CHAPTER 5

DETENTION

CHAPTER 5 DETENTION

5.1 INTRODUCTION

The criteria presented in this section shall be used in the design and evaluation of all detention facilities. The review of all planning submittals will be based on the criteria presented in this section.

The main purpose of a detention facility is to store the excess storm runoff associated with an increased basin imperviousness and discharge this excess at a rate similar to the rate experienced from the basin without development. Any special design conditions which cannot be defined by these CRITERIA shall be reviewed by the Engineering representative of the Town before proceeding with design.

5.2 DETENTION METHODS

The various detention methods are defined on the basis of where the facility is constructed, such as open space detention, parking lot, underground or rooftop. The Town permits all methods of detention except for rooftop.

5.3 DESIGN CRITERIA

5.3.1 Volume and Release Rates

The minimum required volume shall be determined using the CUHP method, the FAA method, or the following equations. These empirical equations were developed as part of the UD&FCD hydrology research program. The equations are based on a computer modeling study and represent average conditions. One of the most difficult aspects of storm drainage is obtaining consistent results between various methods for estimating detention requirements. These equations will provide consistent and more effective approaches to the sizing of onsite detention ponds. For larger water sheds where where the Colorado Urban Hydrograph procedure can be used (i.e., ±90 acres), hydrograph routing procedures will be permitted in the design of these ponds, provided the historic imperviousness of two percent or less is used.

Minimum Detention Volume:

$$V = KA$$ **Equation 504**

For the 100 year,

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{1000}$$ **Equation 505**

For the 10 year,

$$K_{10} = \frac{(0.95I - 1.90)}{1000}$$ **Equation 506**

Where V = required volume for the 100 or 10 year storm (acre-feet)

I = Developed basin imperviousness (%)

A = Tributary area (Acres)

The maximum release rates at the ponding depths corresponding to the 10 and 100 year volumes are as follows:

ALLOWABLE RELEASE RATES FOR DETENTION PONDS - CFS/ACRE

CONTROL FREQUENCY	SOIL GROUP A	SOIL GROUP B	SOIL GROUP C & D
10 YEAR	0.13	0.23	0.30
100 YEAR	0.50	0.85	1.00

Historical and/or undeveloped peak flows are also acceptable as allowable release rates.

2. Orifice Flow

The equation governing the orifice opening and plate is the orifice flow equation:

$$A = C_d A (2gh)^{1/2}$$

Where

Q = Flow (C.F.S.)

C_d = Orifice coefficient

A = Area (ft^2)

g = Gravitational constant = 32.2 ft/sec^2

h = Head on orifice measured from centerline of orifice (ft)

An orifice coefficient (c-sub d) value of 0.65 shall be used for sizing of square edged orifice openings and plates.

5.4 DESIGN STANDARDS FOR OPEN SPACE DETENTION

5.4.1 State Engineer's Office

Any dam constructed for the purpose of storing water, with a surface area, volume, or dam height as specified in Colorado Revised Statutes 37-87-105 as amended, shall require the approval of the plans by the State Engineer's Office. All detention storage areas shall be designed and constructed in accordance with these CRITERIA. Those facilities subject to state statutes shall be designed and constructed in accordance with the criteria of the state.

5.4.2 Grading Requirements

Slopes on earthen embankments less than 5 feet in height shall not be steeper than 4 (horizontal) to 1 (vertical). for embankment heights between 5 feet and 10 feet, the slopes shall not be steeper than 3 (horizontal) to 1 (vertical), but the horizontal distance of the slope shall not be less than 20 feet. For embankments greater than 10 feet in height, the slopes shall be such to maintain slope stability, but the horizontal distance of the slope shall not be less than 30 feet. Contact the Town Engineering representative for additional requirements for embankments greater than 10 feet in height. All earthen slopes shall be covered with topsoil and revegetated with grass. Slopes on riprapped earthen embankments shall not be steeper than 3 (horizontal) to 1 (vertical). For grassed detention facilities, the minimum bottom slope shall be 0.5 percent measured perpendicular to the trickle channel.

5.4.3 Freeboard Requirements

The minimum required freeboard for open space detention facilities is 1.0 foot above the computed 100-year water surface elevation.

5.4.4 Trickle Flow Control

All grassed bottom detention ponds shall include a concrete trickle channel or equivalent performing materials and design.

5.4.5 Outlet Configuration

Presented on Figure 501 are two examples for detention pond outlet configuration. A Type 1 outlet consists of a grated drop inlet, outlet pipe, and an overflow weir in the pond embankment. The control for the 10-year discharge shall be at the throat of the outlet pipe under the head of water as defined on Figure 501. The grate must be designed to pass the 10-year flow with a minimum of 50 percent blockage (i.e., twice the 10-year flow). Since the minimum size of the outlet pipe is 12 inches, then a control orifice plate at the entrance of the pipe may be required to control the discharge of the design flow (see Section 5.4.2). An example orifice plate is shown on Figure 2. Other outlet configurations will be allowed, provided they meet the requirements of the permitted release rates at the required volume and include proper provisions for maintenance and reliability.

The outlet shall be designed to minimize unauthorized modifications which effect proper function. A sign with a minimum area of 0.75 square feet shall be attached to the outlet or posted nearby with the following message:

"WARNING
Unauthorized modification of this
outlet is a code violation and subject
to the penalties as provided by law."

The difference between the 100-year discharge and the surcharged discharge on the 10-year outlet is released by the overflow weir or spillway. If sufficient pond depth is available, the drop inlet and the grate can be replaced by a depressed inlet with a headwall and trashrack. Depression of the inlet is required to reduce nuisance backup of flow into the pond during trickle flows. The maximum trashrack opening dimension shall be equal to the minimum opening in the orifice plate.

A Type 2 outlet consists of a drop inlet with an orifice controlled inlet for the 10-year discharge and a crest overflow and pipe inlet control for the 100-year discharge. The control for the 10-year discharge occurs at the orifice opening for the head as shown on the figure. The control for the 10--year discharge occurs at the throat of the outlet pipe as shown on the figure. However, the difference between the 100-year and 10-year discharge must pass over the weir and therefore the weir must be of adequate length.

The effective weir length (L) occurs for three sides of the box. To ensure the 100-year control occurs at the throat of the outlet pipe, a 50 percent increase in the required weir length is recommended. In addition, the outlet pipe must have an adequate slope to ensure throat control in the pipe.

5.4.6 Embankment Protection

Whenever a detention pond uses an embankment to contain water, the embankment shall be protected from catastrophic failure due to overtopping. Overtopping can occur when the pond outlets become obstructed or when a larger than 100-year storm occurs. Failure protection for the embankment may be provided in the form of a buried heavy riprap layer on the entire downstream face of the embankment or a separate emergency spillway having a minimum capacity of twice the maximum release rate for the 100-year storm. Structures shall not be permitted in the path of the emergency spillway or overflow. The invert of the emergency spillway should be set equal to or above the 100-year water surface elevation.

5.4.7 Vegetation Requirements

All open space detention ponds shall be revegetated by either irrigated sod or natural dry-land grasses in accordance with the manual "Guideline for Development and Maintenance of Natural Vegetation" by Donald H. Godi & Associates, Inc., July 23, 1984, available through the UD&FCD.

5.5 DESIGN STANDARDS FOR PARKING LOT DETENTION

The requirements for parking lot detention are as follows:

5.5.1 Depth Limitation

The maximum allowable design depth of the ponding for the 100-year flood is 18 inches.

