Appendix A – Overview of Stormwater Control Practices, Site Design and Stormwater BMP Performance Standards

A.1. STORMWATER CONTROL PRACTICES

A.1.1. Source Control Measures

Source controls are management techniques that reduce the amount of pollutants and volumes of water entering the storm water drainage system. Reducing the volume of pollution entering the storm water system can often be the most effective and least expensive means of control. The following presents a brief description of the common source controls that are applicable to Moran Lake watershed.

Covering. Areas that are potential sources of chronic loading or acute releases of pollutants to the environment (such as fuel dispensing facilities, hazardous materials/waste storage areas, solid waste storage areas, and vehicle maintenance areas) should be covered with a permanent canopy, roof, or awning. Rainfall should not come in contact with materials and activities in these areas. Areas that are covered should be paved beneath the cover and hydraulically isolated through grading, berms, or drains to prevent uncontaminated storm water from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area is directed to an approved on-site industrial wastewater treatment facility, or other approved on-site temporary storage facility or containment device/structure.

Pavement. Areas used to store potentially reactive materials should be paved with Portland cement concrete and the pavement should be epoxy coated. Gasoline and other materials can react with asphalt pavement, causing the release of toxic oils from the pavement. If the area is already paved with asphalt, an asphalt sealant can be applied to the pavement surface.

Alternative Paving. There are two categories of alternative paving: porous pavement and concrete grid or modular paving. (This method of pavement is only applicable in areas where the sub-soils have adequate infiltration rates, which should be determined prior to final design.) Porous pavement is an open-graded aggregate laid on top of a permeable soil layer. Modular pavements are formed using concrete blocks with open spaces that are filled with sand and vegetation. Alternative paving is used to reduce the amount of impervious cover and to maximize infiltration of rainfall at a site. Alternative paving systems also provide passive treatment of storm water through adsorption and biodegradation of pollutants entering these systems. The use of alternative paving materials is appropriate in low-trafficked areas, such as employee parking lots and emergency access roads or driveways. Modular paving is generally more expensive than porous paving, however porous paving is subject to clogging.

Street Sweeping. Street sweepers remove debris and particulate from paved surfaces using rotating brushes, water jets, and/or vacuums. They are a good method of pollution reduction for urban areas that are hard to retrofit with physical structures or biological areas. Optimal frequencies of street sweeping are usually between weekly and monthly.

Revegetation. Revegetation is the conversion of paved areas to vegetated areas. This technique not only helps to reduce the volume of runoff from these areas, but runoff directed to these areas will infiltrate through the soil and passively reduce pollution levels. There are also secondary benefits associated with revegetation, such open space and soil stabilization.

A.1.2. Filtration Control Measures

Filtration controls are either structural or non-structural (landscape based) treatment systems that are normally installed or integrated as a part of a storm drain system. They usually take up less surface area than downstream controls and can be integrated into the site design as landscaped areas. Inline controls are often located underground.

Bioretention filter. Bioretention filters utilize landscaped areas to reduce pollutants in storm water runoff. In this system, the site is graded so that storm water runoff is directed over a curtain drain and buffer strip to a vegetated bioretention area. The bioretention area is composed of several layers including woody and herbaceous plants, mulch, soil, and a sand bed. As runoff percolates through the system, pollutants are transformed, sequestered, or filtered out by the plant and soil system. Bioretention areas are generally designed in a manner that allows water to pond on the surface for brief periods of time. Bioretention is typically used as a storm water management BMP in road medians and parking lot islands. An example of typical bioretention filter is presented in Figure A.1 actual dimensions of an installed bioretention filter will vary depending on actual site conditions and volume of runoff to be treated.

Typical maintenance for bioretention filters might include mowing grass and removing grass clippings, occasional removal of sediment especially at inlets, revegetation as necessary, and the removal of debris that has blown onto the filter.

Vegetated Channels. Vegetated channels refer to ditches, grass channels, vegetated dry and wet swales. These are vegetated channels with a slope that is similar to that of a standard storm drain, but is wider and shallower to minimize velocity and maximize infiltration and adsorption of pollutants. Often vegetated channels are used in road medians like bioretention filters, but unlike bioretention, they emphasize flow along the surface rather than infiltration and subsurface flow. An example of a dry swale is shown in Figure A.2. The actual dimensions of the swale, including depth, width and length will depend on site conditions, such a depth to shallow groundwater and volume of water conveyed in the swale system.

Sand filter. Sand filter units are located either in open units or in vaults. In a sand filter, storm water filters through a sand layer and into an underdrain. They are convenient for urban areas because they can be located underground. However, they can only treat a relatively small area and storm water must be pretreated to remove large solids. These systems have been shown effective at removing a range of pollutants, but they can require a high level of maintenance.

