Appendix C.1

Design Example 1 – Shallow Wetland (W-1)

Design Example 1 – Shallow Wetland (W-1)

The following example demonstrates the process for the design of a shallow wetland (W-1) BMP.

Site Specific Data

Clevenger Community Center is a recreational center located in Charles County, Maryland. The site area and drainage area to the proposed stormwater management facility is 5.3 acres. The project consists of constructing the community center and parking for a total impervious area of 1.94 acres. Existing ground at the outlet of the facility is 44.5' above mean sea level (MSL). Soil borings indicate that the seasonally high water table is at elevation 41'. The underlying soils are loams. TR-55 calculations for the existing and developed hydrologic conditions are shown in Figures C.1.2 and C.1.3.

Confirm Design Criteria

The site is within the Eastern Rainfall Zone and located on the Western Shore of the Chesapeake Bay (see Volume I, Chapter 2, Figures 2.1 and 2.4). Additionally, the site is located within a USE I watershed. Therefore, the following criteria apply:

1. WQ_v treatment is required. In the Eastern Rainfall Zone, P = 1".
2. Re_v treatment is required.
3. Cp_v treatment is required.
4. Q_{p10} may be required by the local jurisdiction. For this example, Q_{p10} will be required.
5. Q_f may be required by the local jurisdiction. For this example, Q_f will not be required. However, safe conveyance of the 100-year design storm is required through the proposed stormwater management facility.

Preliminary Design

<u>Step 1. Compute WQ_v</u>

Step 1a. Compute Volumetric Runoff Coefficient (R_v)

R_v = 0.05 + (0.009)(I); I = 1.94 acres / 5.3 acres = 0.366 or 36.6%
= 0.05 + (0.009)(36.6) = 0.379

Step 1b. Compute WQ_v

WQ_v = [(P)(R_v)(A)]/12
= [(1")(0.379)(5.3 ac)]/12
= <u>0.167 ac-ft</u> (7,292 cf.)