5.5.2 Outlet Configuration

The minimum pipe size for the outlet is 12" diameter where a drop inlet is used to discharge to a storm sewer or drainageway. Where a weir and a small diameter outlet through a curb are used, the size and shape are dependent on the discharge/storage requirements. A minimum pipe size of 3" diameter is recommended.

5.5.3 Performance

To assure that the detention facility performs as designed, maintenance access shall be provided. The outlet shall be designed to minimize unauthorized modifications which effect function. the designer shall account for estimated future parking lot repaving in the available detention storage volume. A sign shall be attached or posted in accordance with Section 5.4.5.

5.5.4 Flood Hazard Warning

All parking lot detention areas shall have a minimum of two signs posted identifying the detention pond area. The signs shall have a minimum area of 1.5 square feet and contain the following message:

"Warning
This area is a detention pond and is subject to periodic flooding to a depth of (provide design depth for 10-year or 100-year storm, whichever will be contained in parking lot)."

Any suitable materials and geometry of the sign are permissible, subject to approval by the Engineering representative of the Town.

5.6 DESIGN STANDARDS FOR UNDERGROUND DETENTION

Underground detention is generally discouraged and will only be allowed when all other options have been proven to be insufficient. Under no circumstances will the town accept underground detention as a publicly owned facility. However, if a developer must use this technique and agrees to maintain it, the facility will be allowed if designed according to the following criteria:

5.6.1 Materials

Underground detention shall be constructed using corrugated aluminum pipe (CAP), polyvinyl chloride (PVC) pipe, or reinforced concrete pipe (RCP). The pipe thickness cover, bedding, and backfill shall be designed to withstand HS-20 loading or as required by the Town.

5.6.2 Configuration

Pipe segments shall be sufficient in number, diameter, and length to provide the required minimum storage volume for the 100-year design. As an option, the 10-year design can be stored in the pipe segments and the difference for the 100-year stored above the pipe in an open space detention (Section 5.4) or in a parking lot detention (Section 5.5). the minimum diameter of the pipe segments shall be 36 inches.

The pipe segments shall be placed side by side and connected at both ends by elbow tee fittings and across the fitting at the outlet (see Figure 5). The pipe segments shall be continuously sloped at a minimum of 0.25% to the outlet. Manholes for maintenance access (see Section 5.6.4) shall be placed in the tee fittings and in the straight segments of the pipe, when required.

Permanent buildings or structures shall not be placed directly above the underground detention.

5.6.3 Inlet and Outlet Design

The outlet from the detention shall consist of a short (maximum 25 ft.) length(s) of CAP or RCP with a 12" minimum diameter. A two-pipe outlet may be required to control both design frequencies. The invert of the lowest outlet pipe shall be set at the lowest point in the detention pipes. The outlet pipe(s) shall discharge into a standard manhole (see Standard Detail SD-1) or into a drainageway with erosion protection provided per Figure SF-11. If an orifice plate is required to control the release rates, the plate(s) shall be hinged to open into the detention pipes to facilitate back flushing of the outlet pipe(s).

Inlet to the detention pipes can be by way of surface inlets and/or by a local private storm sewer system.

5.6.4 Maintenance Access

Access easements to the detention site shall be provided. To facilitate cleaning of the pipe segments, 3-feet-diameter maintenance access ports shall be placed according to the following schedule:

MAINTENANCE ACCESS REQUIREMENTS

Detention Pipe Size	Maximum Spacing	Minimum Frequency
36" to 54"	150'	Every pipe segment
60" to 66"	200'	Every other pipe segment
>66"	200'	One at each end of the battery of pipes

The manholes shall be constructed in accordance with Standard Detail SD-1.

5.7 SEQUENTIAL DETENTION PROCEDURE

Local detention facilities are to be designed using the "sequential detention procedure" if any storm runoff is detained by two or more detention facilities in sequence before leaving the subject property. The sequential detention method accounts for the inherent decrease in efficiency of two sequential detention facilities versus one facility by considering the released runoff from one facility to be equivalent to runoff from an incremental area tributary to the second facility. Thus, the storage volume of the second facility is increased to accommodate the incremental area runoff. By minimizing the second detention facility's release rate, the volumes of any additional sequential facilities are minimized.

The sequential detention procedure shall be used for detention ponds that are sized using Equations 504, 505, and 506. When detention ponds are sized for larger basins using the CUHP method, routing processes should be used to determine the effect of sequential detention and to determine the detention capacity that is needed to reduce flows to the 10-year and 100-year flow rates.

Sequential detention facilities are to be designed using Standard Form F-4. The form is divided into two parts: Singular Detention and Sequential detention. The singular detention part is for listing and computing the parameters associated with a single detention facility. Each facility is analyzed using the "equation detention procedure" criteria.

The sequential detention part of the form evaluates the combined effect of the detention facilities. The results of the second-part computations will yield the minimum volume required and the maximum release rates allowed for each detention facility. The description of Standard Form F-4 is as follows:

<u>Column 1</u>: Facility Number: Designated number of the detention facility being analyzed.

<u>Column 2</u>: Basin Area: Area of basin (sub-basin) tributary to the detention facility <u>not</u> including any area tributary to an upstream detention facility.

<u>Column 3</u>: (Q-sub 1): Peak inflow in C.F.S. from the area described in Column 2.

<u>Column 4</u>: IMP %: Percent imperviousness of the area described in Column 2 to be used in Equations 505 and 506.

<u>Column 5</u>: K: K-factor calculated from Equations 505 and 506 and the percent imperviousness (IMP %) in Column 4.

<u>Column 6</u>: (Q-sub 1/A): Peak inflow (**Q sub I**) in Column 3 divided by the area (A) in Column 2.

<u>Column 7</u>: Q: Peak inflow into detention facility computed by summation of the peak inflow in Column 3 and the maximum release rate from the detention facilities just upstream in Column 10.

<u>Column 8</u>: Z: Equivalent inflow areas computed by dividing Column 7 by Column 6 [$\Sigma Q/(Q_I/A)$].

<u>Column 9</u>: Minimum S-sub m: Minimum allowed storage volume for the respective detention facility computed using Equation 504 and the parameters in Column 5 (K-factor) and Column 8 (Z = A).

<u>Column 10</u>: Maximum Q-sub m: Maximum allowed release rate for the respective detention facility, from the Table, and the Z parameter in Column 8.

Example 10 is an example of the sequential detention procedure.

5.8 DESIGN STANDARDS FOR RETENTION

5.8.1 Facility Requirements

When the Town determines that stormwater retention must be employed for a specific development, the facility shall be designed using the following criteria:

1. The minimum retention volume shall equal the runoff from a 100-year storm of 24-hour duration (i.e., storm depth of 4.8 inches). No credit shall be taken for infiltration in establishing the minimum volume.

2. An overflow section shall be provided for the detention facility that will protect embankments from overflow resulting from a 100-year storm when the pond is full and the tributary area is fully developed.

3. Side slopes shall not be steeper than four horizontal and one vertical.

4. One foot minimum freeboard above the maximum retention volume water surface.

5. The applicant must evaluate or assess the impacts of the retention facility on local groundwater levels and the potential for damage to nearby properties.

6. A slow release will be permitted of .25 C.F.S. or less if the small flows will be conveyed to a major drainageway and will not cause nuisance conditions such as icing on highways.

7. This policy does not relieve the land developer of making permanent detention improvements on his property as a condition of subdivision approval.