Filter traps. There are a variety of commercially available catch-basin type filter traps. These systems are typically designed with baffles and/or cartridge type filters that trap sediment, oil and grease. Many are designed to capture and treat the 'first flush' or rainfall events of one inch or less, and are designed to bypass peak storm events in excess of the one-inch event. These events are the most frequent events and often generate the highest pollution loads over the course of a rainy season. Routine cleaning, often after every storm, is critical to maintain the effectiveness of the traps. These units are designed to remove trash, sediment, oil and grease and some systems are designed specifically to remove hydrocarbons from storm water. Performance of these systems is highly variable and generally dependent on the design of the system and maintenance frequency. Filters are not worth using and should not be used unless they can be inspected and maintained on a very frequent basis.

Centrifugal Units. There are a variety of specially designed systems for storm water treatment that use vortex or adjustable weirs to route low flows to a water quality treatment unit to remove solids, oil and grease. Higher flows from more intense storms are restricted by low-flow orifices and directed over the adjustable weir, bypassing the water quality facility and preventing the resuspension of sediments. They can also be used in conjunction with other storm water treatment BMPs to provide higher levels of treatment. These systems are appropriate to pretreat runoff from areas with high concentration of solids and oil and grease, such as truck tire washing areas, processing plant yards and material storage areas. A conceptual drawing of this system is presented in Figure A.3.

Pre-Engineered Stormwater Treatment System. The Storm water Management's StormFilter™ is typical of a more advanced inline treatment system that is designed to remove solids, oil and grease and soluble metals. The StormFilter uses filter cartridges housed in concrete vaults creating a self-contained storm water filtering system that is inline with storm drains. The filter media traps particulate and adsorbs materials such as dissolved metals and hydrocarbons. A conceptual drawing of a typical StormFilter system is presented in Figure A.4.

Infiltration. Infiltration can be achieved using trenches and basins. They reduce pollution loading by infiltrating storm water into the ground. Media such as coarse gravel and sand are used to allow for rapid percolation into the soil. The life expectancy of infiltration system can be short if the permeable bed becomes clogged. Infiltration of polluted storm water into the underlying ground water can also be a concern.

A.1.3. Detention Type Stormwater Treatment Systems

Detention type storm water treatment systems are generally located at the outlet of the conveyance system just before storm water runoff enters receiving waters or exits a site. Detention type controls are typically larger then filtration systems because they usually handle a larger volume of water. They typically have higher construction costs than other types of treatments, but their cost per volume of water treated and pounds of pollution removed can be competitive or less than other treatment schemes.

Dry Ponds. Dry ponds are conventional extended ponds that are normally dry between storm events. They detain water over a course of days to allow particulates to settle out of the runoff. Pollutant removal efficiency is variable with dry ponds. Heavier pollutants that settle out of runoff can be partially removed; however, negligible removal of soluble pollutants is achieved.

Wet Ponds. Wet ponds have a permanent pool of water for treating incoming storm water runoff. Pollutants are removed via settling, plant uptake, and bacterial decomposition. The degree of pollutant removal is a function of the pool size in relationship to the drained area. Maintenance is often low and is partially a function of aesthetic value required.

Constructed Wetlands. Wetlands operate in a similar manner to ponds and can provide very effective storm water treatment. They are generally shallow, allowing vegetation to grow, but they are less tolerant to fluctuations in water depth. They provide more habitat value than ponds; however, they can require a lot of space. An example of a multiple pond storm water wetland is shown in Figure A.5.

