6.10 Retention and Detention BMPs

6.10.1 Constructed Treatment Wetland

Figure 6-21: Constructed Treatment Wetland at University of California, Santa Barbara

Applications

- Regional detention & treatment
- Roads, highways, parking lots, commercial, residential
- Parks, open spaces, and golf courses

Advantages

- Enhanced pollutant removal
- Aesthetically pleasing
- Creates wildlife habitat
- Treatment of large tributary areas

Limitations

- Requires year-round base flow
- Requires large footprint
- Concerns regarding vector infestation

6.10.1.1 Description

A constructed treatment wetland is a system consisting of a sediment forebay and one or more permanent micro-pools with aquatic vegetation covering a significant portion of the basin. Constructed treatment wetlands typically include components such as an inlet with energy dissipation, a sediment forebay for settling out coarse solids and to facilitate maintenance, a base with shallow sections (1 to 2 feet deep) planted with emergent vegetation, deeper areas or micro pools (3 to 5 feet deep), and a water quality outlet structure. The interactions between the incoming storm water runoff, aquatic vegetation, wetland soils, and the associated physical, chemical, and biological unit processes are a fundamental part of constructed treatment wetlands. Therefore, it is critical that dry weather base flows exceed evaporation and infiltration losses to prevent loss of aquatic vegetation and to avoid stagnation and vector problems. In situations where dry weather flows are inadequate to support the treatment wetland size, an additional source of water may be needed during summer months. Otherwise, the wetland shall be sized based on the available base flow. In addition to water quality treatment, constructed wetlands can be designed for flow control by including extended detention above the permanent pool elevation.

Constructed treatment wetlands are generally designed as plug flow systems where the water already present in the permanent pool is displaced by incoming flows with minimal mixing and no short circuiting. Plug flow describes the hypothetical condition of storm water moving through the wetland in such a way that older “slugs” of water (meaning water that’s been in the wetland for longer) are displaced by incoming slugs of water with little or no mixing in the direction of flow. Short circuiting occurs when quiescent areas or “dead zones” develop in the

wetland where pockets of water remain stagnant, causing other volumes to bypass using shorter paths through the basin (e.g., incoming storm water slugs bypass these zones). Water quality benefits are also improved when the permanent wet pool volume is significantly greater than the water quality volume, resulting in longer residence times. If flow control using extended detention is desired for meeting peak discharge requirements, the wetland will first displace water present in the permanent pool with incoming flows (usually equal to or greater than the water quality treatment volume) and will then fill the wetland above the permanent pool elevation and allow the water level to drop back to the permanent pool elevation allowing higher flows to discharge from the wetland at rates required for meeting the peak runoff discharge requirements.

It is important to note the difference between constructed treatment wetlands and mitigation wetlands that are constructed as part of mitigation requirements. Constructed mitigation wetlands are intended to provide fully functional habitat similar to the habitat they replace. Constructed treatment wetlands are intended for water quality treatment and, when applicable, flow control. They shall be designed to capture and treat pollutants to protect receiving waters, including natural wetlands and other ecologically significant habitat. The accumulation of pollutants in sediment and vegetation of constructed treatment wetlands may impact the health of aquatic biota. As such, periodic sediment and vegetation removal within constructed treatment wetlands may be required. Constructed treatment wetlands can provide opportunities for wildlife enhancement, education, and aesthetics.

Factors that favor the selection of storm water wetlands over other kinds of BMPs include enhanced treatment capability (including dry-weather flow treatment), aesthetics, and the ability to mitigate large tributary areas. Factors that may limit the use of storm water wetland basins include overly permeable soils and/or non-existent base flows, public acceptance with regard to the potential for vector infestation, large footprint to tributary area ratios (up to 12% percent of tributary area, dependant on overall imperviousness of the tributary area) and high initial capital cost of implementation.

6.10.1.2 Performance, Applicability, and Limitations

Table 6-58, Table 6-59, and Table 6-60 provide a summary of BMP performance, applicability, and limitations for constructed treatment wetlands. *It is important to note that information in these tables shall be used to provide general guidance for constructed treatment wetlands and shall not replace the evaluation performed by a water quality professional.*

Applicability and Performance

Table 6-58 and associated guidance provide general volume reduction capabilities and treatment effectiveness for constructed treatment wetlands. Refer to Section 6.4 for the process that shall be used for selecting BMPs based on pollutants of concern. Refer to Table 6-1 to determine the ranking of constructed treatment wetlands for removal of pollutants of concern as compared with other storm water runoff BMPs provided in Chapter 6. Refer to Table 6-2 to assess the applicability of constructed treatment wetlands for your site based on site suitability considerations as compared with other storm water runoff BMPs provided in Chapter 6. Constructed treatment wetlands are volume-based BMPs intended to provide water quality treatment and, when applicable, control of the peak runoff discharge rate using

extended detention above the wetland permanent pool (see Table 6-58). Although constructed treatment wetlands can produce significant volume reduction though evapotranspiration in the summer months, credit towards meeting the volume reduction requirement, $V_{reduction}$, is not given for constructed treatment wetlands because little volume reduction occurs during the winter months when storm water runoff is highest. See Section 6.2 for specific storm water runoff requirements for Tier 3 projects.

Table 6-58: Volume Reduction & Treatment Effectiveness for Treatment Wetland

Storm Water Runoff BMP	Volume Mitigation (% of inflow)	Treatment Effectiveness for Pollutants of Concern[1]					
		Trash	Nutrients	Bacteria	Metals (particulate and dissolved fractions)	Sediment	Organics (hydro-carbons, oil, and grease)
Constructed Treatment Wetland	◒	◒	◎	◒	●	◒	●
Volume/Treatment Effectiveness: ● = *Very High,* ◓ = *High,* ◎ = *Moderate,* ◒ = *Low,* ○ = *Very Low*							

[1] Effectiveness may change based on design variations; standard BMP designs have been assumed.

Constructed treatment wetlands have very high pollutant removal efficiencies and use multiple processes to treat storm water runoff including sedimentation, filtration, adsorption, plant uptake, and microbial/chemical biodegradation and precipitation. Sedimentation and filtration assist in the removal of total suspended solids (i.e., a surrogate for sediment), floating debris, trash, soil-bound phosphorus, and some soil-bound pathogens. Adsorption to soil particles assists in removal of dissolved metals and soluble phosphorus. Microbial processes (e.g., nitrification and dentrification) and chemical processes (e.g., precipitation) assist in removal of nitrogen, organics, pathogens, and metals. Plants can uptake small amounts of nutrients including nitrogen and phosphorus and, depending on plant type, can uptake varying amounts of metals. Some plant types can uptake large quantities of metals; this is called phytoremediation. Exposure to sunlight and dryness on the edges of the wetland and in areas that do not consistently stay wet assist in removal of pathogens (Hunt and Doll, 2000).

Site Suitability Recommendations and Limitations

Table 6-59 provides general considerations for assessing a site's suitability for constructed treatment wetlands.

Table 6-59: Site Suitability Considerations for Treatment Wetlands

BMP	Tributary Area (Acres)[1]	Site Slope (%)	Depth to Seasonally High Groundwater Table (ft)	Hydrologic Soil Group	Horizontal Setback from Drinking Water Wells (ft)
Constructed Treatment Wetland	> 5 Acres; 435,600 Sq.Ft.	< 8 [2]	N/A	"A" soils may require pond liner; "B" soils may require infiltration testing	N/A

[1] Tributary area is the area of the site draining to the BMP. Tributary areas provided here shall be used as a general guideline only. Tributary areas can be larger or smaller in some instances.

[2] If site slope exceeds that specified or if the system is within 200 ft from the top of a hazardous slope or landslide area (on the uphill side), a geotechnical investigation and report addressing slope stability shall be prepared by a licensed civil engineer.

Table 6-60 provides additional site suitability considerations for special design districts within the City, including coastal bluff areas and hillside design districts.

Table 6-60: Applicability of Treatment Wetlands for Special Design Districts

Coastal Bluff Area	Hillside Design District
Generally not acceptable in Coastal Bluff Areas	Acceptable if: (1) a geotechnical investigation proves that the facility does not compromise the stability of the site slope or surrounding slopes, or (2) the facility meets the site slope criteria in Table 6-59 and the facility is fully contained with an impermeable liner and overflow to a storm water conveyance system.

The following provides additional site suitability guidelines and limitations:

- In theory, there are no limitations on the tributary area size draining to a constructed treatment wetland; however, constructed treatment wetlands usually require considerable land area. Typically, treatment wetlands capture runoff from tributary areas larger than 10 acres and less than 10 square miles. Smaller “pocket” wetlands can be feasible in areas where space is restricted.
- If the constructed treatment wetland is not used for flow control, the wetland must not interfere with flood control functions of existing conveyance and detention structures.
- Constructed treatment wetlands shall not be permitted in areas with site slopes greater than 7% or within 200 feet (on the uphill side) of a steep slope hazard area or a mapped landslide area unless a geotechnical investigation and report is completed by a licensed civil engineer.
- Constructed treatment wetlands require a regular source of water (base flow) to maintain wetland vegetation and associated treatment processes. If adequate base flow

is not available year-round, supplemental water may be needed during the summer months to maintain adequate base flow.

Multi-Use and Treatment Train Opportunities

Provided that the constructed treatment wetland has adequate storage, the wetland may be combined with a flow control basin to provide both water quality control and peak flow control. Wetlands can also be designed with wildlife viewing areas and walking trails around the perimeter to provide passive recreation. Flows may enter a constructed treatment wetland from a pretreatment BMP such as a vegetated swale filter or Vegetated filter strip. The vegetated swales and filter strips not only filter course sediments but also increase the site's time of concentration, T_c, thereby providing infiltration and evapotranspiration as well as reductions in site runoff discharge rates prior to entering the constructed treatment wetland.

6.10.1.3 Design Criteria and Procedure

The main challenge associated with constructed treatment wetlands is maintaining base flow to support vegetation. A constructed treatment wetland is illustrated schematically in Figure 6-22.

Constructed treatment wetlands shall be designed according to the current policies of the City and the County of Santa Barbara Flood Control District. Principal design criteria for constructed treatment wetlands are listed in Table 6-61.

Table 6-61: Treatment Wetland Design Criteria

Design Parameter	Unit	Design Criteria
Water quality design volume, V_{wq}	ft^3	See Section 6.2.3 and Appendix C
Drawdown time for extended detention (over permanent pool)	hours	36-48
Sediment forebay volume	%	10-20 of total basin volume
Depth of sediment forebay	feet	4-8 (1 foot of sediment storage required)
Depth of wetland basin	feet	Varies see facility geometry section below
Maximum residence time	Days	7 (dry weather)
Freeboard (minimum)	inches	12 (off-line); 24 (on-line)
Flow path length to width ratio	L:W	3:1 (min.) 4:1 (preferred)
Side slope (maximum)	H:V	4:1 Interior; 2:1 Exterior; 3:1 Landscaped
Vegetation Type	--	Varies see vegetation section below and Appendix G
Vegetation Height	--	Varies see vegetation section below
Buffer zone (minimum)	feet	25
Maintenance access ramp width	feet	16
Minimum outflow device diameter	inches	18

Sizing for Meeting the Storm Water Runoff Requirements

Constructed treatment wetlands can be sized to meet all or part of the water quality design volume and peak runoff discharge rate requirements as outlined in Section 6.2 and Appendix C. A constructed treatment wetland sizing example is provided in Appendix D.

Maintaining peak runoff discharge rate requirement

The constructed treatment wetland can be designed with extended detention to provide sufficient storage for meeting all or part of the peak runoff discharge requirement for the 2-year through the 100-year, 24-hr design storm.

Volume reduction requirement

The volume reduction requirement cannot be met with constructed treatment wetlands.

Water quality treatment volume requirement

The constructed treatment wetland can be designed to treat all or part of the water quality treatment volume with a 36 to 48 hour drawdown time.

Sizing for Meeting the Storm Water Runoff Requirements

Wet retention basins can be sized to meet all or part of the water quality design volume and peak runoff discharge rate requirements as outlined in Section 6.2 and Appendix C. A wet retention basin sizing example is provided in Appendix D.

Maintaining peak runoff discharge rate requirement

The wet retention basin can be designed with extended detention (above the permanent pool) to provide sufficient storage for meeting all or part of the peak runoff discharge requirement for the 2-year through the 100-year, 24-hr design storm.

Volume reduction requirement

The volume reduction requirement cannot be met with constructed treatment wetlands.

Water quality treatment volume requirement

The constructed treatment wetland can be designed with or without extended detention (above the permanent pool) to treat all or part of the water quality treatment volume. If extended detention is provided, the drawdown time shall between 36 to 48 hours.

Geometry and Size

In most cases, the constructed treatment wetland permanent pool shall be sized to be greater than or equal to the water quality design volume. If extended detention is provided above the permanent pool and the wetland is designed for water quality treatment only, then the permanent pool volume shall be a minimum of 80 percent of the water quality design volume and the surcharge volume (above the permanent pool) shall make up the remaining 20 percent and provide at least 12 hours of detention. If extended detention is provided and the basin is designed for water quality treatment and peak flow attenuation, then the permanent pool

volume shall be equal to the water quality treatment volume and the surcharge volume shall be sized to attenuate peak flows to meet the peak runoff discharge requirements. See Section 6.2 and Appendix C for water quality design volume and peak runoff discharge requirements and calculations. A constructed treatment wetland design example is provided in Appendix D. The extended detention portion of the wetland above the permanent pool, if provided, functions like a dry extended detention (ED) basin (see Section 6.10.3 for dry ED basin sizing guidelines).

1. Constructed treatment wetlands shall consist of at least two cells including a sediment forebay and a wetland basin.

2. The sediment forebay must contain between 10 and 20 percent of the total basin volume.

3. The depth of the sediment forebay shall be between 4 and 8 feet.

4. One foot of sediment storage shall be provided in the sediment forebay.

5. The "berm" separating the two basins shall be uniform in cross-section and shaped such that its downstream side gradually slopes to the main wetland basin.

6. The top of berm shall be either at the water quality design water surface or submerged 1 foot below the water quality design water surface, as with wet retention basins. Correspondingly, the side slopes of the berm must meet the following criteria:

    a. If the type of the berm is at the water quality design water surface, the berm side slopes shall be no steeper than 4H:1V.

    b. If the top of berm is submerged 1 foot, the upstream side slope may be a max of 3H:1V.

7. The constructed treatment wetlands shall be designed with a "naturalistic" shape and a range of depths intermixed throughout the wetland basin to a maximum of 5 feet.

Depth Range (feet)	Percent by Area
0.1 to 1	15
1 to 3	55
3 to 5	30

8. The flowpath length-to-width ratio shall be a minimum of 3:1, but preferably at least 4:1 or greater. *Intent: a high flow path length to width ratio will maximize fine sediment removal.*

9. The minimum freeboard shall be 1 foot above the maximum water surface elevation for on-line basins (2 feet preferable) and 1 foot above the maximum water surface elevation for on-line basins.

10. Wetland pools shall be designed such that the residence time for dry weather flows is no greater than 7 days. *Intent: Minimize vector and stagnation issues.*

Water Supply

Water balance calculations shall be provided to demonstrate that adequate water supply will be present to maintain a permanent pool of water during a drought year when precipitation is 50% of average for the site. Water balance calculations shall include evapotranspiration, infiltration, precipitation, spillway discharge, and dry weather flow (where appropriate).

Where water balance indicates that losses will exceed inputs, a source of water shall be provided to maintain the wetland water surface elevation throughout the year. The water supply shall be of sufficient quantity and quality to not have an adverse impact on the wetland water quality. Water that meets drinking water standards shall be assumed to be of sufficient quality.

Soils Considerations

1. Implementation of constructed treatment wetlands in areas with high permeability soils (>0.1 in/hr) requires liners to increase the chances of maintaining permanent pools and/or micro-pools in the basin. Liners can be either synthetic materials or imported lower permeability soils (i.e., clays). The water balance assessment shall determine whether a liner is required. The following conditions can be used as a guideline.

2. The wetland basin must retain water for at least 10 months of the year.

3. The sediment forebay must retain at least 3 feet of water year-round.

4. Many wetland plants can adapt to periods of summer drought, so a limited drought period is allowed in the wetland basin. This may allow for a soil liner rather than a geosynthetic liner. The sediment forebay must retain water year-round for presettling to be effective.

5. If low permeability soils are used for the liner, a minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with 3 parts native soil) must be placed over the liner (see soil amendment Section 5.10). If a synthetic material is used, a soil depth of 2 feet is recommended to prevent damage to the liner during planting.

Buffer Zone

A minimum of 25 feet buffer shall be provided around the top perimeter of the constructed treatment wetlands.

Energy Dissipation

1. The inlet to the constructed treatment wetland shall be submerged with the inlet pipe invert a minimum of two feet from the cell bottom (not including sediment storage). The top of the inlet pipe shall be submerged at least 1 foot, if possible. *Intent: the inlet is submerged to dissipate energy of the incoming flow. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.*

2. Energy dissipation controls must also be used at the outlet/spillway from the constructed treatment wetlands unless the wetland discharges to a storm water conveyance system or hardened channel.

Vegetation

1. The wetland cell(s) shall be planted with emergent wetland plants following the recommendations of a wetlands specialist.

2. Landscaping outside of the basin is required for all constructed wetlands and must adhere to the following criteria so as not to hinder maintenance operations:

    a. No trees or shrubs may be planted within 15 feet of inlet or outlet pipes or manmade drainage structures such as spillways, flow spreaders, or earthen embankments. Species with roots that seek water, such as willow or poplar, shall not be used within 50 feet of pipes or manmade structures. Weeping willow (*Salix babylonica*) shall not be planted in or near detention basins.

    b. Prohibited non-native plant species will not be permitted. For more information on invasive weeds, including biology and control of listed weeds, look at the encycloweedia located at the California Department of Food and Agriculture website- http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm or the California Invasive Plant Council website at www.cal-ipc.org.