8. A drainage maintenance easement shall be granted to the Town to ensure that emergency maintenance and access can be legally provided to keep the facility operable. This easement may be vacated when the retention pond function is no longer needed.

9. Acceptable alternatives to these requirements may include:

   a. Agreements among landowners wherein historic flow rates are exceeded by upstream landowners and will be accepted by downstream landowners. Such agreements are subject to review by the Engineering representative of the Town.

   b. The developer providing offsite drainage improvements to convey stormwater, at historic rates, to an acceptable outfall point

5.9 DESIGN EXAMPLES

Example 8: Detention Design

Given: A basin that has the following characteristics:

Basin Area (A) = 23 acres

Basin Imperviousness (I) = 55%

Predominate Soil Group = D

Required: 100-year and 10-year storage volumes and release rates.

Solution:

Step 1: Determine $K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{1000}$

$$= \frac{[1.78(55) - 0.002(55)^2 - 3.56]}{1000}$$

$$= 0.0883$$

Step 2: Determine K_{10} using Equation 506

$$K_{10} = \frac{(0.95I - 1.90)}{1000}$$

$$= 0.0504$$

Step 3: Determine minimum required 100-year storage volume using Equation 504.

$$V = KA$$

$$= 0.0883 \times 23$$

$$= 2.03 \text{ acre-feet } (88{,}500 \text{ ft}^3)$$

Step 4: Repeat Step 3 for 10-year storage

$$V = KA$$

$$= 0.0504 \times 23$$

$$= 1.16 \text{ acre-feet } (50{,}500 \text{ ft}^3)$$

Step 5: Determine maximum allowed 100-year release rate

$$Q_{100} = 1.00A$$

$$= 1.00 \times 23$$

$$= 23.0 \text{ C.F.S.}$$

Step 6: Repeat Step 5 for 10-year release rate

$$Q_{10} = 0.30$$

$$= 0.30 \times 23$$

$$= 6.9 \text{ C.F.S.}$$

<u>Example 9:</u> <u>Detention Outlet Structure Design</u>

<u>Given</u>: Detention pond with the following characteristics (see Example 8)

Maximum 100-year release rate = 23.0 C.F.S.

Maximum 10-year release rate = 6.9 C.F.S.

Type 2 outlet (refer to Figure 1)

100-year water surface elevation = 105.0

10-year water surface elevation = 103.0

100-year outlet pipe invert elevation = 98.0

10-year outlet orifice invert elevation = 100.0

18-inch diameter outlet pipe

<u>Required:</u> 10-year and 100-year outlet sizing

<u>Solution:</u> (see Figure 4)

Step 1: Determine 10-year orifice opening size, depth to centerline of orifice = 2.5 feet

$$A = \frac{Q}{[C_d \ (2gh)^{1/2}]} \text{ Rearranged Equation 503}$$

$$= \frac{6.9}{[0.65 \ (2 \ [32.2] \ [2.5])^{1/2}]}$$

$$= 0.85 \text{ ft}^2$$

Step 2: Determine 10-year orifice diameter

$$\text{Diameter} = \frac{4A}{\pi}^{1/2}$$

$$= \frac{4[0.85]}{\pi}^{1/2}$$

$$= 1.0 \text{ feet (12 inches)}$$

Therefore, an orifice opening with a 12-inch diameter hole is required at the entrance to the outlet box.

Step 3: Determine discharge through 10-year outlet for 100-year headwater (h = 4.5 feet).

$$Q = C_d A\,(2gh)^{1/2}$$

$$= 0.65(.85)\ (2[32.2][4.5]^{1/2})$$

$$= 9.3 \text{ C.F.S.}$$

Step 4: Determine discharge for sizing of 100-year weir

$$Q_{weir} = Q_{100} - Q \text{ (from Step 3)}$$

$$= 23.0 - 9.3$$

$$= 13.7 \text{ C.F.S. (for sizing weir only)}$$

Step 5: Size weir plate for 100-year outlet (18" RCP, h = 6.25 feet)

$$A = \frac{Q}{(C_d[2gh]^{1/2})} \qquad \text{Equation 503}$$

$$= \frac{23.0}{(0.65\ [2 \times 32.2 \times 6.25])^{1/2}}$$

$$= 1.76 \text{ ft.}^2$$

Step 6: Determine 100-year orifice diameter

$$\text{Diameter} = \frac{4A}{\pi}^{1/2}$$

$$= \frac{4 \times 1.57}{\pi}^{1/2}$$

$$= 1.5 \text{ feet} = 18 \text{ inches}$$

Since orifice diameter is approximately equal to the pipe diameter (±15%), then no orifice plate is required.

Step 7: Determine minimum box dimensions (i.e., weir length) to assure control of the pipe inlet.

$$L = \frac{Q_{weir}}{CH^{3/2}} \qquad \text{Equation 501}$$

C = 3.4 from Table 501

$$L = \frac{13.7}{[3.4 \times 2.0]^{3/2}}$$

L = 1.4 feet

Since required weir length is only 1.4 feet, selected box dimensions suit construction and maintenance access. A minimum size of 3 feet by 3 feet is recommended.

Step 8: Check minimum size for trashrack opening area

Minimum area = 2 x orifice area

= 2 x 1.76

Minimum area = 3.5 ft.^{2}

Since box opening is 3 ft. by 3 ft. = 9 sq. ft., then design requirements are satisfied.

Example 10: Sequential Detention Procedure

Given: Drainage basin shown on Figure 6. The following sub-basin parameters.

SUB-BASIN	AREA ACRES	%IMP	Q_{10} C.F.S.	Q_{100} C.F.S.
A-1	11	40	21.0	47.0
A-2	7	70	23.0	41.0
A-3	10	40	17.0	37.0
A-4	16	50	29.0	57.0
B-1	9	45	23.0	47.0

Undetained Area = 0 acres.
Offsite flow from B-1 is routed around the development.

Required: 10-year and 100-year storage volumes and release rates for all detention facilities.

Solution:

Step 1: Using Standard Form F-4, fill in the given 10-year sub-basin parameters in Columns 1,2,3, and 4 for the uppermost detention facility.

Step 2: Compute K_{10} as shown in Example 8 and enter the result in Column 5.

$$K_{10} = \frac{0.95I - 1.90}{1000}$$

$$= \frac{0.95 \times 40 - 1.90}{1000}$$

$$= 0.0361$$

Step 3: Divide Column 3 by Column 2 and enter the result in Column 6.

$$\frac{Q_I}{A} = \frac{21}{11} = 1.909 \text{ C.F.S. per acre}$$

Step 4: Compute the 10-year peak inflow to the detention facility. For this facility, the peak inflow is equal to the peak inflow from sub-basin A-1 or 21.0 C.F.S. Enter the result in Column 7.

Step 5: Divide Column 7 by Column 6 and enter the result in Column 8.

$$Z = [\text{sum of } Q/Q_I/A]$$

$$= \frac{21.0}{1.909}$$

$$= 11.0 \text{ acres}$$

Step 6: Compute the minimum required 10-year storage volume as shown in Example 8 using Z = A and K_{10} from Column 9.

Enter the result in Column 9.

$V = KZ$

$= 0.0361 \times 11.0 = 0.40$ acre-feet (17,300 $ft.^3$)

Step 7: Compute the minimum allowable 10-year release rate as shown in Example 8 using Z = A and enter the result in Column 10.

$Q_{10} = 0.24Z$

$= 0.24 \times 11.0$

$= 2.6$ C.F.S.

Step 8: Repeat Steps 1 through 3 for the next detention facility.

