.47
"	0.5	0.000	0.000	0.00	0.00	0.00

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	10-7-75	(2) [illegible]	11-5-75	2005
SUBJECT				SHEET 23 OF
Emergency Spillway				

Uplift Without Flow Diagram



Rate of change in the uplift per foot of horiz. Contact = 13.57 ÷ 3 = 4.52 ✓

$y = x + (4.52 \times 35.0) = x + 158.3$ ✓

See Sht. 22

Uplift per ft. of width = 4730 ✓

(79.2)

$[(x+y) \div 2]\, d = 4730$

$\frac{x+y}{2} = \frac{4730}{35.0} = 135.1$ ✓

$x + 79.2 = 135.1$

$x = 55.9$ lbs ✓

$y = 55.9 + 158.3 = 214.2$ ✓ lbs.

Pressure After Backfill No Flow

Horizontal Pressures

5ft 11
4.12

Assume that the backfill is Drainage material for the entire height of the sidewall

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	11-14-75	[illegible]	12-2-75	2005
SUBJECT				SHEET 50 OF
Emergency Spillway (Headwall)				

NEH Sec 11 Drop Spwys

Shear

$\frac{b}{a} = 1.43$

Pa →		Shear Coefficients		Shear (Kips/Ft.)		Total Shear Kips/Ft.
X/a	± Y/b	10.8	1.6			
		P_E	P_s	V_E	V_s	
0	0.5	0.094	0.804	1.02	1.29	2.31
0.2	0.5	0.197	0.756	2.13	1.21	3.34
0.4	0.5	0.238	0.590	2.57	0.94	3.51
0.6	0.5	0.254	0.440	2.74	0.70	3.44
0.8	0.5	0.138	0.130	1.49	0.21	1.70
1.0	0.5	-0.018	-0.065	-0.19	- 0.10	= 0.29
1.0	0.4	0.119	0.0775	1.29	0.12	1.41
1.0	0.3	0.256	0.320	2.76	0.51	3.27
1.0	0.2	0.340	0.502	3.67	0.80	4.47
1.0	0.1	0.383	0.610	4.14	0.98	5.12
1.0	0	0.397	0.645	4.29	1.03	5.32

→ This is the worst condition for shear See Sht 46

K+E 20 X 20 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

4.5 kip

Use

With Full Flow

d=9.5"

Horizontal Moments (M_y)

4.5 kips = 5.0

Temp. Steel

Use #5's @ 12"

Vertical Moments (M_x)

Use #4's @ 12"

Use #7's @ 12"

Use #5's @ 12"

Use #4's @ 12"

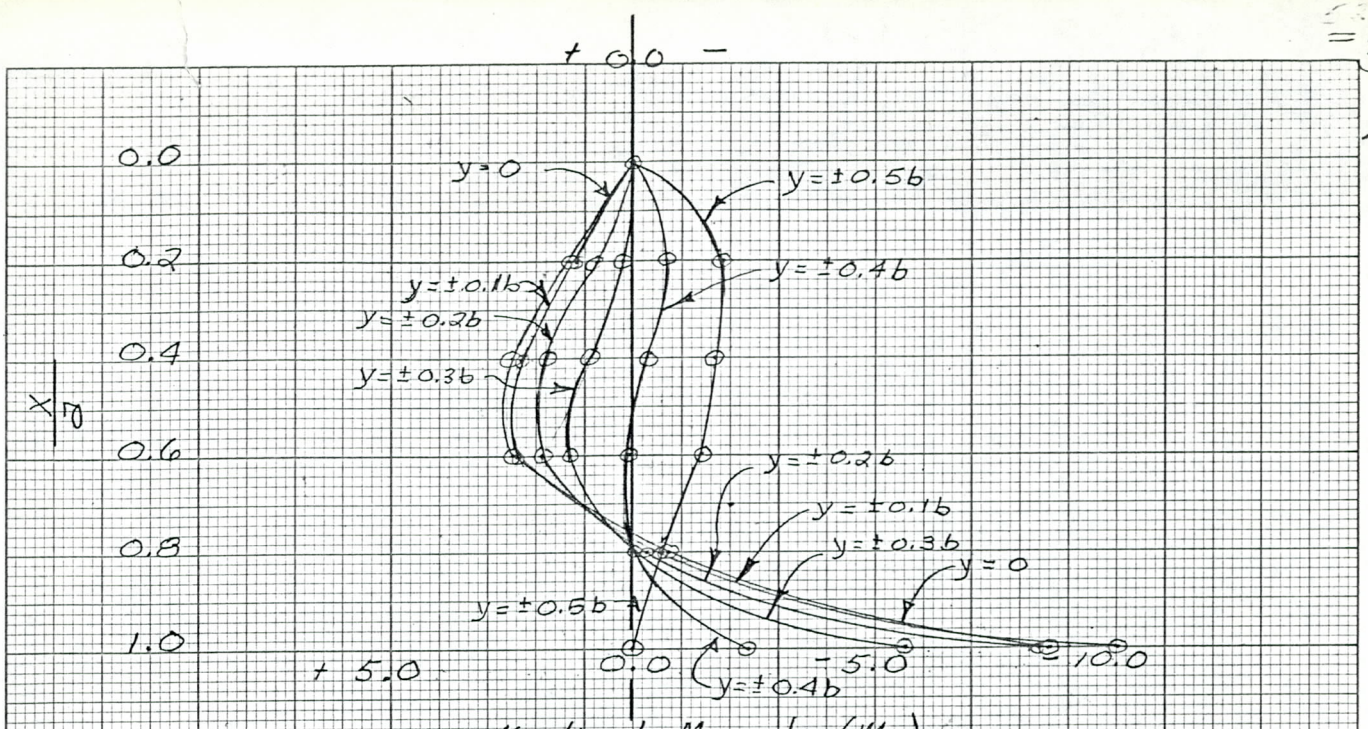
Tension Steel Unexposed Face

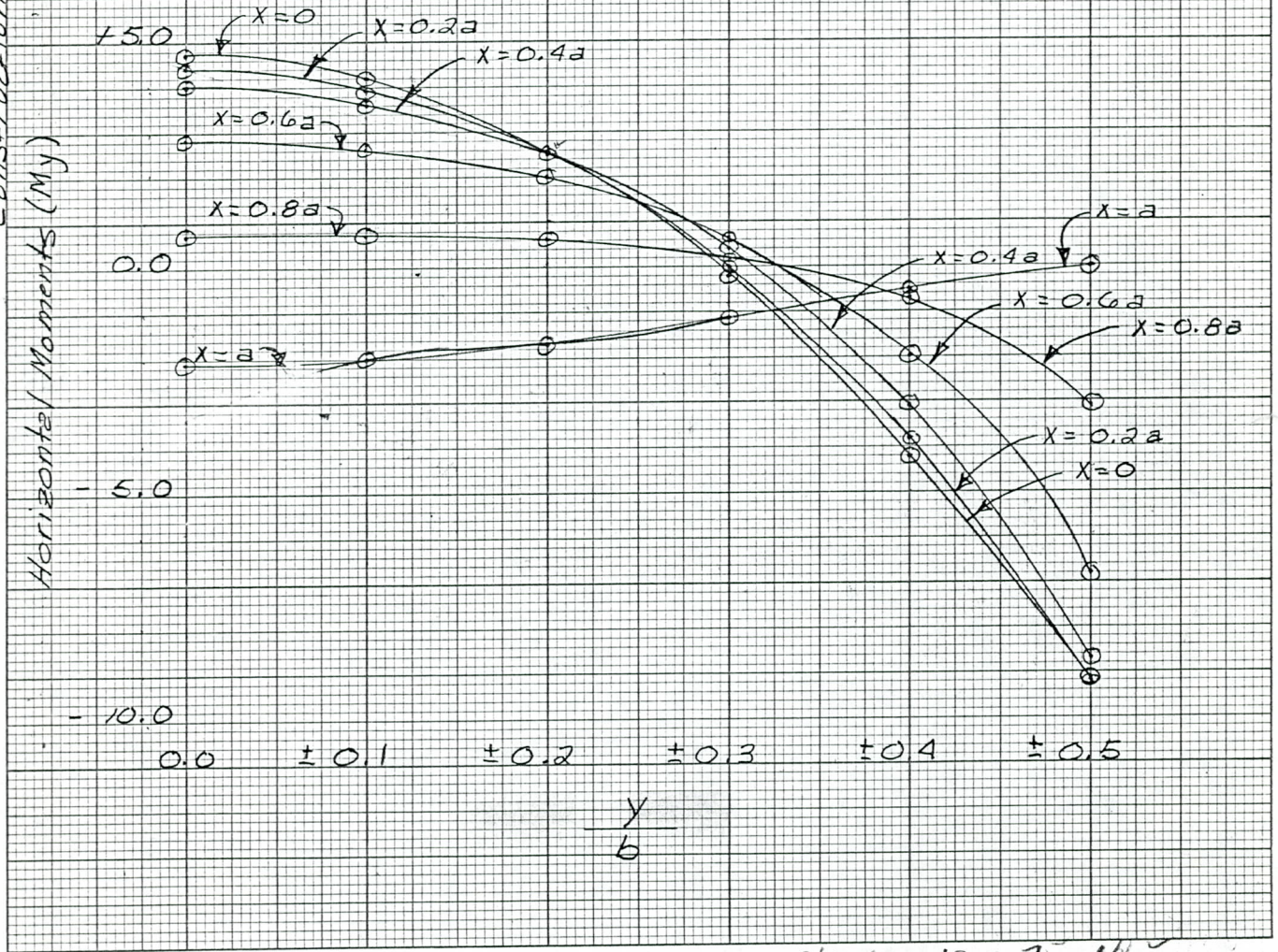
Tension Steel Exposed Face

4 Tension Steel Exposed Face

Tension Steel Unexposed Face

checked 12-2-77 DMW





Checked 12-2-74 MJS

46 1240
KE 20 X 20 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	11-14-75	DRT	12-2-75	2005
SUBJECT				SHEET 53 OF
Emergency Spillway				

Full Flow

Vertical Steel (Unexposed Face)

USEd=8.5
#7@12
#4@12
OK
PJM 9/16/76

$d = 12.0 - 2.5 = 9.5''$

$-M_x = -11.8$ (10.1) ft. Kips/ft @ $x = a$ & $y = \pm 0.1b$

Req'd A_s (structural) $= 0.83\ \square''$ — Use #6's @ 6"

Req'd Temp. $A_s = 0.14\ \square''$

Use #4's @ 12" $= 0.20\ \square''$ allows 3 kips

0.88

$\frac{5.32}{9.5} = 0.56$

$V = 5.32$ @ $x = a$ & $y = 0$ $\quad V/d = 0.56$

Req'd $\Sigma_o = 1.30$ #6's give 4.71 ∴ ok

Anchorage bond — $u = \frac{f_s D}{4L}$

79

$f_s = 11.8/0.88 = 13.41$ ksi $\quad u = 405 \quad D = 0.75''$

$L = \frac{(13410)(.75)}{(4)(405)} = 6.21''$ for anchorage

487

$.14 \times 14 + 2.0 = 4.96$ use 5.0'

$9/14 = 0.64$

8.28

Vertical Steel (Exposed Face)

USEd=8.5
#5@12
OK 8.46
PJM 9/16/76

$d = 9.5''$

$M_x = 3.1$ ft Kips/ft @ $y = 0$ & $x = 0.4a$

Req'd A_s (structural) $= 0.21$

Req'd A_s (Temp.) $= 0.29$ $\quad$ Use #5's @ 12

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	11-14-75	[illegible]	12-2-75	2005
SUBJECT				SHEET 54 OF
Emergency Spillway				

#6s@6" = 0.88 ??
#6s@5 3/4" = 0.92
P_t = 0.002
4.3

Horizontal Steel (Unexposed Face)

$-M_y$ = -13.1 ft. Kips/ft. @ x=0 & y = ± 0.5b

Req'd. As (structural) = 0.92 □" - Use #6's @6" ✓

Req'd As (Temp.) = 0.29 □" - #5's @12" ✓ Allows 4.3 Kips

V = 3.67 @ x = 0.4a & y = ± 0.5b V/d = 0.39

Req'd. Σ_o = 0.89 #6's @6" give 4.71 ok

f_s = 13.1/0.88 = 14.89 Ksi

$L = \frac{(14,890)(0.75)}{(4)(405)} = 6.89$

Length of #6's = (1.125)(20) + 2.0 = 4.5 ft

5.5/20 = 0.275 b

Horizontal Steel (Exposed Face)

M_y = 6.6 ft. Kips/ft. ; x=0 & y=0

Req'd As (structural) = 0.45 □" ✓
Req'd As (Temp.) = 0.43 □" ✓
} Use #6's @12" ✓

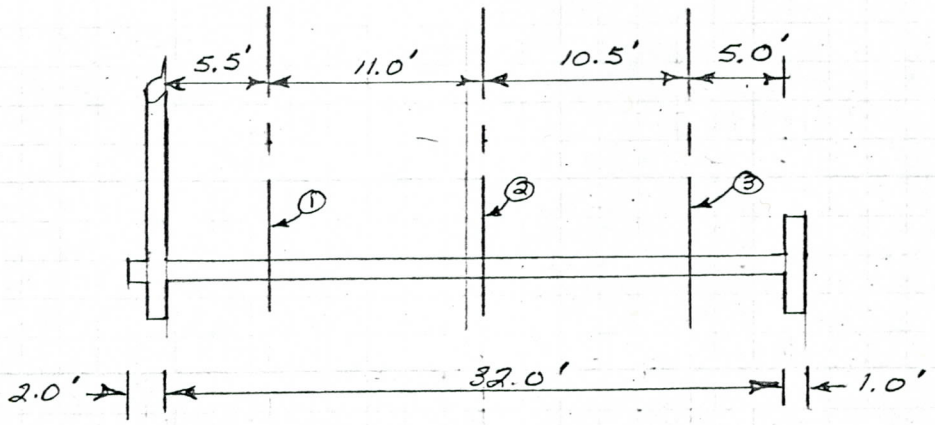
6, 12, 4 0

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-8-76	D Riddle	1-27-76	2005

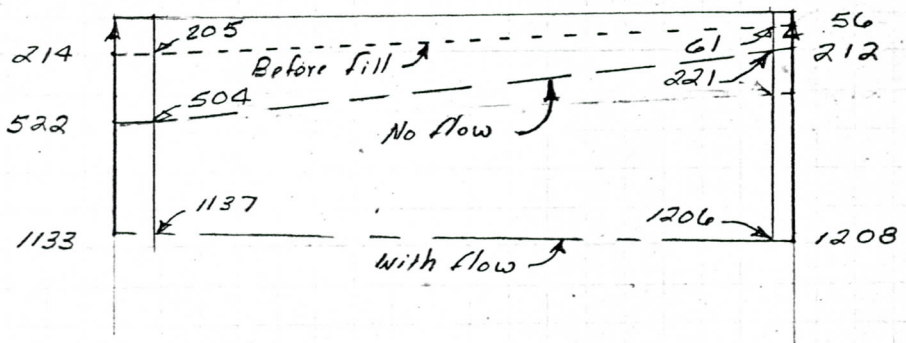
SUBJECT: Emergency Spillway (Floor) — SHEET 110 OF

6- -4

5-10-



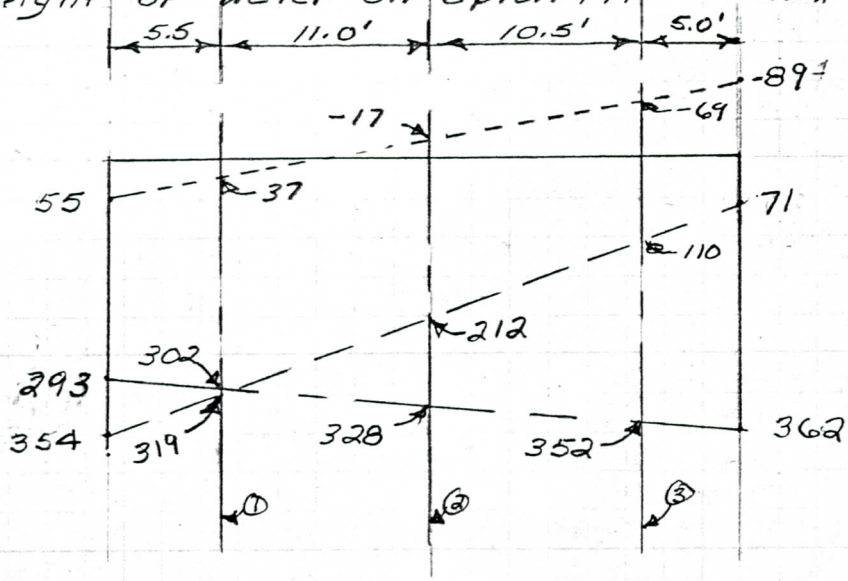
214-56 X 2/35



11.12

Weight of concrete / ft² = 150 lbs

Weight of water on apron / ft² = 11.12 x 62.4 = 694 lbs



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-8-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 111 OF
Emergency Spillway (Apron)				

Width of outside bays - 10.0'

Width of interior bays - 20.0'

10'
20'

$l_1 = l_3 = 10.0'$

$l_2 = 20.0'$

At Section (1)

Before Fill

Sidewall Moment, $M_{ab} = 0$

$$M_{ba} = \frac{M_{ab} l_1 + \frac{1}{4} w (l_1^3 + l_2^3)}{2 l_1 + 3 l_2}$$

$$= \frac{\frac{1}{4}(37)(10^3 + 20^3)}{(2)(10) + (3)(20)} = 1040 \text{ ft-lbs.}$$

$$20 + 60$$

$$M_{bc} = -M_{ba} = -1040 \text{ ft-lbs}$$

$$V_{ab} = -\frac{1}{2} w l_1 + \left(\frac{M_{ab} + M_{ba}}{l_1}\right)$$

$$= -\frac{1}{2}(37)(10) + \frac{1040}{10} = -185 + 104 = -81 \text{ lbs}$$

$$V_{ba} = w l_1 + V_{ab}$$

$$= (37)(10) - 81 = 289 \text{ lbs}$$

$$V_{bc} = -\frac{1}{2} w l_2$$

$$= -\frac{1}{2}(37)(20) = -370 \text{ lbs.}$$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
JL. Sullivan	1-8-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 112 OF
Emergency Spillway (Apron)				

1000
8000
9000

After Fill-No Flow

$M_{ab} = 0 \qquad w = 319$

$$M_{ba} = \frac{(1/4)(319)(10^3 + 20^3)}{(2)(10) + (3)(20)} = \underset{20 \quad 60}{} = 8,972 \text{ ft-lbs}$$ ✓

$$V_{ab} = -\tfrac{1}{2}(319)(10) + \frac{8,972}{10} = -1595 + 897 = -698 \text{ lbs}$$ ✓

$V_{ba} = (319)(10) - 698 = 2,492$ lbs. ✓

$V_{bc} = -\tfrac{1}{2}(319)(20) = -3,190$ lbs. ✓

After Fill - Flowing

$M_{ab} = 0 \qquad w = 302$

$$M_{ba} = \frac{(1/4)(302)(9000)}{80} = 8,494 \text{ ft.-lbs.}$$ ✓

$$V_{ab} = -(\tfrac{1}{2})(302)(10) + \frac{8494}{10} = -1510 + 849 = -661 \text{ lbs}$$ ✓

$V_{ba} = (302)(10) - 661 = 2359$ lbs. ✓

$V_{bc} = -\tfrac{1}{2}(302)(20) = -3020$ lbs ✓

Moment & Shear Diagrams

$M = 1/8\ w l^2$

$M_{10} = 1/8\ w (10)^2 = 12.50\ w$ ✓

$M_{20} = 1/8\ w (20)^2 = 50\ w$ ✓

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-8-76	D Riddle	1-23-76	2005

SUBJECT Emergency Spillway (Apron) SHEET 1&2 OF

Section (1) End Section (ℓ=10) (12.50 IN)

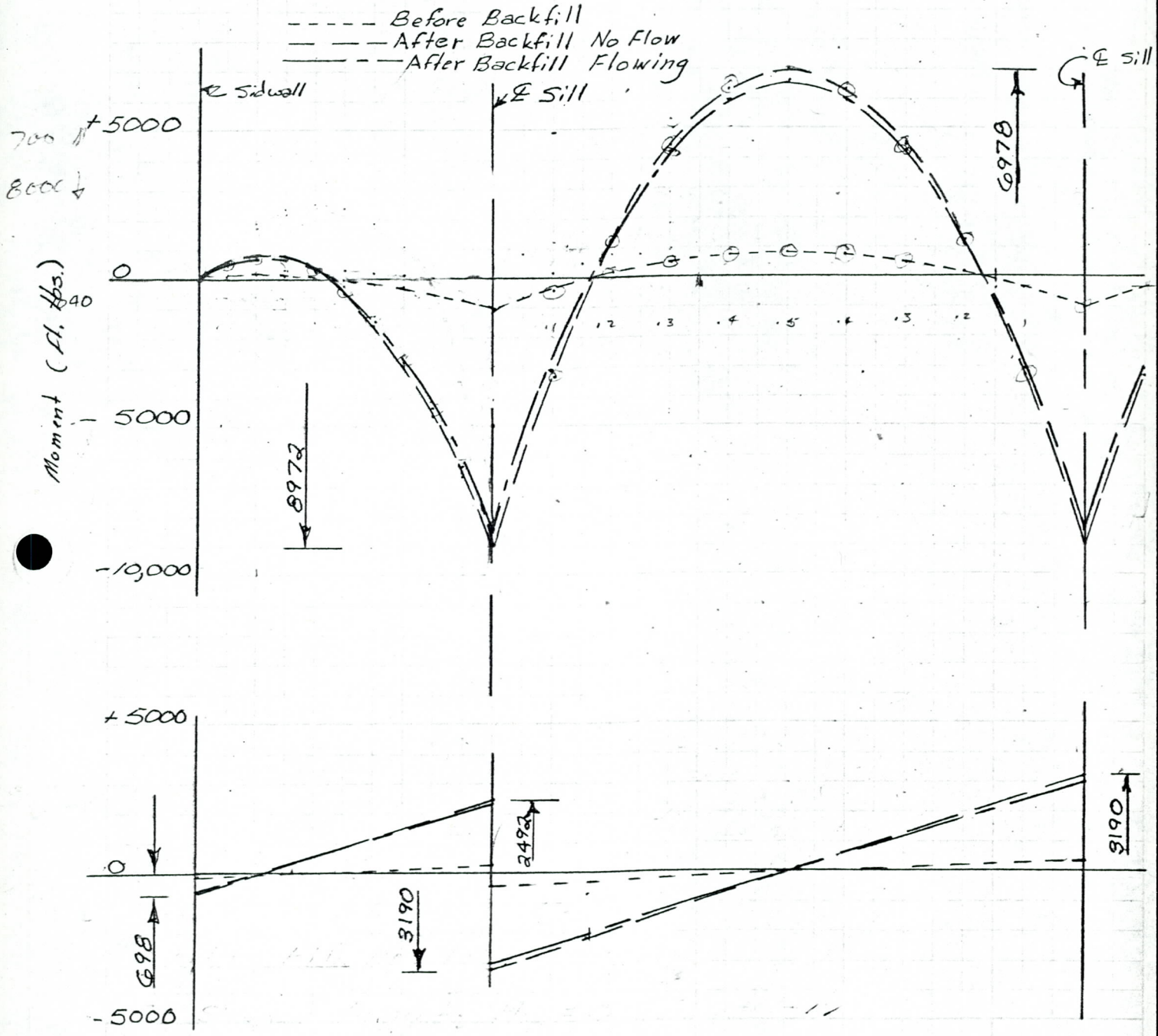
X/ℓ	M_x/M@E	No Fill W=37	No Flow W=319	Flowing W=302
0.5	1.0	463	3988	3775
0.4	0.96	444	3828	3624
0.3	0.84	389	3350	3171
0.2	0.64	296	2552	2416
0.1	0.36	167	1436	1359

Section (1) Interior Section (ℓ=20)

50 IN

X/ℓ	M_x/M@E	No Fill W=37	No Flow W=319	Flowing W=302
0.5	1.0	1850	15,950	15,100
0.4	0.96	1776	15,312	14,496
0.3	0.84	1554	13,398	12,684
0.2	0.64	1184	10,208	9,664
0.1	0.36	666	5,742	5,436

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
JL. Sullivan	1-8-76	D Riddle	1-26-76	2005
SUBJECT				SHEET 114 OF
Emergency Spillway (Apron)				



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-9-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 115 OF
Emergency Spillway (Apron)				

At Section ②

Before Fill

Sidewall Moments $M_{ab} = 0$ $w = -17$

$$M_{ba} = \frac{(1/4)(-17)(9000)}{80} = -478 \text{ ft-lbs}$$

$$V_{ab} = -1/2(-17)(10) + \frac{-478}{10} = 85 - 48 = 37 \text{ lbs}$$

$$V_{ba} = (-17)(10) + 37 = -133 \text{ lbs.}$$

$$V_{bc} = -1/2(-17)(20) = 170 \text{ lbs.}$$

After Fill No Flow

$M_{ab} = 0$ $w = 212$

$$M_{ba} = \frac{(1/4)(212)(9000)}{80} = 5963 \text{ ft-lbs}$$

$$V_{ab} = -1/2(212)(10) + \frac{5963}{10} = -1060 + 596 = -464 \text{ lbs.}$$

$$V_{ba} = (212)(10) - 464 = 1656 \text{ lbs}$$

$$V_{bc} = -1/2(212)(20) = -2120 \text{ lbs}$$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-9-76	D Riddle	1-28-76	2005

SUBJECT Emergency Spillway (Apron) SHEET 116 OF

After Fill Flowing

$M_{ab} = 0 \qquad W = 328$

$$M_{ba} = \frac{(1/4)(328)(9000)}{80} = 9225 \text{ ft-lbs}$$

$$V_{ab} = -\tfrac{1}{2}(328)(10) + \frac{9225}{10} = -1640 + 922 = -718 \text{ lbs}$$

$$V_{ba} = (328)(10) - 718 = 2562 \text{ lbs.}$$

$$V_{bc} = -\tfrac{1}{2}(328)(20) = -3280 \text{ lbs.}$$

Moment & Shear Diagrams

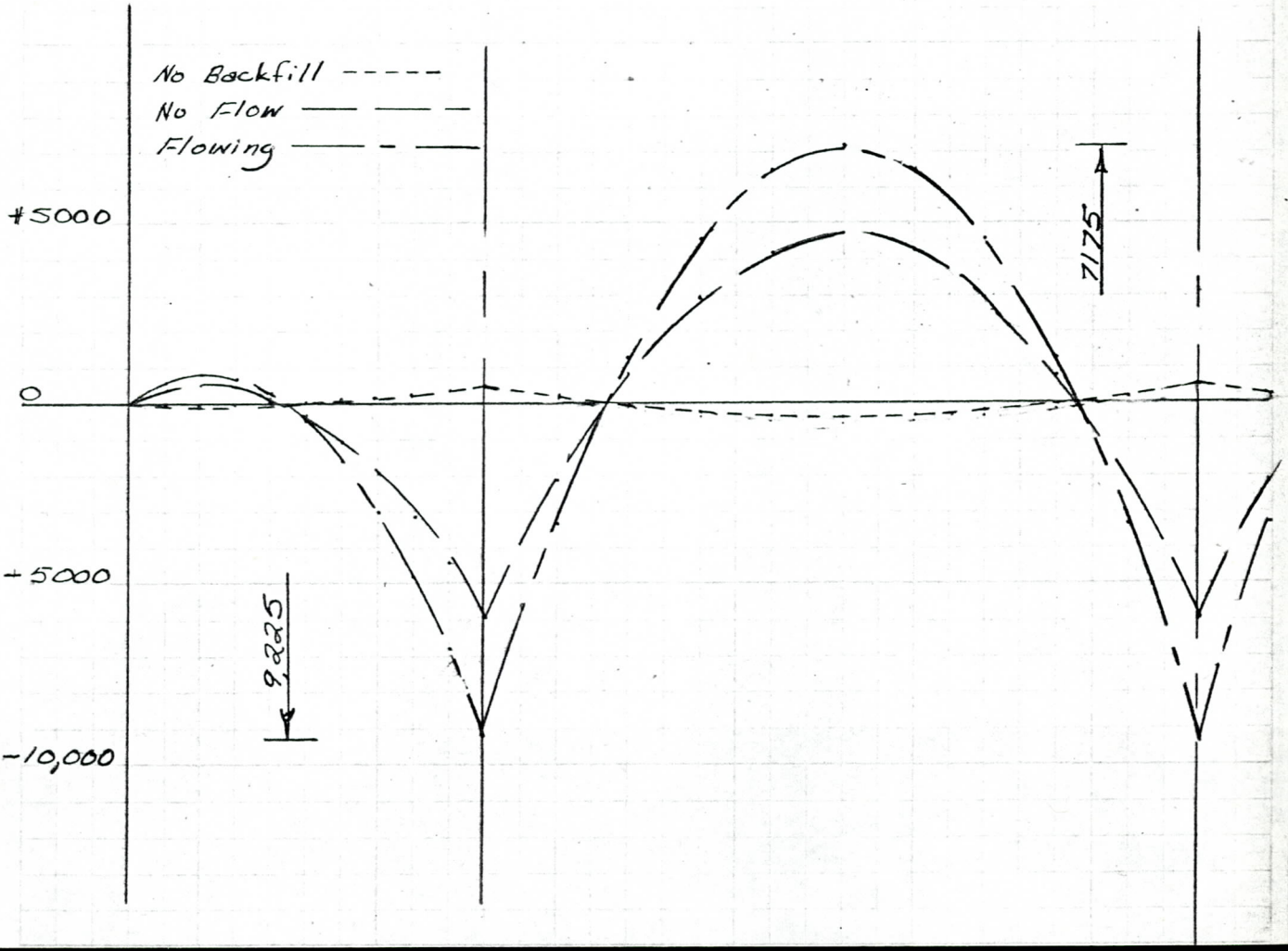
Section ② $\ell = 10 \qquad M_E = 12.5\,W$

X/ℓ	$M_x/M_E\ell$	No Fill W = -17	No Flow W = 212	Flowing 328
0.5	1.0	-213	2650	4100
0.4	0.96	-204	2544	3936
0.3	0.84	-179	2226	3444
0.2	0.64	-136	1696	2624
0.1	0.36	-77	954	1476

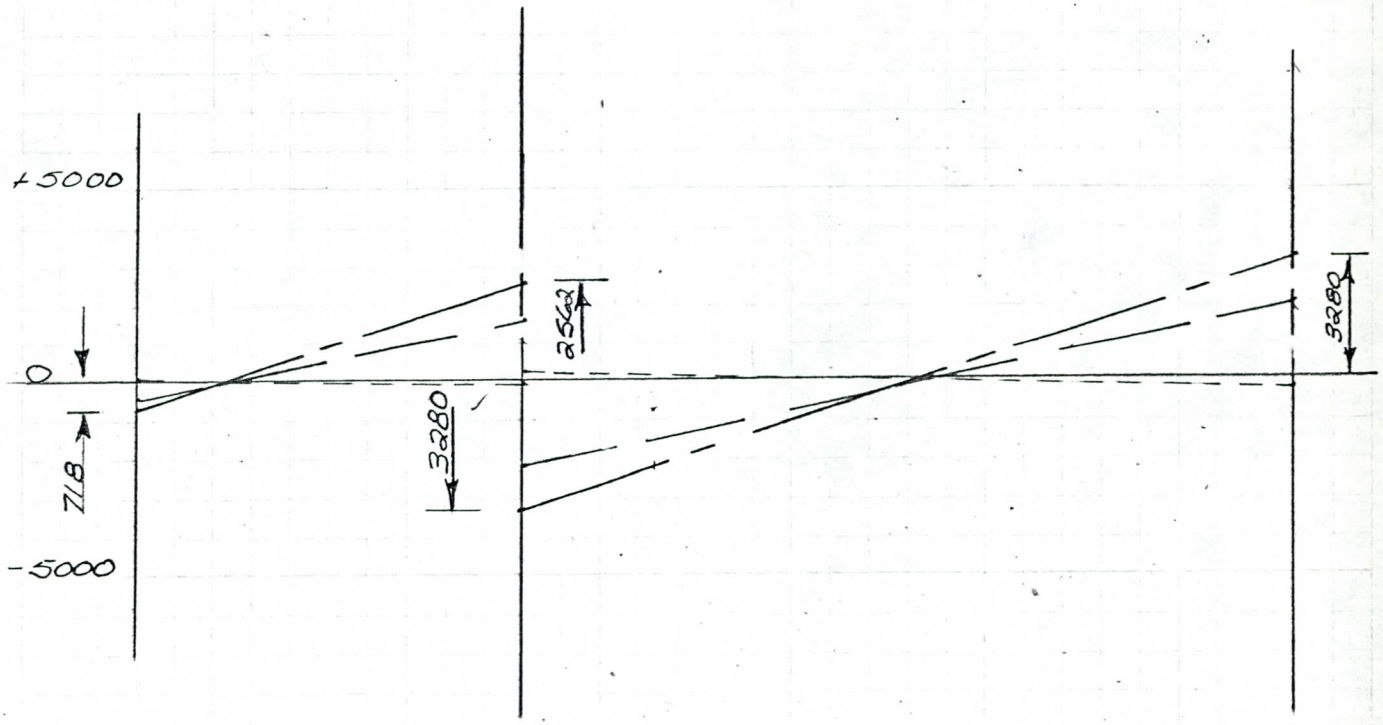
STATE		PROJECT		
Arizona		Buckhorn Mesa WPS, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-12-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 117 OF
Emergency Spillway (Apron)				