3. See Appendix G for a recommended native plant list for constructed treatment wetlands, a list of local nurseries where these plants can be purchased, and a list of local and regional on-line resources. The plant list shall be used as a guide only and shall not replace project-specific planting recommendations provided by a wetland ecologist or a qualified landscape professional including recommendations on appropriate plants, fertilizer, mulching applications, and irrigation requirements (if any) to ensure healthy vegetation growth. See Section 5.11 for more information on landscaping/planting recommendations and Section 5.10 for more information on soil amendment recommendations.

Outlet Structure

An outlet pipe and outlet structure shall be provided. The outlet pipe may be a perforated standpipe strapped to a manhole (see Figure 6-25) or placed in an embankment, suitable for extended detention, or may be back-sloped to a catch basin with a grated opening (jail house window) or manhole with a cone grate (birdcage) (see Figure 6-26). The grate or birdcage openings provide an overflow route should the basin outlet pipe become clogged.

For wetlands with detention, the outlet structures shall be designed to provide 12 hours emptying time for the water quality volume or the required detention necessary for achieving the peak runoff discharge requirements if the extended detention is designed for flow attenuation.

The wetland outlet pipe shall be sized, at a minimum, to pass flows greater than the water quality design peak flow for on-line basins or flows greater than the peak runoff discharge rate for the 100-year, 24-hr design storm for on-line basins.

See the dry extended detention section (Section 6.10.3) and Appendix E for further detail on outlet sizing.

Emergency Spillway

An emergency overflow spillway in addition to the primary overflow outlet (as described above) is required. The emergency spillway shall be sized for flows greater than the peak 100-year 24-hour storm if the basin is designed on-line or, if the basin is designed on-line, the spillway shall be sized for flows greater than the basin design volume (e.g., water quality design volume). The spillway shall be constructed with reinforced concrete and provide for adequate energy dissipation downstream. The spillway shall allow for at least 12 inches of freeboard above the emergency overflow water surface elevation if the basin is on-line. If the basin is on-line, 2 feet of freeboard is preferable.

Spillways shall meet the California Department of Water Resources, Division of Safety of Dams Guidelines for the Design and Construction of Small Embankment Dams (http://damsafety.water.ca.gov/docs/GuidelinesSmallDams.pdf). *Intent: Emergency overflow spillways are intended to control the location of basin overtopping and safely direct overflows back into the downstream conveyance system or other acceptable discharge point.*

<u>On-line Basins</u>

1. On-line basins must have an emergency overflow spillway to prevent overtopping of walls or berms should blockage of the primary outlet occur based on a downstream risk assessment.
2. The overflow spillway must be sized to pass flows greater than the design peak runoff discharge rate for the 100-yr, 24-hr storm.
3. The minimum freeboard shall be 1 foot (but preferably at least 2 feet) above the maximum water surface elevation over the emergency spillway.

<u>Off-line Basins</u>

1. Off-line basins must have either an emergency overflow spillway or an emergency overflow riser. The emergency overflow must be designed to pass the 100-yr 24-hr post-development peak storm water runoff discharge rate (see Appendix E for further detail) directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a steep slope, an emergency overflow riser, *in addition* to the spillway shall be provided.
2. The emergency overflow spillway shall be armored to withstand the energy of the spillway flows (Figure 6-32). The spillway shall be constructed of grouted rip-rap.
3. The minimum freeboard shall be 1 foot above the maximum water surface elevation over the emergency spillway.

Side Slopes

1. Interior side slopes above the water quality design depth and up to the emergency overflow water surface shall be no steeper than 4:1 (H:V), unless stabilization has been approved by a licensed civil engineer and the City.

2. Exterior side slopes shall be no steeper than 2:1 (H:V), unless stabilization has been approved by a licensed civil engineer and the City.

3. For any slope (interior or exterior) steeper than 2:1 (H:V), a geotechnical investigation and report must be submitted and approved by the City.

4. Landscaped slopes must be no steeper than 3:1 (H:V) to allow for maintenance.

5. Basin walls may be vertical retaining walls, provided: (a) they are constructed of reinforced concrete, (b) a fence is provided along the top of the wall (see fencing below) or further back, and (c) the design is stamped by a licensed civil engineer and approved by the City.

Embankments

1. Earthworks and berm embankments shall be performed in accordance with the latest edition of the "Greenbook Standard Specifications for Public Works Construction".

2. Embankments are earthen slopes or berms used for detaining or redirecting the flow of water.

3. Top of berm shall be 2 feet minimum below the water quality design water surface and shall be keyed into embankment a minimum of 1 foot on both sides.

4. Typically, the top width of berm embankments is at least 20 feet, but narrower embankments may be plausible if approved by the civil engineer and the City.

5. Basin berm embankments must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a licensed civil engineer) free of loose surface soil materials, roots, and other organic debris.

6. Basin berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50% of the berm embankment cross-sectional height and width. This requirement may be waived if specifically recommended by a licensed civil engineer.

7. The berm embankment shall be constructed of compacted soil (95% minimum dry density, modified proctor method per ASTM D1557), placed in 6-inch lifts.

8. Low growing native or non-invasive perennial grasses shall be planted on downstream embankment slopes. See vegetation section below.

Fencing

Safety is provided either by fencing of the facility or by managing the contours of the basin to eliminate drop-offs and other hazards.

1. In accordance with the Santa Barbara Flood Control District *Standard Conditions of Project Plan Approval*, facilities to be dedicated to the City, perimeter fencing (minimum height of 42 inches) shall be required on all basins exceeding two feet in depth or where interior side slopes are steeper than 6:1 (H:V).

2. If fences are required, fences shall be designed and constructed in accordance with current policies of the Santa Barbara County Flood Control District and must be located at or above the overflow water surface elevation. Shrubs (approved, California-adapted species) can be used to hide the fencing. See vegetation section above.

Right-of-Way

1. Constructed treatment wetlands and associated access roads to be maintained by the City shall be dedicated in fee or in an easement to the City with appropriate access.

Maintenance Access

1. Ownership of the basin and maintenance thereof is the responsibility of the developer/applicant. A maintenance agreement with the City is required to ensure adequate performance and allow the City emergency access to the facilities.

2. Maintenance access road(s) shall be provided to the control structure and other drainage structures associated with the basin (e.g., inlet, emergency overflow or bypass structures). Manhole and catch basin lids must be in or at the edge of the access road.

3. A graded 16-foot wide access ramp into the basin shall be constructed near the basin outlet. An access ramp is required for removal of sediment with a backhoe or loader and truck. The ramp must extend to the basin bottom to avoid damage to vegetation planted on the basin slope. A 16-foot wide commercial driveway approach shall be provided where curb and gutter front the maintenance ramp.

4. All access ramps and roads shall be provided in accordance with the current policies of the Flood Control District.

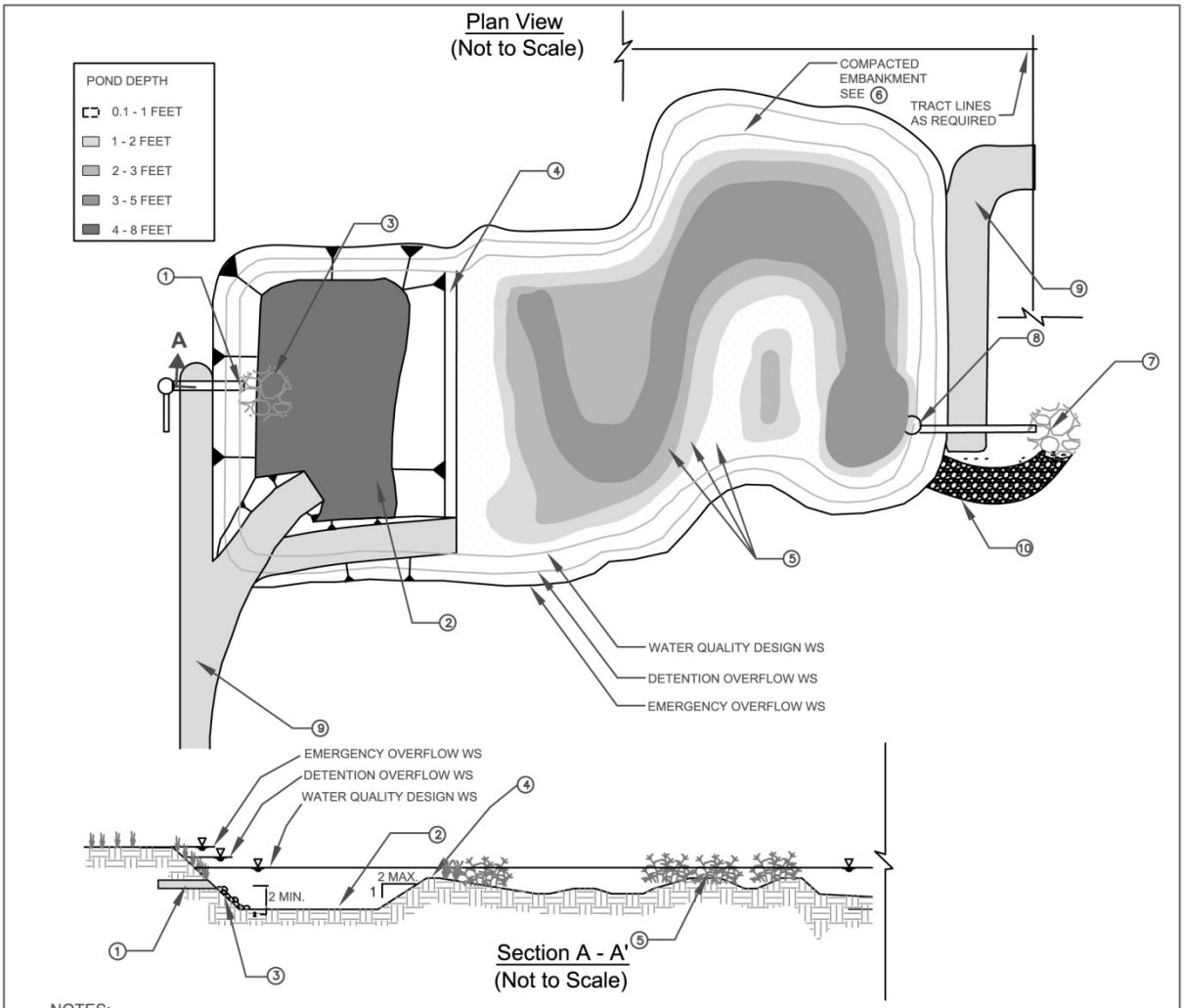
Vector Control

1. A Mosquito Management Plan or Service Contract must be approved or waived by the Santa Barbara Coastal Vector Control District for any facility that maintains a pool of water for 72 hours or more.

6.10.1.4 Construction Considerations

The use of treated wood or galvanized metal anywhere inside the facility is prohibited. The use of galvanized fencing is permitted if in accordance with the Fencing requirement above.

Figure 6-22: Constructed Treatment Wetland Schematic



NOTES:

1. INLET PIPE SHOULD BE SUBMERGED WITH A MINIMUM OF 2' DISTANCE FROM THE BOTTOM.
2. SEDIMENT FOREBAY. FOREBAY VOLUME SHALL EQUAL 10% TO 20% 0F TOTAL WETLAND VOLUME. FOREBAY DEPTH SHALL BE 4' TO 8' PLUS AN ADDITIONAL I' MIN SEDIMENT STORAGE DEPTH.
3. RIPRAP APRON OR OTHER INLET ENERGY DISSIPATION.
4. BERM AT WATER QUALITY DESIGN WATER SURFACE ELEVATION OR SUBMERGED 1' BELOW WATER QUALITY DESIGN WATER SURFACE ELEVATION. EXTEND BERM ACROSS ENTIRE WIDTH OF THE WETLAND AND SHALL BE KEYED INTO EMBANKMENT A MINIMUM OF 1' ON BOTH SIDES.
5. WETLAND VEGETATION PLANTING SCHEME MUST BE DESIGNED BY A WETLAND ECOLOGIST OR QUALIFIED LANDSCAPE PROFESSIONAL.
6. EMBANKMENT SIDE SLOPES SHALL BE NO STEEPER THAN 2H:1V OUTSIDE AND 4H:1V INSIDE. FENCING SHOULD BE PROVIDED FOR EMBANKMENT SLOPES GREATER THAN 6H:1V OR IF BASIN DEPTH EXCEED 2'.
7. SIZE OUTLET PIPE TO PASS 100-YEAR PEAK FLOW FOR ONLINE AND WATER QUALTIY PEAK FLOW FOR OFFLINE BASINS. OUTLET PIPE DIAMETER SHALL BE A MINIMUM OF 18".
8. WATER QUALITY OUTLET STRUCTURE. SEE FIGURE 6-25 AND FIGURE 6-26 FOR DETAILS.
9. MAINTENANCE RAMP SHOULD BE PAVED. WIDTH SHALL BE A MINIMUM OF 16' AND SLOPE SHALL NOT EXCEED 12%. MAINTENANCE RAMP SHOULD PROVIDE ACCESS TO BOTH THE FOREBAY AND MAIN BASIN.
10. INSTALL EMERGENGY OVERFLOW SPILWAY AS NEEDED. SEE FIGURE 6-32 FOR DETAILS.

Geosyntec consultants

Figure 6 - 22
CONSTRUCTED TREATMENT WETLAND

6.10.1.5 Operations and Maintenance

General Requirements

Maintenance is of primary importance if constructed treatment wetlands basins are to continue to function as originally designed. A specific maintenance plan shall be formulated for each facility outlining the schedule and scope of maintenance operations, as well as the data handling and reporting requirements. The following are general maintenance requirements:

1. The constructed treatment wetlands basin shall be inspected annually and inspections after major storm events are encouraged (see Appendix H for a constructed treatment wetland inspection and maintenance checklist). Trash and debris shall be removed as needed, but at least annually prior to the beginning of the wet season.

2. Site vegetation shall be maintained as frequently as necessary to maintain the aesthetic appearance of the site and to prevent clogging of outlets, creation of dead volumes, and barriers to mosquito fish to access pooled areas, and as follows:

3. Vegetation, large shrubs, or trees that limit access or interfere with basin operation shall be pruned or removed.

4. Slope areas that have become bare shall be revegetated and eroded areas shall be regraded prior to being revegetated.

5. Invasive vegetation, such as Alligatorweed (*Alternanthera philoxeroides*), Halogeton (*Halogeton glomeratus*), Spotted Knapweed (*Centaurea maculosa*), Giant Reed (*Arundo donax*), Castor Bean (*Ricinus communis*), Perennial Pepperweed (*Lepidium latifolium*), and Yellow Starthistle (*Centaurea solstitalis*) must be removed and replaced with non-invasive species. Invasive species shall never contribute more than 25% of the vegetated area. For more information on invasive weeds, including biology and control of listed weeds, look at the encycloweedia located at the California Department of Food and Agriculture website- http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm or the California Invasive Plant Council website at www.cal-ipc.org.

6. Dead vegetation shall be removed if it exceeds 10% of area coverage. This does not include seasonal die-back where roots would grow back later in colder areas. Vegetation shall be replaced immediately to maintain cover density and control erosion where soils are exposed.

7. Sediment buildup exceeding 6 inches over the storage capacity in the first cell shall be removed. Sediments shall be tested for toxic substance accumulation in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed. If toxic substances are encountered at concentrations exceeding thresholds of Title 22, Section 66261 of the California Code of Regulations, the sediment must be disposed of in a hazardous waste landfill.

8. Following sediment removal activities, replanting, and/or reseeding of vegetation may be required for reestablishment.

Maintenance Standards

A summary of the routine and major maintenance activities recommended for wetland basins is shown in Table 6-62. Detailed routine and major maintenance standards listed in Table 6-63 and Table 6-64 are intended to be measures to determine if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedance of these thresholds or measures at any time between inspections and/or scheduled maintenance does not constitute a violation of these standards. These standards are violated only when an inspection identifies required maintenance action that has not been scheduled before the next regular inspection.

Table 6-62: Treatment Wetland Maintenance Quick Guide

Inspection and Maintenance Activities Summary	
Routine Maintenance	• Trash and debris removal • Remove minor sediment accumulation near inlet and outlet structures • Stabilize/repair eroded banks and fill in animal burrows if present • Remove any evidence of visual contamination from floatables such as oil and grease • Eliminate pests and conditions suitable for creating ideal breeding habitat • Install or repair pond liner to ensure that first cell maintains a permanent pool • Remove algae mats as often as needed to prevent coverage of more than 20% of wetland surface • Mow berms routinely if applicable to maintain aesthetic appeal and to suppress weeds
Major Maintenance	• Remove dead, diseased, or dying trees and woody vegetation that interfere with facility maintenance. • Correct problems associated with berm settlement • Repair berm/dike breaches and stabilize eroded parts of the berm • Repair and rebuild spillway as needed to reverse the effects of severe erosion • Remove sediment build up in forebay and main wetland area to restore original sediment holding capacity • Re-grade main wetland bottom to restore bottom slope and eliminate the incidence of standing pools • Aerate compacted areas to promote infiltration if volume reductions are desired • Repair or replace gates, fences, flow control structures, and inlet/outlet structures as needed to maintain full functionality

Table 6-63: Routine Maintenance Standards – Treatment Wetlands

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 sf of wetland area (one standard garbage can). In general, there shall be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance. If trash and debris is observed blocking or partially blocking an outlet structure or inhibiting flows between cells, it shall be removed quickly.	Trash and debris cleared from site.	Annually prior to wet season After major storm events (>0.75 in/24 hrs) if spot checks of some basins indicate widespread damage/ maintenance needs
Sediment Accumulation	Sediment accumulation in wetland bottom that exceeds the depth of sediment zone plus 6 inches in the sediment forebay. If sediment is blocking an inlet or outlet, it shall be removed.	Sediment cleaned out.	
Erosion	Erosion of wetland's side slopes and/or scouring of wetland bottom.	Slopes shall be stabilized using appropriate erosion control measure(s) and repair methods.	
Oil Sheen on Water	Prevalent and visible oil sheen.	No oil sheen present.	
Noxious Pests	Visual observations or receipt of complaints of numbers of pests that would not be naturally occurring and could pose a threat to human or aquatic health.	Vectors controlled per Santa Barbara Coastal Vector Control District. A Mosquito Management Plan or Service Contract must be presented to the Vector Management District for any facility that maintains a pool of water for 72 hours or more.	
Water Level	First cell empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. The first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.	