$K_{10} = 0.0646$

$\frac{Q_1}{A} = 3.286$

Step 9: Repeat Step 4 but include the peak outflow from detention facility A-1.

$Q = 23 + 2.6$

$= 25.6$ C.F.S.

Step 10: Repeat Steps 5 through 7.

$Z = 7.8$

$s_m = 0.50$ acre-feet

$Q_m = 1.9$ C.F.S.

Step 11: Repeat Steps 1 through 7 for the remaining detention facilities for both the 10-year and 100-year floods.

5.10 CHECKLIST

To aide the designer and reviewer, the following checklist has been prepared:

(1) Earth slopes are to be 4:1 or flatter.

(2) Minimum freeboard of 1 foot for the 100-year detention is required.

(3) Open space detention areas to include trickle channels.

(4) Protect embankment for overtopping condition by adding riprap.

(5) Provide trashracks at all outlet structures.

(6) Provide signs as required.

(7) Provide maintenance access.

Note

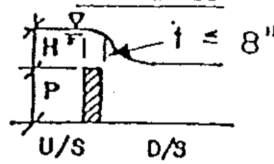
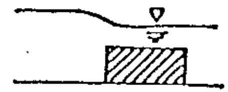
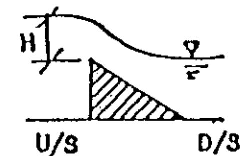
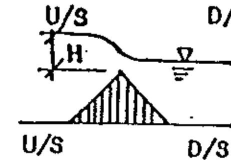
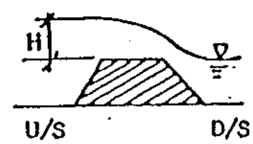
For controlled discharge from relatively small detention areas, strucutres as per Figure 8 are recommended.

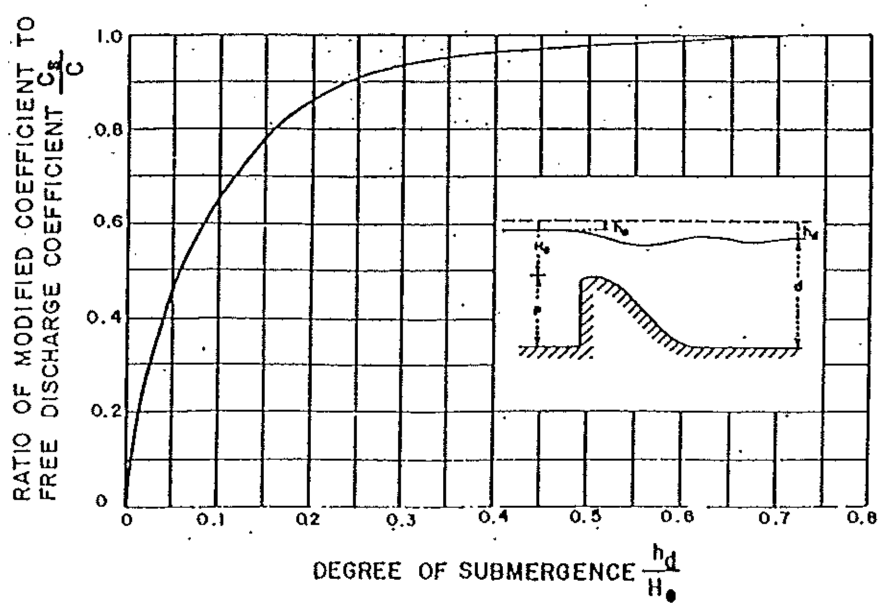
TABLES & FIGURES

(DETENTION)

The following tables are provided for the designer and should be filled out as completely as possible. Any assumptions should be specified. Other formats are acceptable but should show the information in a conventional and understandable method.

WEIR FLOW COEFFICIENTS

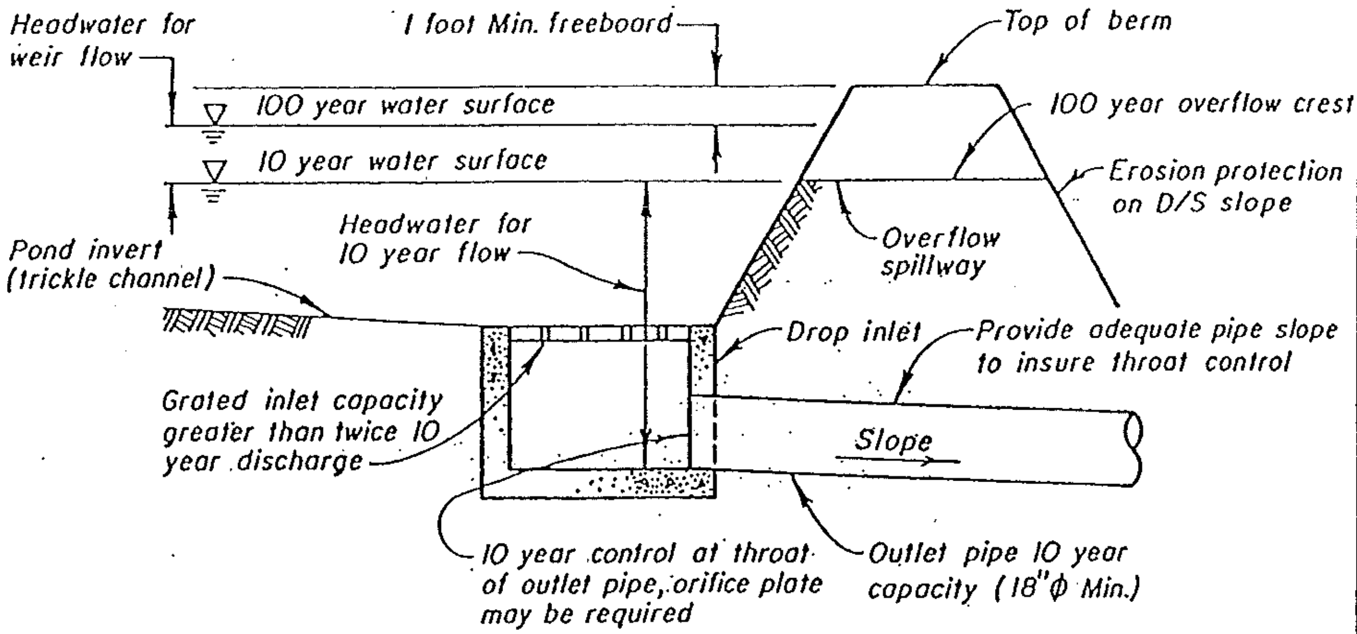
SHAPE	COEFFICIENT	COMMENTS	SCHEMATIC
Sharp Crested	–		
Projection Ratio (H/P = 0.4)	3.4	H< 1.0	
Projection Ratio (H/P = 2.0)	4.0	H> 1.0	
Broad Crested	–		
W/Sharp U/S Corner	2.6	Minimum Value	
W/Rounded U/S Corner	3.1	Critical Depth	
Triangular Section	–		
A) Vertical U/S Slope	–		
1:1 D/S Slope	3.8	H > 0.7	
4:1 D/S Slope	3.2	H > 0.7	
10:1 D/S Slope	2.9	H > 0.7	
B) 1:1 U/S Slope	–		
1:1 D/S Slope	3.8	H >0.5	
3:1 D/S Slope	3.5	H >0.5	
Trapezoidal Section			
1:1 U/S Slope, 2:1 D/S Slope	3.4	H > 1.0	
2:1 U/S Slope, 2:1 D/S Slope	3.4	H > 1.0	
Road Crossings			
Gravel	3.0	H > 1.0	
Paved	3.1	H > 1.0	