Figure C.1.1 Clevenger Community Center Site Plan

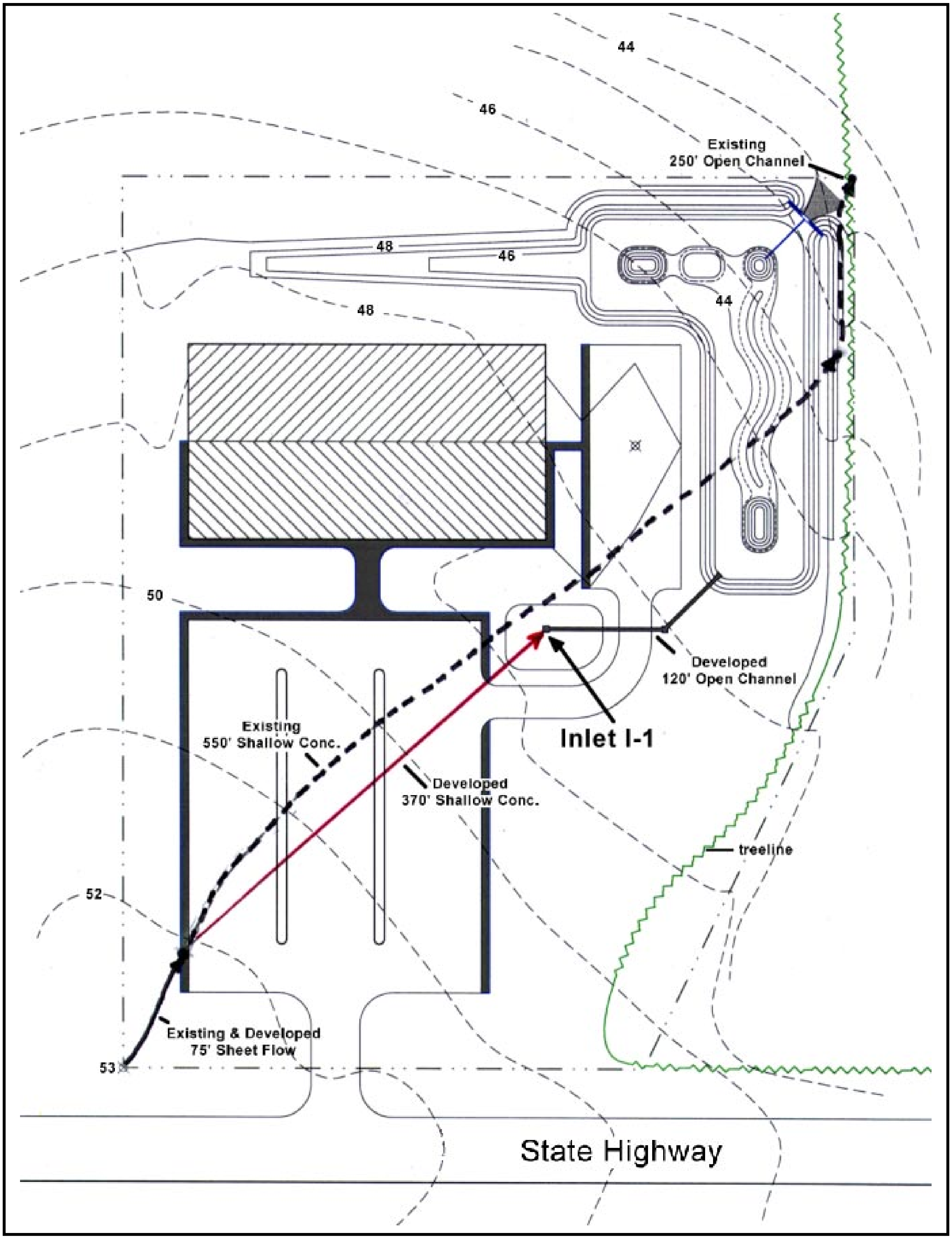


Figure C.1.2 Clevenger Community Center – Existing Conditions
(source: TR-55 computer printouts)

```
RUNOFF CURVE NUMBER COMPUTATION            Version 2.00
Project : CLEVENGER COMMUNITY CENTER             User: SRC      Date: 06-18-99
County  : CHARLES              State: MD      Checked: ____     Date: ________
Subtitle: EXISTING
-------------------------------------------------------------------------------
Hydrologic Soil Group
COVER DESCRIPTION                                A        B        C        D
Acres (CN)
-------------------------------------------------------------------------------
OTHER AGRICULTURAL LANDS
Meadow -cont. grass (non grazed) ----            -    5.0(58)       -        -
Woods                           good             -    0.3(55)       -        -
Total Area (by Hydrologic Soil Group)                 5.3
-------------------------------------------------------------------------------
TOTAL DRAINAGE AREA: 5.3 Acres       WEIGHTED CURVE NUMBER: 58*
-------------------------------------------------------------------------------
* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME        Version 2.00
-------------------------------------------------------------------------------
Flow Type   2 year   Length   Slope  Surface   n   Area     Wp   Velocity  Time
rain     (ft)   (ft/ft)   code       (sq/ft)  (ft)  (ft/sec)  (hr)
-------------------------------------------------------------------------------
Sheet        3.3      75       0.013    F                                 0.221
Shallow Concent'd     550      0.016    U                                 0.075
Open Channel          250                                         4.0    0.017
                                                 Time of Concentration = 0.31*
--- Sheet Flow Surface Codes ---
A Smooth Surface           F Grass, Dense     --- Shallow Concentrated ---
B Fallow (No Res.)         G Grass, Burmuda   ---     Surface Codes    ---
C Cultivated < 20 % Res.   H Woods, Light             P Paved
D Cultivated > 20 % Res.   I Woods, Dense             U Unpaved
E Grass-Range, Short       J Range, Natural
* - Generated for use by GRAPHIC method

GRAPHICAL PEAK DISCHARGE METHOD            Version 2.00
Data: Drainage Area        :  5.3 * Acres
Runoff Curve Number  :  58 *
Time of Concentration:  0.31 * Hours
Rainfall Type        :  II
Pond and Swamp Area  :  NONE
```

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr Rainfall (in)	2.7	3.3	4.4	5.3	6	6.6	7.5
Ia/P Ratio	0.54	0.44	0.33	0.27	0.24	0.22	0.19
Used	0.50	0.44	0.33	0.27	0.24	0.22	0.19
Runoff (in)	0.18	0.38	0.85	1.34	1.76	2.14	2.76
Unit Peak Discharge (cfs/acre/in)	0.460	0.615	0.835	0.904	0.929	0.946	0.967
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Peak Discharge (cfs)	0	1	4	6	9	11	14

* - Value(s) provided from TR-55 system routines

Figure C.1.3 Clevenger Community Center – Developed Conditions
(source: TR-55 computer printouts)

RUNOFF CURVE NUMBER COMPUTATION Version 2.00
Project : CLEVENGER COMMUNITY CENTER User: SRC Date: 06-18-99
County : CHARLES State: MD Checked: ____ Date: ________
Subtitle: DEVELOPED

COVER DESCRIPTION		Hydrologic Soil Group A	B	C	D
Acres (CN)					
FULLY DEVELOPED URBAN AREAS (Veg Estab.)					
Open space (Lawns,parks etc.)					
Good condition; grass cover > 75%		-	3.06(61)	-	-
Impervious Areas					
Paved parking lots, roofs, driveways		-	1.94(98)	-	-
OTHER AGRICULTURAL LANDS					
Woods	good	-	0.3(55)	-	-
Total Area (by Hydrologic Soil Group)			5.3		

TOTAL DRAINAGE AREA: 5.3 Acres WEIGHTED CURVE NUMBER: 74*

* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.3	70	0.013	F					0.209
Shallow Concent'd		310	0.013	P					0.037
Open Channel								5.0	0.007

Time of Concentration = 0.26*

--- Sheet Flow Surface Codes ---

A Smooth Surface F Grass, Dense
B Fallow (No Res.) G Grass, Burmuda
C Cultivated < 20 % Res. H Woods, Light
D Cultivated > 20 % Res. I Woods, Dense
E Grass-Range, Short J Range, Natural

--- Shallow Concentrated --- Surface Codes ---

P Paved
U Unpaved

* - Generated for use by GRAPHIC method

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Data: Drainage Area : 5.3 * Acres
Runoff Curve Number : 74 *
Time of Concentration: 0.26 * Hours
Rainfall Type : II
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr Rainfall (in)	2.7	3.3	4.4	5.3	6	6.6	7.5
Ia/P Ratio	0.26	0.21	0.16	0.13	0.12	0.11	0.09
Used	0.26	0.21	0.16	0.13	0.12	0.11	0.10
Runoff (in)	0.72	1.10	1.90	2.61	3.18	3.70	4.48
Unit Peak Discharge (cfs/acre/in)	0.995	1.033	1.076	1.098	1.110	1.119	1.124
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Peak Discharge (cfs)	4	6	11	15	19	22	27

* - Value(s) provided from TR-55 system routines

Step 2. Compute Re_v

Step 2a. Determine Soil Specific Recharge Factor (*S*) Based on Hydrologic Soil Group

Soils found throughout the site are loams and silt loams therefore $S = 0.26$

Step 2b. Compute Re_v Using Percent Volume Method

$$\begin{aligned} Re_v &= [(S)(R_v)(A)]/12 \\ &= [(0.26)(0.379)(5.3)]/12 \\ &= \underline{0.0456 \text{ ac-ft.}} \ (1{,}986 \text{ cf}) \end{aligned}$$

Step 2c. Compute Re_v Using Percent Area Method

$$\begin{aligned} Re_v &= (S)(A_i) \\ &= (0.26)(1.94 \text{ ac.}) \\ &= 0.50 \text{ acres} \end{aligned}$$

The Re_v requirement may be met by: a) treating 1,986 cf using structural methods, b) treating 0.50 acres using non-structural methods, or c) a combination of both (e.g. 994 cf structurally and 0.25 acres non-structurally).