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Aesthetics	Minor vegetation removal and thinning. Mowing berms and surroundings	Facility is well kept.	Monthly (or as dictated by agreement between County and landscape contractor)
Noxious Weeds	Any evidence of noxious weeds.	Eradicate all noxious weeds; control and prevent the spread of all noxious weeds. Use Integrated Pest Management techniques, if applicable. See http://www.ipm.ucdavis.edu for more information.	

Table 6-64: Major Maintenance Standards – Treatment Wetlands

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Tree Growth	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering, do not remove. Dead, diseased, or dying trees shall be removed.	Trees do not hinder maintenance activities. Remove dead, diseased, or dying trees. (Use a certified Arborist to determine health of tree or removal requirements).	Annual or as needed (infrequent) After major storm events (>0.75 in/24 hrs) if spot checks of some basins indicate widespread damage/ maintenance needs.
Settling of Berm	If settlement is apparent. Settling can be an indication of more severe problems with the berm or outlet works. A civil engineer shall be consulted to determine the source of the settlement if the dike/berm is serving as a dam.	Dike is built back to the design elevation.	
Piping through Berm	Discernable water flow through basin berm. Ongoing erosion with potential for erosion to continue. A licensed civil engineer shall be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved and berm stability achieved.	

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Tree and Large Shrub Growth on Downstream Slope of Embankments	Tree and large shrub growth on downstream slopes of embankments may prevent inspection and provide habitat for burrowing rodents.	Trees and large shrubs shall be removed. All dead roots shall be removed if practical. Otherwise, dead roots shall be removed to a minimum of 36 inches below grade and replaced with cement grout to 12 inches below grade. The top 12 inches of the root holes shall be filled with compacted, in-situ soils. The area facility engineer may require additional root removal if necessary for dam safety or maintenance purposes.	
Erosion on Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks and pad depth are restored to design standards.	
Gate/Fence Damage	Damage to gate/fence, including missing locks and hinges	Gate/Fence repaired.	

6.10.2 Wet Retention Basins

Figure 6-23: Wet Retention Basin with Vegetation Along Perimeter

Applications

- Regional detention & treatment
- Roads, highways, parking lots, commercial, residential
- Parks, open spaces, and golf courses

Advantages

- Efficient removal of pollutants adsorbed to sediments
- Can provide treatment for large tributary areas

Limitations

- Require regular base flows if water level is to be maintained
- Large footprint area required
- Not permitted near steep slopes

6.10.2.1 Description

Wet retention basins are constructed, naturalistic ponds with a permanent or seasonal pool of water (also called a “wet pool” or “dead storage”). Aquascape facilities, such as artificial lakes, are a special form of wet pool facility that can incorporate innovative design elements to allow them to function as a storm water treatment facility in addition to an aesthetic water feature. Wetponds require base flows to exceed or match losses through evaporation and/or infiltration and they must be designed with the outlet positioned and/or operated in such a way as to maintain a permanent pool. Wetponds can be designed to provide extended detention of incoming flows using the volume above the permanent pool surface.

The applications for wet retention basins are similar to those of dry extended detention (ED) basins and include peak flow attenuation (with ED), varying amounts of volume reduction, and pollutant removal. The main pollutant removal mechanism in wet retention basins is sedimentation; other pollutant reduction processes occurring in wet retention basins include dilution, adsorption, biological and chemical processes such as microbially-mediated biodegradation and precipitation, plant uptake, and storage. The permanent pool of water in the wet retention basins improves treatment of fine particulates and associated pollutants and provides treatment of dry weather flows (nuisance flows). Permanent pools also allow wet retention basins to be designed as aesthetically pleasing water features with additional recreational, wildlife habitat, and educational benefits. Compared to an ED basin of equal volume, a well-designed wet retention basin provides improved water quality treatment by increasing the average hydraulic residence time of storm water in the facility.

Wet retention basins work best under plug flow conditions where the water already present in the permanent pool is displaced by incoming flows with minimal mixing and no short circuiting.

Plug flow describes the hypothetical condition of storm water moving through the basin in such a way that older "slugs" of water (meaning water that's been in the basin for longer) are displaced by incoming slugs of water with little or no mixing in the direction of flow. Short circuiting occurs when quiescent areas or "dead zones" develop in the basin where pockets of water remain stagnant, causing other volumes to bypass using shorter paths through the basin (e.g., incoming storm water slugs bypass these zones). Water quality benefits are also improved when the permanent wet pool volume is significantly greater than the water quality volume, resulting in longer residence times.

Of specific concern in Southern California is the drying of permanent pools due to lack of sufficient base flow to balance evaporation and infiltration. While water quality and aesthetics are sacrificed through loss of the permanent pool, it is acceptable for wet retention basins to dry out for part of the year. Even without a permanent pool, wet retention basins will still provide water quality benefits through capture and infiltration of nuisance flows. However, lakes shall be designed to maintain a permanent pool of water year-round to support the riparian and aquatic vegetation. Consequently, lakes are only appropriate where base flows are sufficient to maintain the permanent pool, or an additional source of water supply (e.g., potable, reclaimed, etc.) is available to supplement base flows during critical periods.

6.10.2.2 Performance, Applicability, and Limitations

Table 6-65, Table 6-66, and Table 6-67 provide a summary of BMP performance, applicability, and limitations for wet retention basins. *It is important to note that information in these tables shall be used to provide general guidance for wet retention basins and shall not replace the evaluation performed by a water quality professional.*

Applicability and Performance

Table 6-65 and associated guidance provide general volume reduction capabilities and treatment effectiveness for wet retention basins. Refer to Section 6.4 for the process that shall be used for selecting BMPs based on pollutants of concern. Refer to Table 6-1 to determine the ranking of constructed treatment wetlands for removal of pollutants of concern as compared with other storm water runoff BMPs provided in Chapter 6. Refer to Table 6-2 to assess the applicability of constructed treatment wetlands for your site based on site suitability considerations as compared with other storm water runoff BMPs provided in Chapter 6. Wet retention basins are volume-based BMPs intended to provide water quality treatment and, when extended detention is provided, attenuate peak runoff discharge rates (see Table 6-65). Although wet retention basins can produce significant volume reduction though evapotranspiration in the summer months (although not as much as constructed treatment wetlands), credit towards meeting the volume reduction requirement, $V_{reduction}$, is not given for wet retention basins because little volume reduction occurs during the winter months when storm water runoff is highest. See Section 6.2 for specific storm water runoff requirements for Tier 3 projects.

Table 6-65: Volume Reduction & Treatment Effectiveness for Wet Retention Basins

Storm Water Runoff BMP	Volume Mitigation (% of inflow)	Treatment Effectiveness for Pollutants of Concern[1]					
		Trash	Nutrients	Bacteria	Metals (particulate and dissolved fractions)	Sediment	Organics (hydro-carbons, oil, and grease)
Wet Retention Basin	◓	◒	◎	◒	●	◓	●
Volume/Treatment Effectiveness: ● = *Very High,* ◓ = *High,* ◎ = *Moderate,* ◒ = *Low,* ○ = *Very Low*							

[1] Effectiveness may change based on design variations; standard BMP designs have been assumed.

Research has shown that wet retention basins have a very high removal rate for sediment, often 70 percent and higher for total suspended solids (TSS), provided the basin is well-maintained. This is because the runoff slows down as it enters the basin and the sediment, as well as sediment bound pollutants such as phosphorus, metals, and pesticides, are removed through sedimentation. Wet retention basins are not as efficient at removal of nitrate-nitrogen as constructed treatment wetlands due to less opportunity for anaerobic denitrification to occur.

Site Suitability Recommendations and Limitations

Table 6-66 provides general guidance for assessing a site's suitability for wet retention basins.

Table 6-66: Site Suitability Considerations for Wet Retention Basins

BMP	Tributary Area (Acres)[1]	Site Slope (%)	Depth to Seasonally High Groundwater Table (ft)	Hydrologic Soil Group	Horizontal Setback from Drinking Water Wells (ft)
Wet Retention Basins	> 10 Acres; 435,600 Sq.Ft.	< 15 [2]	N/A	"A" soils may require pond liner; "B" soils may require infiltration testing	N/A

[1] Tributary area is the area of the site draining to the BMP. Tributary areas provided here shall be used as a general guideline only. Tributary areas can be larger or smaller in some instances.

[2] If site slope exceeds that specified or if the system is within 200 ft from the top of a hazardous slope or landslide area (on the uphill side), a geotechnical investigation and report addressing slope stability shall be prepared by a licensed civil engineer. In addition, for swales, if the longitudinal slope exceeds 6%, check dams shall be provided.

Table 6-67 provides additional site suitability considerations for special design districts within the City including coastal bluff areas and hillside design districts.

Table 6-67: Applicability of Wet Retention Basins for Special Design Districts

Coastal Bluff Area	Hillside Design District
Generally not acceptable in Coastal Bluff Areas.	Acceptable if: (1) a geotechnical investigation proves that the facility does not compromise the stability of the site slope or surrounding slopes, or (2) the facility meets the site slope criteria in Table 6-66 and the facility is fully contained with an impermeable liner and overflow to a storm water conveyance system.

The following provides additional site suitability recommendations and limitations related to wet retention basins.

- Wet retention basins typically are used for treating areas larger than 10 acres and less than 10 square miles. They are especially applicable for regional water quality treatment and flow control.
- Off-line wet retention basins must not interfere with flood control functions of existing conveyance and detention structures.
- If wet retention basins are located in areas with site slopes greater than 15% or within 200 feet of a hazardous steep slope or mapped landslide area (on the uphill side), a geotechnical investigation and report must be provided to ensure that the basin does not compromise the stability of the site slope or surrounding slopes.
- Wet retention basins require a regular source of base flow if water levels are to be maintained. If base flow is insufficient during summer months, supplemental water may be necessary to maintain water levels.

Multi-Use and Treatment Train Opportunities

Provided adequate surcharge storage, a wet retention basin may be combined with a flood control basin to provide both water quality control and peak flow control. This type of basin is termed an extended detention (ED) wet retention basin. Wet retention basins can also be designed with wildlife viewing areas and walking trails around the perimeter to provide passive recreation. Flows may enter a wet retention basin from a pretreatment BMP such as a vegetated swale filter or Vegetated filter strip. The vegetated swales and filter strips not only filter course sediments but also increase the site's time of concentration, T_c, thereby providing some infiltration and evapotranspiration as well as reducing the site's runoff discharge rates.

6.10.2.3 Design Criteria and Procedure

The main challenge associated with wet retention basins is maintaining desired water levels. A wet retention basin is illustrated schematically in Figure 6-24.

Wet retention basins shall be designed according to the current policies of the City and the County of Santa Barbara Flood Control District. Principal design criteria for a wet retention basin are listed in Table 6-68.

Table 6-68: Wet Retention Basin Design Criteria

Design Parameter	Unit	Design Criteria
Maintaining peak runoff discharge rate requirement	cfs	See Section 6.2.1 and Appendix C, must be used with a extended detention
Water quality design volume, V_{wq}	ft^3	See Section 6.2.3 and Appendix C
Drawdown time for extended detention (over permanent pool)	hours	48
Depth without sediment storage	feet	4 (first cell minimum) 8 (any cell maximum)
Maximum residence time	Days	7 (dry weather)
Freeboard (minimum)	inches	12 (off-line); 24 (on-line)
Flow path length to width ratio	L:W	1.5:1 (min.) 2:1 (preferred)
Side slope (maximum)	H:V	4:1 (H:V) Interior and 2:1 (H:V) Exterior
Longitudinal slope	percentage	1 (forebay) and 0-2 (main basin)
Vegetation Type	--	Varies see vegetation section below and Appendix G
Vegetation Height	--	Varies see vegetation section below
Buffer zone (minimum)	feet	25
Maintenance access ramp width	feet	16
Minimum outflow device diameter	inches	18

Sizing for Meeting the Storm Water Runoff Requirements

Wet retention basins can be sized to meet all or part of the water quality design volume and peak runoff discharge rate requirements as outlined in Section 6.2 and Appendix C. A wet retention basin sizing example is provided in Appendix D.

Maintaining peak runoff discharge rate requirement

The wet retention basin can be designed with extended detention (above the permanent pool) to provide sufficient storage for meeting all or part of the peak runoff discharge requirement for the 2-year through the 100-year, 24-hr design storm.

Volume reduction requirement

The volume reduction requirement cannot be met with constructed treatment wetlands.

Water quality treatment volume requirement

The constructed treatment wetland can be designed with or without extended detention (above the permanent pool) to treat all or part of the water quality treatment volume. If extended detention is provided, the drawdown time shall be between 36 to 48 hours.

Geometry and Size

1. If there is no extended detention provided, wet retention basins shall be sized to provide a minimum wet pool volume equal to the water quality design volume plus an additional 5% for sediment accumulation. If extended detention is provided above the permanent pool and the basin is designed for water quality treatment only, then the permanent pool volume shall be a minimum of 10 percent of the water quality design volume and the surcharge volume (above the permanent pool) shall make up the remaining 90 percent. If extended detention is provided above the permanent pool and the basin is designed for water quality treatment and peak flow attenuation, then the permanent pool volume shall be equal to the water quality treatment volume and the surcharge volume shall be sized to attenuate peak flows to meet the peak runoff discharge requirements. The extended detention portion of the wet retention basin above the permanent pool, if provided, functions like a dry extended detention (ED) basin (see Section 6.10.3 for dry ED basin sizing guidelines).

2. The wet retention basin shall be divided into two cells separated by a berm or baffle. The first cell shall contain between 25 to 35 percent of the total volume. The berm or baffle volume shall not count as part of the total volume. *Intent: The full-length berm or baffle reduces short-circuiting and promotes plug flow. Use of a pipe and full-width manifold system to introduce water into the second cell is possible on a case-by-case basis if deemed necessary and approved by the City.*

3. Wet retention basins with wetpool volumes less than or equal to 4,000 cubic feet may be single-celled (i.e., no baffle or berm is required).

4. Sediment storage shall be provided in the first cell. The sediment storage shall have a minimum depth of 1 foot. This volume shall not be included as part of the required water quality volume.

5. The minimum depth of the first cell shall be 4 feet, exclusive of sediment storage requirements. The depth of the first cell may be greater than the depth of the second cell.

6. The maximum depth of each cell shall not exceed 8 feet (exclusive of sediment storage in the first cell).

7. For wet retention basin depths in excess of 6 feet, some form of recirculation shall be provided, such as a fountain or aerator, to prevent stratification, stagnation and low dissolved oxygen conditions.

8. Interior side slopes above the permanent pool shall be 4:1 (H:V).

9. The edge of the basin shall slope from the surface of the permanent pool to a depth of 12 to 18 inches at a slope of 1:1 or greater. If soil conditions will not support a 1:1 (H:V) slope then the steepest slope that can be supported shall be used or a shallow retaining wall constructed (18 inch max). Beyond the edge of the basin, a bench sloped at 4:1 (H:V) maximum shall extend into the basin to a depth of at least 3 feet. A steeper slope may be used beyond the 3 foot depth to a maximum of 8 feet. *Intent: steep slopes at waters edge will minimize very shallow areas that can support mosquitoes.*

10. At least 25% of the basin area shall be deeper than 3 feet to prevent the growth of emergent vegetation across the entire basin. If greater than 50% of the wet pool area is in excess of 6 feet deep, some form of recirculation shall be provided, such as a fountain or aerator, to prevent stratification, stagnation and low dissolved oxygen conditions.

11. A wet retention basin shall have a surface area of not less than 0.3 acres for each acre-foot of permanent pool volume. In addition, extra area needed to provide a design that meets all other provisions of this section shall be provided. Additional surface area in excess of the minimum may be provided. There is no maximum surface area provided that all provisions of this section are met.

12. Inlets and outlets shall be placed to maximize the flowpath through the facility. The flowpath length-to-width ratio shall be a minimum of 1.5:1, but a flowpath length-to-width ratio of 2:1 or greater is preferred. The flowpath length is defined as the distance from the inlet to the outlet, as measured at mid-depth. The width at mid-depth can be found as follows: width = (average top width + average bottom width)/2. *Intent: a long flowpath length will improve fine sediment removal.*

13. All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.

14. The minimum freeboard shall be 1 foot above the maximum water surface elevation (2 feet preferred) for on-line basins and 1 foot above the maximum water surface elevation for on-line basins.

15. The maximum residence time for dry weather flows shall be 7 days. *Intent: Vector control.*

Internal Berms and Baffles

1. A berm or baffle shall extend across the full width of the wet retention basin and be keyed into the basin side slopes. If the berm embankments are greater than 4 feet in height, the berm must be constructed by excavating a key equal to 50% of the embankment cross-sectional height and width. This requirement may be waived if recommended by a licensed civil engineer for the specific site conditions. The geotechnical investigation must consider the situation in which one of the two cells is empty while the other remains full of water.

2. The top of the berm shall extend to the permanent pool surface or be one foot below the permanent pool surface to discourage public access. If the top of the berm is at the water

permanent pool surface, the side slopes must be 4H:1V. Berm side slopes may be steeper (up to 3:1) if the berm is submerged one foot.

3. If good vegetation cover is not established on the berm, erosion control measures shall be used to prevent erosion of the berm back-slope when the basin is initially filled.

4. The interior berm or baffle may be a retaining wall provided that the design is prepared and stamped by a licensed civil engineer. If a baffle or retaining wall is used, it shall be submerged one foot below the permanent pool surface to discourage access by pedestrians.

5. Internal earthen berms 6 feet high or less shall have a minimum top width 6 feet or as recommended by a civil engineer.

Water Supply

1. Water balance calculations shall be provided to demonstrate that adequate water supply will be present to maintain a pool of water during a drought year when precipitation is 50% of average for the site. Water balance calculations shall include evapotranspiration, infiltration, precipitation, spillway discharge, and dry weather flow (where appropriate).

2. Where water balance indicates that losses will exceed inputs, a source of water shall be provided to maintain the basin water surface elevation throughout the year. The water supply shall be of sufficient quantity and quality to not have an adverse impact on the wet retention basin water quality. Water that meets drinking water standards shall be assumed to be of sufficient quality.

3. Wet retention basin may be designed as seasonal ponds where the water balance and water supply conditions make it infeasible to sustain a permanent wet retention basin.

Soils Considerations

Wet retention basin implementation in areas with high permeability soils requires liners to increase the chances of maintaining a permanent pool in the basin. Liners can be either synthetic materials or imported lower permeability soils (i.e., clays). The water balance assessment shall determine whether a liner is required.

If low permeability soils are used for the liner, a minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with 3 parts native soil) must be placed over the liner (see soil amendment Section 5.10). If a synthetic material is used, a soil depth of 2 feet is recommended to prevent damage to the liner during planting.

Buffer Zone

A minimum of 25 feet buffer shall be provided around the top perimeter of the wet retention basin. The portion of the access road outside of the maximum water level may be included as part of the buffer.

Water Quality Design Features

1. Wet retention basins that are located in publicly-accessible or highly visible locations shall include design features that will improve and maintain the quality of water within the BMP at a level suitable for the proposed location and uses of the surrounding area. Typical design features include aeration, pumped circulation, filters, biofilters, and other facilities that operate year-round to remove pollutants and nutrients. Water quality design features will result in higher quality water in the BMP and lower discharges of pollutants downstream.

2. Wet retention basins in publicly-accessible or highly visible locations shall have a maintenance plan that includes regular collection and removal of trash from the area within and surrounding the BMP.

3. If fencing is required for wet retention basins in publicly-accessible or highly visible locations, the fence can be designed to be aesthetically incorporated into the site and Shrubs (approved, California-adapted species) can be used to hide the fencing. See vegetation section below.

Energy Dissipation

1. The inlet to the wet retention basin shall be submerged with the inlet pipe invert a minimum of two feet from the basin bottom (not including sediment storage). The top of the inlet pipe shall be submerged at least 1 foot, if possible. Intent: The inlet is submerged to dissipate energy of the incoming flow. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

2. Energy dissipation controls must also be used at the outlet from the wet retention basin unless the basin discharges to a storm water conveyance system or hardened channel.

Vegetation

A plan shall be prepared that indicates how aquatic, temporarily submerged areas (extended detention wet retention basins) and terrestrial areas will be stabilized with vegetation.

1. If the second cell of the wet retention basin is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation.

2. Emergent aquatic vegetation shall be planted to cover 25-75% of the area of the permanent pool.

3. Outside of the basin, native vegetation adapted for site conditions shall be used in non-irrigated sites.

4. The area surrounding a wet retention basin must be landscaped to minimize erosion and must adhere to the following criteria so as not to hinder maintenance operations:

5. No trees or shrubs may be planted within 15 feet of inlet or outlet pipes or manmade drainage structures such as spillways, flow spreaders, or earthen embankments. Species with roots that seek water, such as willow or poplar, shall not be used within 50 feet of pipes or manmade structures. Weeping willow (*Salix babylonica*) shall not be planted in or near detention basins.

6. Prohibited non-native plant species will not be permitted. For more information on invasive weeds, including biology and control of listed weeds, look at the encycloweedia located at the California Department of Food and Agriculture website- http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm or the California Invasive Plant Council website at www.cal-ipc.org.

7. See Appendix G for a recommended native plant list for wet retention basins, a list of local nurseries where these plants can be purchased, and a list of local and regional on-line resources. The plant list shall be used as a guide only and shall not replace project-specific planting recommendations provided by a landscape professional including recommendations on appropriate plants, fertilizer, mulching applications, and irrigation requirements (if any) to ensure healthy vegetation growth. See Section 5.11 for more information on landscaping/planting recommendations and Section 5.10 for more information on soil amendment recommendations.

Outlet Structure

1. An outlet pipe and outlet structure shall be provided. The outlet pipe may be a perforated standpipe strapped to a manhole (see Figure 6-25) or placed in an embankment, suitable for extended detention, or may be back-sloped to a catch basin with a grated opening (jail house window) or manhole with a cone grate (birdcage) (see Figure 6-26). The grate or birdcage openings provide an overflow route should the basin outlet pipe become clogged.

2. For extended detention wet retention basin, outlet structures shall be designed to provide 12 to 48 hour emptying time for the water quality volume above the permanent pool.

3. The basin outlet pipe shall be sized, at a minimum, to pass flows greater than the water quality design peak flow for off-line basins or flows greater than the peak runoff discharge rate for the 100-year, 24-hr design storm for on-line basins.

4. See the dry extended detention section (Section 6.10.3) and Appendix E for further detail on outlet sizing.

Emergency Spillway

An emergency overflow spillway in addition to the primary overflow outlet (as described above) is required. The emergency spillway shall be sized for flows greater than the peak 100-year 24-hour storm if the basin is designed on-line or, if the basin is designed on-line, the spillway shall be sized for flows greater than the basin design volume (e.g., water quality design volume). The spillway shall be constructed with reinforced concrete and provide for adequate energy dissipation downstream. The spillway shall allow for at least 12 inches of freeboard above the

emergency overflow water surface elevation if the basin is on-line. If the basin is on-line, 2 feet of freeboard is preferable.

Spillways shall meet the California Department of Water Resources, Division of Safety of Dams Guidelines for the Design and Construction of Small Embankment Dams (http://www.water.ca.gov/damsafety/docs/GuidelinesSmallDams.pdf). *Intent: Emergency overflow spillways are intended to control the location of basin overtopping and safely direct overflows back into the downstream conveyance system or other acceptable discharge point.*

On-line Basins

1. On-line basins must have an emergency overflow spillway to prevent overtopping of walls or berms should blockage of the primary outlet occur based on a downstream risk assessment.
2. The overflow spillway must be sized to pass flows greater than the design peak runoff discharge rate for the 100-yr, 24-hr storm.
3. The minimum freeboard shall be 1 foot (but preferably at least 2 feet) above the maximum water surface elevation over the emergency spillway.

Off-line Basins

1. Off-line basins must have either an emergency overflow spillway or an emergency overflow riser. The emergency overflow must be designed to pass flows greater than the basin design volume (e.g., water quality design volume) directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a steep slope, an emergency overflow riser, *in addition* to the spillway shall be provided. See Appendix E for further detail on basin/pond outlet sizing.
2. The emergency overflow spillway shall be armored to withstand the energy of the spillway flows (Figure 6-32). The spillway shall be constructed of grouted rip-rap.
3. The minimum freeboard shall be 1 foot above the maximum water surface elevation over the emergency spillway.

Side Slopes

1. Interior side slopes above the water quality design depth and up to the emergency overflow water surface shall be no steeper than 4:1 (H:V), unless stabilization has been approved by a licensed civil engineer and the City.
2. Exterior side slopes shall be no steeper than 2:1 (H:V), unless stabilization has been approved by a licensed civil engineer and the City.
3. For any slope (interior or exterior) steeper than 2:1 (H:V), a geotechnical investigation and report must be submitted and approved by the City.
4. Landscaped slopes must be no steeper than 3:1 (H:V) to allow for maintenance.

5. Basin walls may be vertical retaining walls, provided: (a) they are constructed of reinforced concrete, (b) a fence is provided along the top of the wall (see fencing below) or further back, and (c) the design is stamped by a licensed civil engineer and approved by the City.

Embankments

1. Earthworks and berm embankments shall be performed in accordance with the latest edition of the "Greenbook Standard Specifications for Public Works Construction".

2. Embankments are earthen slopes or berms used for detaining or redirecting the flow of water.

3. Top of berm shall be 2 feet minimum below the water quality design water surface and shall be keyed into embankment a minimum of 1 foot on both sides.

4. Typically, the top width of berm embankments are at least 20 feet, but narrower embankments may be plausible if approved by the civil engineer and the City.

5. Basin berm embankments must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a licensed civil engineer) free of loose surface soil materials, roots, and other organic debris.

6. The berm embankment shall be constructed of compacted soil (95% minimum dry density, modified proctor method per ASTM D1557), placed in 6-inch lifts.

7. Basin berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50% of the berm embankment cross-sectional height and width. This requirement may be waived if specifically recommended by a licensed civil engineer.

8. The berm embankment shall be constructed of compacted soil (95% minimum dry density, modified proctor method per ASTM D1557), placed in 6-inch lifts.

9. Low growing native or non-invasive perennial grasses shall be planted on downstream embankment slopes. See vegetation section below.

Fencing

Safety is provided either by fencing of the facility or by managing the contours of the basin to eliminate drop-offs and other hazards.

1. In accordance with the Santa Barbara Flood Control District *Standard Conditions of Project Plan Approval*, facilities to be dedicated to the City, perimeter fencing (minimum height of 42 inches) shall be required on all basins exceeding two feet in depth or where interior side slopes are steeper than 6:1 (H:V).

2. If fences are required, fences shall be designed and constructed in accordance with current policies of the Santa Barbara County Flood Control District and must be located at or above the overflow water surface elevation. Shrubs (approved, California-adapted species) can be used to hide the fencing. See vegetation section above.

Right-of-Way

1. Constructed treatment wetlands and associated access roads to be maintained by the City shall be dedicated in fee or in an easement to the City with appropriate access.

Maintenance Access

1. Ownership of the basin and maintenance thereof is the responsibility of the developer/applicant. A maintenance agreement with the City is required to ensure adequate performance and allow the City emergency access to the facilities.
2. Maintenance access road(s) shall be provided to the control structure and other drainage structures associated with the basin (e.g., inlet, emergency overflow or bypass structures). Manhole and catch basin lids must be in or at the edge of the access road.
3. A graded 16-foot wide access ramp into the basin shall be constructed near the basin outlet. An access ramp is required for removal of sediment with a backhoe or loader and truck. The ramp must extend to the basin bottom to avoid damage to vegetation planted on the basin slope. A 16-foot wide commercial driveway approach shall be provided where curb and gutter front the maintenance ramp.
4. All access ramps and roads shall be provided in accordance with the current policies of the Flood Control District.

Vector Control

1. A Mosquito Management Plan or Service Contract must be approved or waived by the Santa Barbara Coastal Vector Control District for any facility that maintains a pool of water for 72 hours or more.

Design Requirements Specific to Lakes

Lakes designed to provide treatment may be used for storm water quality management, but will not be publicly maintained. Many of the wet retention basin design specifications discussed above are applicable to lakes such as the outlet works and maintenance access, but specific design features are also required. For example, a consistent water supply is required to maintain the wet pool in the lake year-round and to flush the system during spring and fall turnover to reduce the potential for the build-up of salts and nutrients in the lake. The wet retention basin shall also be sized as three times the water quality design volume so that the water quality does not drastically fluctuate during such events. Lakes shall also have depths greater than 8 feet, and preferably up to 15 feet at the center, to reduce light penetration, maintain a lower average temperature, allow for temperature stratification, and minimize evaporation. Lakes may be exempt from the fencing requirements applicable to wet retention basins if they exceed one acre in surface area and are used for recreational purposes. Additional design elements specific to lakes to provide storm water treatment and to maintain the water quality in the lake include wetland planters, lake biofilter beds, dry weather flow pretreatment, aeration, and storm water retention.

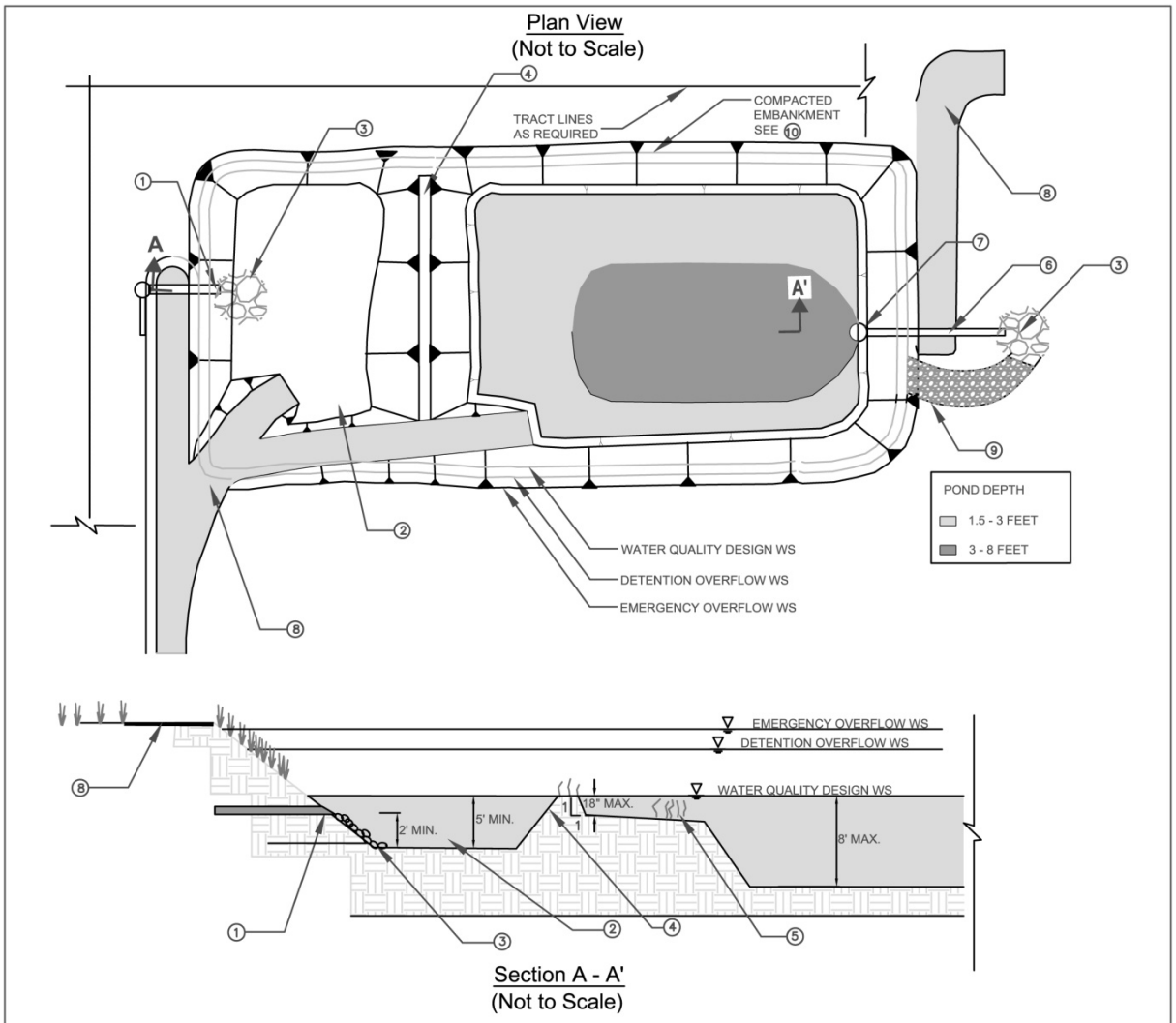
Submerged wetland planters may be constructed on shelves or floating rafts within the lake to assist in promoting overall water quality through filtering. Lake biofilters, through which lake

water is circulated and distributed by a slotted-pipe system, shall consist of separate, self-contained, submerged gravel beds placed at terminal ends of the lake geometry. A naturally occurring biomass of microorganisms coats the gravel and reduces nutrients that would otherwise promote algae growth in the lake. Pretreatment filters also shall be provided to treat all dry weather flows prior to entering the lake. In addition, fine-bubble diffusion aerators and recirculation pumping shall be installed to reintroduce oxygen into the system and increase overall dissolved-oxygen content. Adequate capacity shall be provided in the lake to maintain a permanent pool, retain the water quality design storm, and provide storage of runoff for irrigation reuse.

6.10.2.4 Construction Considerations

The use of treated wood or galvanized metal anywhere inside the facility is prohibited. The use of galvanized fencing is permitted if in accordance with the Fencing requirement above.

Figure 6-24: Wet Retention Basin Schematic



NOTES:

1. INLET PIPE SHOULD BE SUBMERGED WITH A MINIMUM OF 2' DISTANCE FROM THE BOTTOM.
2. FIRST CELL VOLUME SHALL EQUAL 25% TO 35% OF TOTAL WETPOND VOLUME. DEPTH SHALL BE 4' TO 8' PLUS AN ADDITIONAL I' MIN SEDIMENT STORAGE DEPTH FOR THE FIRST CELL.
3. RIPRAP APRON OR OTHER ENERGY DISSIPATION.
4. BERM SHALL EXTEND ACROSS ENTIRE WIDTH OF THE WETPOND AND SHALL BE KEYED INTO EMBANKMENT A MINIMUM OF 1' ON BOTH SIDES.
5. EMERGENT VEGETATION SHALL BE PLANTED IN REGIONS OF THE POND THAT ARE 3' DEEP OR LESS.
6. SIZE OUTLET PIPE TO PASS 100-YEAR PEAK FLOW FOR ON-LINE PONDS AND WATER QUALITY PEAK FLOW FOR OFF-LINE PONDS. MINIMUM DIAMETER OF OUTLET PIPE SHALL BE 18".
7. WATER QUALITY OUTLET STRUCTURE. SEE FIGURE 6-25 AND FIGURE 6-26 FOR DETAILS.
8. INSTALL PAVED MAINTENANCE ACCESS ROAD.WIDTH SHALL BE A MINIMUM OF 16' AND SLOPE SHALL NOT EXCEED 12%. SHALL PROVIDE ACCESS TO BOTH THE FIRST CELL AND MAIN BASIN.
9. INSTALL EMERGENCY OVERFLOW SPILLWAY AS NEEDED. SEE FIGURE 6-32 FOR DETAILS.
10. EMBANKMENT SIDE SLOPES SHALL BE NO STEEPER THAN 2H:1V OUTSIDE AND 4H:1V INSIDE. FENCING (MINIMUM HEIGHT OF 42") SHALL BE REQUIRED ON ALL BASINS EXCEEDING TWO FEET IN DEPTH OR WHERE INTERIOR SIDE SLOPES ARE GREATER THAN 6H:1V.