ADJUSTMENT FOR TAILWATER

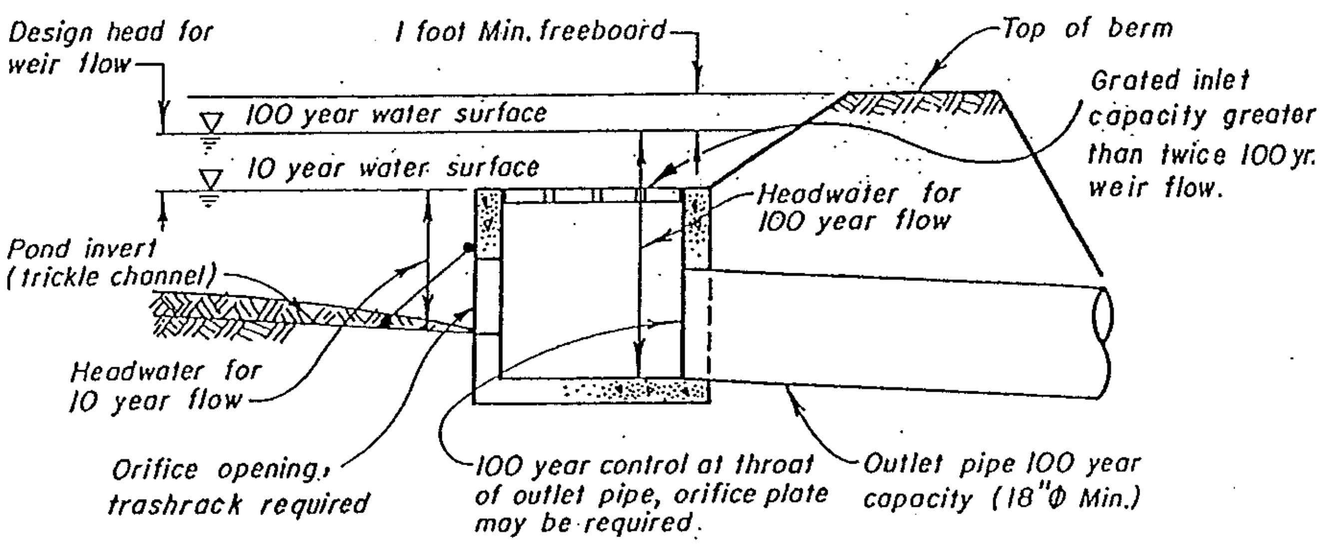
Date:	REFERENCE: King & Brater, Handbook of Hydraulics, McGraw Hill
Rev:	Book Company, 1963 – Design of Small Dams, Bureau of Reclam., 1977

DETENTION POND OUTLET CONFIGURATIONS



TYPE 1 OUTLET

No Scale

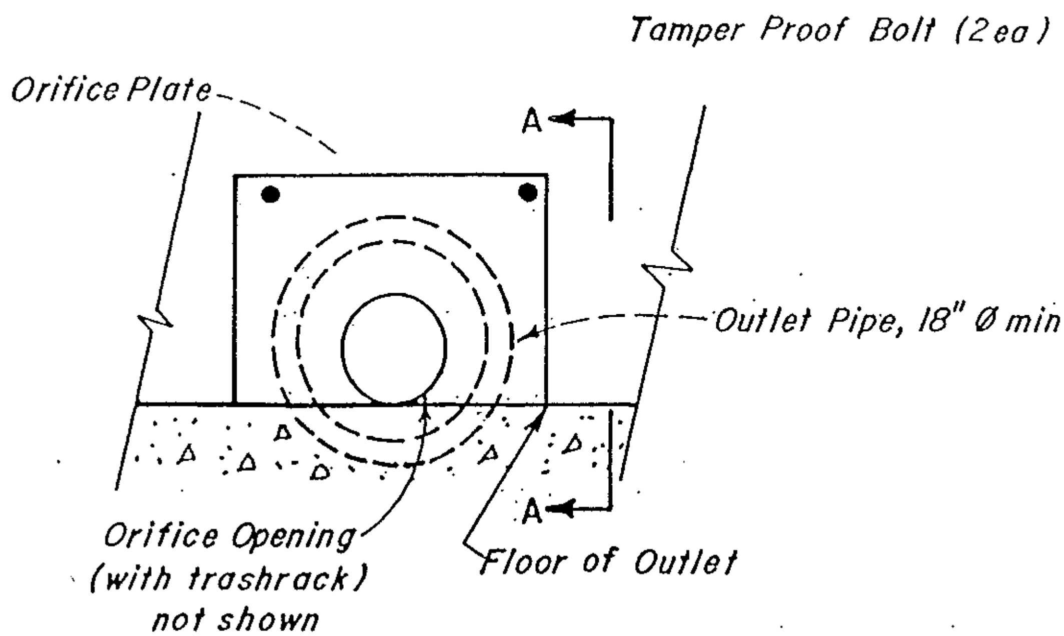


TYPE 2 OUTLET

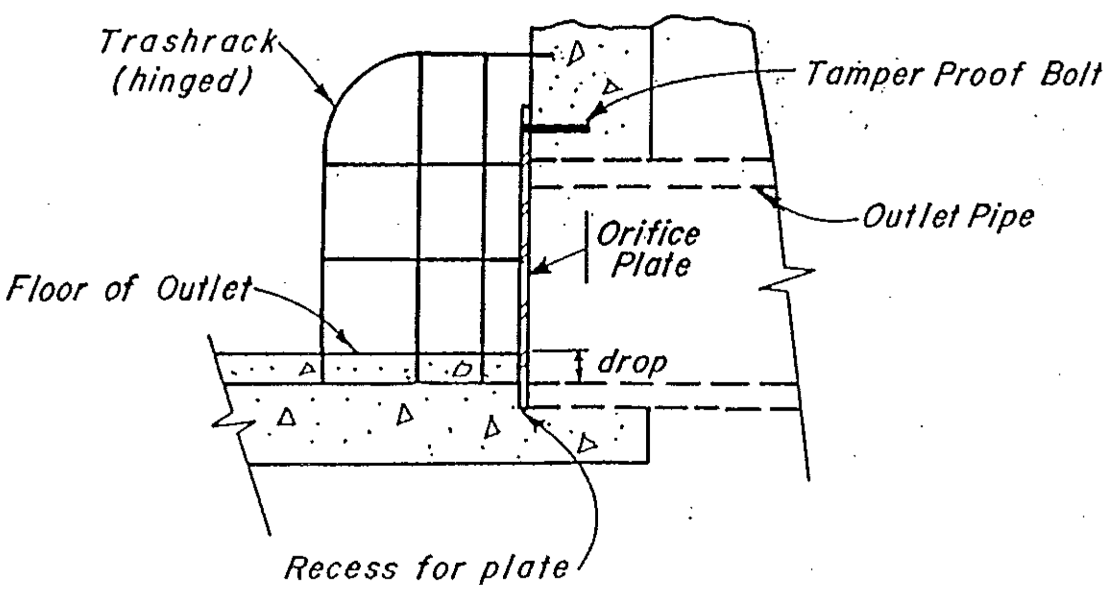
No Scale

Date: Rev:	REFERENCE:

