PART D

SURFACE WATER MANAGEMENT PROJECT DESIGN EXAMPLES

DESIGN EXAMPLE

FOR

AN AGRICULTURAL SITE

AGRICULTURAL SITE
(N.T.S.)

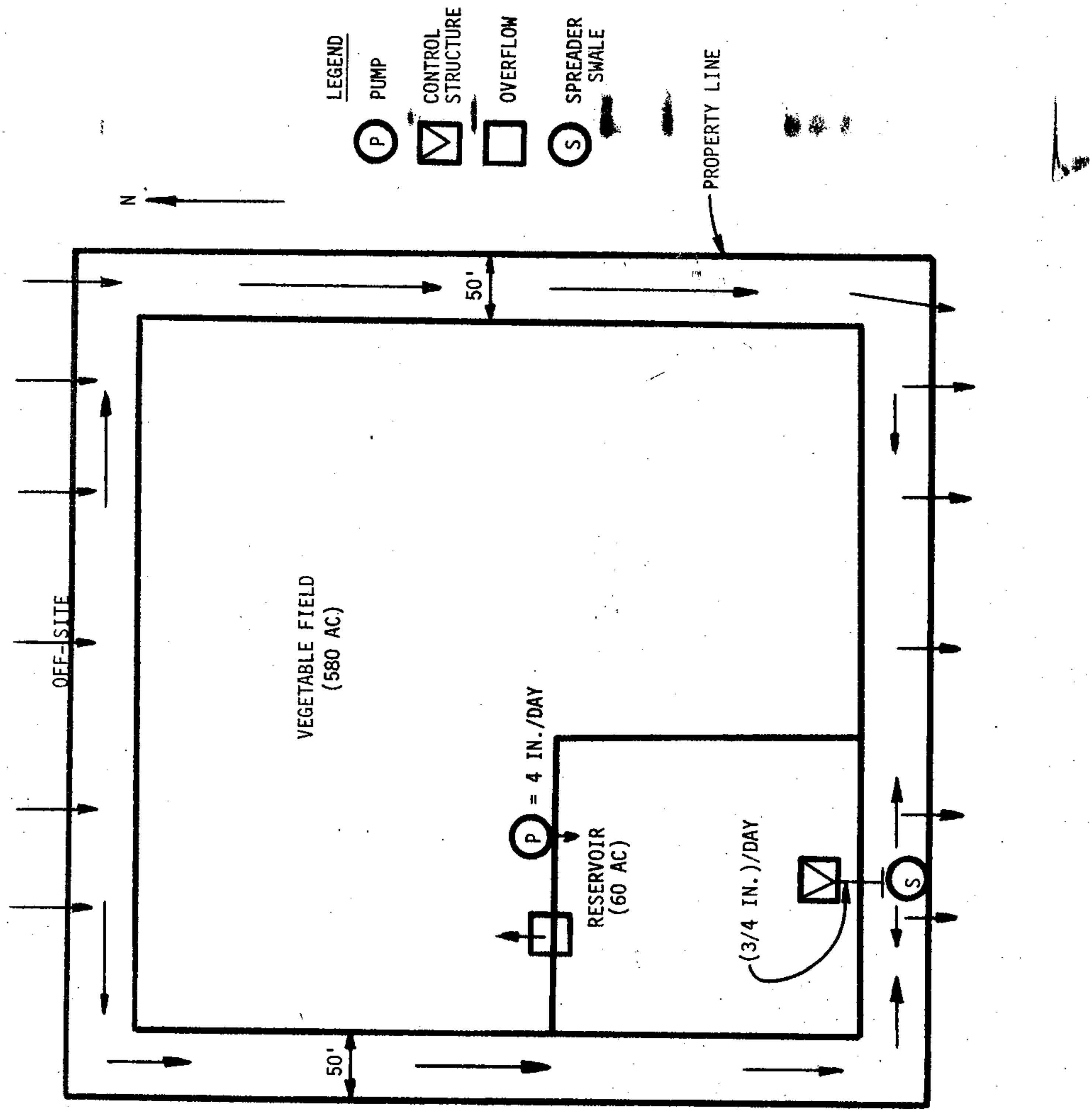


Figure D-A-1

I. Given

A. Proposed Acreages

1. Total = 640 ac

2. Reservoir = 60 ac

3. Laterals = 40 ac

4. Vegetable Field = 540 ac

B. Elevations

1. Laterals extend from elevation 60' (bed) to 64' NGVD (banks).

2. Field extends from elevations 64' to 68' NGVD.

3. Field control elevation is 60' NGVD.

4. Reservoir control elevation is 65' NGVD, to maintain wetlands.

C. Off-site areas contribute sheetflow runoff to the site. The off-site runoff will be routed around the site via perimeter swales. (Toes of the berms are set back at least 50 feet from the property line; berms have a top width of 5 feet; have external sideslopes of 2.5H:1V, and interior sideslopes of 3H:1V for ease of maintenance.)

D. Discharge off-site will continue to be by sheetflow, to preserve natural conditions.

E. Natural depth to water table = 4.0 ft

F. A pumping rate of 4 in./day (97.6 cfs) from the field is proposed.

Pump capacity: 43,800 gpm = 97.6 cfs

Pump schedule	on	off
1 - 43800 gpm	61.5' NGVD	60.0' NGVD

G. Postdevelopment discharge allowed = 20 cfs = 3/4 inch per day.

NOTE: Discharge allowed can be determined two ways:

1. Predevelopment = postdevelopment

2. Receiving body discharge criteria if they have been established.

H. 25-year 3-day design storm rainfall = 7.0 in. x 1.359 = 9.5 in.

Treat the systems as two basins:

1. Basin 1 (field) routed into Basin 2

2. Basin 2 (reservoir) routed to receiving body.

II. Computations

A. Field

1. Compute Pervious/Impervious (P/I).

540 acre field

40 acre laterals (to be assumed impervious)

%I = (40 ac/580 ac) x 100% = 7%

%P = (540 ac/580 ac) x 100% = 93%.

2. Compute Soil Storage and SCS Curve Number.

a. Average depth to water table = 4.0 ft.

b. From <u>Basis of Review</u>, 10.9 inches of moisture can be stored in the soil column beneath pervious areas.

c. Ground storage under pervious areas

= 10.9 in. x (1 ft/12 in.) x 540 ac

= 490.5 ac-ft.

d. Equivalent soil storage, S

= (490.5 ac-ft x (12 in./1 ft))/580 ac

= 10.2 in.

e. SCS curve number, CN

= 1000/(S + 10)

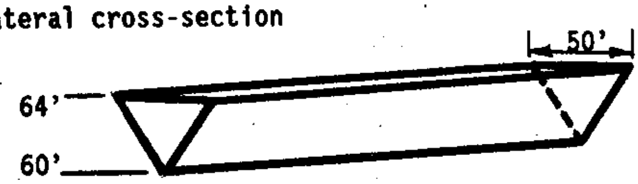
= 1000/(10.2 + 10)

= 50.

3. Compute Open Surface Stage versus Storage

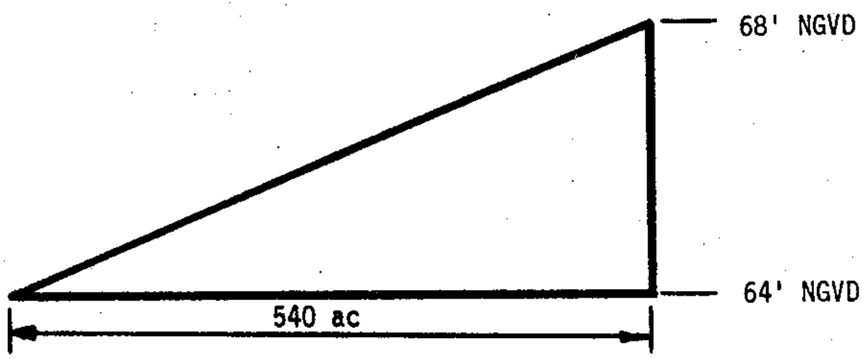
a. Laterals store between elevations 60' and 64' NGVD

Typical lateral cross-section



40 acres of laterals at top of bank

b. Developed field area stores linearly between elevation 64' and 68' NGVD.



Stage (ft,NGVD)	Storage Laterals (ac-ft)	Site (ac-ft)	Total (ac-ft)
60	0	0	0
61	0.5(10ac)(1ft) = 5	0	5
62	0.5(20ac)(2ft) = 20	0	20
63	0.5(30ac)(3ft) = 45	0	45
64	0.5(40ac)(4ft) = 80	0	80
65	80 + 40ac(1ft) =120	0.5(540ac)((1x1ft)/4) = 67.5	188
66	80 + 40ac(2ft) =160	0.5(540ac)((2x2ft)/4) = 270	430
67	80 + 40ac(3ft) =200	0.5(540ac)((3x3ft)/4) = 607.5	808
68	80 + 40ac(4ft) =240	0.5(540ac)((4x4ft)/4) = 1080	1320

4. Flood Route the Design Storm

25-year 3-day event

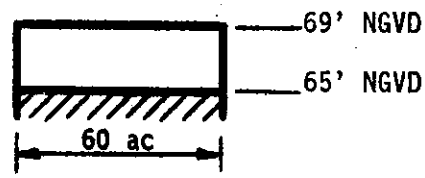
(See the five pages titled "Example Grove," at end of this example)

Maximum Stage in field = 63.6' NGVD.

B. Reservoir

1. S = 0.01 in. (District computer program will not accept zero.)

2. Since the reservoir will be used to mitigate for the loss of some wetlands, 1 foot of water will be maintained in parts of the reservoir at elevation 64.0' NGVD. Storage will then start at the control elevation, 65.0' NGVD.



Stage (ft,NGVD)	Storage (ac-ft)
65	0
66	60
67	120
68	180
69	240

3. Allowable Discharge

20 cfs was determined by pre- versus postdevelopment.

4. Weir crest elevation required.

a. First inch of runoff

b. Volume = 1 in. x (1 ft/12 in.) x 640 ac = 53.3 ac-ft. From the table in B.2., above, the weir crest should be set at elevation 65.9' NGVD, so that 53.3 ac-ft are detained.

5. Compute weir length

a. Rainfall from the 25-year 3-day storm is 9 inches. Using the S value calculated for the field,

$$\text{runoff} = Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} = 3.2 \text{ in.}$$

b. Volume of runoff

= 3.2 in. x (1 ft/12 in.) x 640 ac

= 171 ac-ft, or a reservoir stage of elevation 67.9' NGVD (table in B.2.), or 2 ft above the proposed weir crest.

c. The maximum design head is 2.0 feet.

$Q = 3.13LH^{1.5}$

$L = 20 \text{ cfs}/(3.13 \times (2)^{1.5}) = 2.3$ feet

6. Water quality control device should be designed to discharge an amount (Q) equal to 1/2 inch in 24 hours.

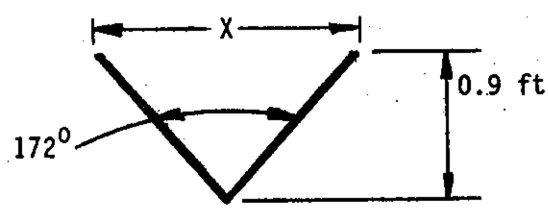
53.3 ac-ft/2 = 26.7 ac-ft in 24 hours, or about 13 cfs

$Q = 2.5 \times (\tan(\theta/2)) \times (H)^{2.5}$, or

$\theta = 2 \times \tan^{-1}(0.492 \times Q/(H)^{2.5})$

$\theta = 2 \times \tan^{-1}(0.492 \times 26.7/(0.9)^{2.5})$

$= 172$ degrees



$\tan(\theta/2) = (X/2)/0.9$

$X = 2 \times (0.9 \text{ ft} \times \tan(172/2))$

X = <u>25.7 ft</u> - will not fit into weir.

7. Try an orifice

$Q = 4.8 \times A \times (H)^{0.5}$

where Q = discharge, cfs

A = area of orifice, sq ft

H = head above notch centroid, ft

therefore, $Q = 20$ cfs*

$A = 0.5 \times b \times h$

assume $h = 2$ ft

Notch centroid will be 2/3 of h above notch invert, or 1.3 ft above elevation 65.0' NGVD, or at elevation 66.3' NGVD.

H = 67.9' NGVD - 66.3' NGVD

= 1.6 ft

$Q = 4.8 \times A \times H^{0.5}$

$= 4.8 \times (0.5 \times b \times h) \times H^{0.5}$

therefore,

$b = Q/(4.8 \times 0.5 \times h \times (H)^{0.5})$

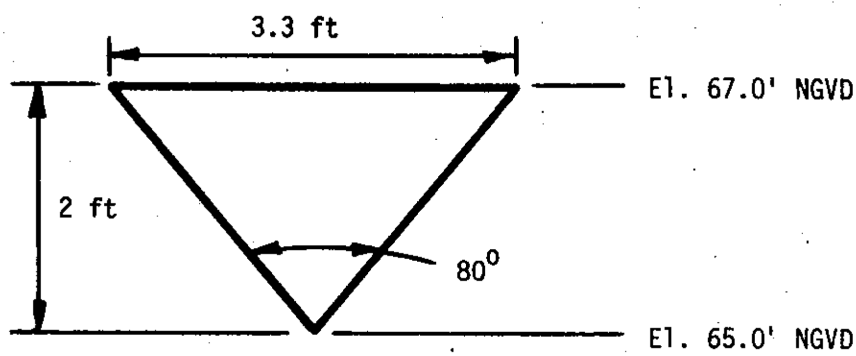
$= 20 \text{ cfs}/(4.8 \times 0.5 \times 2 \text{ ft} \times (1.6 \text{ ft})^{0.5})$

= 20 cfs/6.05

= 3.3 ft.

*(NOTE: The orifice was designed using the more restrictive condition created by the allowable discharge criteria rather than the water quality rate.)

Therefore, the structure is 1-2.0 ft high by 3.3 ft wide triangular orifice with an invert at elevation 65.0' NGVD. Only an orifice is used since the allowable discharge is low and the lake size is preferred to be left unchanged, so a V-notch is impractical. The proposed control structure will be considerably smaller than what is required to meet the detention requirements for water quality. Therefore, discharge at elevation 67.0' NGVD will be considerably less than 0.5 inch in 24 hours.



Stage-discharge values for this control structure are given in the computer printouts at the end of this example. The structure should be properly baffled, to reduce the possibility of clogging. The outfall pipe should be large enough so that the peak design storm discharge is not limited by culvert control.

8. Check the routed design storm discharge.

   a. The design storm is the 25-year 3-day event.

   b. The one-day rainfall amount is given to be 7 inches.

   c. The three-day rainfall amount

      = (one-day amount) x 1.359

      = 7 in. x 1.359

      = 9.51 inches of rainfall.

   d. The page at the back of this example entitled "Santa Barbara Program-Project Name: Example Grove", along with the four sheets which follow it, are the results of calculations of pumping rainfall runoff into the reservoir. (Notice, on the final sheet, that the peak water surface elevation in the field was 63.57' NGVD.)

   e. The pages which begin with the one entitled "Santa Barbara Program-Project Name: Reservoir" are the routings of the pumped inflow, plus the rainfall on the reservoir.

      i. On the last sheet, the peak design storm discharge is listed as 20.6 cfs. Flows in excess of 20 cfs occur from hours 77.5 to 82.0, or for a period of 4.5 hours, and never exceed 20.6 cfs. This is deemed acceptable, since the allowed rate of 20 cfs was based on 3/4 in. per day.

ii. Also on the last sheet, the peak design storm elevation is listed as 68.01' NGVD. District recommended criteria are that, in the absence of a detailed dam structural safety analysis, the maximum above-grade stored depth of water shall be 4.0 feet. Since the average grade in the reservoir is 65' NGVD, which is just 3 feet less than the design storm peak,

<u>the above-grade water depth is adequate</u>.

iii. District recommended criteria on freeboard are 3 feet above the stored routed design storm.

Since the routed design storm peaks at elevation 68.0' NGVD,

<u>the top of the reservoir berms should be no lower than elevation 71.0' NGVD</u>.

9. Overflow Structure

a. Criteria

i. For gravity filled impoundments, no separate overflow structure is required, because the inflow structure will allow reservoir and field stages to be the same.

ii. The weir crest shall be set at the peak elevation of the routed 25-year 3-day storm.

iii. The weir crest length shall be adequate to pass the peak of:

the sum of the volume of the 100-year 3-day storm falling on the reservoir surface plus the inflow pump hydrograph for the same event, minus the routed discharge control structure outflow, with not more than 6 inches of head on the overflow structure weir crest.

iv. A simple culvert, or culverts, extending through the reservoir side, and with inverts at the design storm peak stage, are not acceptable, because of the danger of erosion of the reservoir dike.

v. There are at least two acceptable overflow structure designs.

I. A non-adjustable shaft spillway.

II. A properly designed and built non-adjustable sharp- or broad- crested weir in the reservoir dike.

vi. Sodded earthen berms are not acceptable as overflow structures.

vii. The inflow pump system shall be the same as that used for designing the control structure.

viii. Other proposed designs should be discussed with District staff as early in the design process as possible.

b. Design calculations

i. Treat the system as two basins: Basin 1 (field) routed into Basin 2 (reservoir).

ii. Basin 1 (field) pumps shall turn on at elevation 61.5' NGVD, and turn off at elevation 60.0' NGVD.

(Other methods of calculating the pumped flow hydrograph into the reservoir - for the purposes of computing the overflow weir length - may be submitted by the applicant for District staff consideration.)

iii. The stage-storage information for Basin 2 (reservoir) is unchanged from that previously calculated.

iv. After some preliminary calculations try a <u>70-foot long broad crested weir</u>.

v. The weir crest is set at the peak elevation of the 25-year 72-hour routed storm, in this case 68.0' NGVD, to the nearest tenth of a foot.

vi. The stage-discharge calculations for the overflow weir are based on the equation $Q = CLH^{1.5}$

where:

Q = discharge, cfs

C = weir coefficient, 3.00 for this broad-crested weir

L = weir length, in this case: 70.0 ft

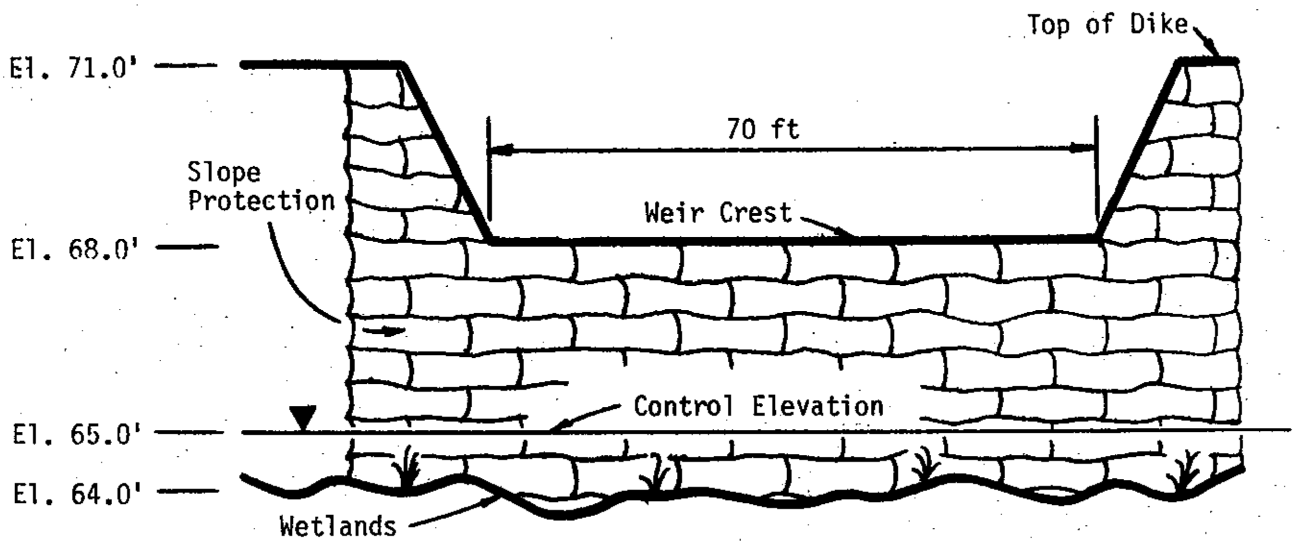
H = head on the weir, ft; which is not to exceed 0.5 ft

vii. The computer model utilized for analyzing the overflow structure contains a method for determining flows over the sharp-crested control structure weir which is slightly different from the method which was used in the design of the control structure. As a result, computed control structure flows will vary slightly between the two analyses, but the variance is negligible. Also, because the model calculation method will not work if the pump cut-off elevation is exactly equal to the lowest site storage elevation, the pump cut-off elevation is 60.03, instead of 60.0.

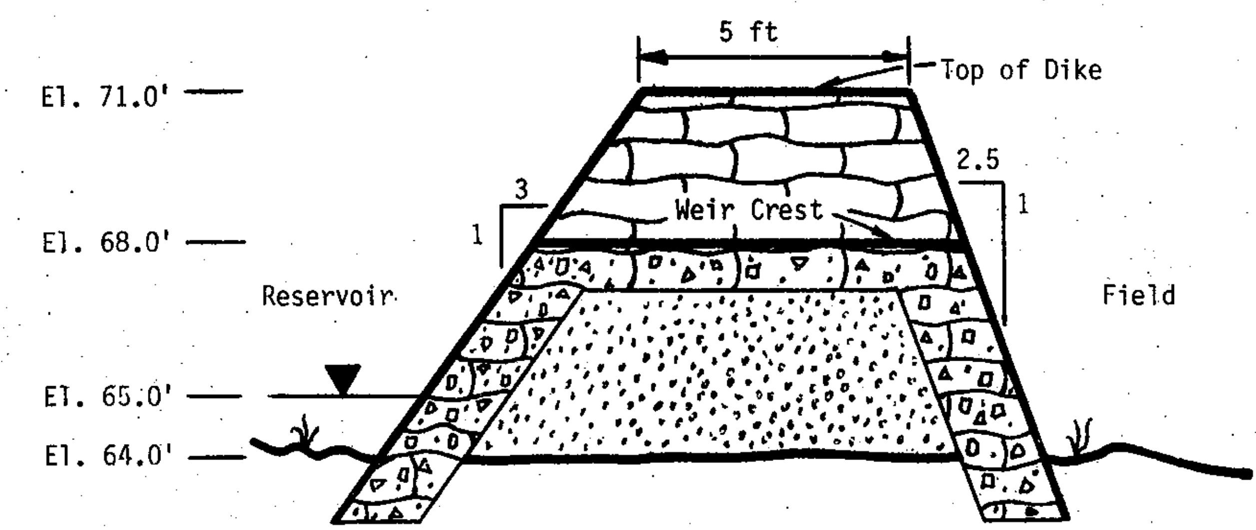
viii. The pages which begin "Santa Barbara - Project Name: Agricultural Example, Reservo" are selected from the hydrograph of the design event for the reservoir overflow structure. They show the results of routing the pumped inflow ("Structure 1") plus the 100-year 72-hour rainfall on the reservoir, out of the combination of the control ("Structure 2") and overflow ("Structure 3") structures.

The last page contains a summary of peak stage and discharges. Peak discharges occur at elevation 68.5' NGVD, which is 0.5 foot (6 inches) higher than the crest of the overflow structure. Therefore, <u>the trial overflow structure is adequate</u>.

A sketch of the proposed overflow structure is on the next page. A complete design would include, among other things, proper attention to erosion control around the overflow weir, and energy dissipation devices downstream of it.



Elevation View (N.T.S.)



Section View (N.T.S.)

OVERFLOW STRUCTURE

Figure D-A-2

WEIR LENGTH	0 FT.
WEIR ELEVATION	70 FT. NGVD
WEIR COEFFICIENT	3.13
TYPE OF BLEEDER SLOT	TRIANGLAR ORIFICE
INVERT ELEV.	65 FT. NGVD
ICE HEIGHT	2 FT.
ORIFICE BASE WIDTH	3.3 FT.

WEIR FLOW IN CFS

STAGE	WEIR	BLEEDER	TOTAL
65.00	0.00	0.00	0.00
65.10	0.00	0.01	0.01
65.20	0.00	0.04	0.04
65.30	0.00	0.11	0.11
65.40	0.00	0.23	0.23
65.50	0.00	0.41	0.41
65.60	0.00	0.64	0.64
65.70	0.00	0.94	0.94
65.80	0.00	1.31	1.31
65.90	0.00	1.76	1.76
66.00	0.00	2.29	2.29
66.10	0.00	2.91	2.91
66.20	0.00	3.62	3.62
66.30	0.00	4.42	4.42
66.40	0.00	5.32	5.32
66.50	0.00	6.32	6.32
66.60	0.00	7.43	7.43
66.70	0.00	8.64	8.64
66.80	0.00	9.97	9.97
6[illegible] 90	0.00	11.41	11.41
[illegible]0	0.00	12.98	12.98
[illegible].10	0.00	13.92	13.92
[illegible]7.20	0.00	14.80	14.80
67.30	0.00	15.63	15.63
67.40	0.00	16.41	16.41
67.50	0.00	17.17	17.17
67.60	0.00	17.89	17.89
67.70	0.00	18.58	18.58
67.80	0.00	19.25	19.25
67.90	0.00	19.89	19.89
68.00	0.00	20.52	20.52
68.10	0.00	21.12	21.12
68.20	0.00	21.71	21.71
68.30	0.00	22.29	22.29
68.40	0.00	22.85	22.85
68.50	0.00	23.39	23.39
68.60	0.00	23.93	23.93
68.70	0.00	24.45	24.45
68.80	0.00	24.96	24.96
68.90	0.00	25.46	25.46
69.00	0.00	25.95	25.95
69.10	0.00	26.43	26.43
69.20	0.00	26.91	26.91
69.30	0.00	27.37	27.37
69.40	0.00	27.83	27.83
69.50	0.00	28.28	28.28
[illegible]0	0.00	28.72	28.72
[illegible]0	0.00	29.16	29.16
[illegible]80	0.00	29.59	29.59
[illegible].90	0.00	30.01	30.01
70.00	0.00	30.43	30.43

S A N T A   B A R B A R A   P R O G R A M

PROJECT NAME . . . . : EXAMPLE GROVE
REVIEWER . . . . . . :
PROJECT AREA . . . . : 580.00 ACRES
GROUND STORAGE . . . : 10.20 INCHES
TERMINATION DISCHARGE : 90.00 CFS
TIME OF CONCENTRATION : 2.00 HOURS
TIME STEP . . . . . . : .50 HOURS
DISTRIBUTION TYPE . . : SFWMD
RETURN FREQUENCY . . : 25.00 YEARS
RAINFALL DURATION . . : 3-DAY
24-HOUR RAINFALL . . : 7.00 INCHES
DISCHARGE HYDROGRAPH : GROVE1
REPORTING SEQUENCE . : INCREMENTAL

STAGE (FT)	STORAGE (AF)
60.00	.00
61.00	5.00
62.00	20.00
63.00	45.00
64.00	80.00
65.00	188.00

PUMP NO.	PUMP ON ELEVATION (FEET)	PUMP OFF ELEVATION (FEET)	PUMP DISCHARGE (GPM)	PUMP DESCRIPTION
1	61.50	60.00	43800.00	43800 GPM PUMP

					- - - - - - R E S E R V O I R - - - - - -				
TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
.00	.00	.00	.0	.0	.0	.0	.0	.0	60.00
.50	.02	.00	.0	.0	.0	.0	.0	.0	60.00
1.00	.04	.00	.0	.0	.0	.0	.0	.0	60.00
1.50	.06	.00	.0	.0	.0	.0	.0	.0	60.00
2.00	.09	.00	.0	.0	.0	.0	.0	.0	60.00
2.50	.11	.00	.0	.0	.0	.0	.0	.0	60.00
3.00	.13	.00	.0	.0	.0	.0	.0	.0	60.00
3.50	.15	.00	.0	.0	.0	.0	.0	.0	60.00
4.00	.17	.00	.0	.0	.0	.0	.0	.0	60.00
4.50	.19	.00	.0	.0	.0	.0	.0	.0	60.00
5.00	.21	.00	.0	.0	.0	.0	.0	.0	60.00
5.50	.23	.00	.0	.0	.0	.0	.0	.0	60.00
6.00	.26	.00	.0	.0	.0	.0	.0	.0	60.00
6.50	.28	.00	.0	.0	.0	.0	.0	.0	60.00
7.00	.30	.00	.0	.0	.0	.0	.0	.0	60.00