Step 3. Compute Cp_v

The proposed community center is located within a USE I watershed, therefore an extended detention time (*T*) of 24 hours for the one-year storm event. The time of concentration (t_c) and one-year runoff (Q_a) are 0.26 hours and 0.72" respectively (see Fig. C.1.3).

Use the MDE Method to Compute Storage Volume (Appendix D.11):

Initial abstraction (I_a) for CN of 74 is 0.703: (TR-55) [$I_a = (200/CN)-2$]

$$I_a/P = (0.703)/2.7" = 0.26$$
$$t_c = 0.26 \text{ hours}$$

$q_u = 625$ csm/in. (Figure D.11.1, Appendix D.11)

$q_i = q_u A Q_a$ where *A* is the drainage area in square miles

$= (625 \text{ csm})(0.0083 \text{ square miles})(0.72")$

$= 3.7$ cfs; $q_i > 2.0$ cfs $\therefore Cp_v$ is required.

Knowing q_u and *T* (extended detention time), find q_o/q_i from Figure D.11.2, "Detention Time Versus Discharge Ratios."

Peak outflow discharge / peak inflow discharge (q_o/q_i) = 0.030

With q_o/q_i, compute V_s/V_r for a Type II rainfall distribution,

$V_s/V_r = 0.683 - 1.43(q_o/q_i) + 1.64(q_o/q_i)^2 - 0.804(q_o/q_i)^3$; (Appendix D.11)
$V_s/V_r = 0.64$

Therefore, $V_s = [(V_s/V_r)(Q_a)(A)] / 12$
= [(0.64)(0.72")(5.3 ac.)] / 12
= 0.204 ac-ft (8,886 cf.)

With q_o/q_i, compute the Cp_v release rate,

$q_o = (q_o/q_i)(q_i)$; $q_i = 4.0$ cfs
= (0.030)(4.0 cfs)
= 0.12 cfs

With q_o, determine the required orifice area (A_o) for extended detention design:

$$A_o = \frac{q_o}{C\sqrt{2gh_o}} = \frac{q_o}{4.81\sqrt{h_o}}$$

"h_o" is the maximum storage depth associated with V_s. For this example, assume h_o to be no more than 3.0 ft.

$\therefore A_o$ = (0.12 cfs) / (4.81√3.0 ft)
= (0.12 cfs) / (8.33 ft)
= 0.014 sf.

With A_o, determine the required orifice diameter (d_o):

$$d_o = \sqrt{4A_o/\pi} = \sqrt{4 \times 0.014sf/\pi} = 0.134\ ft$$ (1.6") USE 1.5"

"d_o's" of less than 3" are subject to local jurisdictional approval, and are not recommended unless an internal control for orifice protection is used. For this example, use a d_o of 3".

Step 4. Compute Q_{p10} Storage Volume

Per TR-55, Figure 6-1 (Page 6-2 of TR-55) for an inflow (Q_{in}) of 15 cfs and an allowable outflow (Q_{out}) of 6 cfs, the volume of storage (V_s) necessary for control is 0.37 ac-ft, with a developed CN of 74 (see TR-55 Worksheet 6a, Page 6-5 of TR-55). Note that there is 5.3 inches of rainfall during this event with 2.6 inches of runoff.

Step 5. Compute Q_f

For this example, management of Q_f is not required. However, the 100-year storm event must be conveyed safely through the stormwater management practice.

Table C.1.1 Summary of General Storage Requirements for Clevenger Community Center

Step	Requirement	Volume Required (acre-feet)	Notes
1.	WQ_v	0.167	
2.	Re_v	0.0456 (or 0.50 acres)	volume is included within the WQ_v storage
3.	Cp_v	0.204	Cp_v release rate is 0.10 cfs
4.	Q_{p10}	0.36	10-year release rate is 6.0 cfs
5.	Q_f	N/A	provide safe passage for the 100-year event in final design

Final Design

Step 1. BMP Selection Process

While the stormwater management BMP's listed in Chapter 2.7 (Volume I) are equivalent in meeting the established pollutant removal goals, site characteristics are an important consideration in selecting the most appropriate BMP for a specific design. The process outlined in Chapter 4 (Volume I) provides guidance for screening BMP's as part of the selection process.

❶ **Watershed Factors: Is the project located in a watershed that has special design objectives or constraints that must be met?** This project is located in a USE I watershed and there are no other special objectives or constraints that must be considered.

❷ **Terrain Factors: Is the project located in a portion of the State that has particular design constraints imposed by local terrain and or underlying geology?** The project is located in a region of the State that has no constraints imposed by local terrain or underlying geology

❸ **Stormwater Treatment Suitability: Can the BMP meet all five stormwater criteria at the site or are a combination of BMPs needed?** For this project, a single BMP will not satisfy all of the required criteria (see Table 4.3 BMP Selection Matrix No. 3). Therefore, one BMP will treat WQ_v, Cp_v, and Q_{p10} while a separate BMP will treat Re_v.

❹ **Physical Feasibility Factors: Are there any physical constraints at the project site that may restrict or preclude the use of a particular BMP?** Although the soils encountered are infiltratable, the depth to the existing water table is less than 4.0'. Therefore infiltration is not feasible for treating WQ_v. Additionally, the soils indicate that wet pond designs may require a liner. Sand filters will require substantial pretreatment as the proposed imperviousness is near 37%. The drainage area, 5.3 acres, is marginally low to support either ponds or wetlands. However, the groundwater table may be sufficient to support a shallow wetland.