ORIFICE PLATE DETAILS

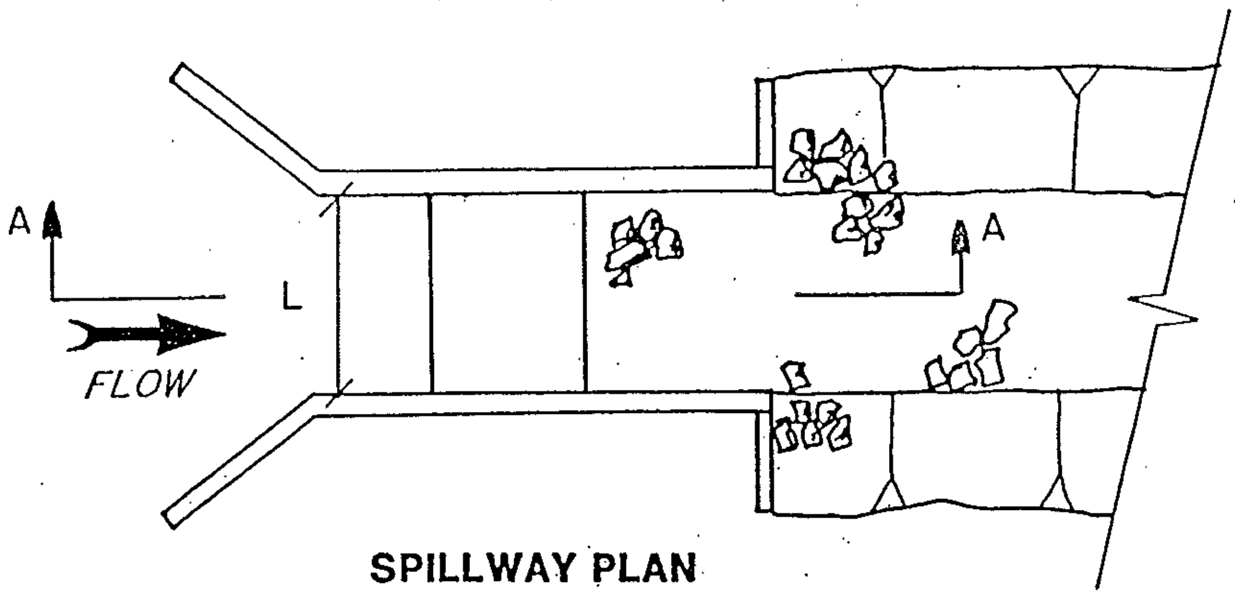


NOTE: Trashrack clear area to be 10 times orifice opening area.

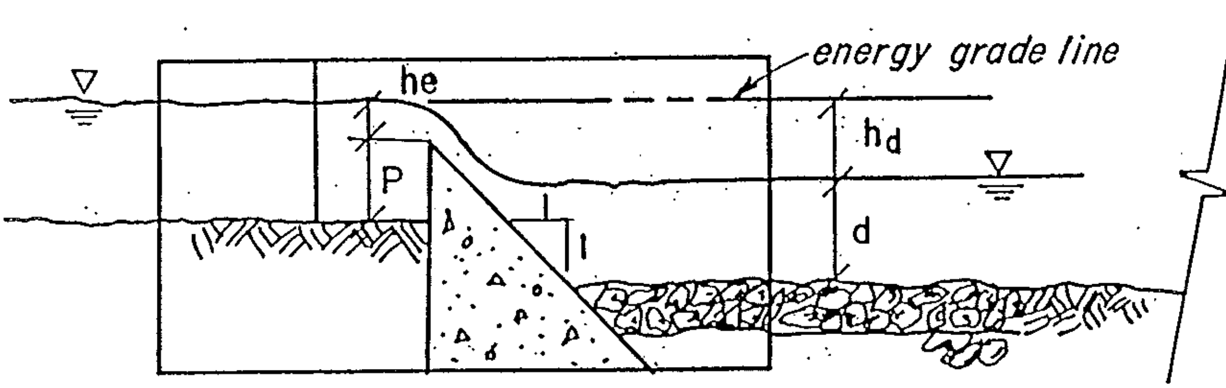


DATE: REV:	REFERENCE:

WEIR DESIGN EXAMPLE



SPILLWAY PLAN



SPILLWAY SECTION A-A

GIVEN: Q = 100 CFS, Triangular weir with vertical face, and 1:1 downstream slope, P = 2', h_e = 2', tailwater depth = 4.5', h_d = 1.5

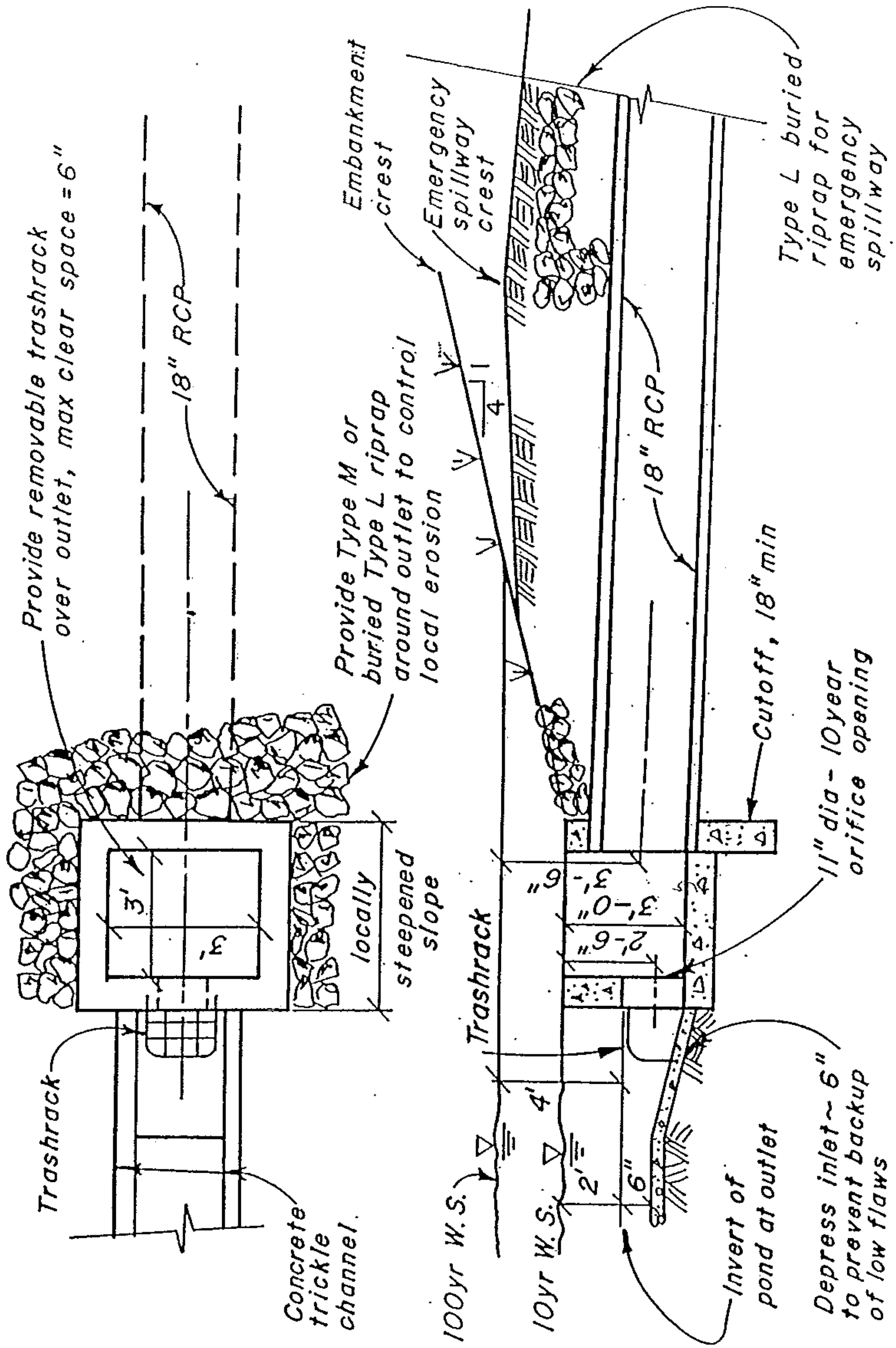
FIND: L, and check submergence

SOLUTION: $C_w = 3.8$ (Table-1401)