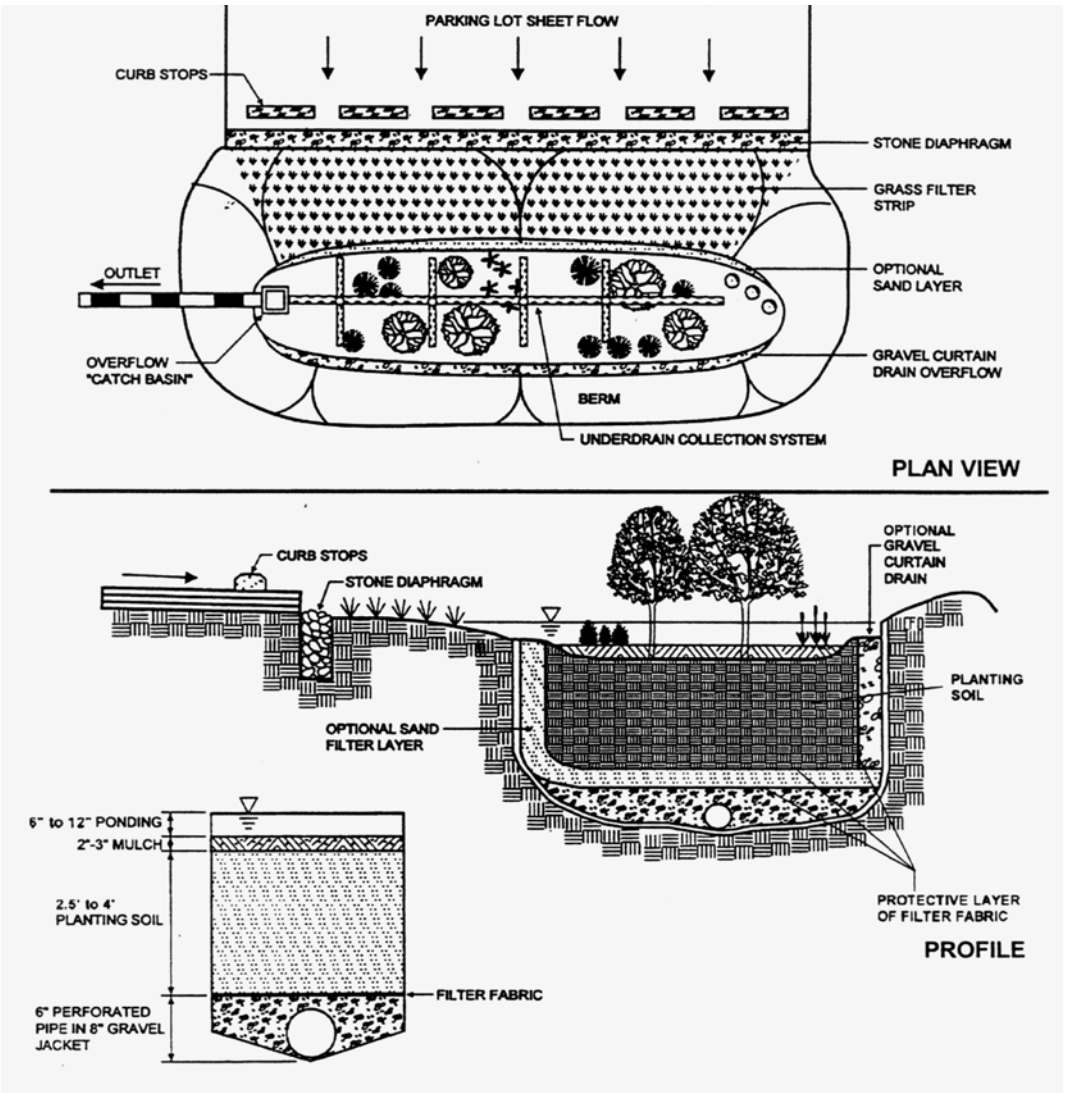

Figure A.1. Typical Bioretention Filter (MDE, 2000)