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	- - - R E S E R V O I R - - - VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
7.50	.32	.00	.0	.0	.0	.0	.0	.0	60.00
8.00	.34	.00	.0	.0	.0	.0	.0	.0	60.00
8.50	.36	.00	.0	.0	.0	.0	.0	.0	60.00
9.00	.38	.00	.0	.0	.0	.0	.0	.0	60.00
9.50	.40	.00	.0	.0	.0	.0	.0	.0	60.00
10.00	.43	.00	.0	.0	.0	.0	.0	.0	60.00
10.50	.45	.00	.0	.0	.0	.0	.0	.0	60.00
11.00	.47	.00	.0	.0	.0	.0	.0	.0	60.00
11.50	.49	.00	.0	.0	.0	.0	.0	.0	60.00
12.00	.51	.00	.0	.0	.0	.0	.0	.0	60.00
12.50	.53	.00	.0	.0	.0	.0	.0	.0	60.00
13.00	.55	.00	.0	.0	.0	.0	.0	.0	60.00
13.50	.57	.00	.0	.0	.0	.0	.0	.0	60.00
14.00	.60	.00	.0	.0	.0	.0	.0	.0	60.00
14.50	.62	.00	.0	.0	.0	.0	.0	.0	60.00
15.00	.64	.00	.0	.0	.0	.0	.0	.0	60.00
15.50	.66	.00	.0	.0	.0	.0	.0	.0	60.00
16.00	.68	.00	.0	.0	.0	.0	.0	.0	60.00
16.50	.70	.00	.0	.0	.0	.0	.0	.0	60.00
17.00	.72	.00	.0	.0	.0	.0	.0	.0	60.00
17.50	.75	.00	.0	.0	.0	.0	.0	.0	60.00
18.00	.77	.00	.0	.0	.0	.0	.0	.0	60.00
18.50	.79	.00	.0	.0	.0	.0	.0	.0	60.00
19.00	.81	.00	.0	.0	.0	.0	.0	.0	60.00
19.50	.83	.00	.0	.0	.0	.0	.0	.0	60.00
20.00	.85	.00	.0	.0	.0	.0	.0	.0	60.00
20.50	.87	.00	.0	.0	.0	.0	.0	.0	60.00
21.00	.89	.00	.0	.0	.0	.0	.0	.0	60.00
21.50	.92	.00	.0	.0	.0	.0	.0	.0	60.00
22.00	.94	.00	.0	.0	.0	.0	.0	.0	60.00
22.50	.96	.00	.0	.0	.0	.0	.0	.0	60.00
23.00	.98	.00	.0	.0	.0	.0	.0	.0	60.00
23.50	1.00	.00	.0	.0	.0	.0	.0	.0	60.00
24.00	1.02	.00	.0	.0	.0	.0	.0	.0	60.00
24.50	1.05	.00	.0	.0	.0	.0	.0	.0	60.00
25.00	1.08	.00	.0	.0	.0	.0	.0	.0	60.00
25.50	1.12	.00	.0	.0	.0	.0	.0	.0	60.00
26.00	1.15	.00	.0	.0	.0	.0	.0	.0	60.00
26.50	1.18	.00	.0	.0	.0	.0	.0	.0	60.00
27.00	1.21	.00	.0	.0	.0	.0	.0	.0	60.00
27.50	1.24	.00	.0	.0	.0	.0	.0	.0	60.00
28.00	1.27	.00	.0	.0	.0	.0	.0	.0	60.00
8.50	1.30	.00	.0	.0	.0	.0	.0	.0	60.00
9.00	1.33	.00	.0	.0	.0	.0	.0	.0	60.00

					------ R E S E R V O I R ------				
TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
29.50	1.36	.00	.0	.0	.0	.0	.0	.0	60.00
30.00	1.39	.00	.0	.0	.0	.0	.0	.0	60.00
30.50	1.43	.00	.0	.0	.0	.0	.0	.0	60.00
31.00	1.46	.00	.0	.0	.0	.0	.0	.0	60.00
31.50	1.49	.00	.0	.0	.0	.0	.0	.0	60.00
32.00	1.52	.00	.0	.0	.0	.0	.0	.0	60.00
32.50	1.55	.00	.0	.0	.0	.0	.0	.0	60.00
33.00	1.58	.00	.0	.0	.0	.0	.0	.0	60.00
33.50	1.61	.00	.0	.0	.0	.0	.0	.0	60.00
34.00	1.64	.00	.0	.0	.0	.0	.0	.0	60.00
34.50	1.67	.00	.0	.0	.0	.0	.0	.0	60.00
35.00	1.71	.00	.0	.0	.0	.0	.0	.0	60.00
35.50	1.74	.00	.0	.0	.0	.0	.0	.0	60.00
36.00	1.77	.00	.0	.0	.0	.0	.0	.0	60.00
36.50	1.80	.00	.0	.0	.0	.0	.0	.0	60.00
37.00	1.83	.00	.0	.0	.0	.0	.0	.0	60.00
37.50	1.86	.00	.0	.0	.0	.0	.0	.0	60.00
38.00	1.89	.00	.0	.0	.0	.0	.0	.0	60.00
38.50	1.92	.00	.0	.0	.0	.0	.0	.0	60.00
39.00	1.95	.00	.0	.0	.0	.0	.0	.0	60.00
39.50	1.98	.00	.0	.0	.0	.0	.0	.0	60.00
40.00	2.02	.00	.0	.0	.0	.0	.0	.0	60.00
40.50	2.05	.00	.0	.0	.0	.0	.0	.0	60.00
41.00	2.08	.00	.0	.0	.0	.0	.0	.0	60.00
41.50	2.11	.00	.1	.0	.0	.0	.0	.0	60.00
42.00	2.14	.00	.2	.0	.0	.0	.0	.0	60.00
42.50	2.17	.00	.3	.0	.0	.0	.0	.0	60.00
43.00	2.20	.00	.4	.0	.0	.0	.0	.0	60.00
43.50	2.23	.00	.6	.1	.1	.0	.0	.0	60.01
44.00	2.26	.00	.8	.1	.1	.0	.0	.0	60.01
44.50	2.30	.01	.9	.1	.1	.0	.0	.0	60.02
45.00	2.33	.01	1.1	.2	.2	.0	.0	.0	60.03
45.50	2.36	.01	1.3	.2	.2	.0	.0	.0	60.04
46.00	2.39	.01	1.5	.3	.3	.0	.0	.0	60.05
46.50	2.42	.01	1.7	.3	.3	.0	.0	.0	60.06
47.00	2.45	.02	1.9	.4	.4	.0	.0	.0	60.07
47.50	2.48	.02	2.1	.5	.5	.0	.0	.0	60.09
48.00	2.51	.02	2.3	.6	.6	.0	.0	.0	60.11
48.50	2.55	.02	2.5	.7	.7	.0	.0	.0	60.12
49.00	2.58	.03	2.8	.8	.8	.0	.0	.0	60.15
49.50	2.62	.03	3.1	.9	.9	.0	.0	.0	60.17
50.00	2.65	.03	3.3	1.0	1.0	.0	.0	.0	60.19
50.50	2.70	.04	3.7	1.2	1.2	.0	.0	.0	60.22
51.00	.74	.04	4.2	1.3	1.3	.0	.0	.0	60.25

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	- - - - - - - R E S E R V O I R - - - - - - VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
51.50	2.78	.05	4.6	1.5	1.5	.0	.0	.0	60.29
52.00	2.83	.06	5.1	1.7	1.7	.0	.0	.0	60.33
52.50	2.88	.06	5.9	2.0	2.0	.0	.0	.0	60.37
53.00	2.95	.07	6.9	2.2	2.2	.0	.0	.0	60.42
53.50	3.02	.09	8.0	2.5	2.5	.0	.0	.0	60.47
54.00	3.09	.10	9.5	2.9	2.9	.0	.0	.0	60.54
54.50	3.18	.11	11.1	3.3	3.3	.0	.0	.0	60.62
55.00	3.27	.13	13.0	3.8	3.8	.0	.0	.0	60.71
55.50	3.37	.15	15.1	4.4	4.4	.0	.0	.0	60.82
56.00	3.47	.18	17.5	5.1	5.1	.0	.0	.0	60.95
56.50	3.58	.20	20.1	5.8	5.8	.0	.0	.0	61.03
57.00	3.71	.23	23.3	6.7	6.7	.0	.0	.0	61.09
57.50	3.85	.27	27.2	7.8	7.8	.0	.0	.0	61.15
58.00	4.00	.32	31.8	9.0	9.0	.0	.0	.0	61.23
58.50	4.17	.37	37.2	10.4	10.4	.0	.0	.0	61.31
59.00	4.40	.44	45.2	12.1	12.1	.0	.0	.0	61.42
59.50	4.75	.57	61.0	14.3	14.3	.0	97.6	48.8	61.55
60.00	7.11	1.68	208.4	19.9	15.8	4.1	97.6	97.6	61.54
60.50	7.62	1.97	344.5	31.3	23.2	8.1	97.6	97.6	61.84
61.00	7.88	2.13	326.0	45.2	33.1	12.1	97.6	97.6	62.25
61.50	8.08	2.25	289.2	57.9	41.7	16.2	97.6	97.6	62.62
62.00	8.24	2.34	253.0	69.1	48.9	20.2	97.6	97.6	62.95
62.50	8.36	2.42	219.0	78.8	54.6	24.2	97.6	97.6	63.14
63.00	8.46	2.48	188.4	87.2	59.0	28.2	97.6	97.6	63.28
63.50	8.57	2.55	163.5	94.5	62.3	32.2	97.6	97.6	63.39
64.00	8.67	2.61	144.3	100.9	64.6	36.3	97.6	97.6	63.47
64.50	8.74	2.65	126.1	106.5	66.1	40.4	97.6	97.6	63.52
65.00	8.80	2.69	108.4	111.3	66.9	44.4	97.6	97.6	63.56
65.50	8.86	2.73	94.8	115.5	67.1	48.4	97.6	97.6	63.57
66.00	8.93	2.77	84.2	119.2	66.8	52.4	97.6	97.6	63.57
66.50	8.99	2.82	76.1	122.5	66.1	56.4	97.6	97.6	63.55
67.00	9.05	2.86	69.7	125.5	65.0	60.5	97.6	97.6	63.53
67.50	9.11	2.90	64.9	128.3	63.8	64.5	97.6	97.6	63.50
68.00	9.18	2.94	61.1	130.9	62.4	68.5	97.6	97.6	63.46
68.50	9.22	2.97	56.4	133.3	60.7	72.6	97.6	97.6	63.42
69.00	9.26	2.99	51.1	135.6	58.9	76.7	97.6	97.6	63.37
69.50	9.30	3.02	46.9	137.6	56.9	80.7	97.6	97.6	63.31
70.00	9.35	3.05	43.7	139.5	54.8	84.7	97.6	97.6	63.25
70.50	9.39	3.08	41.2	141.2	52.5	88.7	97.6	97.6	63.19
71.00	9.43	3.10	39.2	142.9	50.1	92.8	97.6	97.6	63.12
71.50	9.47	3.13	37.8	144.5	47.7	96.8	97.6	97.6	63.05
72.00	9.51	3.16	36.6	146.0	45.2	100.8	97.6	97.6	62.98
72.50	9.51	3.16	32.1	147.4	42.6	104.8	97.6	97.6	62.87
3.00	9.51	3.16	25.0	148.6	39.7	108.9	97.6	97.6	62.76

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	- - - - - - - R E S E R V O I R - - - - - - VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
73.50	9.51	3.16	19.4	149.5	36.6	112.9	97.6	97.6	62.65
74.00	9.51	3.16	15.1	150.2	33.3	116.9	97.6	97.6	62.52
74.50	9.51	3.16	11.8	150.8	29.8	121.0	97.6	97.6	62.38
75.00	9.51	3.16	9.1	151.2	26.2	125.0	97.6	97.6	62.24
75.50	9.51	3.16	7.1	151.6	22.5	129.1	97.6	97.6	62.09
76.00	9.51	3.16	5.5	151.8	18.7	133.1	97.6	97.6	61.94
76.50	9.51	3.16	4.3	152.0	14.9	137.1	97.6	97.6	61.65
77.00	9.51	3.16	3.3	152.2	11.0	141.2	97.6	97.6	61.40
77.50	9.51	3.16	2.6	152.3	7.1	145.2	97.6	97.6	61.14
78.00	9.51	3.16	2.0	152.4	3.2	149.2	97.6	97.6	60.88
78.50	9.51	3.16	1.6	152.5	-.7	153.2	.0	48.8	59.84

SUMMARY INFORMATION

MAXIMUM STAGE WAS 63.57 FEET AT 65.50 HOURS
MAXIMUM DISCHARGE WAS 97.6 CFS AT 59.50 HOURS

PUMPING HISTORY

PUMP 1 "ON " AT 59.50 HOURS
PUMP 1 "OFF" AT 78.50 HOURS

S A N T A   B A R B A R A   P R O G R A M

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 JJECT NAME  . . . . . : RESERVOIR
REVIEWER  . . . . . . . :
PROJECT AREA  . . . . . :      60.00 ACRES
GROUND STORAGE  . . . . :        .01 INCHES
TERMINATION DISCHARGE   :      10.00 CFS
TIME OF CONCENTRATION   :        .50 HOURS
TIME STEP . . . . . . . :        .50 HOURS
DISTRIBUTION TYPE . . . : SFWMD
RETURN FREQUENCY  . . . :      25.00 YEARS
RAINFALL DURATION . . . :        3-DAY
24-HOUR RAINFALL  . . . :       7.00 INCHES
INFLOW HYDROGRAPH . . . : GROVE1  LAGGED BY   .00 HOURS
REPORTING SEQUENCE  . . : INCREMENTAL
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STAGE (FT)	STORAGE (AF)	DISCHARGE (CFS)
65.00	.00	.00
66.00	60.00	2.30
67.00	120.00	13.00
68.00	180.00	20.50
69.00	240.00	26.00

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	- - - - - - - R E S E R V O I R - - - - - - VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
.00	.00	.00	.0	.0	.0	.0	.0	.0	65.00
.50	.02	.01	.5	.0	.0	.0	.0	.0	65.00
1.00	.04	.03	1.5	.1	.1	.0	.0	.0	65.00
1.50	.06	.05	2.1	.1	.1	.0	.0	.0	65.00
2.00	.09	.07	2.4	.2	.2	.0	.0	.0	65.00
2.50	.11	.10	2.5	.3	.3	.0	.0	.0	65.00
3.00	.13	.12	2.5	.4	.4	.0	.0	.0	65.01
3.50	.15	.14	2.6	.5	.5	.0	.0	.0	65.01
4.00	.17	.16	2.6	.6	.6	.0	.0	.0	65.01
4.50	.19	.18	2.6	.7	.7	.0	.0	.0	65.01
5.00	.21	.20	2.6	.8	.8	.0	.0	.0	65.01
5.50	.23	.22	2.6	1.0	.9	.1	.0	.0	65.01
6.00	.26	.24	2.6	1.1	1.1	.0	.0	.0	65.02
6.50	.28	.27	2.6	1.2	1.2	.0	.0	.0	65.02
7.00	.30	.29	2.6	1.3	1.3	.0	.0	.0	65.02
7.50	.32	.31	2.6	1.4	1.4	.0	.1	.0	65.02
8.00	.34	.33	2.6	1.5	1.5	.0	.1	.1	65.02
8.50	.36	.35	2.6	1.6	1.6	.0	.1	.1	65.03
9.00	.38	.37	2.6	1.7	1.7	.0	.1	.1	65.03
9.50	.40	.39	2.6	1.8	1.8	.0	.1	.1	65.03

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	- - - - - - - R E S E R V O I R VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS) - - - - - -	STAGE (FT)
10.00	.43	.41	2.6	1.9	1.9	.0	.1	.1	65.03
10.50	.45	.44	2.6	2.0	2.0	.0	.1	.1	65.03
11.00	.47	.46	2.6	2.1	2.1	.0	.1	.1	65.03
11.50	.49	.48	2.6	2.2	2.2	.0	.1	.1	65.04
12.00	.51	.50	2.6	2.3	2.3	.0	.1	.1	65.04
12.50	.53	.52	2.6	2.4	2.4	.0	.1	.1	65.04
13.00	.55	.54	2.6	2.5	2.5	.0	.1	.1	65.04
13.50	.57	.56	2.6	2.7	2.6	.1	.1	.1	65.04
14.00	.60	.58	2.6	2.8	2.7	.1	.1	.1	65.04
14.50	.62	.61	2.6	2.9	2.8	.1	.1	.1	65.05
15.00	.64	.63	2.6	3.0	2.9	.1	.1	.1	65.05
15.50	.66	.65	2.6	3.1	3.0	.1	.1	.1	65.05
16.00	.68	.67	2.6	3.2	3.1	.1	.1	.1	65.05
16.50	.70	.69	2.6	3.3	3.2	.1	.1	.1	65.05
17.00	.72	.71	2.6	3.4	3.3	.1	.1	.1	65.05
17.50	.75	.73	2.6	3.5	3.4	.1	.1	.1	65.06
18.00	.77	.75	2.6	3.6	3.5	.1	.1	.1	65.06
18.50	.79	.78	2.6	3.7	3.6	.1	.1	.1	65.06
19.00	.81	.80	2.6	3.8	3.7	.1	.1	.1	65.06
19.50	.83	.82	2.6	3.9	3.8	.1	.1	.1	65.06
20.00	.85	.84	2.6	4.0	3.9	.1	.1	.1	65.06
20.50	.87	.86	2.6	4.1	4.0	.1	.2	.2	65.07
21.00	.89	.88	2.6	4.3	4.1	.2	.2	.2	65.07
21.50	.92	.90	2.6	4.4	4.2	.2	.2	.2	65.07
22.00	.94	.92	2.6	4.5	4.3	.2	.2	.2	65.07
22.50	.96	.95	2.6	4.6	4.4	.2	.2	.2	65.07
23.00	.98	.97	2.6	4.7	4.5	.2	.2	.2	65.07
23.50	1.00	.99	2.6	4.8	4.6	.2	.2	.2	65.08
24.00	1.02	1.01	2.6	4.9	4.7	.2	.2	.2	65.08
24.50	1.05	1.04	3.0	5.0	4.8	.2	.2	.2	65.08
25.00	1.08	1.07	3.5	5.1	5.0	.1	.2	.2	65.08
25.50	1.12	1.10	3.7	5.3	5.1	.2	.2	.2	65.08
26.00	1.15	1.13	3.7	5.4	5.2	.2	.2	.2	65.09
26.50	1.18	1.17	3.7	5.6	5.4	.2	.2	.2	65.09
27.00	1.21	1.20	3.8	5.7	5.5	.2	.2	.2	65.09
27.50	1.24	1.23	3.8	5.9	5.7	.2	.2	.2	65.09
28.00	1.27	1.26	3.8	6.1	5.8	.3	.2	.2	65.10
28.50	1.30	1.29	3.8	6.2	6.0	.2	.2	.2	65.10
29.00	1.33	1.32	3.8	6.4	6.1	.3	.2	.2	65.10
29.50	1.36	1.35	3.8	6.5	6.3	.2	.2	.2	65.10
30.00	1.39	1.38	3.8	6.7	6.4	.3	.2	.2	65.11
30.50	1.43	1.41	3.8	6.8	6.6	.2	.2	.2	65.11
31.00	1.46	1.44	3.8	7.0	6.7	.3	.3	.3	65.11
31.50	1.49	1.48	3.8	7.1	6.8	.3	.3	.3	65.11

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	------- R E S E R V O I R ----- VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
32.00	1.52	1.51	3.8	7.3	7.0	.3	.3	.3	65.12
32.50	1.55	1.54	3.8	7.5	7.1	.4	.3	.3	65.12
33.00	1.58	1.57	3.8	7.6	7.3	.3	.3	.3	65.12
33.50	1.61	1.60	3.8	7.8	7.4	.4	.3	.3	65.12
34.00	1.64	1.63	3.8	7.9	7.6	.3	.3	.3	65.12
34.50	1.67	1.66	3.8	8.1	7.7	.4	.3	.3	65.13
35.00	1.71	1.69	3.8	8.2	7.8	.4	.3	.3	65.13
35.50	1.74	1.72	3.8	8.4	8.0	.4	.3	.3	65.13
36.00	1.77	1.76	3.8	8.5	8.1	.4	.3	.3	65.13
36.50	1.80	1.79	3.8	8.7	8.3	.4	.3	.3	65.14
37.00	1.83	1.82	3.8	8.9	8.4	.5	.3	.3	65.14
37.50	1.86	1.85	3.8	9.0	8.6	.4	.3	.3	65.14
38.00	1.89	1.88	3.8	9.2	8.7	.5	.3	.3	65.14
38.50	1.92	1.91	3.8	9.3	8.8	.5	.3	.3	65.15
39.00	1.95	1.94	3.8	9.5	9.0	.5	.3	.3	65.15
39.50	1.98	1.97	3.8	9.6	9.1	.5	.3	.3	65.15
40.00	2.02	2.00	3.8	9.8	9.3	.5	.4	.3	65.15
40.50	2.05	2.04	3.8	9.9	9.4	.5	.4	.4	65.16
41.00	2.08	2.07	3.8	10.1	9.5	.6	.4	.4	65.16
41.50	2.11	2.10	3.8	10.3	9.7	.6	.4	.4	65.16
42.00	2.14	2.13	3.8	10.4	9.8	.6	.4	.4	65.16
42.50	2.17	2.16	3.8	10.6	10.0	.6	.4	.4	65.16
43.00	2.20	2.19	3.8	10.7	10.1	.6	.4	.4	65.17
43.50	2.23	2.22	3.8	10.9	10.2	.7	.4	.4	65.17
44.00	2.26	2.25	3.8	11.0	10.4	.6	.4	.4	65.17
44.50	2.30	2.28	3.8	11.2	10.5	.7	.4	.4	65.17
45.00	2.33	2.31	3.8	11.3	10.7	.6	.4	.4	65.18
45.50	2.36	2.35	3.8	11.5	10.8	.7	.4	.4	65.18
46.00	2.39	2.38	3.8	11.7	10.9	.8	.4	.4	65.18
46.50	2.42	2.41	3.8	11.8	11.1	.7	.4	.4	65.18
47.00	2.45	2.44	3.8	12.0	11.2	.8	.4	.4	65.19
47.50	2.48	2.47	3.8	12.1	11.4	.7	.4	.4	65.19
48.00	2.51	2.50	3.8	12.3	11.5	.8	.4	.4	65.19
48.50	2.55	2.54	3.9	12.4	11.6	.8	.4	.4	65.19
49.00	2.58	2.57	4.1	12.6	11.8	.8	.4	.4	65.19
49.50	2.62	2.61	4.2	12.8	11.9	.9	.5	.5	65.20
50.00	2.65	2.64	4.2	12.9	12.1	.8	.5	.5	65.20
50.50	2.70	2.68	4.5	13.1	12.2	.9	.5	.5	65.20
51.00	2.74	2.73	4.9	13.3	12.4	.9	.5	.5	65.21
51.50	2.78	2.77	5.0	13.5	12.6	.9	.5	.5	65.21
52.00	2.83	2.82	5.3	13.7	12.8	.9	.5	.5	65.21
52.50	2.88	2.87	6.0	14.0	13.0	1.0	.5	.5	65.22
53.00	2.95	2.94	6.8	14.2	13.3	.9	.5	.5	65.22
53.50	3.02	3.01	7.6	14.5	13.5	1.0	.5	.5	65.22

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TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
54.00	3.09	3.08	8.5	14.9	13.9	1.0	.5	.5	65.23
54.50	3.18	3.17	9.3	15.2	14.2	1.0	.5	.5	65.23
55.00	3.27	3.26	10.2	15.6	14.6	1.0	.6	.5	65.24
55.50	3.37	3.36	11.0	16.1	15.0	1.1	.6	.6	65.25
56.00	3.47	3.46	11.9	16.5	15.4	1.1	.6	.6	65.25
56.50	3.58	3.57	12.7	17.1	15.9	1.2	.6	.6	65.26
57.00	3.71	3.70	13.8	17.6	16.4	1.2	.6	.6	65.27
57.50	3.85	3.84	15.3	18.2	17.0	1.2	.6	.6	65.28
58.00	4.00	3.99	17.0	18.9	17.7	1.2	.7	.7	65.29
58.50	4.17	4.16	18.6	19.6	18.4	1.2	.7	.7	65.30
59.00	4.40	4.38	22.0	20.4	19.2	1.2	.7	.7	65.31
59.50	4.75	4.73	30.5	23.6	22.3	1.3	.8	.8	65.35
60.00	7.11	7.09	119.4	30.7	29.3	1.4	1.0	.9	65.43
60.50	7.62	7.60	155.6	40.4	39.0	1.4	1.3	1.1	65.57
61.00	7.88	7.87	83.2	49.4	47.9	1.5	1.7	1.5	65.72
61.50	8.08	8.07	46.4	56.1	54.6	1.5	2.0	1.8	65.85
62.00	8.24	8.23	29.9	61.7	60.1	1.6	2.2	2.1	65.95
62.50	8.36	8.35	21.2	66.8	65.1	1.7	2.7	2.5	66.04
63.00	8.46	8.45	16.1	71.6	69.7	1.9	3.6	3.2	66.12
63.50	8.57	8.56	13.8	76.2	74.2	2.0	4.4	4.0	66.20
64.00	8.67	8.66	13.1	80.8	78.6	2.2	5.2	4.8	66.27
64.50	8.74	8.72	11.1	85.3	82.9	2.4	6.0	5.6	66.34
65.00	8.80	8.79	8.8	89.8	87.1	2.7	6.7	6.4	66.41
65.50	8.86	8.85	8.0	94.2	91.2	3.0	7.5	7.1	66.48
66.00	8.93	8.91	7.8	98.5	95.2	3.3	8.2	7.8	66.55
66.50	8.99	8.98	7.7	102.9	99.2	3.7	8.9	8.5	66.62
67.00	9.05	9.04	7.6	107.2	103.2	4.0	9.6	9.3	66.68
67.50	9.11	9.10	7.6	111.6	107.1	4.5	10.3	10.0	66.75
68.00	9.18	9.17	7.6	115.9	111.0	4.9	11.0	10.7	66.81
68.50	9.22	9.21	6.8	120.3	114.9	5.4	11.7	11.4	66.88
69.00	9.26	9.25	5.6	124.5	118.7	5.8	12.4	12.0	66.94
69.50	9.30	9.29	5.3	128.8	122.4	6.4	13.0	12.7	67.00
70.00	9.35	9.33	5.1	133.1	126.1	7.0	13.5	13.3	67.07
70.50	9.39	9.38	5.1	137.3	129.8	7.5	14.0	13.7	67.13
71.00	9.43	9.42	5.1	141.5	133.4	8.1	14.4	14.2	67.19
71.50	9.47	9.46	5.1	145.8	137.1	8.7	14.9	14.6	67.25
72.00	9.51	9.50	5.1	150.0	140.7	9.3	15.3	15.1	67.31
72.50	9.51	9.50	3.4	154.2	144.3	9.9	15.8	15.5	67.37
73.00	9.51	9.50	1.1	158.4	147.7	10.7	16.2	16.0	67.43
73.50	9.51	9.50	.4	162.4	151.1	11.3	16.6	16.4	67.48
74.00	9.51	9.50	.1	166.5	154.5	12.0	17.1	16.8	67.54
74.50	9.51	9.50	.0	170.5	157.8	12.7	17.5	17.3	67.60
75.00	9.51	9.50	.0	174.5	161.1	13.4	17.9	17.7	67.65
75.50	9.51	9.50	.0	178.6	164.4	14.2	18.3	18.1	67.71

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	------- R E S E R V O I R ------ VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
76.00	9.51	9.50	.0	182.6	167.6	15.0	18.7	18.5	67.76
76.50	9.51	9.50	.0	186.6	170.9	15.7	19.1	18.9	67.81
77.00	9.51	9.50	.0	190.7	174.1	16.6	19.5	19.3	67.87
77.50	9.51	9.50	.0	194.7	177.3	17.4	19.9	19.7	67.92
78.00	9.51	9.50	.0	198.7	180.6	18.1	20.3	20.1	67.98
78.50	9.51	9.50	.0	200.8	181.7	19.1	20.6	20.4	68.01
79.00	9.51	9.50	.0	200.8	180.9	19.9	20.6	20.6	68.01
79.50	9.51	9.50	.0	200.8	180.0	20.8	20.5	20.5	68.00
80.00	9.51	9.50	.0	200.8	179.2	21.6	20.4	20.4	67.99
80.50	9.51	9.50	.0	200.8	178.3	22.5	20.3	20.3	67.97
81.00	9.51	9.50	.0	200.8	177.5	23.3	20.2	20.2	67.96
81.50	9.51	9.50	.0	200.8	176.7	24.1	20.1	20.1	67.94
82.00	9.51	9.50	.0	200.8	175.8	25.0	20.0	20.0	67.93
82.50	9.51	9.50	.0	200.8	175.0	25.8	19.9	19.9	67.92
83.00	9.51	9.50	.0	200.8	174.2	26.6	19.8	19.8	67.90
83.50	9.51	9.50	.0	200.8	173.4	27.4	19.7	19.7	67.89
84.00	9.51	9.50	.0	200.8	172.6	28.2	19.6	19.6	67.88
84.50	9.51	9.50	.0	200.8	171.8	29.0	19.5	19.5	67.86
85.00	9.51	9.50	.0	200.8	171.0	29.8	19.4	19.4	67.85
85.50	9.51	9.50	.0	200.8	170.2	30.6	19.3	19.3	67.84
86.00	9.51	9.50	.0	200.8	169.4	31.4	19.2	19.2	67.82
86.50	9.51	9.50	.0	200.8	168.6	32.2	19.1	19.1	67.81
87.00	9.51	9.50	.0	200.8	167.8	33.0	19.0	19.0	67.80
87.50	9.51	9.50	.0	200.8	167.0	33.8	18.9	18.9	67.78
88.00	9.51	9.50	.0	200.8	166.2	34.6	18.8	18.8	67.77
88.50	9.51	9.50	.0	200.8	165.5	35.3	18.7	18.7	67.76
89.00	9.51	9.50	.0	200.8	164.7	36.1	18.6	18.6	67.74
89.50	9.51	9.50	.0	200.8	163.9	36.9	18.5	18.5	67.73
90.00	9.51	9.50	.0	200.8	163.2	37.6	18.4	18.4	67.72
90.50	9.51	9.50	.0	200.8	162.4	38.4	18.3	18.3	67.71
91.00	9.51	9.50	.0	200.8	161.6	39.2	18.2	18.3	67.69
91.50	9.51	9.50	.0	200.8	160.9	39.9	18.1	18.2	67.68
92.00	9.51	9.50	.0	200.8	160.2	40.6	18.0	18.1	67.67
92.50	9.51	9.50	.0	200.8	159.4	41.4	17.9	18.0	67.66
93.00	9.51	9.50	.0	200.8	158.7	42.1	17.8	17.9	67.64
93.50	9.51	9.50	.0	200.8	157.9	42.9	17.7	17.8	67.63
94.00	9.51	9.50	.0	200.8	157.2	43.6	17.7	17.7	67.62
94.50	9.51	9.50	.0	200.8	156.5	44.3	17.6	17.6	67.61
95.00	9.51	9.50	.0	200.8	155.8	45.0	17.5	17.5	67.60
95.50	9.51	9.50	.0	200.8	155.0	45.8	17.4	17.4	67.58
96.00	9.51	9.50	.0	200.8	154.3	46.5	17.3	17.3	67.57
96.50	9.51	9.50	.0	200.8	153.6	47.2	17.2	17.2	67.56
97.00	9.51	9.50	.0	200.8	152.9	47.9	17.1	17.2	67.55
97.50	9.51	9.50	.0	200.8	152.2	48.6	17.0	17.1	67.54