$L = Q/CH^{3/2} = (100)/(3.8)/(2)^{3/2} = 9.3$ FT

Submergence check

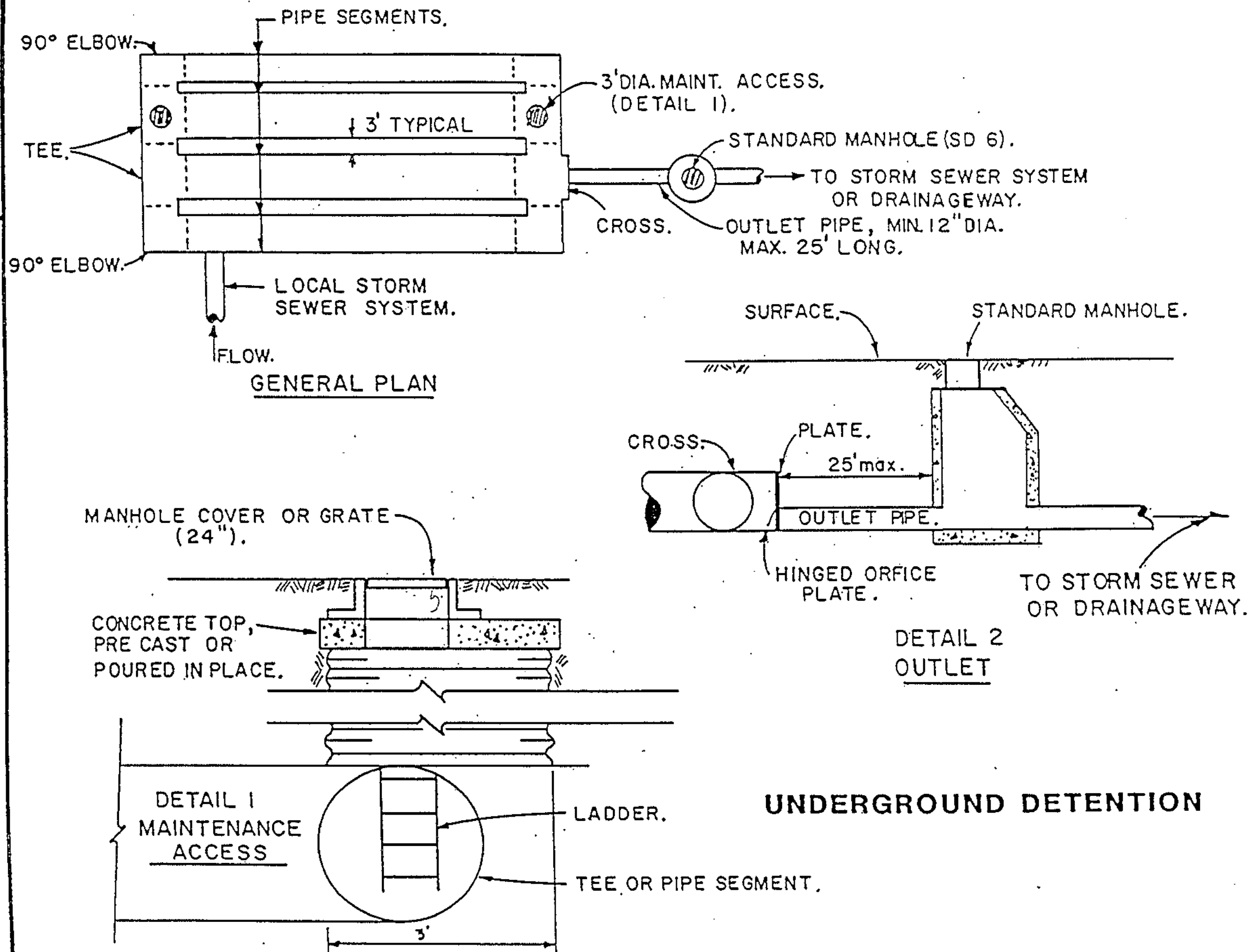
$\frac{h_d}{h_e} = \frac{1.5}{2.0} = 0.75$, then from Table-1 $C_s/C = 1.0$, therefore no submergence adjustment is required



OUTLET DESIGN EXAMPLE

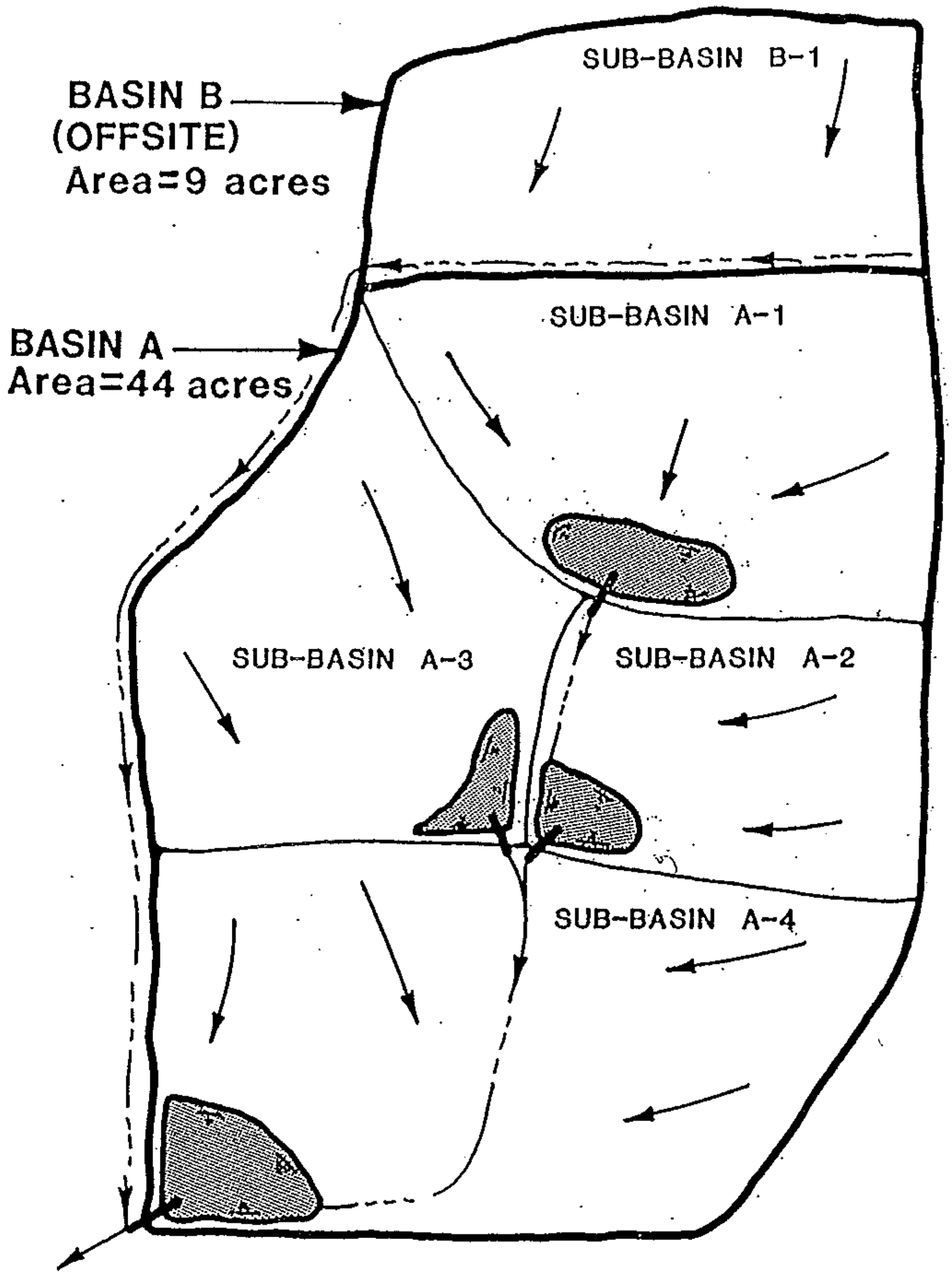
DATE:
REV:

