These calculations should be used when designing the outlet structures for extended wet and dry detention basins (Sections 4. 7 and 4.8). The water quality outlet size and the trash rack design will vary depending on structure type. Be sure to follow the design procedure outlined in Sections 4.7 and 4.8 to determine appropriate water quality outlet type.

WQ Outlet Design

Single Orifice

Orifice diameter

Equation G.1 $D_O = 24\sqrt{\dfrac{Q_{WQ}}{C_O \times \Pi \times \sqrt{2 \times g \times H_{WQ}}}}$

Where:

D_O	=	Orifice diameter (inches)
Q_{WQ}	=	Average WQ outflow rate (cubic feet per second)
C_O	=	Orifice coefficient (1.0 for circular entrance, 0.62 for square-edged entrance)
H_{WQ}	=	Average head of WQ_V over invert of WQ outlet (feet)

Perforated riser/Orifice Plate

Outlet area per perforation row

Equation G.2 $A_O = \dfrac{WQ_V}{n \times Z_{WQ}^2 + 0.22 Z_{WQ} - .10}$

Where:

A_O	=	Recommended maximum outlet area per row (square inches)
WQ_V	=	Water quality volume (acre feet)
Z_{WQ}	=	Depth of WQ_V over above permanent pool (feet) (determined by designer)
n	=	Manning's 'n' for perforated pipe

Circular perforation diameter per row

Equation G.3 $D_1 = \sqrt{\dfrac{4A_O}{\Pi}}$

Where:

D_1	=	Circular perforation diameter per row (inch)
A_O	=	Maximum outlet area per row of perforations (square inch)

Circular perforation diameter

Equation G.4 $D_{perf} = \sqrt{\dfrac{4A_O}{\Pi n_C}}$

Where:

D_{perf}	=	Circular perforation diameter (inch)
A_O	=	Maximum outlet area per row of perforations (square inch)
n_C	=	Number of columns of perforations

Number of perforation rows

Equation G.5 $n_f = \dfrac{12 Z_{WQ}}{Sc}$

Where:

n_f	=	Number of rows of perforations
Z_{WQ}	=	Depth of WQ_V over above permanent pool (feet)
S_C	=	Center to center column spacing; if n>1, S_C = 4inch

V-notch Weir

Weir angle (with calculator set in radians)

Equation G.6 $\theta = 2\left(\frac{180}{\Pi}\right)\arctan\left(\frac{Q_{WQ}}{C_V \times H_{WQ}^{5/2}}\right)$

Where:

θ	=	V-notch weir angle (degrees)
Q_{WQ}	=	Average WQ outflow rate (cubic feet per second)
C_V	=	V-notch coefficient (2.5 is typical value)
H_{WQ}	=	Average head of WQ_V over invert of WQ outlet (feet)

OR

Weir angle (with calculator set in degrees)

Equation G.7 $\theta = 2\arctan\left(\frac{Q_{WQ}}{C_V \times H_{WQ}^{5/2}}\right)$

Where:

θ	=	V-notch weir angle (degrees)
Q_{WQ}	=	Average WQ outflow rate (cubic feet per second)
C_V	=	V-notch coefficient (2.5 is typical value)
H_{WQ}	=	Average head of WQ_V over invert of WQ outlet (feet)

Top width of V-notch weir

Equation G.8 $W_V = 2 \times Z_{WQ} \times \tan\left(\frac{\theta}{2}\right)$

Where:

W_V	=	V-notch top width (feet)
θ	=	V-notch weir angle (degrees)
Z_{WQ}	=	Depth of WQ_V over above permanent pool (feet)

Trash Rack Design

Single Orifice

Water quality outlet area

Equation G.9 $A_{OT} = \frac{\Pi}{4} D_O^2$

Where:

A_{OT}	=	Outlet area (square inches)
D_O	=	Orifice diameter (inches) calculated in Equation G.1

Trash rack open area

Equation G.10 $A_T = A_{OT} \times 77e^{(-0.124D_O)}$

Where:

A_T	=	Required trash rack open area (square inches)
A_{OT}	=	Outlet area (square inches) calculated in Equation G.9
D_O	=	Orifice diameter (inches) calculated in Equation G.1

Perforated riser/Orifice Plate

Water quality outlet area

Equation G.11 $A_{OT} = A_O \times n_C \times n_F$

Where:

A_{OT} = Outlet area (square inches)

A_O = Maximum outlet area per row (square inches) calculated in Equation G.2.

n_C = Number of perforation columns calculated in Equation G.4

n_f = Number of perforations rows calculated in Equation G.5

Trash rack open area

Equation G.12 $A_T = \frac{A_{OT}}{2} \times 77e^{(-0.124 D_1)}$

Where:

A_T = Required trash rack open area (square inches)

A_{OT} = Outlet area (square inches) calculated in Equation G.11

D_1 = Circular perforation diameter per row (inch) calculated in Equation G.3.

V-notch Weir

Water quality outlet area

Equation G.13 $A_{OT} = \frac{1}{2} W_V \times \sin\left(\frac{\theta}{2}\right)$

Where:

A_{OT} = Outlet area (square inches)

W_V = V-notch top width (feet) calculated in Equation G.8.

θ = V-notch weir angle (degrees) calculated in Equation G.7.

Trash rack open area

Equation G.13 $A_T = 4A_{OT}$

Where:

A_T = Required trash rack open area (square inches)

A_{OT} = Outlet area (square inches) calculated in Equation G.13

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: ____________________
Checked By: ____________________
Company: ____________________
Date: ____________________
Project: ____________________
Location: ____________________

I. Basin Water Quality Storage Volume

Step 1) Tributary area to EDDB, A_T (ac) — A_T (ac) = 50.0

Step 2) Calculate WQv — WQv (ac-ft) = 2.4

Step 3) Add 20 percent to account for silt and sediment deposition in the basin. — V_{design} (ac-ft) = 2.9

IIa. Water Quality Outlet Type

Step 1) Set water quality outlet type: — Outlet Type = 1.0
Type 1 = single orifice
Type 2 = perforated riser or plate
Type 3 = v-notch weir

Step 2) Proceed to step 2b, 2c, or 2d based on water quality outlet type selected

IIb. Water Quality Outlet, Single Orifice

Step 1) Depth of water quality volume at outlet, Z_{WQ} (ft) — Z_{WQ} (ft) = 3.0

Step 2) Average head of water quality volume over invert of orifice, H_{WQ} (ft)
$H_{WQ} = 0.5 * Z_{WQ}$ — H_{WQ} (ft) = 1.5

Step 3) Average water quality outflow rate, Q_{WQ} (cfs)
$Q_{WQ} = (WQv * 43,560)/(40 * 3,600)$ — Q_{WQ} (cfs) = 0.7

Step 4) Set value of orifice discharge coefficient, C_o

C_o = 0.6

Step 5) Water quality outlet orifice diameter (m inimum of 4 inches), D_o (in)
$D_o = 12 * 2 * (Q_{WQ}/(C_o * \pi * (2 * g * H)^{0.5}))^{0.5}$ — D_o (in) = 4.7
(If orifice diameter < 4 inches, use outlet type 2 or 3)

Step 6) To size outlet orifice for EDDB with an irregular stage-volume relationship, use the Single Orifice Worksheet

IIc. Water Quality Outlet, Perforated Riser

Step 1) Depth at outlet above lowest perforation, Z_{WQ} (ft) — Z_{WQ} (ft) = ________

Step 2) Recommended maximum outlet area per row, A_o (in^2)
$A_o = (WQv)/(0.013 * Z_{WQ}^2 + 0.22 * Z_{WQ} - 0.10)$ — A_o (in^2) = ________

Step 3) Circular perforation diameter per row assuming a single column, D_1 (in) — D_1 (in) = ________

Step 4) Number of columns, n_c — n_c = ________

Step 5) Design circular perforation diameter (should be between 1 and 2 inches), D_{perf} (in) — D_{perf} (in) = ________

Step 6) Horizontal perforation column spacing when $n_c > 1$, center to center, S_c — S_c (in) = ________
If D_{perf} >/= 1.0 in, $S_c = 4$

Step 7) Number of rows (4" vertical spacing between perforations, center to center), n_r — n_r = ________

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: ____________________
Checked By: ____________________
Company: ____________________
Date: ____________________
Project: ____________________
Location: ____________________

IId. Water Quality Outlet, V-notch Weir

Step 1) Depth of water quality volume above permanent pool, Z_{WQ} (ft) — Z_{WQ} (ft) = ________

Step 2) Average head of water quality pool volume over invert of v-notch, H_{WQ} (ft)
$H_{WQ} = 0.5 * Z_{WQ}$ — H_{WQ} (ft) = ________

Step 3) Average water quality pool outflow rate, Q_{WQ} (cfs)
$Q_{WQ} = (WQv * 43,560)/(40 * 3,600)$ — Q_{WQ} (cfs) = ________

Step 4) V-notch weir coefficient, C_v — C_v = ________

Step 5) V-notch weir angle, θ (deg)
$\theta = 2 * (180/\pi) * \arctan(Q_{WQ}/(C_v * H_{WQ}^{5/2}))$
V-notch angle should be at least 20 degrees. Set to 20 degrees if calculated angle is smaller. — θ (deg) = ________

Step 6) Top width of V-notch weir
$Wv = 2*Z_{WQ} * TAN(\theta/2)$ — W_V (ft) = ________

Step 7) To calculate v-notch angle for EDDB with an irregular stage-volume relationship, use the V-notch Weir Worksheet

III. Flood Control

Refer to local agency specification.

IV. Trash Racks

Step 1) Total outlet area, A_{ot} (in^2) — A_{ot} (in^2) = 17.0

Step 2) Required trash rack open area, A_t (in^2)
$A_t = A_{ot} * 77 * e^{(-0.124 * D)}$ for single orifice outlet
$A_t = (A_{ot}/2) * 77 * e^{(-0.124 * D)}$ for orifice plate outlet
$A_t = 4 * A_{ot}$ for v-notch weir outlet — A_t (in^2) = 732.1

V. Basin Shape

Step 1) Length to width ratio should be at least 3:1 (L:W) wherever practicable — (L:W) = ________

Step 2) Low flow channel side lining
Concrete: ________
Soil / riprap: ________
No low flow channel: ________

Step 3) Top stage floor drainage slope (toward low flow channel), S_{ts} (%) — S_{ts} (%) = ________
Top stage depth, D_{ts} (ft) — D_{ts} (ft) = ________

Step 4) Bottom stage volume, V_{bs} (ac-ft)
V_{bs} (% of WQv) ________
V_{bs} (ac-ft) ________

VI. Forebay (Optional)

Step 1) Volume should be greater than 10% of WQv — Min Vol_{FB} (ac-ft) = 0.2

Step 2) Forebay depth, Z_{FB} (ft) — Z_{FB} (ft) = 4.0

Step 3) Forebay surface area, A_{FB} (ac) — Min A_{FB} (ac) = 0.1

Step 4) Paved/hard bottom and sides? ________

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: ____________________
Checked By: ____________________
Company: ____________________
Date: ____________________
Project: ____________________
Location: ____________________

VII. Basin side slopes

Basin side slopes should be at least 4:1 (H:V) Side Slope (H:V) = ________

VIII. Dam Embankment side slopes

Dam Embankment side slopes should not exceed 3:1 (H:V) Dam Embankment (H:V) = ________

IX. Vegetation

Check the method of vegetation planted in the EDDB or describe "other"

___ Native Grass
___ Irrigated Turf Grass
___ Other: ___ __________
____

X. Inlet Protection

Indicate method of inlet protection/energy dissipation at EDDB inlet ________

XI. Access

Indicate that access has been provided for maintenance vehicles. ________

Design Procedure Form: Extended Wet Detention Basin (EWDB)
Main Worksheet

Designer: ____________________
Checked By: ____________________
Company: ____________________
Date: ____________________
Project: ____________________
Location: ____________________

I. Basin Water Quality Volume

Step 1) Tributary area to EWDB, A_T (ac)	A_T (ac) =	50.0
Step 2) Calculate WQv	WQv (ac-ft) =	4.0

IIa. Permanent Pool Volume

Step 1) Average 14 day wet season rainfall, R_{14} (in)	R_{14} (in) =	2.0
Step 2) Rational runoff coefficient, C C = 0.3 + 0.6 * I I = percent impervious area divided by 100	C =	0.8
Step 3) Permanent pool volume 1, V_{P1} (ac-ft) $V_{P1} = (C * A_T * R_{14})/12$	V_{P1} (ac-ft) =	6.7

IIb. Sedimentation Volume,

Step 1) Ratio of basin volume to runoff volume, $V_{B/R}$ (from Figure 12; $V_{B/R}$ should be >= 4.0)	$V_{B/R}$ =	4.0
Step 2) Mean storm depth, S_d (in)	S_d (in) =	0.5
Step 3) Impervious tributary area, A_I (ac)	A_I (ac) =	42.5
Step 4) Permanent pool volume by Method 2, V_{P2} (ac-ft) $V_{P2} = (V_{B/R} * S_d * A_I)/12$	V_{P2} (ac-ft) =	6.5

IIc. Permanent Pool Design Volume

Step 1) Design permanent pool volume, V_P, as larger of volumes calculated in IIa and Iib plus 20%	V_P (ac-ft) =	8.0
Step 2) Average permanent pool depth, Z_P (ft)	Z_P (ft) =	4.0
Step 3) Permanent pool surface area, A_P (ac)	A_P (ac) =	2.0

Design Procedure Form: Extended Wet Detention Basin (EWDB)
Main Worksheet

Designer: ____________________
Checked By: ____________________
Company: ____________________
Date: ____________________
Project: ____________________
Location: ____________________

IIIa. Water Quality Outlet Type

Step 1) Set water quality outlet type: Outlet Type = 2.0
- Type 1 = single orifice
- Type 2 = perforated riser or plate
- Type 3 = v-notch weir

Step 2) Proceed to part IIIb, IIIc, or IIId based on water quality outlet type selected

IIIb. Water Quality Pool Outlet, Single Orifice

Step 1) Depth of water quality volume above permanent pool, Z_{WQ} (ft) — Z_{WQ} (ft) = ________

Step 2) Average head of water quality volume over invert of orifice, H_{WQ} (ft)
$H_{WQ} = 0.5 * Z_{WQ}$ — H_{WQ} (ft) = ________

Step 3) Average water quality outflow rate, Q_{WQ} (cfs)
$Q_{WQ} = (WQv * 43{,}560)/(40 * 3{,}600)$ — Q_{WQ} (cfs) = ________

Step 4) Set value of orifice discharge coefficient, C_o

C_o = ________

Step 5) Water quality outlet orifice diameter (minimum of 1/2 inch), D_o (in)
$D_o = 12 * 2 * (Q_{WQ}/(C_o * \pi * (2 * g * H)^{0.5}))^{0.5}$ — D_o (in) = ________
(If orifice diameter < 4 inches, use outlet type 2 or 3)

Step 6) To size outlet orifice for EWDB with an irregular stage-volume relationship, use the Single Orifice Worksheet

IIIc. Water Quality Outlet, Perforated Riser

Step 1) Depth of water quality volume above permanent pool, Z_{WQ} (ft) — Z_{WQ} (ft) = 3.0

Step 2) Recommended maximum outlet area per row, A_o (in^2)
$Ao = WQv/(0.013 * Z_{WQ}^2 + 0.22 * Z_{WQ} - 0.10)$ — A_o (in^2) = 5.9

Step 3) Circular perforation diameter per row assuming a single column, D_1 (in) — D_1 (in) = 2.8

Step 4) Number of columns, n_c — n_c = 2.0

Step 5) Design circular perforation diameter (between 1 and 2 inches), D_{perf} (in) — D_{perf} (in) = 1.9

Step 6) Horizontal perforation column spacing when $n_c > 1$, center to center, S_c — S_c (in) = 4.0
If D_{perf} >/= 1.0 in, $S_c = 4$

Step 7) Number of rows (4" vertical spacing between perforations, center to center), n_r — n_r = 9.0

Design Procedure Form: Extended Wet Detention Basin (EWDB)
Main Worksheet

Designer: ____________________
Checked By: ____________________
Company: ____________________
Date: ____________________
Project: ____________________
Location: ____________________

IIId. Water Quality Outlet, V-Notch Weir[6]

Step 1) Depth of water quality volume above permanent pool, Z_{WQ} (ft)	Z_{WQ} (ft) =	________
Step 2) Average head of water quality pool volume over invert of v-notch, HWQ (ft) $H_{WQ} = 0.5 * Z_{WQ}$	H_{WQ} (ft) =	________
Step 3) Average water quality pool outflow rate, Q_{WQ} (cfs) Q_{WQ} = (WQv * 43,560)/(40 * 3,600)	Q_{WQ} (cfs) =	________
Step 4) V-notch weir coefficient, C_v	C_v =	________
Step 5) V-notch weir angle, θ (deg) $\theta = 2 * (180/\pi) * \arctan(Q_{WQ}/(C_v * H_{WQ}^{5/2}))$ V-notch angle should be at least 20 degrees. Set to 20 degrees if calculated angle is smaller.	θ (deg) =	________
Step 6) V-notch weir top width, W_v (ft) $W_v = 2 * Z_{WQ} * TAN(\theta/2)$	W_v (ft) =	________

Step 7) To calculate v-notch angle for EWDB with an irregular stage-volume relationship, use the V-notch Weir Worksheet

IV. Trash Racks

Step 1) Total outlet area, A_{ot} (in^2)	A_{ot} (in^2) =	106.4
Step 2) Required trash rack open area, A_t (in^2) $A_t = A_{ot} * 77 * e^{(-0.124 * D)}$ for single orifice outlet $A_t = (A_{ot}/2) * 77 * e^{(-0.124 * D)}$ for orifice plate or perforated riser outlet $A_t = 4 * A_{ot}$ for v-notch weir outlet	A_t (in^2) =	2910.6

V. Forebay

Step 1) Volume should equal at least 10% of WQv	Min Vol_{FB} (ac-ft) =	0.4
Step 2) Forebay depth, Z_{FB} (ft)	Z_{FB} (ft) =	4.0
Step 3) Minimum forebay surface area, A_{FB} (ac)	Min A_{FB} (ac) =	0.1
Step 4) Paved/hard bottom and sides?		________

Design Procedure Form: Extended Wet Detention Basin (EWDB)
Main Worksheet

Designer: ____________________
Checked By: ____________________
Company: ____________________
Date: ____________________
Project: ____________________
Location: ____________________

VI. Littoral Bench

Step 1) Littoral bench should be 25% - 50% of the permanent pool surface area	Min A_{LB} (ac) =	0.5
	Max A_{LB} (ac) =	1.0
Step 2) Approximate minimum and maximum bench widths, assuming circular permanent pool	Min W_{LB} (ft) =	83.4
	Max W_{LB} (ft) =	117.9
Step 3) Design bench width around perimeter of EWDB, W_{LB} (ft)	W_{LB} (ft) =	100.0
Step 4) Bench depth below permanent pool surface, Z_{LB} (ft)	Z_{LB} (ft) =	12.0

VII. Basin side slopes

Basin side slopes should be at least 4:1 (H:V) — Side Slope (H:V) = ________

VIII. Dam Embankment side slopes

Dam Embankment side slopes should be at least 3:1 (H:V) — Dam Embankment (H:V) = ________

IX. Vegetation

Check the method of vegetation planted in the EWDB or describe "other"

___ Native Grass
___ Irrigated Turf Grass
___ Native Aquatic Species
___ Other: ___ __________
____

X. Inlet Protection

Indicate method of inlet protection/energy dissipation at EWDB inlet ________