❺ **Community and Environmental Factors: Do the remaining BMPs have any important community or environmental benefits or drawbacks that might influence the selection process?** The projected use of the site as a community center may require that BMPs possess a greater acceptance by the community. Additionally, habitat quality is important if environmental education is provided at the center. Finally, ease of maintenance and costs relative to drainage area are important considerations as the sources of future funding may be limited.

❻ **Location and Permitting Factors: What environmental features must be avoided or considered when locating the BMP system at a site to fully comply with local, State and federal regulations?** There are no wetlands, stream buffers, floodplains or forest conservation areas located on the site although the area of existing woods should be preserved if possible.

After considering all factors and the site layout, use a shallow wetland (W-1) for treating WQ_v. Cp_v and Q_{p10} will be treated by providing sufficient storage above the shallow wetland. Finally, Re_v will be treated prior to the wetland by providing storage around the inlet, I-1.

Step 2. Shallow Wetland (W-1) Design

Using the information developed in Preliminary Design Steps 1 and 2, design a shallow wetland to treat WQ_v (see Figure C.1.4).

A. Calculate Design Volume

Because Re_v will be treated prior to the shallow wetland, Re_v may be subtracted from the WQ_v for the design of this BMP:

$$\begin{aligned} WQ_v' &= WQ_v - Re_v \\ &= 7{,}292 \text{ cf.} - 1{,}986 \text{ cf.} \\ &= 5{,}306 \text{ cf.} \end{aligned}$$

B. Calculate Pretreatment (Forebay) Volume

Forebays shall be sized to capture 10% of the design runoff volume (in this case WQ_v') at each inflow point; assume that inflow is divided equally between the two inflow points for this design.

forebay volume = (10%)(5,306 cf./ 2)
= 265.3 cf. at each inflow point

forebay volume provided = 800 cf. and 700 cf. respectively

B. Determine Shallow Wetland Size Criteria

Using the design criteria set forth in Chapter 3 for the design of shallow wetland systems, the configuration shown in Figure C.1.4, and the information in Table C.1.2, design a shallow wetland to treat WQ_v'. Specific criteria that govern the configuration of the shallow wetland design are as follows.

1. Surface area ≥ 1.5% × drainage area
≥ 1.5% × 5.3 acres
≥ 0.0795 acres (3,463 sf.)

Surface area of shallow wetland at elevation 44.0 = 0.1366 acres (5,950 sf.) -OKAY

2. Deepwater (depth ≥ 4') zones ≥ 25% × WQ_v'
≥ 25% × 5,306 cf.
≥ 1,326.5 cf.

Deepwater zones provided = 1,950 cf. (forebays and micropool)

3. High marsh (depth ≤ 6") zones ≥ 35% × total surface area
≥ 35% × 3,463 sf.
≥ 1,212.1 sf.

High marsh area provided = 2,160 sf.

4. Total marsh area (depth ≤ 18") zones ≥ 65% × total surface area
≥ 65% × 3,463 sf.
≥ 2,251 sf.

Total marsh area provided = 4,200 sf.

5. Check for water balance (see Appendix D.3) for maintenance of wet pool:

a. Calculate maximum drawdown:

Inflow Runoff Volume = *P x E* where *P* = Precipitation & *E* = Runoff Efficiency
- for a CN of 74, Volume of runoff (2 year storm) = 1.10"
- for Charles County, *P* (2 year rainfall) = 3.3" (0.275')
- *E* = 1.1"/3.3" = 0.33

∴ Inflow = *P x E* = 0.275' x 0.33 x 5.3 acres = 0.48 ac-ft

Outflow = surface area x evaporation losses
= 0.137 acres x 0.54 ft (see Table D.3.2)
= 0.074 ac-ft

Inflow (0.48 ac-ft) is greater than Outflow (0.074 ac-ft) –OKAY

b. Check for drawdown over an extended period without rainfall:

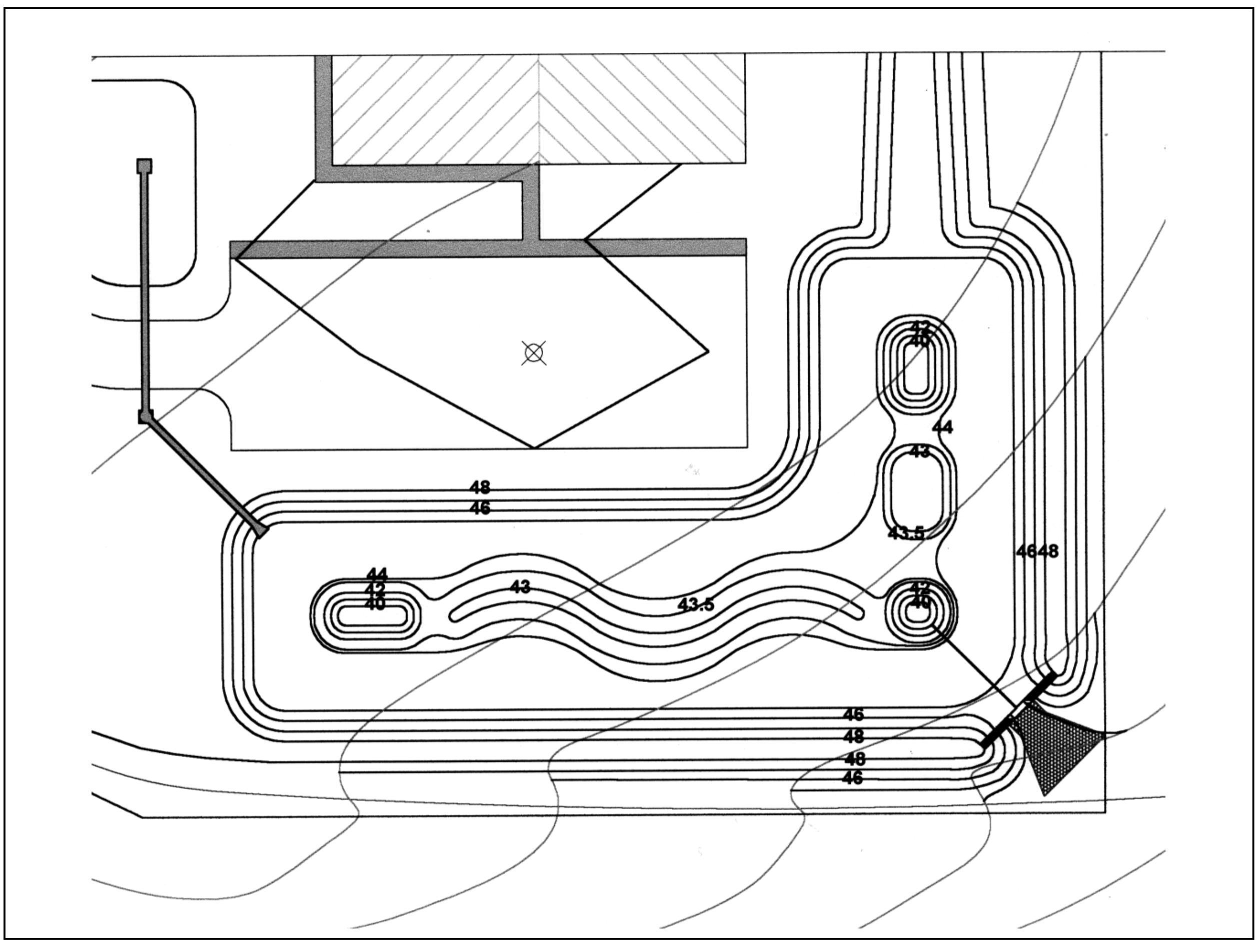
Using 45 day "worst case" drought conditions