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	RAIN	ACCUM.	BASIN	ACCUM.		ACCUM.	INSTANT	AVERAGE	
TIME (HR)	FALL (IN)	RUNOFF (IN)	DISCHGE (CFS)	INFLOW (AF)	VOLUME (AF)	OUTFLOW (AF)	DISCHGE (CFS)	DISCHGE (CFS)	STAGE (FT)
98.00	9.51	9.50	.0	200.8	151.5	49.3	16.9	17.0	67.52
98.50	9.51	9.50	.0	200.8	150.8	50.0	16.8	16.9	67.51
99.00	9.51	9.50	.0	200.8	150.1	50.7	16.8	16.8	67.50
99.50	9.51	9.50	.0	200.8	149.4	51.4	16.7	16.7	67.49
100.00	9.51	9.50	.0	200.8	148.7	52.1	16.6	16.6	67.48
100.50	9.51	9.50	.0	200.8	148.0	52.8	16.5	16.5	67.47
101.00	9.51	9.50	.0	200.8	147.4	53.4	16.4	16.5	67.46
101.50	9.51	9.50	.0	200.8	146.7	54.1	16.3	16.4	67.44
102.00	9.51	9.50	.0	200.8	146.0	54.8	16.3	16.3	67.43
102.50	9.51	9.50	.0	200.8	145.3	55.5	16.2	16.2	67.42
103.00	9.51	9.50	.0	200.8	144.7	56.1	16.1	16.1	67.41
103.50	9.51	9.50	.0	200.8	144.0	56.8	16.0	16.0	67.40
104.00	9.51	9.50	.0	200.8	143.3	57.5	15.9	16.0	67.39
104.50	9.51	9.50	.0	200.8	142.7	58.1	15.8	15.9	67.38
105.00	9.51	9.50	.0	200.8	142.0	58.8	15.8	15.8	67.37
105.50	9.51	9.50	.0	200.8	141.4	59.4	15.7	15.7	67.36
106.00	9.51	9.50	.0	200.8	140.7	60.1	15.6	15.6	67.35
106.50	9.51	9.50	.0	200.8	140.1	60.7	15.5	15.6	67.33
107.00	9.51	9.50	.0	200.8	139.5	61.3	15.4	15.5	67.32
107.50	9.51	9.50	.0	200.8	138.8	62.0	15.4	15.4	67.31
108.00	9.51	9.50	.0	200.8	138.2	62.6	15.3	15.3	67.30
108.50	9.51	9.50	.0	200.8	137.6	63.2	15.2	15.2	67.29
109.00	9.51	9.50	.0	200.8	136.9	63.9	15.1	15.2	67.28
109.50	9.51	9.50	.0	200.8	136.3	64.5	15.0	15.1	67.27
110.00	9.51	9.50	.0	200.8	135.7	65.1	15.0	15.0	67.26
110.50	9.51	9.50	.0	200.8	135.1	65.7	14.9	14.9	67.25
111.00	9.51	9.50	.0	200.8	134.5	66.3	14.8	14.8	67.24
111.50	9.51	9.50	.0	200.8	133.9	66.9	14.7	14.8	67.23
112.00	9.51	9.50	.0	200.8	133.2	67.6	14.7	14.7	67.22
112.50	9.51	9.50	.0	200.8	132.6	68.2	14.6	14.6	67.21
113.00	9.51	9.50	.0	200.8	132.0	68.8	14.5	14.5	67.20
113.50	9.51	9.50	.0	200.8	131.4	69.4	14.4	14.5	67.19
114.00	9.51	9.50	.0	200.8	130.8	70.0	14.4	14.4	67.18
114.50	9.51	9.50	.0	200.8	130.3	70.5	14.3	14.3	67.17
115.00	9.51	9.50	.0	200.8	129.7	71.1	14.2	14.2	67.16
115.50	9.51	9.50	.0	200.8	129.1	71.7	14.1	14.2	67.15
116.00	9.51	9.50	.0	200.8	128.5	72.3	14.1	14.1	67.14
116.50	9.51	9.50	.0	200.8	127.9	72.9	14.0	14.0	67.13
117.00	9.51	9.50	.0	200.8	127.3	73.5	13.9	14.0	67.12
117.50	9.51	9.50	.0	200.8	126.8	74.0	13.8	13.9	67.11
118.00	9.51	9.50	.0	200.8	126.2	74.6	13.8	13.8	67.10
118.50	9.51	9.50	.0	200.8	125.6	75.2	13.7	13.7	67.09
119.00	9.51	9.50	.0	200.8	125.1	75.7	13.6	13.7	67.08
119.50	9.51	9.50	.0	200.8	124.5	76.3	13.6	13.6	67.08

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TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
120.00	9.51	9.50	.0	200.8	123.9	76.9	13.5	13.5	67.07
120.50	9.51	9.50	.0	200.8	123.4	77.4	13.4	13.5	67.06
121.00	9.51	9.50	.0	200.8	122.8	78.0	13.4	13.4	67.05
121.50	9.51	9.50	.0	200.8	122.3	78.5	13.3	13.3	67.04
122.00	9.51	9.50	.0	200.8	121.7	79.1	13.2	13.3	67.03
122.50	9.51	9.50	.0	200.8	121.2	79.6	13.1	13.2	67.02
123.00	9.51	9.50	.0	200.8	120.7	80.1	13.1	13.1	67.01
123.50	9.51	9.50	.0	200.8	120.1	80.7	13.0	13.0	67.00
124.00	9.51	9.50	.0	200.8	119.6	81.2	12.9	13.0	66.99
124.50	9.51	9.50	.0	200.8	119.0	81.8	12.8	12.9	66.98
125.00	9.51	9.50	.0	200.8	118.5	82.3	12.7	12.8	66.98
125.50	9.51	9.50	.0	200.8	118.0	82.8	12.6	12.7	66.97
126.00	9.51	9.50	.0	200.8	117.5	83.3	12.5	12.6	66.96
126.50	9.51	9.50	.0	200.8	117.0	83.8	12.5	12.5	66.95
127.00	9.51	9.50	.0	200.8	116.4	84.4	12.4	12.4	66.94
127.50	9.51	9.50	.0	200.8	115.9	84.9	12.3	12.3	66.93
128.00	9.51	9.50	.0	200.8	115.4	85.4	12.2	12.2	66.92
128.50	9.51	9.50	.0	200.8	114.9	85.9	12.1	12.1	66.92
129.00	9.51	9.50	.0	200.8	114.4	86.4	12.0	12.1	66.91
129.50	9.51	9.50	.0	200.8	113.9	86.9	11.9	12.0	66.90
0.00	9.51	9.50	.0	200.8	113.4	87.4	11.8	11.9	66.89
130.50	9.51	9.50	.0	200.8	113.0	87.8	11.7	11.8	66.88
131.00	9.51	9.50	.0	200.8	112.5	88.3	11.7	11.7	66.87
131.50	9.51	9.50	.0	200.8	112.0	88.8	11.6	11.6	66.87
132.00	9.51	9.50	.0	200.8	111.5	89.3	11.5	11.5	66.86
132.50	9.51	9.50	.0	200.8	111.0	89.8	11.4	11.4	66.85
133.00	9.51	9.50	.0	200.8	110.6	90.2	11.3	11.4	66.84
133.50	9.51	9.50	.0	200.8	110.1	90.7	11.2	11.3	66.84
134.00	9.51	9.50	.0	200.8	109.6	91.2	11.2	11.2	66.83
134.50	9.51	9.50	.0	200.8	109.2	91.6	11.1	11.1	66.82
135.00	9.51	9.50	.0	200.8	108.7	92.1	11.0	11.0	66.81
135.50	9.51	9.50	.0	200.8	108.3	92.5	10.9	10.9	66.80
136.00	9.51	9.50	.0	200.8	107.8	93.0	10.8	10.9	66.80
136.50	9.51	9.50	.0	200.8	107.4	93.4	10.7	10.8	66.79
137.00	9.51	9.50	.0	200.8	106.9	93.9	10.7	10.7	66.78
137.50	9.51	9.50	.0	200.8	106.5	94.3	10.6	10.6	66.77
138.00	9.51	9.50	.0	200.8	106.1	94.7	10.5	10.6	66.77
138.50	9.51	9.50	.0	200.8	105.6	95.2	10.4	10.5	66.76
139.00	9.51	9.50	.0	200.8	105.2	95.6	10.4	10.4	66.75
139.50	9.51	9.50	.0	200.8	104.8	96.0	10.3	10.3	66.75
140.00	9.51	9.50	.0	200.8	104.4	96.4	10.2	10.2	66.74
0.50	9.51	9.50	.0	200.8	103.9	96.9	10.1	10.2	66.73
1.00	9.51	9.50	.0	200.8	103.5	97.3	10.1	10.1	66.73
141.50	9.51	9.50	.0	200.8	103.1	97.7	10.0	10.0	66.72

						- - - - - - R E S E R V O I R - - - - - -				
	RAIN	ACCUM.	BASIN	ACCUM.		ACCUM.	INSTANT	AVERAGE	
TIME	FALL	RUNOFF	DISCHGE	INFLOW	VOLUME	OUTFLOW	DISCHGE	DISCHGE	STAGE
(HR)	(IN)	(IN)	(CFS)	(AF)	(AF)	(AF)	(CFS)	(CFS)	(FT)

SUMMARY INFORMATION

MAXIMUM STAGE WAS 68.01 FEET AT 79.00 HOURS
MAXIMUM DISCHARGE WAS 20.6 CFS AT 79.00 HOURS

SANTA BARBARA

PROJECT NAME . . . . : AGRICULTURAL EXAMPLE, RESERVO
REVIEWER . . . . : YALN
PROJECT NUMBER - 1

THE ROUTING IS COMPLETE WHEN THE DISCHARGE FOR BASIN 2 IS REDUCED TO 10.00CFS

********************** BASIN 1 *****************
AREA - 580.00 ACRES GROUND STORAGE - 10.20 INCHES

TIME STEP - 2.00 HOURS TIME OF CONCENTRATION - 2.00 HOURS

RETURN FREQUENCY - 100.00 YEARS RAINFALL DISTRIBUTION - 3-DAY 24-HOUR RAINFALL - 9.00 INCHES

STAGE (FT)	STORAGE (AF)
60.00	.00
61.00	5.00
62.00	20.00
63.00	45.00
64.00	80.00
65.00	188.00
66.00	430.00

********************** BASIN 2 *****************
AREA - 60.00 ACRES GROUND STORAGE - .01 INCHES

TIME STEP - 2.00 HOURS TIME OF CONCENTRATION - .50 HOURS

RETURN FREQUENCY - 100.00 YEARS RAINFALL DISTRIBUTION - 3-DAY 24-HOUR RAINFALL - 9.00 INCHES

STAGE (FT)	STORAGE (AF)
65.00	.00
66.00	60.00
67.00	120.00
68.00	180.00
69.00	240.00
70.00	300.00

DISCHARGE STRUCTURE INFORMATION

STRUCT NO.	PIPE SLOPE (%)	DIAMETER (FT)	ROUGHNESS	LENGTH (FT)	WEIR WEIR CREST TYPE/ELEV	WEIR LENGTH	HEAD INVERT ELEVATION	TAIL INVERT ELEVATION	
1	SEE PUMP TABLE								
2									BASIN 2 TO BASIN 3
3					BROAD/ 68.0	70.00			BASIN 2 TO BASIN 1

BLEEDER INFORMATION

STRUCT NO.	BLEEDER TYPE	DIAMETER OR WIDTH (FT)	ORIFICE INVERT ELEVATION (FT-NGVD)	AREA (FT2)	V-NOTCH ANGLE (DEG)	V-NOTCH INVERT ELEVATION (FT-NGVD)	TOP ELEVATION (FT-NGVD)
1	NO BLEEDER INCLUDED IN STRUCTURE						
2	V-NOTCH	NA	NA	NA	80.0	65.0	67.0
3	NO BLEEDER INCLUDED IN STRUCTURE						

PUMP TABLE

PUMP NO.	PUMP ON ELEVATION (FEET)	PUMP OFF ELEVATION (FEET)	PUMP DISCHARGE (GPM)	DISCHARGES FROM BASIN	TO BASIN
1	61.50	60.03	43800.00	1	2

OFFSITE RECEIVING WATER

TIME(HR)	STAGE(FT-NGVD)
.00	60.00
1000.00	60.00

SUMMARY REPORT

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
.0	1	1	.0	.0	.0	.0	.00	60.00	1	2	
	2	2	.0	.0	.0	.1	.00	65.00	2	3	
	3	2	.0	.0	.0	.0	.00	65.00	2	1	
2.0	1	1	.1	.0	.0	.0	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	.1	.1	3.3	3.2	.00	65.01	2	3	BLEEDER
	3	2	.1	.1	3.3	3.2	.00	65.01	2	1	NO FLOW
4.0	1	1	.2	.0	.0	.0	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	.2	.2	3.3	3.3	.00	65.01	2	3	BLEEDER
	3	2	.2	.2	3.3	3.3	.00	65.01	2	1	NO FLOW
6.0	1	1	.3	.0	.0	.0	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	.3	.3	3.3	3.3	.00	65.02	2	3	BLEEDER
	3	2	.3	.3	3.3	3.3	.00	65.02	2	1	NO FLOW
8.0	1	1	.4	.0	.0	.0	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	.4	.4	3.3	3.3	.00	65.03	2	3	BLEEDER
	3	2	.4	.4	3.3	3.3	.00	65.03	2	1	NO FLOW
10.0	1	1	.5	.0	.0	.0	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	.5	.5	3.3	3.3	.00	65.04	2	3	BLEEDER
	3	2	.5	.5	3.3	3.3	.00	65.04	2	1	NO FLOW
12.0	1	1	.7	.0	.0	.0	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	.7	.6	3.3	3.3	.00	65.05	2	3	BLEEDER
	3	2	.7	.6	3.3	3.3	.00	65.05	2	1	NO FLOW
14.0	1	1	.8	.0	.0	.0	.00	60.00	1	2	NO FLOW

OFFSITE STAGE IS 60.00 FT.NGVD

	2	2	.8	.8	3.3	3.3	.00	65.06	2	3	BLEEDER
	3	2	.8	.8	3.3	3.3	.00	65.06	2	1	NO FLOW
16.0	1	1	.9	.0	.0	.0	.00	60.00	1	2	NO FLOW

OFFSITE STAGE IS 60.00 FT.NGVD

	2	2	.9	.9	3.3	3.3	.00	65.07	2	3	BLEEDER
	3	2	.9	.9	3.3	3.3	.00	65.07	2	1	NO FLOW
18.0	1	1	1.0	.0	.0	.0	.00	60.00	1	2	NO FLOW

OFFSITE STAGE IS 60.00 FT.NGVD

	2	2	1.0	1.0	3.3	3.3	.00	65.08	2	3	BLEEDER
	3	2	1.0	1.0	3.3	3.3	.00	65.08	2	1	NO FLOW
20.0	1	1	1.1	.0	.0	.0	.00	60.00	1	2	NO FLOW

OFFSITE STAGE IS 60.00 FT.NGVD

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
	2	2	1.1	1.1	3.3	3.3	.00	65.09	2	3	BLEEDER
	3	2	1.1	1.1	3.3	3.3	.00	65.09	2	1	NO FLOW
22.0	1	1	1.2	.0	.0	.0	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	1.2	1.2	3.3	3.3	.01	65.10	2	3	BLEEDER
	3	2	1.2	1.2	3.3	3.3	.00	65.10	2	1	NO FLOW
24.0	1	1	1.3	.0	.0	.1	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	1.3	1.3	3.3	3.3	.01	65.11	2	3	BLEEDER
	3	2	1.3	1.3	3.3	3.3	.00	65.11	2	1	NO FLOW
26.0	1	1	1.5	.0	.0	.1	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	1.5	1.5	4.8	4.8	.01	65.12	2	3	BLEEDER
	3	2	1.5	1.5	4.8	4.8	.00	65.12	2	1	NO FLOW
28.0	1	1	1.6	.0	.0	.1	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	1.6	1.6	4.8	4.8	.01	65.13	2	3	BLEEDER
	3	2	1.6	1.6	4.8	4.8	.00	65.13	2	1	NO FLOW
30.0	1	1	1.8	.0	.0	.1	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	1.8	1.8	4.8	4.8	.02	65.14	2	3	BLEEDER
	3	2	1.8	1.8	4.8	4.8	.00	65.14	2	1	NO FLOW
32.0	1	1	2.0	.0	.0	.0	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	2.0	1.9	4.8	4.8	.02	65.16	2	3	BLEEDER
	3	2	2.0	1.9	4.8	4.8	.00	65.16	2	1	NO FLOW
34.0	1	1	2.1	.0	.7	.1	.00	60.00	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	2.1	2.1	4.8	4.8	.03	65.17	2	3	BLEEDER
	3	2	2.1	2.1	4.8	4.8	.00	65.17	2	1	NO FLOW

112.0	1	1	12.2	5.1	.0	.K	97.59	61.14	1	2	PUMP
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	23.74	68.50	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	73.85	68.50	2	1	WEIR
114.0	1	1	12.2	5.1	.0	.K	97.59	60.64	1	2	PUMP
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	23.74	68.50	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	73.85	68.50	2	1	WEIR

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
PUMP 1 "OFF" AT 115.55 HOURS											
116.0	1	1	12.2	5.1	.0	.0	.00	60.53	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	23.43	68.44	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	61.63	68.44	2	1	WEIR
118.0	1	1	12.2	5.1	.0	.0	.00	61.31	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	22.40	68.26	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	27.97	68.26	2	1	WEIR
PUMP 1 "ON " AT 119.65 HOURS											
120.0	1	1	12.2	5.1	.0	.0	97.59	61.34	1	2	PUMP
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	22.00	68.19	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	17.82	68.19	2	1	WEIR
PUMP 1 "OFF" AT 121.72 HOURS											
122.0	1	1	12.2	5.1	.0	.0	.00	60.18	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	22.54	68.29	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	31.99	68.29	2	1	WEIR
124.0	1	1	12.2	5.1	.0	.0	.00	60.91	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	21.82	68.16	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	13.90	68.16	2	1	WEIR
126.0	1	1	12.2	5.1	.0	.0	.00	61.07	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	21.32	68.08	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	4.74	68.08	2	1	WEIR
128.0	1	1	12.2	5.1	.0	.0	.00	61.09	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	20.92	68.02	2	3	BLEEDER

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
	2	2	12.2	12.2	.0	.0	11.70	66.99	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	.00	66.99	2	1	NO FLOW
174.0	1	1	12.2	5.1	.0	.0	.00	61.09	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	11.24	66.96	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	.00	66.96	2	1	NO FLOW
176.0	1	1	12.2	5.1	.0	.0	.00	61.09	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	10.81	66.93	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	.00	66.93	2	1	NO FLOW
178.0	1	1	12.2	5.1	.0	.0	.00	61.09	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	10.40	66.90	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	.00	66.90	2	1	NO FLOW
180.0	1	1	12.2	5.1	.0	.0	.00	61.09	1	2	NO FLOW
OFFSITE STAGE IS 60.00 FT.NGVD											
	2	2	12.2	12.2	.0	.0	10.02	66.87	2	3	BLEEDER
	3	2	12.2	12.2	.0	.0	.00	66.87	2	1	NO FLOW

STRUCTURE NO.	PEAK DISCHARGE (CFS)	TIME OF QPEAK	PEAK STAGE (FT-NGVD)	TIME OF HPEAK
1	97.6	54.7	64.4	67.2
2	23.7	115.6	68.5	115.6
3	73.9	115.6	68.5	115.6

DESIGN EXAMPLE

FOR

A MAJOR IMPOUNDMENT

AGRICULTURAL SITE WITH MAJOR IMPOUNDMENT

(N.T.S.)

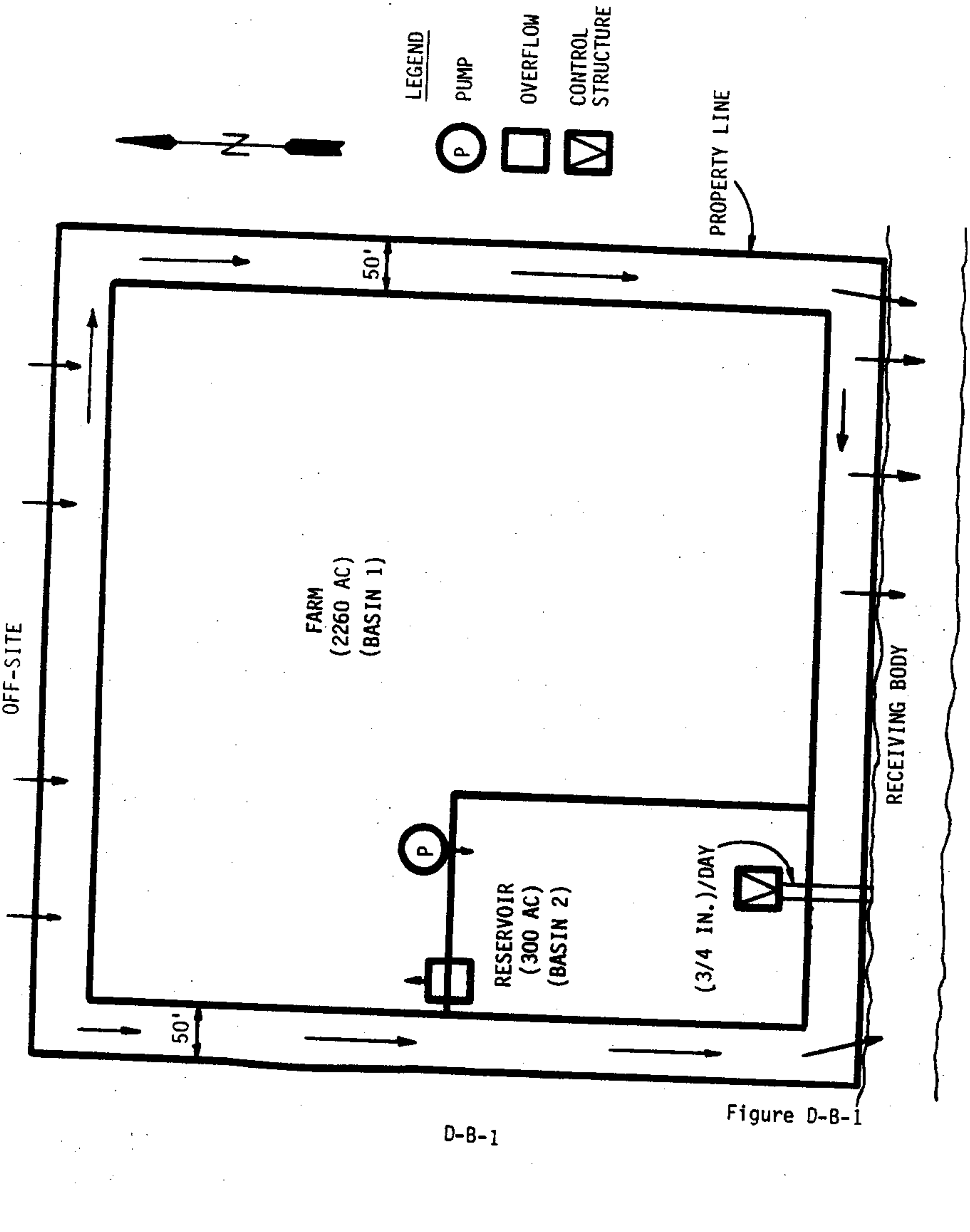


Figure D-B-1

I. Given

A. Proposed Land Use

1. Total = 2560 ac
2. Reservoir = 300 ac
3. Lateral Canals = 60 ac
4. Sod Farm = 2200 ac

B. A large mobile home park is immediately adjacent to the west boundary of the sod farm.

C. Elevations

1. Laterals extend from elevation 18' (bed) to 22' NGVD (banks).
2. Developed farm site grading varies from elevation 22' to 25' NGVD.
3. Farm control elevation is 20' NGVD.
4. Reservoir control elevation is 23' NGVD to maintain wetlands.

D. Off-site areas contribute sheetflow runoff to the site. The off-site runoff will be routed around the site via perimeter swales. Discharge off-site will continue to be sheetflow, to simulate pre-development natural conditions. (Toes of the perimeter berms are set back at least 50 feet from the property line; berms have a top width of 5 feet; have external sideslopes of 2.5H:1V, and interior sideslopes of 3H:1V for ease of maintenance.)

E. Farm discharge will be routed through a control structure, culvert, and spreader swale to the adjacent receiving body.

F. Natural depth to water table is 2.0 ft.

G. A pumping rate of 4 in./day (380 cfs) from the farm to the detention area is proposed.

Pump capacity: 4 @ 42,636 gpm = 95 cfs; or 170,544 gpm = 380 cfs
Pump schedule: On at 21.5' NGVD, off at 20.0' NGVD

H. Post development discharge allowed = 81 cfs = 3/4 in. per day.

NOTE: Discharge allowed can be determined two ways:

1. Predevelopment = postdevelopment
2. Receiving body discharge criteria if they have been established.

I. 25-year 3-day design storm rainfall = 8.0 in. x 1.359 = 10.9 in.

Treat the systems as two basins:

1. Basin 1 (farm) routed into Basin 2 (reservoir).

2. Basin 2 (reservoir) routed to receiving body.

II. Computations

A. Farm

1. Compute Pervious/Impervious (P/I)

2200 ac farm (pervious)
60 ac laterals (assumed impervious for soil storage calculations)

%I = (60 ac/2260 ac) x 100 = 2.7%
%P = (2200 ac/2260 ac) x 100 = 97.3%.

2. Compute Soil Storage and SCS Curve Number

a. Average depth to water table = 2.0 ft

b. From <u>Basis of Review</u>, 2.5 inches of moisture can be stored in the soil column beneath pervious areas.

c. Ground storage under pervious areas
= 2.5 in. x (1 ft/12 in.) x 2200 ac
= 458 ac-ft.

d. Equivalent soil storage, S

= 458 ac-ft x ((12 in./1 ft)/2260 ac)
= 2.4 in.

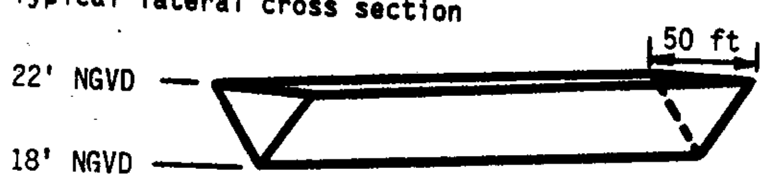
e. SCS curve number, CN

= 1000/(S + 10)
= 1000/(2.4 + 10)
= 81

3. Compute Open Surface Stage versus Storage

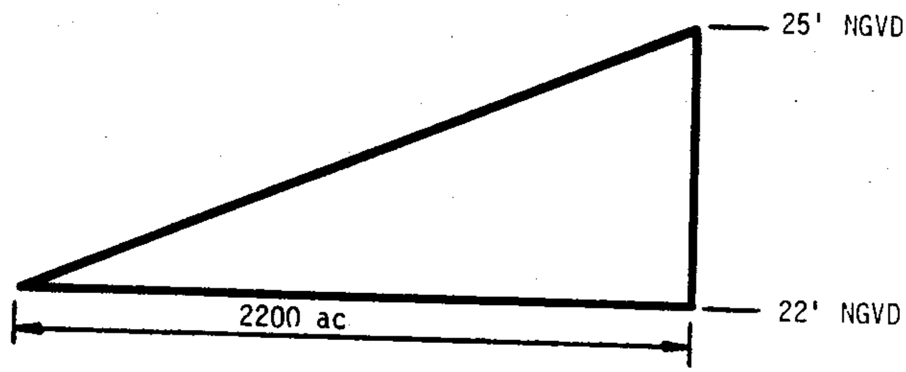
a. Laterals store between elevations 20' and 22' NGVD

Typical lateral cross section



60 acres of laterals at top of bank

b. Developed farm area stores linearly between elevations 22' and 25' NGVD.



	Storage		
Stage (ft,NGVD)	Laterals (ac-ft)	Site (ac-ft)	Total (ac-ft)
20	0	0	0
21	((30 ac + 45 ac)/2)(1 ft)	0	37.5
22	((30 ac + 60 ac)/2)(2 ft)	0	90.0
23	90 + 60 ac(1 ft)	0.5(2200 ac)((1x1 ft)/3)	516.67
24	90 + 60 ac(2 ft)	0.5(2200 ac)((2x2 ft)/3)	1676.67
25	90 + 60 ac(3 ft)	0.5(2200 ac)((3x3 ft)/3)	3570.00

4. Flood Route the Design Storm

   25-year 3-day event

   (See the selected pages titled "Santa Barbara Project Name: Ag Maj Impound" at end of this example)

   Maximum stage in farm (Basin 1) = 23.1' NGVD.

B. Reservoir

1. S = 0.01 in. (District computer program will not accept zero.)

2. Since the reservoir will be used to mitigate for the loss of some wetlands, 1 foot of water will be maintained in parts of the reservoir at elevation 22.0' NGVD. Storage will then start at the control elevation, 23.0' NGVD.