Section ② $l = 20$ $M_c = 50\,W$

x/l	M_x/M_c	No Backfill $W = -17$ ✓	No Flow $W = 212$ ✓	Flowing $W = 328$ ✓
0.5	1.0	-850 ✓	10,600 ✓	16,400 ✓
0.4	0.96	-816 ✓	10,176 ✓	15,744 ✓
0.3	0.84	-714 ✓	8,904 ✓	13,776 ✓
0.2	0.64	-544 ✓	6,784 ✓	10,496 ✓
0.1	0.36	-306 ✓	3,816 ✓	5,904 ✓



STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-12-76	D Ridalla	1-28-76	2005
SUBJECT				SHEET 118 OF
Emergency Spillway (Apron)				



At Section ③

Before Fill

Sidewall Moment, $M_{ab} = 0$ $\quad W = -69$

$$M_{ba} = \frac{(1/4)(-69)(9000)}{80} = -1940 \text{ ft.-lbs.}$$

$$V_{ab} = -\tfrac{1}{2}(-69)(10) + \frac{-1940}{10} = 345 - 194 = 151 \text{ lbs.}$$ ✓

$$V_{ba} = (-69)(10) + 151 = -539 \text{ lbs.}$$ ✓

$$V_{bc} = -\tfrac{1}{2}(-69)(20) = 690 \text{ lbs.}$$ ✓

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-12-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 119 OF
Emergency Spillway (Apron)				

After Fill No Flow

$M_{ab} = 0$, $W = 110$

$$M_{ba} = \frac{(1/4)(110)(9000)}{80} = 3095 \text{ ft-lbs.}$$

$$V_{ab} = -\tfrac{1}{2}(110)(10) + \frac{3095}{10} = -550 + 310 = -240 \text{ lbs.}$$

$$V_{ba} = (110)(10) - 240 = 860 \text{ lbs.}$$

$$V_{bc} = -\tfrac{1}{2}(110)(20) = -1100 \text{ lbs.}$$

After Fill - Flowing

$M_{ab} = 0$, $W = 352$

$$M_{ba} = \frac{(1/4)(352)(9000)}{80} = 9900 \text{ ft-lbs.}$$

$$V_{ab} = -\tfrac{1}{2}(352)(10) + \frac{9900}{10} = -1760 + 990 = -770 \text{ lbs.}$$

$$V_{ba} = (352)(10) - 770 = 2750 \text{ lbs.}$$

$$V_{bc} = -\tfrac{1}{2}(352)(20) = -3520 \text{ lbs.}$$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-12-76	D.R. Riddle	1-28-76	2005

SUBJECT: Emergency Spillway (Apron) — SHEET 120 OF

Moment & Shear Diagrams

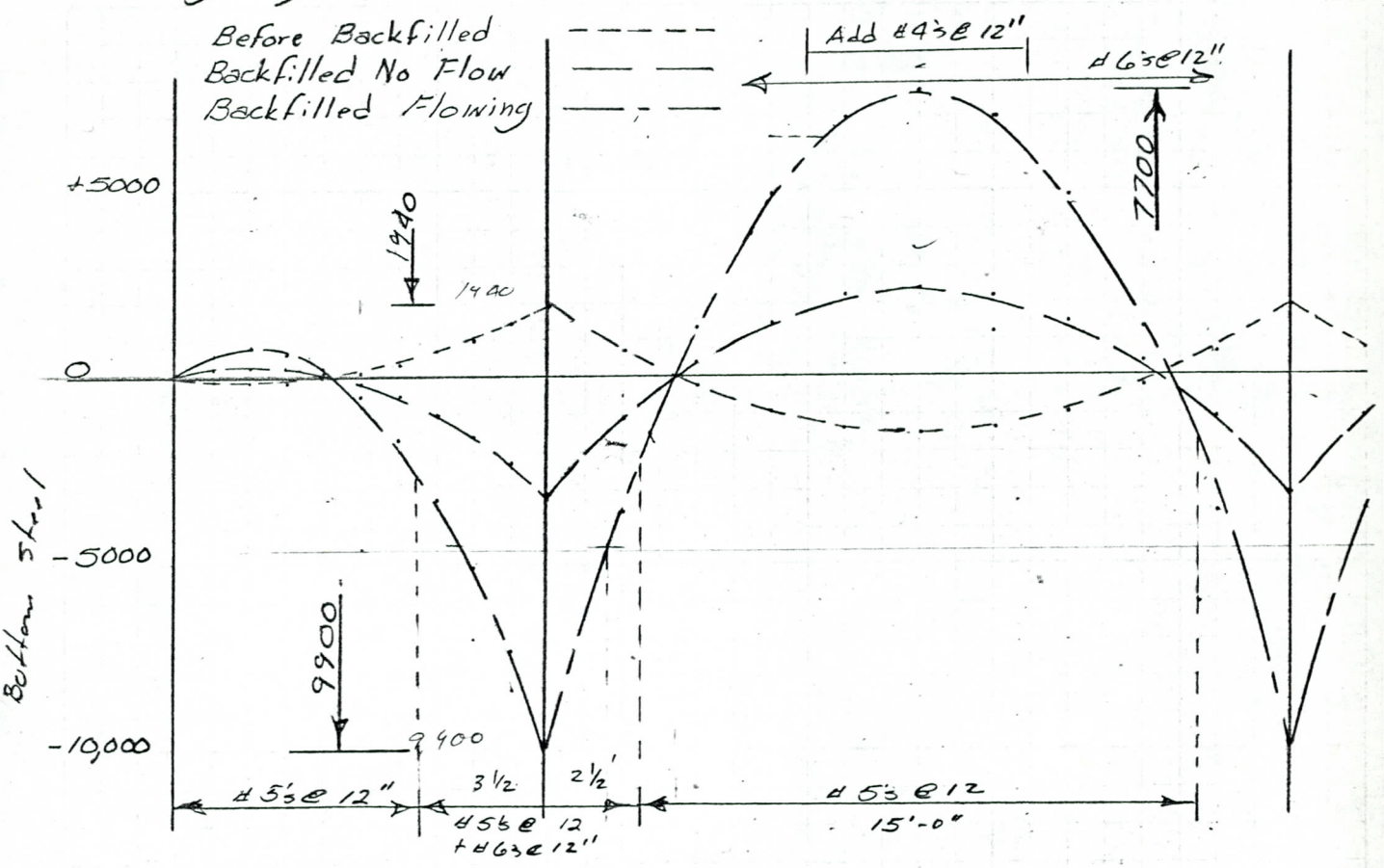
Section ③ $l = 10$ $M_E = 12.5W$

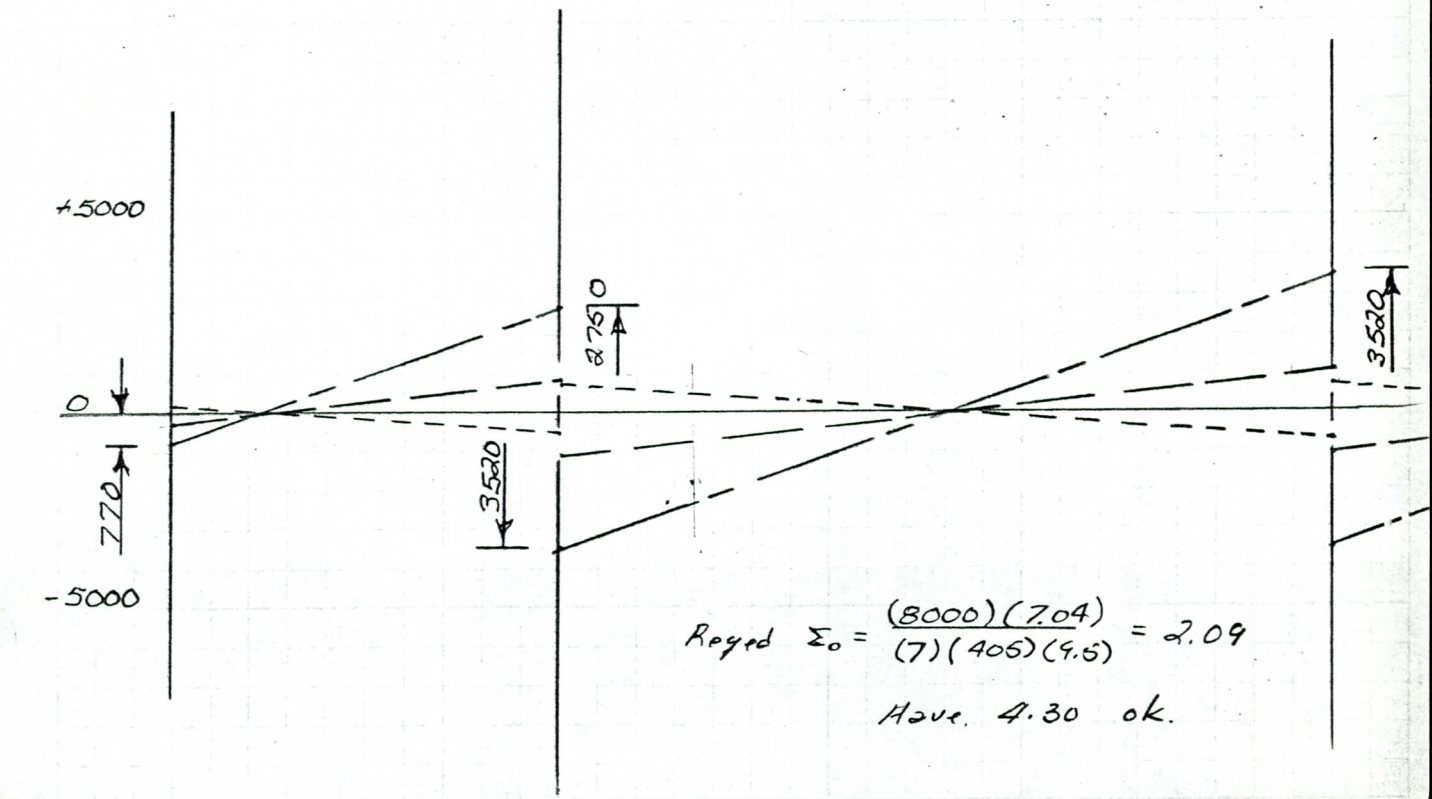
X/l	M_x/M_E	No Fill W = -69	No Flow W = 110	Flowing W = 352
0.5	1.0	-863	1375	4400
0.4	0.96	-828	1320	4224
0.3	0.84	-725	1155	3696
0.2	0.64	-552	880	2816
0.1	0.36	-310	495	1584

Section ③ $l = 20$ $M_E = 50W$

X/l	M_x/M_E	No Fill W = -69	No Flow W = 110	Flowing W = 352
0.5	1.0	-3450	5500	17,600
0.4	0.96	-3312	5280	16,896
0.3	0.84	-2898	4620	14,784
0.2	0.64	-2208	3520	11,264
0.1	0.36	-1242	1980	6,336

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-12-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 121 OF
Emergency Spillway (Apron)				





Reqd $\Sigma_o = \frac{(8000)(7.04)}{(7)(405)(9.5)} = 2.09$

Have 4.30 ok.

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-13-76	D Riddle	1-28-76	2005

SUBJECT Emergency Spillway (Apron) SHEET 122 OF

Bottom Steel (Transverse)

At Sidewall $M = 0$

① V = -698 (Backfilled No Flow)
② V = -718 (Back Filled Flowing)
③ V = -770 (Backfilled Flowing)

At Sill Max M =

① 8972 ft-lbs (Backfilled No Flow)

② 9225 ft-lbs (Backfilled Flowing)

③ 9900 ft-lbs (Backfilled Flowing)

Max. Shear

① 3190 lbs (Backfilled No Flow)

② 3280 lbs (Backfilled Flowing)

③ 3520 lbs (Backfilled Flowing)

Temp Steel
(.002)(12)(13)
= .31
#5's @ 12

Effective depth $d = 13 - 3.5 = 9.5"$

Required As for 9.9 Kips = $0.69 \square"$

Use #8's @ 12" $A_o = 0.79$ $\Sigma_o = 3.14$

$U = 4.8\frac{\sqrt{4000}}{D} = 485$

Req'd $\Sigma_o = \frac{8000}{(7)(U)} V/d = \frac{8000}{(7)(304)} \times \frac{3.52}{9.5} = 1.39$ ✓ ok

Bottom Steel (Longitudinal)

Temp Steel req'd $A_o = (P_t)(b)(\text{depth})$

$= (.002)(12)(13) = 0.31 \square"$ ✓

Use #5's @ 12" ✓

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-13-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 123 OF
Emergency Spillway (Apron)				

Top Steel (Transverse)

End Span Max. M occurs ③ at sill

M = 1940 ft. lbs (Before Backfilled)

V = 2760

Reqed As for 1.94 Kips < Temp Steel

Temp Steel = (.003)(12)(13) = 0.47 - Use #6's @ 12"

As = 0.44 Zo = 2.36

Interior Spans.

Max Moment

① = 6,978 ft-lbs (Backfilled No Flow)

② = 7,175 ft.-lbs (Backfilled Flowing)

③ = 7,700 ft lbs (Backfilled Flowing)

Reqed As for 7.7 kips = 0.46

Use Temp. Steel As = 0.47 - #6's @ 12"

Top Steel (Longitudinal)

Use Temp Steel > 30' use #6's @ 12"

Checked by ES 47 6"@12"
OK

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-22-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 138 OF
Emergency Spillway (Floor Blocks)				

Reference - Calc. Made by P. Monville for the Principal Spillway Outlet Structure Sht. 21, 22, & 23 of 25

Dynamic Load

$$F = \frac{Q W}{g} (v - v_0)$$

Q = discharge cfs = 17,513/260 = 67.4 ✓ cfs/A.
W = Unit Wt. of fluid = 62.4 lbs/ft³
g = 32.2 ft/sec.
v = Velocity of Jet after block
v_0 = Velocity of Jet hitting block - 6.9 ft/sec.

Q = 17,513

Assumptions

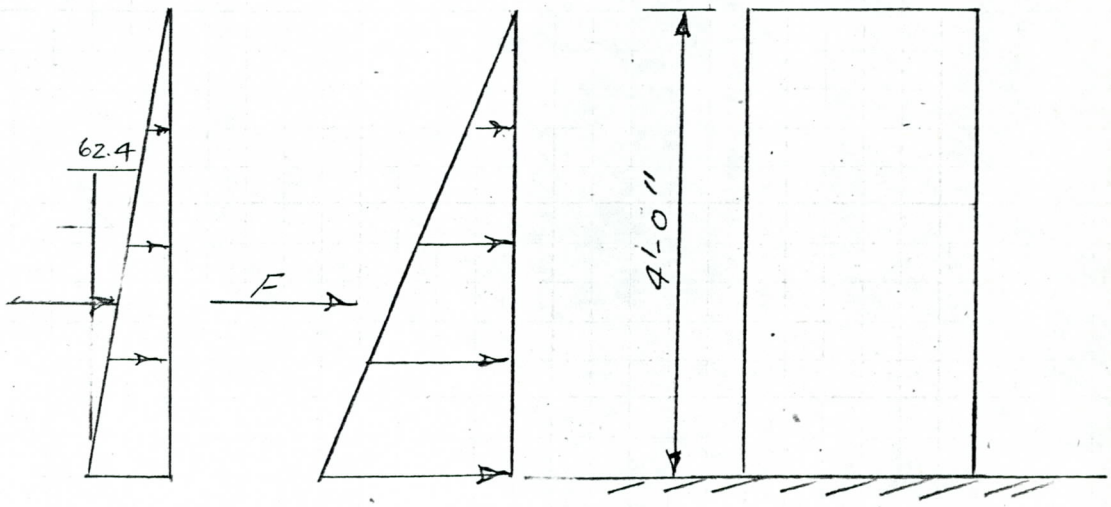
1. Q is even on all block
2. $v_0 = v_1 = 6.9$ ft./sec
3. $v = 0$

Floor Blocks

$Q = 67.4 \times 2.0 = 134.8$ ✓ cfs per block

$$F = \frac{(134.8)(62.4)(6.9)}{32.2} = 1803 \text{ ✓ lbs.}$$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	1-22-76	D Riddle	1-28-76	2005
SUBJECT				SHEET 139 OF
Emergency Spillway (Floor Blocks				



Total Force = 1803 + 62.4 x 4/2 = 1927 lbs ✓

Use 1950 ✓

Incorrect but temp stl still governs RMH 1/27/76

$V = F_{tot} = 1950$ lbs

$d = 2 \times 12 - 2.5 = 21.5$ ✓

$v = \frac{1950}{(2)(21.5)} = 45$ psi ✓ < 70 psi ok

$M_{max} = \frac{(2)(1950)}{(3)(2)} = 650$ lbs/ft. ✓

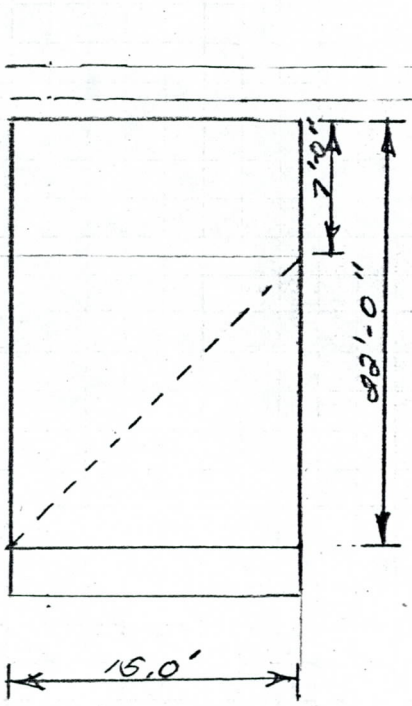
Floor block

Only Temp Steel required = .002 x 12 x 16

= 0.38 □" ✓

Use □ 4's @ 6" both ways = 0.39 ✓
or d 6's @ 12" = 0.44

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	2-2-76			2005
SUBJECT				SHEET 140 OF
Emergency Spillway				



$M = 1/6 (y-h)^2 (y+2h)$

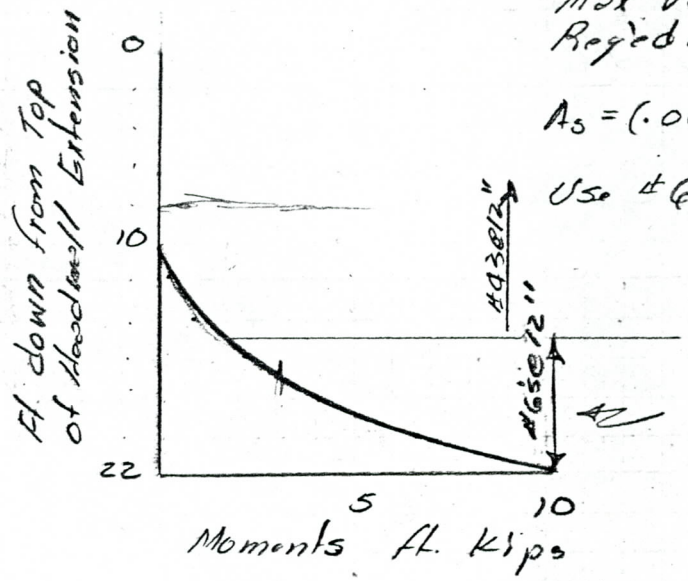
Where $h = 10$

Equivalent Fluid Press. Differential
10 pcf acting either direction
Vertical Cantilever

$y = 12'$	$M = (1/6)(2)^2(32)$	$= 213$
14	$M = (1/6)(4)^2(34)$	$= 907$
16	$M = (1/6)(6)^2(36)$	$= 2160$
18	$M = (1/6)(8)^2(38)$	$= 4053$
20	$M = (1/6)(10)^2(40)$	$= 6667$
22	$M = (1/6)(12)^2(42)$	$= 10,080$

Horizon

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	2-2-76			2005
SUBJECT				SHEET 141 OF
Emergency Spillway (Headwall Extension)				



Max Vertical Steel Req'd. For Temp

$A_s = (.002)(12)(16) = 0.38$ in²

Use #6's @ 12" = 0.44

Note: 8' of the Extension is exposed

~~Top Match Headwall Use #6's @ 12"~~

3 kips

Max Moment 10.1 kips

18.0 - 2.5

effective depth = 15.5 $A_s = 0.42$

Use #6's @ 12" Reqd $\Sigma_o = \frac{(8000)(1.92)}{(7)(405)(155} = 0.35$

$V = w/2 (y^2 - h^2)$

y = 12'	$V = (5)(12^2 - 10^2)$	= 220 lbs
14	$V = (5)(14^2 - 10^2)$	= 480
16	$V = (5)(16^2 - 10^2)$	= 780
18	$V = (5)(18^2 - 10^2)$	= 1120
20	$V = (5)(20^2 - 10^2)$	= 1500
22	$V = (5)(22)^2 - 10^2)$	= 1920

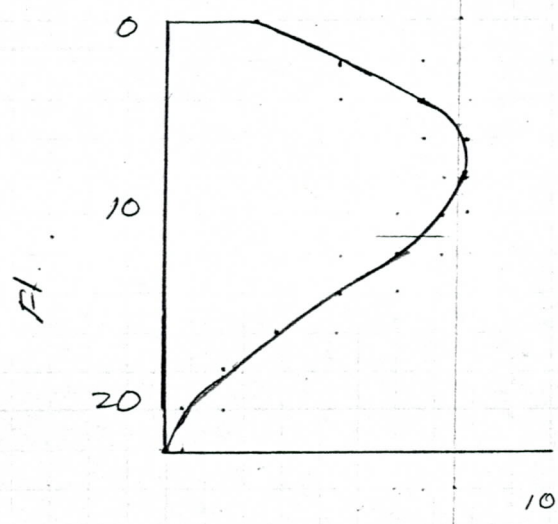
$v = \frac{1920}{(12)(15.5)} = 10.3$ ok < 70

$\Sigma_o =$

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	2-2-76	T.D. Ruddle	2-3-76	2005

SUBJECT Emergency Spillway (Headwall Extension) SHEET 142 OF

2	$(5)(2)(15.0)^2$	=	2250 ✓
X = 4	$M = (5)(4)(15.0)^2$	=	4500 ✓
6	$(5)(6)(15.0)^2$	=	6750 ✓
7	$(5)(7)(15.0)^2$	=	7875 ✓
8	$(5)(8)(14.6)^2$	=	7840 ✓
10	$(5)(10)(12.0)^2$	=	7200 ✓
12	$(5)(12)(10.0)^2$	=	6000 ✓
14	$(5)(14)(8.0)^2$	=	4480 ✓
16	$(5)(16)(6.0)^2$	=	2880 ✓
18	$(5)(18)(4.0)^2$	=	1440 ✓
20	$(5)(20)(2.0)^2$	=	400 ✓



Max Horizontal Moment.

8 kips.

As reqd = 0.33

#6's @ 12" = 0.44

#5's @ 12" = 0.31

Use #6's need for temp anyway

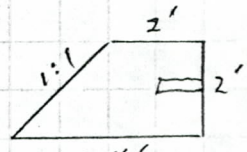
(.002)(12)(16) = 0.38

STATE	PROJECT			
Arizona	Parkhorn Mesa W.P.P.-Spookhill Dam			
BY	DATE	CHECKED BY	DATE	JOB NO.
O R. Riddle	2-11-76			2005

SUBJECT Design Drain Fill & Gravel filter — SHEET 1 OF 9

Graded Gravel filter

$$\frac{85\%\ \text{size of gravel}}{\text{diam. of Perforation}} \geq 1.0$$



Pipe is 4" dia with ¼" dia perforation
four rows 3 in spacing see ASTM C-211

1½" = 38.1 mm 85% = 18.0 mm

Pipe Perf. = 0.25 x 25.4 = 6.35 mm

$$\frac{85\%\ \text{grav.}}{\text{Pipe Perf.}} = \frac{18.0}{6.35} = 2.83 > 1.0 \quad \text{ok} \quad \text{use } 1\tfrac{1}{2}"$$

to $D_{15} = \#10$

Drain fill Material

(see Drop Spwg Sec 11)

$$\frac{15\%\ \text{Size of Gravel}}{85\%\ \text{Size of Drain}} = \frac{1.80}{16.0} = 0.11 < 4 \text{ ok}$$

$$\frac{15\%\ \text{Size of Gravel}}{15\%\ \text{Size of Drain}} = \frac{1.80}{0.42} = 4.29 > 4.0 \text{ ok}$$

$$\frac{15\%\ \text{Size of Drain}}{85\%\ \text{Size of Backfill}} = \frac{0.42}{4.76} = 0.09 < 4.0 \text{ ok}$$

$$\frac{15\%\ \text{Size of Drain}}{15\%\ \text{Size of Backfill}} = \frac{0.42}{0.092} = 4.56 > 4.0 \text{ ok}$$

$D_{100} = 1\tfrac{1}{2}"$ $D_{50} = \#30$ $D_0 = \#200$

∴

Sieve Size	% Passing
1½"	100%
#4	75 - 100
#10	25 - 70
#40	5 - 20
#200	0 - 3

STATE	PROJECT			
Arizona	Buckhorn Mesa WPP Spookhill Dam			
BY	DATE	CHECKED BY	DATE	JOB NO.
D Riddle	2-11-76			2005

SUBJECT
Design Drain Filter Emer. Spwy Drop Str. SHEET 2 OF 9

k = Coeffic. of Permeability = 87.8 $\frac{\text{w. ft}}{\text{w. ft}^2/\text{day}}$ (See Geology Report Hole #7) 2N 5(2.223+00 ℄ of Dam

$i = \frac{H}{L} = \frac{16.97}{21} = 0.868.$

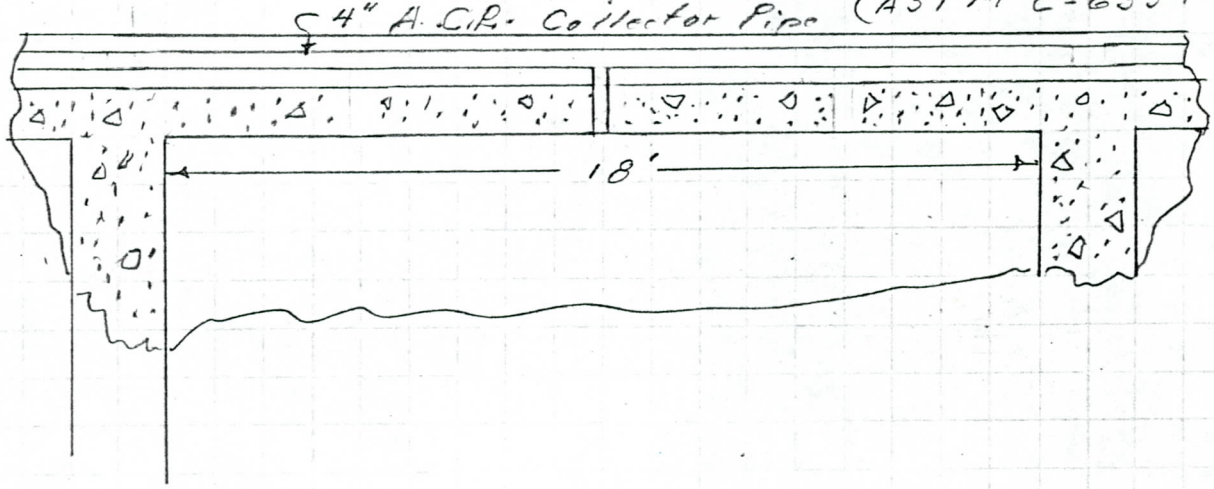
A = Area = (19.97)(1) = 19.97

$Q = k\,i\,a = (87.8)(0.808)(19.97) = 1,416.7 \frac{\text{cu ft}}{\text{cu ft}^2\,\text{Day}}$

Q = 0.0164 c.f.s. P.f = 8.4 G.P.M. = 1.0 sq in

Aver thickness of 9.0f, $\alpha = 45°$

, Chart ~~B-A~~ A-3 20 - $\frac{1}{4}$" = 1.0 sq in openings OK



1974 Dodge Manual 1.57+20% = 1.88 ft Installed

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	2-18-76			2005
SUBJECT				SHEET 3 OF 9
Emergency Spillway Drain Material Check				

S.M. Nole #1 ≠ N.E.H. Sec. 11

Limits

Piping Control Requirements P.I. ≤ 7

Backfill Material - SM

$D_5 \geq$ 200 sieve size

$D_{15} \leq 4 \times D_{85}$ size of Base (Backfill Material)

$D_{15} \leq 4 \times 4.76 = 19.04$ mm

$D_{50} \leq 25 \times D_{50}$ size of Base (Backfill Material)

$D_{50} \leq 25 \times 1.18 = 29.50$ mm

$D_{100} \leq 3''$

$Cu < 20 = D_{60}/D_{10}$

$\frac{1}{4}'' = 6.35$mm

For the pipe $D_{85} \geq$ dia of holes = 6.35 mm.

Also D_{15} filter $\geq D_{15}$ base $\times 5$

D_{15} filter $\geq 0.092 \times 5 = 0.46$ mm.

Select Limits that a blending of concrete aggregates can be used

Fine

Sieve	% Passing

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	2-18-76			2005
SUBJECT				SHEET 4 OF 9
Check Emergency Spillway Drain Material				

ASTM C-33

Fine Aggregate

Sieve	% Passing
3/8"	100
# 4	95 to 100
# 8	80 to 100
# 16	50 to 85
# 30	25 to 60
# 50	10 to 30
#100	2 to 10

Coarse Aggregate (467)

Sieve	% Passing
2"	100
1½"	95-100
¾"	35-70
3/8"	10-30
#4	0-5

Based on 100 lbs. try using 25 lbs fine aggregate & 75% Coarse aggregate

	Min.	Max.
2"	25+75 = 100	25+75 = 100
1½"	25+71 = 96	25+75 = 100
¾"	25+26 = 51	25+53 = 78
3/8"	25+ 8 = 33	25+23 = 48
#4	24+ 0 = 24	25+ 4 = 29
#8	20+ 0 = 20	25+ 0 = 25
#16	13+ 0 = 13	21+ 0 = 21
#30	6+ 0 = 6	15+ 0 = 15
#50	3+ 0 = 3	8+ 0 = 8
#100	1+ 0 = 1	3+ 0 = 3

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	2-18-76			2005
SUBJECT				SHEET 5 OF 9
Check Emergency Spillway Drain Filter				

Gradition of Blend (25% Fine 75% Coarse

Sieve	% Passing
2"	100
1½"	96 to 100
¾"	51 to 78
⅜"	33 to 48
# 4	24 to 29
# 8	20 to 25
# 16	13 to 21
# 30	6 to 15
# 50	3 to 8
#100	1 to 3
#200	0 to 1

Drain Fill Gradation

Sieve	% Passing
2"	100
1"	55-100
⅜"	30-60
#16	10-25
#50	3-10
#200	0-3

No good!