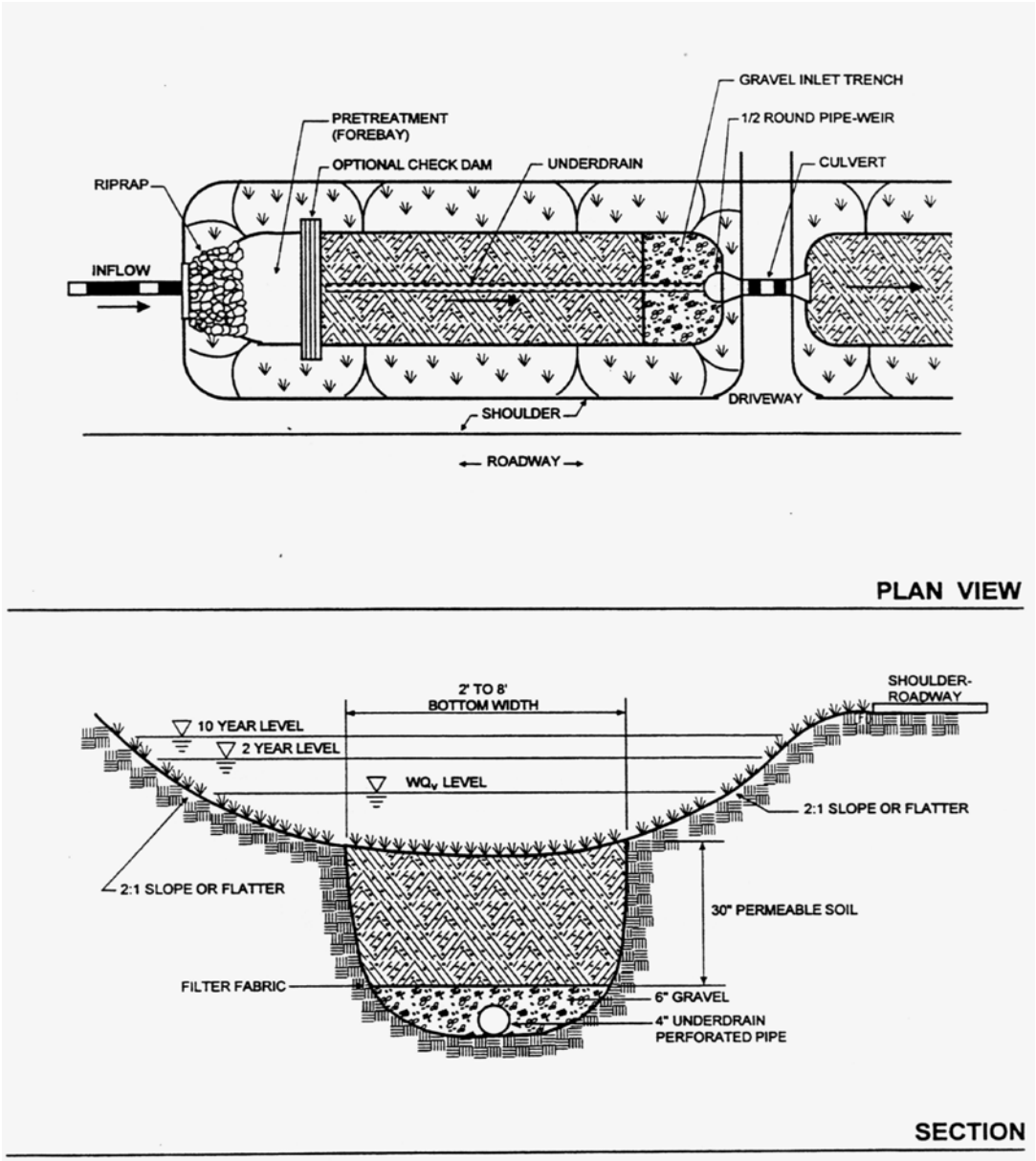

Figure A.2. Typical Dry Swale

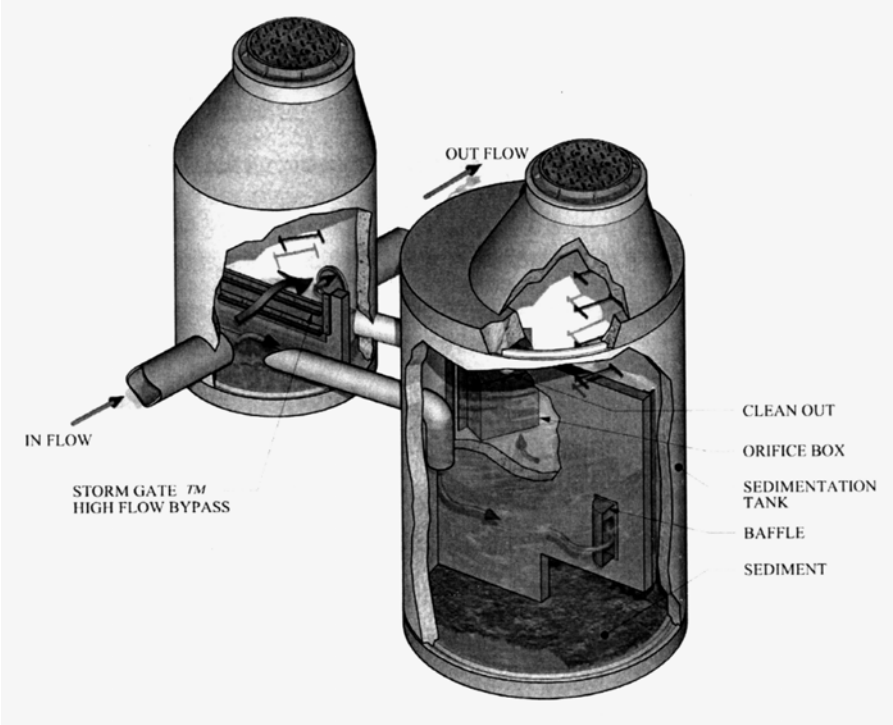

Figure A.3. Common Filter Trap Type System

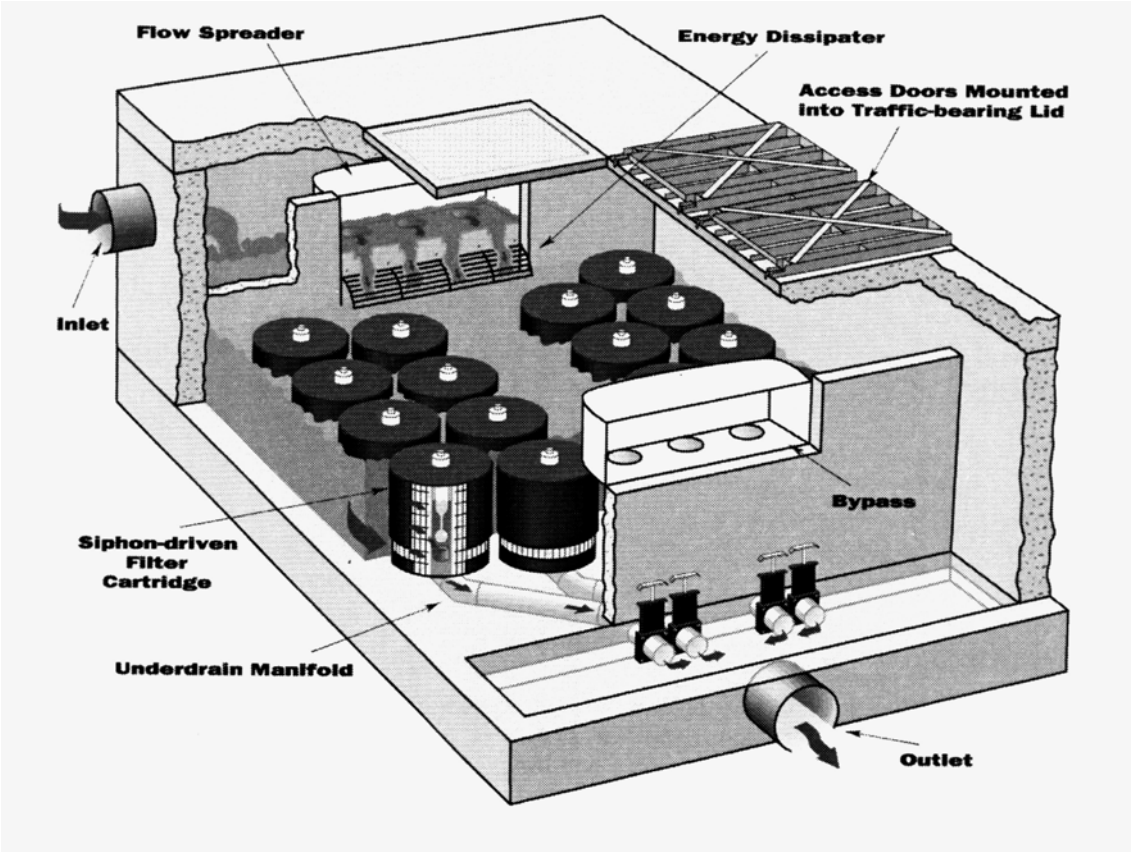

Figure A.4. Advance Storm Water Treatment System

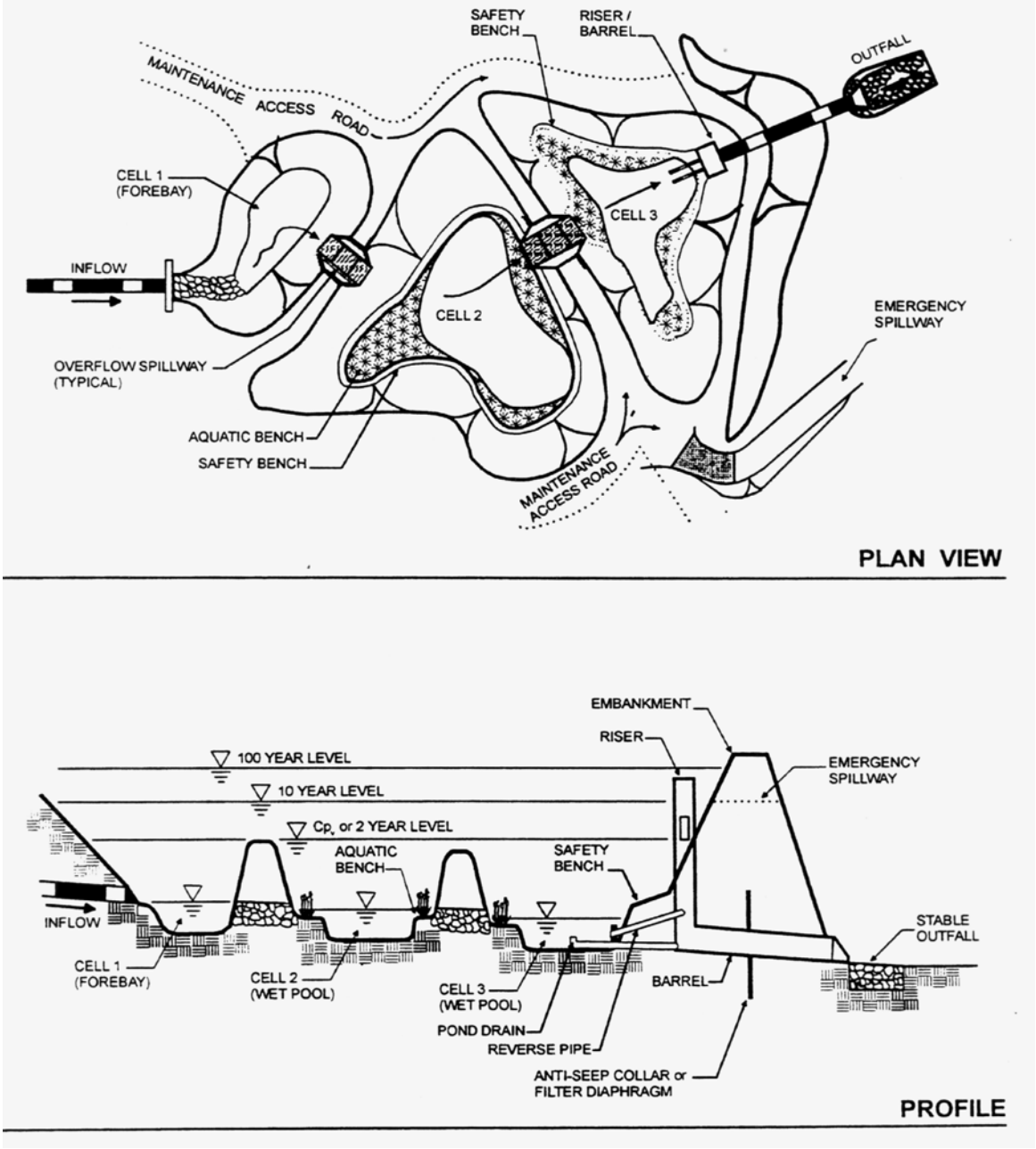

Figure A.5. Typical Multiple Pond Storm Water Wetland

Summary of Storm Water Treatment BMP Performance and Planning Information

Table A.1 presents a summary based on performance and planning information for the source control, filtration, and detention type treatment measures described in the previous sections.