Stage (ft,NGVD)	300-acre Reservoir Storage (ac-ft)
23	0
24	300
25	600
26	900
27	1200
28	1500
29	1800
30	2100
31	2400
32	2700
33	3000
34	3300
35	3600
36	3900
37	4200

3. Allowable Discharge

   81 cfs was determined by pre- versus postdevelopment.

4. Weir crest elevation required

   a. First inch of runoff

   b. Volume = 1 in. x (1 ft/12 in.) x 2560 ac = 213 ac-ft. From the reservoir storage calculation (B.2), the weir crest should be set at elevation 23.7' NGVD, so that 213 ac-ft are detained.

5. Compute weir length

   a. Rainfall from the 25-year 3-day storm is 10.9 inches. Using the S value calculated for the sod farm,

   $$\text{runoff} = Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} = 8.5 \text{ in.}$$

   b. Volume of runoff

   = 8.5 in. x (1 ft/12 in.) x 2560 ac

   = 1813 ac-ft, or a reservoir stage of elevation 29' NGVD (per reservoir stage storage table), or 5.3 ft. above the proposed weir crest.

   c. The maximum design head is 5.3 feet.

   $Q = 3.13LH^{1.5}$

   $L = 81 \text{ cfs}/(3.13 \times (5.3 \text{ ft})^{1.5}) = 2.1 \text{ ft}$

6. Water quality control device should be designed to discharge an amount (Q) equal to 1/2 inch in 24 hours.

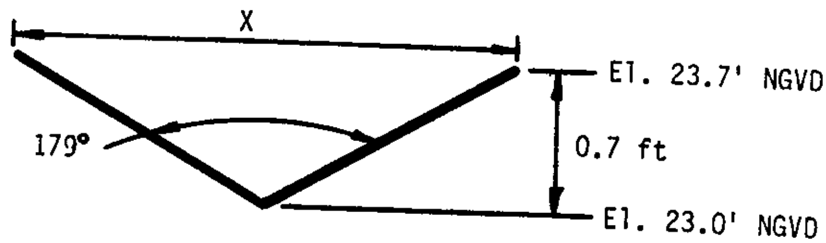
213 ac-ft/2 = 107 ac-ft in 24 hours, or about 54 cfs.
(1 cfs = 1.9835 ac-ft per 24 hrs.)

$Q = 2.5 \times (\tan(\theta/2)) \times (H)^{2.5}$, or

$\theta = 2 \times \tan^{-1}(0.492 \times Q/(H)^{2.5})$

$\theta = 2 \times \tan^{-1}(0.492 \times 107 \text{ ac-ft}/(0.7 \text{ ft})^{2.5})$

$= 179$ degrees



$\tan(\theta/2) = (X/2)/0.7 \text{ ft}$

$X = 2 \times 0.7 \text{ ft} \times (\tan(179°/2))$

X = <u>160 ft</u> - will not fit into weir.

7. Try a triangular orifice

$Q = 4.8 \times A \times (H)^{0.5}$

where Q = discharge, cfs

A = area of orifice, sq ft

H = head above orifice centroid, ft

therefore, Q = 81 cfs [see * on next page]

$A = 0.5 \times b \times h$

assume h = 3 ft

Orifice centroid will be 2/3 of h above orifice invert, or 2.0 ft above elevation 23.0' NGVD, or at elevation 25.0' NGVD.

H = 29.0' NGVD - 25.0' NGVD

= 4.0 ft

$$Q = 4.8 \times A \times H^{0.5}$$

$$= 4.8 \times (0.5 \times b \times h) \times (H)^{0.5}$$

therefore,

$$b = Q/(4.8 \times 0.5 \times h \times (H)^{0.5})$$

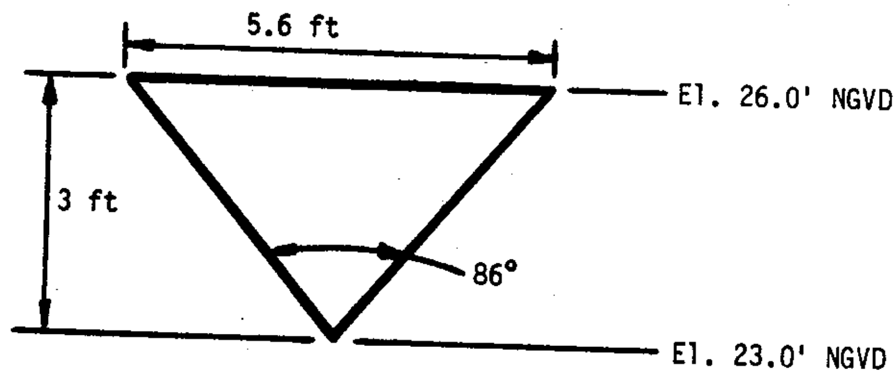
$$= 81 \text{ cfs}/(4.8 \times 0.5 \times 3 \text{ ft} \times (4.0 \text{ ft})^{0.5})$$

$$= 81 \text{ cfs}/14.4$$

$$= 5.6 \text{ ft.}$$

*(NOTE: The orifice was designed using the more restrictive condition created by the allowable discharge criteria rather than the water quality rate.)

Therefore, the structure is 1-3.0 ft high by 5.6 ft wide triangular orifice with an invert at elevation 23.0' NGVD. Only an orifice is used since the allowable discharge is low and the lake size is preferred to be left unchanged, so a V-notch is impractical. The proposed control structure will be considerably smaller than what is required to meet the detention requirements for water quality. Therefore, discharge at elevation 26.0' NGVD will be considerably less than 0.5 inch in 24 hours.



Stage-discharge values for this control structure are given in the computer printouts at the end of this example. The structure should be properly baffled, to reduce the possibility of clogging. The outfall pipe should be large enough so that the peak design storm discharge is not limited by culvert control.

8. Check the routed design storm discharge.

   a. The design storm is the 25-year 3-day event.

   b. The one-day rainfall amount is given to be 8 inches.

c. The three-day rainfall amount

= (one-day amount) x 1.359

= 8 in. x 1.359

= 10.9 inches of rainfall.

d. The pages titled "Santa Barbara Project Name: Ag Maj Impound" also are the selected results of calculations of pumping rainfall runoff into the reservoir (Basin 2), plus the rainfall on the reservoir.

i. On the last sheet, the peak design storm discharge from the reservoir is listed as 77 cfs. This is deemed acceptable, since the allowed rate of 81 cfs is based on 3/4 in. per day.

ii. Also on the last sheet, the peak design storm elevation is listed as 28.6' NGVD. District recommended criteria are that if the stored depth of water is greater than 4 feet above the surrounding ground, and berm failure would cause significant damage to the property of others besides the permittee, the impoundment should be designed as a major impoundment.

The lowest elevations of the surrounding areas are not substantially different from the 22' NGVD on the project, so the 28.6' NGVD stage represents a depth of water substantially in excess of 4 feet; there is a mobile home park just west of the farm. Consequently, this reservoir must be designed as a major impoundment.

(NOTE: A detailed influence line analysis is beyond the scope of this text. Applicants should seek expert advice from experienced consultants.

The article "Dam-Breach Flood Wave Models" by Ralph A. Wurbs, in the January 1987 Journal of Hydraulic Engineering, Volume 113, Number 1, published by the American Society of Civil Engineers, contains a discussion and comparison of several leading dam-breach flood wave models. Anyone contemplating designing a major impoundment should contact District staff as early in the project development process as possible for guidance on applicable District criteria and methods of analysis.)

iii. Freeboard requirement will be dependent upon the maximum water depth which is, in turn, dependent upon the design of the overflow structure.

9. Overflow Structure

a. Criteria

i. For gravity filled impoundments, no separate overflow structure is required, because the inflow structure will allow reservoir and farm stages to be the same.

ii. The weir crest should be set no lower than the peak elevation of the routed 25-year 3-day storm.

iii. The minimum freeboard requirement for a given reservoir and depth of water is three feet, or that required to prevent overtopping or failure due to hurricane force winds, as derived from the South Florida Building Code.

iv. The weir crest length shall be adequate to pass the peak of:

the sum of the volume of the appropriate storm (ref. Appendix 6 of Basis of Review) falling on the reservoir surface plus the inflow pump hydrograph for the same event, minus the routed discharge control structure outflow.

v. A simple culvert, or culverts, extending through the reservoir side, and with inverts at the design storm peak stage, are not acceptable, because of the danger of erosion of the reservoir berm.

vi. There are at least two acceptable overflow structure designs.

I. A non-adjustable shaft spillway.

II. A properly designed and built non-adjustable sharp- or broad-crested weir in the reservoir berm.

vii. Sodded earthen berms are not acceptable as overflow structures.

viii. Other proposed designs should be discussed with District staff as early in the design process as possible.

b. Design Calculations

i. Treat the system as two basins: Basin 1 (farm) routed into Basin 2 (reservoir).

ii. Basin 1 (farm) shall be considered to have the pumps running continuously.

(Other methods of calculating the pumped flow hydrograph into the reservoir - for the purposes of computing the overflow weir length - may be submitted by the applicant for District staff consideration.)

The pages which begin "Santa Barbara Project Name: Major Impoundment Example, Reservoir" are selected from the hydrograph of continuous farm pumping into the reservoir.

iii. After some preliminary calculations try a <u>100-foot long broad crested weir</u>.

iv. The weir crest should be set no lower than the peak elevation of the 25-year 72-hour routed storm, in this case 28.6' NGVD, to the nearest tenth of a foot.

v. The stage-discharge calculations for the overflow weir are based on the equation $Q = CLH^{1.5}$

where:

Q = discharge, cfs

C = weir coefficient, 2.60

L = weir length, in this case: 100.0 ft

H = head on the weir, ft

vi. Tabulated below are the total stage-discharge values for the reservoir, which are the sum of those previously generated for the control structure plus the overflow structure.

Stage (ft,NGVD)	Control (cfs)	Overflow (cfs)	Total (cfs)
23.0	0.0	0	0.0
24.0	2.6	0	2.6
25.0	14.7	0	14.7
26.0	40.5	0	40.5
27.0	57.2	0	57.2
28.0	70.1	0	70.1
28.6	76.8	0	76.8
29.6	86.8	260.0	346.8
30.6	95.7	735.4	831.1

vii. The pages which begin "Santa Barbara Project Name: Major Impoundment Example, Reservoir" are the results of routing continuous pumped inflow plus the 36-inch 72-hour rainfall into the reservoir, out of the combination of the control and overflow structures. Peak discharge occurs at elevation 29.9' NGVD.

Determining the length and crest elevation of the overflow weir is largely an economic and operational consideration. The length and elevation used in this example result in approximately the minimum additional water depth from the severe storm established in Appendix 6. It is conceivable that additional water depth may be desirable to the permittee. However, it should be noted that additional depth may sharply increase both design requirements imposed by the District and subsequent construction costs.

10. Freeboard Analysis

a. Criteria - Minimum freeboard is three feet above maximum water depth, or that amount required to prevent overtopping or failure due to hurricane force winds as derived from the South Florida Building Code, whichever is greater.

b. Minimum crest elevation is at least 32.9' NGVD based on the three foot minimum requirement, but may be higher based on overtopping requirement.

c. The rise in still water depth on the leeward side of the reservoir can be calculated using the Zuider Zee Formula:

$$S = \frac{V \times F}{1400 \times D}$$

Where: V = Wind velocity, mph

F = Fetch, statute miles

D = Average depth along fetch, feet

Wind velocity per South Florida Building Code is 120 mph, approximate maximum fetch is about 0.70 mile and average depth is:

$$29.9' \text{ NGVD} - ((22+23)'\text{NGVD}/2) = 7.4 \text{ ft}$$

Therefore, average increased depth on the leeward side is:

$$S = \frac{(120 \text{ mph}) \times 0.70 \text{ mi}}{1400 \times 7.4 \text{ ft}}$$

$$= 0.97 \text{ ft}$$

Maximum still water depth (D_{max}) would be:

$$D_{max} = 7.9 \text{ ft} + 0.97 \text{ ft}$$

$$= 8.87 \text{ ft}$$

Which represents a surface water elevation of 30.87' NGVD.

Maximum wave height is given by the equation:

$$H = 0.034 \times V^{1.06} \times F^{0.47}$$

Where: V = Wind velocity, mph

F = Fetch, statute miles

Therefore:

$$H = 0.034 \times (120 \text{ mph})^{1.06} \times (0.7 \text{ mi})^{0.47}$$

$$= 4.6 \text{ ft}$$

Wave run-up on slope = about 1.5 x H

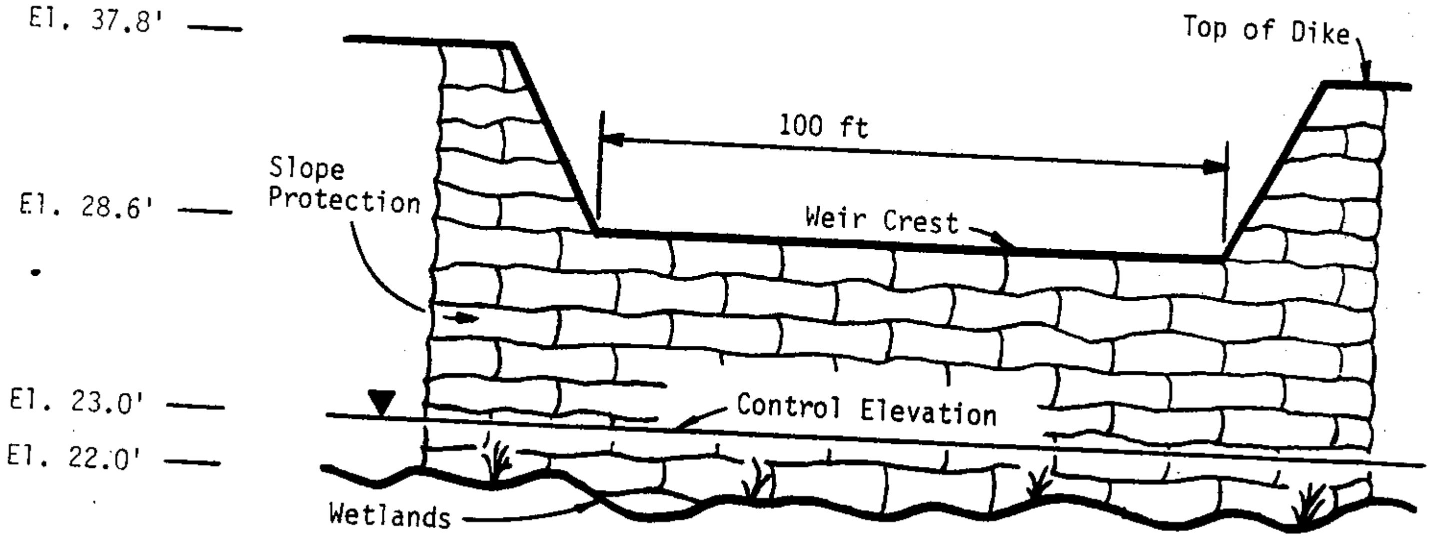
The elevation of the top of the embankment is equal to the maximum still water depth elevation, plus the wave run-up:

= 30.87' NGVD + (1.5 x 4.6 ft)

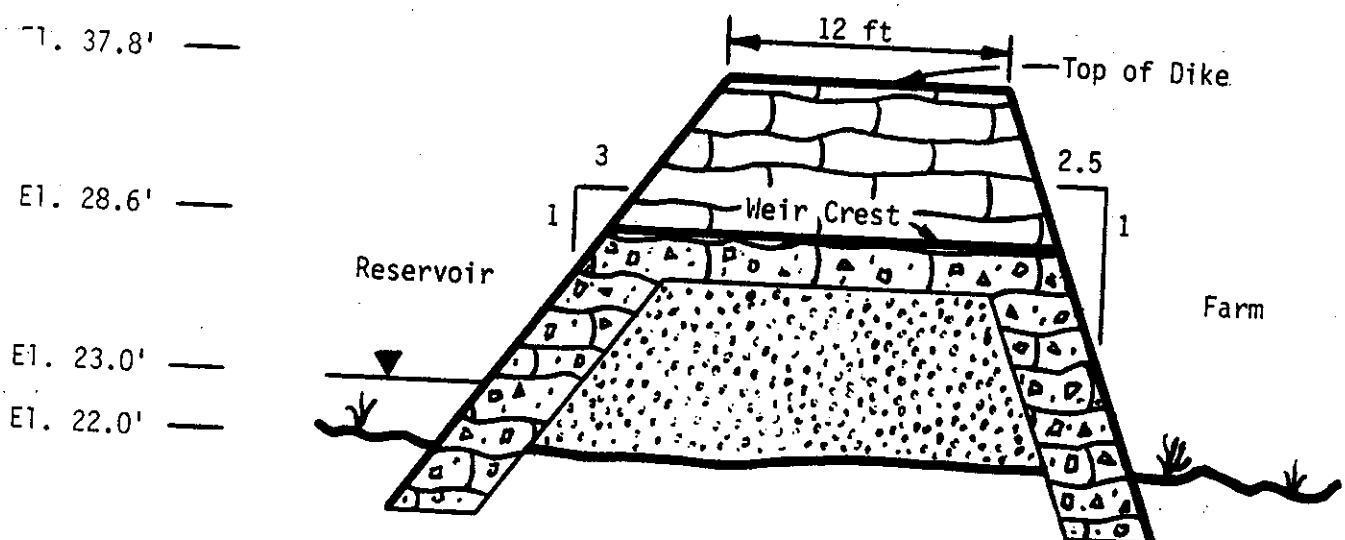
= 37.8' NGVD

Freeboard or wind and wave analysis can become very involved, and a thorough presentation is beyond the scope of this text. The following references are suggested (others may be acceptable): Brater and King, Handbook of Hydraulics, Sixth Edition; Saville, McClendon, and Cochran, "Freeboard Allowance for Waves in Inland Reservoirs," Journal of the Waterways and Harbors Division, May, 1962; U.S. Bureau of Reclamation, Design of Small Dams, 1977.

A sketch of the proposed overflow structure is on the next page. A complete design would include, among other things, proper attention to erosion control around the overflow weir, and energy dissipation devices downstream of it. Additional design requirements may include, but not be limited to, a site-specific geotechnical investigation; and slope stability, seepage and dambreak analyses. Paragraphs 1.4.1 and 2.1.1 - 2.1.5, in Appendix 6 to the Basis of Review, also provide a list of design and information requirements for major impoundments.



Elevation View (N.T.S.)



Section View (N.T.S.)

OVERFLOW STRUCTURE

Figure D-B-2

SANTA BARBARA

PROJECT NAME . . . . : AG MAJ IMPOUND
REVIEWER . . . . : ED MACIEJKO
PROJECT NUMBER - 2

THE ROUTING IS COMPLETE WHEN THE DISCHARGE FOR BASIN 2 IS REDUCED TO [redacted]

********************** BASIN 1 *****************
AREA - 2260.00 ACRES
GROUND STORAGE - 2.40 INCHES

TIME STEP - 1.00 HOURS
TIME OF CONCENTRATION - 4.00 HOURS

RETURN FREQUENCY - 25.00 YEARS
RAINFALL DISTRIBUTION - 3-DAY
24-HOUR RAINFALL - 8.00 INCHES

STAGE (FT)	STORAGE (AF)
20.00	.00
21.00	37.50
22.00	90.00
23.00	516.67
24.00	1676.67
25.00	3570.00

********************** BASIN 2 *****************
AREA - 300.00 ACRES
GROUND STORAGE - .01 INCHES

TIME STEP - 1.00 HOURS
TIME OF CONCENTRATION - .01 HOURS

RETURN FREQUENCY - 25.00 YEARS
RAINFALL DISTRIBUTION - 3-DAY
24-HOUR RAINFALL - 8.00 INCHES

STAGE (FT)	STORAGE (AF)
23.00	.00
24.00	300.00
25.00	600.00
26.00	900.00
27.00	1200.00
28.00	1500.00
29.00	1800.00
30.00	2100.00
31.00	2400.00
32.00	2700.00
33.00	3000.00
34.00	3300.00
35.00	3600.00
36.00	3900.00
37.00	4200.00

DISCHARGE STRUCTURE INFORMATION

STRUCT NO.	SLOPE (%)	DIAMETER (FT)	ROUGHNESS	LENGTH (FT)	WEIR WEIR CREST TYPE/ELEV	WEIR LEN	HEAD INVERT ELEVATION	TAIL INVERT ELEVATION

1	SEE PUMP TABLE						
2	.000	****	.100	100.00	NO RISER INCLUDED WITH PIPE		BASIN 2 TO BASIN 3
3	NO PIPE				BROAD/ 28.6	100.00	BASIN 2 TO BASIN 1

BLEEDER INFORMATION

STRUCT NO.	BLEEDER TYPE	ORIFICE DIAMETER OR WIDTH (FT)	ORIFICE INVERT ELEVATION (FT-NGVD)	AREA (FT2)	V-NOTCH ANGLE (DEG)	V-NOTCH INVERT ELEVATION (FT-NGVD)	V-NOTCH TOP ELEVATION (FT-NGVD)
1	NO BLEEDER INCLUDED IN STRUCTURE						
2	V-NOTCH	NA	NA	NA	86.0	23.0	26.0
3	NO BLEEDER INCLUDED IN STRUCTURE						

PUMP TABLE

PUMP NO.	PUMP ON ELEVATION (FEET)	PUMP OFF ELEVATION (FEET)	PUMP DISCHARGE (GPM)	DISCHARGES FROM BASIN	TO BASIN
1	21.50	20.01	170544.00	1	2

OFFSITE RECEIVING WATER

TIME(HR)	STAGE(FT-NGVD)
.00	20.00
1000.00	20.00

SUMMARY REPORT

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
.0	1	1	.0	.0	.0	.0	.00	20.00	1	2	
	2	2	.0	.0	.0	.0	.00	23.00	2	3	
	3	2	.0	.0	.0	.0	.00	23.00	2	1	
1.0	1	1	.0	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.0	.0	14.3	14.2	.00	23.00	2	3	BLEEDER
	3	2	.0	.0	14.3	14.2	.00	23.00	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
2.0	1	1	.1	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.1	.1	14.6	14.6	.00	23.01	2	3	BLEEDER
	3	2	.1	.1	14.6	14.6	.00	23.01	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
3.0	1	1	.1	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.1	.1	14.7	14.7	.00	23.01	2	3	BLEEDER
	3	2	.1	.1	14.7	14.7	.00	23.01	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
4.0	1	1	.2	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.2	.2	14.7	14.7	.00	23.02	2	3	BLEEDER
	3	2	.2	.2	14.7	14.7	.00	23.02	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
5.0	1	1	.2	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.2	.2	14.7	14.7	.00	23.02	2	3	BLEEDER
	3	2	.2	.2	14.7	14.7	.00	23.02	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
6.0	1	1	.3	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.3	.3	14.7	14.7	.00	23.02	2	3	BLEEDER
	3	2	.3	.3	14.7	14.7	.00	23.02	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
7.0	1	1	.3	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.3	.3	14.7	14.7	.00	23.03	2	3	BLEEDER
	3	2	.3	.3	14.7	14.7	.00	23.03	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
8.0	1	1	.4	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.4	.4	14.7	14.7	.00	23.03	2	3	BLEEDER
	3	2	.4	.4	14.7	14.7	.00	23.03	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
9.0	1	1	.4	.0	.0		.00	20.00	1	2	NO FLOW
		2	.4	.4	14.7		.00	23.04	2	3	BLEEDER
		2	.4	.4	14.7		.00	23.04	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
64.0	1	1	9.9	7.5	524.4	1227.0	380.00	22.91	1	2	PUMP
	2	2	9.9	9.9	72.6	72.6	24.46	25.56	2	3	BLEEDER
	3	2	9.9	9.9	72.6	72.6	.00	25.56	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
65.0	1	1	10.1	7.7	315.0	1025.6	380.00	23.02	1	2	PUMP
	2	2	10.1	10.0	43.6	43.6	27.16	25.67	2	3	BLEEDER
	3	2	10.1	10.0	43.6	43.6	.00	25.67	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
66.0	1	1	10.2	7.8	315.3	868.4	380.00	23.06	1	2	PUMP
	2	2	10.2	10.2	43.6	43.6	30.01	25.78	2	3	BLEEDER
	3	2	10.2	10.2	43.6	43.6	.00	25.78	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
67.0	1	1	10.3	7.9	315.6	746.1	380.00	23.09	1	2	PUMP
	2	2	10.3	10.3	43.6	43.6	33.02	25.89	2	3	BLEEDER
	3	2	10.3	10.3	43.6	43.6	.00	25.89	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
68.0	1	1	10.5	8.1	315.9	650.9	380.00	23.11	1	2	PUMP
	2	2	10.5	10.5	43.6	43.6	36.17	25.99	2	3	BLEEDER
	3	2	10.5	10.5	43.6	43.6	.00	25.99	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
69.0	1	1	10.6	8.2	210.7	553.7	380.00	23.13	1	2	PUMP
	2	2	10.6	10.6	29.0	29.0	42.11	26.10	2	3	BLEEDER
	3	2	10.6	10.6	29.0	29.0	.00	26.10	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
70.0	1	1	10.7	8.3	210.8	477.8	380.00	23.14	1	2	PUMP
	2	2	10.7	10.7	29.0	29.0	44.02	26.20	2	3	BLEEDER
	3	2	10.7	10.7	29.0	29.0	.00	26.20	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
71.0	1	1	10.8	8.3	210.9	418.8	380.00	23.14	1	2	PUMP
	2	2	10.8	10.8	29.0	29.0	45.84	26.30	2	3	BLEEDER
	3	2	10.8	10.8	29.0	29.0	.00	26.30	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
72.0	1	1	10.9	8.4	211.1	372.8	380.00	23.14	1	2	PUMP
	2	2	10.9	10.9	29.0	29.0	47.59	26.40	2	3	BLEEDER
	3	2	10.9	10.9	29.0	29.0	.00	26.40	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
73.0	1	1	10.9	8.4	.0	290.7	380.00	23.14	1	2	PUMP
	2	2	10.9	10.9	.0	.0	49.13	26.49	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	26.49	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
74.0	1	1	10.9	8.4	.0	226.4	380.00	23.13	1	2	PUMP
	2	2	10.9	10.9	.0	.0	50.62	26.58	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	26.58	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
75.0	1	1	10.9	8.4	.0	176.3	380.00	23.12	1	2	PUMP
	2	2	10.9	10.9	.0	.0	52.06	26.67	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	26.67	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
76.0	1	1	10.9	8.4	.0	137.3	380.00	23.10	1	2	PUMP
	2	2	10.9	10.9	.0	.0	53.45	26.76	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	26.76	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
77.0	1	1	10.9	8.4	.0	106.9	380.00	23.08	1	2	PUMP
	2	2	10.9	10.9	.0	.0	54.81	26.85	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	26.85	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
78.0	1	1	10.9	8.4	.0	83.3	380.00	23.06	1	2	PUMP
	2	2	10.9	10.9	.0	.0	56.12	26.94	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	26.94	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
79.0	1	1	10.9	8.4	.0	64.9	380.00	23.04	1	2	PUMP
	2	2	10.9	10.9	.0	.0	57.41	27.03	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	27.03	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
80.0	1	1	10.9	8.4	.0	50.5	380.00	23.02	1	2	PUMP
	2	2	10.9	10.9	.0	.0	58.65	27.12	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	27.12	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
81.0	1	1	10.9	8.4	.0	39.3	380.00	22.99	1	2	PUMP
	2	2	10.9	10.9	.0	.0	59.87	27.21	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	27.21	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
91.0	1	1	10.9	8.4	.0	3.2	380.00	22.28	1	2	PUMP
	2	2	10.9	10.9	.0	.0	70.71	28.07	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	28.07	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
92.0	1	1	10.9	8.4	.0	2.5	380.00	22.21	1	2	PUMP
	2	2	10.9	10.9	.0	.0	71.68	28.16	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	28.16	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
93.0	1	1	10.9	8.4	.0	2.0	380.00	22.13	1	2	PUMP
	2	2	10.9	10.9	.0	.0	72.64	28.24	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	28.24	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
94.0	1	1	10.9	8.4	.0	1.5	380.00	22.06	1	2	PUMP
	2	2	10.9	10.9	.0	.0	73.59	28.33	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	28.33	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
95.0	1	1	10.9	8.4	.0	1.2	380.00	21.90	1	2	PUMP
	2	2	10.9	10.9	.0	.0	74.52	28.41	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	28.41	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
96.0	1	1	10.9	8.4	.0	.9	380.00	21.30	1	2	PUMP
	2	2	10.9	10.9	.0	.0	75.43	28.49	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	28.49	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
97.0	1	1	10.9	8.4	.0	.7	380.00	20.59	1	2	PUMP
	2	2	10.9	10.9	.0	.0	76.33	28.58	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.00	28.58	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
PUMP 1 "OFF" AT 97.70 HOURS											
98.0	1	1	10.9	8.4	.0	.6	.00	20.01	1	2	NO FLOW
	2	2	10.9	10.9	.0	.0	76.89	28.63	2	3	BLEEDER
	3	2	10.9	10.9	.0	.1	1.35	28.63	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
99.0	1	1	10.9	8.4	.0	.4	.00	20.01	1	2	NO FLOW
	2	2	10.9	10.9	.0	.0	76.66	28.61	2	3	BLEEDER
	3	2	10.9	10.9	.0	.0	.21	28.61	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											

STRUCTURE NO.	PEAK DISCHARGE (CFS)	TIME OF QPEAK	PEAK STAGE (FT-NGVD)	TIME OF HPEAK
1	380.0	33.2	23.1	71.8
2	77.0	97.7	28.6	97.7
3	1.8	97.7	28.6	97.7

BASIN NO.	TOTAL INFLOW (AC-FT)	TOTAL OUTFLOW (AC-FT)	FINAL TIME (HOURS)	FINAL STAGE (FT-NGVD)
1	.13	1589.61	494.57	20.01
2	1589.61	1324.00	494.57	24.79

WEIR LENGTH	100 FT.
WEIR ELEVATION	28.6 FT. NGVD
WEIR COEFFICIENT	2.6
TYPE OF BLEEDER SLOT	TRIANGLAR ORIFICE
SLOT INVERT ELEV.	23 FT. NGVD
ORIFICE HEIGHT	3 FT.
ORIFICE BASE WIDTH	5.6 FT.