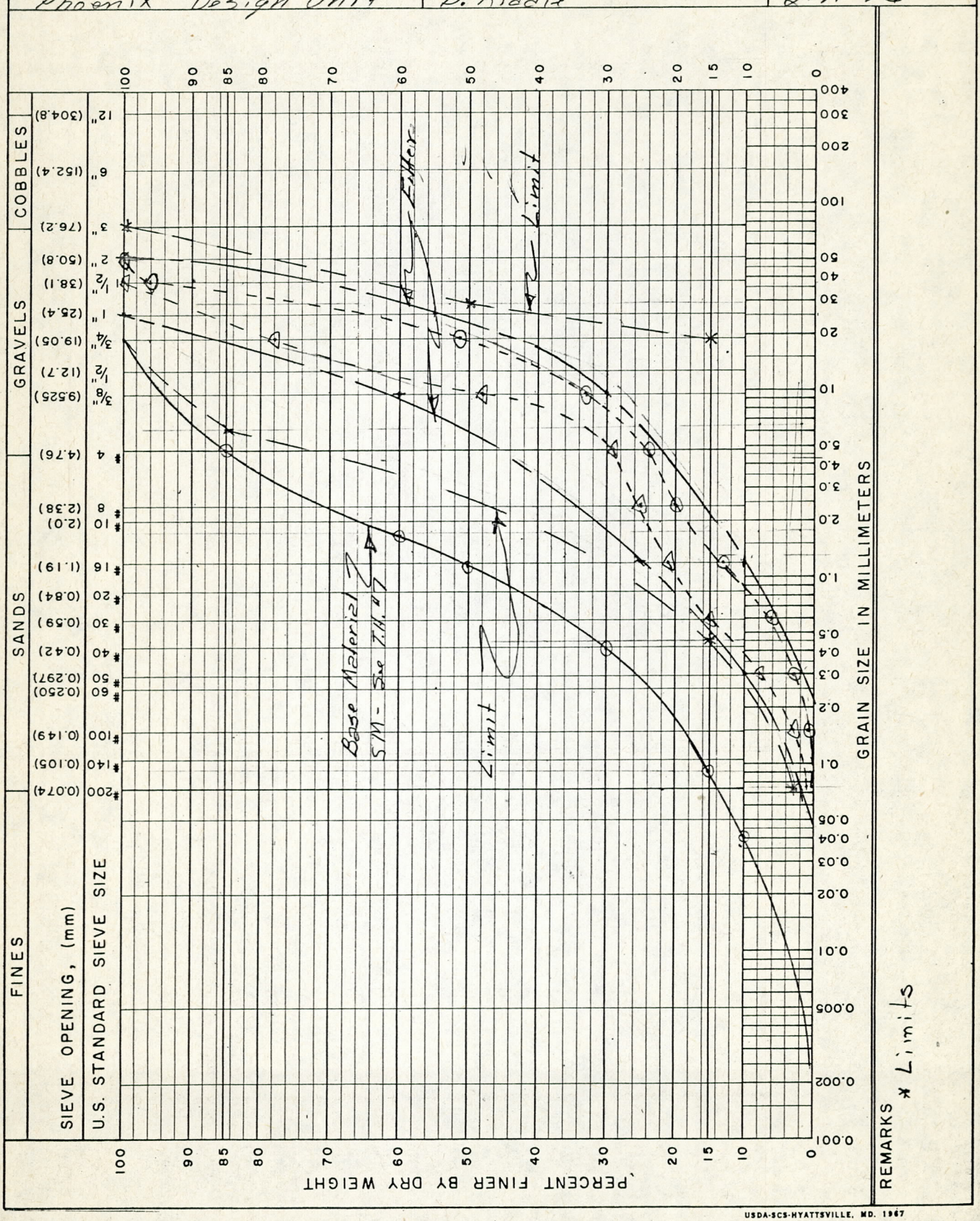
Form SCS 130
5-65

Sheet 6 of 9

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	DRAIN MATERIALS

PROJECT and STATE: Buckhorn Mesa, WPP, Spook Hill FRS - Arizona

DESIGNED AT: Phoenix Design Unit | BY: D. Riddle | DATE: 2-11-76



REMARKS * Limits

USDA-SCS-HYATTSVILLE, MD. 1967

STATE Arizona | PROJECT Buckhorn Mesa WPP, Spook Hill FRS
BY L.L. Sullivan | DATE 2-19-76 | CHECKED BY | DATE | JOB NO. 2005
SUBJECT Emergency Spillway Drain Fill | SHEET 1 OF 9

Hole	D.I.	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	Dmax.
Sta. 202+00 (6)	(SC-SM (5))	0.0058 ✓	0.022 ✓	0.049	0.27	0.90 ✓	3.6	19.0
Sta. 223+00 (7)	(SW-SM N.P.)	0.04	0.092	0.41	1.18	1.7	4.76	19.0
E.S. Sta. 18+00 (221.1)	(SP-SM N.P.)	0.064	0.270	0.88	1.60	2.2	4.90	38.1
Borrow Sta. 298+70 (2107)	(SC-SM (7))	0.011	0.029	0.13	1.05	1.6	4.76	38.1
Sta. 146+00 (2108)	(SM-1 N.P.)	0.01	0.023	0.04 ✓	0.17 ✓	0.71	3.8	38.1
Borrow Sta. 277+00 (2109)	(SM-1 N.P.)	0.025	0.04	0.31	1.45	2.2	4.76	38.1
Sta. 187+00 (2112)	(SM-1 N.P.)	0.02	0.037	0.32	1.45	2.2	5.4	38.1
Sta. 263+00 (2120)	(SM-2 N.P.)	0.02	0.031	0.11	0.98	1.5	4.3	38.1
Sta. 295+00 (2134)	(GM N.P.)	0.038	0.085	0.7	4.4	6.9	21.0	38.1
Sta. 106+00 (2103.1)	(SM-1 N.P.)	0.0072	0.0145	0.04 ✓	0.48	1.6	3.8	38.1
Sta. 106+00 (2103.2)	(SM-1 N.P.)	0.022	0.036	0.21	1.0	1.6	4.8	19.0

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP, Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
J.L. Sullivan	2-19-76			2005
SUBJECT				SHEET 8 OF 9
Emergency Spillway Drain Fill				

See Sht. 7

Use T.H. 2108 To design filter

$D_{15} = 0.023$ $D_{50} = 0.17$ $D_{85} = 3.8$

$5 \times D_{15} \leq D_{15} \leq 4 \times D_{85}$

$= 0.115 \leq D_{15} \leq 15.2$

$D_{50} \leq 25 \times D_{50} = 4.25$

$D_{85} \geq 6.35$

$D_{100} \leq 3"$

Drain Fill Gradation

Sieve	% Passing
3"	100
3/4"	76 to 100
#4	52 to 80
#16	28 to 56
#40	8 to 38
#200	0 to 3

Use

C_u $D_{60}/D_{10} = 7.9/0.49 = 16.12 < 20$ ok

$1.5/0.1 = 15.0 < 20$ ok

Form SCS 130
5-65

(210 E)

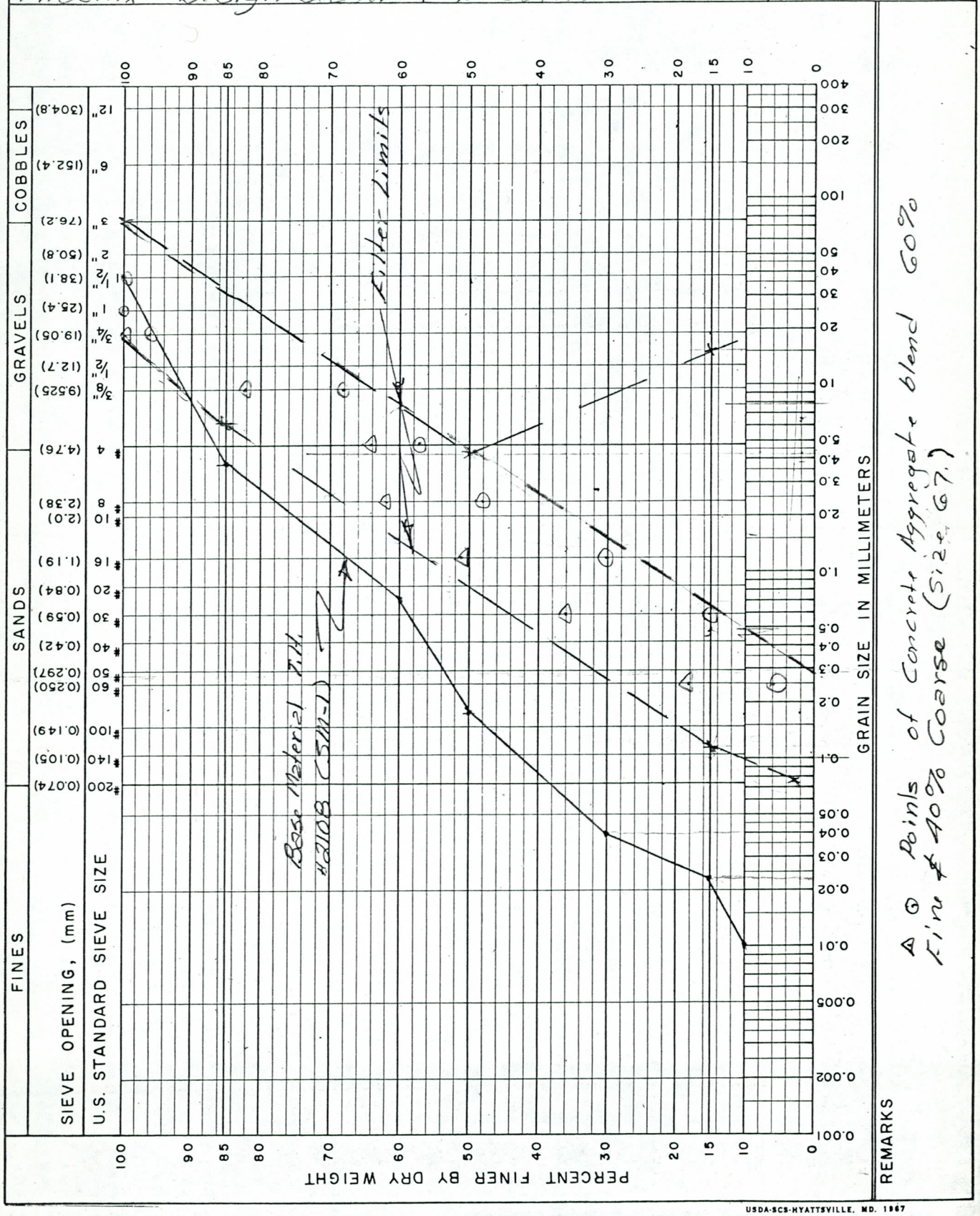
346 of 429

Sheet 9 of 9

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	DRAIN MATERIALS

PROJECT and STATE: Buckhorn Mesa WPP, Spook Hill FRS

DESIGNED AT	BY	DATE
Phoenix Design Section	J.L. Sullivan	2-19-76



Use

REMARKS

△ 60 Points of Concrete Aggregate blend 60%
Fine #10 Coarse (Size 67)

USDA-SCS-HYATTSVILLE, MD. 1967

STATE		PROJECT		
Arizona		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-2-16			

SUBJECT Structural Design E.S.

SHEET 1 OF

Redesign emergency spillway abutments

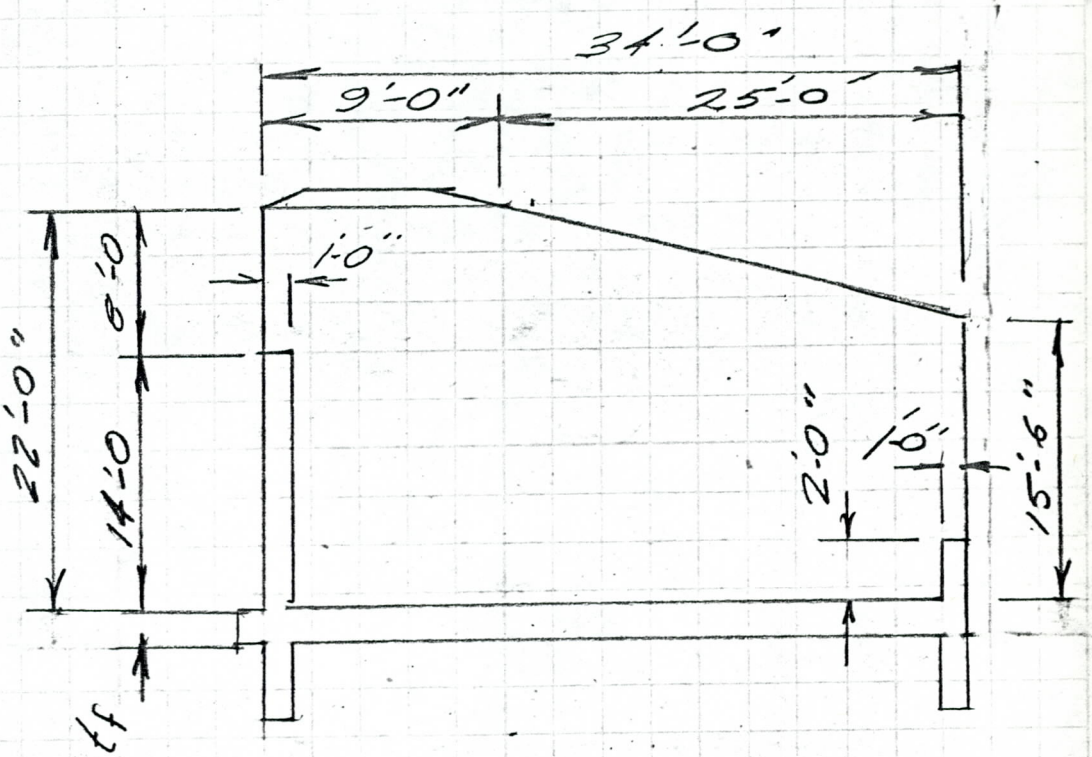


Table 12 p125 Concrete Manual USDI Bu Rec
1.6* < γ < 1.85*
*T/CY

Sidewalls

Use clean sand & gravel backfill
Assume: $\gamma_d = 124$ pcf
$\gamma_m = 130$ pcf
$\gamma_{sat} = 138$ pcf
$\gamma_b = 75.5$ pcf
$\phi = 36°$
$c = 0$

FHS EDS Supplement to p 2.2

For non-cohesive clean backfill & yielding retaining wall use active earth pressure

$\therefore \quad K = 0.26$

STATE Ariz | PROJECT Buckhorn Mesa WPP Spook Hill FRS

BY RJM | DATE 8-2-76 | CHECKED BY | DATE | JOB NO.

SUBJECT Structural Design ES. | SHEET 2 OF

Drainage Conditions

Table 4.1 Sec 11 NEH

For Case B, Low water table, relative permeability of foundation less than back fill, 6 Drainage

No Flow Condition

$$y_o = s + 0.1F$$

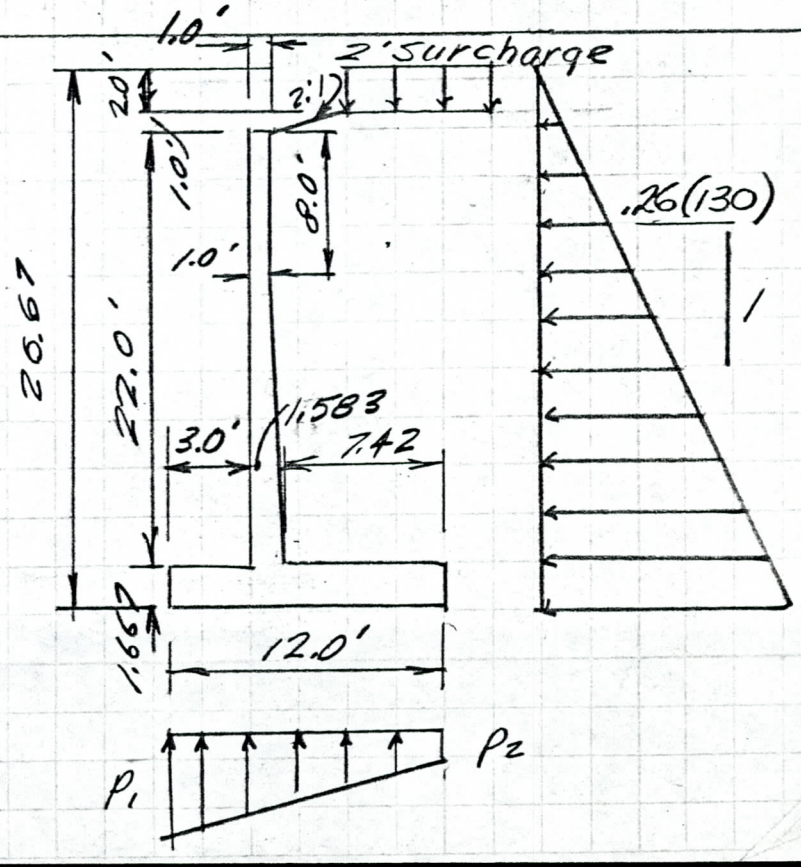
Full Flow Condition

$$y_o = .t + s + 0.1F$$

Analyze structure for As-built, No Flow and Full Flow conditions

As-Built

Trial No 1



STATE Ariz | PROJECT Buckhorn Mesa WPP Spook Hill FRS
BY PJM | DATE 8-2-76 | CHECKED BY | DATE | JOB NO.
SUBJECT Structural Design ES | SHEET 3 OF

Part		wt	Arm	Moment
Wall ①	(1)(22)(150)	3300	8.50	28,000
②	(0.583)(14)(150)/2	612	7.81	4,720
Footing	(1.667)(12)(150)	3000	6.00	18,000
Earth ①	(0.583)(8)(130)	606	7.71	4,670
②	(0.583)(14)(130)/2	530	7.61	4,040
③	(7.42)(25)(130)	24,100	3.71	89,500
		32,148		148,930
Horiz Force □	(.26)(130)(3)(23.67)	(2,400)	11.83	28,400
△	(.26)(130)(23.67)²/2	(9,470)	7.89	74,700
		32,148	7.84	252,030

$$p = \frac{V}{A}\left(1 \pm \frac{6e}{d}\right)$$

$$e = 12/2 - 7.84 = -1.84$$

$$p_1 = \frac{32,148}{12}\left(1 + \frac{(6)(1.84)}{12}\right)$$

$$= \underline{5143 \text{ psf}}$$

$$p_2 = \frac{32,148}{12}\left(1 - \frac{(6)(1.84)}{12}\right)$$

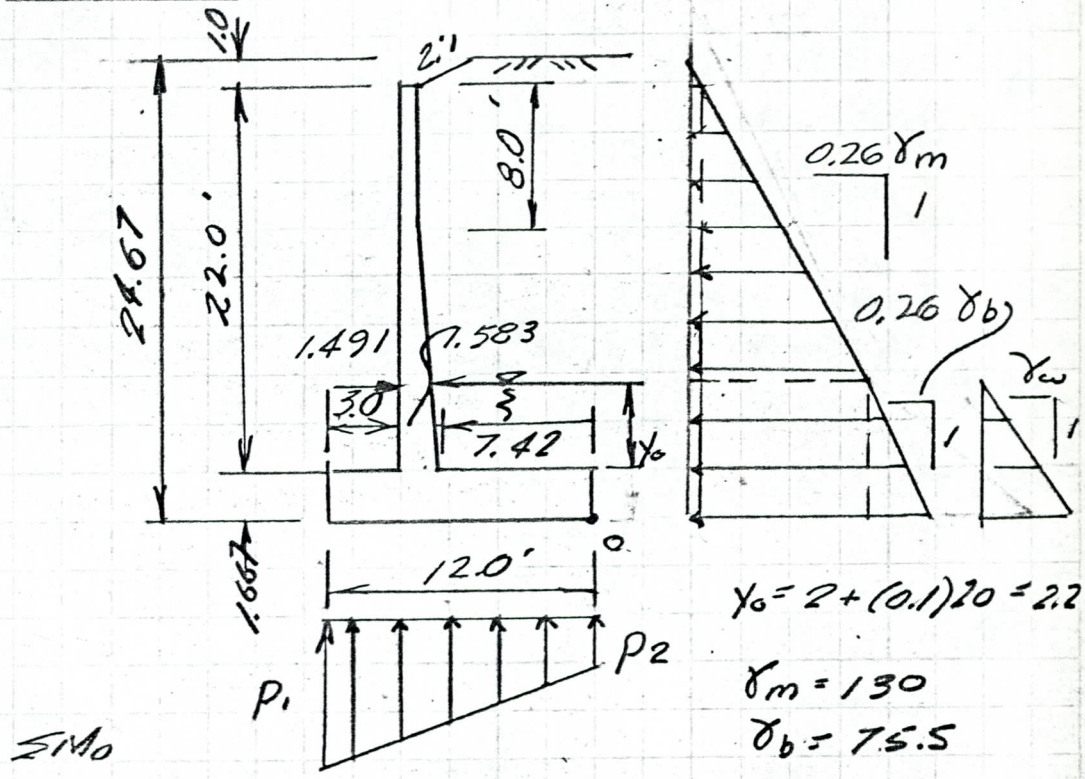
$$= \underline{214 \text{ psf}}$$

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-3-76			

SUBJECT
Structural Design ES

SHEET 4 OF

No Flow



ΣM_o

$Y_o = 2 + (0.1)20 = 2.2$

$\gamma_m = 130$

$\gamma_b = 75.5$

Part		Wt	Arm	Moment
Ret Wall	See sheet 3	6912	—	50,720
Earth ①	(.491)(8)(130)	511	7.76	3,960
②	(.491)(11.8)(130)/2	377	7.67	2,890
③	(7.51)(20.8)(130)	20,300	3.76	76,400
④	(0.092)(2.2)(75.5)/2	8	7.45	57
⑤	(7.42)(2.2)(75.5)	1,232	3.71	4,570
		29,340		138,597
Horiz Force △	(.26)(130)(19.8)²/2	(6,630)	10.47	69,400
□	(.26)(130)(3.87)(19.8)	(2,590)	1.935	5,010
△	(.26)(75.5)(3.87)²/2	(147)	1.290	190
△	(64.4)(3.87)²/2	(482)	1.290	622
↓	(.26)(130)(24.67)	(834)	12.34	10,290
		0		85,512
		29,340	7.64	224,109

STATE	PROJECT		
Ariz	Buckboard Mesa WPP Spook Hill FRS		
BY RJM	DATE 8-3-76	CHECKED BY	DATE

JOB NO.

SUBJECT Structural Design

SHEET 5 OF

$c = -1.64$

$$p_1 = \frac{29.360}{12}\left[1 + \frac{(6)(1.64)}{12}\right]$$

$$= 4450 \text{ psf}$$

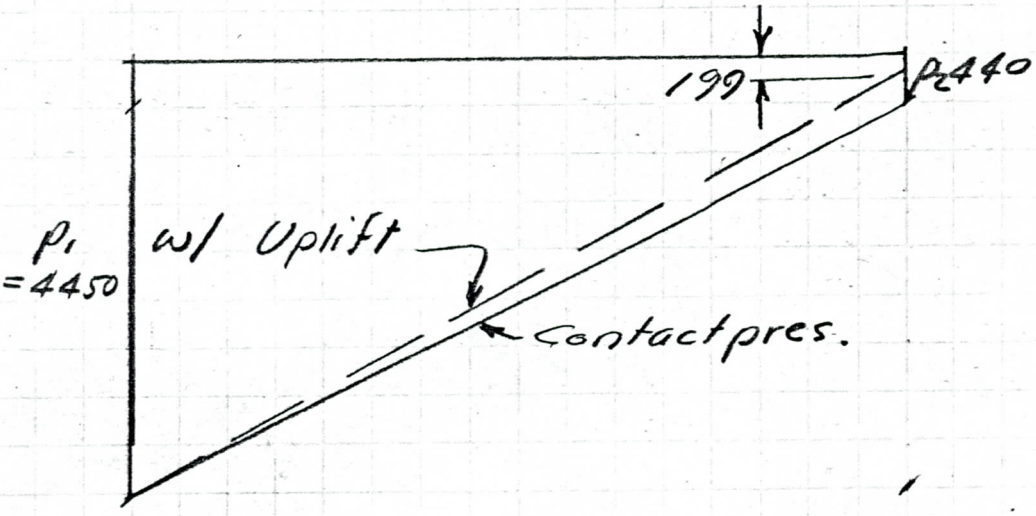
$$p_2 = \frac{29.360}{12}\left[1 - \frac{(6)(1.64)}{12}\right]$$

$$= 440 \text{ psf}$$

UPLIFT

$p_{1u} = 0$ $\quad p_{2u} = 3.87(62.4) = 241 \text{ psf}$

Total Uplift $= 12(241)/2 = 1446$ #

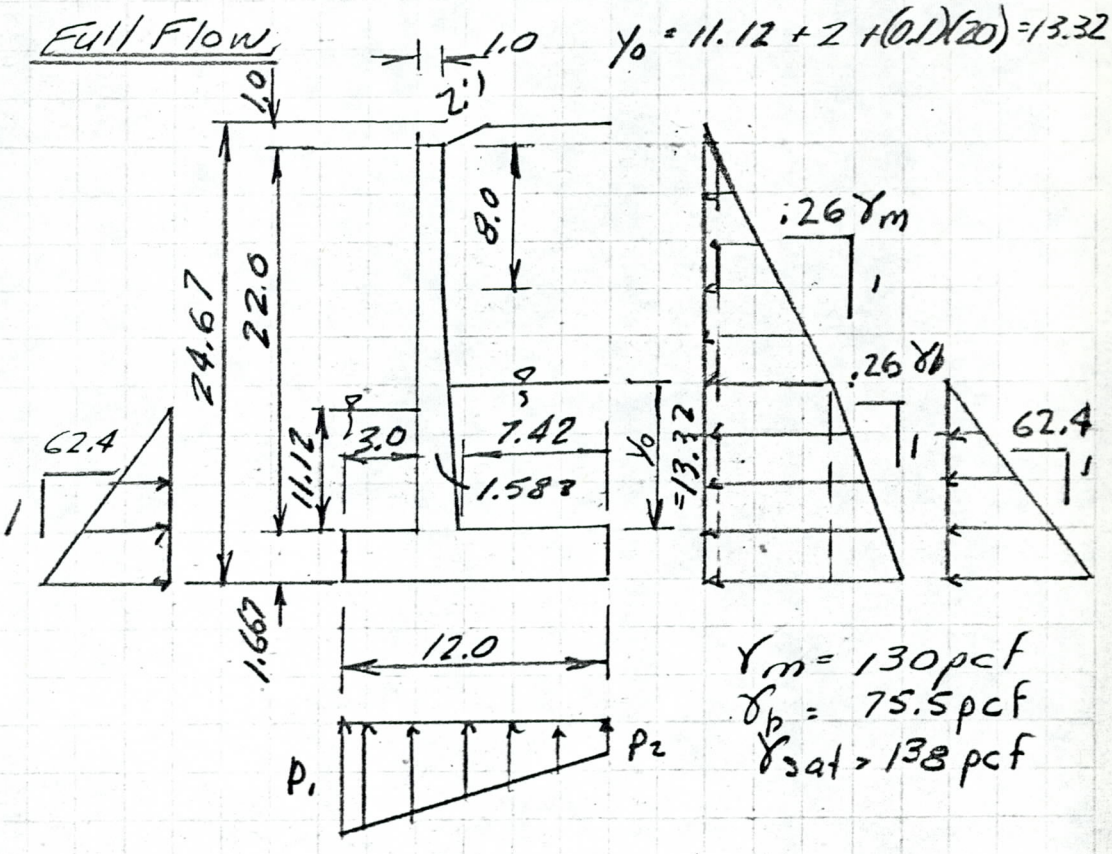


STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-4-76			

SUBJECT
Structural Design ES

SHEET 6 OF

Full Flow



Part			Wt	Arm	Moment
Ret Wall		See Sheet 3	6,912	-	50,720
Earth	①	(.583)(8)(130)	606	7.71	4,670
	②	(.583)(14)(138)/2	563	7.61	4,290
	③	(7.42)(9.68)(130)	9,340	3.71	34,600
	④	(7.42)(13.32)(138)	13,630	3.71	50,600
Water		(3)(11.12)(62.4)	2,080	10.50	21,900
Horiz Force	▮	(.26)(130)(24.67)	(834)	12.34	10,290
	◺	(.26)(130)(8.68)²/2	(1273)	17.88	23,800
	▭	(.26)(130)(8.68)(14.99)	(4400)	7.50	33,000
	◺	(.26)(75.5)(14.99)²/2	(3800)	5.00	18,990
	◺	(62.4)(14.99)²/2	(7010)	5.00	35,100
	◺	(62.4)(12.79)²/2	-(5100)	4.26	-21,700
			33,131		265,260
Uplift	▭	(12.79)(62.4)(12)	- 9,580	6.00	- 57,500
	◺	(2.20)(62.4)(12)/2	- 823	4.00	3,290
		NG	22,728	9.00	204,47?

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RLM	8-3-76			

SUBJECT Structural Design ES

SHEET 7 OF

$e = -1.84$

$$P_1 = \frac{31.051}{12}\left[1 + \frac{(6)(1.84)}{12}\right]$$

$= 4970$ psf

$P_2 = 2590(1 - 0.920)$
$= 207$ psf

UPLIFT

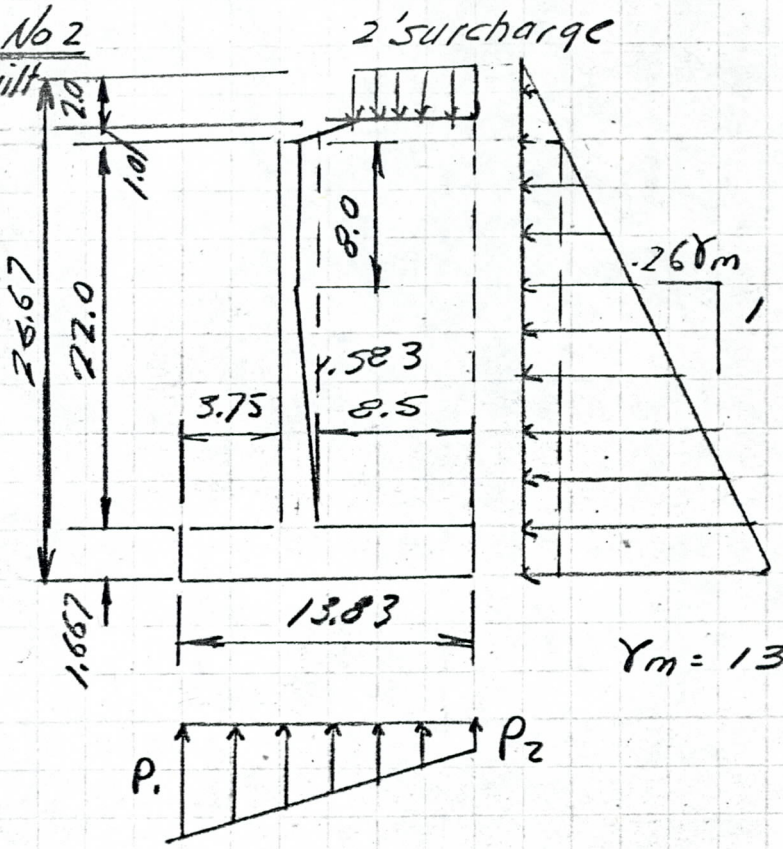
$P_{1u} = 798$ psf $\quad P_{2u} = 935$ psf

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RM	8-4-76			

SUBJECT
Structural Design ES

SHEET 8 OF

Trial No 2
As-Built



γ_m = 130 pcf

Part			Wt	Arm	Moment
Wall	①	(11)(22)(150)	3300	9.58	31,600
	②	(.583)(14)(150)/2	612	8.89	5,440
Footing		(1.667)(13.83)(150)	3460	6.92	23,900
Earth	①	(.583)(8)(130)	606	8.79	5,330
	②	(.583)(14)(130)/2	530	8.69	4,610
	③	(8.5)(26.67)(130)	29,500	4.25	125,200
Horiz Force	□	(.26)(130)(3)(23.67)	(2,400)	11.84	28,400
	△	(.26)(130)(23.67)²/2	(9,470)	7.89	74,700
			38,008	7.87	299,180

$e = -0.96$

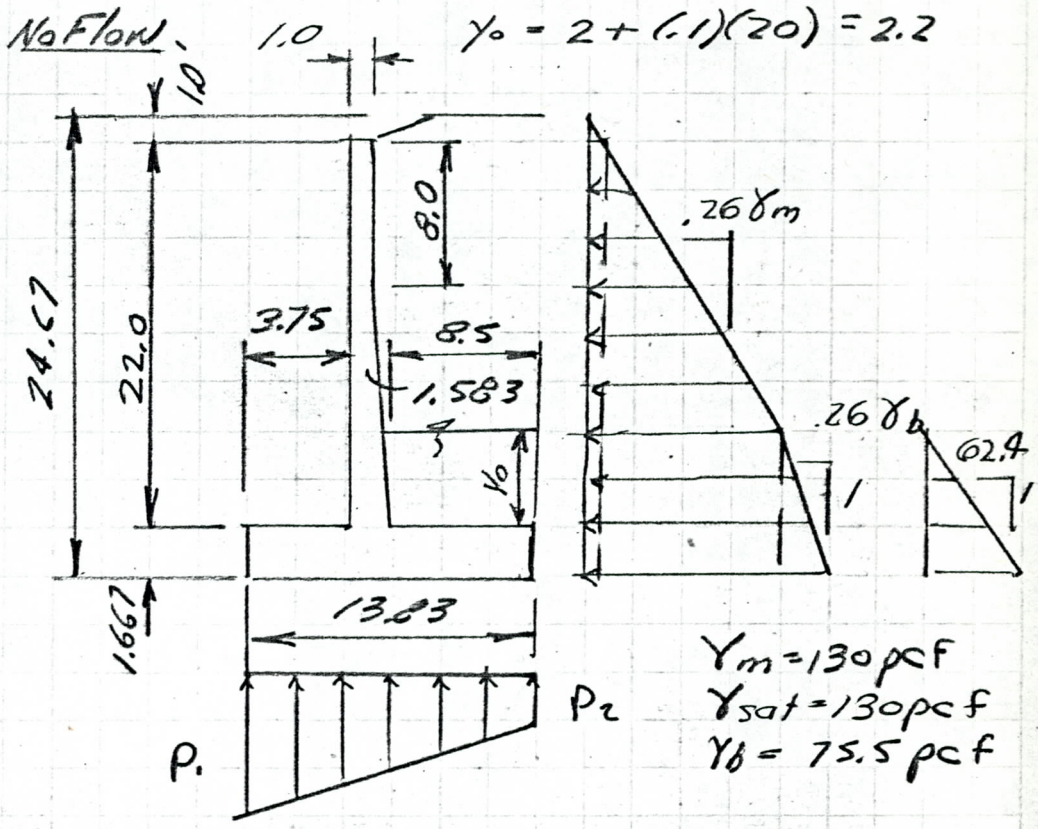
$p_1 = (38{,}000/13.83)[1 + (6)(0.96)/13.83] = 3900$ pcf

$p_2 = (38{,}000/13.83)[1 - (6)(0.96)/13.83] = 1600$ pcf

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-4-76.			

