EXTENDED DETENTION BASIN EXAMPLE	1113-3
	REFERENCE SECTION 1113

Given:

- Total Tributary Area = 7.5 ac
    - Tributary Area within Existing R/W = 5.8 ac
    - Tributary Area, Impervious, Outside of R/W = 0.0 ac
    - Tributary Area, Pervious, Outside of R/W = 1.7 ac
    - Tributary Area, Pavement and Paved Shoulders = 1.5 ac
    - Tributary Area, Berms and Slopes 4:1 or Flatter = 6.0 ac
- Rainfall Area B
- Time of Concentration, t_c = 25 min (calculation shown in this example)

Calculate the water quality volume WQ_v:

- WQ_v= (R_V * P * A) / 12
- P = 0.90 in
- A = 7.5 ac
- RV = 0.05 + 0.9 * i
    - i = impervious area divided by the total area (within the BMP drainage area)
    - The area within existing ODOT right-of-way is considered impervious area for the purpose of post-construction BMP design considerations. (L&D Vol 2, Sec. 1111.6.1)
    - i = $\frac{5.8\ ac + 0.0\ ac}{7.5\ ac}$ = 0.773
- R_V = 0.05 + 0.9 * 0.773 = 0.746
- WQ_V = (0.746 * 0.90 in * 7.5 ac) / 12
- WQ_V = <u>0.42 ac-ft</u>

Calculate the minimum detention basin volume, forebay volume, and micropool volume:

- Minimum basin volume = WQ_V * 1.2 (due to 20% increase)
        - WQ_V* 1.2 = 0.42 ac-ft *1.2 = 0.504 ac-ft
- 10% WQ_V for forebay volume, 10% * 0.042 ac-ft = <u>0.042 ac-ft</u>
- 10% WQ_V for micropool volume, 10% * 0.42 ac-ft = <u>0.042 ac-ft</u>

Layout a detention basin configuration that meets the following requirements:

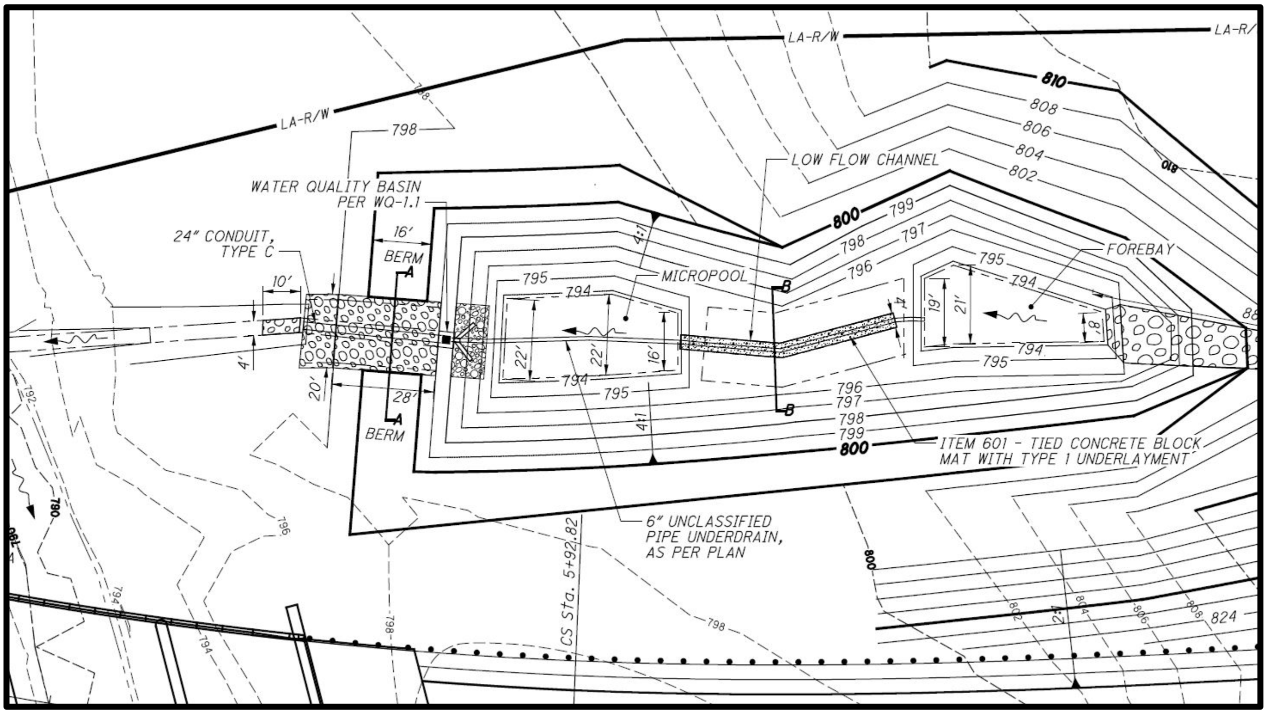
- Forebay volume below the lowest outlet elevation at upstream end of the basin
- Micropool volume below the lowest water quality outlet invert elevation at the downstream end of the basin
- Maximum 4:1 side slopes
- Include provisions for vehicle access