REFERENCE:



UNDERGROUND DETENTION

EXAMPLE NO. 10
SEQUENTIAL DETENTION METHOD
DRAINAGE BASIN



REFERENCE:

EXAMPLE NO. 10
STANDARD FORM F - 4
SEQUENTIAL DETENTION CALCULATION

SUBDIVISION EXAMPLE No. 10

CACULATED BY AJL DATE FEB. 24, 1984

	FACILITY NUMBER (1)	SINGULAR DETENTION: BASIN AREA (A) Ac (2)	Q_i CFS (3)	IMP % (4)	K Ft (5)	Q_i/A CFS/Ac (6)	SEQUENTIAL DETENTION: ΣQ CFS (7)	Z Ac (8)	S_m Ac-Ft (9)	Q_m CFS (10)
10-YEAR	A-1	11	21	40	0.0361	1.909	21.0	11.0	0.40	2.6
10-YEAR	A-2	7	23	70	0.0646	3.286	25.6	7.8	0.50	1.9
10-YEAR	A-3	10	17	40	0.0361	1.700	17.0	10.0	0.36	2.4
10-YEAR	A-4	16	29	50	0.0456	1.813	33.3	18.4	0.84	4.4
100-YEAR	A-1	11	47	40	0.0644	4.272	47.0	11.0	0.71	11.0
100-YEAR	A-2	7	41	70	0.1112	5.857	52.0	8.9	0.99	8.9
100-YEAR	A-3	10	37	40	0.0644	3.700	37.0	10.0	0.64	10.0
100-YEAR	A-4	16	57	50	0.0804	3.563	75.9	21.3	1.71	21.3

$\Sigma Q = Q_i \div$ Previous Q_m

$Z = \Sigma Q / (Q_i / A)$

$S_m = KZ$

DATE:
REV:

REFERENCE:

"V" NOTCH WEIR

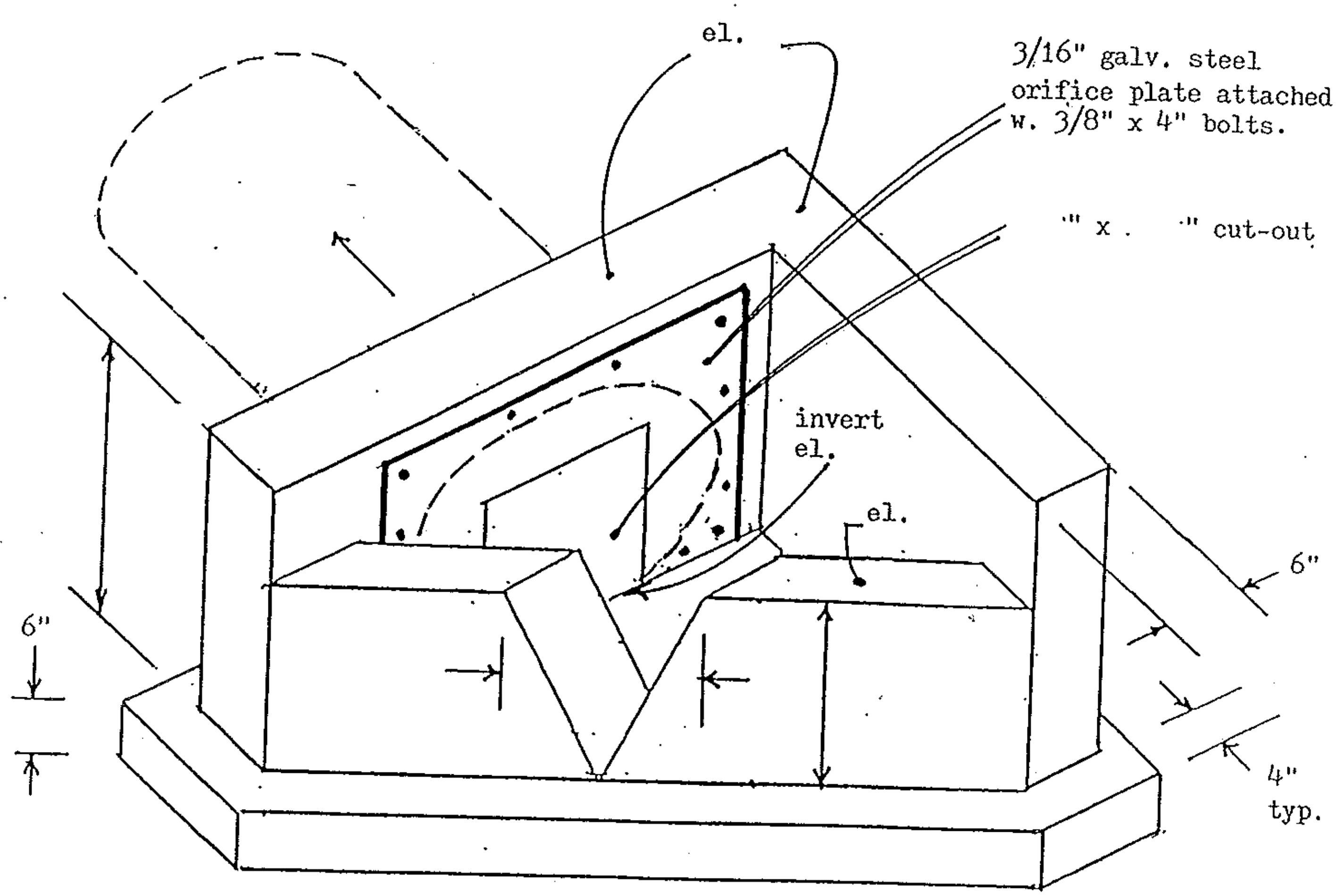
10 - YR.

d =   Allowable Release =   cfs. (Net Q10)

$*L = Q/1.25H^{3/2}$

$= 0.5 / 1.25 (\quad)^{3/2}$

= ft. (")



$*$ FROM KINGS HANDBOOK - $Q = C1 \; TAN \frac{\theta}{2} H^{5/2}$

$C1 = 2.5$

TRIANGULAR WEIR