- highest evaporation occurs in July – 0.54 ft per month
- average evaporation per day = 0.54/31 days = 0.017 ft/day
- over 45 day interval, evaporation loss = 45 x 0.017 ft/day = 0.78 ft.
- assume surface of wetland may drop up to 0.78 ft. over this interval -OKAY

Table C.1.2 Stage – Storage Data for Stormwater Management Design

Stage - Storage Data				
Elevation	Δ Storage	Storage (cubic feet)	Storage (acre-feet)	Storage Above WQ_v (acre-feet)
40.0	0.0	0.0	0.0	
41.0	372.0	372.0	0.0085	
42.0	665.0	1,037.0	0.0238	
43.0	1,428.0	2,465.0	0.0566	
44.0	3,990.0	6,455.0	0.1482	0.0
45.0	11,200.0	17,665.0	0.4055	0.2573
45.5	8,478.0	26,133.0	0.5999	0.4517
46.0	8,987.0	35,120.0	0.8062	0.6581
47.0	19,530.0	54,650.0	1.2546	1.1064
48.0	21,646.0	76,296.0	1.7515	1.6033

Figure C.1.4 Plan View of Shallow Wetland Design



Step 3. Cp_v Design

Using the information from Preliminary Design Step 3, the stage–storage data from Table C.1.2, and the stage-discharge data for the 3" orifice in Table C.1.3, design an extended-detention basin to treat Cp_v.

Table C.1.3 Stage – Discharge Data for Clevenger Community Center

Stage - Discharge Data							
Elevation	3" Orifice[1] centerline – 44.125'		5.2' Weir[2] crest @ 45.00'		10.0' Weir[3] crest @ 45.50'		Total Discharge
	Head (h)	**Discharge**	**Head (h)**	**Discharge**	**Head (h)**	**Discharge**	
44.00	0.0	0.00					0.00
44.25	0.1	0.085					0.085
44.50	0.4	0.150					0.150
44.75	0.6	0.194					0.194
45.00	0.9	0.229	0.0	0.0			0.229
45.50	1.4	0.287	0.5	5.70	0.0	0.0	5.70
46.00	1.9	0.335	1.0	16.12	0.5	10.96	27.08
47.00	2.9	0.415	2.0	45.59	1.5	56.95	102.54
48.00	3.9	0.482	3.0	83.76	2.5	122.53	206.29

1. Using orifice equation $Q = ca\sqrt{2gh}$ where c=0.61, a=0.05 sf., and g= 32.2 ft/sec^2
2. Using weir equation $Q = clh^{3/2}$ where c= 3.1 & l =5.2'
3. Using weir equation $Q = clh^{3/2}$ where c= 3.1 & l =10.0'

From Preliminary Step 3, the storage volume (V_s) for Cp_v is 0.204 ac-ft and the required orifice diameter (d_o) is 3". Using Table C.1.2 and starting at elevation 44.0, the storage volume of the proposed stormwater management structure is 0.2573 ac-ft at elevation 45.0'. Therefore, Cp_v treatment will be provided between elevations 44.0' and 45.0'.

Step 4. Q_{p10} Treatment

From Preliminary Step 5, the estimated storage volume (V_s) for treating Q_{p10} is 0.36 ac-ft and the allowable discharge rate is 6.0 cfs. Using Table C.1.2 and starting at elevation 44.0', the storage volume of the proposed stormwater management structure is 0.4517 ac-ft at elevation 45.5'. Therefore, design a control structure that will produce a discharge rate of 6.0 cfs at storage elevation 45.5'. This will be a conservative design since the volume provided (0.4517 ac-ft) is greater than the 0.36 ac-ft required. Using a weir with crest at elevation 45.0' and including flow from the 3" orifice, the ten-year discharge (q_{10}) may be computed as follows:

$$q_{10} = c_w l h_w^{3/2} + c_o a\sqrt{2gh_o}$$

where: q_{10} = 10 yr. discharge = 6.0 cfs
c_w = weir coefficient = 3.1
l = length of weir
h_w = head on weir; at elevation 45.5, h_w = 0.5'
c_o = orifice coefficient = 0.61
a = area of 3" orifice = 0.05
g = gravitational acceleration = 32 ft/sec^2
h_o = head on orifice; at elevation 45.5, h_o = 1.375