STAGE	WEIR FLOW IN CFS		
	WEIR	BLEEDER	TOTAL
23.00	0.00	0.00	0.00
24.00	0.00	2.60	2.60
25.00	0.00	14.68	14.68
26.00	0.00	40.45	40.45
27.00	0.00	57.21	57.21
28.00	0.00	70.07	70.07
28.60	0.00	76.76	76.76
29.60	260.00	86.77	346.77
30.60	735.39	95.73	831.12

S A N T A   B A R B A R A

PROJECT NAME . . . . : MAJOR IMPOUNDMENT EXAMPLE, RESERVOIR
REVIEWER . . . . :ED MACIEJKO
PROJECT NUMBER - 2

THE ROUTING IS COMPLETE WHEN THE DISCHARGE FOR BASIN 2 IS REDUCED TO 50.00CFS

********************** BASIN 1 *****************

AREA - 2260.00 ACRES
GROUND STORAGE - 2.40 INCHES

TIME STEP - 1.00 HOURS
TIME OF CONCENTRATION - 4.00 HOURS

RETURN FREQUENCY - ****** YEARS
RAINFALL DISTRIBUTION - 3-DAY
24-HOUR RAINFALL - 26.50 INCHES

STAGE (FT)	STORAGE (AF)
20.00	.00
21.00	37.50
22.00	90.00
23.00	516.67
24.00	1676.67
25.00	3570.00
26.00	5830.00
27.00	8090.00
28.00	10350.00
29.00	12610.00
30.00	14870.00

********************** BASIN 2 *****************

AREA - 300.00 ACRES
GROUND STORAGE - .01 INCHES

TIME STEP - 1.00 HOURS
TIME OF CONCENTRATION - .01 HOURS

RETURN FREQUENCY - ****** YEARS
RAINFALL DISTRIBUTION - 3-DAY
24-HOUR RAINFALL - 26.50 INCHES

STAGE (FT)	STORAGE (AF)
23.00	.00
24.00	300.00
25.00	600.00
26.00	900.00
27.00	1200.00
28.00	1500.00
29.00	1800.00
30.00	2100.00
31.00	2400.00
32.00	2700.00
33.00	3000.00
34.00	3300.00
35.00	3600.00
36.00	3900.00
37.00	4200.00

DISCHARGE STRUCTURE INFORMATION

STRUCT NO.	PIPE SLOPE (%)	DIAMETER (FT)	ROUGHNESS	LENGTH (FT)	WEIR WEIR CREST TYPE/ELEV	WEIR LENGTH	HEAD INVERT ELEVATION	TAIL INVERT ELEVATION	
1	SEE PUMP TABLE								
2	.000	****	.100	100.00	NO RISER INCLUDED WITH PIPE				
3	NO PIPE								BASIN 2 TO BASIN 3
					BROAD/ 28.6	100.00			BASIN 2 TO BASIN 1

BLEEDER INFORMATION

STRUCT NO.	BLEEDER TYPE	DIAMETER OR WIDTH (FT)	ORIFICE INVERT ELEVATION (FT-NGVD)	AREA (FT2)	V-NOTCH ANGLE (DEG)	V-NOTCH INVERT ELEVATION (FT-NGVD)	TOP ELEVATION (FT-NGVD)
1	NO BLEEDER INCLUDED IN STRUCTURE						
2	V-NOTCH	NA	NA	NA	86.0	23.0	26.0
3	NO BLEEDER INCLUDED IN STRUCTURE						

PUMP TABLE

PUMP NO.	PUMP ON ELEVATION (FEET)	PUMP OFF ELEVATION (FEET)	PUMP DISCHARGE (GPM)	DISCHARGES FROM BASIN	TO BASIN
1	21.50	20.01	170544.00	1	2

OFFSITE RECEIVING WATER

TIME(HR)	STAGE(FT-NGVD)
.00	20.00
1000.00	20.00

SUMMARY REPORT

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
.0	1	1	.0	.0	.0	.0	.00	20.00	1	2	
	2	2	.0	.0	.0	.0	.00	23.00	2	3	
	3	2	.0	.0	.0	.0	.00	23.00	2	1	
1.0	1	1	.2	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.2	.1	48.6	48.6	.00	23.01	2	3	BLEEDER
	3	2	.2	.1	48.6	48.6	.00	23.01	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
2.0	1	1	.3	.0	.0	.0	.00	20.00	1	2	NO FLOW
	2	2	.3	.3	48.7	48.7	.00	23.03	2	3	BLEEDER
	3	2	.3	.3	48.7	48.7	.00	23.03	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
3.0	1	1	.5	.0	.7	.0	.00	20.00	1	2	NO FLOW
	2	2	.5	.5	48.7	48.7	.00	23.04	2	3	BLEEDER
	3	2	.5	.5	48.7	48.7	.00	23.04	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
4.0	1	1	.6	.0	45.4	5.5	.00	20.00	1	2	NO FLOW
	2	2	.6	.6	48.8	48.8	.00	23.05	2	3	BLEEDER
	3	2	.6	.6	48.8	48.8	.00	23.05	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
5.0	1	1	.8	.0	82.3	18.7	.00	20.03	1	2	NO FLOW
	2	2	.8	.8	48.8	48.8	.00	23.07	2	3	BLEEDER
	3	2	.8	.8	48.8	48.8	.00	23.07	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
6.0	1	1	1.0	.1	113.3	36.4	.00	20.09	1	2	NO FLOW
	2	2	1.0	1.0	48.8	48.8	.00	23.08	2	3	BLEEDER
	3	2	1.0	1.0	48.8	48.8	.00	23.08	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
7.0	1	1	1.1	.1	139.5	56.5	.00	20.19	1	2	NO FLOW
	2	2	1.1	1.1	48.8	48.8	.01	23.09	2	3	BLEEDER
	3	2	1.1	1.1	48.6	48.8	.00	23.09	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
8.0	1	1	1.3	.2	161.8	77.5	.00	20.34	1	2	NO FLOW
	2	2	1.3	1.3	48.8	48.8	.01	23.11	2	3	BLEEDER
	3	2	1.3	1.3	49.8	48.8	.00	23.11	2	1	NO FLOW
OFFSITE STAGE IS		20.00 FT.NGVD									
9.0	1	1	1.5	.3	161.0	[illegible]	.00	20.53	1	2	NO FLOW
		2	1.5	1.4	48.6	[illegible]	.01	23.12	2	3	BLEEDER
		2	1.5	1.4	48.8		.00	23.12	2	1	NO FLOW
OFFSIT[illegible] IS		20.00 FT.NGVD									

TIME (HR)	F NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
10.0	1	1	1.6	.4	197.6	118.6	.00	20.77	1	2	NO FLOW
	2	2	1.6	1.6	48.8	48.8	.02	23.13	2	3	BLEEDER
	3	2	1.6	1.6	48.8	48.8	.00	23.13	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
11.0	1	1	1.8	.5	212.1	137.8	.00	21.04	1	2	NO FLOW
	2	2	1.8	1.8	48.8	48.8	.02	23.15	2	3	BLEEDER
	3	2	1.8	1.8	48.8	48.8	.00	23.15	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
12.0	1	1	1.9	.5	224.8	155.7	.00	21.27	1	2	NO FLOW
	2	2	1.9	1.9	48.8	48.8	.02	23.16	2	3	BLEEDER
	3	2	1.9	1.9	48.8	48.8	.00	23.16	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
PUMP 1 "ON " AT 12.90 HOURS											
13.0	1	1	2.1	.7	236.1	172.3	380.00	21.47	1	2	PUMP
	2	2	2.1	2.1	48.8	48.8	.03	23.18	2	3	BLEEDER
	3	2	2.1	2.1	48.8	48.8	.00	23.18	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
14.0	1	1	2.3	.8	246.0	187.6	380.00	21.15	1	2	PUMP
	2	2	2.3	2.2	48.8	48.8	.12	23.30	2	3	BLEEDER
	3	2	2.3	2.2	48.8	48.8	.00	23.30	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
15.0	1	1	2.4	.9	254.9	201.6	380.00	20.81	1	2	PUMP
	2	2	2.4	2.4	48.8	48.8	.27	23.42	2	3	BLEEDER
	3	2	2.4	2.4	48.8	48.8	.00	23.42	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
16.0	1	1	2.6	1.0	262.8	214.3	380.00	20.43	1	2	PUMP
	2	2	2.6	2.6	48.8	48.8	.49	23.54	2	3	BLEEDER
	3	2	2.6	2.6	48.8	48.8	.00	23.54	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
17.0	1	1	2.7	1.1	269.9	225.8	380.00	20.08	1	2	PUMP
	2	2	2.7	2.7	48.8	48.8	.81	23.66	2	3	BLEEDER
	3	2	2.7	2.7	48.8	48.8	.00	23.66	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											
PUMP 1 "OFF" AT 17.20 HOURS											
18.0	1	1	2.9	1.2	276.3	236.3	.00	20.42	1	2	NO FLOW
	2	2	2.9	2.9	48.8	48.8	.92	23.69	2	3	BLEEDER
	3	2	2.9	2.9	48.8	48.8	.00	23.69	2	1	NO FLOW
OFFSITE STAGE IS 20.00 FT.NGVD											

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
64.0	1	1	32.8	30.1	1803.0	4358.3	380.00	24.61	1	2	PUMP
	2	2	32.8	32.8	240.5	240.5	89.23	29.89	2	3	BLEEDER
	3	2	32.8	32.8	240.5	240.5	378.94	29.89	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
65.0	1	1	33.3	30.6	1082.0	3634.7	380.00	24.79	1	2	PUMP
	2	2	33.3	33.3	144.3	144.3	89.37	29.90	2	3	BLEEDER
	3	2	33.3	33.3	144.3	144.3	385.59	29.90	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
66.0	1	1	33.8	31.1	1082.1	3070.0	380.00	24.93	1	2	PUMP
	2	2	33.8	33.8	144.3	144.3	89.48	29.91	2	3	BLEEDER
	3	2	33.8	33.8	144.3	144.3	391.29	29.91	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
67.0	1	1	34.3	31.5	1082.2	2630.3	380.00	25.05	1	2	PUMP
	2	2	34.3	34.3	144.3	144.3	89.58	29.92	2	3	BLEEDER
	3	2	34.3	34.3	144.3	144.3	396.34	29.92	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
68.0	1	1	34.7	32.0	1082.3	2287.9	380.00	25.14	1	2	PUMP
	2	2	34.7	34.7	144.3	144.3	89.68	29.93	2	3	BLEEDER
	3	2	34.7	34.7	144.3	144.3	400.81	29.93	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
69.0	1	1	35.1	32.3	721.6	1942.0	380.00	25.22	1	2	PUMP
	2	2	35.1	35.0	96.2	96.2	89.64	29.93	2	3	BLEEDER
	3	2	35.1	35.0	96.2	96.2	399.24	29.93	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
70.0	1	1	35.4	32.7	721.7	1672.1	380.00	25.28	1	2	PUMP
	2	2	35.4	35.4	96.2	96.2	89.61	29.93	2	3	BLEEDER
	3	2	35.4	35.4	96.2	96.2	397.76	29.93	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
71.0	1	1	35.7	33.0	721.7	1461.9	380.00	25.34	1	2	PUMP
	2	2	35.7	35.7	96.2	96.2	89.59	29.92	2	3	BLEEDER
	3	2	35.7	35.7	96.2	96.2	396.46	29.92	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
72.0	1	1	36.0	33.3	721.8	1298.1	380.00	25.39	1	2	PUMP
	2	2	36.0	36.0	96.2	96.2	89.56	29.92	2	3	BLEEDER
	3	2	36.0	36.0	96.2	96.2	395.31	29.92	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											

TIME (HR)	IPF NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
73.0	1	1	36.0	33.3	.0	1012.2	380.00	25.43	1	2	PUMP
	2	2	36.0	36.0	.0	.0	89.32	29.90	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	383.38	29.90	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
74.0	1	1	36.0	33.3	.0	788.3	380.00	25.47	1	2	PUMP
	2	2	36.0	36.0	.0	.0	89.10	29.87	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	372.76	29.87	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
75.0	1	1	36.0	33.3	.0	613.9	380.00	25.49	1	2	PUMP
	2	2	36.0	36.0	.0	.0	88.90	29.85	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	363.46	29.85	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
76.0	1	1	36.0	33.3	.0	478.1	380.00	25.51	1	2	PUMP
	2	2	36.0	36.0	.0	.0	88.73	29.83	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	355.30	29.83	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
77.0	1	1	36.0	33.3	.0	372.4	380.00	25.52	1	2	PUMP
	2	2	36.0	36.0	.0	.0	88.58	29.81	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	348.13	29.81	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
78.0	1	1	36.0	33.3	.0	290.0	380.00	25.53	1	2	PUMP
	2	2	36.0	36.0	.0	.0	88.44	29.80	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	341.82	29.80	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
79.0	1	1	36.0	33.3	.0	225.8	380.00	25.54	1	2	PUMP
	2	2	36.0	36.0	.0	.0	88.32	29.79	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	336.25	29.79	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
80.0	1	1	36.0	33.3	.0	175.9	380.00	25.55	1	2	PUMP
	2	2	36.0	36.0	.0	.0	88.22	29.78	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	331.34	29.78	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											
81.0	1	1	36.0	33.3	.0	137.0	380.00	25.55	1	2	PUMP
	2	2	36.0	36.0	.0	.0	88.12	29.77	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	327.00	29.77	2	1	WEIR
OFFSITE STAGE IS 20.00 FT.NGVD											

TIME (HR)	PIPE NO	BASIN NO	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	INSTANT. RUNOFF (CFS)	RUNOFF HYDROGRAPH (CFS)	DISCHARGE (CFS)	INSTANT. STAGE (FT)	FROM	TO	STRUCTURE CONTROL
82.0	1	1	36.0	33.3	.0	106.7	380.00	25.55	1	2	PUMP
	2	2	36.0	36.0	.0	.0	88.04	29.76	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	323.17	29.76	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									
83.0	1	1	36.0	33.3	.0	83.1	380.00	25.56	1	2	PUMP
	2	2	36.0	36.0	.0	.0	87.96	29.75	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	319.77	29.75	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									
84.0	1	1	36.0	33.3	.0	64.7	380.00	25.56	1	2	PUMP
	2	2	36.0	36.0	.0	.0	87.89	29.74	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	316.76	29.74	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									
85.0	1	1	36.0	33.3	.0	50.4	380.00	25.56	1	2	PUMP
	2	2	36.0	36.0	.0	.0	87.83	29.73	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	314.09	29.73	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									
86.0	1	1	36.0	33.3	.0	39.2	380.00	25.56	1	2	PUMP
	2	2	36.0	36.0	.0	.0	87.78	29.73	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	311.72	29.73	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									
87.0	1	1	36.0	33.3	.0	30.6	380.00	25.55	1	2	PUMP
	2	2	36.0	36.0	.0	.0	87.73	29.72	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	309.62	29.72	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									
88.0	1	1	36.0	33.3	.0	23.8	380.00	25.55	1	2	PUMP
	2	2	36.0	36.0	.0	.0	87.69	29.72	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	307.76	29.72	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									
89.0	1	1	36.0	33.3	.0	18.5	380.00	25.55	1	2	PUMP
	2	2	36.0	36.0	.0	.0	87.65	29.71	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	306.10	29.71	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									
90.0	1	1	36.0	33.3	.0	14.4	380.00	25.55	1	2	PUMP
	2	2	36.0	36.0	.0	.0	87.62	29.71	2	3	BLEEDER
	3	2	36.0	36.0	.0	.0	304.63	29.71	2	1	WEIR
OFFSITE STAGE IS		20.00 FT.NGVD									

STR. NO.	PEAK DISCHARGE (CFS)	TIME OF QPEAK	PEAK STAGE (FT-NGVD)	TIME OF HPEAK
1	380.0	12.9	[redacted]	84.1
2	89.7	68.0		68.0
3	400.9	68.0		68.0

BASIN NO.	TOTAL INFLOW (AC-FT)	TOTAL OUTFLOW (AC-FT)	FINAL TIME (HOURS)	FINAL STAGE (FT-NGVD)
1	17384.30	23614.44	918.57	21.02
2	23614.44	23452.29	918.57	26.54

DESIGN EXAMPLE

FOR

EXFILTRATION TRENCH

I. Given:

A. Proposed acreages

1. Lake = 1 ac
2. Roofs = 5 ac
3. Other paving = 8 ac
4. Green areas = 2 ac
5. Total = 16 ac

B. Other

1. An existing canal, along one border of the property, will be the receiving body.
2. The receiving body regulated stage is elevation 8.0' NGVD.
3. The existing average site grade is about elevation 17' NGVD.
4. The site soil drains well. Three percolation tests yield an average hydraulic conductivity of

$$1.2 \times 10^{-4} \text{ cfs/(sq ft - ft of head)}.$$

5. Average wet season water table elevation is 8.25' NGVD.
6. Current zoning is "Commercial".

II. Design Criteria

A. Quality

1. If a wet detention system, then whichever is the greater of
   a. The first inch of runoff from the entire site.
   b. The amount of 2.5 in. times the percentage of impervious.
2. If a dry detention system, then 75% of the volume required for wet detention.
3. If a retention system, then 50% of the volume required.
4. Because the site zoning is "Commercial", at least 0.5 in. of retention or dry detention pretreatment shall be provided.

5. Any detention system shall be designed to discharge not more than 0.5 in. of the detained volume per day. A V-shaped configuration is desirable.

B. Quantity

1. The allowable discharge for the basin in which this project is located is 50 csm for a 25-year 3-day storm.

2. First floors are desired to be no lower than elevation 18.5' NGVD.

3. Parking areas.

   a. Are proposed to range in elevation from 16.0' to 17.5' NGVD.

   b. Shall be at least 2 ft above the control elevation.

III. Computations

A. Quality

1. Compute the first inch of runoff from the entire developed site.

   = 1 in. x 16 ac x 1 ft/12 in.

   = <u>1.3 ac-ft</u> for the first inch of runoff.

2. Compute 2.5 in. times the percentage of imperviousness.

   a. Site area, for water quality pervious/impervious calculation <u>only</u>

      = Total project - (lake + roof)

      = 16 ac - (1 ac + 5 ac)

      = <u>10 ac</u> site area, for water quality pervious/impervious.

   b. Impervious area, for water quality pervious/impervious calculations <u>only</u>

      = (Site area for water quality pervious/impervious) - pervious

      = 10 ac - 2 ac

      = <u>8 ac</u> impervious area, for water quality pervious/impervious.

c. Percentage of imperviousness for water quality.

$$= \frac{\text{Impervious area for water quality}}{\text{Site area for water quality}} \times 100\%$$

= (8 ac/10 ac) x 100%

= <u>80%</u> impervious

d. For 2.5 in. times the percentage impervious

= 2.5 in. x 0.80

= <u>2.00 in.</u> to be treated

e. Compute volume required for quality detention

= inches to be treated x (total site - lake)

= 2.00 in. x (16 ac - 1 ac) x 1 ft/12 in.

= 2.00 in. x 15 ac x 1 ft/12 in.

= <u>2.5 ac-ft</u> required detention storage

3. Since the 2.5 ac-ft are greater than the 1.3 ac-ft computed for the first inch of runoff, the volume of <u>2.5 ac-ft</u> controls. (The system proposed is wet detention, so no volume reductions are possible.)

4. Because this is a project on commercial zoned land, 0.5 in. of dry retention/detention must be provided.

= 0.5 in. x (total site - lake)

= 0.5 in. x (16 ac - 1 ac) x 1 ft/12 in.

= <u>0.6 ac-ft</u> required for pretreatment

5. Compute credit for placing some system inlets in grassed swales.

a. Given:

i. Each inlet in a grassed swale drains about 0.75 acre.

ii. A typical grassed swale will consist of an area about 15 ft long and 5 ft wide. The inlet will be considered a negligible part of the area.

iii. No other pervious areas drain into the grassed swale.

b. Compute ratio of impervious to pervious area.

i. Pervious area

= 15 ft x 5 ft

= <u>75 sq ft</u> pervious area.

ii. Impervious area

= 0.75 ac x 43,560 sq ft/ac

= <u>32,670 sq ft</u> impervious area.

iii. Compute Impervious : Pervious ratio

= 32,670 sq ft : 75 sq ft

= 436:1

A ratio of 436:1 results in <u>negligible credit</u>.

6. It is proposed that the dry pretreatment be accomplished totally by exfiltration trench, and to utilize the lake for aesthetics and wet detention. Since the system should be designed to maintain the water table no more than 6 feet below natural ground, and the average site grade is at elevation 17' NGVD, the control elevation shall be <u>11.0' NGVD</u>. (Note: existing water table elevation is 8.25' NGVD.)

7. Compute volume to be treated in the lake

= Total Quality Volume - Dry Pretreatment Volume

= 2.5 ac-ft - 0.6 ac-ft

= <u>1.9 ac-ft</u> to be detained in the lake.

B. Trench

1. Design Criteria

a. A minimum of 2 ft of paving and backfill will be required above the trench.

b. Minimum parking area elevation is 16.0' NGVD.

c. Trench width shall be 3 ft.

d. Since control elevation is 11.0' NGVD and existing wet season water table is 8.25' NGVD, assume the water table in the vicinity of the trench to be at elevation 10.5' NGVD.

e. For trench to be considered dry, the water table must be no higher than the invert of the trench pipe. For this system, the trench bed will extend down to elevation 11' NGVD. The pipe invert will be at elevation 12' NGVD.

2. Compute trench length

a. $L = V/(K(H_2W + 2H_2Du - Du^2 + 2H_2D_s) + (1.39 \times 10^{-4})WDu)$

L = Length of trench required (feet)

V = Volume to be exfiltrated (ac-in.)

W = Trench width (feet)

K = Hydraulic conductivity (cfs/sq ft - ft head)

H_2 = Depth to water table (feet)

Du = Non-saturated trench depth (feet)

D_s = Saturated trench depth (feet)

b. In this project, L is to be determined

V = 0.6 ac-ft = 7.2 ac-in.

W = 3 ft

$K = 1.2 \times 10^{-4}$ cfs/(sq ft - ft of head)

*H_2 = 5 ft

**Du = 3 ft

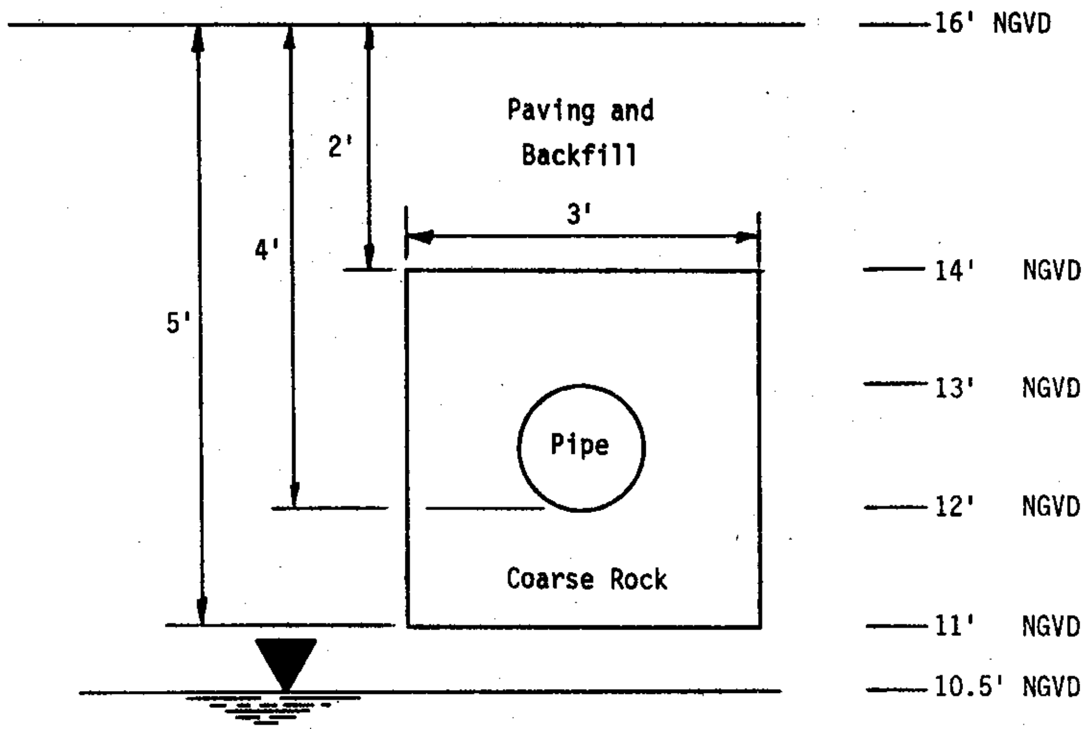
D_s = 0

*H_2 can extend no lower than the trench bottom.

**Du is the entire trench depth, from elevations 11 to 14' NGVD, because the water table is below the trench bottom.

c. $$L = \frac{7.2}{1.2\text{x}10^{-4}\text{x}((5\text{x}3)+(2\text{x}5\text{x}3)-(3\text{x}3)+(2\text{x}5\text{x}0))+((1.39\text{x}10^{-4})\text{x}3\text{x}3)}$$

= 1,290, say, <u>1,300 l.f.</u> of trench for dry retention.



CROSS SECTION OF PROPOSED EXFILTRATION TRENCH

Figure D-E-1

C. Other considerations

1. A weir must be installed at the downstream end of the trench system, to create true retention. The crest of the weir must be no lower than the top of the trench pipe.

2. The proposed lake-trench system should be checked to be certain it provides adequate storage for road and parking lot protection, can meet design storm discharge criteria, and can provide adequate floor protection. This would include a control structure on the lake discharge route.

DESIGN EXAMPLE

FOR

FLOOD PLAIN STORAGE COMPENSATION

I. General

In paragraph 3.2.1.5, Flood Plain Encroachment, it is stated "No net encroachment into the floodplain, between the average wet season water table and that encompassed by the 100-year event, which will adversely affect the existing rights of others, will be allowed." With regard to runoff storage, this means the volume of useful storage available to the stream shall not be decreased as a result of the proposed development.

It should be noted that this policy is based on the assumption that flood plain conveyance can also be maintained, and any additional considerations, such as wetlands preservation, are not a complicating factor.

II. "Exporter" or "Importer"

A. To begin the analysis, there are three values which must be computed:

1. Site predevelopment 100-year 3-day storm runoff volume.

2. Site predevelopment storage available to the basin during the 100-year flood.

3. The difference between items 1 and 2 above.

B. If the difference is positive (runoff volume is larger than available storage), then the project site is contributing runoff to the basin. Such a site is called an <u>exporter</u> of basin runoff.

C. Example: A basin runoff volume exporter

<u>Undeveloped Site</u>

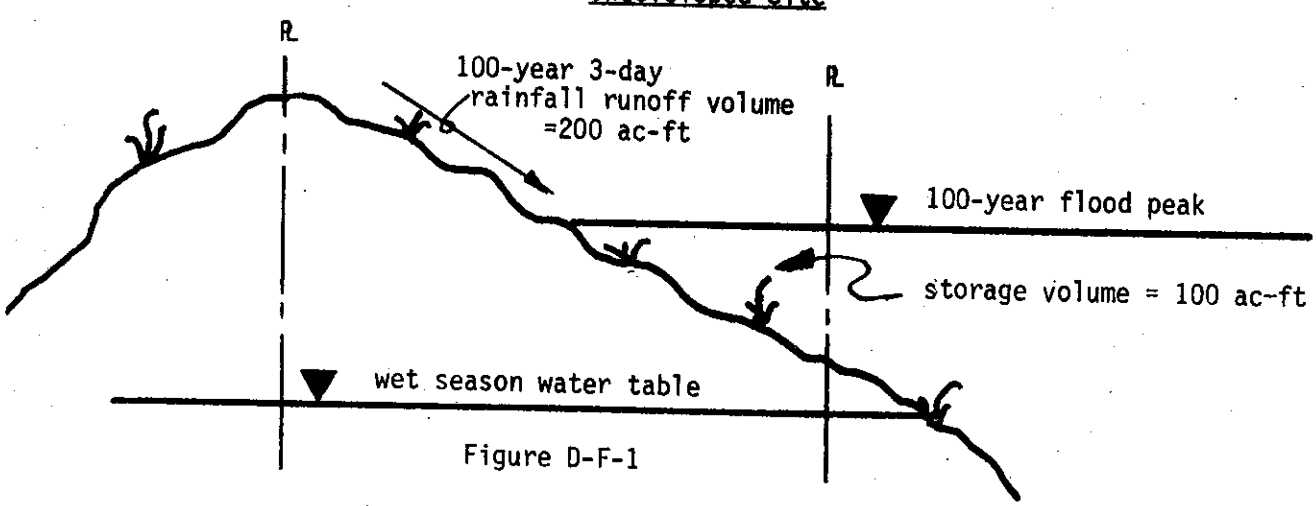


Figure D-F-1

1. First, check to see if the site is an exporter or importer

(Site predevelopment runoff volume) - (Site predevelopment storage available to the stream)

= (200 ac-ft)-(100 ac-ft)

= <u>+ 100 ac-ft</u>.

The volume difference is positive; the undeveloped site is indeed a basin runoff volume <u>exporter</u>.

2. For a developed project on this exporting site, the volume exported after development should not exceed that which would have been exported from the undeveloped site.

The design below meets that criteria.