Table A.1 Summary of Storm Water BMP Performance and Planning Information

	Runoff Reduction		Contaminant Reduction Capability						Comparative Cost		Maintenance & Longevity		Environmental/Community Benefits			
Management Practice	Peak Runoff	Volume Reduction	TSS	TPH	PAH	Metals	O&G	Nutrients	Capital Cost	O&M	Maintenance Requirements	Longevity (years)	Recreation	Natural/Open Space\	Bay Access	Environmental Education
Source Controls																
Covering	NA	NA	M	H	H	M	H	NA	L	L	L	20+	NA	NA	NA	NA
Drainage Controls	M	L	M	M	M	M	M	M	L	L	L	20+	NA	NA	NA	NA
Alternative Roofing	NA	NA	L	NA	NA	H	NA	NA	L	L	L	15+	NA	NA	NA	NA
Permeable Pavement	H	M	M	M	M	M	M	M	M	M	M	5+	NA	NA	NA	M
Street Sweeping	NA	NA	H	L	L	M	L	L	M	L	M	NA	NA	NA	NA	NA
Revegetation	H	M	H	H	H	H	H	M	L	L	M	10+	NA	NA	NA	NA
Inline Controls																
Bioretention	H	M	H	H	H	H	H	M	L	L	M	20+	L	M	L	M
Vegetative Channels	M	L	M	M	M	L	M	L	L	L	M	20+	M	M	M	M
Sand Filters	M	L	H	H	H	M	H	L	H	H	H	15+	L	L	L	L
Filter Traps	L	L	L-M	L-M	L-M	L	M	L	M	M	M-H	20+	L	L	L	L
Stormwater Filters	L	L	H	H	H	H	H	M	H	M	M	20+	L	L	L	L
Infiltration	H	H	H	H	H	H	H	M	H	H	H	5+	L	L	L	L
Downstream Controls																
Dry Ponds	H	H	H	H	H	M	H	M	M	M	M	20+	M	M	H	M
Wet ponds	H	H	H	H	H	M	H	M	M-H	M	M	20+	M	M	H	M
Constructed Wetlands	H	H	H	H	H	H	H	M	M-H	M	M	20+	H	H	H	H