therefore: $q_{10} = (3.1)(l)(0.5)^{3/2} + (0.61)(0.05)[(2)(32.2)(1.375)]^{1/2}$
6.0 cfs = 1.1l cfs + 0.29 cfs
by rearranging this equation and solving for l; l = 5.2'

use a 5.2' weir with crest at elevation 45.0 –OKAY

Step 5. Q_f Treatment

From Preliminary Step 5, the 100-year storm event must be conveyed safely through the stormwater management facility. From Figure C.1.3, 100-year discharge rate (q_{100}) is 27 cfs and from Figure C.1.4, the top of the proposed stormwater management facility is at elevation 48.0'. Allowing for 2.0' of freeboard, design a control structure that will discharge 27 cfs at elevation 46.0'. Using a weir with crest at elevation 45.5', including flow from the 5.5' weir and assuming that the 3" orifice is clogged, q_{100} may be computed as follows:

$$q_{100} = cl_{100}h_{100}^{3/2} + cl_{10}h_{10}^{3/2}$$

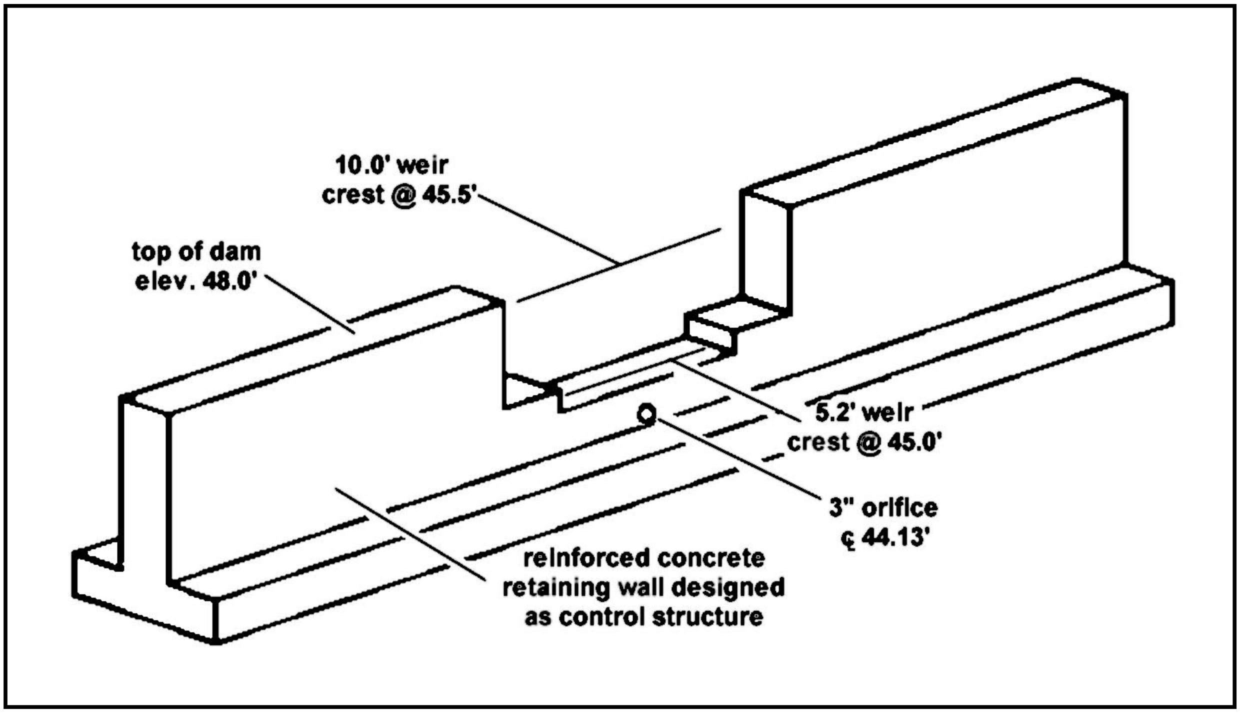
where: q_{100} = 100 yr. discharge = 27 cfs.
c = weir coefficient = 3.1
l_{100} = length of 100 yr. weir
h_{100} = head on 100 yr. weir; at elev. 46.0', h_{100} = 0.5'
l_{10} = length of 10 yr. weir = 5.2'
h_{10}= head on 10 yr. weir; at elev. 46.0', h_{10} = 1.0'

therefore: $q_{100} = (3.1)(l_{100})(0.5)^{3/2} + (3.1)(5.2')(1.0)^{3/2}$
27 cfs = 1.1l_{100} cfs + 16.1 cfs
by rearranging this equation and solving for l_{100}; l_{100} = 9.89'

use a 10.0' weir with crest at elevation 45.5' –OKAY

See Figure C.1.5 for a schematic of the control structure and Figure C.1.6 for a profile through the centerline of the dam and control structure. See Figures C.1.7 and C.1.8 for the TR-20 input and summary tables.

Figure C.1.5 Schematic of Control Structure



Step 6. Investigate Potential Pond Hazard Classification

Using NRCS-MD Code No. 378 Pond Standards/Specifications (Appendix B.1), review downstream conditions and compute a preliminary Breach Peak Discharge (Q_{max}) to determine pond hazard classification.

$$Q_{\max} = (3.2)(H_w^{5/2})$$

where: Q_{max} = Breach Peak Discharge
H_w = depth of water at the dam at time of failure, in feet, and is measured from the design high water to the lowest point in the original cross section at the centerline of the dam; H_w = 46.0' – 44.0' = 2.0'

$Q_{max} = (3.2)(2.0)^{5/2} = 18.1$ cfs

Q_{max} will not overtop downstream roads or infrastructure, therefore the stormwater management facility may be considered as a Class "a" low hazard structure per the NRCS-MD 378 standards.

Figure C.1.6 Profile of Principle Spillway

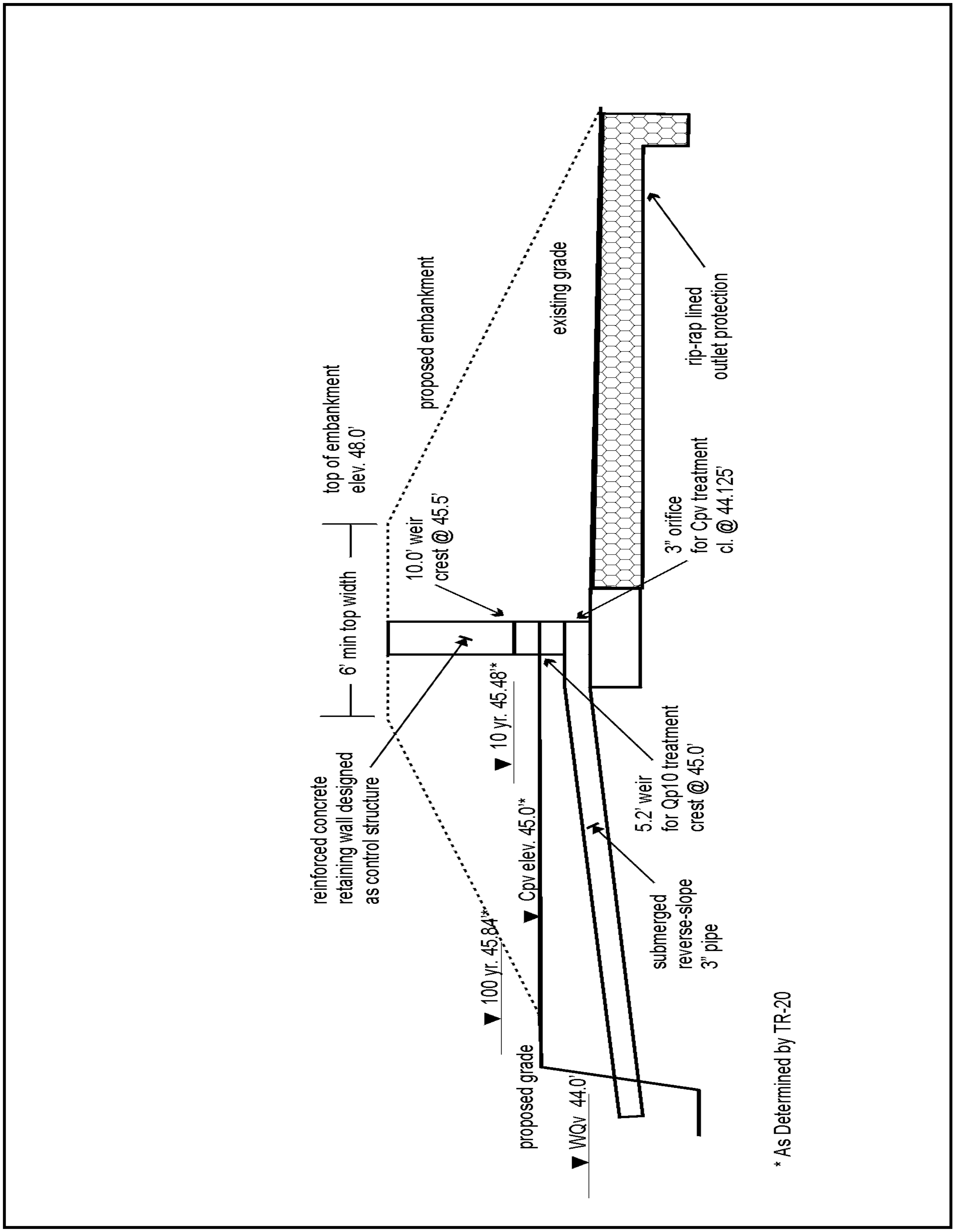


Figure C.1.7 TR-20 Computer Program Input File

```
JOB TR-20 EXAMPLE1  ECON      FULLPRINT PASS=001  SUMMARY   GRAPHICS
TITLE     DESIGN EXAMPLE 1  CLEVENGER COMMUNITY CENTER
 3 STRUCT      01
 8                      44.0        0.0         0.0
 8                      44.25       0.12        0.060
 8                      44.5        0.17        0.128
 8                      44.75       0.21        0.180
 8                      45.0        0.24        0.2573
 8                      45.5        5.70        0.4517
 8                      46.0        27.08       0.6581
 8                      47.0        102.54      1.1064
 8                      48.0        206.29      1.6033
 9 ENDTBL
 6 RUNOFF 1 001       1 .00828      74.         0.26        1 1   1 1 1
 6 RESVOR 2    01 1   2 44.0                                1 1 1 1 1 1
 6 RUNOFF 1 003       3 .00828      58.         0.31        1 1   1 1 1
   ENDATA
 7 INCREM 6             0.10
 7 COMPUT 7 001   003   0.0         2.7         1.0         2 2  01  01
   ENDCMP 1
 7 INCREM 6             0.10
 7 COMPUT 7 001   003   0.0         3.3         1.0         2 2  01  02
   ENDCMP 1
 7 INCREM 6             0.10
 7 COMPUT 7 001   003   0.0         5.3         1.0         2 2  01  10
   ENDCMP 1
 7 INCREM 6             0.10
 7 COMPUT 7 001   003   0.0         7.5         1.0         2 2  01  99
   ENDCMP 1
   ENDJOB 2
```

Figure C.1.8 TR-20 Computer Program Output Summary Table

```
                            SUMMARY TABLE 1
                            ---------------
SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL IN ORDER PERFORMED.
A CHARACTER FOLLOWING THE PEAK DISCHARGE TIME AND RATE (CFS) INDICATES:
F-FLAT TOP HYDROGRAPH   T-TRUNCATED HYDROGRAPH   R-RISING TRUNCATED HYDROGRAPH

XSECTION/  STANDARD                                   PEAK DISCHARGE
STRUCTURE   CONTROL    DRAINAGE   RUNOFF   ------------------------------------
   ID      OPERATION     AREA     AMOUNT   ELEVATION   TIME     RATE    RATE
                       (SQ MI)     (IN)      (FT)      (HR)     (CFS)   (CSM)

RAINFALL OF   2.70 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  2,    ARC 2
MAIN TIME INCREMENT   .100 HOURS

   ALTERNATE    1   STORM    1
   ---------------------------
XSECTION   1  RUNOFF      .01      .72        ---     12.07T       4T   400.0
STRUCTURE  1  RESVOR      .01      .71        ---       .00        0       .0
XSECTION   3  RUNOFF      .01      .71        ---       .00        0       .0
XSECTION   3  RUNOFF      .01      .71        ---       .00        0       .0

RAINFALL OF   3.30 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.

   ALTERNATE    1   STORM    2
   ---------------------------
XSECTION   1  RUNOFF      .01     1.10        ---     12.06        7    700.0
STRUCTURE  1  RESVOR      .01     1.09        ---       .00        0       .0
XSECTION   3  RUNOFF      .01      .38        ---     12.14T       1T   100.0

RAINFALL OF   5.30 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
MAIN TIME INCREMENT   .100 HOURS

   ALTERNATE    1   STORM   10
   ---------------------------
XSECTION   1  RUNOFF      .01     2.60        ---     12.05       16   1600.0
STRUCTURE  1  RESVOR      .01     2.59      45.50     12.32        6    600.0
XSECTION   3  RUNOFF      .01     1.34        ---     12.10        7    700.0

RAINFALL OF   7.50 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.

   ALTERNATE    1   STORM   99
   ---------------------------
XSECTION   1  RUNOFF      .01     4.48        ---     12.04       28   2800.0
STRUCTURE  1  RESVOR      .01     4.43      45.84     12.18       20   2000.0
XSECTION   3  RUNOFF      .01     2.75        ---     12.09       16   1600.0
```

Step 7. Re_v Treatment

Using the information developed n Preliminary Step 2, design a structural practice to treat Re_v. Non-structural practices will not be utilized therefore the entire Re_v (1,986 cf) must be treated. For this example, design an infiltration area around inlet I-1 (see Figure C.1.9) that will treat the entire Re_v. Because of its high visibility and the communal nature of the project, this infiltration area will be designed and planted similar to a bioretention area.

The surface area around I-1 that is available for this practice has an area (*A*) of 2,250 sf. Using a porosity (*n*) of 0.30* for the sand and planting soil mixture, the required depth (*d*) to treat the entire Re_v is equal to:

$$[(Re_v)/(A)] / n$$
$$= [(1{,}986 \text{ cf.})/(2{,}250 \text{ sf.})] / 0.30$$
$$= 0.883 / 0.30$$
$$= 2.94 \text{ ft. } \textit{Use } d = 3.0 \textit{ ft.}$$

*Note: The porosity of mixed-grained sand varies from 0.30 (dense) to 0.40 (loose). Using the minimum value, 0.30, results in a more conservative design.

Using a depth of 3.0', a surface area of 2,250 sf. and a *n* of 0.3, storage for Re_v treatment is equal to:

$$(A \times d) \times n$$
$$= (2{,}250 \text{ sf.} \times 3.0 \text{ ft.}) \times 0.3$$
$$= 2{,}025 \text{ cf. -OKAY}$$

Using the dimensions above, a cross section of the infiltration area is shown in Figure C.1.10.

Step 8. Landscaping

The BMP's for both WQ_v and Re_v treatment have specific landscaping requirements for proper implementation. Therefore, landscaping plans developed in accordance with Chapter 3 and using the guidelines provided in Appendix A will be required with submittal of the final design.

Figure C.1.9 Location of Re_v Treatment

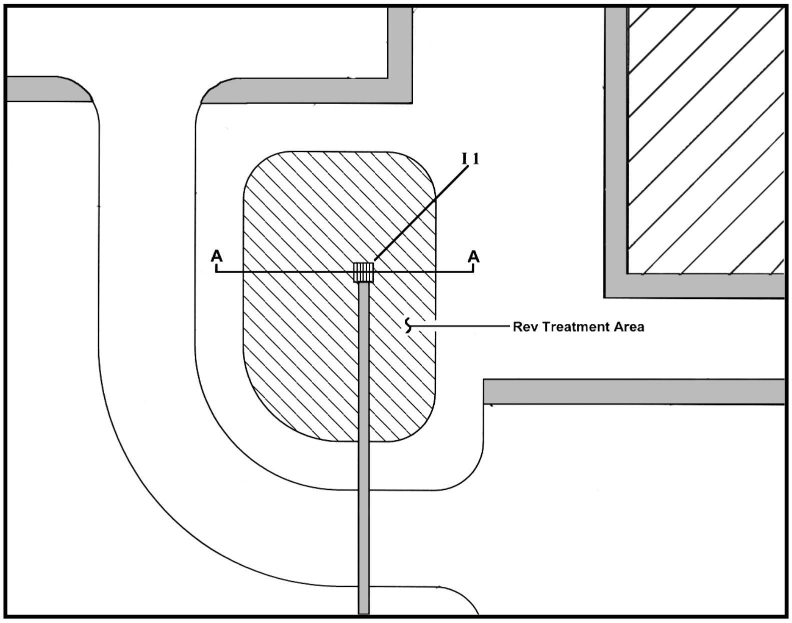


Figure C.1.10 Cross Section "A-A"