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Figure 6 - 24
WET RETENTION BASIN

Figure 6-25: Riser Outlet Schematic – Option 1

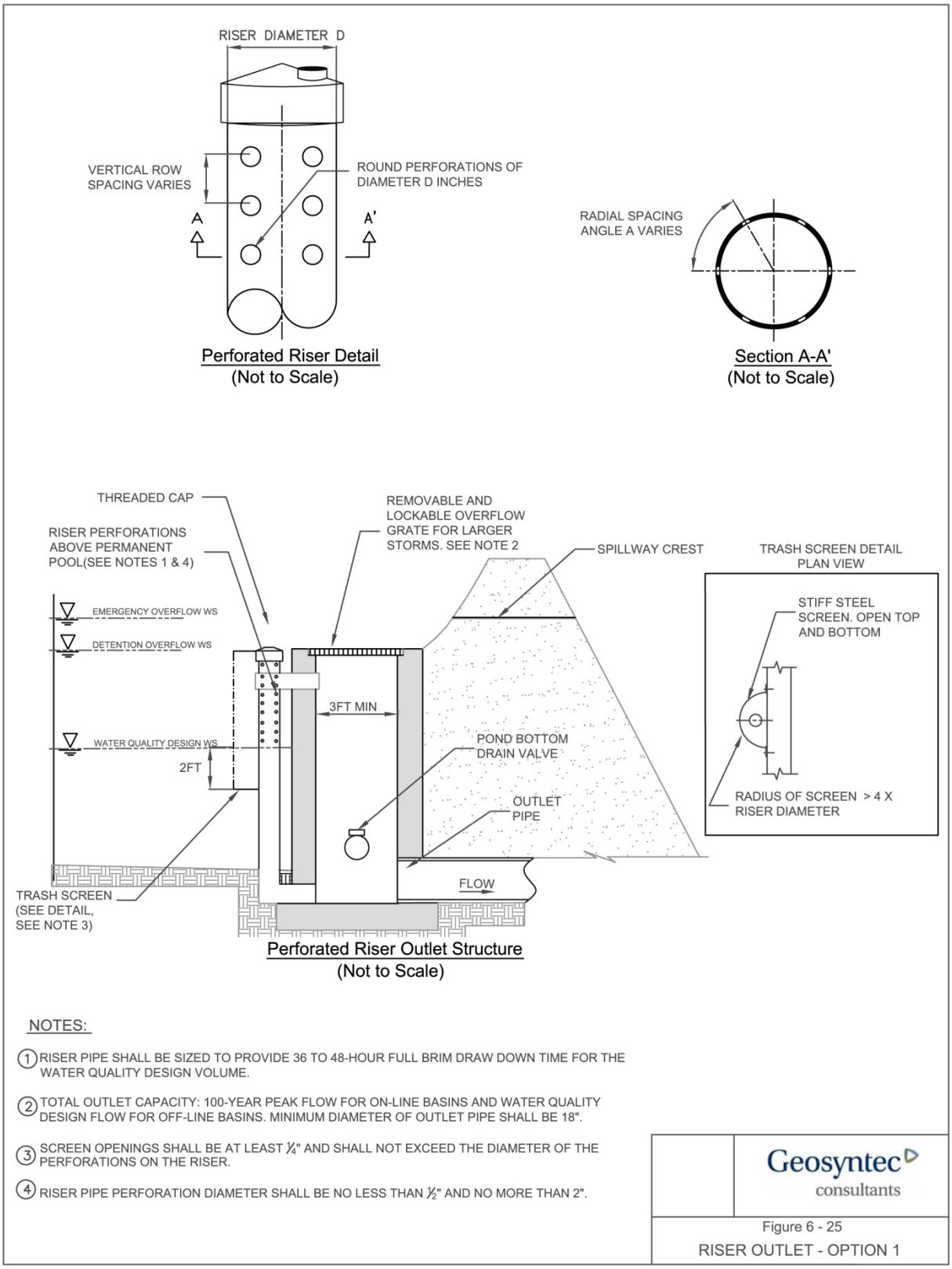
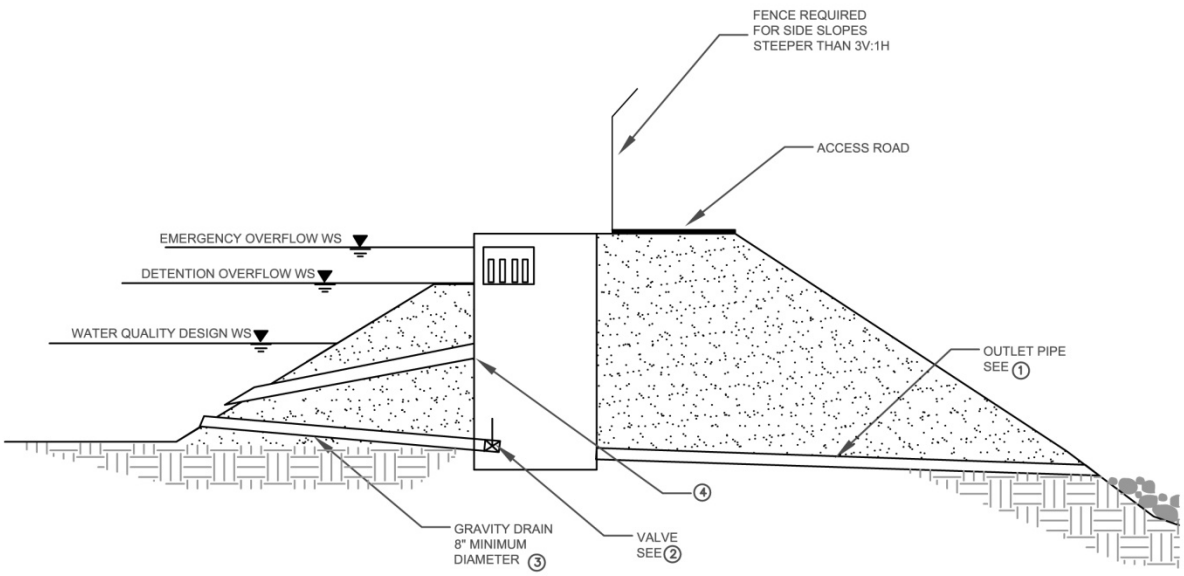


Figure 6-26: Inverted Pipe Outlet Schematic – Option 2



Inverted Pipe Outlet Structure
(Not to Scale)

NOTES:

1. SIZE OUTLET PIPE SYSTEM TO PASS 100-YEAR FLOW FOR ON-LINE PONDS AND WATER QUALITY PEAK FLOW FOR OFF-LINE PONDS.
2. VALVE MAY BE LOCATED INSIDE MANHOLE OR OUTSIDE WITH APPROVED OPERATIONAL ACCESS.
3. INVERT OF DRAIN SHALL BE 6" MINIMUM BELOW TOP OF INTERNAL BERM. LOWER PLACEMENT IS DESIRABLE. INVERT SHALL BE 6" MINIMUM ABOVE BOTTOM OF POND.
4. OUTLET PIPE INVERT SHALL BE AT WATER QUALITY DESIGN WATER SURFACE.

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Figure 6 - 26
INVERTED PIPE OUTLET - OPTION 2

6.10.2.5 Operations and Maintenance

General Requirements

Maintenance is of primary importance if wet retention basins are to continue to function as originally designed. A specific maintenance plan shall be formulated for each facility outlining the schedule and scope of maintenance operations, as well as the data handling and reporting requirements. The following are general maintenance requirements:

1. The wet retention basin shall be inspected at a minimum annually and inspections after major storm events are encouraged (see Appendix H for a wet retention basin inspection and maintenance checklist). Trash and debris shall be removed as needed, but at least annually prior to the beginning of the wet season.

2. Site vegetation shall be maintained as frequently as necessary to maintain the aesthetic appearance of the site, and as follows:

3. Vegetation, large shrubs, or trees that limit access or interfere with basin operation shall be pruned or removed.

4. Slope areas that have become bare shall be revegetated and eroded areas shall be regraded prior to being revegetated.

5. Grass shall be mowed and grass clippings shall be removed.

6. Fallen leaves and debris from deciduous plant foliage shall be raked and removed.

7. Invasive vegetation, such as Alligatorweed (*Alternanthera philoxeroides*), Halogeton (*Halogeton glomeratus*), Spotted Knapweed (*Centaurea maculosa*), Giant Reed (*Arundo donax*), Castor Bean (*Ricinus communis*), Perennial Pepperweed (*Lepidium latifolium*), and Yellow Starthistle (*Centaurea solstitalis*) must be removed and replaced with non-invasive species. For more information on invasive weeds, including biology and control of listed weeds, look at the encycloweedia located at the California Department of Food and Agriculture website- http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm or the California Invasive Plant Council website at www.cal-ipc.org.

8. Dead vegetation shall be removed if it exceeds 10% of area coverage. Vegetation shall be replaced immediately to maintain cover density and control erosion where soils are exposed.

9. Sediment buildup exceeding 1.5 inches in the first cell shall be removed (or 6 inches above the sediment storage depth which is recommended to be 1 foot). Sediment from the second basin cell shall be removed when 6 inches of sediment accumulates.

10. Sediments shall be tested for hazardous substance accumulation in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed.

11. Following sediment removal activities, replanting, and/or reseeding of vegetation may be required for reestablishment.

Maintenance Standards

A summary of the routine and major maintenance activities recommended for wet retention basins is shown in Table 6-69. Routine and major maintenance standards listed in Table 6-70 and Table 6-71 are intended to be measures to determine if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedance of these thresholds or measures at any time between inspections and/or scheduled maintenance does not constitute a violation of these standards. These standards are violated only when an inspection identifies required maintenance action that has not been scheduled before the next regular inspection.

Table 6-69: Wet Retention Basin Maintenance Quick Guide

Inspection and Maintenance Activities Summary	
Routine Maintenance	• Trash and debris removal • Remove minor sediment accumulation near inlet and outlet structures • Stabilize/repair eroded banks and fill in animal burrows if present • Remove any evidence of visual contamination from floatables such as oil and grease • Eliminate pests and conditions suitable for creating ideal breeding habitat • Remove algae mats as often as needed to prevent coverage of more than 20% of basin surface • Mow berms routinely if applicable to maintain aesthetic appeal and to suppress weeds • Periodically observe function under wet weather conditions • Photographs taken before and after maintenance is encouraged
Major Maintenance	• Remove dead, diseased, or dying trees and woody vegetation that interfere with facility maintenance • Install or repair basin liner to ensure that first cell maintains a permanent pool • Correct problems associated with berm settlement • Remove trees, large shrubs and roots from downstream slope of embankments. • Repair berm/dike breaches and stabilize eroded parts of the berm • Repair and rebuild spillway as needed to correct severe erosion damage • Remove sediment build up in forebay and main basin area to restore original sediment holding capacity • Re-grade main basin bottom to restore bottom slope and eliminate the incidence of standing pools • Aerate compacted areas to promote infiltration if volume reductions are desired • Repair or replace gates, fences, flow control structures, and inlet/outlet structures as needed to maintain full functionality

Table 6-70: Routine Maintenance Standards – Wet Retention Basin

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 sf of basin area (one standard garbage can) or if trash and debris is excessively clogging the outlet structure. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.	Annually prior to wet season After major storm events (>0.75 in/24 hrs) if spot checks of some basins indicate widespread damage/ maintenance needs
Sediment Accumulation	Sediment accumulation in basin bottom that exceeds the depth of the design sediment zone plus 6 inches, usually in the first cell.	Sediment cleaned out.	
Erosion	Erosion of basin's side slopes and/or scouring of basin bottom.	Slopes shall be stabilized using appropriate erosion control measure(s) and repair methods.	
Oil Sheen on Water	Prevalent and visible oil sheen.	Oil sheen removed using absorbent boom or skimmer.	
Noxious Pests	Visual observations or receipt of complaints of numbers of pests that would not be naturally occurring and could pose a threat to human or aquatic health.	Vectors controlled per Santa Barbara Coastal Vector Control District. A Mosquito Management Plan or Service Contract must be presented to the Vector Management District for any facility that maintains a pool of water for 72 hours or more.	
Water Level	First cell empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.	
Algae Mats	Algae mats over more than 20% of the water surface.	Algae mats removed using rake or other skimming device.	

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Aesthetics	Minor vegetation removal and thinning. Mowing berms and surroundings	Facility is well kept.	Monthly (or as dictated by agreement between County and landscape contractor)
Noxious Weeds	Any evidence of noxious weeds.	Eradicate all noxious weeds; control and prevent the spread of all noxious weeds. Use Integrated Pest Management techniques, if applicable. See http://www.ipm.ucdavis.edu for more information.	

Table 6-71: Major Maintenance Standards – Wet Retention Basin

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Tree Growth	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering, do not remove. Dead, diseased, or dying trees shall be removed.	Trees do not hinder maintenance activities. Remove dead, diseased, or dying trees. (Use a certified Arborist to determine health of tree or removal requirements).	Annual or as needed (infrequent) After major storm events (>0.75 in/24 hrs) if spot checks of some basins indicate widespread damage/ maintenance needs.
Settling of Berm	If settlement is apparent. Settling can be an indication of more severe problems with the berm or outlet works. A civil engineer shall be consulted to determine the source of the settlement if the dike/berm is serving as a dam.	Dike is built back to the design elevation.	
Piping through Berm	Discernable water flow through basin berm. Ongoing erosion with potential for erosion to continue. A licensed civil engineer shall be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved and berm stability achieved.	

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Tree and Large Shrub Growth on Downstream Slope of Embankments	Tree and large shrub growth on downstream slopes of embankments may prevent inspection and provide habitat for burrowing rodents.	Trees and large shrubs shall be removed. All dead roots shall be removed if practical. Otherwise, dead roots shall be removed to a minimum of 36 inches below grade and replaced with cement grout to 12 inches below grade. The top 12 inches of the root holes shall be filled with compacted, in-situ soils. The area facility engineer may require additional root removal if necessary for dam safety or maintenance purposes.	
Erosion on Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks and pad depth are restored to design standards.	
Gate/Fence Damage	Damage to gate/fence, including missing locks and hinges	Gate/Fence repaired.	

6.10.3 Dry Extended Detention Basins

Figure 6-27: Dry ED Basin ***(dual use; playing field when dry)***

Applications

- Roads and highways
- Commercial developments
- Office building developments
- Multi-family developments

Performance/Advantages

- Efficient removal of pollutants adsorbed to sediments
- Potentially significant volume mitigation

Limitations

- Requires large tributary area
- Must be sited in areas where current flood control structures are not adversely affected

6.10.3.1 Description

Dry extended detention (ED) basins (e.g., dry ponds, extended detention basins, detention ponds, or extended detention ponds) are basins whose outlets have been designed to detain the water quality design volume, V_{wq}, for 36 to 48 hours to allow sediment particles and associated pollutants to settle and be removed. Dry ED basins do not have a permanent pool; they are designed to drain completely between storm events. They can also be used to provide hydromodification and/or flood control by modifying the outlet control structure and providing additional detention storage. Where soil conditions allow, they can also be modified to achieve volume reduction goals by including a sand filter layer beneath the basin to detain and infiltrate additional runoff. The slopes, bottom, and forebay of dry ED basins are typically vegetated. Without the addition of a sand filter beneath the basin, considerable storm water volume reduction can still occur, depending on the infiltration capacity of the subsoil. Data from the International BMP Database have shown that as much as 30 percent of storm water volume captured by dry extended detention basins can be lost to infiltration (Strecker et al., 2004).

Dry ED basins can be designed either on-line or off-line. If it is designed just for water quality treatment, it is recommended that the basin be off-line from flood conveyance. For off-line basins, a flow diversion structure (i.e., flow splitter) is used to divert the water quality design volume to the basin. For on-line basins, storm events exceeding the water quality design volume will be routed through the basin and discharged from a primary overflow structure at rates that do not exceed pre-development rates for storms up to the 100-year, 24-hr design storm. Storm events that exceed the 100-year design storm will exit the basin over an emergency spillway. If basins are to be on-line, they must be designed to pass the appropriate flood without damage to the basin, as well as to minimize re-entrainment of pollutants. In both

types of basins, influent flows enter a sediment forebay where coarse solids are first removed prior to flowing into the main cell of the basin where finer sediment and associated pollutants settle as storm water is detained and slowly released through a controlled outlet structure. Dry weather flows and very low storm flows are often infiltrated within the basin. If standing water is a concern due to dry weather flows, a low flow drain can be installed to convey the dry weather flows out of the basin and to another storm water runoff BMP, storm water conveyance system, or other acceptable discharge point.

6.10.3.2 Performance, Applicability, and Limitations

Table 6-72, Table 6-73, and Table 6-74 provide a summary of BMP performance, applicability, and limitations for dry ED basins. *It is important to note that information in these tables shall be used to provide general guidance for dry ED basins and shall not replace the evaluation performed by a water quality professional.*

Applicability and Performance

Table 6-72 and associated guidance provide general volume reduction capabilities and treatment effectiveness for dry ED basins. Refer to Section 6.4 for the process that shall be used for selecting BMPs based on pollutants of concern. Refer to Table 6-1 to determine the ranking of constructed treatment wetlands for removal of pollutants of concern as compared with other storm water runoff BMPs provided in Chapter 6. Refer to Table 6-2 to assess the applicability of constructed treatment wetlands for your site based on site suitability considerations as compared with other storm water runoff BMPs provided in Chapter 6. Dry extended detention basins are volume-based BMPs intended to provide: (1) water quality treatment, (2) varying levels of volume reduction depending on site conditions and design, and (3) control of the peak runoff discharge rate (see Table 6-72). Dry weather flows and small storm flows are often infiltrated within the basin. If site conditions allow, a hybrid sand filter or planting media layer placed beneath the dry extended detention basin (as described in this section), can be designed to increase the infiltration capacity of the basin. In this hybrid case or when the detention basin is underlain by infiltrative soils, credit can be gained towards meeting the volume reduction requirement, $V_{reduction}$, as described below in the basin sizing section. See Section 6.2 for specific storm water runoff requirements for Tier 3 projects.