<u>Developed Site</u>

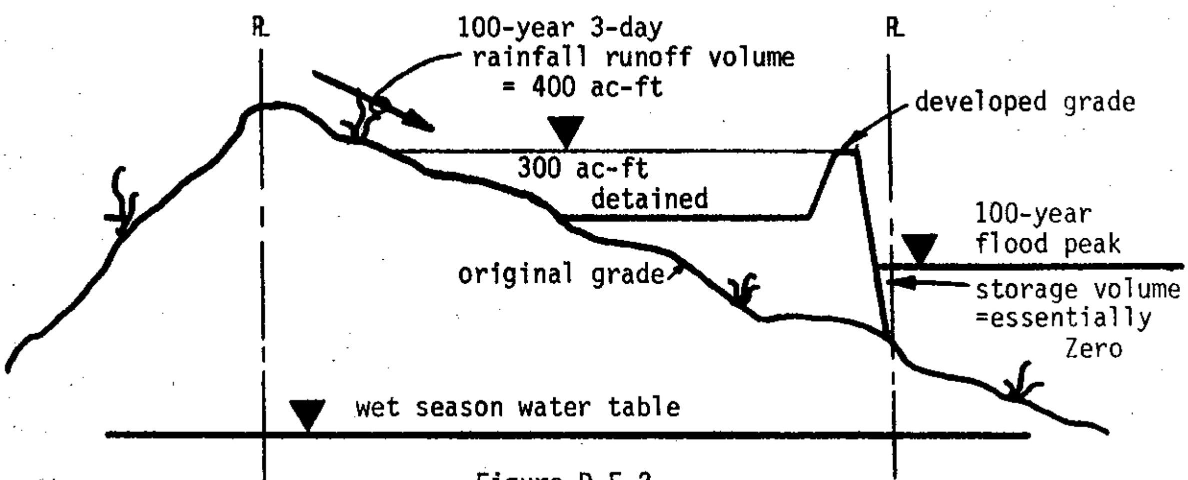


Figure D-F-2

The site meets criteria because the site grading is such that, while the 100-year 3-day storm runoff volume is 400 ac-ft, the site is storing 300, so the net effect of the project is the same: 100-ac-ft are contributed to the basin; all else from the site is stored on-site.

D. If the difference is negative (runoff volume is less than available storage), then the project site is accepting runoff from the basin and is, therefore, an <u>importer</u> of basin runoff.

E. Example: A basin runoff volume importer

<u>Undeveloped Site</u>

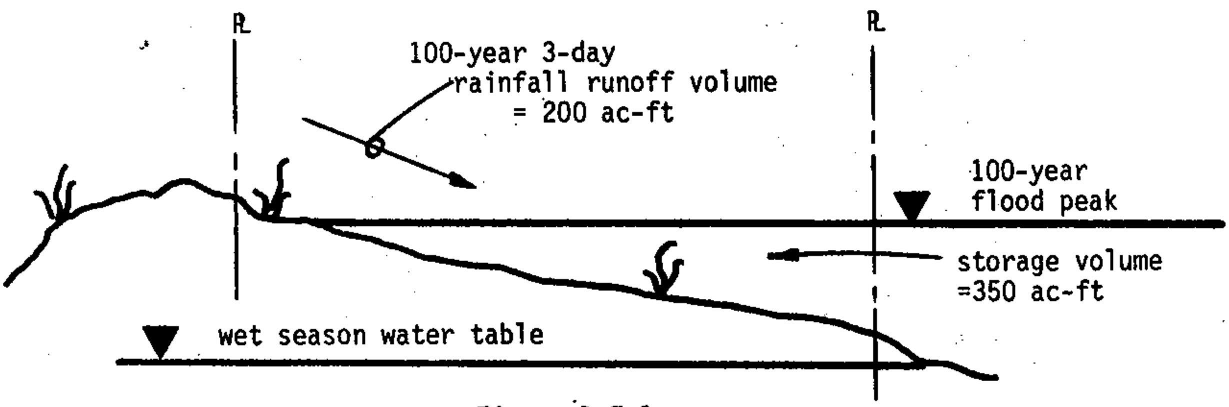


Figure D-F-3

1. First check to see if the site is an exporter or importer:

   (Site predevelopment runoff volume) - (Site predevelopment storage available to the stream)

   = (200 ac-ft) - (350 ac-ft)

   = <u>- 150 ac-ft</u>.

   The volume difference is negative; the undeveloped site is indeed a basin runoff volume <u>importer</u>.

2. Since the 150 ac-ft were available to the basin prior to site development, 150 ac-ft must be available to the basin after development. (Also, as was stated before, any wetlands must be preserved and flood plain conveyance may not be reduced.)

3. The developed site must then be divided into two parts.

   a. One part must be hydraulically contiguous to the water body, and must be capable of storing at least the volume available to the basin prior to development - in this case, 150 ac-ft.

   b. The second part can be developed, but must be graded so that the runoff from the 100-year 3-day rainfall is detained, with no uncontrolled discharge.

4. The design below meets that criteria.

Developed Site

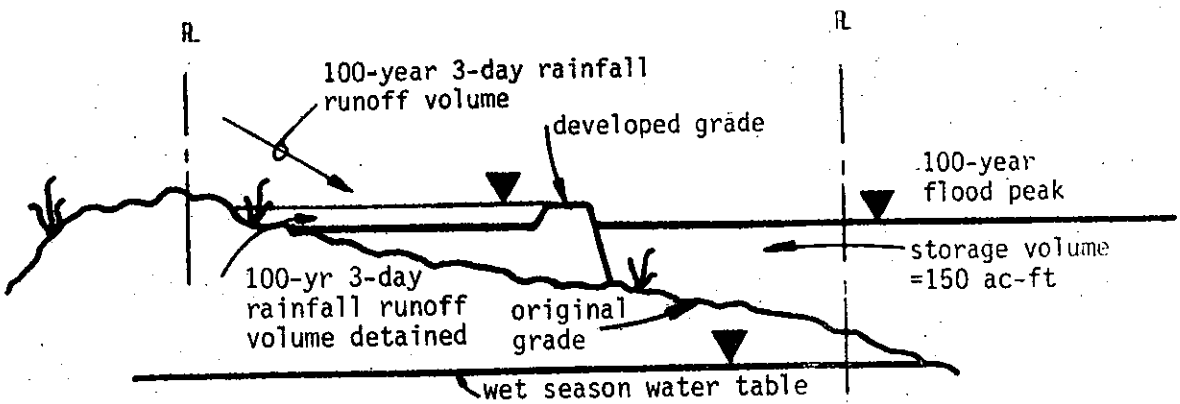


Figure D-F-4

It is worth noting that in this case, because a substantial amount of the site had served as basin storage, some of the site had to remain as storage area, and the volume of developed-site runoff had to be reduced accordingly.

III. Design Example

Undeveloped Site

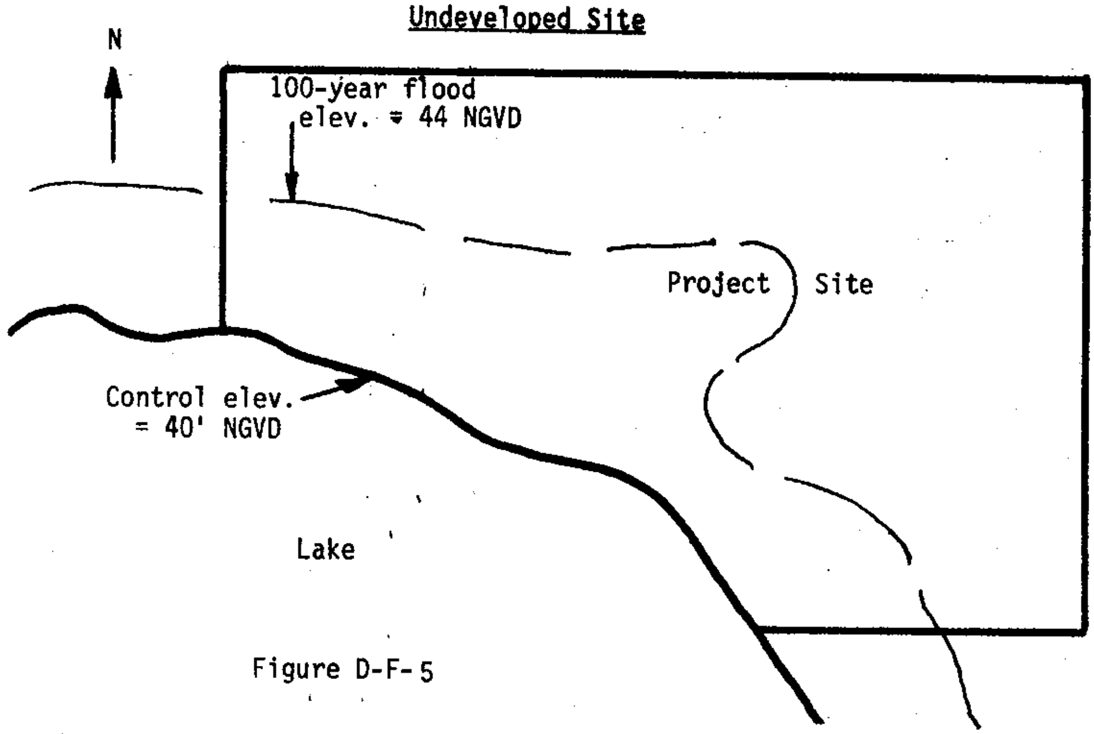


Figure D-F-5

A. Given:

1. Receiving body control elevation = 40' NGVD.

2. Receiving body 100-year flood elevation = 44' NGVD.

3. On-site storage at peak of 100-year flood = 96 ac-ft.

4. The 100-year 3-day rainfall runoff volume = 32 ac-ft.

B. Check if the undeveloped site is a basin runoff volume importer or exporter

(Site predevelopment runoff volume) - (Site predevelopment storage available to the lake)

= (32 ac-ft) - (96 ac-ft)

= - 64 ac-ft.

Since the difference is negative, the undeveloped project site is an importer.

Developed Site (Initial Layout)

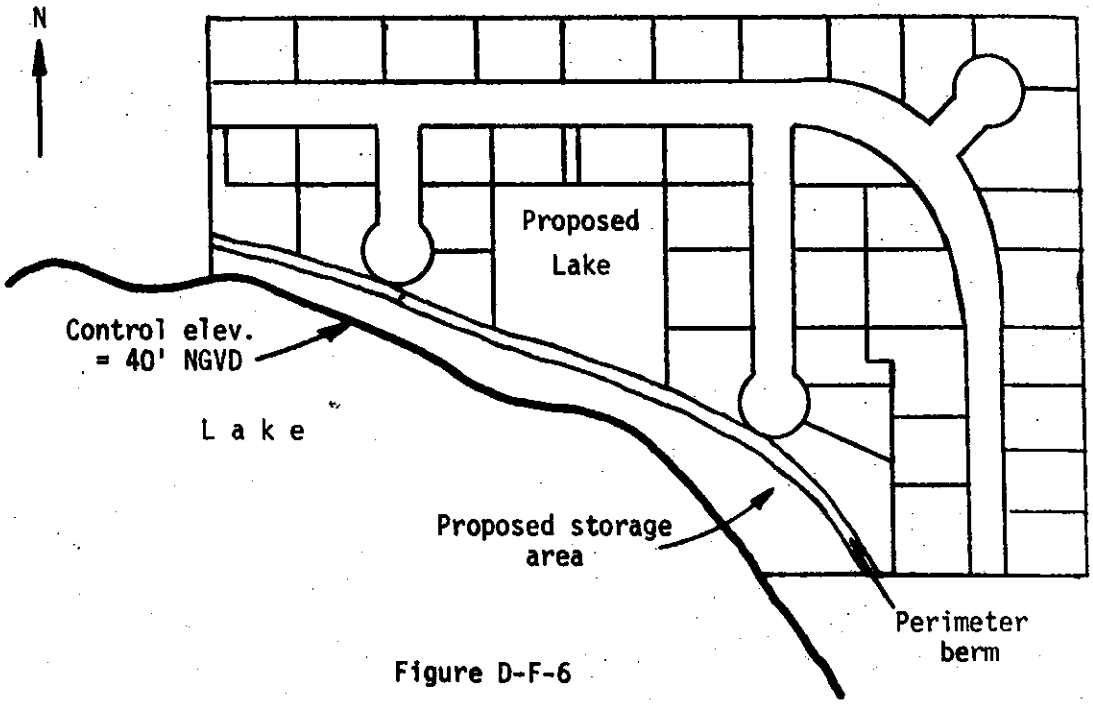


Figure D-F-6

B. Initial Design Parameters

1. Site is less than 40% impervious.

2. The computed 100-year 3-day runoff volume is 50 ac-ft.

3. Site perimeter grading, lot grading, and the proposed lake configuration are such that 50 ac-ft can be detained above the control elevation of 40' NGVD before discharge into the lake via perimeter grade overtopping occurs. (This is based on zero discharge.)

C. Design Check

1. This import site must store at least 64 ac-ft in the proposed storage area between elevations 40' and 44' NGVD. If there are more than 64 ac-ft, a shifting of the perimeter berm lakeward - resulting in more developable land - could be warranted.

   If there are less than 64 ac-ft available in the proposed storage area, a shifting of the berm land-ward - resulting in less developable land and changed design parameters - would be necessary.

DESIGN EXAMPLE

FOR

AN INDUSTRIAL SITE

SITE PLAN VIEW
Scale: 1" = 300'

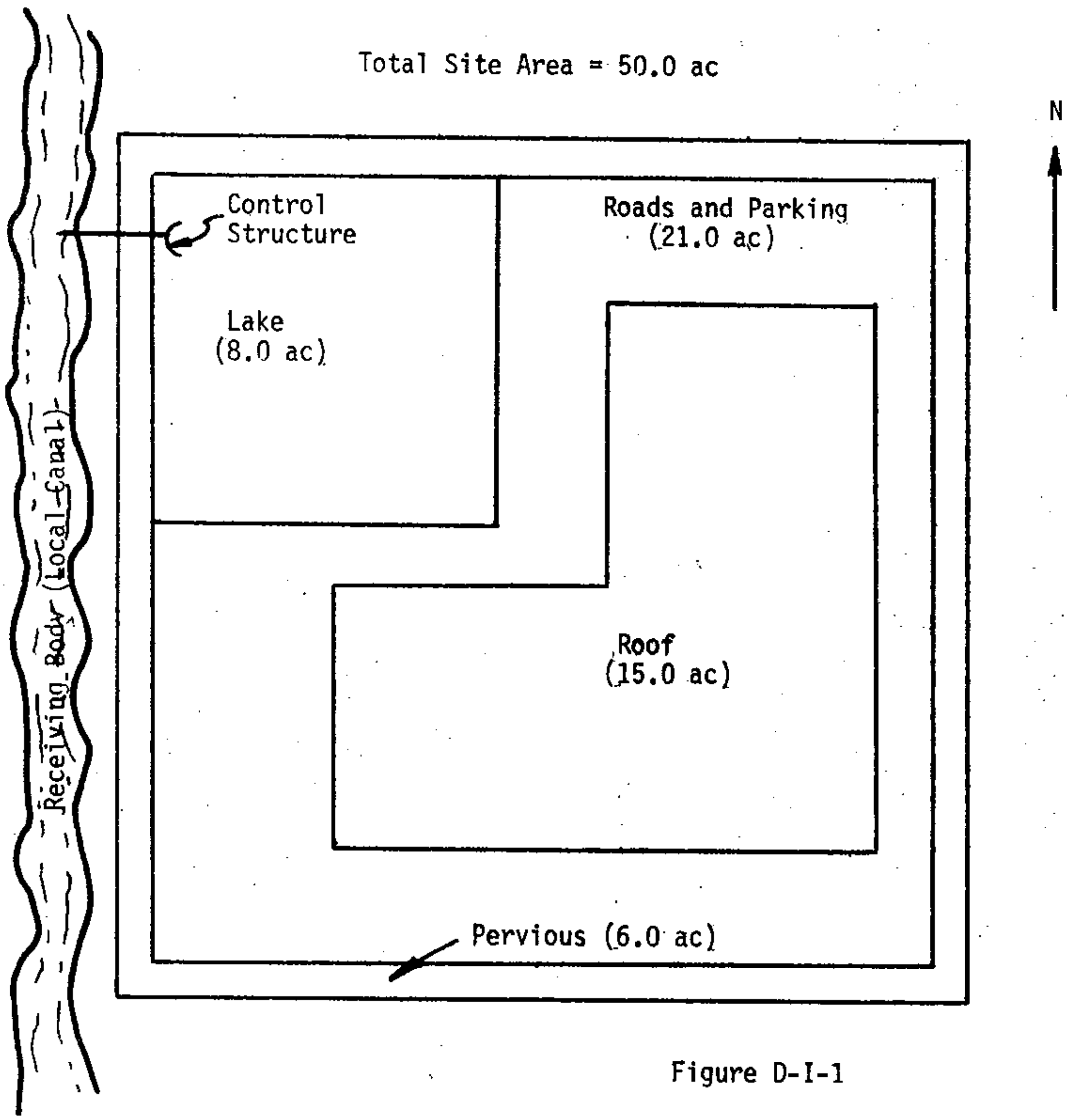


Figure D-I-1

I. Given:

A. Acreages

1. Total = 50.0 ac

2. Impervious

a. Building (roof) = 15.0 ac

b. Roads and parking = 21.0 ac

3. Lake = 8.0 ac

4. Pervious = 6.0 ac

B. Minimum elevations

1. Roads and parking = 14.0' NGVD

2. Floors = 16.5' NGVD

C. Zoning: "Industrial"

D. Allowable discharge: project is in the C-15 basin, where the peak discharge is established by District criteria as 70 csm. No flows from or onto off-site areas need to be considered.

E. Water level elevations

1. Wet season water table = 9.0' NGVD

2. Receiving canal water level = 8.5' NGVD

F. Design storm rainfall amounts

1. Roads (10-year 24-hour event) = 11.0 in.

2. Design (25-year 72-hour event) = 17.5 in.

3. Floors (100-year 72-hour event) = 24.5 in.

II. Design Criteria

A. Quality

1. If a wet detention system, then whichever is the greater of

a. The first inch of runoff from the entire site.

b. The amount of 2.5 inches times the percentage of imperviousness.

2. If a dry detention system, then 75% of the volume required for wet detention.

3. If a retention system, then 50% of the volume required.

4. Because the site zoning is "Industrial", at least 0.5 inch of dry retention or detention pretreatment shall be provided.

5. Any detention system shall be designed to discharge not more than 0.5 inch of the detained volume per day. A V-shaped configuration is desirable.

B. Quantity

1. Roads

a. Centerlines are desired to be no lower than elevation 14.0' NGVD.

b. Shall be at least 2 ft above the control elevation.

2. The allowable discharge for the basin in which this project is located is 70 csm for a 25-year 3-day storm.

3. First floors are desired to be no lower than elevation 16.5' NGVD.

III. Computations

A. Quality

1. Compute the first inch of runoff from the developed project:

= 1 in. x 50.0 ac x (1 ft/12 in.)

= <u>4.2 ac-ft</u> for the first inch of runoff.

2. Compute 2.5 inches times the percentage of imperviousness:

a. Site area for water quality pervious/impervious calculations <u>only</u>

= Total project - (water surface + roof)

= 50.0 ac - (8.0 ac + 15.0 ac)

= 50.0 ac - 23.0 ac

= <u>27.0 ac</u> of site area for water quality pervious/impervious.

b. Impervious area for water quality pervious/impervious calculations <u>only</u>

= (Site area for water quality pervious/impervious) - pervious

= 27.0 ac - 6.0 ac

= <u>21.0 ac</u> of impervious area for water quality pervious/impervious.

c. Percentage of imperviousness for water quality

$$= \frac{\text{Impervious area for water quality}}{\text{Site area for water quality}} \times 100\%$$

= (21.0 ac/27.0 ac) x 100%

= <u>78%</u> impervious.

d. For 2.5 inches times the percentage impervious

= 2.5 in. x percentage impervious

= 2.5 in. x 0.78

= <u>1.95 in.</u> to be treated.

e. Compute volume required for quality detention

= inches to be treated x (total site - lake)

= 1.95 in. x (50.0 ac - 8.0 ac) x (1 ft/12 in.)

= 1.95 in. x 42.0 ac x (1 ft/12 in.)

= <u>6.8 ac-ft</u> required detention storage.

3. Since the 6.8 ac-ft are greater than the 4.2 ac-ft computed for the first inch of runoff, the volume of <u>6.8 ac-ft</u> controls.

   (The system proposed is wet detention, so no volume reductions are possible.)

4. Compute 0.5 inch of pretreatment (which shall include roof areas)

   = 0.5 in. x (total site - lakes)

   = 0.5 in. x (50.0 ac - 8.0 ac) x (1 ft/12 in.)

= 0.5 in. x 42.0 ac x (1 ft/12 in.)

= <u>1.8 ac-ft</u> required for pretreatment.

This volume is required, regardless of whether dry retention or detention is utilized. It can be considered as available storage for the road, allowable discharge, and minimum floor storms only if it is achieved by a detention system, or exfiltration trench, or if the applicant can demonstrate that the site has excellent soil percolation rates which will remain excellent for an indefinite period of time. It will not be considered as available for storage if it is based on a retention system which relies only on natural percolation and evaporation as the mechanisms for re-achieving a dry state.

For this example, it is assumed that dry retention is achieved through exfiltration trench, the design of which will not be addressed herein.

5. Compute required lake volume

   = Total required detention - pretreatment

   = 6.8 ac-ft - 1.8 ac-ft

   = <u>5.0 ac-ft</u> required lake volume.

B. Project surface storage.

1. Assumptions

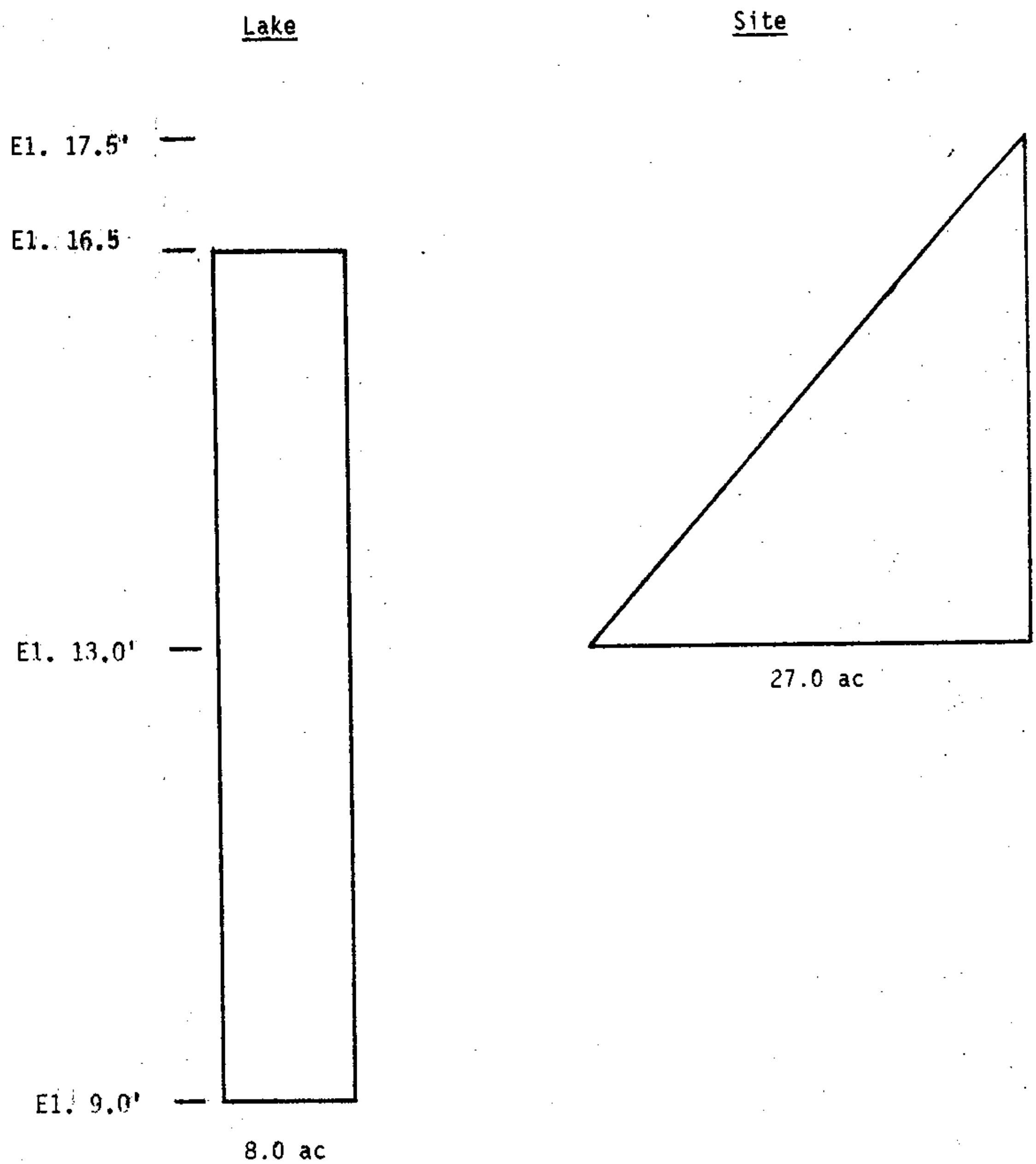
   a. Lake storage begins at a control elevation which is the given wet season water table elevation of 9.0' NGVD.

   b. Lake storage is vertical over the 8.0 ac of lake surface area.

   c. Site storage is linear, starting with some reaches of roadside swales which will be 1 foot lower than the road centerline. If the minimum road centerline elevation is 14.0' NGVD, the minimum elevation for computing site storage will then be 1 foot lower, or 13.0' NGVD. (Note: There may be isolated small areas at lower elevations, but such spots are not considered to be typical of the general site grading plan, for runoff-storage purposes.)

   Some of the site will be graded as much as 1 foot higher than the minimum floor, or up to elevation 17.5' NGVD. Perimeter grading, including road access, will be at least as high as the peak of the 25-year 72-hour (design) storm.

<u>Site Storage Diagrams</u>



2. Develop project stage-storage curve.

Stage (ft NGVD)	Storage: Lake (ac-ft)	Storage: Site (ac-ft)	Storage: Project (ac-ft)
9.0	0	0	0
10.0	8.0 x 1.0 = 8.0	0	8.0
11.0	8.0 x 2.0 = 16.0	0	16.0
12.0	8.0 x 3.0 = 24.0	0	24.0
13.0	8.0 x 4.0 = 32.0	0	32.0
14.0	8.0 x 5.0 = 40.0	((1.0/4.5) x 27.0 ac) x (1.0 ft/2) = 3.0	43.0
15.0	8.0 x 6.0 = 48.0	((2.0/4.5) x 27.0 ac) x (2.0 ft/2) = 12.0	60.0
16.0	8.0 x 7.0 = 56.0	((3.0/4.5) x 27.0 ac) x (3.0 ft/2) = 27.0	83.0
16.5*	8.0 x 7.5 = 60.0	((3.5/4.5) x 27.0 ac) x (3.5 ft/2) = 36.8	96.8

*There is no need to extend the stage-storage curve beyond the minimum floor elevation, since no flooding higher than that is allowed.

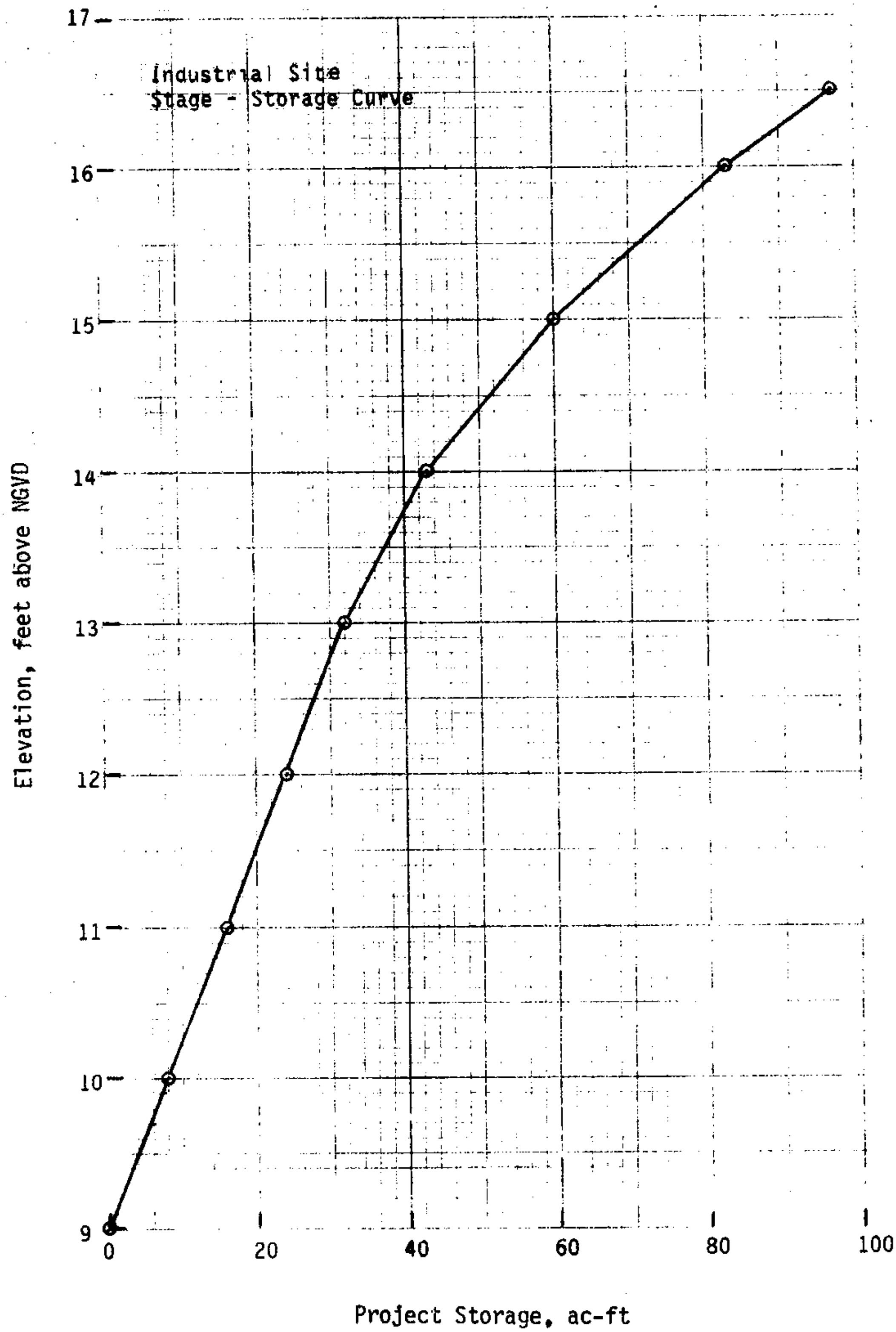

Industrial Site
Stage - Storage Curve
Elevation, feet above NGVD
17
16
15
14
13
12
11
10
9
0
20
40
60
80
100
Project Storage, ac-ft

Figure D-I-2

C. Control structure weir crest elevation.

1. Set the control structure weir crest high enough to store the lake volume quantity of 5.0 ac-ft required to meet quality criteria.