Rating Criteria: L = Low; M = Moderate; H = High; NA = Not Applicable

A.2. Site Design Performance Standards

Adopting site design performance standards provides the opportunity for economically viable, yet environmentally sensitive development. In general, proper site design reduces the amount of impervious cover and reduces the amount of storm water runoff generated at a site. Therefore, reductions in impervious cover result in smaller required storage volumes and, consequently, lower BMP construction costs. Economic benefits can be derived directly by the developer from the reduced construction costs associated with narrower roads, smaller parking areas, use of landscaped based treatment BMPs, and other alternative development strategies designed to minimize impervious cover. In summary, the documented benefits of site design performance standards include (CWP, 1998):

- Minimize the generation of storm water runoff
- Reduced soil erosion during construction
- Reduced development construction costs
- More pedestrian friendly areas and more space for recreation
- Protection and enhancement of creek and lagoon habitat
- A more aesthetically pleasing and naturally attractive landscape
- More sensible locations for storm water facilities
- Easier compliance with stream and wetland and other resource protection regulations
- Neighborhood designs that provide a sense of community
- Urban wildlife habitat through natural area preservation

The County of Santa Cruz can seek opportunities for open space development that incorporate site design strategies to minimize total impervious cover, reduce the total construction costs, preserve and/or enhance natural areas, provide community open space, and promote watershed protection. These strategies are consistent with the County's long-term land use plans for the Live Oak area.

The following are examples of site design performance standards that can be applied to new development sites in the watershed to minimize the generation of storm water.

1. Site designs should minimize the generation of storm water and maximize pervious area for storm water treatment. Several municipal agencies have established impervious surface reduction rules for new and redevelopment projects. For example, the City of Santa Monica requires that any new or redevelopment project must reduce the amount of existing impervious cover by 20 percent. Similarly, in the City of Olympia, the reduction requirement for new and redevelopment projects are 15 percent.

2. Site designers can attempt to minimize the creation of impervious cover in new and redeveloped sites by:

    - Specifying narrow road sections

- Smaller turnarounds and cul-de-sac radii
- Permeable spill-over parking areas
- Smaller parking demand ratios
- Smaller parking stalls
- Angled one way parking
- Preservation or increased landscaped areas
- Shared parking and driveways
- Narrow sidewalks

3. New streets and driveways can be designed for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume and other issues as well.

4. Wherever possible, street right-of-away widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains can be located within the pavement section of the right-of-way, wherever feasible.

5. Where topography, soils, and slope permit, vegetated open channels can be used in the street right-of-way to convey and treat storm water runoff.

6. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.

7. Reducing overall lot imperviousness can be accomplished by using alternative driveway surfaces and shared driveways that connect two or more lots together.

8. Wherever possible, storm water treatment for parking lot runoff can be achieved using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaped areas and traffic islands.

9. Rooftop runoff can be rerouted to pervious areas such as landscaped areas and avoid routing rooftop runoff to the roadway and the storm water conveyance system.

10. Storm water discharges from land uses or activities with higher potential for pollutant loadings (fueling facility, etc.) may require the use of specific structural BMPs and pollution prevention practices. In addition, storm water from these areas should not be infiltrated without proper pretreatment.

A.3. Performance Standards for Storm Water Management and Treatment BMPs

Performance standards for storm water management and treatment BMPs have been recently established and adopted in different regions of the State for new and redevelopment projects. The overall goal of these standards is to reduce pollutant discharges and changes in runoff flows where they can cause damage to downstream

water bodies to the maximum extent practicable. The standards are established to prevent exceedance of receiving water quality standards over the life of the project, through implementation of control measures. The following are example standards that reflect an approach to address provisions of the Phase II Municipal Storm Water Permit to be issued by the California Regional Water Quality Control Board in the near future.

1. All new or redeveloped projects, that create one acre (43,560 square feet) or more of impervious cover, including roof area, streets, parking, driveways, material storage areas and sidewalks, are required to install treatment Best Management Practices (BMPs). The treatment BMPs should be sized according to either a volume hydraulic design basis or a flow hydraulic design basis, as follows:

   a. Volume Hydraulic Design Basis

   Treatment BMPs whose primary mode of action depends on volume capacity, such as detention/retention units or infiltration structures, should be designed to treat storm water runoff equal to:

   - The maximized storm water quality capture volume for the area, based on historical rainfall records, determined using the formula and volume capture coefficients set forth in *Urban Runoff Quality Management*, *WEF Manual of Practice No. 23/ ASCE Manual of Practice No. 87,* (1998), pages 175-178 (e.g., 85 (%) percent of the average annual 24-hour rainfall event, equivalent to approximately 1 inch of precipitation (in the Live Oak area); or