Table 6-72: Volume Reduction & Treatment Effectiveness for Dry ED Basins

Storm Water Runoff BMP	Volume Mitigation (% of inflow)	Treatment Effectiveness for Pollutants of Concern[1]					
		Trash	Nutrients	Bacteria	Metals (particulate and dissolved fractions)	Sediment	Organics (hydro-carbons, oil, and grease)
Dry Extended Detention Basin	◉	◓	◒	◓	◒	◉	◉
Volume/Treatment Effectiveness: ● = *Very High,* ◓ = *High,* ◉ = *Moderate,* ◒ = *Low,* ○ = *Very Low*							

[1] Effectiveness may change based on design variations; standard BMP designs have been assumed.

Water quality treatment is provided in the sediment forebay and the main cell. The sediment forebay provides removal of coarse solids prior to flow entering the main cell of the basin where finer sediment and associated pollutants settle as storm water is detained and slowly released through a controlled outlet structure.

Site Suitability Recommendations and Limitations

Table 6-73 and associated guidance provide general considerations for assessing a site's suitability for dry ED basins.

Table 6-73: Site Suitability Considerations for Dry Extended Detention Basins

BMP	Tributary Area (Acres)[1]	Site Slope (%)	Depth to Seasonally High Groundwater Table (ft)	Hydrologic Soil Group	Horizontal Setback from Drinking Water Wells (ft)
Dry Extended Detention Basin	> 5	< 15 [2]	> 2 if infiltration is not significant; > 5 when basin is designed to achieve volume reduction requirements	Any	100 when basin is designed to achieve volume reduction requirements

[1] Tributary area is the area of the site draining to the BMP. Tributary areas provided here shall be used as a general guideline only. Tributary areas can be larger or smaller in some instances.

[2] If slope exceeds given limit or is within 200 feet from the top of a hazardous slope or landslide area, a geotechnical investigation is required.

Table 6-74 provides additional site applicability considerations for special design districts within the City including coastal bluff areas and hillside design districts.

Table 6-74: Applicability of Dry ED Basins for Special Design Districts

Coastal Bluff Area	Hillside Design District
Generally not acceptable in Coastal Bluff Areas.	Acceptable if: (1) a geotechnical investigation proves that the facility does not compromise the stability of the site slope or surrounding slopes, or (2) the facility meets the site slope criteria in Table 6-73 and the facility is fully contained with an impermeable liner and overflow to a storm water conveyance system.

The following describes additional site suitability recommendations and limitations for dry extended detention basins.

- The tributary area associated with a dry ED basin shall be greater than 10 acres. Use of dry ED basins may be limited in high density locations where insufficient space is available to achieve reductions in storm water runoff discharge flow rate, volume, and/or pollutants.

- Site slope shall be less than 15% due to slope instability and landslide potential. If slopes exceed this limit, a geotechnical investigation is required.

- The location of dry ED basins shall not be within 200 feet from the top of a hazardous slope or landslide area. If so, a geotechnical investigation is required.

- For dry ED basins that do have significant infiltration (i.e., not designed to achieve the volume reduction requirements), maximum groundwater levels shall be at least 2 ft lower than the bottom the dry ED basin to prevent the base from remaining wet between storms. If the dry ED basin is designed for significant infiltration (i.e., designed to achieve the volume reduction requirements), maximum groundwater levels shall be at least 5 ft lower than the bottom of the basin to minimize water quality impacts to groundwater.

- Dry ED basins shall not be designed for significant infiltration in areas of high industrial activity or other locations where a heightened threat of groundwater contamination may exist.

- Dry ED basins shall not be placed within a blue-line (i.e., first order) stream.

Multi-Use and Treatment Train Opportunities

A dry ED basin can sometimes be retrofitted into existing flood control basins or integrated into the design of a park, athletic field, or other green space. Hybrid dry ED basins that incorporate a sand filter or planting media underneath the basin are an option for increasing volume reduction. The hybrid dry ED basin and sand filter or planting media system can also have recreational use by using the system as a volleyball court. Both of these applications can encourage infiltration if site conditions allow and require significant pretreatment to remove coarse solids, trash and debris, and oil and grease. Perforated risers, multiple orifice plate outlets, or similar multi-stage outlets are required for flood control retrofit applications to ensure adequate detention time for small storms while still providing peak flow attenuation for the flood design storms. Recreational multi-use facilities must be inspected after every storm and may require a greater maintenance frequency than dedicated water quality basins as to ensure aesthetics and public safety are not compromised. Any planned multi-use facility may be required to obtain special approval from the City.

Dry ED basins can also be combined with other basic and storm water runoff BMPs to form a "treatment train" that provides enhanced water quality treatment and reductions in runoff volume and rate. For example, a vegetated swale can be placed upgradient of a dry ED basin, allowing the rate and volume of water flowing to the dry ED basin to be reduced and the water quality enhanced. As another example, dry ED basins may be placed upstream of a vegetated swale to reduce the size of the vegetated swale. In both cases, each facility can be reduced in size accordingly based upon demonstrated performance for meeting the storm water runoff requirements as outlined in Section 6.2 and addressing targeted pollutants of concern.

6.10.3.3 Design Criteria and Procedure

Dry ED basins shall be designed according to the current policies of the City and the County of Santa Barbara Flood Control District. Standard design criteria for dry ED basins are listed in Table 6-75.

Table 6-75: Dry Extended Detention Basin Design Criteria

Design Parameter	Unit	Design Criteria
Maintaining peak runoff discharge rate requirement	cfs	See Section 6.2.1 and Appendix C
Design volume reduction requirement, $V_{reduction}$	acre-feet	See Section 6.2.2 and Appendix C
Water quality design volume, V_{wq}	acre-feet	See Section 6.2.3 and Appendix C
Forebay basin size	acre-feet	25% of total basin volume
Drawdown time for V_{wq}	hours	Top 50%: 12-16 hrs; Bottom 50%: 24-32 hrs
Freeboard (minimum)	inches	12; for off-line facilities
Flow path length to width ratio	L:W	3:1; can be achieved using internal berms
Side slope (maximum)	H:V	4:1 (H:V) Interior and 2:1 (H:V) Exterior
Longitudinal slope	percentage	1 (forebay) and 0-2 (main basin)
Low flow channel geometry [1]	feet	Of 'sufficient size' (see footnote below)
Maintenance access ramp width	feet	16
Minimum outflow device diameter	inches	18

Sizing for Meeting the Storm Water Runoff Requirements

Dry extended detention basins can be sized to meet all or part of the storm water runoff requirements as outlined in Section 6.2 and Appendix C. A schematic of a standard dry ED basin is illustrated in Figure 6-28. A dry ED basin sizing example is provided in Appendix D.

Maintaining peak runoff discharge rate requirement

The dry ED basin can be designed with sufficient storage to meet all or part of the peak runoff discharge requirement for the 2-year through the 100-year, 24-hr design storm.

Volume reduction requirement

If the dry ED basin is underlain by a subsoil with an infiltration of 0.5 in/hr or greater (as determined using the methods outlined in Chapter 3), a volume reduction of 15 percent of storm water volume captured by dry ED basin can be credited towards the volume reduction requirement, $V_{reduction}$.

If the dry ED basin is combined with a sand filter, a larger volume reduction can be credited towards the volume reduction requirement, $V_{reduction}$, based on the demonstrated design and performance of the system.

Water quality treatment volume requirement

The dry ED basin can be designed to treat the water quality treatment volume with a 36 to 48 hour drawdown time

Geometry and Size

1. The total basin volume shall be increased an additional 5% of the water quality design volume to account for sediment accumulation. If the basin is designed only for water quality treatment then the basin volume would be 105% of the water quality design volume, V_{wq}. Freeboard is in addition to the total basin volume.

2. The minimum freeboard shall be at least 1 foot above the emergency overflow water surface for dry extended detention basins.

3. The minimum flow-path length to width ratio at half basin height shall be a minimum of 3:1 (L:W) and can be achieved using internal berms or other means to prevent short-circuiting. *Intent: a long flow length will improve fine sediment removal.*

4. The cross-sectional geometry across the width of the basin shall be approximately trapezoidal with a maximum side slope of 4:1 (H:V) on interior slopes and 2:1 (H:V) on exterior slopes unless specifically permitted by the County (see Side Slopes below). Shallower side slopes are necessary if the basin is designed to have recreational uses during dry weather conditions.

5. All dry ED basins shall be free draining and a low flow channel shall be provided. A low flow channel is a narrow, shallow trench filled with pea gravel and encased with filter fabric that runs the length of the basin to drain dry weather flows. The low flow channel shall be of sufficient size considering the natural characteristics of the soil and have a positive-draining gradient flowing toward the outlet structure (typically 1 ft wide by 6 inches deep). If infiltration rates of subsurface soils are insufficient, the low flow channel shall tie into perforated pipe at the outlet structure. If a sand filter or planting media is provided beneath the dry ED basin for increased volume reduction, it may be designed to take the place of the low flow channel.

6. The basin bottom shall have a 1% longitudinal slope (direction of flow) in the forebay, and may range from 0 to 2% longitudinal slope in the main basin. The bottom of the basin shall slope 2% toward the center low flow channel.

7. A basin shall be large enough to allow for equipment access via a graded 16-foot wide access ramp. If the total basin volume is such that the basin bottom is less than 16 feet wide, an alternative BMP shall be considered or the Santa Barbara County Flood Control District shall be contacted for approval. See Maintenance Access below.

Soils Considerations

1. Dry ED basins can be used with almost all soils and geology, with minor design adjustments for rapidly percolating soils (sandy or gravelly soils with infiltration rate > 2.4 in/hr). If rapidly percolating soils are present, dry ED basins shall be lined with compacted low permeability soil or use another other type of liner to prevent rapid, untreated infiltration.

2. The slopes of the detention basin shall be analyzed for slope stability using rapid drawdown conditions and shall meet the minimum standards set by the Santa Barbara County Flood Control District. A 1.5 static factor of safety shall be used. Seismic analysis is not required due to the temporary storage of water in the basin.

3. The infiltration capability of the dry ED basin can be enhanced by incorporating soil amendments. See Section 5.10 for more information.

Energy Dissipation

1. Energy dissipation controls constructed of sound materials such as stones, concrete, or proprietary devices that are rated to withstand the energy of the influent flow shall be installed at the inlet to the sediment forebay. Flow velocity into the basin forebay shall be controlled to 4 feet per second (ft/sec) or less.
2. Energy dissipation controls must also be used at the outlet/spillway from the detention basin unless the basin discharges to a storm drain or hardened channel.

Sediment Forebay

As untreated storm water enters the dry ED basin, it passes through a sediment forebay for coarse solids removal. The forebay may be constructed using an internal berm constructed out of earthen embankment material, grouted riprap, stop logs, or other structurally sound material.

1. The basin shall be sized so that 25% of the total basin volume is in the forebay and 75% of the total basin volume is in the main portion of the basin.

2. A gravity drain outlet from the forebay (2" minimum diameter) must extend the entire width of the internal berm and be designed to completely drain to the main basin within 10 minutes.

3. The forebay outlet shall be offset (horizontally) from the inflow streamline to prevent short-circuiting.

4. Permanent steel post depth markers shall be placed in the forebay to define sediment removal limits at 50% of the forebay sediment storage depth.

Vegetation

Vegetation within the dry ED basin provides erosion protection from wind and water and biofiltration of storm water. The City shall review and approve any proposed basin landscape plan prior to implementation and following guidelines shall be followed:

1. The bottom and slopes of the dry ED basin shall be vegetated. A mix of erosion-resistant plant species that effectively bind the soil shall be used on the slopes and a diverse selection of plants that thrive under the specific site, climatic, and watering conditions shall be specified for the basin bottom. The basin bottom shall not be planted with trees, shrubs, or other large woody plants that may interfere with sediment removal activities. The basin shall be free of floating objects. Only native perennial grasses, forbs, or similar vegetation that can be replaced via seeding shall be used on the basin bottom.

2. Landscaping outside of the basin is required for all dry ED basins and must adhere to the following criteria so as not to hinder maintenance operations:

    a. No trees or shrubs may be planted within 15 feet of inlet or outlet pipes or manmade drainage structures such as spillways, flow spreaders, or earthen embankments. Species with roots that seek water, such as willow or poplar, shall not be used within 50 feet of pipes or manmade structures. Weeping willow (*Salix babylonica*) shall not be planted in or near detention basins.

    b. Prohibited non-native plant species will not be permitted. For more information on invasive weeds, including biology and control of listed weeds, look at the encycloweedia located at the California Department of Food and Agriculture website- http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm or the California Invasive Plant Council website at www.cal-ipc.org.

3. See Appendix G for a recommended native plant list for dry extended detention basins, a list of local nurseries where these plants can be purchased, and a list of local and regional on-line resources. The plant list shall be used as a guide only and shall not replace project-specific planting recommendations provided by a landscape professional including recommendations on appropriate plants, fertilizer, mulching applications, and irrigation requirements (if any) to ensure healthy vegetation growth. See Section 5.11 for more information on landscaping/planting recommendations and Section 5.10 for more information on soil amendment recommendations.

Sand Filter or Planting Media Layer

For increasing the volume reduction capability of a dry ED basin, an appropriately sized sand filter or planting media layer can be placed beneath the dry ED basin to achieve desired volume reduction goals if soil and slope conditions allow (i.e., infiltration rate greater than 0.05 in/hr but less than 2.4 in/hr; site slope less than 15%). The drawdown time of the sand filter or planting media layer shall be less than 72 hours. The base of the sand filter or planting media layer shall be level (i.e., zero slope). If a sand filter/planting media layer is provided over the length of the basin, it can take the place of the low-flow channel so long as it is designed to adequately infiltrate dry weather flows. Sizing of the sand filter and planting media layer for dry ED basins is the same as for sand filters and bioretention areas, respectively. See Sections 6.6.4

for sizing calculations for sand filters and Section 6.6.1 for sizing calculations for bioretention areas. The depth of water in the dry ED basin shall not exceed 6 feet.

Outlet Structure and Drawdown Time

A drawdown time of 36 to 48 hours shall be provided for the water quality design volume, V_{wq}. This drawdown time is for the volume in the basin above the sand filter layer (if provided) and serves the purpose of water quality treatment. An outflow device shall be designed to release the bottom 50% of the detention volume (half-full to empty) over 24 to 32 hours, and the top half (full to half-full) in 12 to 16 hours. *Intent: Drawdown schemes that detain low flows for longer periods than high flows have the following advantages over outlets that drain the basin evenly:*

- *Greater flood control capabilities*
- *Enhanced treatment of low flows which make up the bulk of incoming flows.*

Additional storage, detention, and outlet control is required to achieve pre-development storm water runoff discharge rates for the 2- through 100-year 24-hour storm events as required by the Santa Barbara County Flood Control District. The outlet structure can be designed to achieve flow control for meeting the multiple objectives of water quality and flow attenuation.

The outflow device (i.e., outlet pipe) shall be oversized (18 inch minimum diameter). There are two options that can be used for the outlet structure:

1. Uniformly perforated riser structures.
2. Multiple orifice structures (orifice plate).

The outlet structure can be placed in the basin with a debris screen (Figure 6-29) or housed in a standard manhole (Figure 6-30 and Figure 6-31). If a multiple orifice structure is used, an orifice restriction (if necessary) shall be used to limit orifice outflow to the maximum discharge rates allowable for achieving the desired water quality and flow control objectives. Orifice restriction plates shall be removable for emergency situations. A removable trash rack shall be provided at the outlet. Orifice plates and trash racks shall be galvanized. Mounting hardware shall utilize stainless steel bolts.

Note that a primary overflow (typically a riser pipe connected to the outlet works) shall be sized to pass flows larger than the water quality design storm (if the ED basin is sized only for water quality) or to pass flows larger than the peak flow rate of the maximum design storm to be detained in the basin (e.g., 100-yr, 24-hr). The primary overflow is intended to protect against overtopping or breaching of a basin embankment.

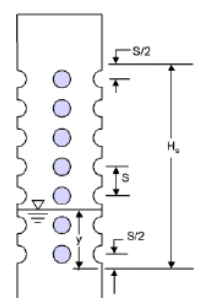
Perforated Risers Outlet Sizing Methodology

The following attributes influence the perforated riser outlet sizing calculations**:**

- Shape of the basin (e.g., trapezoidal)
- Depth and volume of the basin
- Elevation / depth of first row of holes
- Elevation / depth of last row of holes
- Size of perforations
- Number of rows or perforations and number of perforations per row
- Desired drawdown time (e.g., 16 hour and 32 hour draw down for top half and bottom half respectively, 48 hour total drawdown time for the water quality design volume)

The governing the rate of discharge from a perforated riser structure can be calculated using Equation 6-32 below:

$$Q = C_p \frac{2A_p}{3H_s}\sqrt{2g}H^{3/2} \qquad \text{(Equation 6-32)}$$



Where:

Q	=	riser flow discharge (cfs)
C_p	=	discharge coefficient for perforations (use 0.61)
A_p	=	cross-sectional area of all the holes (ft^2)
s	=	center to center vertical spacing between perforations (ft)
H_s	=	distance from s/2 below the lowest row of holes to s/2 above the top row of holes (McEnroe 1988).
H	=	effective head on the orifice (measured from center of orifice to water surface)

For the iterative computations needed to size the perforations in the riser and determine the riser height, a simplified version of Equation 6-32 may be used as shown below in Equation 6-33 and Equation 6-34:

$$Q = kH^{3/2} \qquad \text{(Equation 6-33)}$$

Where:

$$k = C_p \frac{2A_p}{3H_s}\sqrt{2g} \qquad \text{(Equation 6-34)}$$

Uniformly perforated riser designs are defined by the depth or elevation of the first row of perforations, the length of the perforated section of pipe, and the size or diameter of each perforation (Figure 6-29 and Figure 6-30). The steps needed to size a perforated riser outlet are illustrated in Appendix E.

Multiple Orifice Outlet Sizing Methodology

The following attributes influence multiple orifice outlet sizing calculations**:**

- Shape of the basin (e.g., trapezoidal)
- Depth and volume of the basin
- Elevation of each orifice
- Desired draw-down time (e.g., 16 hour and 32 hour draw down times for top half and bottom half respectively, 48 hour drawdown time for water quality design volume)

The rate of discharge from a single orifice can be calculated using Equation 6-35.

$$Q = CA(2gH)^{0.5} \qquad \text{(Equation 6-35)}$$

Where:

Q	=	orifice flow discharge
C	=	discharge coefficient
A	=	cross-sectional area of orifice or pipe (ft^2)
g	=	acceleration due to gravity (32.2 ft/s^2)
H	=	effective head on the orifice (measured from center of orifice to water surface)

Multiple orifice designs are defined by the depth (or elevation) and the size (or diameter) of each orifice (Figure 6-31). The steps needed to size a dual orifice outlet are outlined in Appendix E; multiple orifices may be provided and sized using a similar approach.

Emergency Spillway

An emergency overflow spillway in addition to the primary overflow outlet (as described above) is required. The emergency spillway shall be sized for flows greater than the peak 100-year 24-hour storm if the basin is designed on-line or, if the basin is designed on-line, the spillway shall be sized for flows greater than the basin design volume (e.g., water quality design volume). The spillway shall be constructed with reinforced concrete and provide for adequate energy dissipation downstream. The spillway shall allow for at least 12 inches of freeboard above the emergency overflow water surface elevation if the basin is on-line. If the basin is on-line, 2 feet of freeboard is preferable.

Spillways shall meet the California Department of Water Resources, Division of Safety of Dams Guidelines for the Design and Construction of Small Embankment Dams (http://www.water.ca.gov/damsafety/docs/GuidelinesSmallDams.pdf). *Intent: Emergency overflow spillways are intended to control the location of basin overtopping and safely direct overflows back into the downstream conveyance system or other acceptable discharge point.*

On-line Basins

1. On-line basins must have an emergency overflow spillway to prevent overtopping of walls or berms should blockage of the primary outlet occur based on a downstream risk assessment.

2. The overflow spillway must be sized to pass flows greater than the design peak runoff discharge rate for the 100-yr, 24-hr storm.

3. The minimum freeboard shall be 1 foot (but preferably at least 2 feet) above the maximum water surface elevation over the emergency spillway.

Off-line Basins

1. Off-line basins must have either an emergency overflow spillway or an emergency overflow riser. The emergency overflow must be designed to pass the 100-yr 24-hr post-development peak storm water runoff discharge rate directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a steep slope, an emergency overflow riser, *in addition* to the spillway shall be provided.

2. The emergency overflow spillway shall be armored to withstand the energy of the spillway flows (Figure 6-32). The spillway shall be constructed of grouted rip-rap.

3. The minimum freeboard shall be 1 foot above the maximum water surface elevation over the emergency spillway.

Side Slopes

1. Interior side slopes above the water quality design depth and up to the emergency overflow water surface shall be no steeper than 4:1 (H:V), unless stabilization has been approved by a licensed civil engineer and the City.

2. Exterior side slopes shall be no steeper than 2:1 (H:V), unless stabilization has been approved by a licensed civil engineer and the City.

3. For any slope (interior or exterior) greater than 2:1 (H:V), a geotechnical investigation and report must be submitted and approved by the City.

4. Landscaped slopes must be no greater than 3:1 (H:V) to allow for maintenance.

5. Basin walls may be vertical retaining walls, provided: (a) they are constructed of reinforced concrete, (b) a fence is provided along the top of the wall (see fencing below) or further back, and (c) the design is stamped by a licensed civil engineer and approved by the City.

Embankments

1. Earthworks and berm embankments shall be performed in accordance with the latest edition of the “Greenbook Standard Specifications for Public Works Construction”.

2. Embankments are earthen slopes or berms used for detaining or redirecting the flow of water.

3. Top of berm shall be 2 feet minimum below the water quality design water surface and shall be keyed into embankment a minimum of 1 foot on both sides.

4. Typically, the top width of berm embankments are at least 20 feet, but narrower embankments may be plausible if approved by the civil engineer and the City.

5. Basin berm embankments must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a licensed civil engineer) free of loose surface soil materials, roots, and other organic debris.

6. The berm embankment shall be constructed of compacted soil (95% minimum dry density, modified proctor method per ASTM D1557), placed in 6-inch lifts.

7. Basin berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50% of the berm embankment cross-sectional height and width. This requirement may be waived if specifically recommended by a licensed civil engineer.

8. The berm embankment shall be constructed of compacted soil (95% minimum dry density, modified proctor method per ASTM D1557), placed in 6-inch lifts.

9. Low growing native or non-invasive perennial grasses shall be planted on downstream embankment slopes. See vegetation section below.

Fencing

1. Safety is provided either by fencing of the facility or by managing the contours of the basin to eliminate drop-offs and other hazards.

2. In accordance with the Santa Barbara Flood Control District *Standard Conditions of Project Plan Approval*, facilities to be dedicated to the City, perimeter fencing (minimum height of 42 inches) shall be required on all basins exceeding two feet in depth or where interior side slopes are steeper than 6:1 (H:V).

3. If fences are required, fences shall be designed and constructed in accordance with current policies of the Santa Barbara County Flood Control District and must be located at or above the overflow water surface elevation. Shrubs (approved, California-adapted species) can be used to hide the fencing. See vegetation section above.

Right-of-Way

1. Constructed treatment wetlands and associated access roads to be maintained by the City shall be dedicated in fee or in an easement to the City with appropriate access.

Maintenance Access

1. Ownership of the basin and maintenance thereof is the responsibility of the developer/applicant. A maintenance agreement with the City is required to ensure adequate performance and allow the City emergency access to the facilities.

2. Maintenance access road(s) shall be provided to the control structure and other drainage structures associated with the basin (e.g., inlet, emergency overflow or bypass structures). Manhole and catch basin lids must be in or at the edge of the access road.

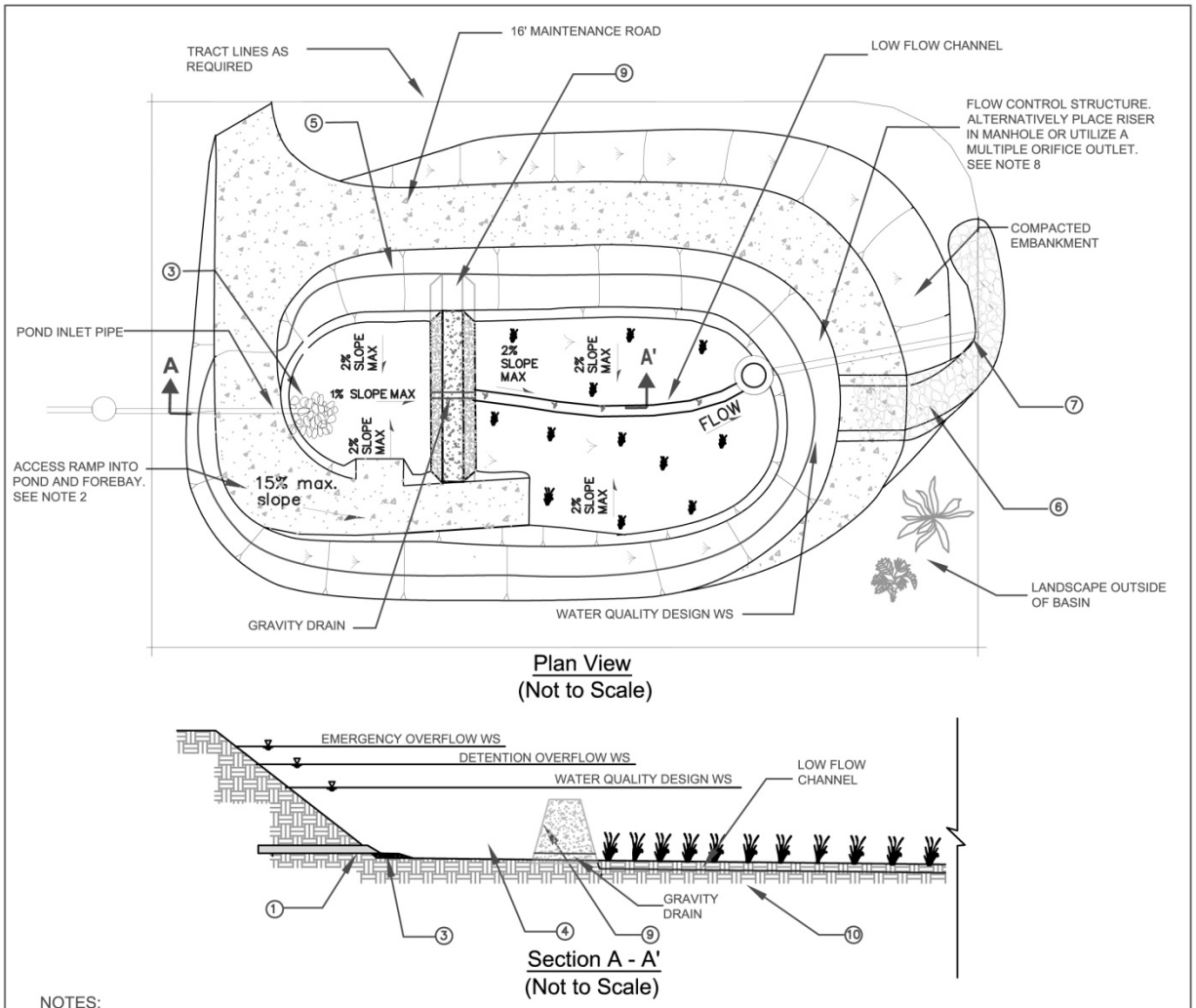
3. A graded 16-foot wide access ramp into the basin shall be constructed near the basin outlet. An access ramp is required for removal of sediment with a backhoe or loader and truck. The ramp must extend to the basin bottom to avoid damage to vegetation planted on the basin slope. A 16-foot wide commercial driveway approach shall be provided where curb and gutter front the maintenance ramp.

4. All access ramps and roads shall be provided in accordance with the current policies of the Flood Control District.

6.10.3.4 Construction Considerations

The use of treated wood or galvanized metal anywhere inside the facility is prohibited. The use of galvanized fencing is permitted by the Flood Control District.

Figure 6-28: Dry Extended Detention Basin Schematic



NOTES:

1. INLET PIPE SHALL BE DESIGNED AND LOCATED SO THAT NON-EROSIVE VELOCITIES OCCUR IN THE FOREBAY.
2. MAINTENANCE RAMP SHOULD BE PAVED AND SHOULD BE 16' WIDE. SLOPE SHOULD NOT EXCEED 12%. MAINTENANCE RAMP SHOULD PROVIDE ACCESS TO BOTH THE FOREBAY AND MAIN BASIN.
3. RIPRAP APRON OR OTHER INLET ENERGY DISSIPATION SHALL BE PROVIDED SUCH THAT VELOCITIES IN THE FOREBAY ARE < 4 FT/S.
4. SEDIMENT FOREBAY SHOULD BE SIZED TO PROVIDE 25% OF THE TOTAL BASIN VOLUME.
5. INTERIOR SIDE SLOPES SHALL NOT EXCEED 4:1 AND EXTERIOR SIDE SLOPES SHALL NOT EXCEED 2:1 UNLESS APPROVED BY A LICENSED CIVIL ENGINEER.
6. EMERGENCY SPILLWAY MUST BE SIZED TO PASS 100-YEAR PEAK FLOW FOR ON-LINE BASINS, AND WATER QUALITY DESIGN FLOW FOR OFF-LINE BASINS. SEE FIGURE 6-32.
7. OUTLET PIPE SHALL BE A MINIMUM 18". ENERGY DISSIPATION SHALL BE PROVIDED UNLESS DISCHARGE IS TO PIPE OR HARDENED CHANNEL.
8. OUTLET STRUCTURE SHOULD BE SIZED TO DRAIN WATER QUALITY VOLUME IN 36 - 48 HOURS (SEE FIGURE 6-29) FOR PERFORATED RISER DETAILS). ALTERNATIVELY PLACE OUTLET STRUCTURE IN A MANHOLE AND UTILIZE PERFORATED RISER OUTLET (SEE FIGURE 6-30) OR MULTIPLE ORIFICE OUTLET (SEE FIGURE 6-31).
9. INSTALL EARTHEN BERM OR EQUIVALENT. TOP OF BERM SHALL BE 2' MINIMUM BELOW WATER QUALITY DESIGN WS BERM SHALL BE KEYED INTO EMBANKMENT A MINIMUM OF 1' ON BOTH SIDES.
10. IF SOIL CONDITIONS ALLOW, INSTALL AN APPROPRIATELY SIZED SAND FILTER LAYER BENEATH THE DRY EXTENDED DETENTION BASIN FOR ENHANCED INFILTRATION.

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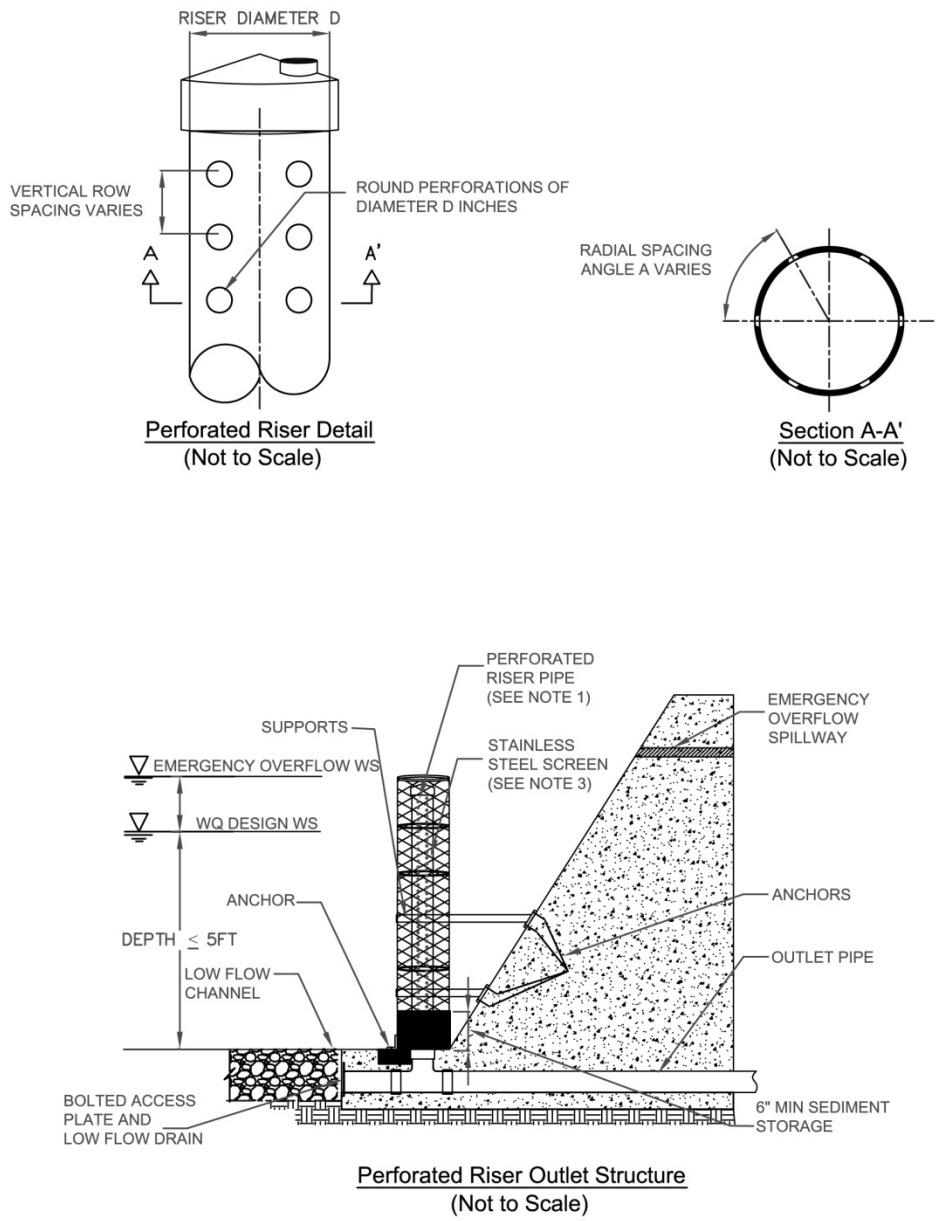
Figure 6 - 28
DRY EXTENDED DETENTION BASIN

Figure 6-29: Perforated Riser Outlet Schematic – Option 1



NOTES:

1. RISER PIPE SHALL BE SIZED TO PROVIDE 36 TO 48-HOUR FULL BRIM DRAW DOWN TIME FOR THE WATER QUALITY DESIGN VOLUME.
2. TOTAL OUTLET CAPACITY: 100-YEAR PEAK FLOW FOR ON-LINE BASINS AND WATER QUALITY DESIGN FLOW FOR OFF-LINE BASINS. MINIMUM DIAMETER OF OUTLET PIPE SHALL BE 18".
3. SCREEN OPENINGS SHALL BE AT LEAST ¼" AND SHALL NOT EXCEED THE DIAMETER OF THE PERFORATIONS ON THE RISER.
4. RISER PIPE PERFORATION DIAMETER SHALL BE NO LESS THAN ½" AND NO MORE THAN 2".

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Figure 6 - 29
PERFORATED RISER OUTLET - OPTION 1

Figure 6-30: Perforated Riser Outlet Schematic – Option 2

Smooth Plastic Riser Standard Dimensions (Wyoming NRCS)

Max Orifice Diameter D (inches)	Pipe Diameter (inches)	Min Wall Thickness (inches)	No. of vertical rows of perforations	Radial Spacing of Vertical Rows A (Degrees)
3½	8	0.15	6	60
5½	10	0.20	8	36
6	12	0.25	10	45

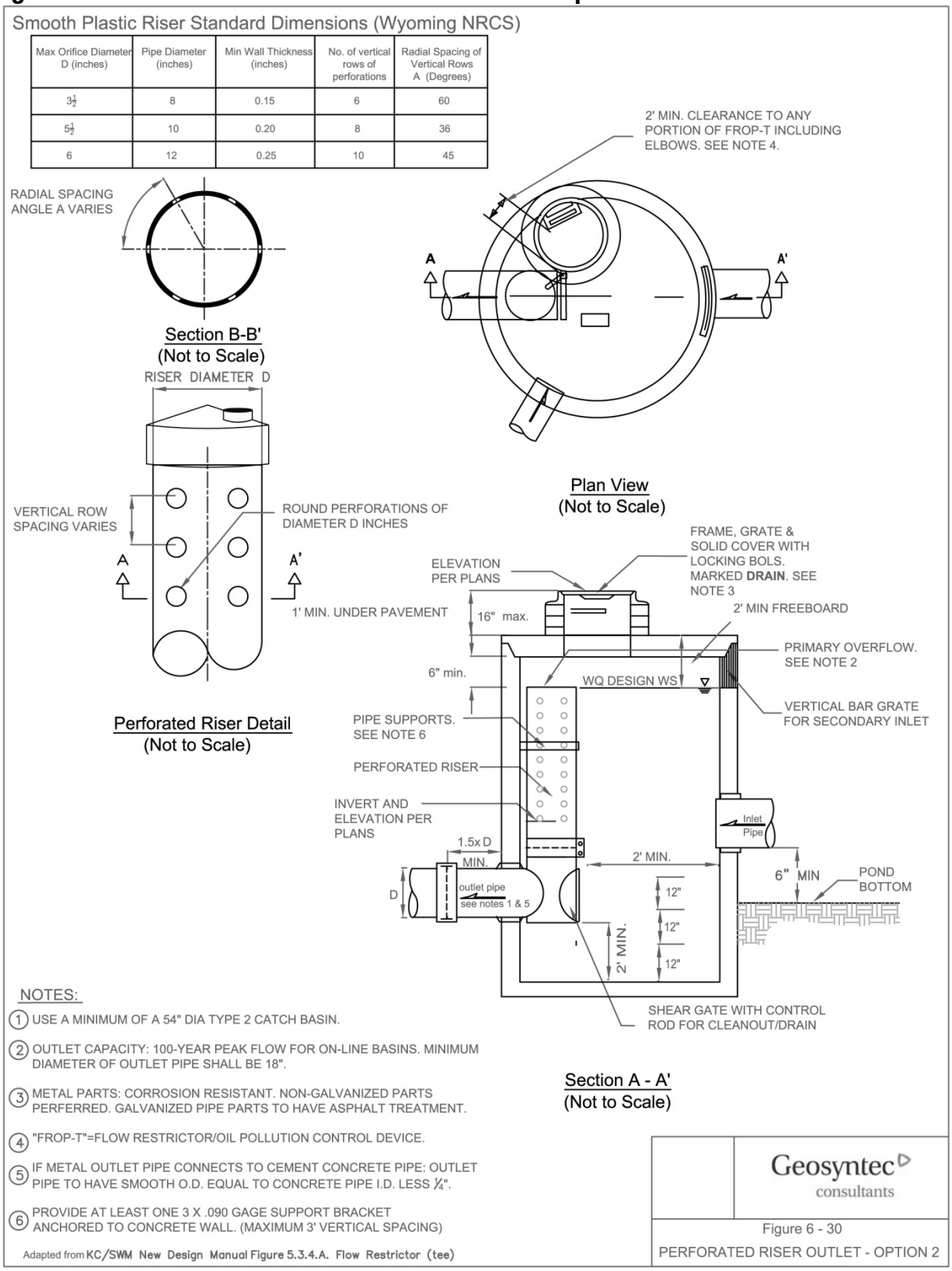


Figure 6-31: Multiple Orifice Outlet Schematic – Option 3

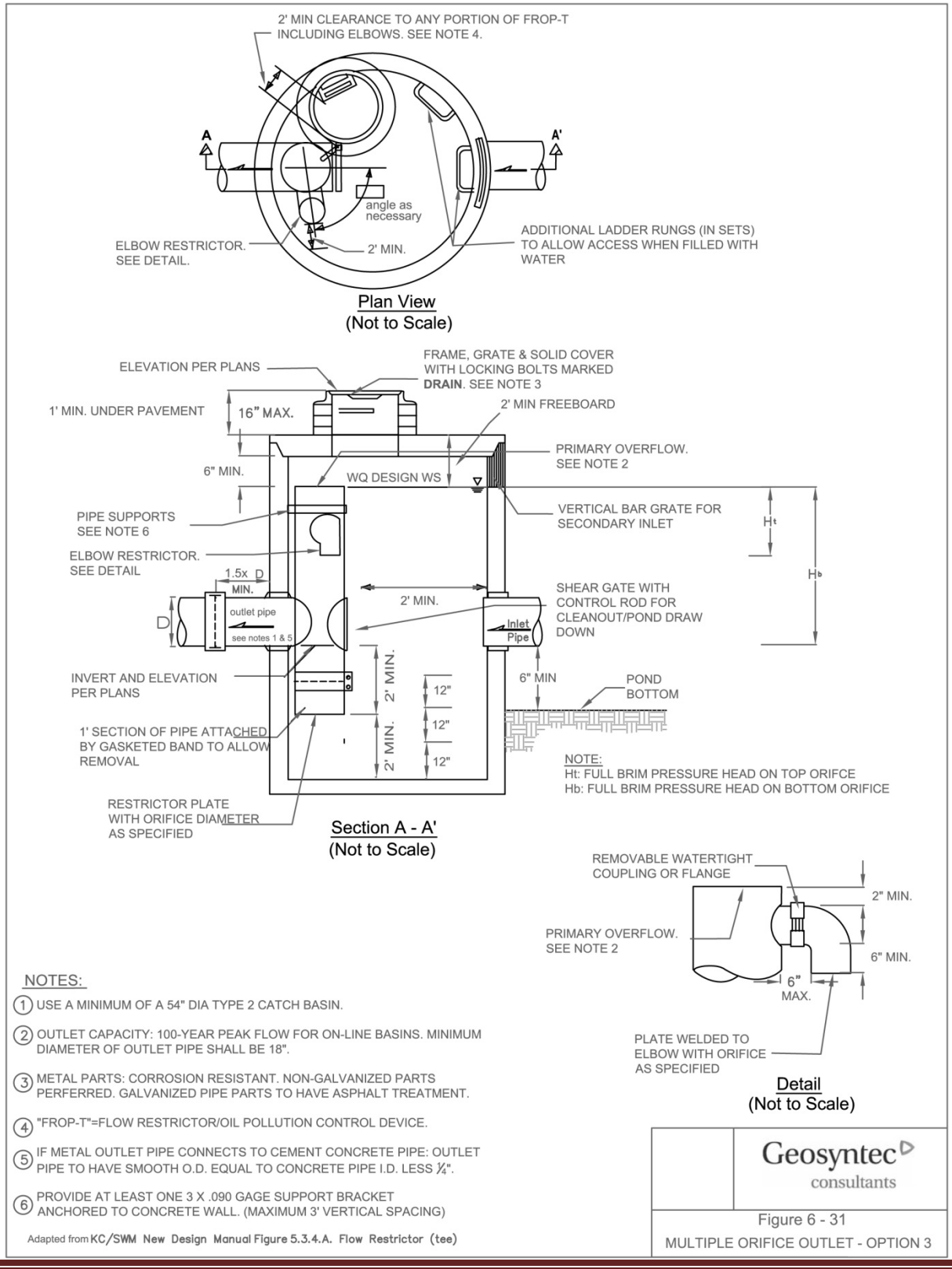
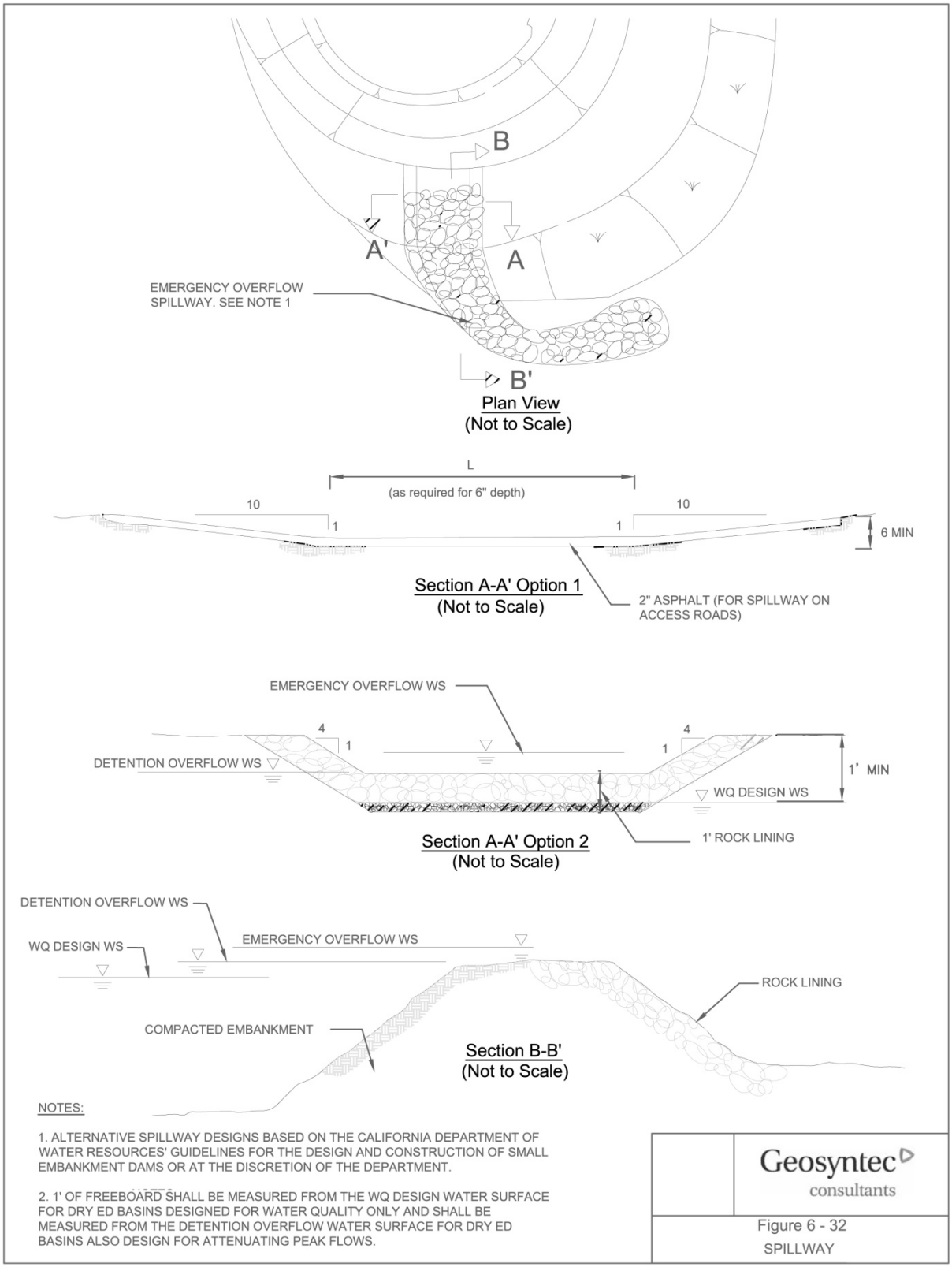


Figure 6-32: Emergency Spillway Schematic



6.10.3.5 Operations and Maintenance

General Requirements

Maintenance is of primary importance if extended detention basins are to continue to function as originally designed. A maintenance agreement must be developed with the Flood Control District to ensure adequate performance and allow the County emergency access. Maintenance of the basin is the responsibility of the development, unless otherwise agreed upon.

A specific maintenance plan shall be formulated for each facility outlining the schedule and scope of maintenance operations, as well as the data handling and reporting requirements. The following are general maintenance requirements:

1. The basin shall be inspected annually and inspections after major storm events are encouraged. Trash and debris shall be removed as needed, but at least annually prior to the beginning of the wet season (see Appendix H for dry extended detention basin inspection and maintenance checklist).

2. Site vegetation shall be maintained as follows:

3. Vegetation, large shrubs, or trees that limit access or interfere with basin operation shall be pruned or removed.

4. Slope areas that have become bare shall be revegetated and eroded areas shall be regraded prior to being revegetated.

5. Grass shall be mowed to 4”-9” high and grass clippings shall be removed.

6. Fallen leaves and debris from deciduous plant foliage shall be raked and removed.

7. Invasive vegetation, such as Alligatorweed (*Alternanthera philoxeroides*), Halogeton (*Halogeton glomeratus*), Spotted Knapweed (*Centaurea maculosa*), Giant Reed (*Arundo donax*), Castor Bean (*Ricinus communis*), Perennial Pepperweed (*Lepidium latifolium*), and Yellow Starthistle (*Centaurea solstitalis*) must be removed and replaced with non-invasive species. Invasive species shall never contribute more than 25% of the vegetated area. For more information on invasive weeds, including biology and control of listed weeds, look at the encycloweedia located at the California Department of Food and Agriculture website- http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm or the California Invasive Plant Council website at www.cal-ipc.org.

8. Dead vegetation shall be removed if it exceeds 10% of area coverage. Vegetation shall be replaced immediately to maintain cover density and control erosion where soils are exposed.

9. No herbicides or other chemicals shall be used to control vegetation.

10. Sediment buildup exceeding 50% of the forebay capacity shall be removed. Sediment from the remainder of the basin shall be removed when 6 inches of sediment accumulates. Sediments shall be tested for toxic substance accumulation in compliance with current

disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed. If toxic substances are encountered at concentrations exceeding thresholds of Title 22, Section 66261 of the California Code of Regulations, the sediment must be disposed of in a hazardous waste landfill.

11. Following sediment removal activities, replanting, and/or reseeding of vegetation may be required for reestablishment.

Maintenance Standards

A summary of the routine and major maintenance activities recommended for dry extended detention ponds is shown in Table 6-76. The routine and major maintenance standards listed in Table 6-77 and Table 6-78 are intended to be measures to determine if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedance of these thresholds or measures at any time between inspections and/or scheduled maintenance does not constitute a violation of these standards. These standards are violated only when an inspection identifies required maintenance action that has not been scheduled before the next regular inspection.

Table 6-76: Dry Extended Detention Basin Maintenance Quick Guide

Inspection and Maintenance Activities Summary	
Routine Maintenance	• Trash and debris removal • Remove any evidence of visual contamination from floatables such as oil and grease • Remove minor sediment accumulation near inlet and outlet structures • Stabilize/repair eroded banks and fill in animal burrows if present • Minor structural repairs to inlet/outlet structures, valves, sluice gates, pumps, fences, locks, access hatches shall be inspected and kept functional • Eliminate pests and conditions that promote breeding of pests • Periodically observe function under wet weather conditions • Photographs taken before and after maintenance is encouraged
Major Maintenance	• Remove dead, diseased, or dying trees and woody vegetation that interfere with facility maintenance • Clean-out underdrains • Correct problems associated with berm settlement • Repair berm/dike breaches and stabilize eroded parts of the berm • Repair and rebuild spillway as needed to reverse the effects of severe erosion • Remove sediment build up in forebay and main basin area to restore original sediment holding capacity • Regrade main basin bottom to restore bottom slope and eliminate the incidence of standing pools • Aerate compacted areas to promote infiltration if volume reductions are desired • Repair or replace gates, fences, flow control structures, and inlet/outlet structures as needed to maintain full functionality

Table 6-77: Routine Maintenance Standards - Extended Detention Basins

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 sf of basin area (one standard garbage can). In general, there shall be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.	Annually prior to wet season After major storm events (>0.75 in/24 hrs) if spot checks of some basins indicate widespread damage/ maintenance needs
Inlet / outlet sediment accumulation	Minor sediment accumulation that affects flow through the facility.	Sediment cleaned out.	
Erosion of banks and channels	Rilling over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes shall be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.	
Visual contaminants and pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No visual evidence of contaminants or pollutants present.	
Noxious pests	Visual observations or receipt of complaints of numbers of pests that would not be naturally occurring and could pose a threat to human or aquatic health.	Vectors controlled per Mosquito and Vector Management District of Santa Barbara County standards. A Mosquito Management Plan or Service Contract must be presented to the Vector Management District for any facility that maintains a pool of water for 72 hours or more.	
Aesthetics	Minor vegetation removal and thinning. Mowing berms and surroundings	Facility is well kept and able to handle dry-weather flows without causing a nuisance (visual eye sore, stagnate water, etc.)	Monthly (or as dictated by agreement between City and landscape

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Noxious Weeds	Any evidence of noxious weeds.	Eradicate all noxious weeds; control and prevent the spread of all noxious weeds. Use Integrated Pest Management techniques, if applicable. See http://www.ipm.ucdavis.edu/ for more information on pest and weed management.	contractor)

Table 6-78: Major Maintenance Standards - Extended Detention Basins

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Tree Growth	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering, do not remove. Dead, diseased, or dying trees shall be removed.	Trees do not hinder maintenance activities. Remove dead, diseased, or dying trees. (Use a certified Arborist to determine health of tree or removal requirements)	Annual or as needed (infrequent) After major storm events (>0.75 in/24 hrs) if spot checks of some basins indicate widespread damage/ maintenance needs.
Settling of berm	If settlement is apparent. Settling can be an indication of more severe problems with the berm or outlet works. A civil engineer shall be consulted to determine the source of the settlement if the dike/berm is serving as a dam.	Dike is built back to the design elevation.	
Piping through berm	Discernable water flow through basin berm. Ongoing erosion with potential for erosion to continue. A licensed civil engineer shall be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved and berm stability achieved. Report of annual burrows.	

Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed	Frequency
Tree and large shrub growth on downstream slope of embankments	Tree and large shrub growth on downstream slopes of embankments may prevent inspection and provide habitat for burrowing rodents.	Trees and large shrubs shall be removed. All dead roots shall be removed if practical. Otherwise, dead roots shall be removed to a minimum of 36 inches below grade and replaced with cement grout to 12 inches below grade. The top 12 inches of the root holes shall be filled with compacted, in-situ soils. The area facility engineer may require additional root removal if necessary for dam safety or maintenance purposes.	
Erosion on Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks and pad depth are restored to design standards.	
Sediment accumulation	Sediment buildup exceeding 50% of the forebay capacity. Six inches or more of accumulated sediment across basin bottom.	Basin capacity restored.	
Standing water	Low flow channel is not draining, standing pools of water are observed.	No standing pools of water in low flow channel.	
Gate/Fence Damage	Damage to gate/fence, including missing locks and hinges	Gate/Fence repaired.	