SUBJECT
Structural Design FS

SHEET 9 OF



Part			Wt	Arm	Moment
Ret Wall		See sheet 8	7,370	—	60,900
Earth	①	(.583)(8)(130)	606	8.79	5,330
	②	(.583)(14)(130)/2	530	8.69	4,610
	③	(8.5)(20.8)(130)	23,000	4.25	97,700
	④	(8.5)(2.2)(138)	2,580	4.25	10,970
Horiz Force	▯	(.26)(130)(23.67)^2/2	(800)	11.84	9,470
	△	(.26)(130)(20.8)/2	(7,310)	10.81	79,000
	□	(.26)(130)(20.8)(3.88)	(2,730)	1.940	5,290
	▯	(.26)(75.5)(3.88)^2/2	(148)	1.293	191
	△	(62.4)(3.88)^2/2	(470)	1.293	607
			34,086		274,068
Uplift	◁	(3.88)(62.4)(13.83)/2	− 1,674	4.53	− 7,580
			32412	8.22	266,488

$p_1 = (32,412/13.83)[1 + (6)(1.307)/13.83] = 3670$ psf

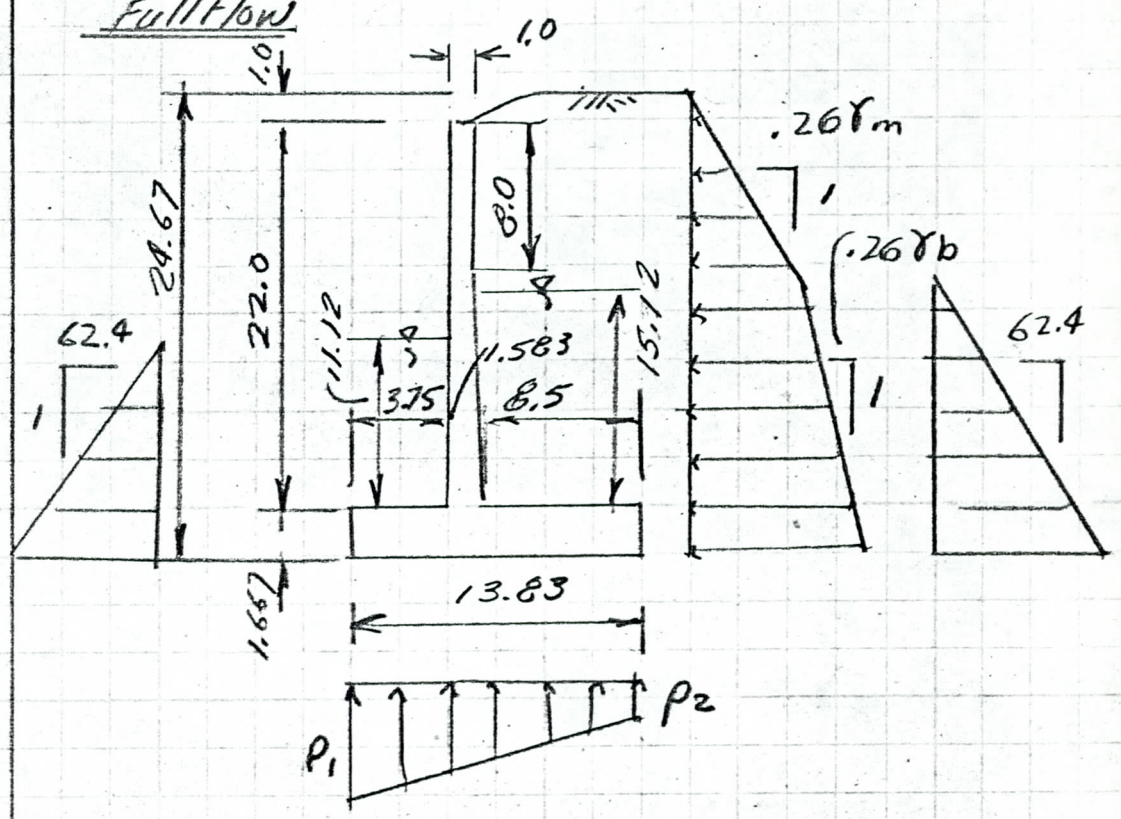
$p_2 = (32,412/13.83)[1 - (6)(1.307)/13.83] = 1075$ psf

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-6-16			

SUBJECT Structural Design

SHEET 10 OF

Full Flow



			Wt	Arm	Moment
Ret Wall		See Sheet 8	7,370	—	60,900
Earth	①	(.583)(8)(130)	606	8.79	5,330
	②	(583)(.14)(138)/2	563	8.69	4,890
	③	(8.5)(7.88)(130)	8,700	4.25	37,000
	④	(8.5)(15.12)(138)	17,740	4.25	75,400
Water		(3.75)(11.12)(62.4)	2,600	11.96	31,100
Horiz Force		See Sheet 6	(12,000)	-	85,900
			37,519		300,520
Uplift	□	(12.79)(62.4)(13.83)	-11,040	6.92	-76,400
	△	(4.00)(62.4)(13.83/2	-1726	4.61	-7,960
		c = -2.19	24,813	8.71	216,160

$p_1 = (24,813/13.83)[1 + (6)(1.79)/13.83] = 3190$ psf

OK

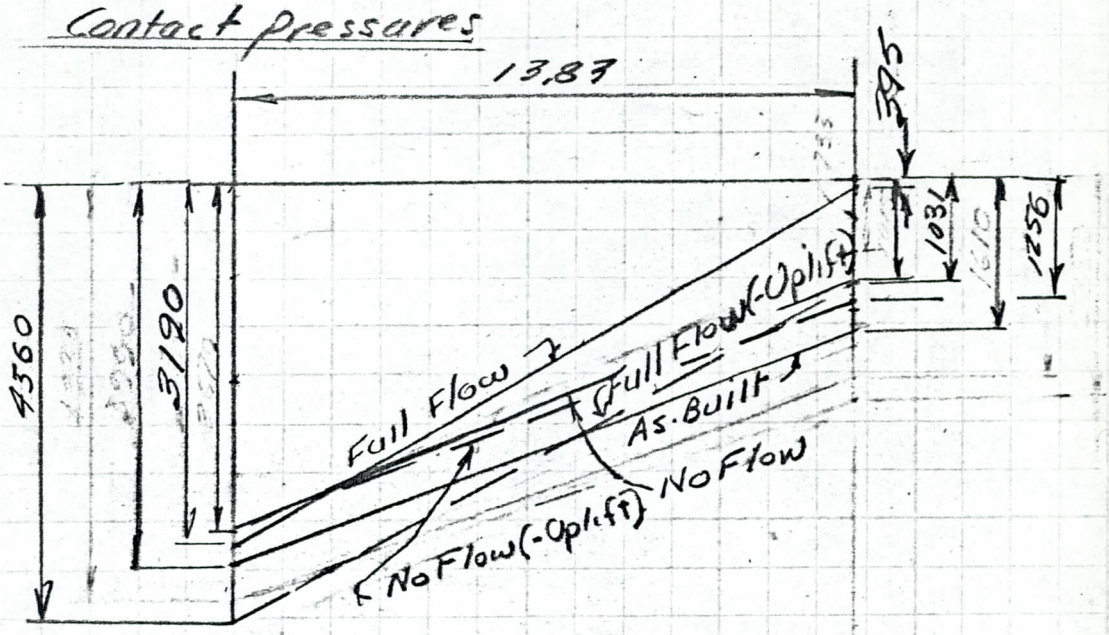
$p_2 = (24,813/13.83)[1 - (6)(1.29)/13.83] = 595$ psf

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-6-76			

SUBJECT
Sidewall Design ES

SHEET 11 OF

Contact pressures



OK - USE 13.83' base w/ 3.75' toe & 8.5' heel

Wall Steel

y	Moments 1K		
	As Built	No Flow	Full Flow
0	0	0	0
8	6.13	3.97	3.97
9.68	[illegible]	6.69	6.69
10.88	13.26	9.25	10.27
20.8	72.60	59.4	56.4
22.0	184.50	69.6	59.0

As-Built condition governs

STATE	PROJECT			
Ariz	Bickhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-9-76			

SUBJECT Structural Design ES

SHEET 12 OF

Y	Shear K		
	As Built	No Flow	Full Flow
0	0	0	0
8	1.89	1.35	1.35
9.68	2.57	1.91	1.91
10.88	3.10	2.37	2.40
20.8	9.42	8.01	7.92
22.0	10.41	8.95	8.72

As-Built Condition governs

Check wall thickness

@ 22.0' $d = 19 - 2.5 = 16.5"$

$V_d = 9.4^K$

$M_{22} = 84,500^{\#} = R b d^2/12$

$d = \sqrt{(12)(84,500/(12)(272)}$

$= 17.63" > d = 16.5$ NG

Required: $17.63 + 2.5 = 20.13"$

Increase base thickness to 21"
& base length to 14'-0"

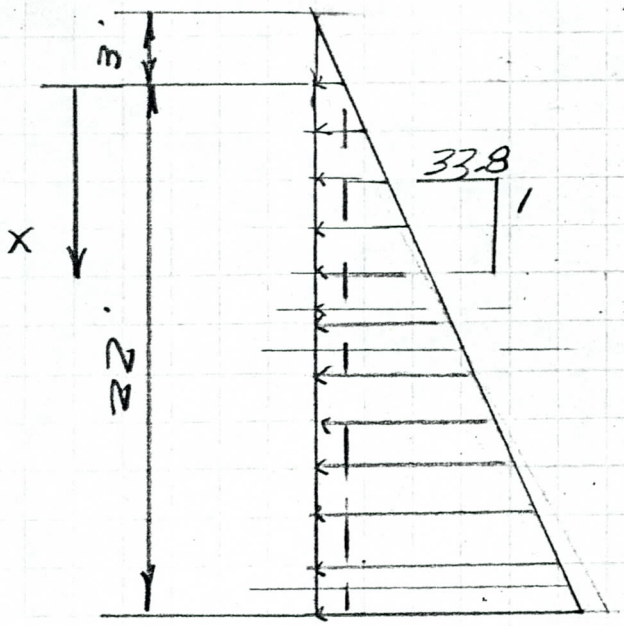
Ignore contract pressure changes.

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-6-76			

SUBJECT Sidewall Design ES

SHEET 13 OF

As Built



0-22'

$V_x = 33.8(3)x + 33.8x^2/2$

$M_x = 33.8(3)x^2/2 + 33.8x^3/6$

$x = 8$

$V_x = 33.8(3)(8) + 33.8(8)^2/2 = 1892\ \#$

$M_x = 33.8(3)(8)^2/2 + 33.8(8)^3/6 = 6129\ \#$

$x = 10.88$

$V_x = 33.8(3)(10.88) + 33.8(10.88)^2/2 = 3104\ \#$

$M_x = (33.8)(3)(10.88)^2/2 + 33.8(10.88)^3/6 = 13,257\ \#$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-6-76			

SUBJECT Structural Design ES

SHEET 14 OF

$X = 20.8$

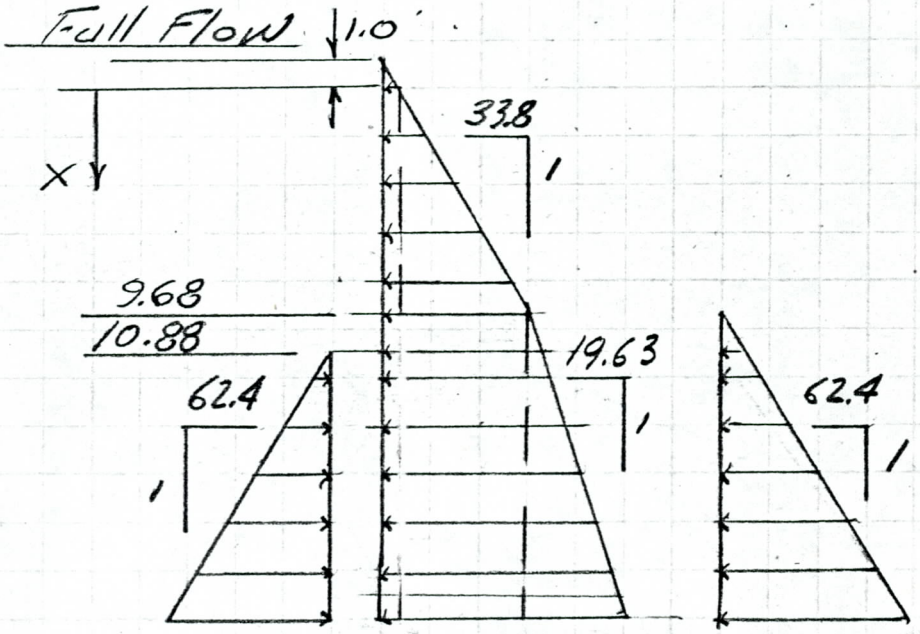
$V_X = 33.8(3)(20.8) + 33.8(20.8)^2/2 = 9,420$ #

$M_X = 33.8(3)(20.8)^2/2 + 33.8(20.8)^3/6 = 72,600$ '#

$X = 22.0'$

$V_X = 33.8(3)(22) + 33.8(22)^2/2 = 10,410$ #

$M_X = 33.8(3)(22)^2/2 + 33.8(22)^3/6 = 84,500$ '#



$X = 0 - 9.68$

$V_X = 33.8X + 33.8X^2/2$

$M_X = 33.8X^2/2 + 33.8X^3/6$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-6-76			

SUBJECT
Structural Design ES

SHEET 15 OF

$X = 8'$

$V_X = 3.38(8) + 3.38(8)^2/2 = 1352^{\#}$

$M_X = 33.8(8)^2/2 + 33.8(8)^3/6 = 3960^{'\#}$

$X = 9.68'$

$V_X = 33.8(9.68) + 33.8(9.68)^2/2 = 1910^{\#}$

$M_X = 33.8(9.68)^2/2 + 33.8(9.68)^3/6 = 6690^{'\#}$

$9.68 - 10.88$

$$V_X = 33.8(9.68) + 33.8(9.68)^2/2 + 33.8(10.68)(X-9.68) + 19.63(X-9.68)^2/2 + 62.4(X-9.68)^2/2 = 1910 + 361(X-9.68) + 41.0(X-9.68)^2$$

$$M_Y = 33.8(9.68)(X-4.84) + 33.8(9.68)^2(X-6.45)/2 + 361(X-9.68)^2/2 + 41.0(X-9.68)^3/3 = 327(X-4.84) + 1583(X-6.45) + 180.5(X-9.68)^2 + 41.0(X-9.68)^3/3$$

$X = 10.88$

$V_X = 1910 + (361)(1.2) + 41.0(1.2)^2 = 2,400^{\#}$

$M_X = 327(6.04) + 1583(4.43) + 180.5(1.2)^2 + 41.0(1.2)^3/3 = 9,270^{'\#}$

STATE	PROJECT			
Ariz	Buckhorn Mesa WPA Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-10-76			

SUBJECT
Structural Design ES

SHEET 16 OF

10.88 - 22.0

$$V_x = 1910 + 361(x-9.68) + 41.0(x-9.68)^2 - 31.2(x-10.88)^2$$

$$M_x = 327(x-4.84) + 1583(x-6.45) + 180.5(x-9.68)^2 + 13.67(x-9.68)^3 - 10.4(x-10.88)^3$$

$x = 20.8$

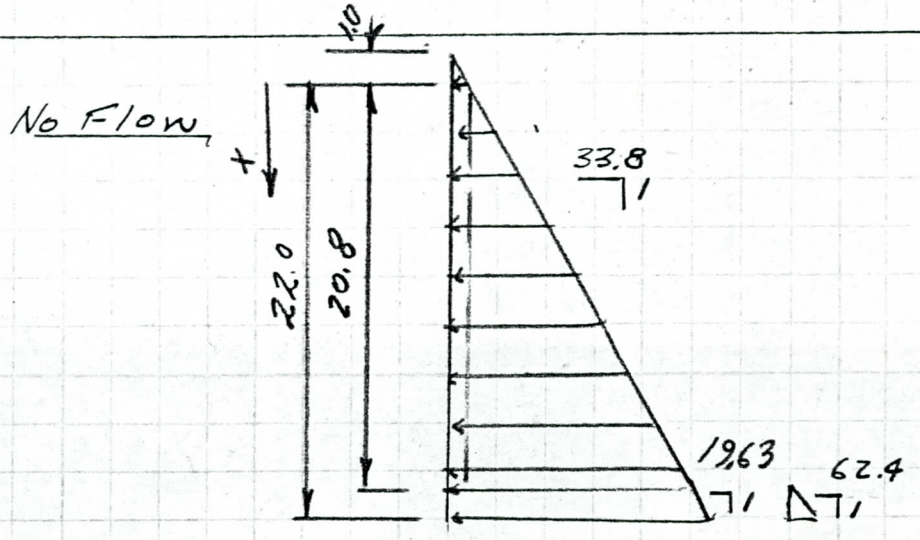
$$V_x = 1910 + 361(11.12) + 41.0(11.12)^2 - 31.2(9.92)^2 = 17,920\#$$

$$M_x = 327(15.96) + 1583(14.35) + 180.5(11.12)^2 + 13.67(11.12)^3 - 10.4(9.92)^3 = 58,900\#$$

$x = 22$

$$V_x = 1910 + 361(12.32) + 41.0(12.32)^2 - 31.2(11.12)^2 = 8720\#$$

$$M_x = 327(17.61) + 1583(15.55) + 180.5(12.32)^2 + 13.67(12.32)^3 - 10.4(11.12)^3 = 69,000\#$$



STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-10-76			

SUBJECT Structural Design ES

SHEET 17 OF

20.8 - 22.0

$$V_x = 33.8(20.8) + 33.8(20.8)^2/2 + 33.8(21.8)(x-20.8) + 19.63(x-20.8)^2/2 + 62.4(x-20.8)^2/2$$
$$= 8010 + 737(x-20.8) + 41.0(x-20.8)^2$$

$$M_x = 703(x-10.4) + 7310(x-13.67) 737(x-20.8)^2/2 + 41(x-20.8)^3/3$$
$$=$$

$x = 20.8$

$$V_x = 8010 + 737(0) + 41.0(0)^2 = 8010^{\#}$$

$$M_x = 703(10.4) + 7310(7.13) + 368(0)^2 + 41.0(0)^3/3 = 59,400^{'\#}$$

$x = 22.0$

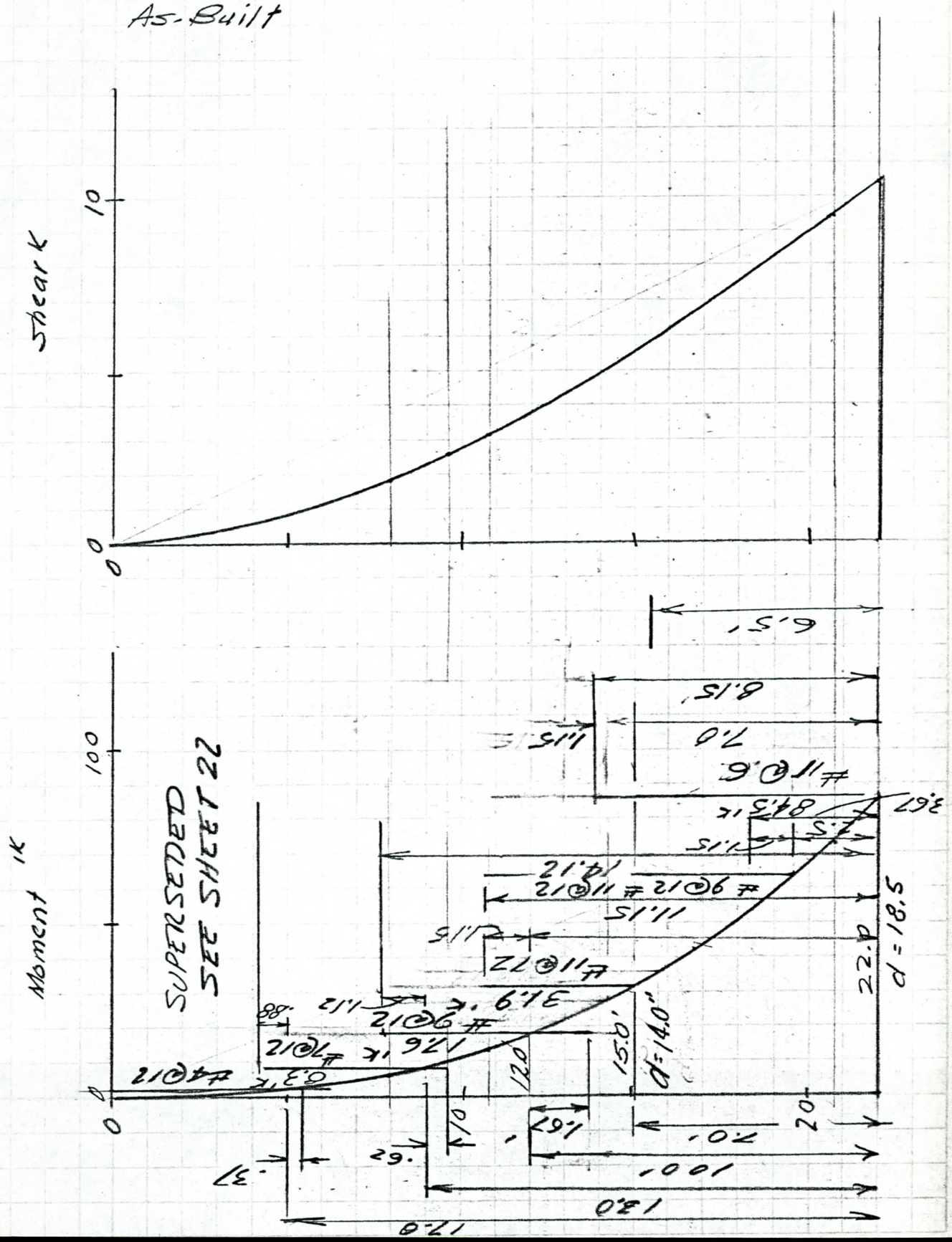
$$V_x = 8010 + 737(1.2) + 41.0(1.2)^2 = 8950^{\#}$$

$$M_x = 703(11.6) + 7310(8.33) + 368(1.2)^2 + 41.0(1.2)^3/3 = 69,600^{'\#}$$

STATE	PROJECT			
Ariz	Duckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-10-76			

SUBJECT
Structural Design ES
As-Built

SHEET 13 OF



STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-10-76			

SUBJECT Structural Design ES

SHEET 19 OF

Steel

@base $d = 18.5$"

$M = 12(84,500) = A_s f_s j d$

$A_s = 12(84,500)/(20,000)(7/8)(18.5)$
$= 3.13$ sq in

USE #11@6 $A_s = 3.12$ sq in $\Sigma_o = 8.80$ in
#9@4 $A_s = 3.00$ sq in $\Sigma_o = 10.63$ in
#9@12
#9@12 $A_s = 3.27$ sq in
#10@12 $\Sigma_o = 11.07$ in

$v = V_d/bd$
$= 9,300/(12)(18.5)$
$= 41.9$ psi $< v_a = 70$ psi OK

$\Sigma_o = V/ujd$
$= 10,410/(500)(7/8)(18.5)$
$= 1.29$ "

Locate cutoff for #11@12

where x is dist @ beginning of batter

$M = (1.56)(20)(7/8)d/12 = 2.28d$
$d = 12 + 9x/14 - 2.5 = 9.5 + .643x$
& $M = 2.28(9.5 + .643x)$
Try $x = 15 - 8 = 7$'

$M = 2.28[9.5 + .643(7)] = 31.9$ 'K OK

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY PJM	DATE 9-24-76	CHECKED BY	DATE	JOB NO.

SUBJECT Structural Design ES

SHEET 12A OF _____

Anchorage length

$L'' = f_s D / 4u$

$u = 4.8 \sqrt{f'_c} / D$ bars other than top bars

Bar Size	u	L" in	L" ft
6	405	9.26	0.77
7	347	12.61	1.05
8	304	16.47	1.37
9	270	20.85	1.74
10	243	25.73	2.14
11	221	31.14	2.60

$u = 3.4 \sqrt{f'_c} / D$ Top bars

=

Bar Size	u psi	L" in	L" ft
6	287	13.08	1.09
7	246	17.80	1.48
8	215	23.2	1.94
9	191	29.4	2.45
10	172	36.3	3.03
11	156	44.0	3.66

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RSM	8-10-76			

SUBJECT Structural Design.

SHEET 20 OF

Locate splice to #9@12

$M = (1)(20)(7/8)d/12 = 1.458d$

$d = 9.5 + .643X$

$\therefore M = 1.458(9.5 + .643X)$

Try $X = 10 - 8 = 2$

$M = 1.458[9.5 + .643(2)] = 15.7$ 'K

vs 11 'K

Try $X = 11 - 8 = 3$

$M = 1.458[9.5 + .643(3)] = 16.7$ 'K

vs 14 'K

Try $X = 12 - 8 = 4$

$M = 1.458[9.5 + .643(4)] = 17.6$ 'K

vs 18.0 'K OK

Locate splice to #7@12

$M = (.60)(20)(7/8)(9.5)/12 = 8.3$ 'K

@ 13' from base

Splice (#7) $= 30(7/8) = 26.3" = 2.19'$

cutoff (#9) $= 12(9/8) = 13.5" = 1.12'$

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-10-76			

SUBJECT Structural Design

SHEET 21 OF

Locate splice for #4@12

$M = (0.20)(20)(7/8)(9.5)/12 = 0.78$ 'K

Try modifying steel by using #11@12 & #9@12 near base

#11@12 $A_s = 1.56$
#9@12 $A_s = 1.00$
$A_T = 2.56$

$M = (2.56)(20)(7/8)d/12 = 3.73d$
$d = 9.5 + .643x$
$\therefore M = 3.73(9.5 + .643x)$

For $x = 20 - 8 = 12$

$M = 3.73[9.5 + (.643)(12)] = 64.2$
$x = 19.5 - 8 = 11.5$

Try $x = 19.75 - 8 = 11.75$

$M = 3.73[9.5 + (.643)(11.75)] = 63.6$
$x = 19.5 - 8 = 11.5$

Try $x = 19.5 - 8 = 11.5$

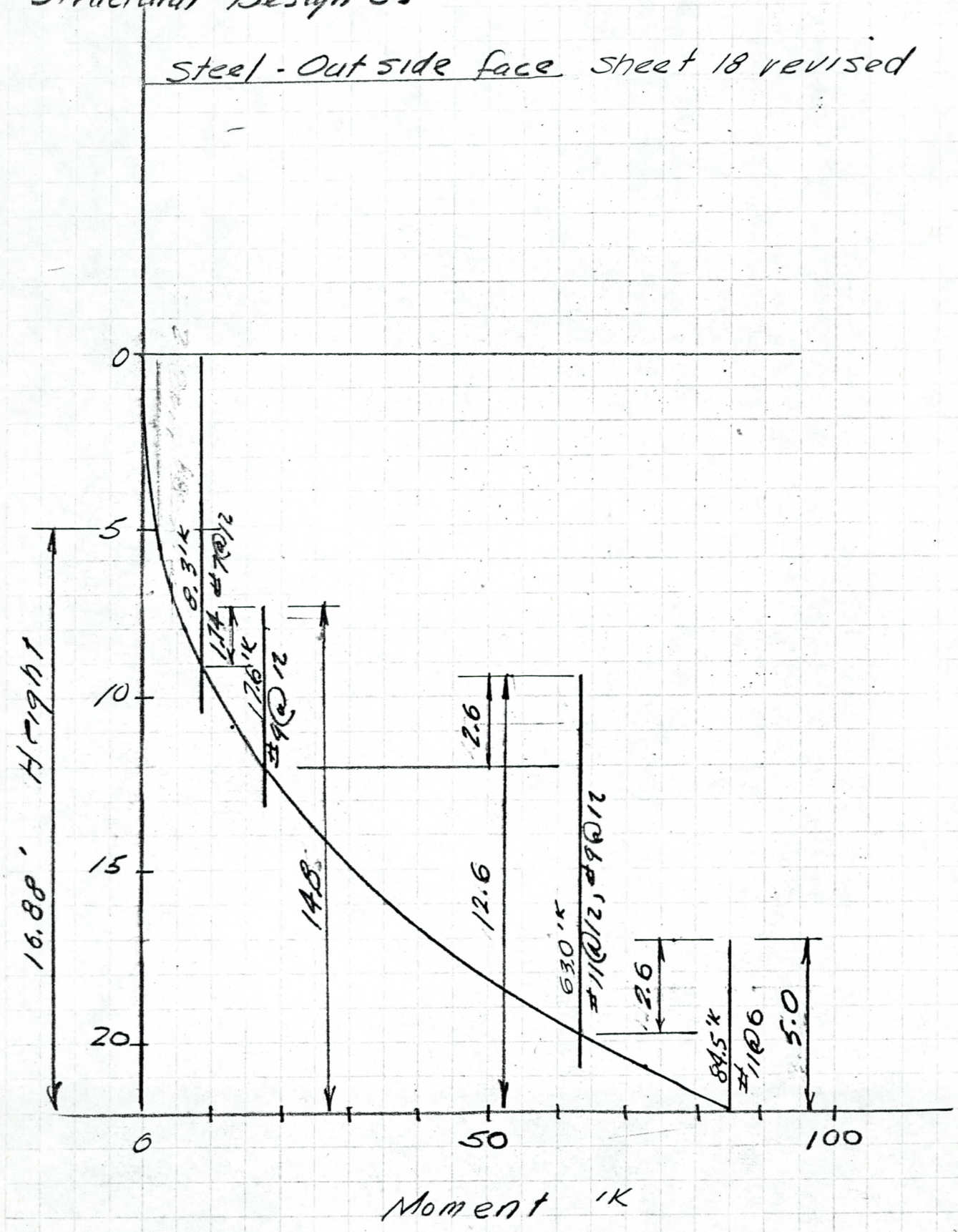
$M = 3.73[9.5 + (.643)(11.5)] = 63.0$
$x = 19.5 - 8 = 11.5$ OK

STATE	PROJECT			
Ariz	Buckhorn Mesa WPP Spook Hill FRS			
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	8-10-76			

SUBJECT Structural Design ES

SHEET 22 OF

Steel - Outside face Sheet 18 revised

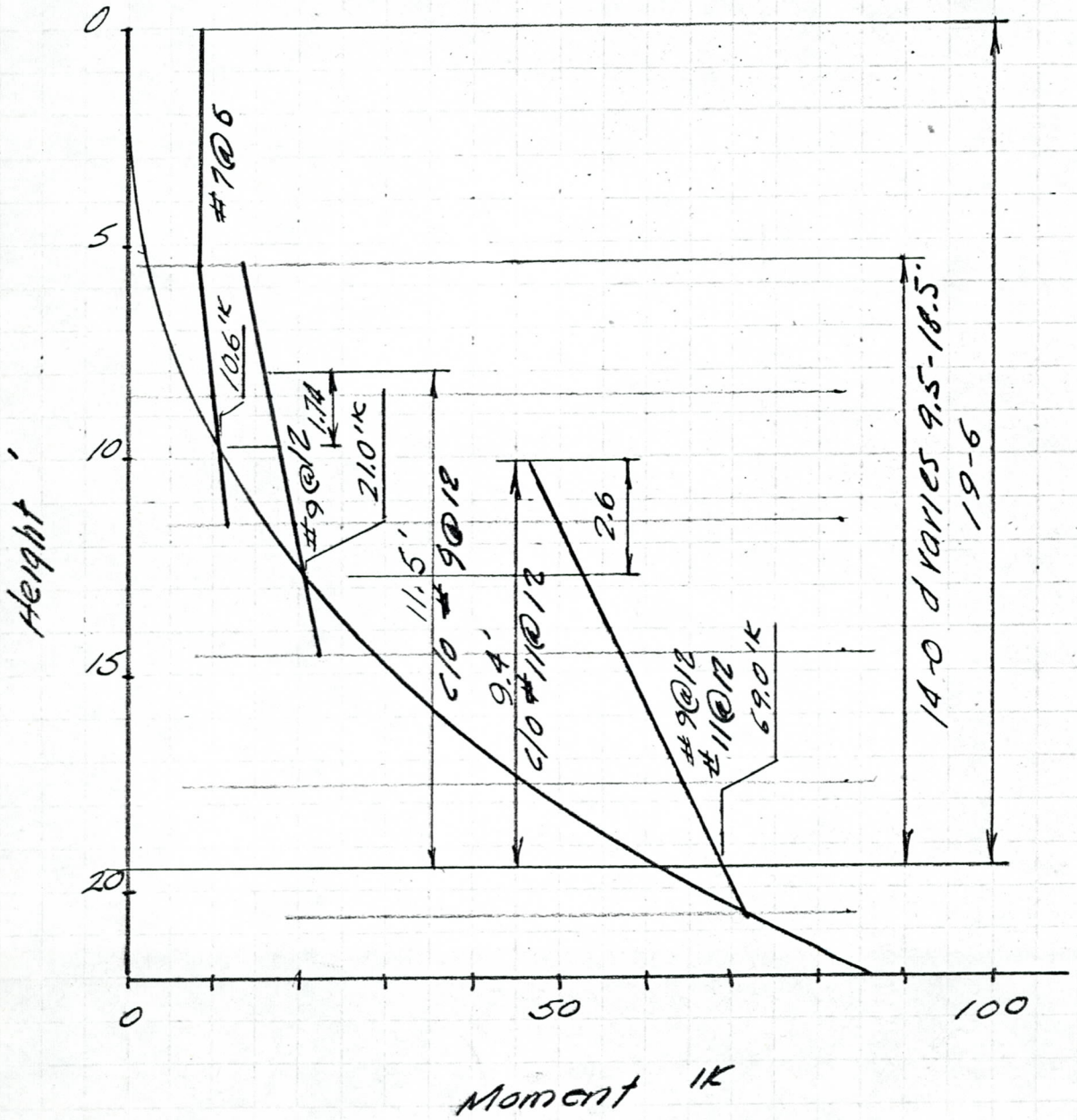


STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	10-14-76			

SUBJECT Structural Design ES

SHEET 22A OF

19 'ds from headwall height - 19'-6"



STATE Ariz | PROJECT Buckhorn Mesa WPP Spook Hill FRS

BY PJM | DATE 10-13-76 | CHECKED BY | DATE | JOB NO.