   - The volume of annual runoff required to achieve 80 percent or more capture determined in accordance with the methodology set forth in Appendix D of the *California Stormwater Best Management Practices Handbook*, (2003), using local rainfall data.

   b. Flow Hydraulic Design Basis

   Treatment BMPs whose primary mode of action depends on flow capacity, such as swales, sand filters, or wetlands, should be sized to treat:

   - 10 (%) percent of the 50-year design flow rate, or

   - the flow of runoff produced by a rain event equal to at least two times the 85th percentile hourly rainfall intensity for the applicable area, based on historical records of hourly rainfall depths; or
   - the flow of runoff resulting from a rain event equal to at least 0.2 inches per hour intensity.

2. To be considered an effective BMP for stand alone treatment of the water quality volume or flow conditions, a design should be capable of:

- Capturing and treating the required water quality volume or flow;
- Removing 80% of the TSS; and
- Having an acceptable longevity rate in the field (15 to 25 years).

3. A storm water management system should be designed to not adversely affect existing storm water conveyance capabilities. It is presumed that a system meets this criteria if one of the following are met:

    - The existing hydraulic conveyance is maintained; and
    - The applicant demonstrates that the storm water BMP will reduce the peak discharge to less than pre-project levels.

4. New or redeveloped projects should not discharge untreated storm water directly to a jurisdictional wetland or local water body without adequate treatment.

5. All storm water BMPs should be designed in a manner to minimize the need for maintenance, and reduce the chances of failure.

6. Storm water BMPs should be designed to accommodate maintenance equipment access and to facilitate regular operational maintenance (such as underdrain replacement, unclogging filters, sediment removal, mowing and vegetation control). Operational maintenance and operation easements shall be provided when necessary to facilitate equipment access.

7. In order to protect groundwater from pollutants that may be present in storm water runoff, the following conditions should be satisfied if infiltration treatment measures (such as infiltration trenches and infiltration basins) are considered as a treatment BMP:

    a. Pollution prevention and source control BMPs should be implemented at a level appropriate to protect groundwater quality at sites where infiltration devices are to be used.
    b. Use of infiltration devices should not cause or contribute to an exceedance of groundwater water quality objectives.
    c. The vertical distance from the base of any infiltration device to the seasonal high groundwater mark should be at least 10 feet.
    d. Unless storm water is first pretreated, infiltration devices are not be recommended for areas of industrial or light industrial activity; areas subject to high vehicular traffic; automotive repair shops; fleet storage areas (bus, truck, etc.); and other high threat to water quality land uses and activities.

A.4. Technical Resources

The following list provides information on readily available technical resources that can be consulted for the selection and design of source control, appropriate site design and treatment BMPs. The information provided pertains to technical literature and professional organizations, but does not include information for equipment manufacturers.

Site Planning and Design

1. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection*. 1999. Bay Area Stormwater Management Agencies Association (BASMAA)
2. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. 1998. Center for Watershed Protection (CWP)
3. *Site Planning for Urban Stream Protection*. 1995. CWP

Best Management Practice Performance

1. *Guide for Best Management Practice (BMP) Selection in Urban Developed Areas*. 2001. ASCE
2. *National Stormwater Best Management Practices (BMP) Database*. 1999. American Society of Civil Engineers (ASCE)
3. *National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition*. 2000. U.S. Environmental Protection Agency and CWP
4. *The Practice of Watershed Protection*: *Techniques for protection our nation's streams, lakes, rivers and estuaries*. 2000. CWP

Storm Water Treatment Design

1. *California Storm Water Best Management Practice Handbooks, Volumes 1 – 3, Municipal, Commercial/Industrial, and Construction BMP Handbooks*. 2003. Storm Water Quality Task Force
2. *Guidance Manual for On-Site Stormwater Quality Control Measures*. 2000. Sacramento Stormwater Management Program, City of Sacramento Department of Utilities, County of Sacramento Water Resources Division
3. *Design and Construction of Urban Stormwater Management Systems*. 1992. ASCE Manuals and Reports of Engineering Practice No. 77, Water Environment Federation (WEF) Manual of Practice FD-20
4. *Design of Stormwater Wetland Systems*: *Guidelines for Creative Diverse and Effective Stormwater Wetland Systems in the Mid-Atlantic Region*. 1992. Metropolitan Washington Council of Governments
5. *Stormwater Design Manual, Volumes I &II*. 2000. State of Maryland, Maryland Department of the Environment
6. *Surface Water Design Manual*. 1998. King County, Washington
7. *Urban Runoff Quality Management*. 1998. ASCE Manual and Report on Engineering Practice No. 87 and WEF Manual of Practice No. 23