EXTENDED DETENTION BASIN EXAMPLE

1113-3

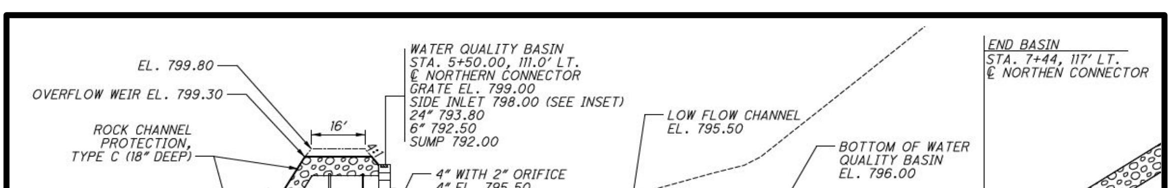
REFERENCE SECTION 1113

Detention Basin Plan View:



Note: Section AA and BB not shown in this example.

Detention Basin Profile View:



Forebay:

- The forebay volume is the volume stored upstream of the low flow channel. The volume in the forebay is held in a permanent pool and is unable to flow downstream towards the outlet. The purpose of the forebay is to allow runoff to slow sufficiently for coarse sediment to settle out. This improves performance and reduces the maintenance burden by concentrating sediment buildup in one location designed for maintenance access.
- Forebay volume must be greater than or equal to 0.042 ac-ft.
- Forebay volume as calculated in CAD for this example = 0.042 ac-ft.
- 0.042 ac-ft is equal to the 0.042 ac-ft requirement: Acceptable

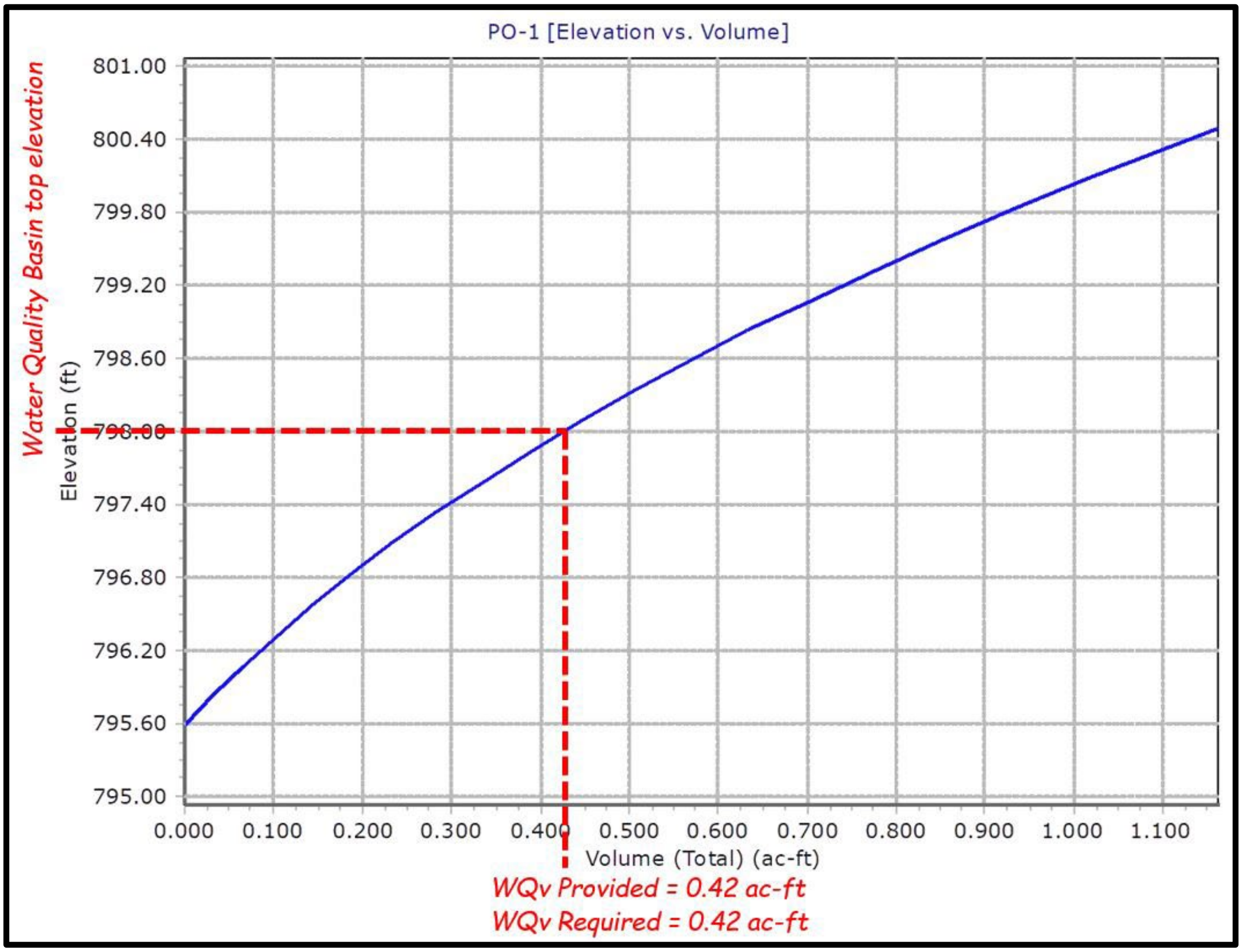
Micropool:

- The micropool volume is the volume that is stored below the lowest invert elevation of the lowest water quality outlet. The purpose of the micropool is to slow runoff draining towards the outlet structure, promote sediment settling below the outlet structure, and allow use of a non-clogging outlet. This improves performance and reduces clogging and maintenance.
- Micropool volume must be greater than or equal to 0.042 ac-ft.
- Micropool volume as calculated in CAD for this example = 0.047 ac-ft.
- 0.047 ac-ft is greater than 0.042 ac-ft requirement: Acceptable

Water Quality Volume (WQ_V) Storage:

- The WQ_V must be fully stored above the lowest water quality outlet elevation.
- The lowest water quality outlet is at an elevation of 795.58 ft.
- The WQ_V (0.42 ac-ft) must be stored between 795.58 ft and side inlet bottom elevation.

Stage (Elevation) vs. Volume Curve:

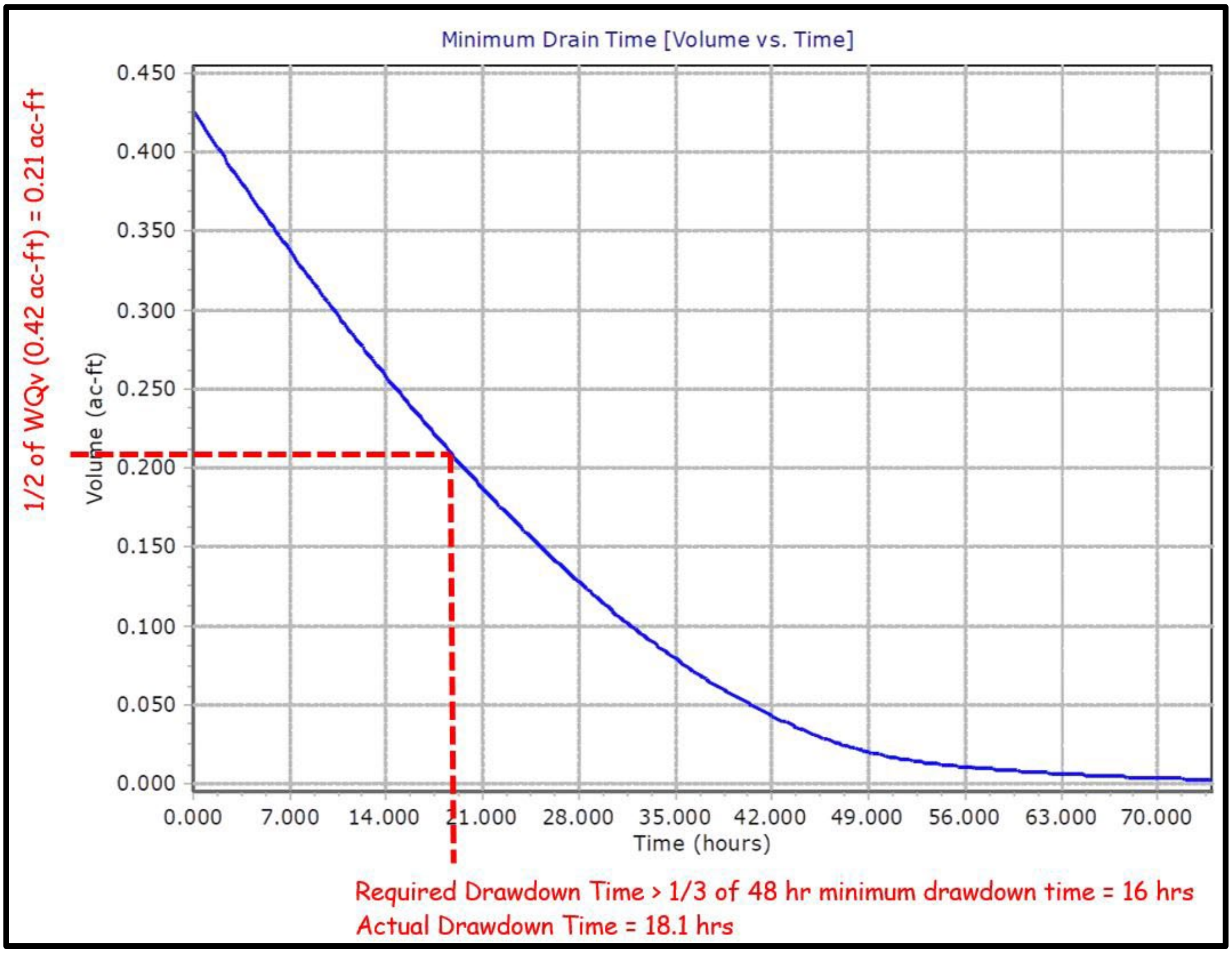


The graph shows that the full WQ_V is stored between 795.58 ft and 798.0 ft in the detention basin. The forebay and micropool have been excluded from this stage vs. volume graph since the volume associated with the forebay and micropool is assumed to be constantly standing in water.

Design the Detention Basin Water Quality Outlet:

- The minimum discharge time of the WQ_V is 48 hours with no more than 50% of the WQ_V being released from the detention basin in the first one-third of the 48 hour drain time.
- WQ_V = 0.42 ac-ft; must take 48 hours or longer to drain
- 50% or less of the WQ_V (i.e. 0.21 ac-ft) must be drained in 16 hours.
- Choose a 2 in diameter circular orifice 795.58 ft
- Calculate the drawdown curve.
    - This calculation can be done by hand by creating a stage vs. discharge table and interpolating between values, but it is generally easier to use a model to simulate runoff through a detention basin such as PondPack or HydroCAD.
- Do not route a design storm hydrograph through a detention basin to determine the drawdown curve. Start the simulation with the water surface at a level equivalent to the WQ_V storage (for this example, at an elevation of 798.00). Then allow the pooled water filling the WQ_V to drain by gravity out of the water quality outlet structure. Include all detention basin outlets that would affect this drawdown curve. Include any downstream constraints such as tailwater or limiting conveyance downstream. For this example, there is no tailwater and there is a free discharge from the detention basin.

Modeled Drawdown Curve using Pond Pack:



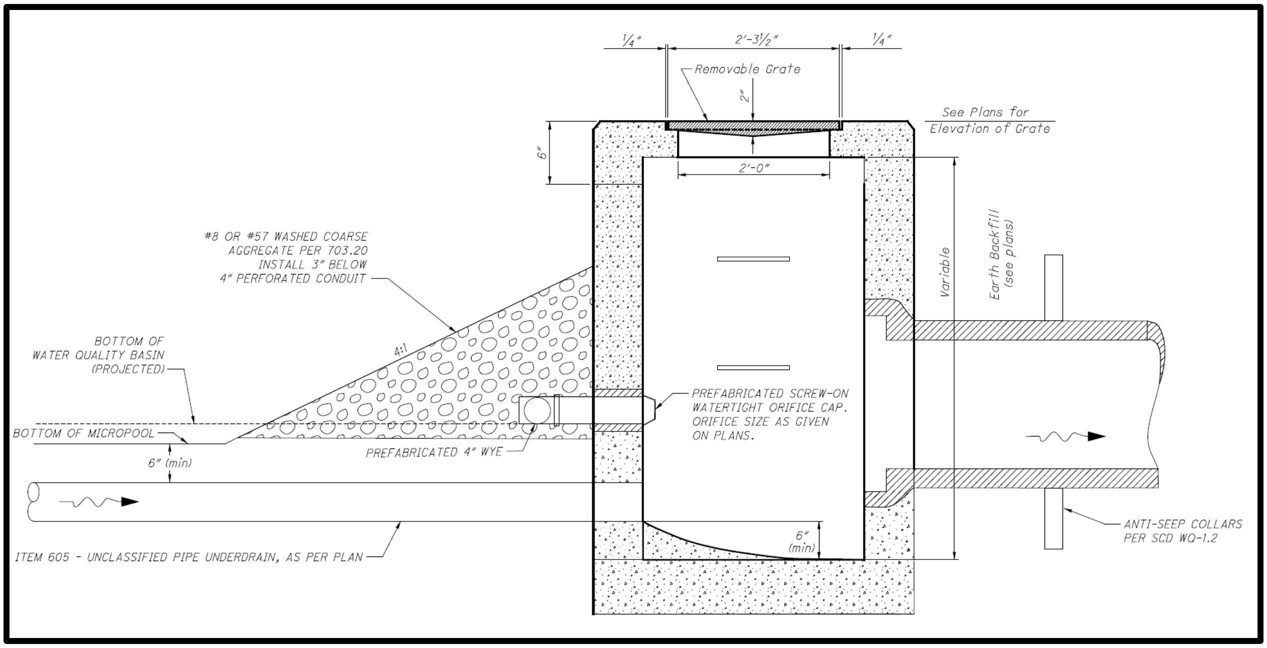
- The graph shows that it takes longer than 48 hours to drain the WQ_v (0.42 ac-ft); therefore, <u>it is acceptable.</u>
- The graph shows that it takes at least 16 hours ($^1/_3$ of the minimum drawdown time) to drain one-half of the WQ Basin WQ_V (0.21 ac-ft); therefore, <u>it is acceptable.</u>

Size the Primary Detention Basin Outlet:

- There are three main parts of a typical extended detention basin discharge structure:
  - Water quality outlet(s)
  - Primary outlet
  - Overflow weir

- The primary detention basin outlet normally consists of a catch basin grate, catch basin side inlets, and the conduit that conveys discharges from the detention basin during all but the least frequent precipitation events.
- The primary outlet should be sized to convey the 10% AEP design storm.

ODOT Water Quality Catch Basin Detail (WQ-1.1):



Determine the 10% AEP design flow rate:

- For the purposes of post-construction BMP calculations, all existing right-of-way is to be considered impervious. For the purpose of general conveyance sizing, runoff coefficients should be calculated using Table 1101-2 in ODOT's L&D Vol. 2.
- Q = CiA

Calculate the weighted C value:

1.5 acres of tributary area are pavement and paved shoulders: C = 0.9

6.0 acres of tributary area are berms and slopes 4:1 or flatter: C = 0.5

$C_{weighted} = \frac{1.5\ ac*0.9+6.0\ ac*0.5}{7.5\ ac} = 0.58$

Time of Concentration (t_c) Calculations:

- t_c = Time of overland flow (t_O) + Time of shallow concentrated flow (t_S) + Time of channel flow (t_C)
- Overland Flow (t_O)
  - $\frac{1.8(1.1-C)(L)^{1/2}}{s^{1/3}}$
  - C = Runoff Coefficient (0.58 for this example)
  - L = Distance to most remote location in drainage in feet (max. 300 ft) (200 ft in this example)
  - s = Overland slope (percent) (0.33% in this example)
  - $\frac{1.8(1.1-0.58)(200)^{1/2}}{0.33^{1/3}}$= **19.16 minutes**
- Shallow Concentrated Flow (t_s)
  - V_S = Velocity of shallow concentrated flow (ft/sec) = $3.281ks^{0.5}$
  - k = Intercept Coefficient (L&D Table 1101-1) = (0.457 in this example)
  - s = Overland slope (percent) (0.33% in this example)
  - $V_S = 3.281 * 0.457 * 0.33^{0.5}$= 0.86 ft/sec
  - Length of shallow concentrated flow = 200 ft.
  - t_S = 200 ft / 0.86 ft/sec = 233 sec = **3.88 minutes**
- Channel Flow (t_C)
  - Manning's Equation: $V = \frac{1.49r^{2/3}\, s^{1/2}}{n}$
  - V = velocity in the channel (ft/sec)
  - r = hydraulic radius (0.69 ft in this example)
  - s = channel slope (0.01 ft/ft in this example)
  - n = Manning's Roughness Coefficient (L&D Vol. 2, Table 1102-3) (0.03 in this example)
  - $V = \frac{1.49*0.69^{2/3}*0.01^{1/2}}{0.03}$= 3.88 ft/sec
  - Channel length = 500 ft (for this example)
  - t_c = 500 ft / 3.88 ft/sec = 129 sec. = **2.15 minutes**
- $t_c = t_O + t_S + t_C$ = 19.16 + 3.88 + 2.15 = 25.19 minutes. Use t_c = **25 minutes**

Determine the precipitation intensity:

Rainfall Area B

t_c = 25 min

(The time of concentration is given in this example as 25 minutes because there is significant overland flow over grassed area. The time of concentration for each site should be based on the site-specific flow path. 25 minutes would likely be too high of a value if the detention basin were receiving flow from a piped system. See the time of concentration calculations above.)

L&D Vol. 2, Figure 1101-2: Area B, 10% AEP frequency, 25 min t_c: i = 3.4 in/hr

- 10% AEP design flow rate: Q = 0.58 * 3.4 in/hr * 7.5 ac = 14.79 cfs

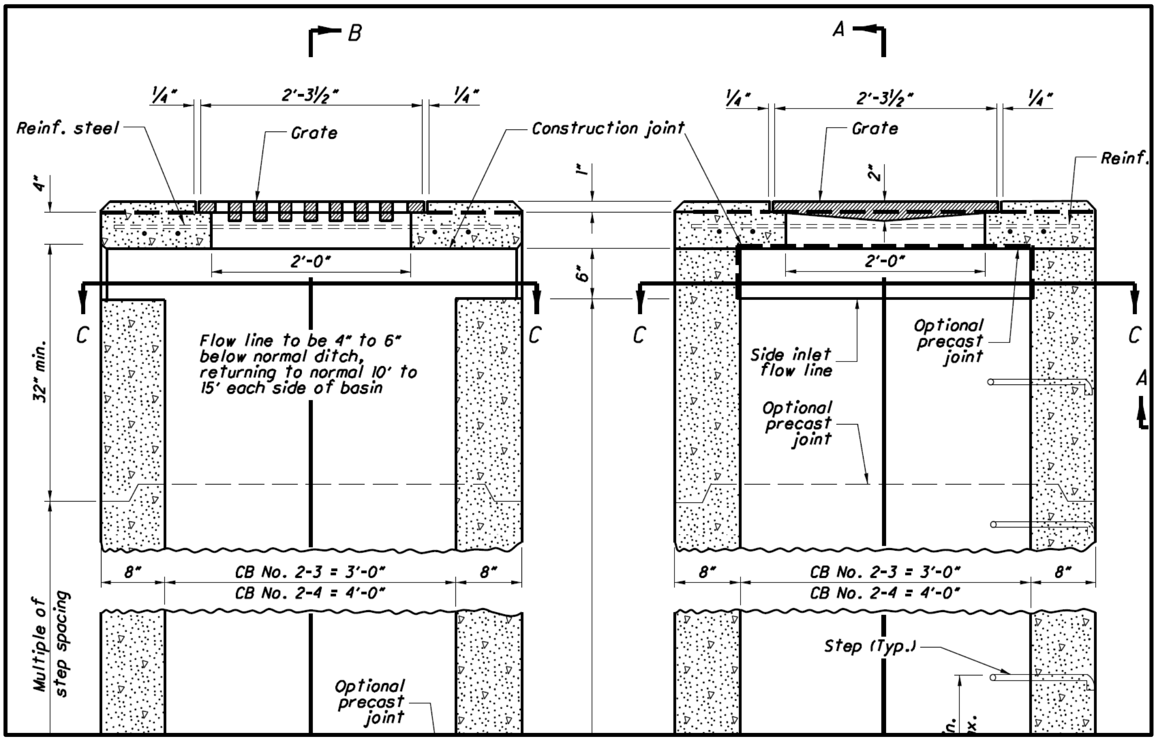
Size the primary detention basin discharge conduit:

- The discharge conduit must be large enough to convey the 10% AEP design storm, keeping the maximum hydraulic grade line within the crown of the pipe.
- This example has the following conduit characteristics:
  - Conduit slope = 0.005 ft/ft
  - No Tailwater; free discharge
  - Pipe Roughness Coefficient = 0.015 (L&D Vol. 2, Section 1104.4.5)
- The minimum conduit size that conveys the 10% AEP design flow (14.79 cfs) with the given characteristics is a 24-inch diameter pipe.

Set the catch basin grate elevation:

- The WQ_V fills the detention basin to an elevation of 798.0 ft at water surface elevations of 798.0 ft and below, all discharge should pass through the water quality outlet. (In this example, the water quality outlet is the 2 in orifice cap at 795.58 located at the outlet of the 4 in conduit at 795.5 ft)
- The ODOT standard water quality catch basin detail (SCD WQ-1.1) calls for either Catch Basin No. 2-3 or 2-4 depending on the outlet pipe size. Both catch basins have a 6-inch high side inlet that is either, 3, or 4 feet wide depending on the catch basin. See the Standard Construction Drawing for details.

ODOT Catch Basin No. 2-3 and No. 2-4:



- The side inlets are set at 1 ft below the grate elevation in accordance with the subject Standard Construction Drawing. The elevation of the bottom of the side inlet should be set at the WQ_V elevation. Therefore, any runoff volume above the WQ_V will discharge into the catch basin through the side inlet and subsequently the grate.
    - Side inlets bottom elevation = 798.0 ft (Top of WQ_V)
    - Catch basin grate elevation = 799.0 ft

Set the catch basin invert elevation:

- Set the catch basin invert elevation to the lowest of:
    - 6 in below the orifice invert
        - 793.58 – 0.5 = 793.08
    - 6 in below the 6 in underdrain invert
        - 792.50 – 0.5 = 792.00
    - Invert of the discharge conduit
        - 793.8
    - Catch basin invert elevation = 792.00 ft

Set the Overflow Weir Invert Elevation:

- The 10% AEP design flow rate (14.79 cfs) should pass fully through the primary discharge. Therefore, no flow should discharge from the overflow weir until the 10% AEP design flow rate has been exceeded.
- Set the overflow weir invert elevation just high enough above the catch basin grate such that the full 10% AEP design flow rate is conveyed through the primary discharge.
- For this example, the primary discharge pipe is sized at 24 inches in diameter; therefore, Water Quality Basin using a Catch Basin No. 2-3 is appropriate.
- Catch Basin No. 2-3 has the same grate as Catch Basin No. 2-2B.
- The Water Quality Basin has three openings, in addition to the water quality outlet, to discharge runoff: 2- Side Inlets and the No. 2-2-B Grate.
- The composite stage-discharge relationship of these two openings can be hand calculated using appropriate weir and orifice equations. Alternatively, most commercial software programs can also perform the required calculations.
- Using a common commercial software program, the water surface elevation required to pass a flow rate of 14.79 cfs is 799.3.
- Set the overflow weir elevation at 799.3.

Size the Emergency Overflow Weir and Set the Top of Basin Elevation:

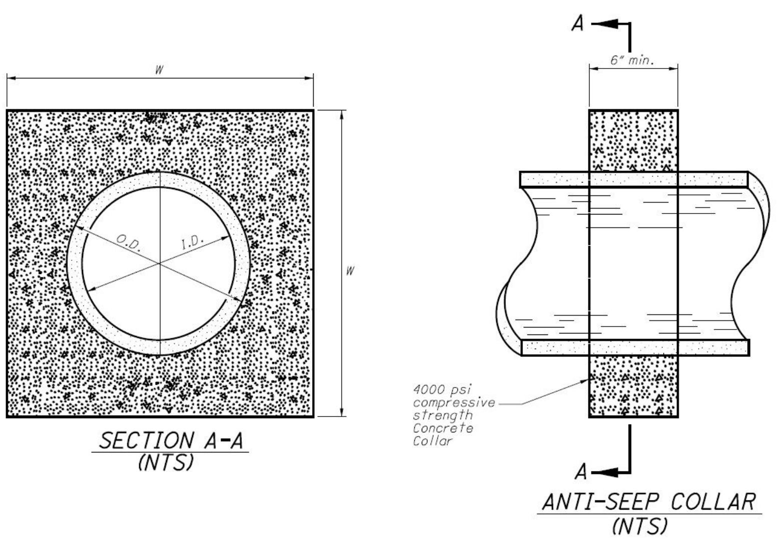
- L&D Vol. 2, Section 1104.3.2 states that the hydraulic grade line should be checked for the 4% AEP storm.
- The 4% AEP design flow rate should pass fully through the overflow weir.
- Calculate the design flow rate:
    - 4% AEP intensity @ t_C = 25 min and Rainfall Area B: 3.8 in/hr
    - 4% AEP design flow rate: Q = CiA = 0.58 * 3.8 in/hr * 7.5 ac = 16.53 cfs
- Calculate the required weir length for each design storm flow:
    - Overflow weir elevation = 799.30 ft
    - Assume a top of detention basin elevation of 799.80 ft.
    - Maximum height at overflow weir = 799.30 ft – 799.80 ft = 0.50 ft
    - Weir equation: $Q = C*L*H^{1.5}$
        - C = 3
        - H = 0.7
        - L = ?
    - Length of a weir: $L = \frac{Q}{C*H^{1.5}}$

  - 4% AEP: L = $\frac{16.53}{3*0.5^{1.5}}$= 15.6 ft
- Provide a 16 ft wide overflow weir.
- The top of basin elevation is 799.80 ft.
- The overflow weir length could be reduced by increasing the top of basin elevation. Or the top of basin elevation can be lowered by increasing the overflow weir length. The 4% AEP design flow rate must fully pass through the overflow weir without overtopping the detention basin.
- Flow rates greater than the 4% AEP design flow rate may overtop the detention basin uncontrolled.
- Provide erosion protection at the overflow weir, to the bottom of the berm, and continuing downstream if there is erosion potential.

Design Anti-Seep Collars:

- Anti-seep collars reduce the conveyance of flow along pipe bedding, outside of a conduit and increase the flow path for the seepage of water. This helps protect the berm above the discharge conduit from a detention basin from internal erosion.

ODOT Standard Drawing WQ-1.2:



DIAMETER (I.D.)	CONCRETE (C.Y.)		
	DIMENSION OF COLLAR W X W (FT.)		
(FT.)	3X3	4X4	5X5
1	0.15	0.28	0.45
2	N/A	0.24	0.40
3	N/A	N/A	0.33

- Calculate the saturated zone length along the conduit (Ls)
    - Ls = Y(Z+4)[1+S/(0.25-S)]
    - Y = depth of water during the 10% AEP storm
    - Z = slope of embankment
    - S = slope of conduit
- Maximum elevation at 10% AEP storm = 799.30 ft
- Conduit elevation = 793.80 ft
- Y = 799.30 ft – 793.80 ft = 5.50 ft
- Z = 4
- S = 0.005
- Ls = 5.50 (4+4)[1+0.005/(0.25-0.005)] = 44.90 ft
- ΔLs = 0.15*Ls = 0.15 * 44.90 ft = 6.7 ft
- Total Projection: P = W – D
    - W = 2ft + 2 ft diameter + 2 ft = 6 ft
    - P = 6 ft – 2 ft = 4 ft
- Number of collars = ΔLs / P = 6.7 ft / 4 ft = 1.7
    - Minimum of 2 collars per outlet conduit
    - <u>Use 2 anti-seep collars</u>
- Place both anti-seep collars in a saturation zone (within 44.90 ft of front edge of berm).
- Spacing between collars: between 10 and 25 feet

Additional Considerations:

- Vegetate the sides of the detention basin with Item 670 Slope Erosion Protection per L&D Vol. 2, Section 1113.3.1.
- Connect the forebay to the micropool in the bottom of the detention basin with a low flow channel lined with tied concrete block or rock channel protection.
- For all open water carriers at each inlet and discharge from the detention basin, check the shear stress and ensure appropriate lining per L&D Vol. 2, Section 1102.3.2.
- For all discharges into or out of a detention basin, ensure that appropriate rock channel protection is included per L&D Vol. 2, Section 1105.2.5.
- Place a 6” thick layer of Item 601.10 Detention Basin Filter to all parts of the detention basin that are expected to be continually inundated with water, such as the forebay and micropool.
- Provide a 6” diameter underdrain (as per plan) located with a minimum of 6 inches of separation between the bottom elevation of the micropool and the crown of the underdrain. Extend the underdrain from the location of the low flow channel, under the micropool, and connecting into the Water Quality Basin. If the invert of the outlet conduit from the Water Quality Basin is not lower than the orifice elevation, then do not include the 6” diameter underdrain. The underdrain is as per plan because the trenching and backfilling requirements are waived to reduce the potential for short circuiting of water in the detention basin.
- Include calculated detention basin ponding elevations in the calculation of the hydraulic grade line for the upstream conveyance system per L&D Vol. 2, Section 1104.3.2.
- Attempt to locate structures outside of designated flood plains. If a detention basin encroaches on a flood plain, follow the flood assessment requirements in L&D Vol. 2 Section 1005.
- Ensure that safety criteria are met in the clear zone per L&D Vol. 1, Section 600.2.
- Ensure that no more than one foot of permanent standing water is located within the clear zone without barrier protection, per L&D Vol. 1, Section 601.1.1.
- Engage local project stakeholders in potential public safety considerations associated with detention basins.
- Develop a plan for how regular maintenance will be performed.
    - Vehicle access
    - Mowing
    - Removal of woody vegetation
    - Regular unclogging of the water quality outlet