SUBJECT Structural Design ES | SHEET 22B OF

$$d = 9.5 + \left(\frac{18.5-9.5}{14}\right)x = 9.5 + 0.643x$$

x	d	Moment		
		#11@12 #9@12	#9@12	#7@12
0	9.5	35.4	13.85	8.31
3	11.43	41.6	16.66	10.00
6	13.35	49.9	19.48	11.69
9	15.29	57.1	22.3	13.37
12	17.22	64.3	25.1	15.06
15	19.15	71.5	27.9	16.75

$$M = A_s f_s j d / 1200$$
$$= 20000 (7/8) A_s d / 12000$$
$$= 14.58 A_s d$$
$$= 14.58 (9.5 + 0.643x) A_s$$

A_s

#11@12 & #9@12 $A_s = 2.56$

#9@12 $A_s = 1.00$

#7@12 $A_s = 0.60$

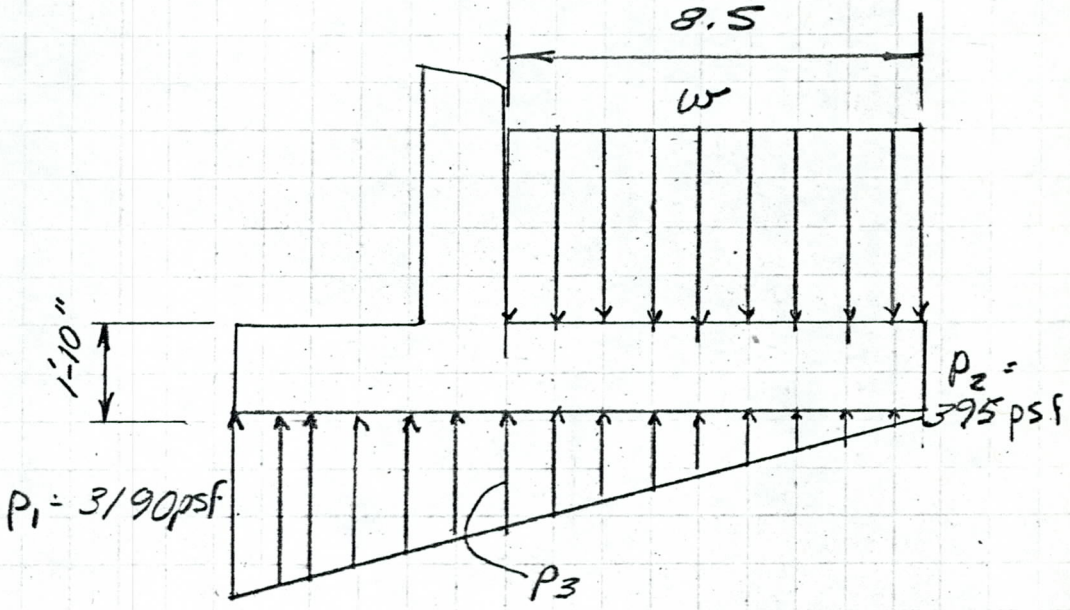
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-10-76			

SUBJECT
Structural Design ES

SHEET 23 OF

Heel Design

Full Flow Condition governs



$W = 7.88(130) + 15.12(138) = 3110$ psf

$p_3 = 395 + (3190-395)(8.5)/14$
$= 395 + 1697 = 2092$ psf

$V_x = wx + p_2x - (p_3-p_2)x^2/(2)(8.5)$
$= 3110x + 395x - 1697x^2/17.0$
$= 2715x - 99.8x^2$

$M_x = wx^2/2 - p_2x^2/2 - \frac{(p_3-p_2)}{8.5}x^3/6$

$= 3110x^2/2 - 395x^2/2 - 1697x^3/51.0$
$= 1358x^2 - 33.3x^3$

STATE		PROJECT		
Ariz		Buckhorn Mesa WRP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-11-76			

SUBJECT Structural Design ES

SHEET 24 OF

X,	Mx 1K	Vx K
0	0	0
2	5.17	5.03
4	19.60	9.26
6	41.7	12.70
8	69.9	15.33
8.5	77.7	15.87

@ face of wall

$M_x = 77.7$ 'K

$A_s = 12(77.7)/(20)(7/8)(18.5)$
$= 2.88$ sq in

#11@6 $A_s = 3.12$ sq in $\Sigma_o = 8.86$ in

For #11@12, #9@12 $A_s = 2.56$ sq in

$M = A_s F_s j d/12$
$= (2.56)(20)(7)(18.5)/(8)(12)$
$= 69.1$ 'K

For #9@12

$M = (1)(20)(7)(18.5)/(8)(12)$
$= 27.0$ 'K

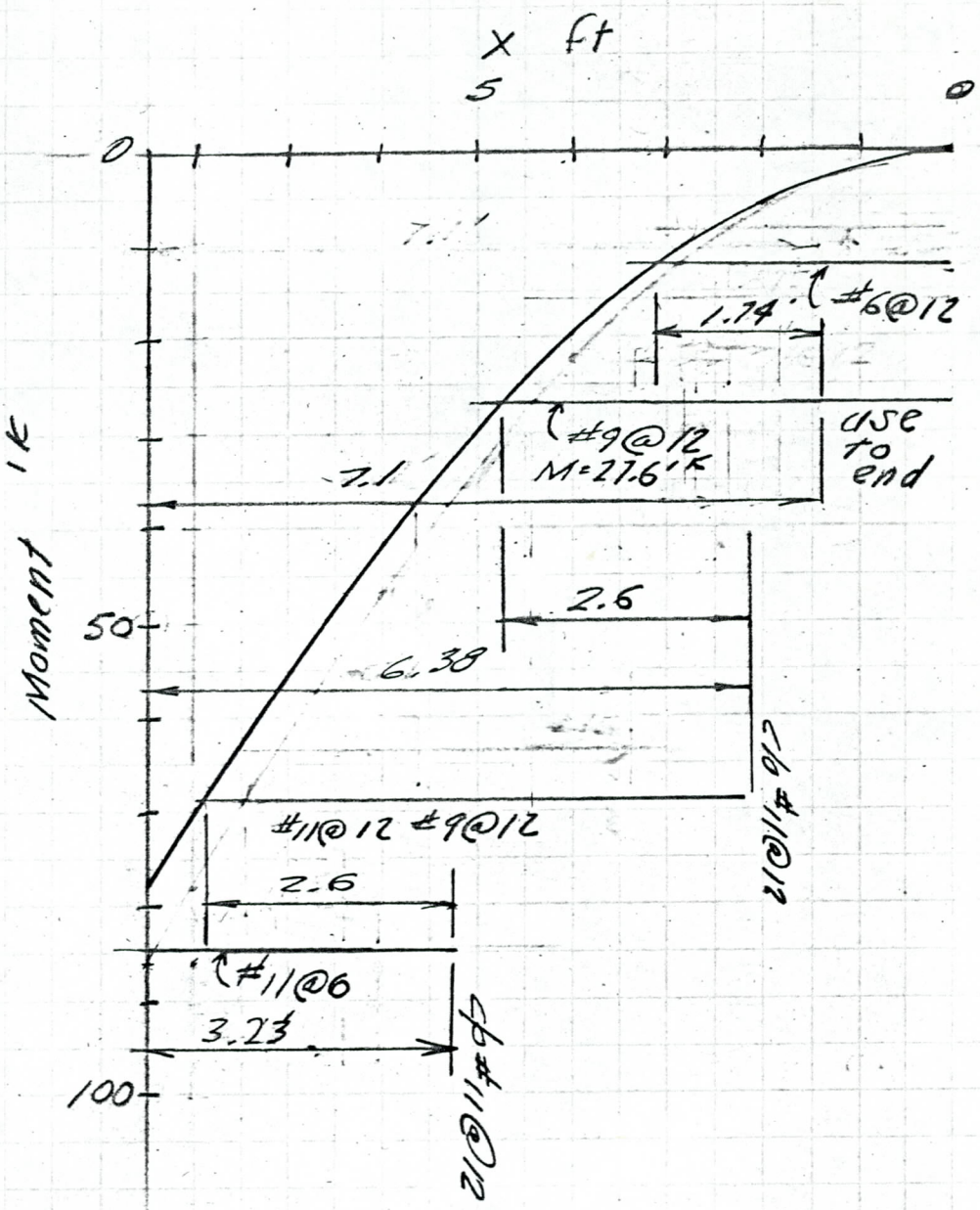
For #7@12

$M = (0.60)(20)(7)(18.5/(96)$
$= 16.19$K

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-11-76			

SUBJECT Structural Design ES

SHEET 25 OF



For #6@12

$M = (0.44)(20)(7)(18.5)/96$
$= 11.87$ 'k

Tempsteel
Top $A_s = 0.002(18)(12) = 0.43$
Bottom $A_s = 0.001(18)(12) = 0.22$

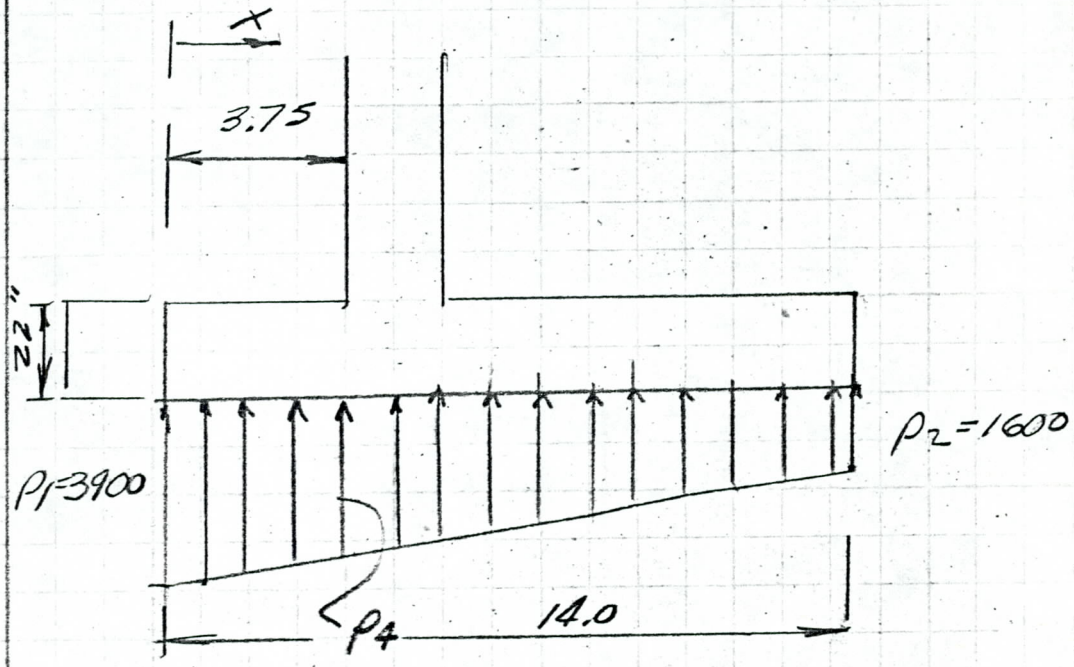
STATE	PROJECT		
Ariz	Buckhorn Mesa WPP Spook Hill FRS		
BY RM	DATE 8-13-76	CHECKED BY	DATE
JOB NO.			

SUBJECT Structural Design

SHEET 26 OF

Toe Design

As Built Condition Governs



$$p_4 = 1600 + (3900-1600)(14.0-3.75)/14.0$$
$$= 3280$$

$$V_x = 3280x + (3900-3280)x - 165.3x^{2}/2$$
$$= 3900x - 82.7x^{2}$$

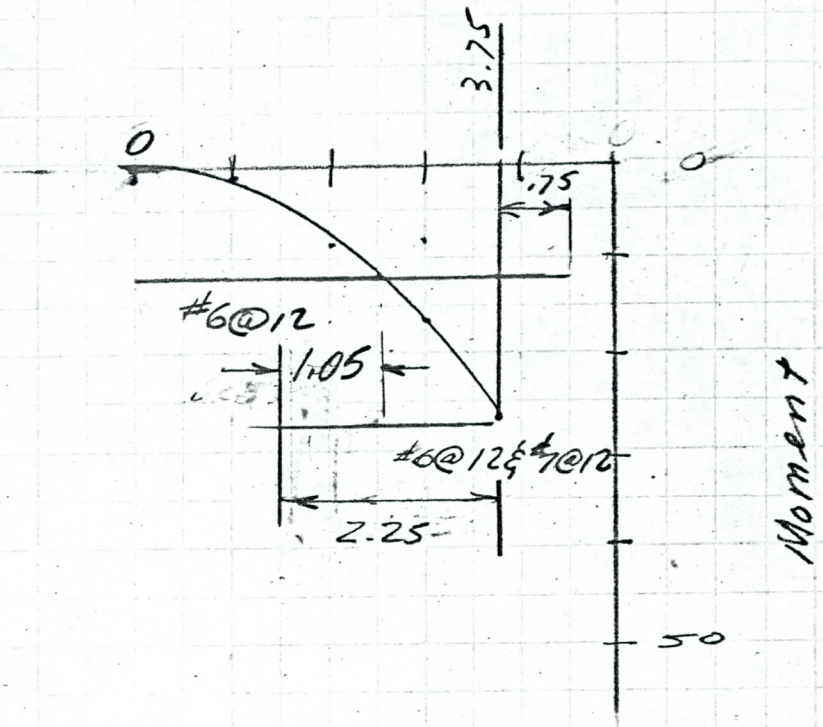
$$M_x = 3900x^{2}/2 - 165.3x^{3}/6$$
$$= 1950x^{2} - 27.6x^{3}$$

X '	M_x 1K	V_x K
0	0	0
1	1.92	3.82
2	7.58	7.47
3	16.80	10.96
3.75	26.0	13.46

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	8-13-76			

SUBJECT Structural Design ES

SHEET 27 OF



$M_{max} = 26.0$ 'K $d = 18.5$"

$M = A_s f_s j d / 12$

$A_s = (26.0)(20)(7/8)(18.5) = 0.96$ sq in

#9 @ 12 $A_s = 1.00$ sq in $\Sigma_o = 4.43$ in

#6 @ 12 $A_s = 0.44$ sq in $\Sigma_o = 2.36$ in
#7 @ 12 $= 0.60$ sq in $= 2.75$ in
A_s 1.04 sq in Σ_o 5.11 in

$V_d = 3900(3.75 - 1.54) - 82.7(2.21)^2$
$= 8220$ #

#6 @ 12 & #7 @ 12

$u = 8220 / (5.11)(7/8)(18.5) = 99$ psi OK

COMPUTATION SHEET
SCS-522 REV 5-58

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO : 1958 O—470868

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
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Structural Design ES				

Check Sliding

For caliche Assume same as SM & SC

$\gamma_d = 128$ pcf $\gamma_m = 139$ pcf $\gamma_{sat} = 146.4$ pcf

$\phi = 33°30'$ $\tan\phi = 0.662$

Sliding resistance = $W \tan\phi = R$

At Rest: R = 38,000 (.662) = 25,200#

Sliding Force F = 11,870#

S = 25,200 / 11,870 = 2.12 OK

No Flow R = 34100 (.662) = 22600#

F 11,460#

S = 22600 / 11,460 = 1.97 OK

Full Flow R = 37500 (.662) = 24800#

F = 12,217#

S = 24800 / 12,200 = 2.03 OK

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Ariz	Buckhorn Mesa WPP Spook Hill FRS			
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RJM	8-16-76			

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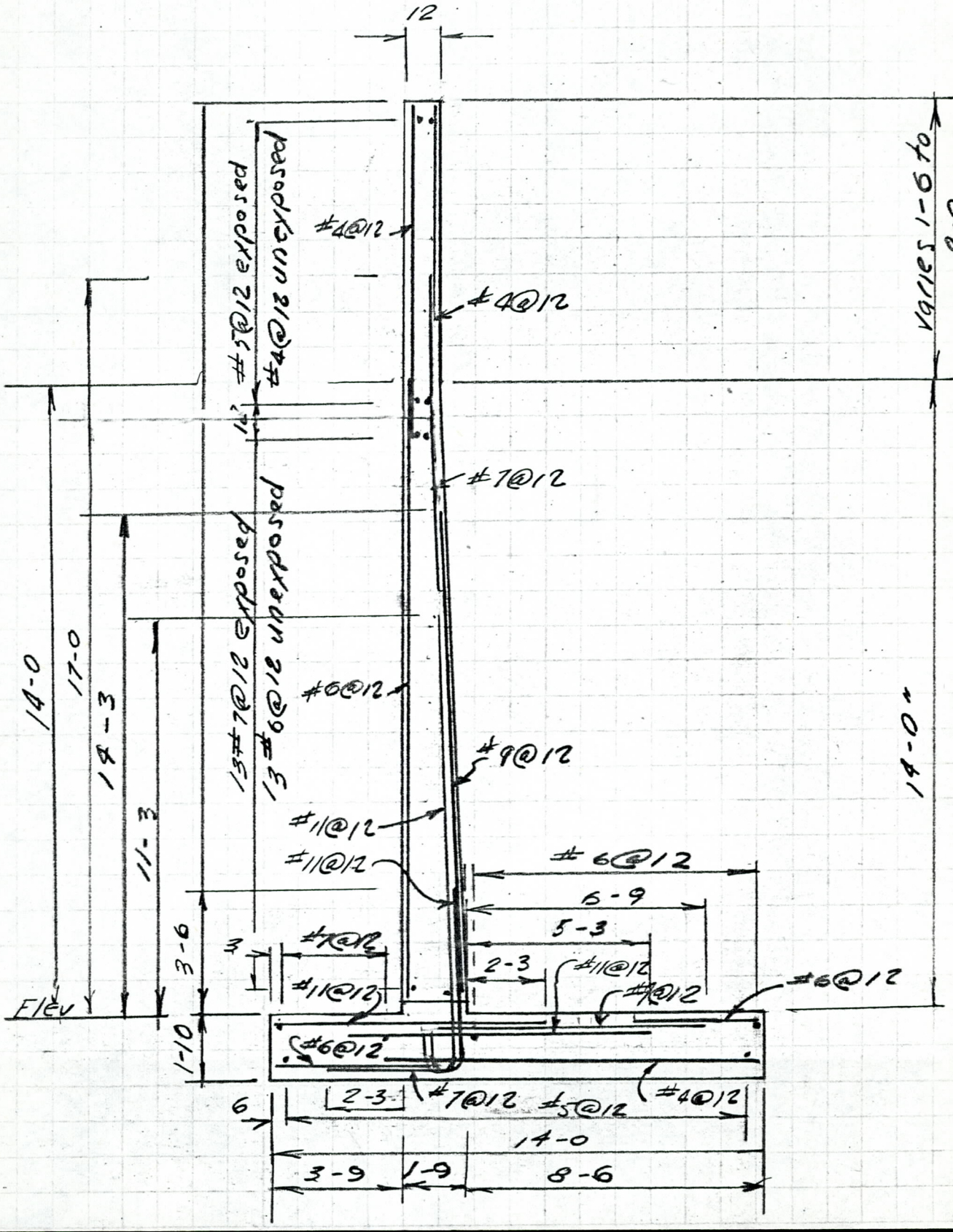

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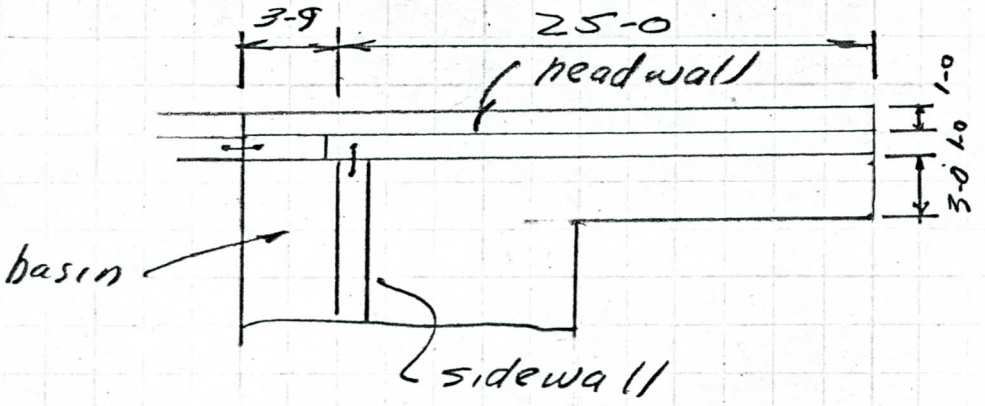
RM	8-17-76			

SUBJECT Structural Designes

SHEET 30 OF

Headwall Design

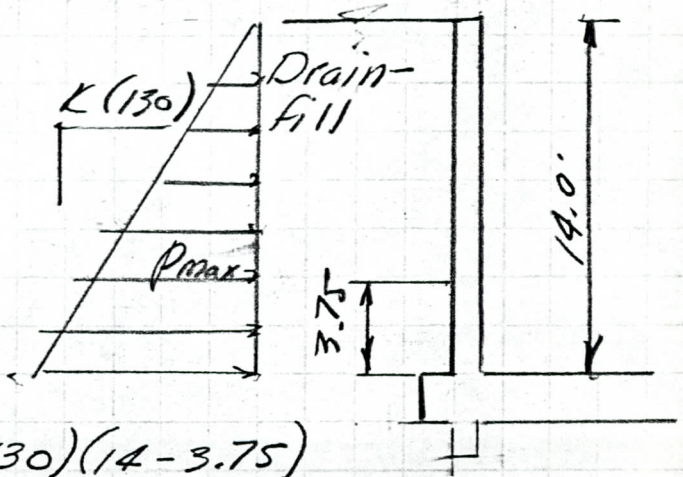
For articulated headwall headwall assume earth pressures on either side of the wall about equal. Design for temperature steel except where headwall extends into the basin. Design this portion as horizontal cantilever



@ Base of headwall in basin

FWS EDS Fig 22

γ_m = 130 pcf
ϕ = 36°
non yielding wall
K = 0.41



$P_{max} = 0.41(130)(14-3.75)$
$= 546$ pcf
$M_{max} = 546(3.75)^2/2 = 3840$ '#
$V_{max} = 546(3.75) - 2050$ #
$V_d = 546(3.75-0.79) = 1616$ #

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For d = 9.5" A_s = 0.26 sq in

USE #5@12 A_s = 0.31 sq in
Σ_o = 1.96"

$v = V_d / bd$
= 1616 / (12)(9.5)
= 14 psi OK

$u = V / \Sigma_o j d$
= 2050 / 1.96 (7/8)(9.5)
= 125 < u = 500 psi OK

Temp Steel Vertical

Exposed Face

A_s = 0.002 (12)(12) = 0.29 sq in
USE #5@12

Unexposed Face

A_s = 0.001 (12)(12) = 0.14 sq in
USE #4@12

Temp Steel Horizontal

USE #5@12 both faces

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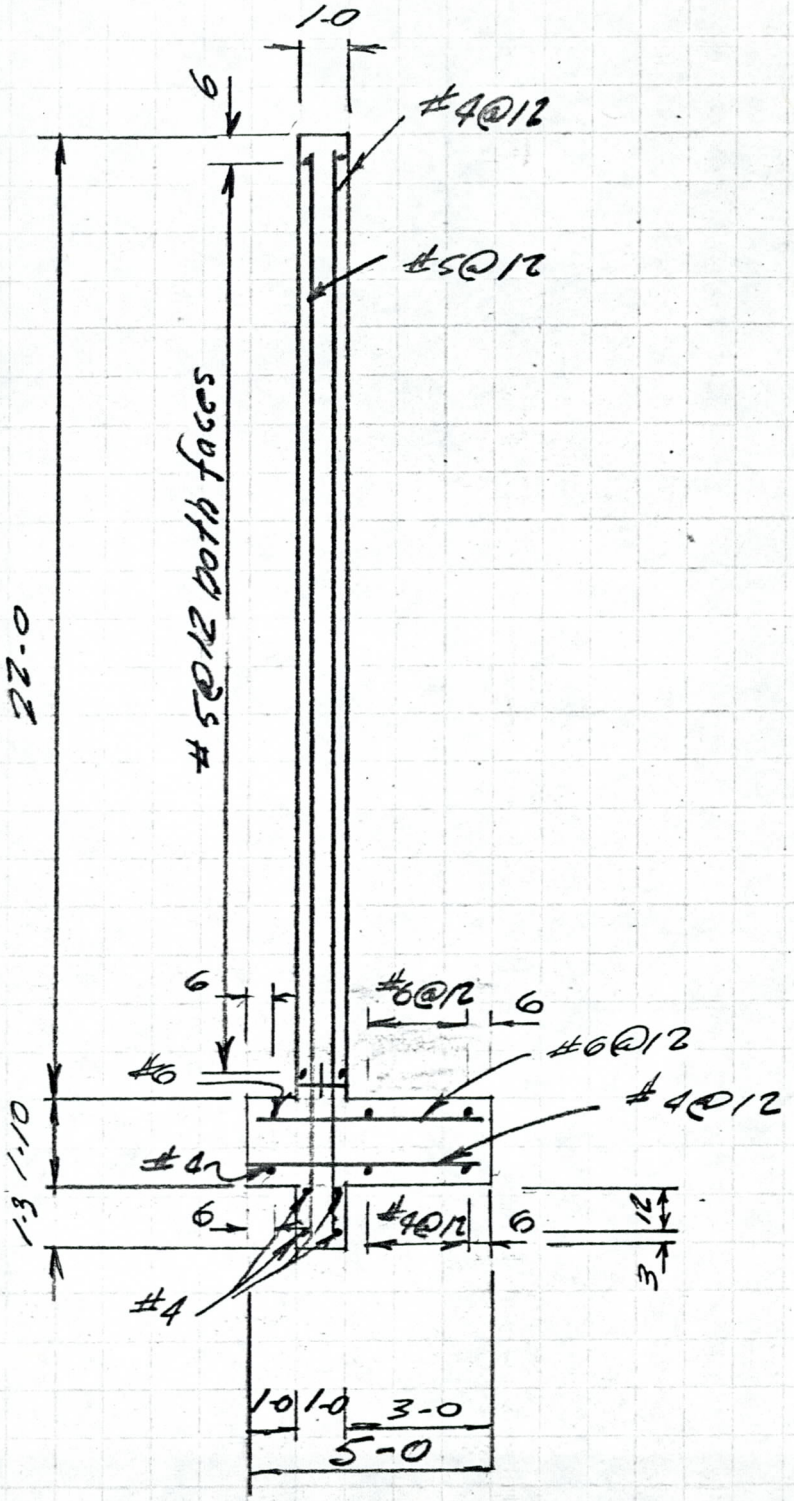

CROSS SECTION
TOP HEADWALL

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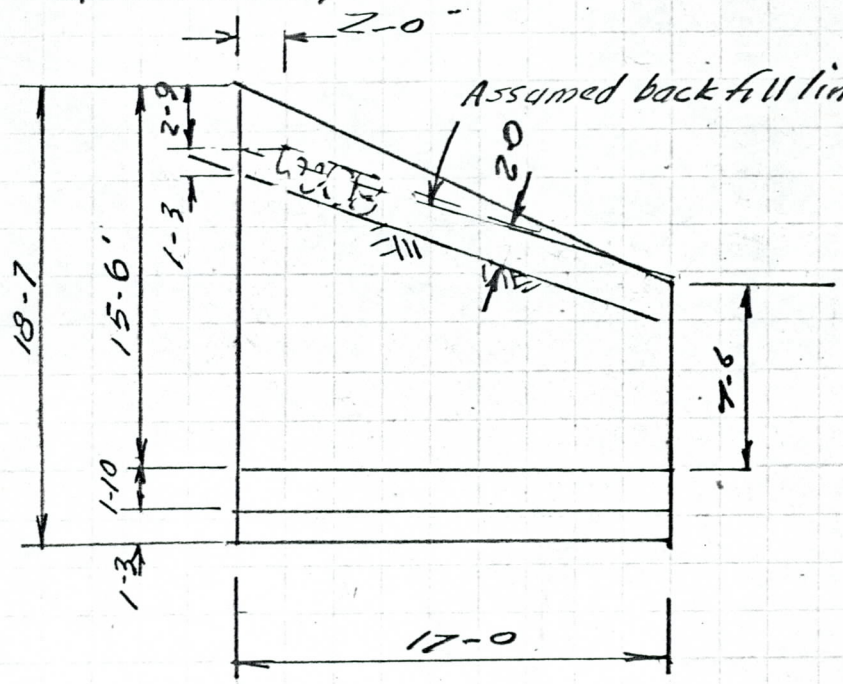
Wingwall Design



USE: Gravel back fill on us side

$\gamma_m = 130$ pcf
$\phi = 36°$
$z = 25°$

NEH Sec 6
p6.2-4

Assume: load on us side only
all gravel backfill

Design footing @ max & min ht & check in center.

The wingwall will be designed as a cantilever wall. Since the wall is yeilding & the back fill clean non-cohesive, permeable soils of high structural strength Coulomb's method of analysis will be used

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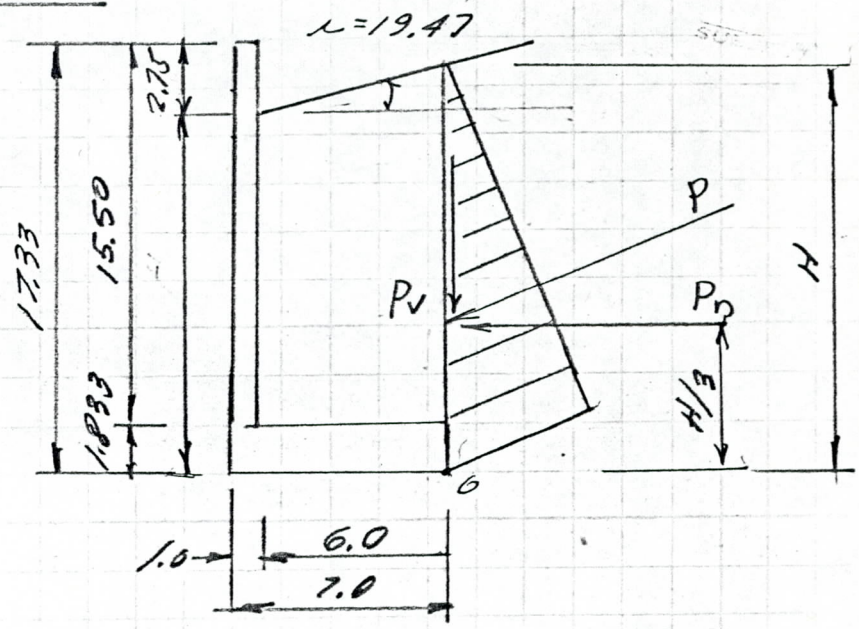
Max. Section



$$P = \frac{wH^2}{2} \frac{\sin^2(\theta-\phi)}{\sin^2\theta \sin(\theta+\delta)\left[1+\sqrt{\frac{\sin(\delta+\phi)\sin(\phi-i)}{\sin(\theta+\delta)\sin(\theta-i)}}\right]^2}$$

$$= \frac{wH^2}{2} \frac{\sin^2 54^\circ}{\sin^2 90^\circ \cos 25^\circ\left[1+\sqrt{\frac{\sin 61^\circ \sin 6.53^\circ}{\cos 25^\circ \sin 70.53^\circ}}\right]^2}$$

$$= \frac{wH^2}{2}(0.305)$$

$P = (65)(16.70)^2(0.305) = 5450$ #

$P_h = P\cos\delta = 5450(0.906) = 4940$ #

$P_v = P\sin\delta = 5450(0.423) = 2300$ #

$H = 17.33 - 2.75 + 6\tan i = 16.70'$

$H/3 = 16.70/3 = 5.57'$

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ΣM_o

Part		Wt	Arm	Moment
Footing	(7.0)(1.833)(150)	1924	3.50	6740
Wall	(15.5)(1)(150)	2320	6.50	15,110
Earth ▭	(6.0)(12.75)(130)	9940	3.00	29,800
◺	(3.0)(2.12)(130)	827	2.00	1,654
P_J		2300	0.00	0
P_h	Force = 4940		5.57	27,500
		17311		80,804

$z = 80,804/17311 = 4.67$ ∴ Stable - Falls within middle third of base
$7.0(2/3) = 4.67$

Min Section

Try 3'-6" width of footing @ d.s. end

$P = (65)(10.57)^2(0.305) = 2220$ #
$P_h = P\cos z = 2220(0.906) = 2010$ #
$P_v = P\sin z = 2220(0.423) = 937$ #
$H: 7.5 + 1.833 + 3.5\tan i = 10.57'$
$H/3 = 10.57/3 = 3.52'$

Part		Wt	Arm	Moment
Footing	(4.5)(1.833)(150)	1237	2.25	2780
Wall	(7.5)(1)(150)	1125	4.00	4500
Earth ▭	(3.5)(7.5)(130)	3410	1.75	5970
◺	(1.75)(1.237)(130)	281	1.167	328
P_J		937	0.00	0
P_h	Force = 2010		3.52	7080
		6990	2.96	20658

$4.5(2/3) = 3.00 > z = 2.96'$ OK

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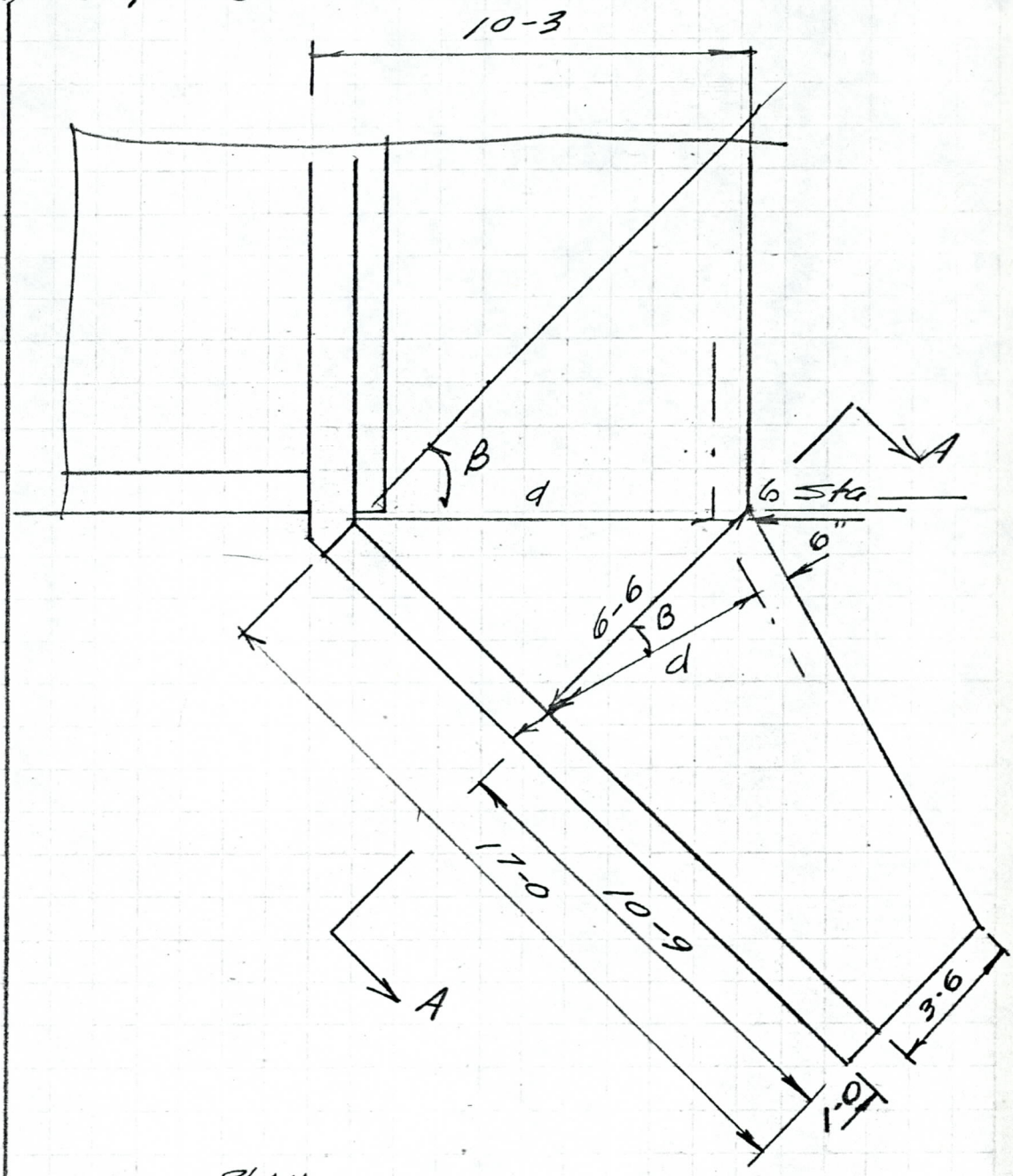

PLAN

wall ht @ sec A-A
= 15.5 - (6.25/17)(15.5-7.5)
= 12.56'
Fill ht = 15.5-2.75 - (6.25/17)(12.75-7.5)
= 10.82'

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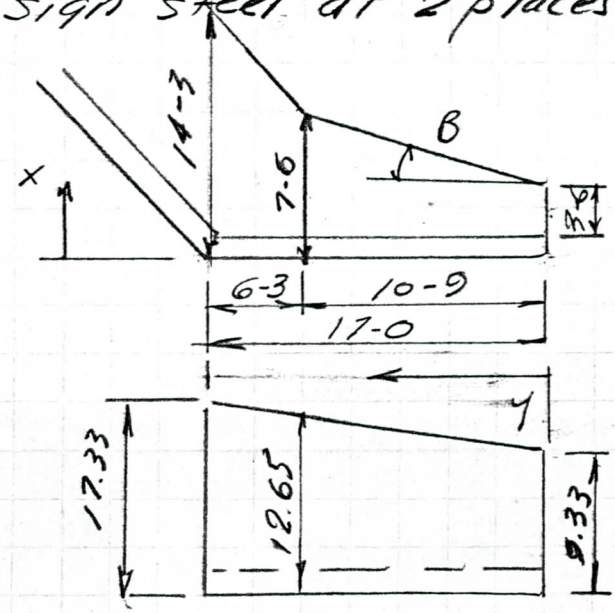
Section A-A

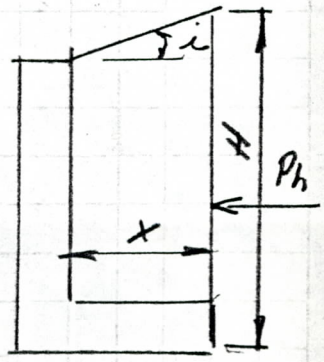
$P = (65)(14.95)^2(0.305) = 4430\#$
$P_h = P\cos 7 = 4430(.906) = 4010\#$
$P_v = P\sin 7 = 4430(0.423) = 1875\#$
$H = 10.82 + 1.833 + 6.5\tan i = 14.95'$
$H/3 = 14.95/3 = 4.98$

Part		Wt	Arm	Moment
Footing	(7.5)(1.833)(150)	2060	3.75	7730
Wall	(12.56)(1)(150)	1884	7.00	13190
Earth ▭	(6.5)(10.82)(130)	9140	3.25	29700
" △	(2.30)(3.25)(130)	972	2.17	2110
P_v		1875	0.00	0
P_h	Force = 4010		4.98	19970
	OK	15931	4.56	72700

Sliding

Following procedures of Sec 11 NEH design steel at 2 places to prevent sliding





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Horizontal Moment

$P_h = P\cos\Sigma = 0.906P$

$P = (\gamma H^2/2)(0.305)$

$\therefore P_h = 0.906[65H^2](0.305) = 17.99H^2$

$H = 9.33 + (8/17)y + x\tan i$

$= 9.33 + 0.471y + 0.354x$

From $y = 0$ to 10.75

$x = 3.5 + (3/10.75)y = 3.5 + 0.279y$

$H = 9.33 + 0.471y + 0.354(3.5 + 0.279y)$

$= 10.57 + 0.570y$

$P_h = 17.94[10.57 + 0.570y]^2$

$= 2000 + 216y + 5.83y^2$

From $y = 10.75$ to 17.0

$x = 6.5 + (6.75/6.25)y = 6.5 + 1.080y$

$H = 9.33 + 0.471y + 0.354[6.5 + 1.080y]$

$= 11.63 + 0.853y$

$P_h = 17.94(11.63 + 0.853y)^2$

$2430 + 356y + 13.05y^2$

@ $y = 10.75$

$$M = \int_0^{10.75} P_h y\,dy = \int_0^{10.75} (2000 + 216y + 5.83y^2)y\,dy$$

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$$= -\left[\frac{2000y^2}{2} + \frac{216y^3}{3} + \frac{5.83y^4}{4}\right]_0^{10.75}$$

$$= 115{,}600 + 89400 + 19{,}460$$

$$= \underline{224{,}460}\ \text{in}\#$$

@ $y = 17.00$

$$M = \int_0^{10.75} P_h y\,dy + (y-10.75)\int_0^{10.75} P_h\,dy$$

$$+ \int_{10.75}^{17} P_h (y-10.75)\,dy$$

$$= 224{,}000 + (17-10.75)\int_0^{10.75} (2000 + 216y + 5.83y^2)\,dy$$

$$+ \int_{10.75}^{17} (2430 + 356y + 13.05y^2)(y-10.75)\,dy$$

$$= 224{,}000 + 6.25\left[2000y + \frac{216y^2}{2} + \frac{5.83y^3}{3}\right]_0^{10.75}$$

$$+ \int_{10.75}^{17} (-26{,}100 - 1397y + 216y^2 + 13.05y^3)\,dy$$

$$= 224000 + 6.25(21500 + 12480 + 2410)$$

$$+ \left[-26{,}100y - \frac{1397y^2}{2} + \frac{216y^3}{3} + \frac{13.05y^4}{4}\right]_{10.75}^{17}$$

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$= 224{,}000 + 227{,}000 - 444{,}000 - 202{,}000$
$+ 354{,}000 + 272{,}000 + 281{,}000$
$+ 80{,}700 - 89{,}400 + 43{,}600$

$= 659{,}700$ #

Effective Depth

@ y = 10.75"

$B = \tan^{-1} 3/10.75 = 15.59°$

$d = (12)(7.5)\cos 15.59° - 6 = 80.7"$
use d = 80"

@ y = 17.0

$B = 45°$

$d = (12)(14.25)\cos 45° - 6 = 114.9"$
use d = 114"

Required Steel

@ y = 10.75'

$A_s = 12M/f_s j d$
$= 12(224)/20(7/8)(80)$
$= 1.9259$ in

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@ y = 17'

$A_s = 12(660)(2)/(20)(70)(114)$
$= 0.40$ sq in

Moment @ y = 10.75 governs

USE 2 #9 bars - 1 in each face
$A_s = 2.00$ sq in

Design of Vertical Wall

Assume Z = 0

$$P = \frac{WH^2}{2} \frac{\cos^2\phi}{\left(1+\sqrt{\frac{\sin\phi \sin(\phi-i)}{\sin(\theta-i)}}\right)^2}$$

$$= \frac{WH^2}{2} \frac{\cos^2 36^\circ}{\left(1+\sqrt{\frac{\sin 36^\circ \sin 16.53^\circ}{\sin 70.53^\circ}}\right)^2}$$

$$= \frac{WH^2}{2}(0.324)$$

H = 12.75'

$P = 130(12.75)^2(.5)(0.324) = 3420$ #
$M = PH/3 = 3420(12.75)/3 = 14{,}550$ ft-#
$V = P = 3420$

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M & As curves for $w = (2)(3420)/(12.75)^2$
$= 42.1$ psf/ft

$M = wH^3/6 = 42.1 H^3/6 = 7.01 H^3$

d = 9.5"

H	H^3	M Ft lb	A_s in^2
12.75	2070	14,530	1.03
12	1728	12,110	0.85
11	1331	9,330	0.64
10	1000	7,010	0.48
9	729	5110	0.35
8	512	3590	0.24
7.5	421	2960	0.22
7.0	343	2400	0.17

@ US End

$M = 14,530$ lbs $V = 3420$
Req'd A_s: $1.03 in^2$, Req'd $\Sigma_o = 0.82$ in
USE #6@12 & #7@12
$A_s = 0.44 + 0.60 = 1.04$ sq in
Find where #6@12 can be used

$H = 9.7'$ ∴ Length of #7 bar
$= 12.75 - 9.7 + 0.88 + 0.88$
$= 4.81$ say 5-0" @ 4-0" above the floor

Find where #4@12 can be used

$H = 7.5'$ ∴ length of #6 bar
$= 12.75 - 7.5 + 1.833 + 1.25 + 1.25 - .17$
$= 9.41$ say 9-6" or 6-6 above floor

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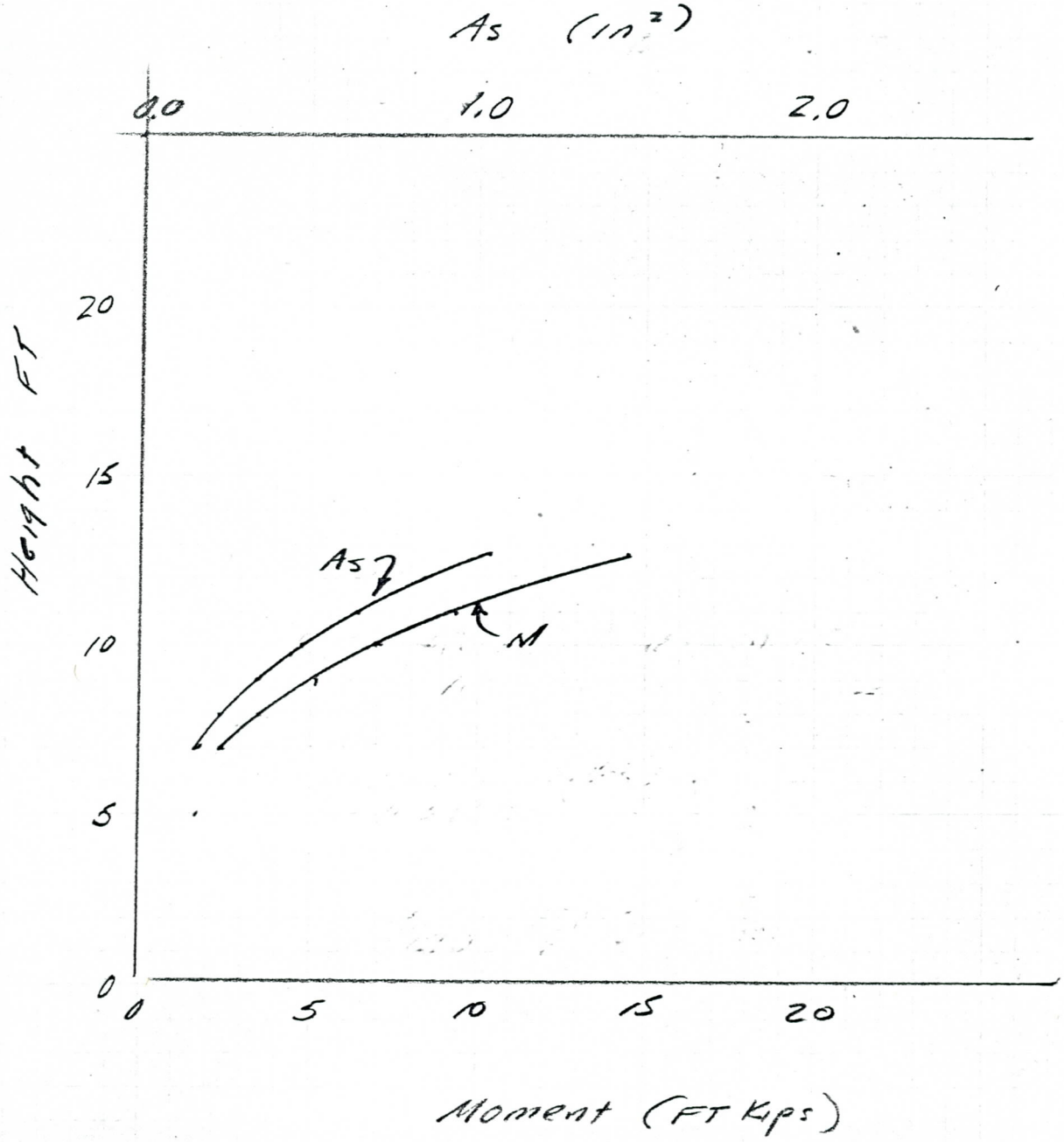

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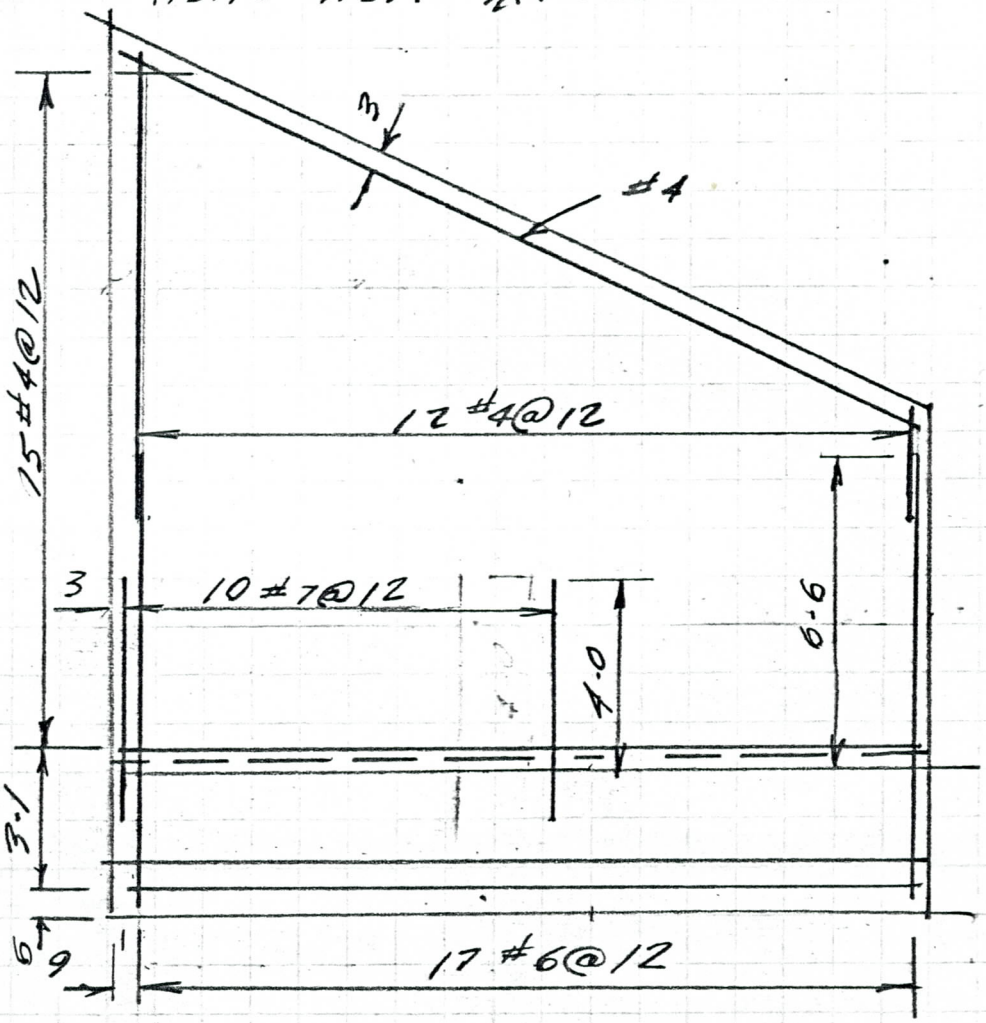
Find point along wall where #6@12 can be used

From curve H = 9.7
Dist from upstream end =
= (12.75 - 9.7)(17)/(12.75-7.5) = 9.88'

Find point along wall where #4@12 can be used

From curve H = 7.5
Dist from upstream end =
(12.75 - 7.5)(17)/(12.75-7.5) = 17'



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Steel in Exposed Face

USE #5@12 both directions

Footing Design

See sheet 37

@ 10.75' from ds end

$p = (V/A)[1 \pm 6e/d]$

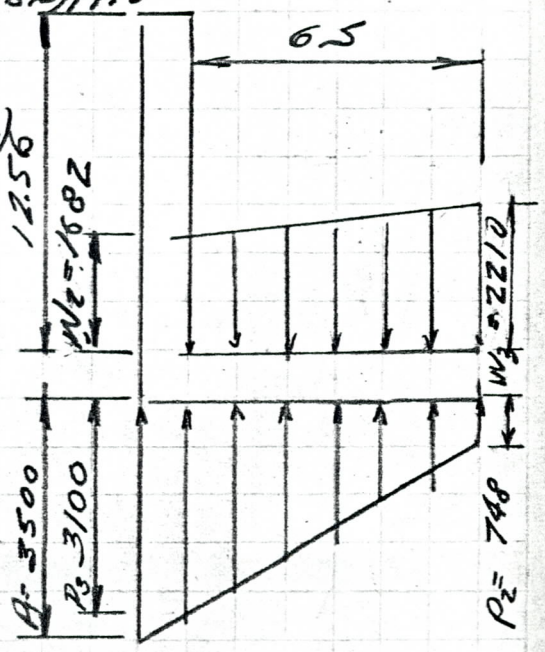
$p_1 = [15930/17.5)][1 + (6)(0.81)/17.5]$
$= 3500$ psf

$p_2 = (15930/17.5)[1 - (6)(0.81)/17.5]$
$= 748$ psf

$p_3 = 748 + (3500 - 748)(6.5)/17.5$
$= 3100$ psf

$W_2 = (0.82)(130) + (0.83)(150)$
$= 1682$ psf

$W_3 = (1.48)(130) + (2.83)(150)$
$= 2210$ psf



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Moment & Shear

$M_{max} = 1682(6.5)^2/2 + (2210-1682)(6.5)^2/3 - 748(6.5)^2/2 + (3100-748)(6.5)^2/6$

$= 10,600$ #

$V_{max} = (1682+2210)(6.5)/2 - (3100+748)(6.5)/2$

$= 143$ #

$d = 19.5$ in

$As_{reqd} = 0.345$ sq in USE #6@12

Loads @ ds. end

$p_1 = (6990/4.5)[1+6(0.71)/4.5] = 3020$ psf

$p_2 = [(6990)/(4.5)][1-6(0.71)/4.5] = 83$ psf

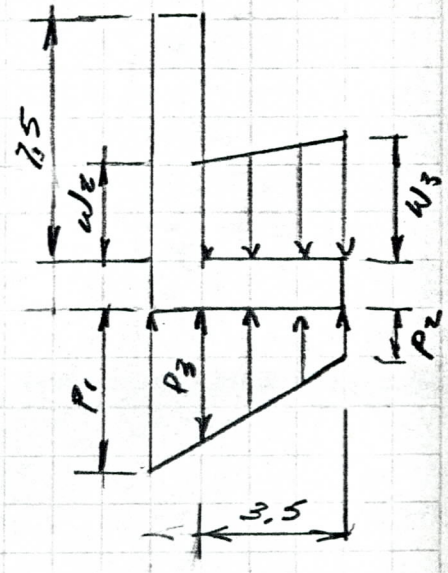
$p_3 = 83 + (3020-83)(3.5/4.5) = 2370$ psf

$w_2 = (7.5)(130)+(1.833)(150)$

$= 1250$ psf

$w_3 = (8.74)(130)+(1.833)(150)$

$= 1411$ psf



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5096 ✓

Moment & Shear

$M_{max} = 1250(3.5)^2/2 + (1411-1250)(3.5)^2/3 - 83(3.5)^2/2 - (2370-83)(3.5)^2/6$

$= 3140$ #

$V_{max} = (1250+1411)(3.5)/2 + (2370+83)(3.5)/2$

$= 3640$ #

$d = 19.51$ in

$A_{s\,req'd} = 0.10$ USE #4@12 from ds. end to 4.5' from ds end

USE #4@12 temp std bottom face transverse & top & bottom face longitudinal

COMPUTATION SHEET
SCS-522 REV 5-58

U. S. DEPARTMENT OF AGRICULTURE
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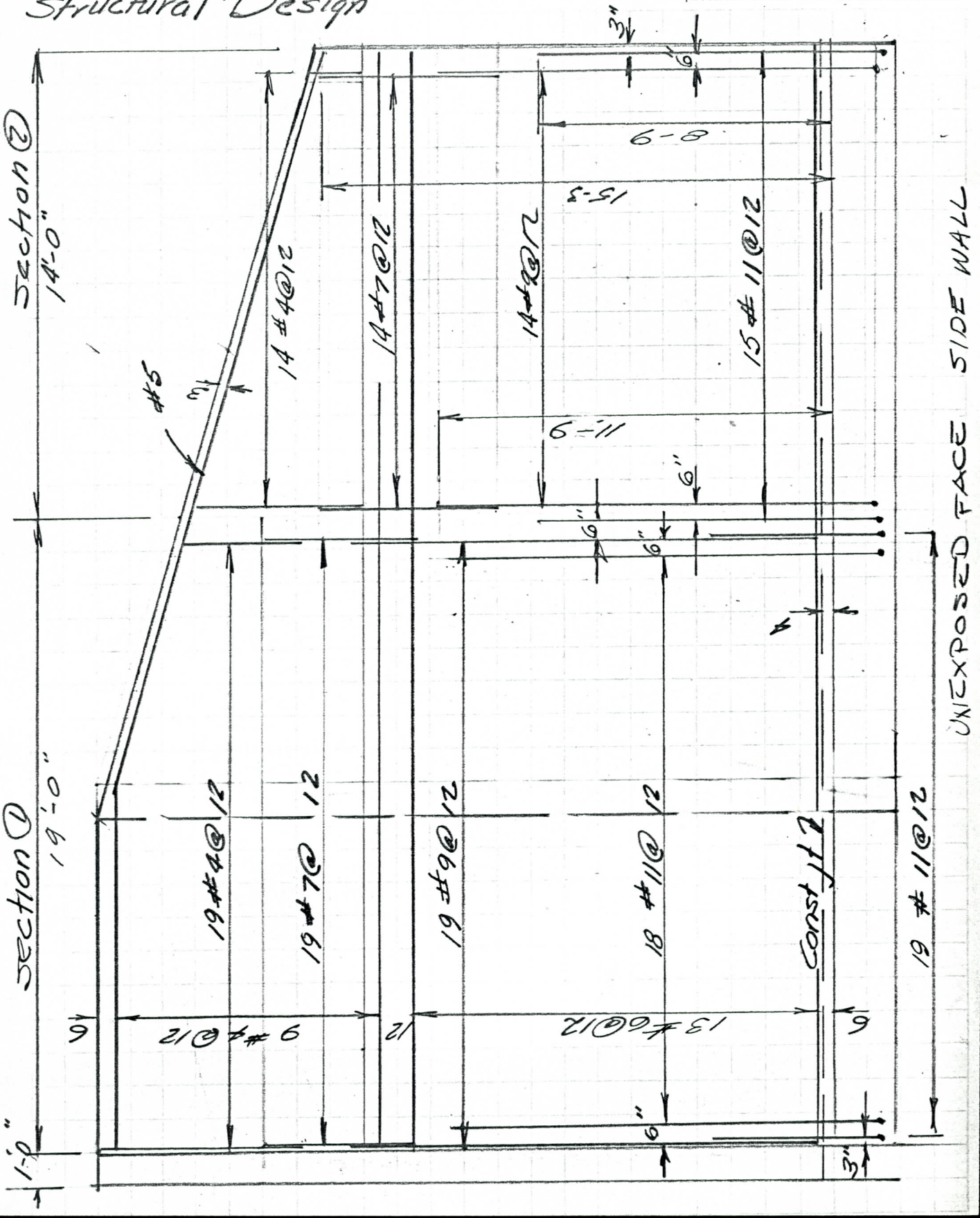

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Ariz		Blackhorn Mesa WP Spook Hill FRS		
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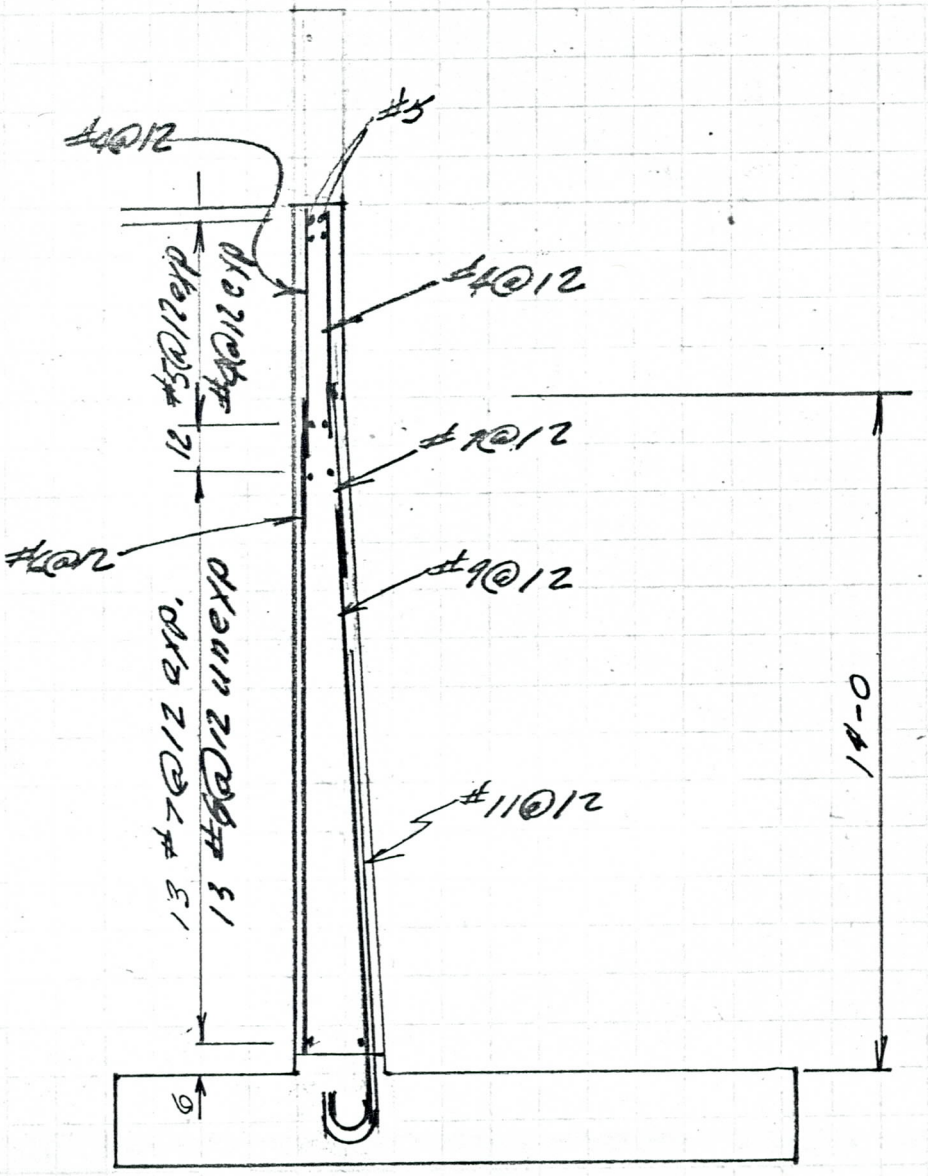
Section 2 Sidewall



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RJM	9-13-16			

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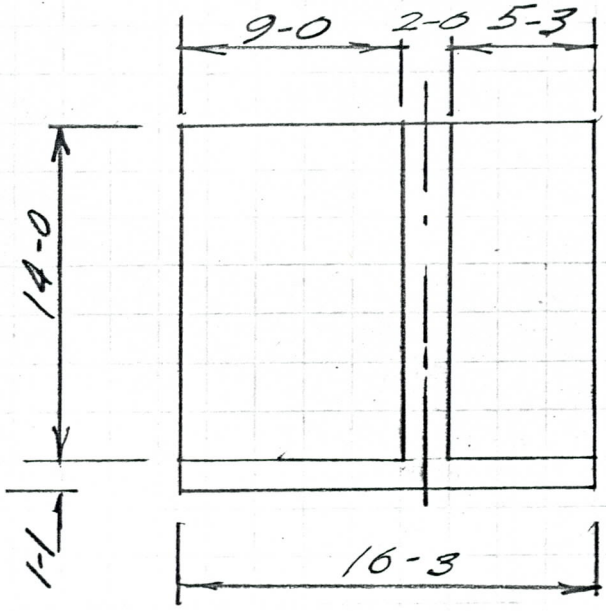
SHEET 49 OF

Revise out side section ES



SECTION @ HEADWALL

Headwall

JLS Designed the headwall as horizontal & vertical cantilevers on 45° axis and for a 10' length of base initially 11/75. He then disregarded this design in favor of a slab fixed on 3 sides w/ 20' width.

The short section of headwall will be redesigned as horizontal & vertical cantilevers on 45° axis.

STATE	PROJECT			
Ariz.	Buckhorn Mesa WPP Spook Hill FB5			
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-13-76			

SUBJECT Structural Design FB5

SHEET 50 OF _____

Apron

JLS designed the apron transversely as a series of continuous beams with the sidewall acting in shear but not resisting moment.

The apron steel will be checked for straight cantilever load.

Buttress & Longitudinal Sill

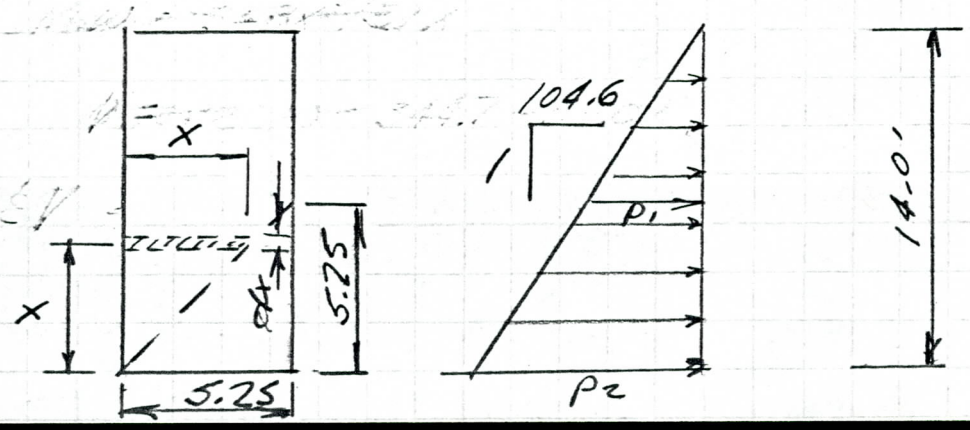
USE: JLS design 11/76

Transverse Sill

Temp steel only required.

Headwall Steel

From JLS Sheet 37 - USE equiv. fluid wt for full flow condition



STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-13-16			

SUBJECT Structural Design ES

SHEET 51 OF

Vertical Steel

$p_1 = 104.6(14 - 5.25) = 915$ psf
$p_2 = 104.6(14) = 1464$ psf

$V_{max} = (915+1464)(5.25)/2 = 6250$ #

$M_{max} = 915(5.25)^2/2 + (1464-915)(5.25)^3/6$
$= 12610 + 13240$
$= 25850$ in# X

Moment

$d_{req'd} = 9.80$ in $\simeq d = 9.5$" OK

$v_d = 6250/(12)(9.5) = 55$ psi $< V = 70$
OK.

ES 164

$A_s = 1.99$ sq in $A_s' = 1.00$ sq in

Unexposed face
USE #9@6 $A_s = 2.00$ sq in $S_o = 5.5$"

Exposed face
USE #7@12 & #6@12.
$A_s = 0.60 + 0.44 = 1.04$ sq in OK

Horizontal Steel

$d = 12 - 2 - 1\frac{1}{8} - \frac{1}{2} = 8\frac{3}{8}$

Find points of max. shear & moment

$V = wx$ where $w = 104.6(14-x)$

$\frac{dV}{dx} = 104.6(14 - 2x) = 0$

$x = 7 > x_{max} = 5.25$

USE $x = 5.25$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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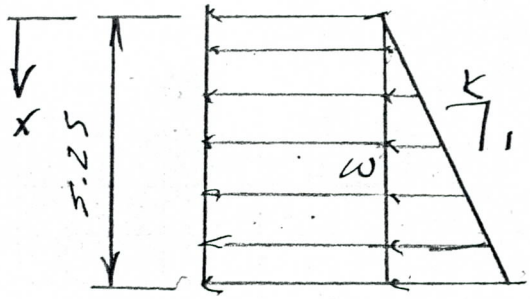
RJM	10-1-76			
SUBJECT				SHEET S1A OF

Plot Vertical Moments & determine steel cutoff points

$w = 104.6(14-5.25)$
$= 915\ p/f$

$K = 104.6\ p/f/ft \times 5.25$

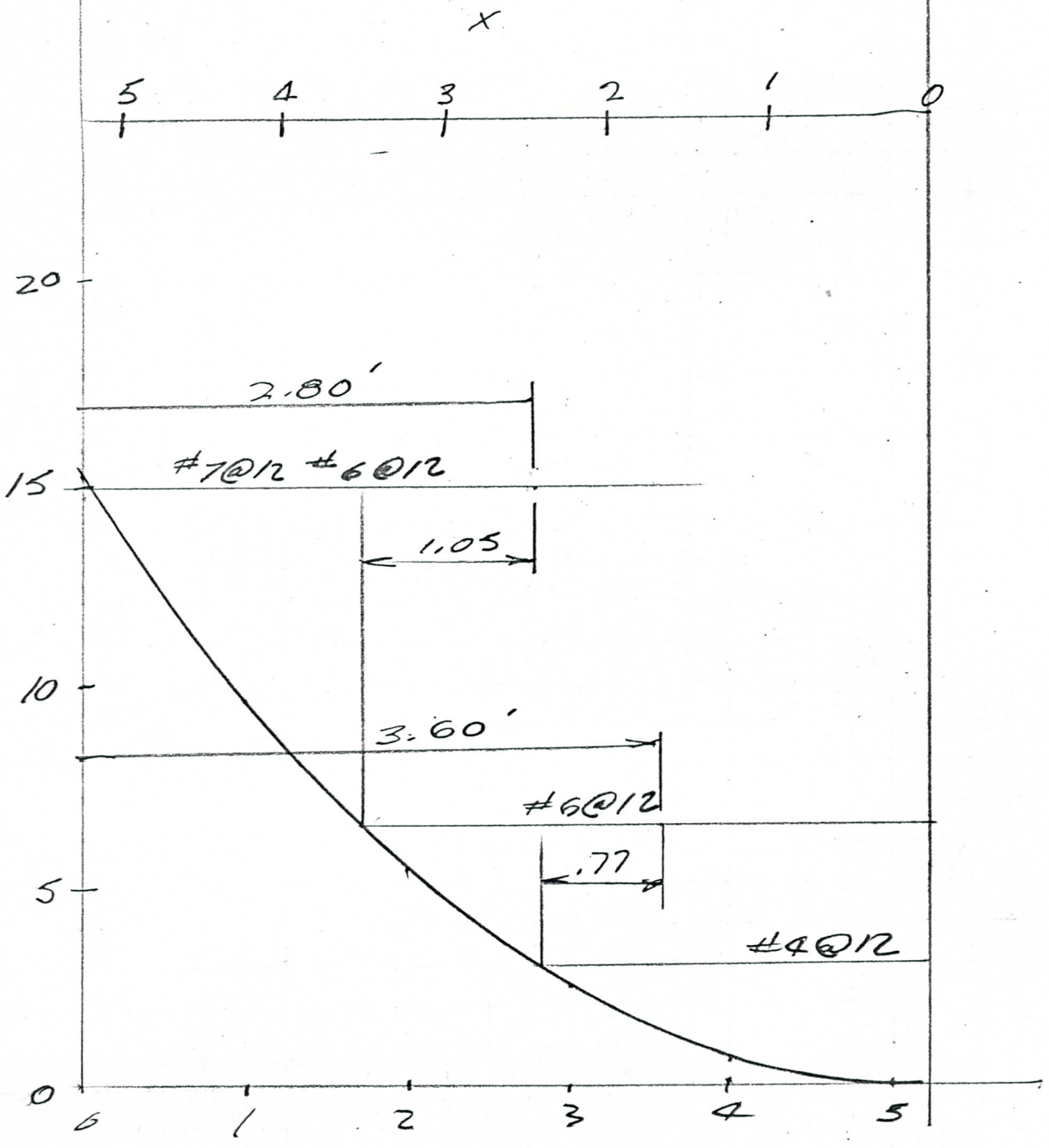


$M_x = wx^2/2 + Kx^3/6$
$= 915x^2/2 + 104.6x^3/6$
$= 458x^2 + 17.43x^3$

X	Mx
0	0
0.25	30
1.25	750
2.25	2520
3.25	5440
4.25	9610
5.25	15140

STATE		PROJECT		
A2		SPOOKHILLS		
BY RJM	DATE 10-1-76	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 52B OF

@ X = 5.25 M_x = 15,140 # A_s = 1.08 sq in
#7@12 #6@12 A_s = 1.04 sq in OK
#6@12 A_s = 0.44 M = 6500 "#
#4@12 A_s = 0.20 " M = 3000 "K



STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-13-76			

SUBJECT Structural Design ES

SHEET 57 OF

$V_{max} = 104.6(14-5.25)(5.25)$
$= 4810\#$

$M = w(14-x)x^2/2 = w(7x^2 - x^3/2)$
$\frac{dM}{dx} = w(14x - 3x^2/2) = 0$

$x = 9.33' > x_{max} = 5.25'$
$\therefore$ USE $x = 5.25$

$M = 104.6[7(5.25)^2 - (5.25)^3/2]$
$= \underline{12,610\ '\#}$

ES164

$d_{req'd} = 6.85" < d = 8.375$ OK

$A_s = 1.01$ sq in

USE #6@12 & #7@12
$A_s = 1.04$ sq in $\Sigma_o = 5.11$ in

Apron Steel

Compare LS Moments sec ① No Flow Sheet p114 1/76 to ACI code moment coefficients for more than 2 spans

$-1/11$ $\quad -1/11 \quad -1/11$
$+1/16 \quad +1/16$

$-M = \frac{1}{11}(319)(18)^2 = 9400\ '\#$ vs $8970\ '\#$

$+M = \frac{1}{16}(319)(18)^2 = 6460\ '\#$ vs $6980\ '\#$

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Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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SUBJECT Structural Design ES

SHEET 53 OF

Section ②

Full Flow -M = 9225 lb +M = 7175 lb

w = 328 plf

-M = (328)(18)²/11 = 9660 lb

+M = (328)(18)²/16 = 6642 lb

Section ③

Full Flow -M = 9900 lb +M = 7700 lb

w = 352 ptf

-M = (352)(18)²/11 = 10370 lb

+M = (352)(18)²/16 = 7130 lb

For -M = 10370 lb d = 9.5 in

As = 0.71 sq in

JLS design uses #8@12 As = 0.79 sq in

OK for center spans

USE JLS center spans

STATE	PROJECT		
Ariz	Buckhorn Mesa WPO Spook Hill FRS		
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SUBJECT Structural Design ES

SHEET 54 OF

Cantilever moment Sec (3)

$-M = wl^2/2$
$= 352(5.25)^2/2$
$= 4851$ lbs. Mdesign OK.

USE JLS steel on end of outside sections.

Check JLS Buttress Steel

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Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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RM	9-20-76			

SUBJECT Structural Design

SHEET 1 OF 20

Longitudinal Sill

Recalculate as beam fixed @ buttress & simply supported @ toe

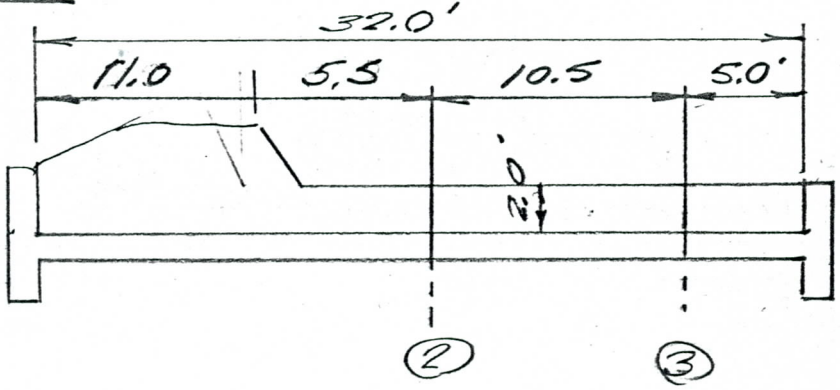
Reaction @ sill from Apron Design

	Section 2	Section 3
Before Fill	303 up	1229 up
No Flow	5776 dn	1960 dn
With Flow	5842 dn	6270 dn

Analyze Before Fill & With Flow conditions

NEH 11 Chap 6

Loads Use buttress W 11.0' base



b = 12"

Wt of long sill/ft = 2(150) = 300 lbs

Loads @ sec 2

Before Fill, load = 303 + 300 = 600 plf dn
With Flow, load = 5842 - 300 = 5542 plf up

Loads @ sec 3
Before Fill, load = 1229 + 300 = 1529 plf dn
With Flow, load = 6270 - 300 = 5970 plf up

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Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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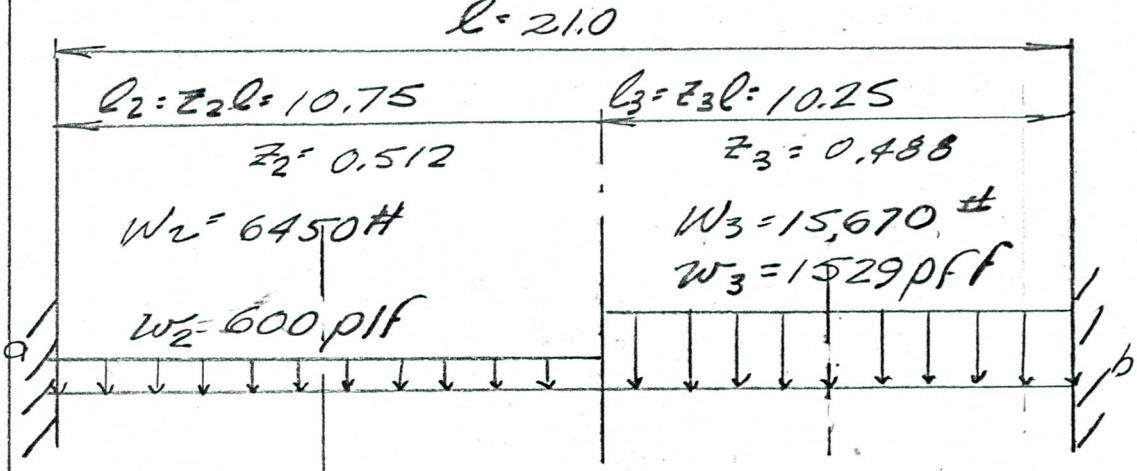
RJM	9-20-76			

SUBJECT Structural Design

SHEET 2 OF 20

Before Fill, Both Ends Fixed



$$M^F_{ab} = \ell z_2(6-8z_2+3z_2^2)W_2/12 + \ell z_3^2(4-3z_3)W_3/12$$
$$= (10.75)[6-(8)(.512)+(3)(.512)^2]6450/12 + (10.25)(.488)[4-3(.488)]15,670/12$$
$$= \underline{32,100}\ ^{\#}$$

$$M^F_{ba} = -\ell z_3(6-8z_3+3z_3^2)W_3/12 - \ell z_2^2(4-3z_2)W_2/12$$
$$= -(10.25)[6-8(.488)+3(.488)^2]15,670/12 - (10.75)(.512)[4-3(.512)]6450/12$$
$$= \underline{-44,500}\ ^{\#}$$

$$V^S_{ab} = W_2(z_3+z_2/2) + W_3 z_3/2$$
$$= 6450[.488+.512/2] + 15670(.488)/2$$
$$= 8620^{\#}$$

$$V^S_{ba} = -W_2 + W_3 + V^S_{ab}$$
$$= -6450 + 15670 + 8620$$
$$= -13,500^{\#}$$

$$V^F_{ab} = V^S_{ab} + (M^F_{ab} + M^F_{ba})/\ell$$
$$= 8620 + [32100 - 44,500]/21$$
$$= 8030^{\#}$$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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RM	9-20-16			

SUBJECT Structural Design

SHEET 3 OF 20

$V_{ba}^F = V_{ba}^S + (M_{ab}^F + M_{ba}^F)/\ell$
$= -13,500 - 590$
$= -14,090$ #

$M_C^S : R_b^S z_3 \ell - W_3 z_3 \ell/2$
$= 13500(10.25) - 15670(10.25)/2$
$= 58100$ #

Simple Moments

@ Sec 2, $M_{\text{¢}} = W_2 z_2 \ell/8 = 8670$ #
@ Sec 3, $M_{\text{¢}} = W_3 z_3 \ell/8 = 20100$ #

	$M_x/M_{\text{¢}}$	for span $z_2\ell$	for span $z_3\ell$
@ 0.5 $z\ell$	1.0	8670	20100
@ 0.4 $z\ell$	0.96	8320	19300
@ 0.3 $z\ell$	0.84	7280	16880
@ 0.2 $z\ell$	0.64	5550	12860
@ 0.1 $z\ell$	0.36	3120	7240

Simply Supported @ b

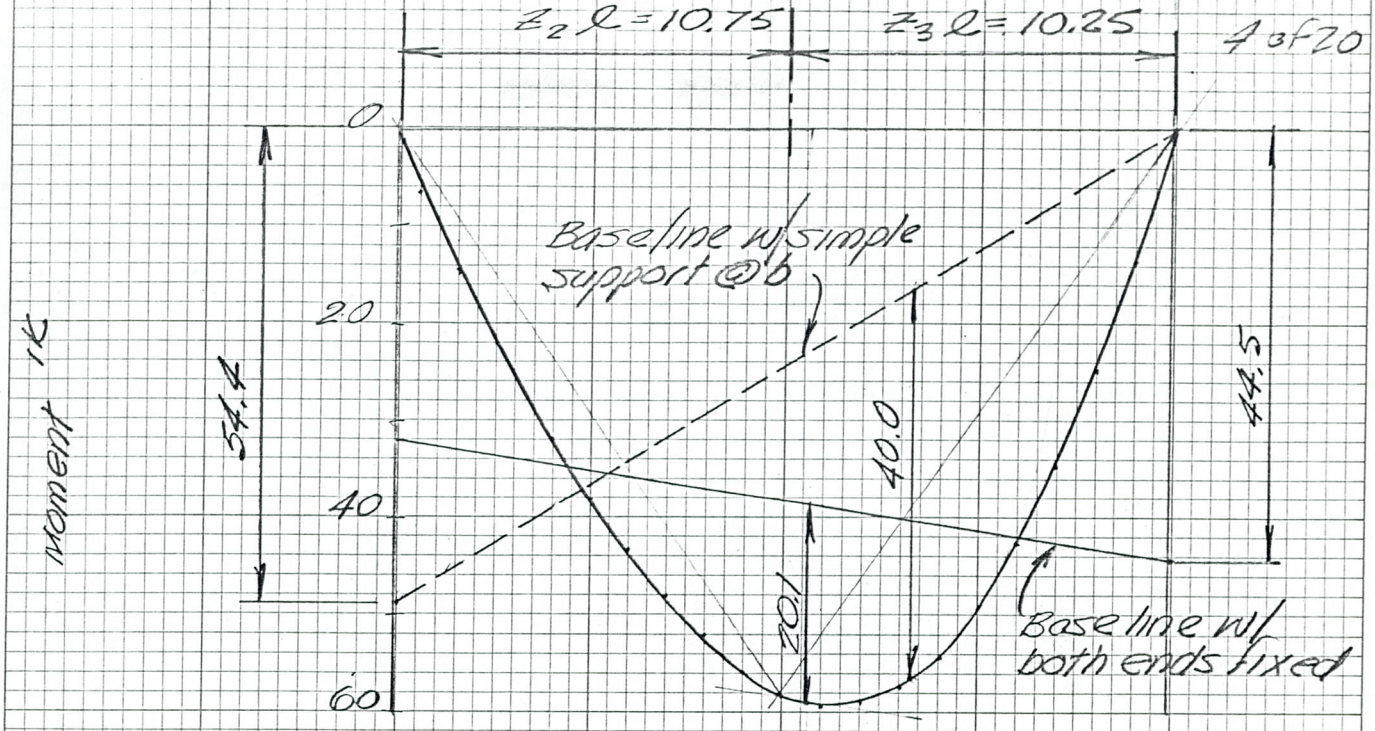
$M_{bd} = 0$

$M_{ab} = M_{ab}^F + (-M_{ba}^F)/2$
$= 32,100 + 44,500/2 = 54,400$ #

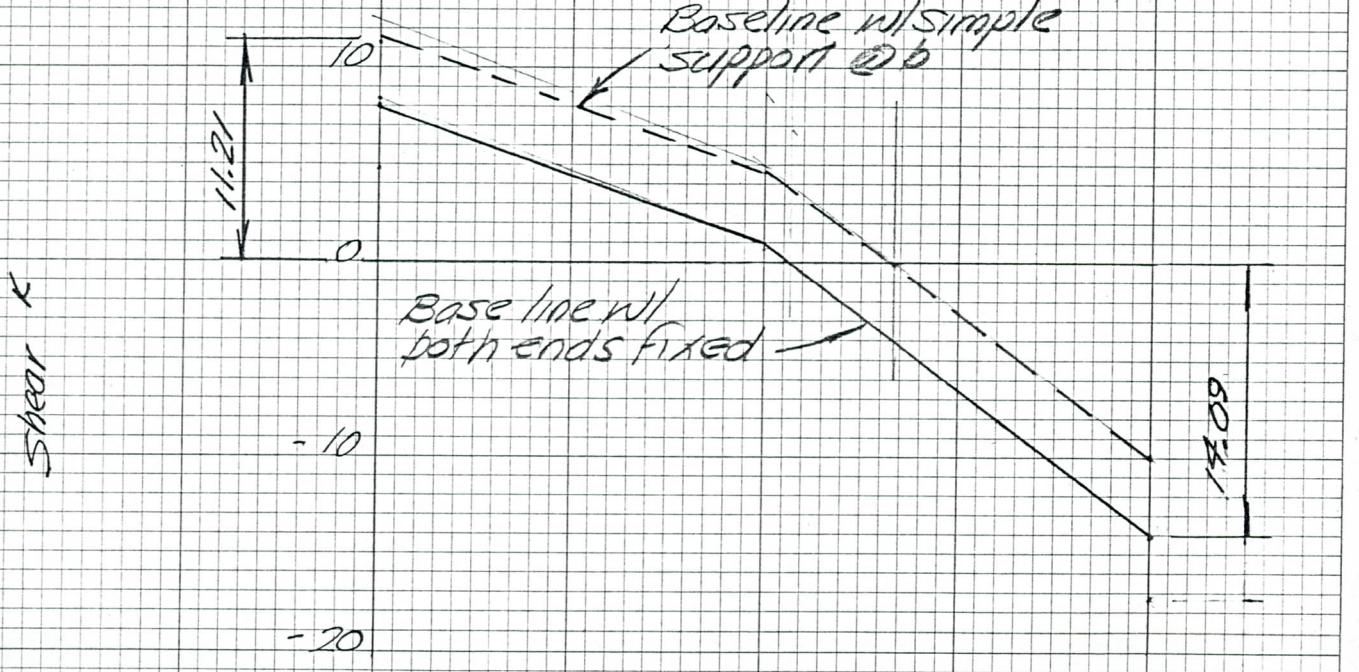
$V_{ab} = V_{ab}^F + (-1.5 M_{ba}^F)/\ell$
$= 8030 + 1.5(44,500)/21 = 11210$ #

$V_{ba} = V_{ba}^F + 3180$
$= -14,090 + 3180 = -10,910$ #

LONGITUDINAL SILL - BEFORE FILL



MOMENT DIAGRAMS



SHEAR DIAGRAMS

46 0700
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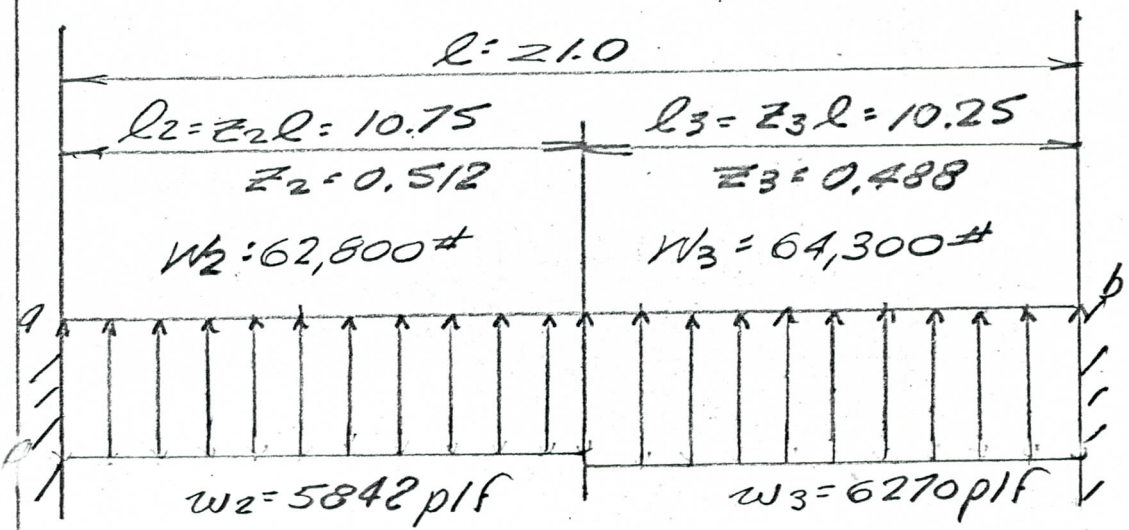
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Dook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RMM	9-20-76			

SUBJECT Structural Design

SHEET 5 OF 20

With Flow, Both Ends Fixed



$$M^F_{ab} = -\ell z_2(6 - 8z_2 + 3z_2^2)W_2/12 - \ell z_3^2(4 - 3z_3)W_3/12$$
$$= -(10.75)[6 - 8(.512) + 3(.512)^2]62,800/12 - (10.25)(.488)[4 - 3(.488)]64,300/12$$
$$= -219,000\ \#$$

$$M^F_{ba} = +(10.25)[6 - 8(.488) + 3(.488)^2]64,300/12 + (10.75)(.512)[4 - 3(.512)]62,800/12$$
$$= 225,000\ \#$$

$$V^S_{ab} = -(z_3 + z_2/2)W_2 - z_3 W_3/2$$
$$= -(.488 + .512/2)62,800 - .488(64,300)/2$$
$$= -62,400\ \#$$

$$V^S_{ba} = W_2 + W_3 - V^S_{ab}$$
$$= 62,800 + 64,300 - 62,400$$
$$= 64,700\ \#$$

$$V^F_{ab} = V^S_{ab} + (M^F_{ab} + M^F_{ba})/\ell$$
$$= -62,400 + [-219,000 + 225,000]/21$$
$$= -62,100\ \#$$

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Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-20-76			

SUBJECT Structural Design

SHEET 6 OF 20

$V_{ba}^{F} = V_{ba}^{S} + 290$
$= 64,700 + 290$
$= 64,990$ #

$M_c^S = R_b^S z_3 \ell - W_3 z_3 \ell/2$
$= 64,700(10.25) - 64300(10.25)/2$
$= 334,000$ '#

Simple Moments

@ Sec 2, $M_{\ell} = W_2 z_2 \ell/8 = 84,400$ '#
@ Sec 3, $M_{\ell} = W_3 z_3 \ell/8 = 82,400$ '#

	Mx/Mℓ	for span $z_2\ell$	for span $z_3\ell$
@ 0.5 $z\ell$	1.0	84,400	82,400
@ 0.4 $z\ell$	0.96	81,000	79,100
@ 0.3 $z\ell$	0.84	70,900	69,200
@ 0.2 $z\ell$	0.64	54,000	52,700
@ 0.1 $z\ell$	0.36	30,400	29,700

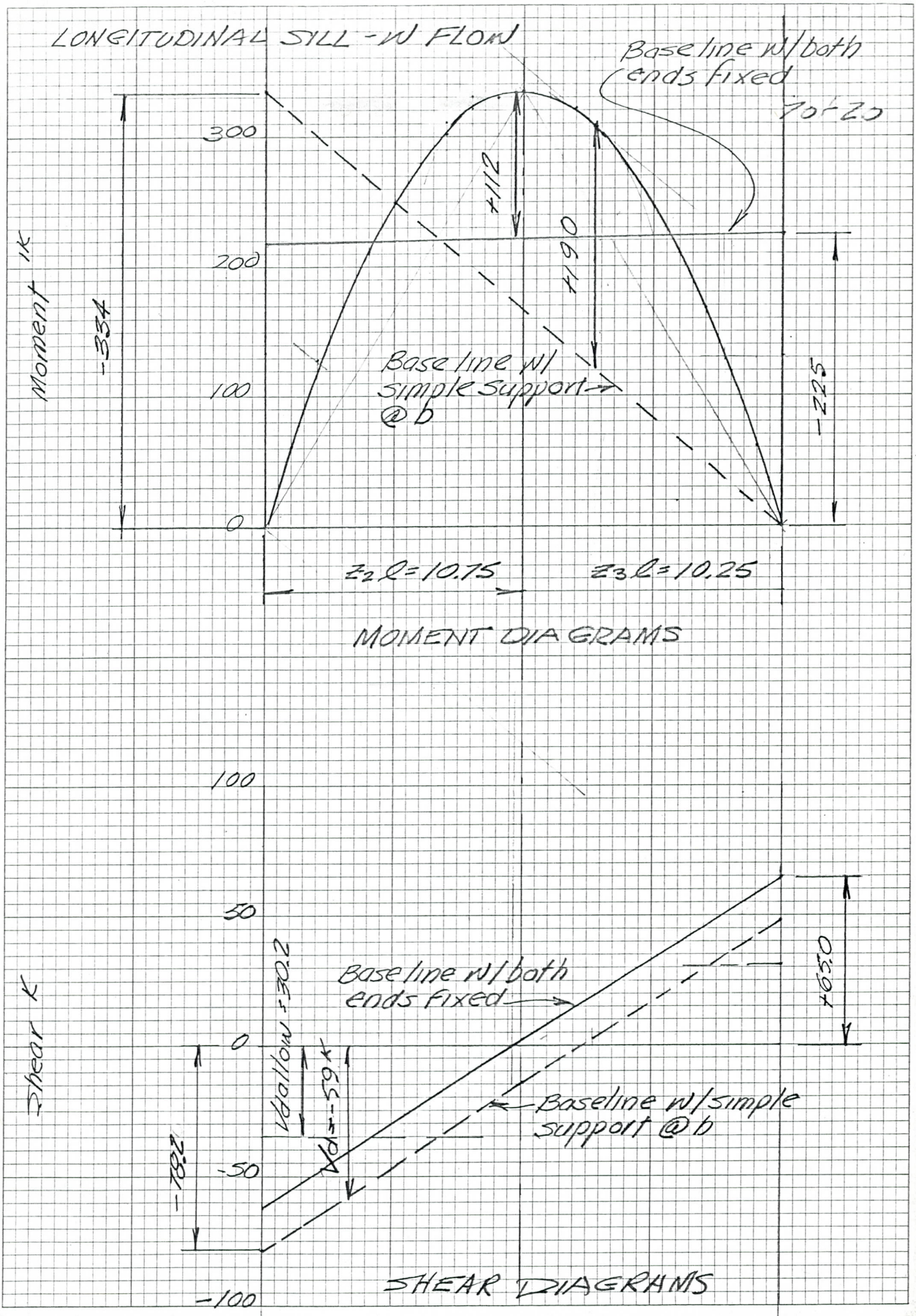
Simply supported @ b

$M_{ba} = 0$

$M_{ab} = M_{ab}^{F} + (-M_{ba}^{F})/2$
$= -219,000 + (-225,000)/2 = 332,000$ '#

$V_{ab} = V_{ab}^{F} + (-1.5 M_{ba}^{F})/\ell$
$= -62,100 + [(-1.5)(225,000)/21] = 78,200$ #

$V_{ba} = V_{ba}^{F} - 16,100$
$= 65,000 - 16,100 =$ 48,900 #



46 0700
10 X 10 TO THE INCH • 7 X 10 INCHES
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Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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RJM	9-21-76			

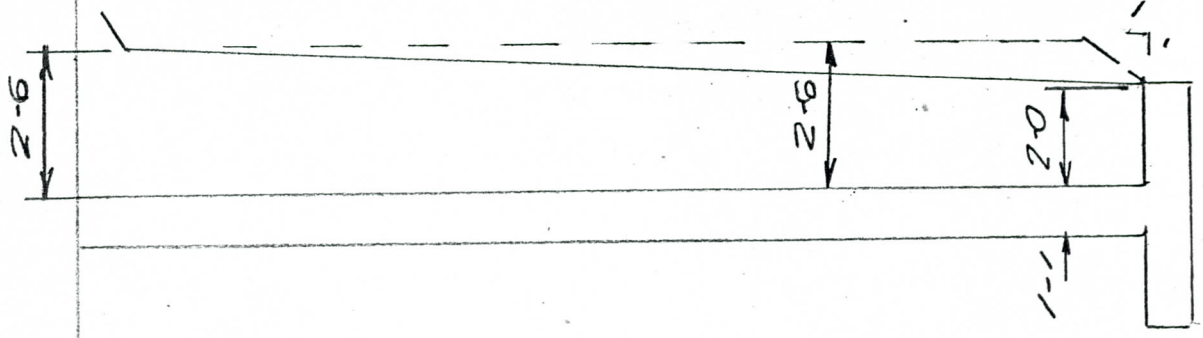
SUBJECT Structural Design

SHEET 8 OF 20

R/C Design
HB ACI SP-3
$f_c' = 4000$
$f_s = 20000$
Table 4

Steel in bottom face

M/K = 354/272 = 1.30 b = 12"
$d_{req'd}$ = 36"
d_{actual} = 13+24-3-1-½-2½ = 30"
increase sill ht @ buttress to 30"
d = 36"



At Buttress

Mab = -334 ᴵᴷ, Vab = 78.2 ᴷ (w/flow simple support)
Req'd As = 12M/$f_s$jd
= 12(334)/20(7/8)(36)
= 6.36 □"
v = Vd/bd = 59000/(12)(36) = 136 psi NG
Vd allow = 70(12)(36) = 30,200 #
V's = 59,000 - 30,200 = 28,800 #
A_v = V's/f_vd = 28,800/(20,000)(36) = .104 □"
For #4 bars @ 18" - stirrups A_v = 0.13 □"
Temp stl As = 0.002(12)(12) = 0.29 sq in
USE #5@12 as stirrups in the sill

For tensile steel

8 #8	As = 6.32 □"	Σ_o = 25.11"
7 #9	As = 7.00 □"	Σ_o = 24.8"
5 #10	As = 6.35 □"	Σ_o = 20.0"

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
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RJM	9-21-76			

SUBJECT Structural Design

SHEET 9 OF 20

$u = V/\Sigma_o jd = 78200(8)/(20.0)(7)(36) = 124$ psi
$u_{allow} = 4.8\sqrt{f'_c}/D = 4.8\sqrt{4000}/1.25 = 243$ psi OK

USE 2 #10 in the top face of the apron
$L'' = f_s D/4u = 20000(1.25)/4(243) = 25.7''$
$> d = 36''$ use d
Extend .23(10.75) + 3 = 5.47 say 5-6"
E into the sill
& 25.7" say 2-6" into the buttress

USE 3 #10 in the bottom face of the apron
Extend 3' past pt of inflection
= 10.75/2 + 3 = 8.38' say 8'-6"
& 2'-6" into the buttress

At Sill

$M^F_{ba} = -225'^K$, $V^F_{ab} = 65^K$ (w flow, both ends fixed)
Req'd $A_s = 12(8)(225)/20(7)(36) = 4.28\square''$
USE 4 #10 $A_s = 5.08\square''$ $\Sigma_o = 16.0''$
$u = 65000(8)/(16)(7)(36) = 129$ psi ok
Cutoff top 2 #10s @ .25(10.25) + 3 = 5.56'
say 6-0 & hook into toewall @ 90°
Cutoff bottom 2 #10 @ .43(10.25) + 3 = 7.40'
say 7'-6" & hook into transsill @ 90°

At center span

$+M_{max} = 40.0'^K$ (Before Fill simple support)
Req'd $A_s = 12(8)(40)/20(7)(36) = 0.76\square''$
Continue 2 #10 through from buttress & apron on the bottom of the apron

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-21-76			

SUBJECT Structural Design

SHEET 10 OF 20

Steel in Top Face

$d = 30 + 13 - 2\frac{1}{2} = 40.5$ say

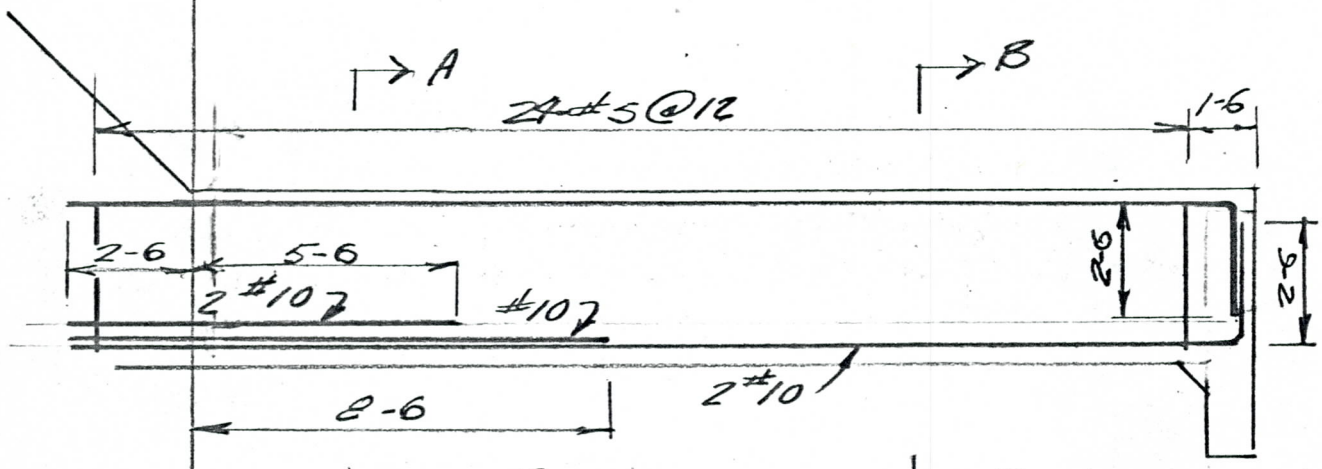
At center span.

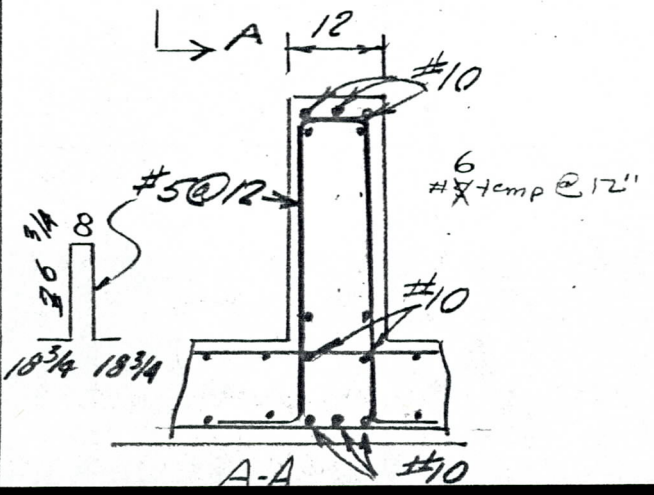
$+M_{max} = 190^{1K}$ (W Flow simple support

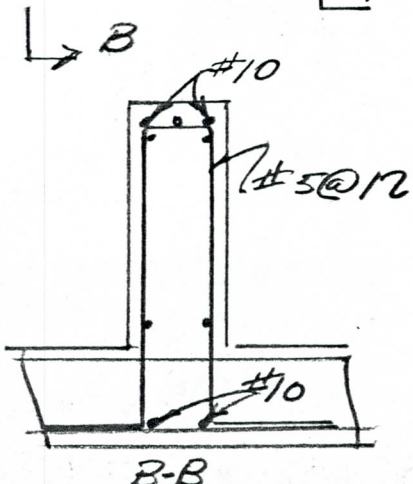
$A_{s\,reqd} = 190(12)(8) / 20(7)(40) = 3.26\ \square"$

3-#10 $A_s = 3.81\ \square"$ $\Sigma_o = 12.0$ "

hook into toewall and carry 2'-6" into buttress







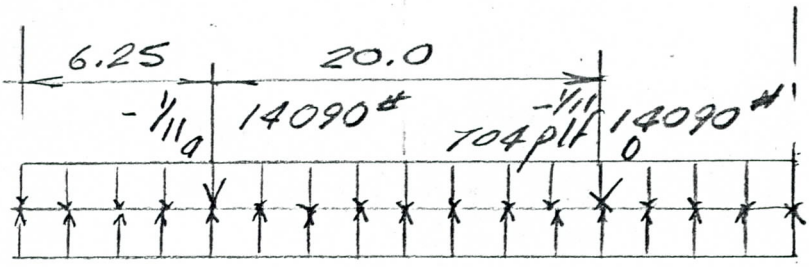
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-22-76			

SUBJECT Structural Design

SHEET 11 OF 20

Transverse Sill

Before Fill



Total base press / ft length
$= (1)(61+56)/2 = 58.5$ plf up
Wt of conc $= 5.08(150)(1) = 762.5$ plf dn
$w = 762.5 - 58.5 = 704$ plf (down)
Conc loads $= R_b$ long sill $= 14090^{\#}$ dn.

Find w & M_a, M_b

$\Sigma V_y = 0$

$13(14090) + 704(252.5) - 252.5w = 0$
$w = 1429$ up OK

$-M = (1429)(19)^2/11 = 46{,}900^{'\#}$
$+M = (1429)(19)^2/16) = 32{,}200^{'\#}$

RC Design HB Table 4

Bottom

$M/K = 46.9/272 = 0.172$
$d_{req'd} = 13.12"$
For $d = 61 - 3.5 = 57.5"$
$-A_s = 12(8)(46{,}900)/(7)(20{,}000)(57.5)$
$= 0.56$ sq in

Top

$+A_s = 12(8)(32{,}200)/(7)(20{,}000)(57.5)$
$= 0.38$ sq in

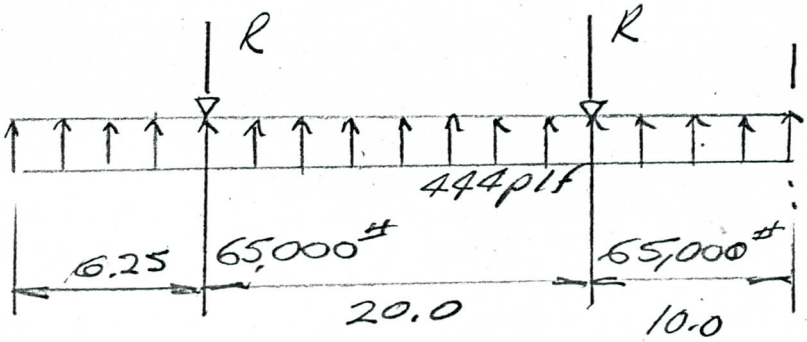
STATE Ariz | PROJECT Buckhorn Mesa WPP Spook Hill FRS

BY RJM | DATE 9-22-76 | CHECKED BY | DATE | JOB NO.

SUBJECT Structural Design | SHEET 12 OF 20

Full Flow

Total base press. = (1)(1206+1208)/2 = 1207 plf up
Wt of conc = 762.5 plf dn
W = 1207 - 762.5 = 444.5 say 444 plf up
Conc loads: R/long sill = 65,000 # dn



$R = 65000 + 444(20) = 73,880^{\#}$

$-M = (444)(19)^2/11 = 14570^{\#}$
$+M = (444)(19)^2/16 = 10020^{\#}$

For d = 57.5"
$-A_s = (8)(12)(14,570)/(7)(20000)(57.5)$
$= 0.17$ sq in
$+A_s = (8)(12)(10,020)/(7)(20000)(57.5)$
$= 0.11$ sq in

USE 2 #5 top & bottom

Design anchors to resist 73,880 #
@ ea long. sill

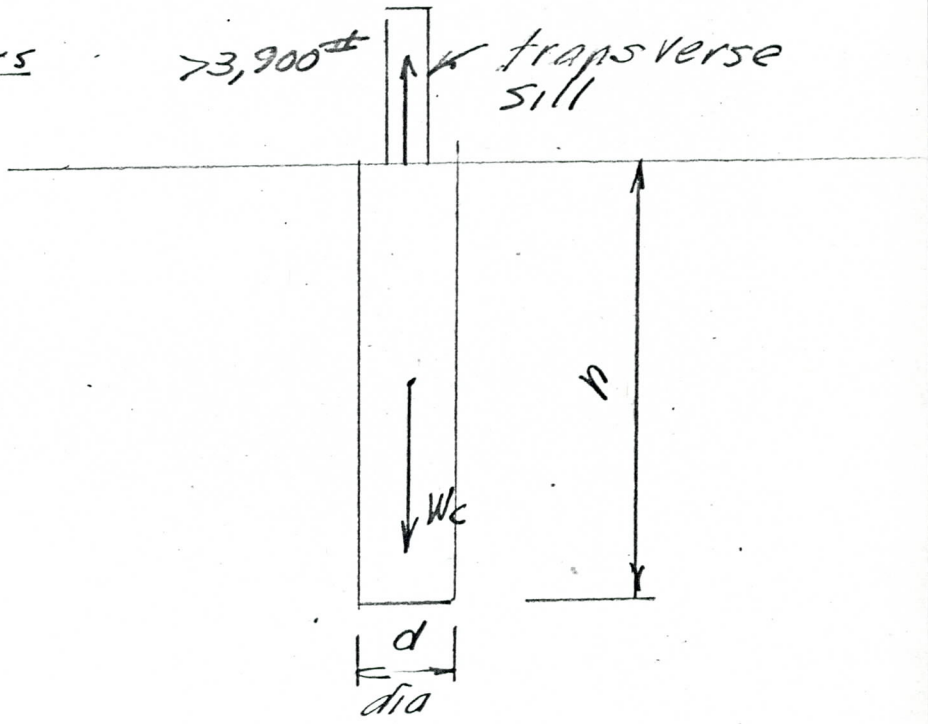
STATE	PROJECT		
Ariz	Buckhorn Mesa WPP Spook Hill FRS		
BY RM	DATE 9-22-76	CHECKED BY	DATE

JOB NO.

SUBJECT Structural Design

SHEET 13 OF 70

Anchors >73,900# ← transverse sill



USING Wt of conc. only

$V_c = 73,900/150 = 493$ cu ft

d	n
1	628
1.5	279
2	157
2.5	100
3	69.8
3.5	51.3
4	39.2
4.5	31.0
5	25
10	6.28

NG

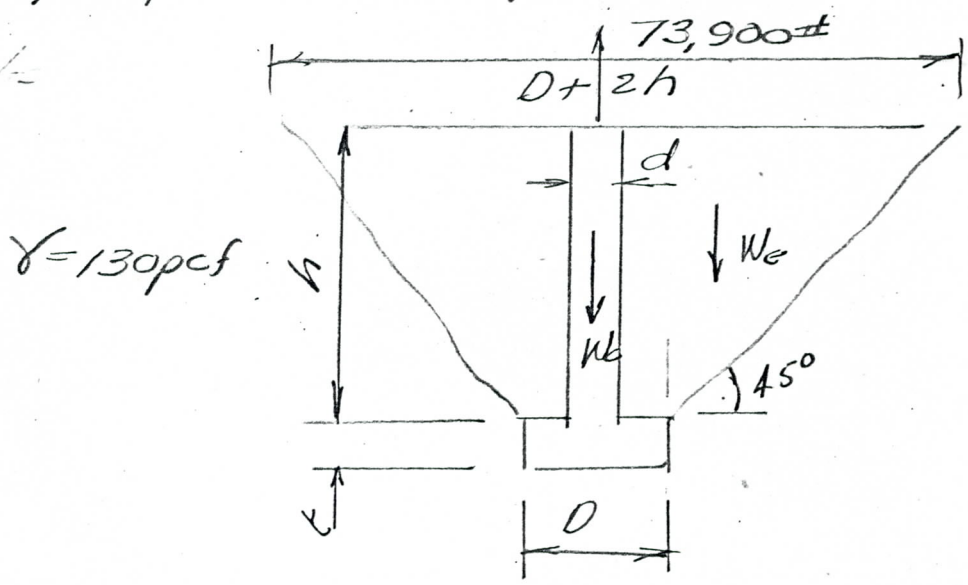
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-18-16			

SUBJECT Structural Design

SHEET 14 OF 20

Try Expanded footing in anchor

Assume moderately indurated caliche will shear @ 45°



USE SF = 1.0

$We + Wc = 73{,}900$

$Wc = [h\pi d^2/4 + t\pi D^2/4]150$

$We = \gamma\{h[\pi D^2/4 + \pi(D+2h)^2/4]/2 + \sqrt{(\pi D^2/4)[\pi(D+2h)^2/4]}\}/3 - (h\pi d^2/4)(150)$

Try: $d = 2'$ $D = 8'$ $h = 10'$ $t = 2'$

$\pi d^2/4 = \pi(2)^2/4 = 3.14$

$\pi D^2/4 = \pi(8)^2/4 = 50.3$

$\pi(D+2h)^2/4 = \pi(8+20)^2/4 = 616$

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RM	9-28-76			

SUBJECT Structural Design

SHEET 15 OF 26

$W_c = [10(3.14) + 2(50.3)]/150 = 19,800^{\#}$

$W_e = 130[10(50.3 + 616) + \sqrt{(50.3)(616)}]/3$
$= \frac{1}{2}10(3.14)(150)$
$= 292,000^{\#}$ high

Try: $d = 2'$ $D = 6'$ $h = 6$ $t = 2$

$\pi d^2/4 = 3.14$

$\pi D^2/4 = \pi(6)^2/4 = 28.3$

$\pi(D+2h)^2/4 = \pi(6+12)^2/4 = 254$

$W_c = [6(3.14) + 2(28.3)]/150 = 11,320^{\#}$

$W_e = 130[6(28.3 + 254) + \sqrt{(28.3)(254)}]/3$
$= 6(3.14)(150) = 74,200$

$W_c + W_e = 85,500^{\#}$ OK

Try $d = 2'$ $D = 6$ $h = 4$ $t = 2$

$\pi d^2/4 = 3.14$

$\pi D^2/4 = 28.3$

$\pi(D+2h)^2/4 = \pi(6+8)^2/4 = 153.9$

$W_c = [4(3.14) + 2(28.3)]/150 = 10,370^{\#}$

$W_e = 130[4(28.3 + 153.9) + \sqrt{(28.3)(153.9)}]/3 - 1884$
$= \cancel{30,300}$ 32,600

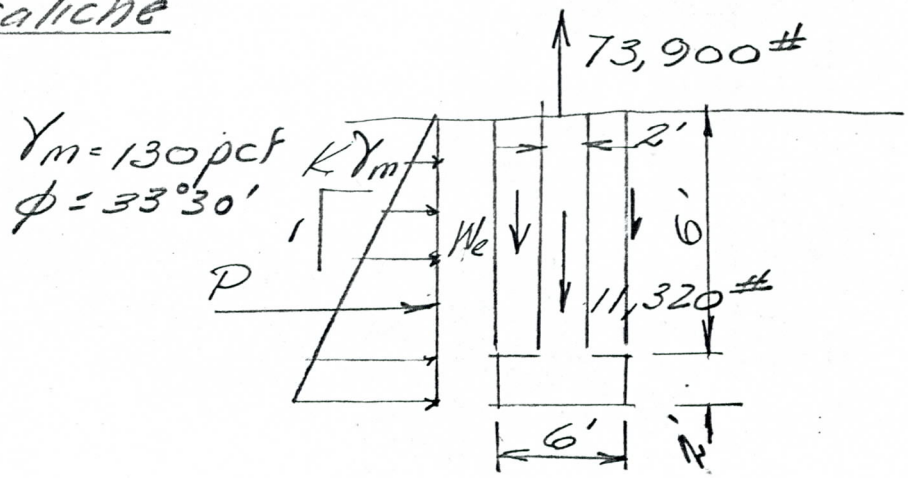
$W_c + W_e = 40,700^{\#}$ NG

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-28-76			

SUBJECT Structural Design

SHEET 16 OF 20

Check Footing in Poorly indurated caliche



$\Sigma F_V = 0$

$73,900 - 11,320 - We - Pf_C = 0$

where $We = [\pi(6)^2/4 - \pi(2)^2/4](6)(130)$
$= 19,600^{\#}$

$\therefore Pf_C \geq 73,900 - 11,320 - 19600$
$\geq 42,980$ say $43,000^{\#}$

EDS FWS Fig 2.2

For $\phi = 33°30'$ Non Yielding Condition
USE 1-sinϕ curve
$K = 0.46$

$P = 0.46(130)(8)^2/2 = 1914$ plf
$f = \tan\phi = \tan 30°30' = 0.589$
$C = \pi D = \pi(6) = 18.85$ ft

$Pf_C = (1914)(0.589)(18.85) = 21200^{\#}$
$< 43,000^{\#}$ NG

STATE	PROJECT		
Ariz	Buckhorn Mesa WPP Spook Hill FRS		
BY RM	DATE 9-28-76	CHECKED BY	DATE
SUBJECT Structural Design			JOB NO.
			SHEET 17 OF 20

Develope program for Monroe 1880 to size footings

Unknowns d = dia bole ft
D = dia expanded bottom ft
h = ht hole to exp bottom ft
t = ht of expanded bottom ft

Equations

R_1 = max reaction in moderately indurated caliche - lbs
R_2 = max reaction in poorly indurated caliche - lbs
$R_1 > 73,900\#$ $R_2 > 73,900\#$

*mod ind. caliche
**poorly ind calic.

1. $R_1 = W_c$ (wt of conc) + W_e (wt of earth)*
2. $R_2 = W_c + W_e$ (wt of earth**) + F (friction force)
3. $W_c = (hA + tB)150$
4. $W_e' = 130[h(B+C) + \sqrt{BC}]/3$
5. $W_e'' = 130h(B-A)$
6. $F = 0.589 P_c$
7. $A = \pi d^2/4$
8. $B = \pi D^2/4$
9. $C = \pi(D+2h)^2/4$
10. $P = (.46)(130)(h+t)^{3/2}$
11. $c = \pi D$
12. $V_c = W_c/1500$

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
GPO: 1968—O-337-998

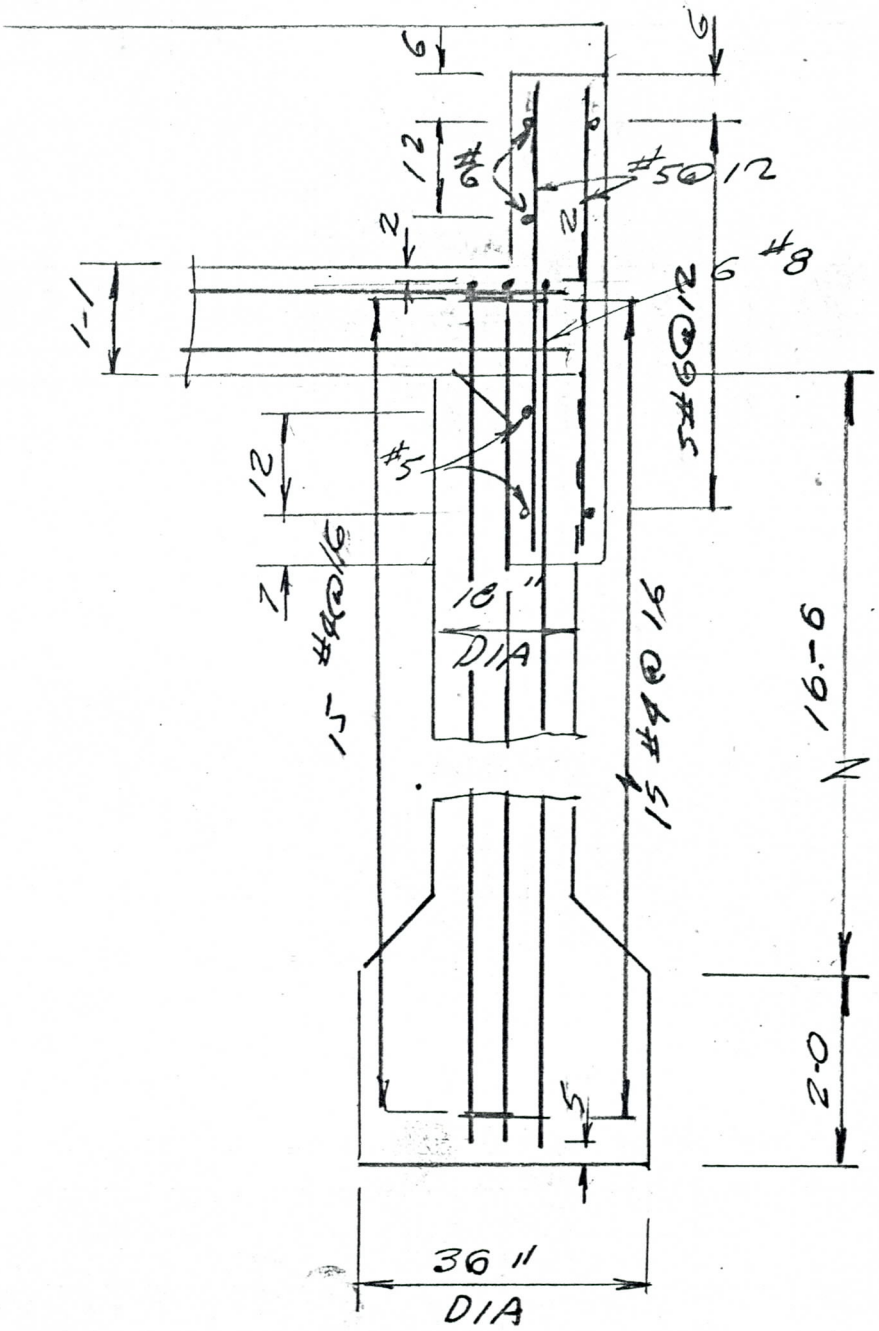
STATE Ariz | PROJECT Buckhorn Mesa Wtsp Spook Hill FRS
BY RJM | DATE 9-29-76 | CHECKED BY | DATE | JOB NO.
SUBJECT | SHEET 18 OF 20

Trial No	d ft	D ft	t ft	h ft	Wc lbs	We lbs	We" lbs	F lbs	R_1 lbs	R_2 lbs	Vc Cy
1	1.0	1.0	2.0	33.5					∞	73,900	1.03
2	"	2.0	2.0	22.0					∞	74,000	0.87
3	"	~~3.0~~	2.0	16.5					∞	74,300	1.00
4	1.25	1.25	2.0	29.5					∞	74,400	1.43
5	"	2.50	2.0	19.0					∞	75,100	1.23
6	"	~~3.75~~	2.0	14.0					∞	76,800	1.45
7	1.50	1.5	"	26.5					∞	75,000	1.87
8	"	3.0	"	16.5					∞	74,700	1.60
9	"	~~4.5~~	"	11.5					∞	74,300	1.93
10	1.75	1.75	"	24.0					∞	74,800	2.32
11		~~3.50~~	"	14.5					∞	74,400	2.00
12		~~5.25~~	"	10.0					∞	76,900	2.49
13	2.00	2.00	"	22.0					∞	75,000	2.79
14		~~4.00~~	"	13.0					∞	75,600	2.44
15		~~6.00~~	"	8.5					176,700	76,900	3.08

Note Max bell = 36" dia — J Holland E&WPU 9/29
Min dia for steel placement = 18"

USE d = 1.5' = 18" D = 3.0' = 36" t = 2.0' h = 16.5'

STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
PJM	9-29-76			
SUBJECT				SHEET 19 OF 20
Structural Design				

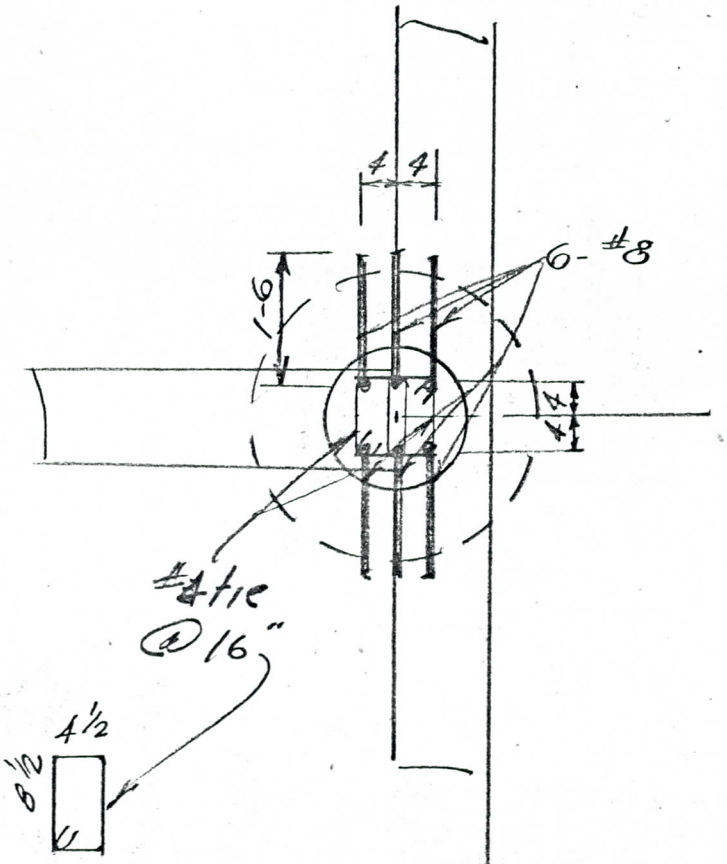


ELEVATION - ANCHOR

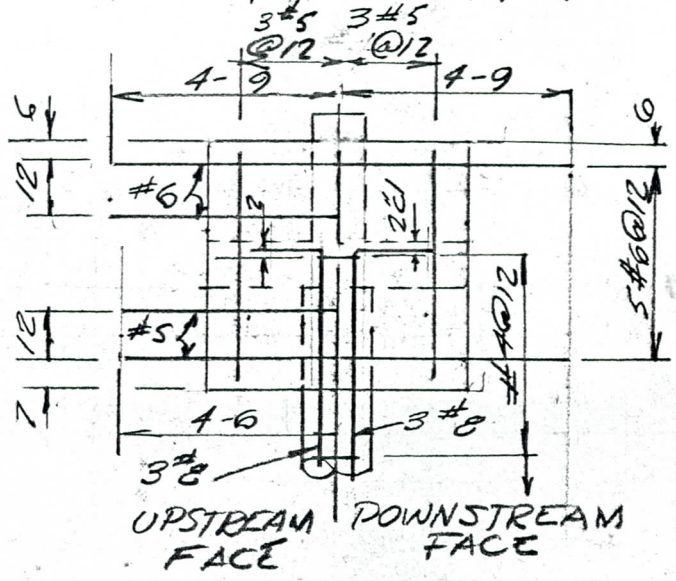
STATE		PROJECT		
Ariz		Buckhorn Mesa WPP Spook Hill FRS		
BY	DATE	CHECKED BY	DATE	JOB NO.
RJM	9-29-76			

SUBJECT Structural Design

SHEET 20 OF 20



PLAN - ANCHOR



TOEWALL

COST ESTIMATE - BUCKHORN-MESA WPP, ARIZONA - SPOOK HILL FRS

ITEM NO.	WORK OR MATERIAL	SPEC. NO.	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1.	Clearing, Grubbing & Chipping	2	101	Acres	200.00	20,200
2.	Clearing and Grubbing	2	89	Acres	150.00	13,350
3.	Pavement Removal	3	19,060	Sq.Yd.	.30	5,720
4.	Mobilization	8	1	L.S.	1,250.00	125,000
5.	Surveys	8	1	L.S.	230,400.00	230,400
6.	Foundation Excavation, Common	21	321,720	C.Y.	.40	128,700
7.	Channel Excavation, Common	21	102,500	C.Y.	.75	76,875
8.	Structure Excavation, Common	21	6,200	C.Y.	3.00	18,600
9.	Structure Backfill	23	3,650	C.Y.	7.00	25,550
10.	Earth Fill	23	1,455,429	C.Y.	.57	829,600
11.	Drain Fill	24	202	C.Y.	10.00	2,020
12.	Salvaging and Spreading Topsoil - 12-inch thickness	26	249,300	S.Y.	.35	87,255
13.	Salvaging & Spreading Topsoil - 6-inch thickness	26	74,400	S.Y.	.32	23,810
14.	Reinforced Concrete Class 4000X	31	1,262	C.Y.	170.00	214,540
15.	Cement	31	1,893	Bbls.	11.00	20,820
16.	Steel Reinforcement	34	193,050	Lbs.	.35	67,570
17.	6-Inch Diameter Drain System	44	1	L.S.	2,500.00	2,500
18.	108" Diameter CMP	51	532	Lin.Ft.	175.00	93,100
19.	Loose Rock Riprap	61	1,010	C.Y.	13.00	13,130
20.	24-Inch Slide Gate	71	1	L.S.	4,000.00	4,000
21.	Metalwork	81	1	L.S.	10,000.00	10,000
22.	Identification Sign	81	1	L.S.	1,000.00	1,000
23.	Fencing	92	28,335	Lin.Ft.	1.00	28,335
24.	Pavement Replacement	400	15,220	Sq.Yd.	10.00	152,200
					TOTAL:	2,194,275

COST ESTIMATE

ITEM NO.	WORK OR MATERIAL	SPEC. NO.	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1.	4-inch Diameter PVC Main Pipe (Class 200, Rubber Ring Pipe and Subsidiary Wire)	202	22,900	L.F.	3.70	$84,730.00
2.	17 Head Irrigation System	202	67	each	$570	$38,190.00
3.	11 Head Irrigation System	202	2	each	340	$ 680.00
4.	3/4-inch, 200 psi, PVC, Lateral Pipe	202	9,350	L.F.	$.39	$ 3,646.50
5.	1-inch, 200 psi, PVC, Lateral Pipe	202	1,750	L.F.	$.45	$ 787.50
6.	1-1/4-inch, 200 psi, PVC, Lateral Pipe	202	3,000	L.F.	$.61	$ 1,830.00
7.	.580 inch PE Emitter Lateral Pipe	202	73,300	L.F.	$.52	$38,116.00
8.	Emitter, PE Riser and Fitting	202	2,337	each	$1.70	$ 3,972.90
9.	Valve Boxes	202	121	each	$30	$ 3,630.00
10.	Butterfly Valve, 4-inch diameter, handle operator	202	2	each	$160	$ 320.00
11.	Butterfly Valve, 4-inch diameter, gear operated	202	2	each	$150	$ 300.00
12.	Check Valve, 4-inch diameter	202	2	each	$250	$ 500.00
13.	Backflow Preventer Valve, 4-inch diameter	202	2	each	$1,800	$ 3,600.00
14.	2" Solenoid Valve and Regulator	202	67	each	$300	$20,100.00
15.	1-1/2 inch Solenoid Valve and Regulator	202	2	each	$240	$ 480.00
16.	3/4 inch Solenoid Valve and Y-Screen	202	13	each	$70	$ 910.00
17.	3/4 inch Regulating Valve	202	41	each	$20	$ 820.00
18.	Salvaging and Transplanting of Saguaro Cacti	400	76	each	$100	$ 7,600.00

COST ESTIMATE

ITEM NO.	WORK OR MATERIAL	SPEC. NO.	QUANTITY	UNIT	UNIT PRICE	AMOUNT
19.	Salvaging and Transplanting of Barrel Cacti	400	58	each	$30	$1,740.00
20.	Salvaging and Transplanting of Ocotillo Shrubs	400	25	each	$60	$1,500.00
21.	Pump Station	401	2	each	$3,600	$7,200.00
22.	Water Supply	401	4	each	$450	$1,800.00
23.	23-Station Controller	401	3	each	$1,200	$3,600.00
24.	7-Station Controller	401	4	each	$250	$1,000.00
25.	Wiring Pump Station	402	2	Lump Sum	$1,500	$3,000.00
26.	Wiring - Controller	402	12,100	Lump Sum	$25,530	$25,530.00
27.	Five Gallon Container Stock	403	2,337	each	$15	$35,055.00
28.	Seed Mix No. One	404	38.5	acre	$660	$25,410.00
29.	Seed Mix No. Two	404	15.1	acre	$660	$9,966.00
30.	Seed Mix No. Three	404	37.4	acre	$440	$16.456.00
31.	Plant Establishment	405	1	Lump Sum	$17,340	$17,340.00
	Total					$359,810.00
	10% Contingency					35,981.00
	Grand Total					395.791.00