

Exhibit A-7.VI

- Local Water Quality Management Plan (WQMP)



COUNTY OF ORANGE LOCAL WATER QUALITY MANAGEMENT PLAN (WQMP)

A-7.VI - 1.0 INTRODUCTION

The County of Orange Local Water Quality Management Plan (County WQMP) has been developed from the countywide Model WQMP to address post-construction urban runoff and stormwater pollution from all new development and significant redevelopment projects in the unincorporated County. The goal for use of the County WQMP is to achieve practicable and enforceable policies to minimize the effects of urbanization on site hydrology, urban runoff flow rates or velocities and pollutant loads. This goal may be achieved through site-specific project-based controls, or a combination of project-based and offsite shared BMPs or regionally or watershed-based controls. Regional or watershed-based controls are encouraged to be considered within the Santa Ana Regional Board Permit area.

The countywide Model WQMP from which this County WQMP was developed identifies appropriate controls, commonly referred to as Best Management Practices (BMPs), for all applicable projects and will be reviewed and approved by the Santa Ana Regional Water Quality Control Board. The Santa Ana Regional Board will solicit public review and comment prior to approval. The San Diego Regional Water Quality Control Board has reviewed the Model WQMP for compliance with the NPDES Permit (Order R9-2002-001). Permittees under this order are required to adopt their own local County/City WQMP (see **DAMP, Appendix A-7**) based on the Regional Board-approved/reviewed Model WQMP and may adapt the Model WQMP for local conditions. The requirements apply to both private and public agency projects.

Using the County WQMP as a guide, the County will approve project-specific Water Quality Management Plans (Project WQMPs) as part of the development plan and entitlement approval process or the ministerial permit approval process for Priority and Non-Priority Projects as defined in **DAMP Section 7.6** and **Table A-7.VI - 1**. New development and significant redevelopment projects are required to develop and implement a Project WQMP that includes BMPs. Depending upon the project size and characteristics, these may include:

- Consideration of Site Design BMPs
- Incorporation of all applicable Source Control BMPs
- Incorporation of project-based Treatment Control BMPs; and/ or participation in offsite shared BMPs or an approved regional or watershed management program as defined in **Section A-7.VI - 3.3.3** of this document in the affected watershed.

Descriptions and examples of the above BMP types are provided later within this document.

This County WQMP provides requirements for two types of new development and significant redevelopment projects:

- Priority Projects (**Section A-7.VI - 3.0**)
- Non-Priority Projects (**Section A-7.VI - 4.0**)

A project is a priority project if it meets any of the following criteria:

Table A-7.VI - 1
Priority Projects Categories

1.	Residential development of 10 units or more
2.	Commercial and industrial development greater than 100,000 square feet including parking area
3.	Automotive repair shops (SIC codes 5013, 5014, 5541, 7532-7534, and 7536-7539)
4.	Restaurants where the land area of development is 5,000 square feet or more including parking area (SIC code 5812)
5.	<i>For San Diego Region</i> - Hillside development greater than 5,000 square feet <i>For Santa Ana Region</i> - Hillside development on 10,000 square feet or more, which are located on areas with known erosive soil conditions or where natural slope is twenty-five percent or more
6.	Impervious surface of 2,500 square feet or more located within, directly adjacent to (within 200 feet), or discharging directly to receiving waters within Environmentally Sensitive Areas
7.	Parking Lots 5,000 square feet or more, or with 15 parking spaces or more, and potentially exposed to urban stormwater runoff
8.	<i>For San Diego Region</i> - Streets, roads, highways, and freeways which would create a new paved surface that is 5,000 square feet or greater

Definitions of the above terms and conditions are located in **Attachment E**.

All priority new development and significant redevelopment projects are required to:

- Incorporate and implement all Source Control BMPs (routine structural and routine non-structural) unless not applicable to the project due to project characteristics, and document clearly why any applicable Source Control BMP was not included.
- Consider and implement Site Design BMPs where applicable and feasible, and document those BMPs included; and
- Implement Treatment Control BMPs, including a selection of such BMPs into the project design or implement offsite, shared treatment control BMPs, or participate in or contribute to an acceptable regional or watershed management program as defined in **Section A-7.VI - 3.3.3** of this document. Projects participating in a regional or watershed management program will also implement Source Control BMPs and Site Design BMPs consistent with the approved program.
- The combination of Source Control, Site Design, and Treatment Control BMPs, offsite shared BMPs or regional or watershed programs must adequately address all identified pollutants of concern.

All Non-Priority Projects are required to:

- Implement all Source Control BMPs (routine structural and routine non-structural) unless not applicable to the project due to project characteristics and document clearly why any applicable Source Control BMP was not included; and
- Consider and implement all Site Design BMPs where applicable and feasible.

In the instance where only a project feature falls into a priority project category, such as a 6,000 sq. ft. parking lot for an industrial development that is less than 100,000 sq. ft., only the parking lot feature is subject to County WQMP requirements.

The Project WQMP must be completed as follows:

- For projects not participating in a regional or watershed program the Project WQMP must be completed either prior to discretionary project approval or ministerial permit, (grading or building) issuance for discretionary projects, and prior to ministerial permit issuance for projects requiring only these types of permits.
- For projects participating in regional or watershed programs the regional or watershed program may be relied upon during the discretionary review process subject to a discussion of how the project will participate in the program, but a site specific Project WQMP must be completed prior to permit issuance.

Requirements of the Project WQMP shall be incorporated into project design and shown in the plans.

Departments carrying out public agency projects that are not required to obtain permits shall be responsible for ensuring County WQMP requirements are incorporated into the project design and shown on the plans prior to bidding for construction contracts, or equivalent. Project WQMP requirements will be incorporated into the design of public agency projects and shown on the plans before allowing the project to commence.

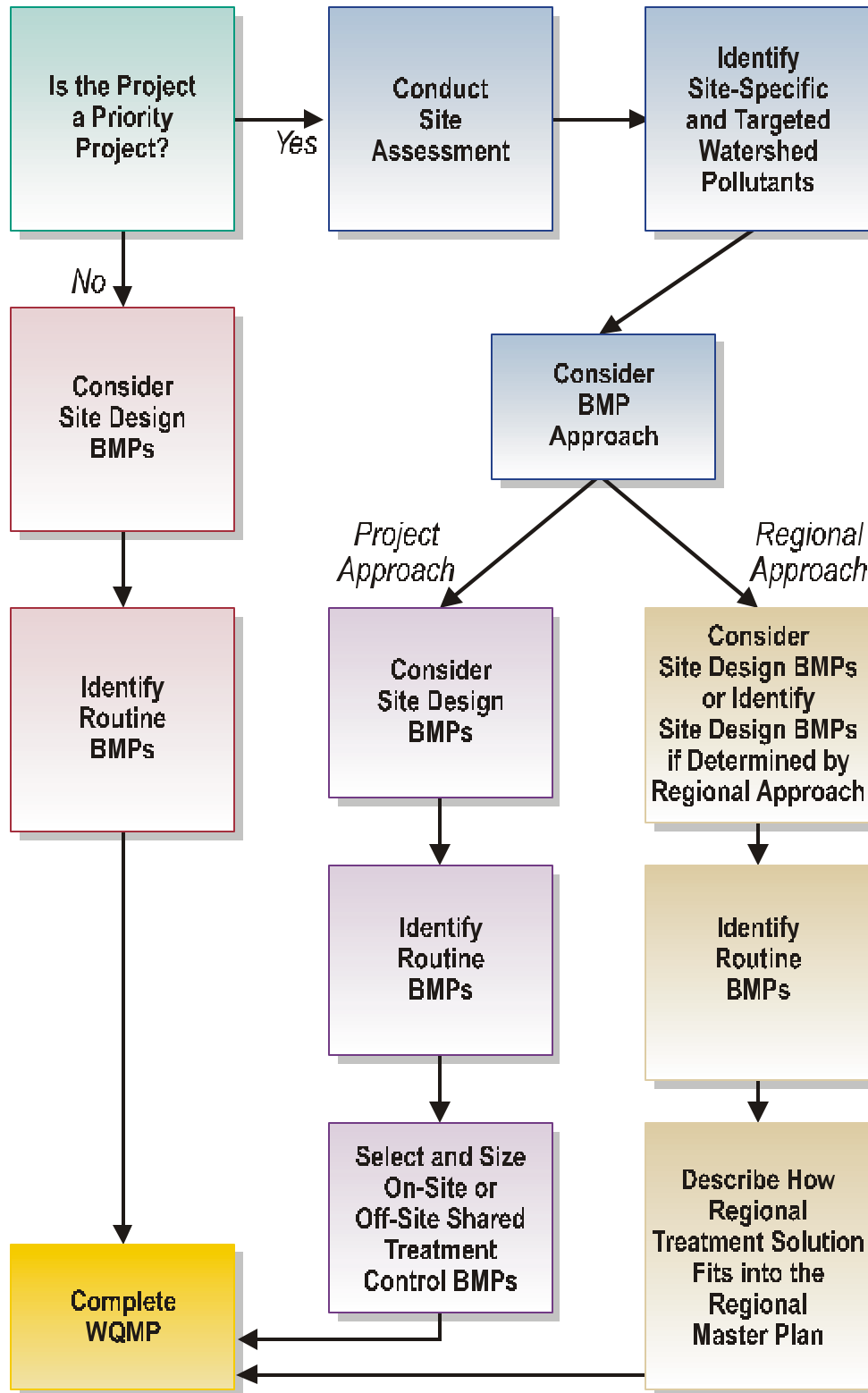
Limited Exclusion: Trenching and resurfacing work associated with utility projects are not considered Priority Projects. Parking lots, buildings, and other structures associated with utility projects are subject to County WQMP requirements if one or more of the criteria for the above categories are met.

A-7.VI - 2.0 WQMP PREPARATION

Several steps are involved in completing an approvable Project WQMP for new development or significant redevelopment projects. **Figure A-7.VI - 1** displays the implementation steps and decision steps that must be followed to successfully complete a Project WQMP.

Figure A-7.VI - 1

Development Planning and WQMP Preparation Steps



A-7.VI - 3.0 Priority Project WQMP Preparation

Priority new development or significant redevelopment projects perform the following steps for Project WQMP preparation:

- Site assessment (**Section A-7.VI - 3.1**)
- Identification of pollutants and hydrologic conditions of concern (**Section A-7.VI - 3.2**)
- Consideration of Site Design BMPs (**Section A-7.VI - 3.3.1.**)
- Incorporation of Source Control BMPs (**Section A-7.VI - 3.3.2**)
- Selection of regional or project-based approach to Treatment Control BMPs (**Section A-7.VI - 3.3.3**)
- Selection, sizing, and incorporation of Treatment Control BMPs (**Section A-7.VI - 3.3.4**)

A-7.VI - 3.1 Site Assessment

Site assessment involves compiling the following:

- Planning Area/Community Name: Provide exhibit of subject and surrounding planning areas in sufficient detail to allow project location to be plotted on a base map of the County
- Site specifics such as general and specific location, site address, and size (acreage to the nearest 1/10 acre)
- Watershed name
- Site characteristics, including description of site drainage and how it ties with drainage of surrounding property. Reference the Project WQMP's Plot Plan showing drainage flow arrows and how drainage ties to drainage of surrounding property

A-7.VI - 3.2 Identification of Pollutants and Hydrologic Conditions of Concern

Priority project proponents shall use these guidelines to identify pollutants of concern from a development, potential pollutants of concern, and conditions of concern for which they need to mitigate or protect against. Once identified, appropriate control measures for these pollutants and conditions are specified in **Section A-7.VI - 3.3**.

Site design and source control measures are based on pollutants commonly associated with the proposed project land uses type (see **Table A-7.VI - 2**). The combination of Site Design, Source Control and on-site Treatment Control BMPs offsite shared BMPs or regional and watershed programs are also required to address a project's expected or potential pollutants of concern.

A-7.VI - 3.2.1 General Categories of Pollutants of Concern

Urban runoff and stormwater pollution from a developed site has the potential to contribute pollutants, including oil and grease, suspended solids, metals, gasoline, pesticides, and pathogens from the municipal storm drain system to tributary receiving waters. For the purpose of identifying pollutants of concern and associated stormwater BMPs, pollutants are grouped in nine general categories:

- **Bacteria and Viruses** – Bacteria and viruses are ubiquitous microorganisms that thrive under certain environmental conditions. Their proliferation is typically caused by the transport of animal or human fecal wastes from the watershed. Water, containing excessive bacteria and viruses can alter the aquatic habitat and create a harmful environment for humans and aquatic life. Also, the decomposition of excess organic waste causes increased growth of undesirable organisms in the water.
- **Metals** – Primary source of metal pollution in stormwater are typically commercially available metals and metal products. Metals of concern include cadmium, chromium, copper, lead, mercury, and zinc. Lead and chromium have been used as corrosion inhibitors in primer coatings and cooling tower systems metals are also raw material components in non-metal products such as fuels, adhesives, paints, and other coatings. At low concentrations naturally occurring in soil, metals are not toxic. However, at higher concentrations, certain metals can be toxic to aquatic life. Humans can be impacted from contaminated groundwater resources, and bioaccumulation of metals in fish and shellfish. Environmental concerns, regarding the potential for release of metals to the environment, have already led to restricted metal usage in certain applications.
- **Nutrients** – Nutrients are inorganic substances, such as nitrogen and phosphorus. They commonly exist in the form of mineral salts that are either dissolved or suspended in water. Primary sources of nutrients in urban runoff are fertilizers and eroded soils. Excessive discharge of nutrients to water bodies and streams can cause excessive aquatic algae and plant growth. Such excessive production, referred to as cultural eutrophication, may lead to excessive decay of organic matter in the water body, loss of oxygen in the water, release of toxins in sediment, and the eventual death of aquatic organisms.

- **Pesticides** – Pesticides (including herbicides) are chemical compounds commonly used to control nuisance growth or prevalence of organisms. Excessive application of a pesticide may result in runoff containing toxic levels of its active component.
- **Organic Compounds** – Organic compounds are carbon-based. Commercially available or naturally occurring organic compounds are found in pesticides, solvents, and hydrocarbons. Organic compounds can, at certain concentrations, indirectly or directly constitute a hazard to life or health. When rinsing off objects, toxic levels of solvents and cleaning compounds can be discharged to storm drains. Dirt, grease, and grime retained in the cleaning fluid or rinse water may also adsorb levels of organic compounds that are harmful or hazardous to aquatic life.
- **Sediments** – Sediments are soils or other surficial materials eroded and then transported or deposited by the action of wind, water, ice, or gravity. Sediments can increase turbidity, clog fish gills, reduce spawning habitat, lower young aquatic organisms survival rates, smother bottom dwelling organisms, and suppress aquatic vegetation growth.
- **Trash and Debris** – Trash (such as paper, plastic, polystyrene packing foam, and aluminum materials) and biodegradable organic matter (such as leaves, grass cuttings, and food waste) are general waste products on the landscape. The presence of trash and debris may have a significant impact on the recreational value of a water body and aquatic habitat. Excess organic matter can create a high biochemical oxygen demand in a stream and thereby lower its water quality. In addition, in areas where stagnant water exists, the presence of excess organic matter can promote septic conditions resulting in the growth of undesirable organisms and the release of odorous and hazardous compounds such as hydrogen sulfide.
- **Oxygen-Demanding Substances** – This category includes biodegradable organic material as well as chemicals that react with dissolved oxygen in water to form other compounds. Proteins, carbohydrates, and fats are examples of biodegradable organic compounds. Compounds such as ammonia and hydrogen sulfide are examples of oxygen-demanding compounds. The oxygen demand of a substance can lead to depletion of dissolved oxygen in a water body and possibly the development of septic conditions.
- **Oil and Grease** – Oil and grease are characterized as high-molecular weight organic compounds. Primary sources of oil and grease are petroleum hydrocarbon products, motor products from leaking vehicles, esters, oils, fats, waxes, and high molecular-weight fatty acids. Introduction of these pollutants to the water bodies are very possible due to the wide uses and applications of some of these products in municipal, residential, commercial, industrial, and construction areas. Elevated oil and grease content can decrease the aesthetic value of the water body, as well as the water quality.

A-7.VI - 3.2.2 Identify Pollutants from the Project Area

Using **Table A-7.VI - 2**, identify pollutants that are anticipated to be generated, or have a potential to be generated from the proposed priority project land use categories. Pollutants associated with any hazardous material sites that have been remediated or are not threatened by the proposed project are not considered a pollutant of concern. Site-specific conditions must also be considered as additional pollutant sources, such as legacy pesticides or nutrients in site soils as a result of past agricultural practices.

A-7.VI - 3.2.3 Identify Pollutants of Concern

To identify pollutants of concern in receiving waters, each priority project proponent shall, at a minimum, do the following:

1. For each of the proposed project discharge points, identify the receiving water for each point of discharge and all water bodies downstream of the receiving water, using hydrologic unit basin numbers as identified in the most recent version of the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) prepared by the State Water Resources Control Board; the Water Quality Control Plan for the Santa Ana Basin prepared by the Santa Ana Regional Water Quality Control Board; or the Water Quality Control Plan for the San Diego Basin¹, prepared by the San Diego Regional Water Quality Control Board.
2. Identify each receiving water identified above that is listed on the most recent list of Clean Water Act Section 303(d) impaired water bodies (**Table A-7.VI - 3**). List any and all pollutants for which the receiving waters are impaired. (**Table A-7.VI - 3**) and identify each Clean Water Act Section 303 9d) impaired water body that is downstream of the receiving waters identified above.

Compare the list of pollutants for which the receiving waters are impaired with the pollutants anticipated to be generated by the project (as discussed in **Section A-7.VI - 3.2.2**).

Primary Pollutants of Concern - Any pollutants identified by **Table A-7.VI - 2**, which have also been identified as causing impairment of receiving waters

Other Pollutants of Concern - Those pollutants identified using **Table A-7.VI - 2** which have not been identified as causing impairment of receiving waters.

Further information on pollutants of concern may also be available from the CEQA analysis of the project (e.g., project-specific pollutant evaluations in Environmental Impact Reports) and this site-specific information should be used to supplement, or in some cases supercede, the information in **Table A-7.VI - 2**. Watershed planning documents should also be reviewed for identification of specific implementation requirements that address pollutants of concern.

Salinity, total dissolved solids (TDS), and chlorides are listed within the above-referenced

¹ http://www.swrcb.ca.gov/~rwqcb9/Programs/Planning_and_Services/SD_Basin/sd_basin.html

303(d) tables, but are not addressed in this County WQMP, as they are not commonly of concern in typical development urban runoff and stormwater pollution.

**Table A-7.VI -2
Anticipated and Potential Pollutants Generated by Land Use Type**

Priority Project Categories and/or Project Features	General Pollutant Categories								
	Bacteria/Virus	Heavy Metals	Nutrients	Pesticides	Organic Compounds	Sediments	Trash & Debris	Oxygen Demanding Substances	Oil & Grease
Detached Residential Development	X		X	X		X	X	X	X
Attached Residential Development	P		X	X		X	X	P ⁽¹⁾	P ⁽²⁾
Commercial/ Industrial Development >100,000 ft ²	P ⁽³⁾		P ⁽¹⁾	P ⁽¹⁾	P ⁽²⁾	P ⁽¹⁾	X	P ⁽¹⁾	X
Automotive Repair Shops		X			X ⁽⁴⁾		X		X
Restaurants	X						X	X	X
Hillside Development >5,000 ft ² In SDRWQCB			X	X		X	X	X	X
Hillside Development >10,000 ft ² In SARWQCB			X	X		X	X	X	X
Parking Lots		X	P ⁽¹⁾	P ⁽¹⁾		P ