4.9 Extended Dry Detention BMP Fact Sheets

Description: A storage facility designed to provide water quantity control and some water quality control through detention and/or extended detention of storm water runoff. It has an outlet structure that detains and attenuates runoff inflows and promotes the settlement of pollutants. Facility normally remains dry between storm events. A subsurface extended detention basin is located entirely below the ground surface in a vault, pipe, or stone bed.

IMPORTANT CONSIDERATIONS

DESIGN REQUIREMENTS:

- A sediment forebay or upstream pretreatment must be provided for above ground and underground detention and be easily-accessible for cleanout and maintenance.
- All inlets must have an energy dissipation structure, which can be incorporated into the forebay.
- The design must provide for sediment storage equal to 20 percent of the detention volume.
- The minimum diameter of any outlet orifice must be 2.5 inches, unless a non-clogging design is provided.
- Minimum length to width ratio of 3:1.
- Water quality volume to be released over 2 days.
- The maximum depth must not exceed 9.0 feet.
- All basin side slopes must not exceed 3:1 (h:v).
- The basin bottom must be sloped at least 1% towards the outlet orifice.
- A landscaping/vegetation and maintenance plan is required.

ADVANTAGES/BENEFITS:

- Very effective in controlling peak flows associated with development.
- Moderately effective at removing TSS and TP.
- Typically less costly than storm water (wet) ponds for equivalent flood storage.
- May be an important part of a treatment train for water quality control.

DISADVANTAGES/LIMITATIONS:

- Does not meet pollutant removal rates required unless used with other water quality BMPs.
- Tend to develop soggy bottom which hinders maintenance and growth of effective vegetation cover.
- Can require extensive maintenance depending on location and characteristics of contributing drainage area.

MAINTENANCE CONSIDERATIONS:

- Adequate easement must be provided for maintenance.
- Inspect inlets and outlets for clogging and damage.
- Remove accumulated sediment and trash.

STORMWATER MANAGEMENT SUITABILITY

L = Low **M** = Moderate **H** = High

M	**1-inch, 6-hr Water Quality Control**
H	**1-yr, 24-hr Channel Protection Volume**
H	**Peak Attenuation Control for 10-yr, 6-hr Storm**
H	**Peak Attenuation Control for 25-yr, 6-hr storm**

Extended detention basins can provide some water quality benefit for the 1-inch, 6-hour storm event. They are typically designed to be good benefit for control of larger storm events such as the 1-year, 24-hour storm or other flood control storm events.

IMPLEMENTATION CONSIDERATIONS

H	**Land Requirements**
M	**Capital Cost**
H	**Maintenance Cost**
H	**Maintenance Considerations**

PRIMARY POLLUTANT REMOVAL PROCESSES

- Settling

POLLUTANT REMOVAL RATES

Effectiveness	Detention Time	Pollutant Removal Rates
Standard	**2.0 days**	**30% TSS 30% TP**

4.9 Extended Dry Detention Basins

4.9.1 General Description

Extended dry detention basins are facilities intended to provide for the temporary storage of storm water runoff to reduce downstream water quantity impacts and provide limited removal of pollutants from storm water runoff. These facilities temporarily detain storm water runoff, releasing the flow over a period of time. They are designed to completely drain following a storm event and are normally dry between rain events. Compatible multi-objective use of extended dry detention facilities is strongly encouraged.

Extended dry detention basins are generally applicable to most types of new development and redevelopment, and can be used in both residential and non-residential areas. Extended dry detention facilities must be used in a treatment train with other structural controls to provide full treatment of the WQ_v. Extended dry detention basins can also be used in retrofit situations.

Figure 4.9.1 shows typical local extended dry detention basins and Figure 4.9.2 shows a schematic of an extended dry detention basin.

Figure 4.9.1 Example of Extended Dry Detention BMP

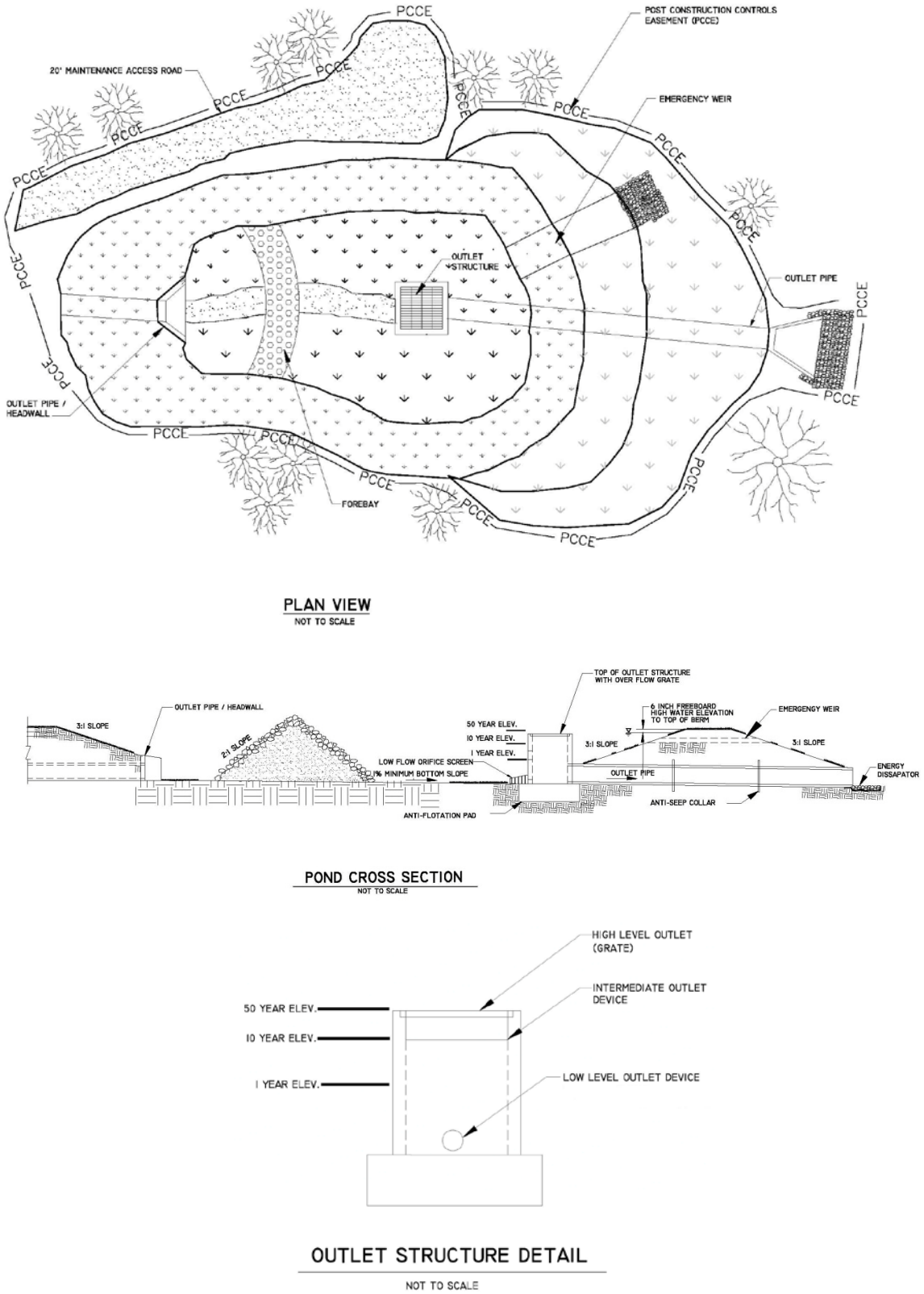

Figure 4.9.2 Schematic of Extended Dry Detention Basin

4.9.2 Storm Water Management Suitability

Extended dry detention basins provide limited pollutant removal benefits and are not intended for full water quality treatment. Extended dry detention facilities must be used in a treatment train approach with other structural controls to provide full treatment of the WQ_v. Extended detention dry basins can provide downstream channel protection volume (CP_v) through extended detention. Extended dry detention basins can provide on-site flood control (peak flow reduction) and can be designed to control the extreme flood (50-year, Q_{50}) storm event.

Water Quality

Extended dry detention basins treat incoming storm water runoff by physical processes. The primary removal mechanism is gravitational settling of particulates, organic matter and metals as storm water runoff resides in the detention basin. Pollutant re-suspension must be minimized in order to ensure that the design pollutant removal efficiencies are achieved.

Channel Protection Volume

A portion of the storage volume in an extended dry detention basin can be used to control the channel protection volume (CP_v). This is accomplished by releasing the 1-year, 24-hour storm runoff volume over 24 hours (extended detention) or longer holding time, if desired. In Charlotte, this extended detention time is a minimum of 48 hours after the center of the 24-hour storm.

Within the City of Charlotte, one of the mitigation options for development and redevelopment in distressed business districts and transit stations areas is to control the 1-year 24 hour volume and 10-year peak. An extended dry detention basin is one of the ways that this volume control requirement can be met.

Peak Attenuation Control (Q_p)

An extended dry detention can very effectively reduce the post-development peak flow of the 10-year and 25-year 6-hour storm (Q_p) (if required) to pre-development levels. The detention emergency spillway design is the 50-year storm with 6 inches of freeboard.

4.9.3 Pollutant Removal Capabilities

One extended detention basin design has been developed for application in the Mecklenburg County area. The *standard efficiency design* has the capability to remove 30% of the total suspended solids and 30% of the total phosphorus load. This design assumes urban post-development runoff conditions that has been observed in the Mecklenburg County area and that the facilities are sized, designed, constructed, and maintained in accordance with the appropriate recommended specifications contained in this manual. The design pollutant removal rates are derived from sampling data and computations completed for the development of this manual. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or treatment train approach. See section 4.9.4 for a discussion of design variables and appropriate pollutant removal rates for specific designs.

4.9.4 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of an extended detention basin. Items listed in Section 4.9.4.A through 4.9.4.B. are requirements and must be addressed in the design. Items listed in Section 4.9.4.C. are recommendations and are optional.

A. Design Requirements

Following is a list of design requirements that must be followed in the design of extended dry detention basins:

- Following are the design values that are required for the extended dry detention basin that is available for application in Mecklenburg County. The appropriate minimum design values and associated pollutant removal rates for each of the design are given in Table 4.9.1.

Table 4.9.1 Design Values and Pollution Removal Rates

Threshold	Minimum Detention Time	Pollution Removal Rate
Standard Efficiency	**2.0 days**	**30% TSS 30% TP**

- A 2-day detention time is required in an extended detention basin in order to achieve a 30 percent TSS and TP removal rate. The detention time is the time from when the center of the rainfall distribution for the design storm event until only 5 percent of that volume remains in an extended detention basin is defined as the basin's detention time. Therefore, for the extended detention basin, 5 percent of the runoff volume must be held within the storage volume at 27 hours (24 hours beyond the center of a 6-hour storm event).

- A sediment forebay sized to have a minimum of 0.2 acre-inches per impervious acre of contributing drainage must be provided for extended dry detention.

- A sediment forebay or upstream pretreatment must be provided for above ground and underground detention BMPs. These structures must trap and store sediment in locations where cleanout and maintenance can be easily performed. For underground detention BMPs, a hydrodynamic structure, a forebay chamber with permanent pool, or other water quality BMP may be used.

- There must be energy dissipation devices at all concentrated inflow locations. The energy dissipation device can be incorporated into the forebay.

- Sediment storage equal to 20 percent of the detention volume must be provided.

- The height of the forebay berm embankment shall be at the elevation of the WQv.

- All embankments shall be designed per the North Carolina Dam Safety Law of 1967, if applicable, and designed according to the requirements in Section 4.0.6 of this manual.

- The berm shall be designed to allow low flow from the forebay to the main compartment of the basin.

- The minimum diameter of any outlet orifice must be 2.5 inches, unless a non-clogging design is provided.

- The basin bottom must be sloped at least 1% towards the outlet orifice.

- Minimum length to width ratio of 3:1.

- The maximum depth of extended dry detention facilities must not exceed 9.0 feet.

- Vegetated slopes must be less than 20 feet in height and must have side slopes no steeper than 3:1. Riprap-protected slopes must be no steeper than 2:1. Geotechnical slope stability analysis is recommended for slopes greater than 10 feet in height and is mandatory for embankment slopes steeper than those given above.

B. Inlet/Outlet Structures

- Inflow channels are to be stabilized with flared riprap aprons, or the equivalent.

- For an extended dry detention basin, the outlet structure is sized to control all design storms (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure. Small outlets that will be subject to clogging or are difficult to maintain are not acceptable.

- The orifice should have a minimum diameter of 2.5 inches (unless a special non-clogging design is provided). See Chapter 5 (Outlet Structures) for more information on the design of outlet works.

- Seepage control or anti-seep collars should be provided for all outlet pipes.

- Riprap, plunge pools or pads, or other energy dissipators must be placed at the end of the outlet to prevent scouring and erosion. If the basin discharges to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance.

- An emergency spillway must to be included in the extended dry detention basin design to safely pass the 50-year flood flow. The spillway prevents pond water levels from overtopping the embankment and causing structural damage. The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.

- Minimum of 0.5 feet of freeboard must be provided, measured from the top of the water surface elevation for the extreme flood, to the lowest point of the dam embankment not counting the emergency spillway.

- A water-tight seal (rubber boot or equivalent) must be provided between all riser and pipe joint connections to minimize leakage.

C. Landscaping

- Landscape design must specify proper grass species and other plants based on specific site, soils, and hydric conditions present within the facility. See Chapter 6 – Vegetation and Landscaping. Figure 4.9.3 presents the planting zones that should be considered when developing a landscaping plan for an extended dry detention basin.

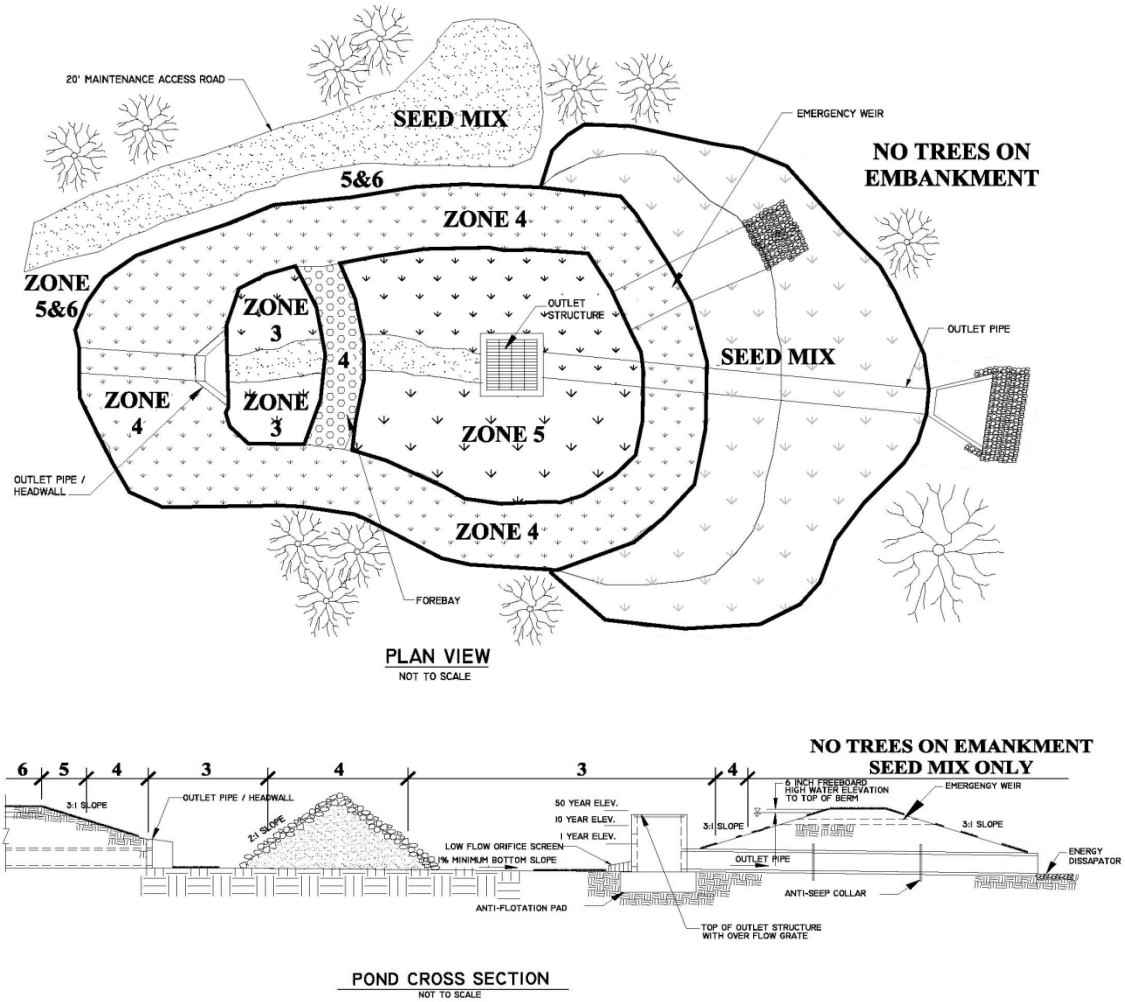

Figure 4.9.3 Planting Zones for Extended Dry Detention

D. Design Recommendations

In addition to the design requirements, following are some design recommendations that should be considered for extended dry detention facility design:

- Extended dry detention basins are normally located downstream of other structural storm water controls providing treatment of the water quality volume (WQ_v). Extended dry detention basins may be part of a treatment train, which treats the WQ_v.

- Storage may be subject to the requirements of the North Carolina Dam Safety Program, based on the volume, dam height, and level of hazard.

- Earthen embankments less than 6 feet in height that are exposed to flood waters should consider the side slopes to be no greater than the natural angle of repose of the fill material as determined by a geotechnical study. In lieu of a geotechnical study side slopes must be 3:1 (horizontal to vertical) maximum.

- The bottom area of extended dry detention basins should be graded toward the outlet to prevent standing water conditions. A low flow or pilot channel across the facility bottom from the inlet to the outlet (often constructed with concrete) is recommended to convey low flows and prevent standing water conditions.

4.9.5. Design Procedure

The following steps outline the procedure to be used for the design of extended dry detention basins.

Step 1 Using the BMP Selection Matrix at the beginning of Chapter 4 determine if the development site and conditions are appropriate for the use of an extended dry detention basin.

Step 2 Consider any special site-specific design conditions and determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

Step 3 Compute water quality volume (WQ_v) using equations 3.2 and 3.3 – $WQ_v = 1.0R_vA/12$.

Step 4 Compute site hydrologic parameters using the SCS procedures and/or computer models that use the SCS procedures.

Step 5 Compute water quality peak flow (WQ_p) using equation 3.4 for a modified curve number and the SCS hydrograph procedures with a 1-inch, 6-hr, balanced storm event.

Step 6 Compute channel protection volume (CP_v) using the SCS method and a 1-yr, 24-hr storm event. Estimate approximate storage volume for channel protection stability using the SCS method.

Step 7 Compute the release rates for the water quality control and channel protection control.

Step 8 Compute pretreatment volume.

A sediment forebay is provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the extended dry detention basin. The forebay should be sized to contain 0.2 inches per impervious acre of contributing drainage and should be 4 to 6 feet deep. The forebay storage volume may be included in subsequent routing calculations.

Step 9 Compute the water quality extended detention volume. Size the extended pool volume to contain the greater of the WQ_v or the CP_v. In most cases the CP_v will be larger than the WQ_v.

Step 10 Determine extended dry detention basin location and preliminary geometry. Conduct basin grading and determine storage available for extended detention, and flood control.

This step involved initially grading the basin (establishing contours) and determining the elevation storage relationship for the basin.

Step 11 Set design elevations and dimensions of facility.

Step 12 Based on the elevations established for the extended dry detention basin water quality volume, the water quality orifice is sized to release this extended detention volume in 2 days. Perform iterative routing computations to ensure that 5 percent of the runoff volume remains within the storage volume after 2 days. Finalize the peak stage for the 1-inch, 6-hour storm event based on the routing computations.

Step 13 Compute extended dry detention basin orifice release rate(s) and size(s), and establish CP_v elevation considering the orifice and peak stages developed in Step 12. Perform iterative routing computations to ensure that 5 percent of the runoff volume remains within the storage volume after the design holding time. Finalize the peak stage for the 1-year, 24-hour storm event based on the routing computations.

Step 14 Calculate Q_p (10-year and 25-year storms – if required) release rate(s) and water surface elevation(s).

Set up a stage-storage-discharge relationship for the control structure for the extended detention orifice(s) and the 10-year and 25-year (if required) storms. Routing procedures must be used in the calculation of release rates and water surface elevations in this step.

Perform routing calculations of all design storms and make appropriate changes to outlets in order to comply with water quality and quantity requirements.

Size emergency spillway, calculate 50-year water surface elevation, set top of embankment elevation, and analyze safe passage of the 50-year flood (Q_{50}).

Step 15 Investigate potential extended dry detention basin hazard classification

Step 16 Assess maintenance access and safety features.

Step 17 Prepare vegetation and landscaping Plan

4.9.6 Inspection and Maintenance Requirements

Specific maintenance inspections and requirements are contained in each jurisdiction's Administrative Manual.

4.9.7 Design Procedure Form

Design Procedure Form: Extended Dry Detention Basin

EXTENDED DRY DETENTION BASIN FEASIBILITY	**NOTES:**
1. Is the use of an extended dry detention basin appropriate?	
2. Confirm local design criteria and applicability.	
PRELIMINARY HYDROLOGIC CALCULATIONS	
3. Compute, WQ_v volume requirements Compute Runoff Coefficient, R_v Compute WQ_v Volume requirements	Rv = _____ WQ_v = _____ acre-ft
4. Compute site hydrologic input parameters Development Conditions Area CN Adjusted CN Time of concentration	Pre-developed / Post-developed _____ acres / _____ acres _____ / _____ _____ / _____ _____ hours / _____ hours
5. Compute WQ_p peak flow	WQ_p = _____ cfs
6. Compute CP_v Compute S Compute 1-yr, 24-hr total rainfall depth Compute Q_d Compute CP_v	S = _____ Rainfall Depth = _____ inches Q_d = _____ inches CP_v =__ acre-ft
7. Compute preliminary release rates Compute WQ_v release rate Compute CP_v release rate	Release Rate = _____ cfs Release Rate = _____ cfs
EXTENDED DRY DETENTION BASIN DESIGN	
8. Pretreatment volume Vol_{pre} = Acres of Impervious Area(0.2")(1'/12")	WQ_{pre} = _____ acre-ft
9. Water Quality Extended Volume Size extended detention – pool volume is greater of WQ_v or CP_v	WQ_v= _____ acre-ft CP_v= _____ acre-ft
10. Conduction grading and determine storage available for extended detention	ED Pool Volume = _____ acre-ft Prepare an elevation-storage table and curve using the average area method for computing volumes.

Elevation MSL	Area ft^2 acres	Average Area Acres	Depth Ft	Incremental Volume Acre-ft	Cumulative Volume acre-ft

11. Determine preliminary outlet geometry and stage-discharge relations.	
12. WQ_v Orifice Computations Average ED release rate Average head, h = (ED elev.) / 2 Area of orifice from orifice equation: $Q = CA(2gh)^{0.5}$	Release Rate = _____cfs h = _____ft A = _____ ft^2 Diameter = _____in
13. Compute release rate for CP_v control and Establish CP_v elevation Release rate Average head h = (CP_velev.) / 2 Area or orifice from orifice equation: $Q = CA(2gh)^{0.5}$	WSEL = _____ ft Release Rate = _____cfs h = _____ft A = _____ ft^2 Diameter = _____in
14. Calculate Qp release rate and water surface elevation	
Peak stage for the 1-inch, 6-hour storm Peak stage for the 1-yr, 24-hour storm Peak Q_{10} – Undeveloped Peak Q_{10} – Developed Peak Q_{25} – Undeveloped Peak Q_{25} – Developed Size emergency spillway, calculate 50-year WSEL and set top of embankment elevation	Peak Stage = _____ ft Peak State = _____ ft $Q_{10\text{-undev}}$ = _____ cfs $Q_{10\text{-dev}}$ = _____ cfs $Q_{25\text{-undev}}$ = _____ cfs $Q_{25\text{-dev}}$ = _____ cfs $WSEL_{50}$ = _____ft Embankment Elevation = _____ft
15. Investigate potential extended dry detention basin hazard classification	**Notes:**
16. Assess maintenance access and safety features.	
17. Attach landscaping plan	

4.9.8 Design Example

See example 4.2.8, which is for a wet pond but the design procedure is similar to an extended dry detention basin except there is no permanent pool.