2. The weir crest should be set no lower than elevation 9.6' NGVD, according to the stage-storage curve.

D. Size the control structure detention discharge weir.

1. Assumptions

a. A V-notch weir is desirable.

b. The size shall be such as to discharge not more than 0.5 inch of the detained volume per day.

2. Computations

a. Volume to be discharged per day

= 0.5 in. x (total site area - lake)

= 0.5 in. x (50.0 ac - 8.0 ac) x (1 ft/12 in.)

= 0.5 in. x 42.0 ac x (1 ft/12 in.)

= 1.8 ac-ft maximum volume to be discharged per day.

b. Compute V-notch angle

$\theta = 2 (\tan^{-1} ((0.492\ V)/H^{2.5}))$

where:

θ = V-notch angle, degrees

V = Volume to be discharged in 24 hours, ac-ft

H = Head on vertex of notch, feet

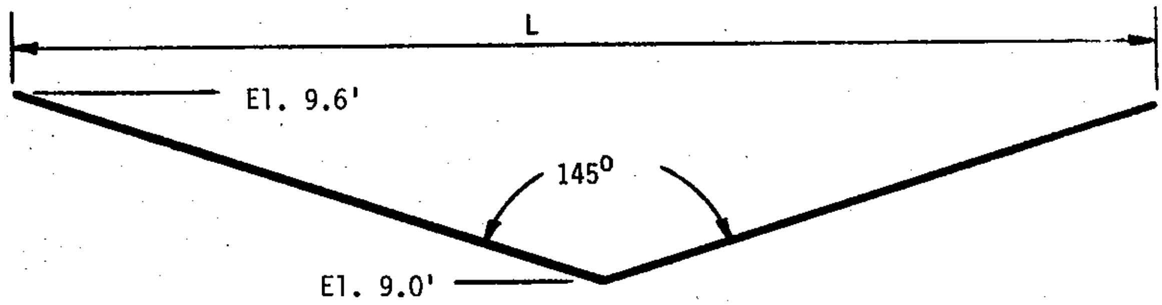
$= 2 \tan^{-1} ((0.492 \times 1.8 \text{ ac-ft})/(0.6 \text{ ft})^{2.5})$

$= 2 \tan^{-1} (3.18)$

= 2 x 72.5 degrees

= Say, 145 degrees for a V-notch angle.

Detention Discharge Weir



c. Compute the weir width (L) at elevation 9.6' NGVD

$(L/2)/0.6' = \tan(145^{\circ}/2)$

$L/2 = 0.6' \times \tan 72.5^{\circ}$

$L = 1.2' \times \tan 72.5^{\circ}$

= 3.8 ft (say, <u>46 inches</u>) wide weir at elevation 9.6' NGVD.

E. Size the allowable peak discharge weir.

1. Allowable discharge is 70 csm

= (70 cfs/sq mi) x project size

= (70 cfs/sq mi) x 50.0 ac x (1 sq mi/640 ac)

= 5.5 cfs (say, <u>6 cfs</u>) allowable discharge for this project.

2. Determine soil storage for the developed site.

a. Compute impervious for soil storage

= Lakes (100%)	= 8.0 ac
+ Buildings (100%)	= 15.0 ac
+ Roads and parking (100%)	= <u>21.0 ac</u>
Total	= <u>44.0 ac</u> of impervious.

b. Compute pervious acreage

= Total acreage - impervious acreage

= 50.0 ac - 44.0 ac

= <u>6.0 ac</u> of pervious.

c. Compute depth to water table

= Average finished site grade elevation - wet season water table elevation

= 15' NGVD - 9' NGVD

= 6 feet.

d. Determine available soil moisture storage.

i. For these typical soils, depth of storage available through percolation during a 3-day event will be 4 feet.

ii. The pervious areas will have been compacted during site development, so a 25% reduction in naturally occurring void spaces will result.

iii. From Figure C-III-1, soil storage of 8.18 inches will be available under pervious areas.

e. Compute composite site soil moisture storage (S)

= (pervious acres/total site acres) x soil storage available under pervious areas

= (6.0 ac/50.0 ac) x 8.18 in.

= 1.0 in. of soil storage available over the entire site.

3. Determine the maximum possible stage (zero discharge) during a design storm (25-year 72-hour event).

a. Total rainfall (P) was given to be 17.5 inches.

b. Calculate total runoff in inches (Q)

$$= (P - 0.2S)^2/(P + 0.8S)$$

$$= \frac{(17.5\text{ in.} - (0.2 \times 1.0\text{ in.}))^2}{17.5\text{ in.} + (0.8 \times 1.0\text{ in.})}$$

$$= (17.3\text{ in.})^2/18.3\text{ in.}$$

= 16.4 in. of total runoff (Q).

c. Calculate total runoff volume

= Q x Project acreage

= 16.4 in. x 50.0 ac x (1 ft/12 in.)

= 68.3 ac-ft of runoff.

d. The zero-discharge stage of the design storm is taken from the previously developed project stage-storage curve (Figure D-I-2), and is 15.4' NGVD.

4. Determine the peak discharge weir dimensions.

a. The maximum design head would be 15.4' NGVD - 9.6' NGVD

= 5.8'. Try a design head of 5.0 ft for sizing the weir.

b. Compute weir length.

i. Basic equation is $Q = 3.13LH^{1.5}$

ii. Rearranged, $L = Q/(3.13 \times (H)^{1.5})$

where:

L = weir length, ft

Q = design discharge, cfs

H = design head on weir, ft

iii. If Q = 6 cfs and H = 5.0 ft, then

$L = 6 \text{ cfs}/(3.13 \times (5.0 \text{ ft})^{1.5})$

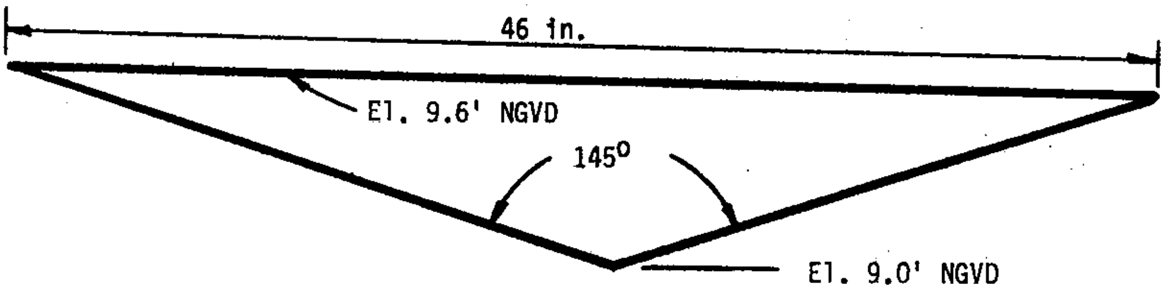
$= 6/(3.13 \times 11.2)$

$= 6/35.1$

= 0.17 ft, say 2 inches weir length

c. This is smaller than the topwidth of the detention discharge weir. Try using the detention discharge opening as the entire outflow control structure.

d. Sketch of trial outfall control structure



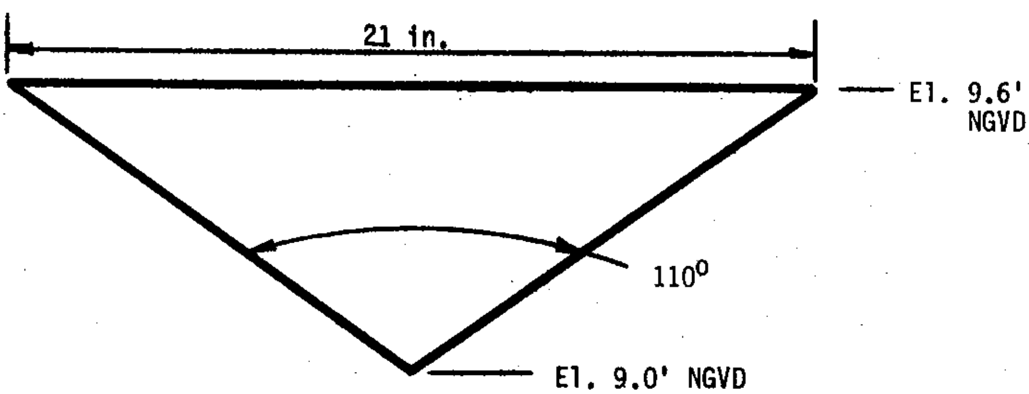
e. Check the allowable peak discharge.

   i. The allowable discharge rate was previously computed to be about 6 cfs.

   ii. The peak discharge of the routed 25-year 72-hour event was computed to be in excess of 11 cfs. (The computations are not included.) This is considerably more than the allowable of 6 cfs, therefore, the trial outfall structure is not adequate.

f. Try using a smaller orifice angle. This will result in discharging less than 0.5 inch of the detained volume per day, which is certainly not in violation of District criteria.

g. Sketch of proposed outfall control structure.



h. The control structure shall include a baffle, to intercept debris before they flow into the receiving body or clog the discharge weir.

F. Check the proposed minimum building floor elevation.

1. By definition, the minimum building floor elevation shall be at least as high as the 100-year 72-hour storm zero discharge runoff.

2. Compute 100-year 72-hour zero discharge runoff volume.

a. Total rainfall (P) was given to be 24.5 inches.

b. Calculate total runoff in inches (Q)

$= (P - 0.2S)^2/(P + 0.8S)$

$= \dfrac{(24.5 \text{ in.} - (0.2 \times 1.0 \text{ in.}))^2}{24.5 \text{ in.} + (0.8 \times 1.0 \text{ in.})}$

$= (24.3 \text{ in.})^2/25.3 \text{ in.}$

= <u>23.3 in.</u> of total runoff (Q).

c. Calculate total runoff volume

= Q x Project acreage

= 23.3 in. x 50.0 ac x (1 ft/12 in.)

= <u>97.1 ac-ft</u> of runoff.

d. From Figure D-I-2, the zero discharge stage of the 100-year 72-hour storm is 16.5' NGVD.

e. Since the proposed minimum floor elevation is 16.5' NGVD,

<u>the proposed minimum floor elevation is adequate.</u>

G. Check the proposed minimum road elevation.

1. By definition, the minimum road elevation shall be at least as high as the routed 10-year 24-hour storm.

2. At the back of this example is the routed 10-year 24-hour event. It peaked at elevation 13.35' NGVD. That is lower than the proposed minimum road elevation of 14.0' NGVD, therefore

<u>the proposed minimum road elevation is adequate.</u>

H. Check the allowable peak discharge.

1. The allowable discharge rate was previously computed to be about 6 cfs.

2. Computation of the peak discharge during the 25-year 72-hour event is shown on the last sheets of this example. It is about 6 cfs; therefore,

   <u>the proposed outfall control structure is adequate.</u>

I. The outfall pipe to the receiving body should be large enough so that the design storm discharge does not come under culvert control.

S C S   P R O G R A M

PROJECT NAME . . . . : Industrial Project
REVIEWER . . . . : SSC
PROJECT AREA . . . . : 50.00 ACRES
GROUND STORAGE . . . : 1.00 INCHES
TERMINATION DISCHARGE : 5.00 CFS
DISTRIBUTION TYPE . . : SFWMD
RETURN FREQUENCY . . : 10.00 YEARS
RAINFALL DURATION . . : 1-DAY
24-HOUR RAINFALL . . : 11.00 INCHES
REPORTING SEQUENCE . : STANDARDIZED

STAGE (FT)	STORAGE (AF)	DISCHARGE (CFS)
9.00	.00	.00
10.00	8.00	1.91
11.00	16.00	3.12
12.00	24.00	3.98
13.00	32.00	4.68
14.00	43.00	5.29
15.00	60.00	5.84

					- - - - - - R E S E R V O I R - - - - -				
TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
.00	.00	.00	.0	.0	.0	.0	.0	.0	9.00
4.00	.50	.07	.0	.3	.3	.0	.1	.0	9.03
8.00	1.51	.74	.0	3.1	3.0	.1	.7	.3	9.36
10.00	2.34	1.46	.0	6.1	5.8	.3	1.3	1.0	9.70
11.00	2.96	2.03	.0	8.4	8.0	.4	1.8	1.6	9.96
11.50	3.51	2.54	.0	10.6	10.1	.5	2.1	2.0	10.20
11.75	5.16	4.13	.0	17.2	16.7	.5	2.7	2.4	10.67
12.00	7.22	6.14	.0	25.6	25.0	.6	3.6	3.2	11.60
12.50	8.02	6.93	.0	28.9	28.1	.8	4.3	4.0	12.41
13.00	8.44	7.35	.0	30.6	29.7	.9	4.4	4.4	12.65
14.00	9.00	7.90	.0	32.9	31.6	1.3	4.6	4.5	12.92
16.00	9.68	8.58	.0	35.7	33.6	2.1	4.8	4.7	13.13
20.00	10.47	9.36	.0	39.0	35.3	3.7	4.9	4.8	13.29
24.00	11.00	9.88	.0	41.2	35.9	5.3	4.9	4.9	13.35

SUMMARY INFORMATION

MAXIMUM STAGE WAS 13.35 FEET AT 24.00 HOURS
MAXIMUM DISCHARGE WAS 4.9 CFS AT 24.00 HOURS

SCS PROGRAM

PROJECT NAME . . . . : Industrial Project
REVIEWER . . . . : SSC
PROJECT AREA . . . . : 50.00 ACRES
GROUND STORAGE . . . : 1.00 INCHES
TERMINATION DISCHARGE : 5.00 CFS
DISTRIBUTION TYPE . . : SFWMD
RETURN FREQUENCY . . : 25.00 YEARS
RAINFALL DURATION . . : 3-DAY
24-HOUR RAINFALL . . : 13.00 INCHES
REPORTING SEQUENCE . . : STANDARDIZED

STAGE (FT)	STORAGE (AF)	DISCHARGE (CFS)
9.00	.00	.00
10.00	8.00	1.91
11.00	16.00	3.12
12.00	24.00	3.98
13.00	32.00	4.68
14.00	43.00	5.29
15.00	60.00	5.84

					------ R E S E R V O I R	-----			
TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
.00	.00	.00	.0	.0	.0	.0	.0	.0	9.00
4.00	.32	.01	.0	.1	.1	.0	.0	.0	9.01
8.00	.63	.13	.0	.5	.5	.0	.1	.1	9.06
12.00	.95	.32	.0	1.3	1.2	.1	.3	.2	9.15
16.00	1.27	.55	.0	2.3	2.1	.2	.5	.4	9.26
20.00	1.58	.80	.0	3.3	2.9	.4	.7	.6	9.36
24.00	1.90	1.07	.0	4.5	3.8	.7	.9	.8	9.47
28.00	2.36	1.48	.0	6.2	5.1	1.1	1.2	1.1	9.63
32.00	2.82	1.90	.0	7.9	6.4	1.5	1.5	1.4	9.80
36.00	3.28	2.33	.0	9.7	7.7	2.0	1.8	1.7	9.95
40.00	3.74	2.76	.0	11.5	8.9	2.6	2.0	1.9	10.10
44.00	4.21	3.21	.0	13.4	10.0	3.4	2.2	2.1	10.24
48.00	4.67	3.65	.0	15.2	11.1	4.1	2.4	2.3	10.38
52.00	5.25	4.22	.0	17.6	12.6	5.0	2.6	2.5	10.57
56.00	6.45	5.39	.0	22.4	16.6	5.8	3.2	2.8	11.05
58.00	7.44	6.36	.0	26.5	20.1	6.4	3.5	3.3	11.47
59.00	8.16	7.08	.0	29.5	22.8	6.7	3.8	3.7	11.79
59.50	8.81	7.72	.0	32.2	25.3	6.9	4.0	3.9	12.07
59.75	10.76	9.65	.0	40.2	33.2	7.0	4.4	4.2	12.65
60.00	13.19	12.07	.0	50.3	43.2	7.1	5.0	4.7	13.56

60.50	14.14	13.01	.0	54.2	46.9	7.3	5.4	5.3	14.17

					- - - - - - R E S E R V O I R - - - - -				
TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
61.00	14.64	13.50	.0	56.3	48.7	7.6	5.5	5.4	14.31
62.00	15.30	14.16	.0	59.0	51.0	8.0	5.5	5.5	14.45
64.00	16.11	14.97	.0	62.4	53.5	8.9	5.6	5.6	14.60
68.00	17.04	15.90	.0	66.2	55.5	10.7	5.7	5.7	14.73
72.00	17.67	16.52	.0	68.8	56.2	12.6	5.7	5.7	14.77
80.00	17.67	16.52	.0	68.8	52.4	16.4	5.6	5.7	14.56
88.00	17.67	16.52	.0	68.8	48.8	20.0	5.5	5.5	14.34
96.00	17.67	16.52	.0	68.8	45.2	23.6	5.4	5.4	14.13
104.00	17.67	16.52	.0	68.8	41.7	27.1	5.2	5.3	13.88
112.00	17.67	16.52	.0	68.8	38.3	30.5	5.0	5.1	13.57
113.50	17.67	16.52	.0	68.8	37.7	31.1	5.0	5.0	13.52

SUMMARY INFORMATION

MAXIMUM STAGE WAS 14.77 FEET AT 72.00 HOURS
MAXIMUM DISCHARGE WAS 5.7 CFS AT 72.00 HOURS

DESIGN EXAMPLE

FOR

A MULTI-FAMILY RESIDENTIAL SITE

I. Given

A. Acreage

1. Total = 95.0 ac

2. Impervious

a. Buildings (roofs) = 9.3 ac

b. Roads and parking = 41.7 ac

3. Lakes = 10.0 ac

4. Pervious = 34.0 ac

B. Minimum elevations

1. Roads and parking = 9.0' NGVD

2. Floors = 11.5' NGVD

C. Design storm allowable discharge has been determined to be 37 cfs.

D. Water level elevations

1. Wet season water table = 5.5' NGVD

2. Receiving body water level has been determined not to affect discharge rates.

(Note: Proposed minimum road grade (9.0' NGVD) is more than 2 ft above the wet season water table, or control elevation, of 5.5' NGVD. This is a criteria which is occasionally overlooked in initial designs.)

E. Rainfall amounts (24-hour)

1. Roads (10-year) = 9.0 inches

2. Design (25-year) = 11.0 inches (this will be adjusted to a 72-hour event later)

3. Floors (100-year) = 14.0 inches (this will be adjusted to a 72-hour event later)

SITE PLAN VIEW
(N.T.S.)

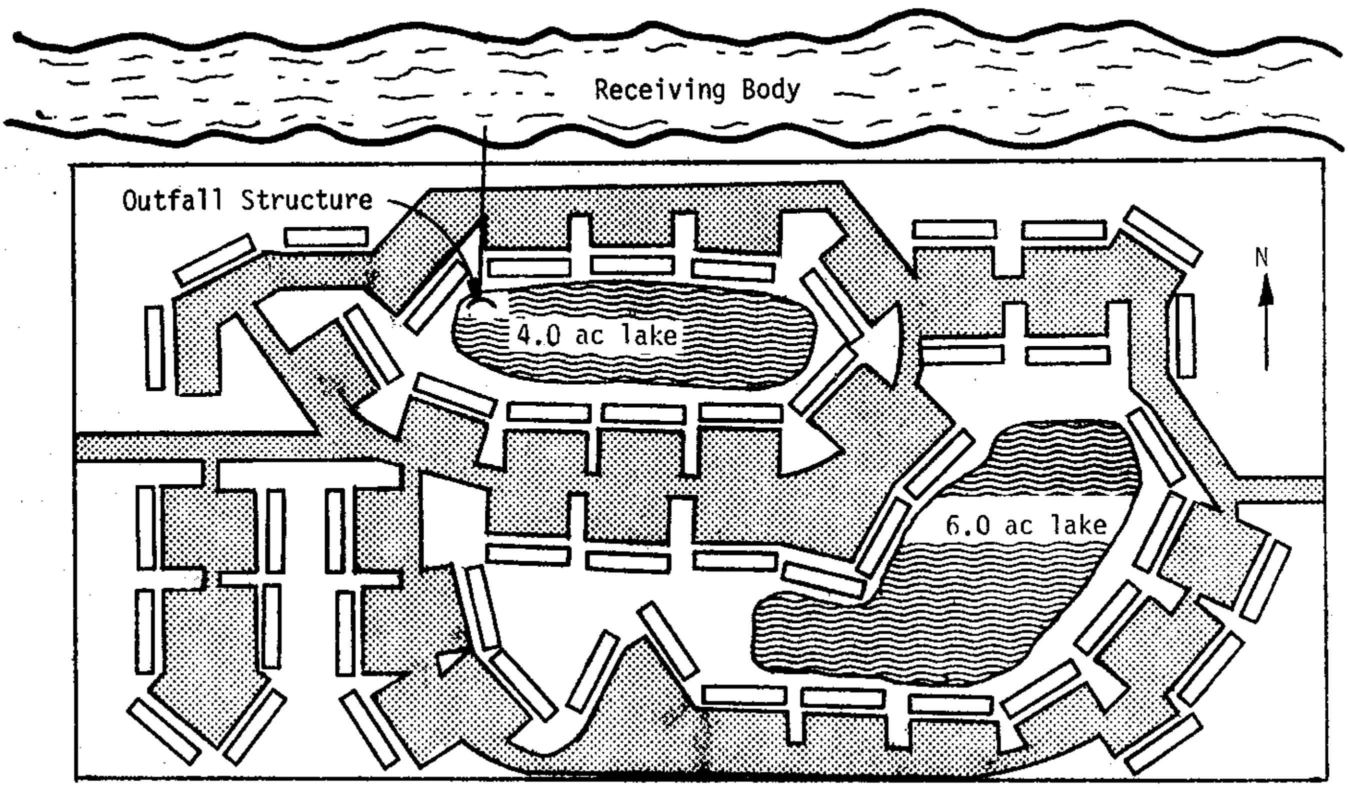


Figure D-M-1

II. Design Criteria

A. Quality

1. Since this is proposed as a wet detention system, then whichever is the greater of:

   a. The first inch of runoff from the entire site, or

   b. The amount of 2.5 inches times the percentage of imperviousness.

2. If this residentially-zoned site were discharging directly into sensitive receiving waters (example: Outstanding Florida Waters), then it might have to provide at least 0.5 inch of dry detention or retention pretreatment. (This will be discussed later in more detail.)

3. Any detention system shall be designed to discharge not more than 0.5 inch of the detained volume per day. A V-shaped configuration is desirable.

B. Quantity

1. The allowable peak discharge is 37 cfs during a 25-year 3-day storm.

2. First floors are desired to be no lower than elevation 11.5' NGVD.

3. Roads and parking are desired to be no lower than elevation 9.0' NGVD.

III. Computations

A. Quality

1. Compute the first inch of runoff from the developed project:

   = 1 in. x 95 ac x 1 ft/12 in.

   = <u>7.9 ac-ft</u> for the first inch of runoff

2. Compute 2.5 inches times the percentage of imperviousness:

   a. Site area for water quality pervious/impervious calculations <u>only</u>:

      = Total project - (water surface + roof)

      = 95 ac - (10 ac + 9.3 ac)

      = 95 ac - 19.3 ac

      = <u>75.7 ac</u> of site area for water quality pervious/impervious.

b. Impervious area for water quality pervious/impervious calculations only

= (Site area for water quality pervious/impervious) - pervious

= 75.7 ac - 34.0 ac

= 41.7 ac of impervious area for water quality pervious/impervious

c. Percentage of imperviousness for water quality:

= (Impervious area for water quality/Site area for water quality) x 100%

= (41.7 ac/75.7 ac) x 100%

= 55% impervious

d. For 2.5 inches times the percentage impervious:

= 2.5 in. x 0.55

= 1.38 in. to be treated.

e. Compute volume required for water quality detention:

= inches to be treated x (total site - lakes)

= 1.38 in. x (95 ac - 10 ac) x 1 ft/12 in.

= 9.8 ac-ft required detention storage.

3. Since the 9.8 ac-ft are greater than the 7.9 ac-ft computed for the first inch of runoff, the volume of 9.8 ac-ft controls.

(Note: The system proposed is wet detention, so no volume reductions are possible.)

4. Sidelight: Pretreatment

a. If this project were discharging directly to a sensitive receiving body, it would have to provide at least 0.5 inch of dry detention or retention pretreatment, because it is more than 40% impervious. The receiving body is not a sensitive one, but the numbers will be computed now, strictly to illustrate the process.

b. Compute 0.5 inch of pretreatment

= 0.5 in. x (total site - lakes)

= 0.5 in. x (95 ac - 10 ac) x 1 ft/12 in.

= 3.5 ac-ft required for pretreatment.

This volume would be required regardless of whether dry retention or detention were utilized. It would be considered as available storage for the road, design, and minimum floor storms if it were a detention system, or utilized properly-designed exfiltration trench. It would not be considered as available for storage if it were a retention system which relied only on natural percolation and evaporation as the mechanisms for re-achieving a dry state.

c. Compute the resulting required lake volume:

= Total required detention - pretreatment

= 9.8 ac-ft - 3.5 ac-ft

= 6.3 ac-ft required lake volume.

B. SCS Curve Number

1. Even though the control elevation is 5.5' NGVD, it is assumed that the wet season water table will vary from 5.5' NGVD at the lakes to about 7' at the project boundaries. Consequently an average water table elevation of 6.25' NGVD will be assumed.

2. The average site finished grades will vary from the lowest inlets in the parking lots (9.0' NGVD), to a little above the 11.5' NGVD floor elevations (say 12' NGVD). Therefore, average site grade elevation will be 10.5' NGVD.

3. The average depth to water table will be

= average site grade elevation - average water table elevation

= 10.5' NGVD - 6.25' NGVD

= 4.25 ft; 4 ft is the maximum depth of percolation assumed possible in three days for the soils on this site.

4. From the soil storage table, assuming the 25% compaction and 4 ft to the water table, up to 8.18 inches of moisture can be stored in the soil under pervious areas.

5. Compute available soil storage

= storage available x pervious areas

= 8.18 in. x 34 ac x 1 ft/12 in.

= 23.2 ac-ft available soil storage onsite.

6. Convert available soil storage to site-wide moisture storage, S

S = available soil storage onsite/site area

= ((23.2 ac-ft)/(95 ac)) x (12 in./1 ft)

= 2.93 in. of site-wide soil storage, S

7. SCS Curve Number, CN

$$CN = 1000/(S + 10)$$
$$= 1000/(2.93 + 10)$$
$$= \underline{77}\text{: SCS Curve Number}$$

C. Project surface storage

1. Assumptions

a. Lake storage begins at a control elevation which is the given wet season water table elevation of 5.5' NGVD.

b. Lake storage is vertical over the 10 acres of lake surface area.

c. Site storage is linear, starting at the minimum road elevation of 9.0' NGVD up through 12.0' NGVD.

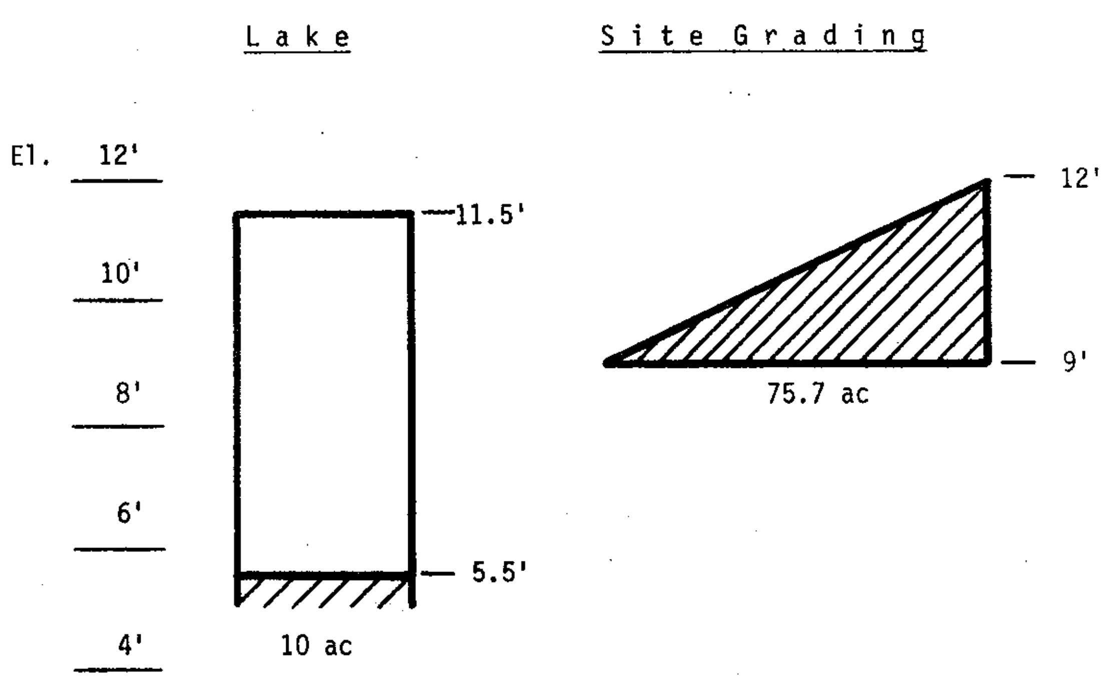
d. Area of developed site grading:

= Total area - (lakes + buildings)

= 95 ac - (10 ac + 9.3 ac)

= 75.7 ac for developed site grading.

2. Stage-Storage Schematic Diagrams



3. Stage-storage curve data

Stage (ft-NGVD)	Storage: Lake (ac-ft)	Storage: Site Grading (ac-ft)	Storage: Total (ac-ft)
5.5	0' x 10 ac = 0	0	0
6.5	1' x 10 ac = 10	0	10
7.5	2' x 10 ac = 20	0	20
8.5	3' x 10 ac = 30	0	30
9.0	3.5' x 10 ac = 35	0	35
9.5	4' x 10 ac = 40	((0.5/3) x 75.7ac) x (0.5ft/2) = 3.2	43.2
10.0	4.5' x 10 ac = 45	((1.0/3) x 75.7ac) x (1.0ft/2) = 12.6	57.6
10.5	5' x 10 ac = 50	((1.5/3) x 75.7ac) x (1.5ft/2) = 28.4	78.4
11.0	5.5' x 10 ac = 55	((2.0/3) x 75.7ac) x (2.0ft/2) = 50.5	105.5
11.5	6' x 10 ac = 60	((2.5/3) x 75.7ac) x (2.5ft/2) = 78.8	138.8

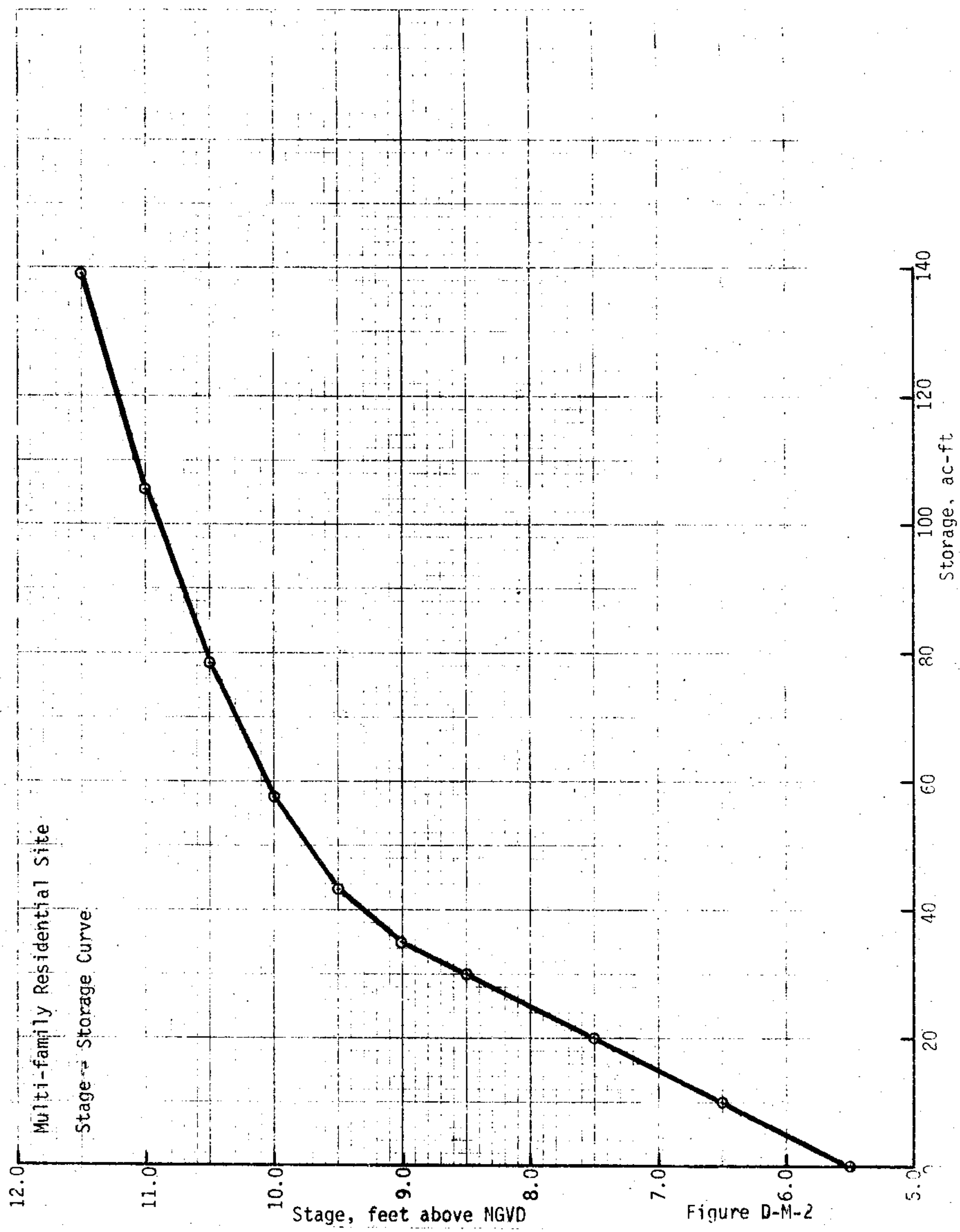

Multi-family Residential Site
Stage - Storage Curve
Storage, ac-ft
0
20
40
60
80
100
120
140
Stage, feet above NGVD
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0

Figure D-M-2

D. Control structure weir crest elevation.

1. Set the crest high enough to store the required quality volume of 9.8 ac-ft.

2. From the stage-storage curve, the weir crest should be set at elevation 6.5' NGVD.

E. Control structure weir crest length.

1. Runoff from the design storm (25-year 3-day).

   a. Rainfall amount for a three-day event

      = 1-day rainfall x 1.359

      = 11.0 in. x 1.359

      = 14.95 in. rainfall in three days.

   b. Runoff in inches (Q)

      $$Q = (P - (0.2 \times S))^2/(P + (0.8 \times S))$$

      $$= \frac{(14.95 \text{ in.} - (0.2 \times 2.93 \text{ in.}))^2}{(14.95 \text{ in.} + (0.8 \times 2.93 \text{ in.}))}$$

      $$= (14.95 \text{ in.} - 0.59 \text{ in.})^2/(14.95 \text{ in.} + 2.34 \text{ in.})$$

      $$= (14.36 \text{ in.})^2/17.29 \text{ in.}$$

      = 11.9 in. of runoff from the 25-year 3-day storm.

   c. Runoff volume

      = inches of runoff x site area

      = 11.9 in. x 95 ac x 1 ft/12 in.

      = 94.2 ac-ft runoff volume.

2. The zero-discharge stage corresponding to 94.2 ac-ft is 10.8' NGVD.

3. The maximum design head would then be 10.8' NGVD - 6.5' NGVD = 4.3'. Therefore, try a design head of 4.0 ft for sizing the weir.

4. Compute weir length.

   a. Basic equation is $Q = 3.13LH^{1.5}$.

   b. Rearranged basic equation is $L = Q/(3.13 \times (H)^{1.5})$

      where: L = weir length, ft

      Q = design discharge, cfs

      H = design head on weir, ft

c. If $Q = 37$ cfs and $H = 4$ ft, then

$L = 37 \text{ cfs}/(3.13 \times (4 \text{ ft})^{1.5})$
$= 37/(3.13 \times 8.0)$
$= 37/25.04$
= say, 1.5 ft weir length.

F. Size the control structure detention discharge weir.

1. Criteria

a. A V-notch is desirable.

b. A triangular or circular orifice may be necessary.

c. Size the weir (or orifice), to discharge no more than 0.5 inch of the detention volume in 24 hours.

2. Volume to be discharged in the first 24 hours is 0.5 inch of the required detention

= 0.5 in. x (total site - lakes)

= 0.5 in. x (95 ac - 10 ac) x 1 ft/12 in.

= 3.5 ac-ft.

3. Design head

= weir crest elevation - control elevation

= 6.5' NGVD - 5.5' NGVD

= 1 ft.

4. From the "Required V-Notch Size" design aid in Part C, for a total head of 1 ft and a desired detention volume of 3.5 ac-ft to be discharged in 24 hours, an angle of about 120 degrees is required.

This would result in a V-notch weir with a width at elevation 6.5' NGVD greater than the 1.5 ft required for the sharp-crested weir. For various reasons, it is deemed unacceptable to alter other segments of the project until all reasonable control structure design possibilities have been exhausted.

One approach is to utilize the 1.5-ft long sharp-crested weir and a V-notch weir with an angle considerably less than the 120^{o} required to obtain the maximum discharge rate of the required quality detention volume. This will result in a maximum discharge rate less than that allowed.

Since the minimum acceptable V-notch invert angle is 20^{o}, the structure will incorporate that feature.

5. In order to avoid culvert control of the discharge, the outfall pipe from the control structure to the receiving body is recommended to be sized so as to pass the allowable design flow at about one-half of the estimated design head. For this project, the design head is four feet, so the culvert will be sized to pass 37 cfs at two feet of head along about 400 l.f. of circular concrete pipe flowing full. From the design charts in Part C, a 30" diameter culvert should be sufficient.

6. The outfall structure will consist of a baffle, a 20^{0} V-notch weir, a 1.5 ft long sharp-crested weir, and 400 l.f. of RCP culvert, as shown in Figure D-M-3.

G. Values of stage-discharge for the control structure are shown in the computer printouts at the end of this example.

IV. Check storm stages and discharges.

A. Minimum building floor elevation.

1. The rainfall of the 100-year 3-day storm

= (1-day amount) x 1.359

= 14.0 in. X 1.359

= <u>19.0 in.</u>

2. Inches of runoff, Q

$= (P - (0.2 \times S))^2/(P + (0.8 \times S))$

$= (19.0 \text{ in.} - (0.2 \times 2.93 \text{ in.}))^2/(19.0 \text{ in.} + (0.8 \times 2.93 \text{ in.}))$

$= (19.0 \text{ in.} - 0.6 \text{ in.})^2/(19.0 \text{ in.} + 2.3 \text{ in.})$

$= (18.4 \text{ in.})^2/21.3 \text{ in.}$

= <u>15.89 in.</u> of runoff.

3. Volume of runoff

= (in. of runoff) x (project area)

= 15.89 in. x 95 ac x 1 ft/12 in.

= <u>125.8 ac-ft</u> required storage (zero discharge).

4. From the stage-storage curve, 125.8 ac-ft corresponds to an elevation of 11.3' NGVD. Since the proposed minimum floor elevation is 11.5' NGVD,

<u>the proposed minimum floor is acceptable</u>.

MULTI-FAMILY RESIDENTIAL SITE OUTFALL STRUCTURE
(N . T . S .)

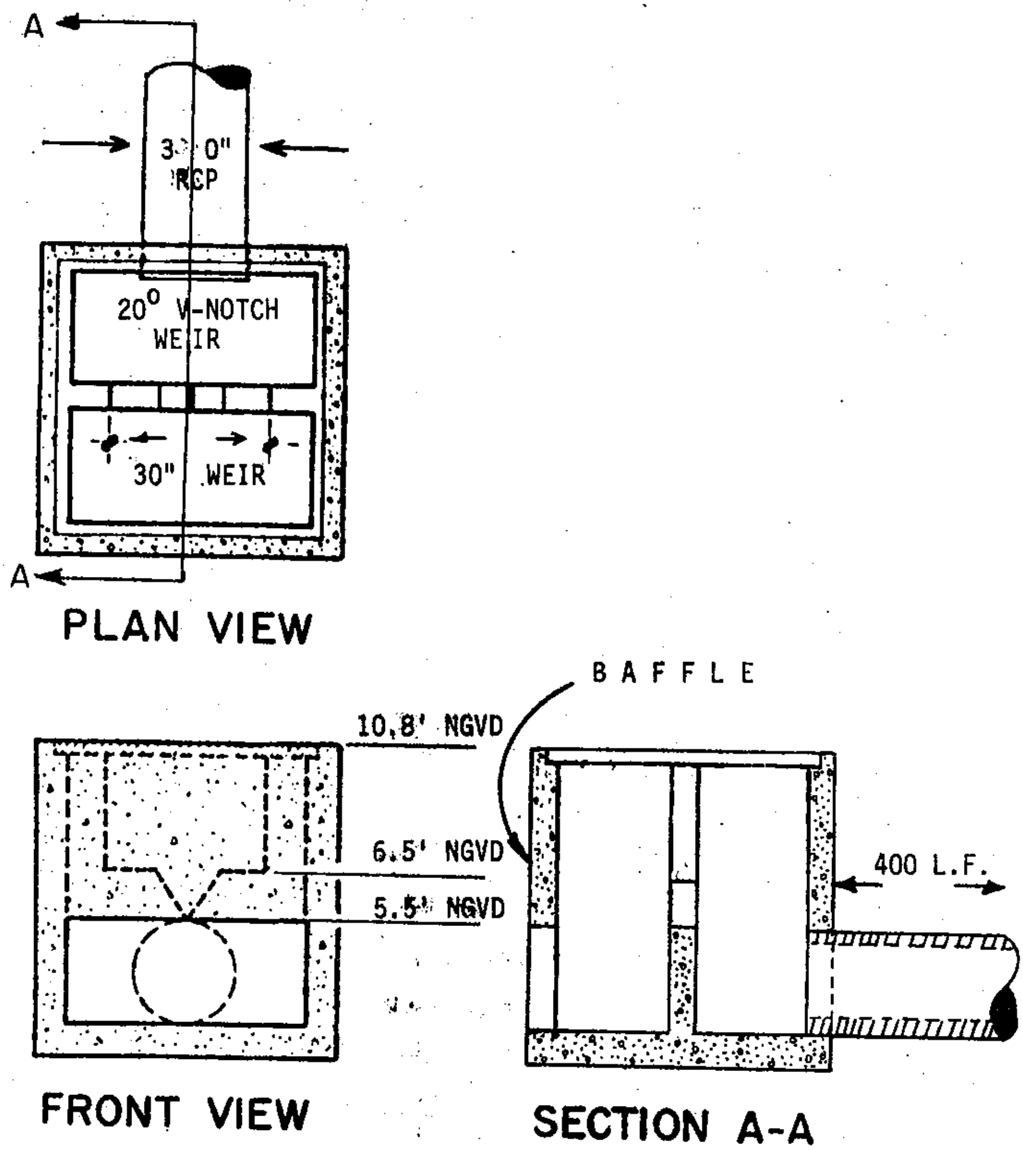


Figure D-M-3

B. Roads versus local criteria

1. The minimum road grade must be at least 2 feet above control elevation, which is 5.5' NGVD. Since minimum proposed road elevation is 9.0' NGVD, the criteria is satisfied.

2. The minimum road grade must also be no lower than the peak of the 10-year 1-day storm, a local criteria. From the flood routing of that event, included at the end of this example, a peak elevation of 9.0' NGVD (to the nearest tenth of a foot) will occur. Since the proposed minimum road elevation is 9.0' NGVD,

<u>the proposed minimum road elevation is acceptable.</u>

C. Allowable peak discharge

1. The allowable peak discharge is 37 cfs. From the flood routing of that event, included at the end of this example, a peak discharge of 35.3, say, 35 cfs will occur. Since the routed peak discharge is less than that allowed,

<u>the proposed outfall structure design is adequate.</u>

WEIR LENGTH 1.5 FT.
WEIR ELEVATION 6.5 FT. NGVD
WEIR COEFFICIENT 3.13
TYPE OF BLEEDER SLOT V-NOTCH
SLOT INVERT ELEV. 5.5 FT. NGVD
NOTCH ANGLE 20 DEG.

PIPE DATA
DIAMETER 2.5 FT.
LENGTH 400 FT.
N-VALUE .012

STAGE	WEIR FLOW IN CFS: WEIR	BLEEDER	TOTAL	PIPE FLOW	FLOW
5.50	0.00	0.00	0.00	.00	.00
6.00	0.00	0.09	0.09	12.94	9.100001E-0
6.50	0.00	0.49	0.49	18.29	.49
7.00	1.66	0.77	2.43	22.41	2.43
7.50	4.70	0.98	5.68	25.87	5.68
8.00	8.63	1.15	9.78	28.93	9.78
8.50	13.28	1.29	14.57	31.69	14.57
9.00	18.56	1.42	19.98	34.22	19.98
9.50	24.40	1.55	25.95	36.59	25.95
10.00	30.74	1.66	32.40	38.81	32.40
10.50	37.56	1.76	39.32	40.91	39.32
11.00	44.82	1.86	46.68	42.90	42.90
11.50	52.49	1.95	54.44	44.81	44.8'
12.00	60.56	2.04	62.60	46.64	46.6

PROJECT NAME . . . . : multi-family residential
REVIEWER . . . . . . : ah
PROJECT AREA . . . . . : 95.00 ACRES
- UND STORAGE . . . : 2.93 INCHES
INATION DISCHARGE : 10.00 CFS
RIBUTION TYPE . . : SFWMD
RETURN FREQUENCY . . : 10.00 YEARS
RAINFALL DURATION . . : 1-DAY
24-HOUR RAINFALL . . : 9.00 INCHES
REPORTING SEQUENCE . : STANDARDIZED

STAGE (FT)	STORAGE (AF)	DISCHARGE (CFS)
5.50	.00	.00
6.00	5.00	.09
6.50	10.00	.49
7.00	15.00	2.43
8.00	25.00	9.78
9.00	35.00	19.98
9.50	43.20	25.95
10.00	57.60	32.40
10.50	78.40	39.32
11.00	105.50	42.90
11.50	138.80	44.81

				------- R E S E R V O I R ------					
TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
.00	.00	.00	.0	.0	.0	.0	.0	.0	5.50
4.00	.41	.00	.0	.0	.0	.0	.0	.0	5.50
8.00	1.23	.12	.0	.9	.9	.0	.0	.0	5.58
10.00	1.92	.42	.0	3.3	3.3	.0	.1	.0	5.81
11.00	2.42	.71	.0	5.6	5.6	.0	.1	.1	6.02
11.50	2.87	1.00	.0	7.9	7.9	.0	.3	.2	6.23
11.75	4.22	2.01	.0	15.9	15.9	.0	1.2	.7	6.69
12.00	5.90	3.43	.0	27.1	27.0	.1	7.1	4.2	7.64
12.50	6.56	4.01	.0	31.7	31.1	.6	14.8	11.9	8.50
13.00	6.90	4.32	.0	34.2	32.9	1.3	17.2	16.2	8.73
14.00	7.36	4.73	.0	37.4	34.6	2.8	19.2	18.4	8.93
16.00	7.92	5.24	.0	41.5	35.4	6.1	20.1	19.8	9.01
20.00	8.57	5.84	.0	46.2	33.8	12.4	18.6	19.3	8.86
24.00	9.00	6.24	.0	49.4	31.2	18.2	16.0	17.2	8.61
29.75	9.00	6.24	.0	49.4	25.2	24.2	9.9	12.8	8.02

SUMMARY INFORMATION

AXIMUM STAGE WAS 9.01 FEET AT 16.00 HOURS
MAXIMUM DISCHARGE WAS 20.1 CFS AT 16.00 HOURS

PROJECT NAME . . . . . : multi-family residential
REVIEWER . . . . : ah
PROJECT AREA . . . . . : 95.00 ACRES
GROUND STORAGE . . . . : 2.93 INCHES
TERMINATION DISCHARGE : 10.00 CFS
DISTRIBUTION TYPE . . : SFWMD
RETURN FREQUENCY . . : 25.00 YEARS
RAINFALL DURATION . . : 3-DAY
24-HOUR RAINFALL . . : 11.00 INCHES
REPORTING SEQUENCE . : STANDARDIZED

STAGE (FT)	STORAGE (AF)	DISCHARGE (CFS)
5.50	.00	.00
6.00	5.00	.09
6.50	10.00	.49
7.00	15.00	2.43
8.00	25.00	9.78
9.00	35.00	19.98
9.50	43.20	25.95
10.00	57.60	32.40
10.50	78.40	39.32
11.00	105.50	42.90
11.50	138.80	44.81

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	- - - - - - RESERVOIR - - - - - VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
.00	.00	.00	.0	.0	.0	.0	.0	.0	5.50
[illegible].00	.27	.00	.0	.0	.0	.0	.0	.0	5.50
8.00	.54	.00	.0	.0	.0	.0	.0	.0	5.50
12.00	.80	.01	.0	.1	.1	.0	.0	.0	5.51
16.00	1.07	.07	.0	.5	.5	.0	.0	.0	5.55
20.00	1.34	.15	.0	1.2	1.2	.0	.0	.0	5.62
24.00	1.61	.26	.0	2.1	2.1	.0	.0	.0	5.70
28.00	2.00	.46	.0	3.6	3.6	.0	.1	.0	5.85
32.00	2.39	.69	.0	5.4	5.4	.0	.1	.0	6.03
36.00	2.78	.94	.0	7.4	7.3	.1	.3	.2	6.22
40.00	3.17	1.21	.0	9.6	9.3	.3	.4	.3	6.43
44.00	3.56	1.50	.0	11.9	11.4	.5	1.0	.6	6.63
48.00	3.95	1.80	.0	14.2	13.3	.9	1.7	1.4	6.82
52.00	4.44	2.19	.0	17.4	15.7	1.7	2.9	2.2	7.06
56.00	5.46	3.04	.0	24.1	20.9	3.2	6.6	4.5	7.57
58.00	6.29	3.77	.0	29.8	25.4	4.4	9.8	8.1	8.00
59.00	6.91	4.32	.0	34.2	28.8	5.4	13.0	11.3	8.32

TIME (HR)	RAIN FALL (IN)	ACCUM. RUNOFF (IN)	BASIN DISCHGE (CFS)	ACCUM. INFLOW (AF)	- - - - - - RESERVOIR - - - - - VOLUME (AF)	ACCUM. OUTFLOW (AF)	INSTANT DISCHGE (CFS)	AVERAGE DISCHGE (CFS)	STAGE (FT)
59.50	7.46	4.82	.0	38.1	32.2	5.9	16.1	14.5	8.62
59.75	9.11	6.34	.0	50.2	43.8	6.4	22.0	19.0	9.17
60.00	11.16	8.28	.0	65.6	58.7	6.9	29.4	25.7	9.77
60.50	11.97	9.05	.0	71.7	63.4	8.3	33.8	32.3	10.10
61.00	12.39	9.45	.0	74.8	65.2	9.6	34.7	34.3	10.16
62.00	12.95	9.99	.0	79.1	66.6	12.5	35.2	35.0	10.20
64.00	13.63	10.65	.0	84.3	65.9	18.4	35.1	35.2	10.19
68.00	14.42	11.42	.0	90.4	60.7	29.7	33.4	34.2	10.07
72.00	14.95	11.93	.0	94.4	54.1	40.3	30.8	32.2	9.88
80.00	14.95	11.93	.0	94.4	36.7	57.7	21.2	26.3	9.11
88.00	14.95	11.93	.0	94.4	26.3	68.1	11.1	15.8	8.13
89.25	14.95	11.93	.0	94.4	25.2	69.2	10.0	10.5	8.02

SUMMARY INFORMATION

MAXIMUM STAGE WAS 10.21 FEET AT 62.25 HOURS
MAXIMUM DISCHARGE WAS 35.3 CFS AT 62.25 HOURS

DESIGN EXAMPLE

FOR

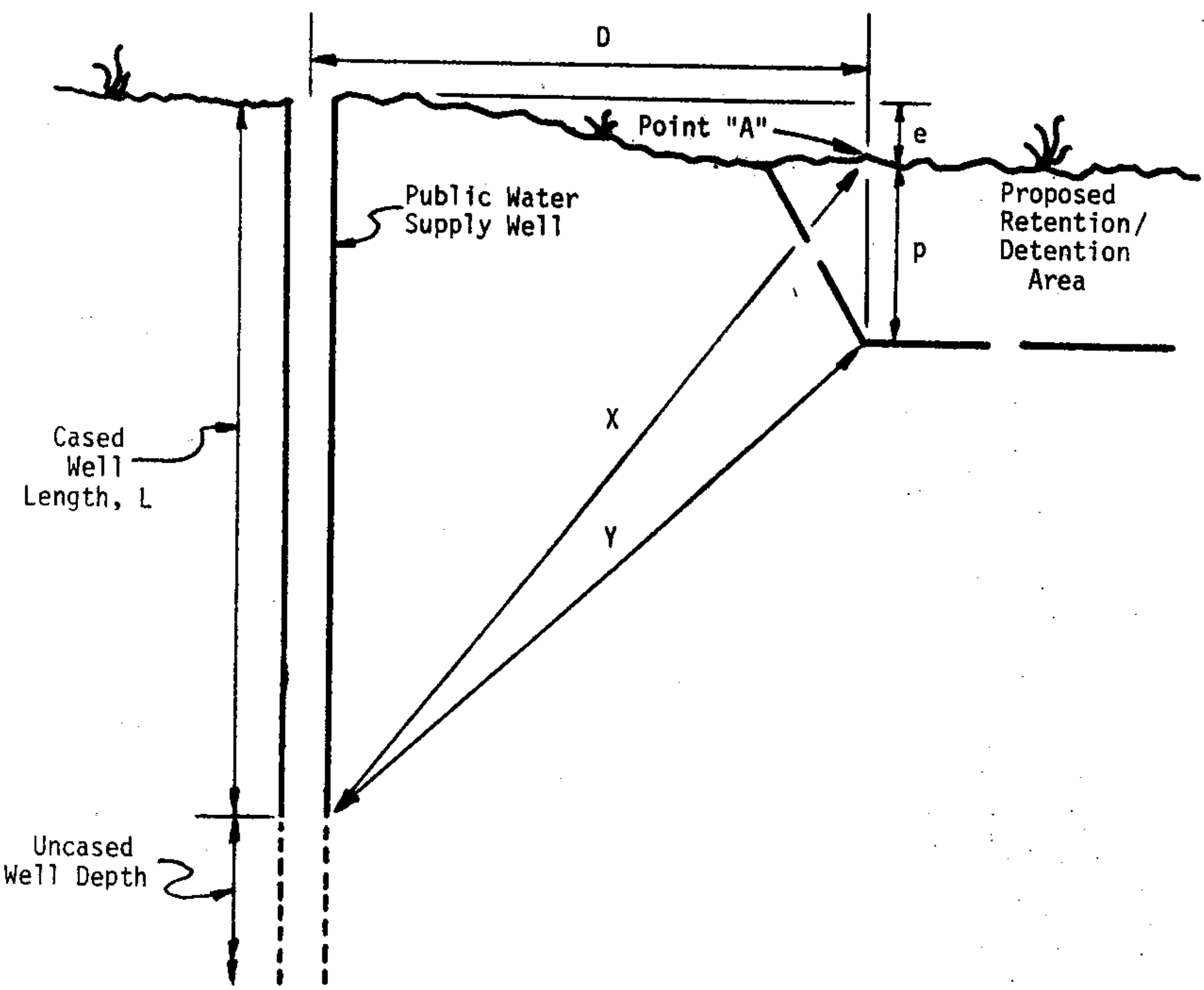
DISTANCE FROM PUBLIC WATER SUPPLY WELLS

In paragraph 3.2.2.4 of the Basis of Review, it is stated that:

> Retention/detention area locations shall not reduce hydraulic recharge distances to public water supply wells in excess of 2 percent nor shall wet retention/detention areas be closer to public water supply wells than 300 feet.

Given below is an example of how to incorporate this criteria.

SITE ELEVATION VIEW
N.T.S.



I. Given

A. A public water supply well.

1. Cased a known length, L.

2. At a known ground surface elevation.

B. A proposed retention/detention area with a proposed maximum depth, p, measured at Point "A" nearest the well.

C. A difference, e, in elevation between the well top and Point "A."

D. No aquiclude interference.

II. Required

A. That D be at least 300 feet.

B. That Y be greater than, or equal to, 0.98 of X.

III. Computations

A. To assure that D be at least 300 feet is simply a matter of properly positioning the various elements of the project within the site.

B. Check that Y is greater than, or equal to, 0.98X.

1. Compute distance X.

a. If Point "A" is lower than the well top:
From the trigonometry of a right triangle:

$$X^2 = (L-e)^2 + D^2$$

so: $$X = ((L-e)^2 + D^2)^{0.5}$$

b. If Point "A" is higher than the well top:
From the trigonometry of a right triangle:

$$X^2 = (L+e)^2 + D^2$$

so: $$X = ((L+e)^2 + D^2)^{0.5}$$

2. Compute distance Y

a. If Point "A" is lower than the well top:
From the trigonometry of a right triangle:

$$Y^2 = (L - (p + e))^2 + D^2$$

so: $$Y = ((L - (p + e))^2 + D^2)^{0.5}$$

b. If Point "A" is higher than the well top:
From the trigonometry of a right triangle:

$$Y^2 = (L - (p - e))^2 + D^2$$

so: $$Y = ((L - (p - e))^2 + D^2)^{0.5}$$

3. Compute 0.98 of Distance X.

4. If Y is greater than, or equal to, 0.98X, the retention/detention depth and location meet the criteria of paragraph 3.2.2.4.

5. If Y is less than 0.98X, a redesign of the retention/detention area is required. This could involve - among other things - any, or all, of the following:

   a. Move the area farther from the well.

   b. Move the area to a place with different ground elevations.

   c. Design the lake less deep.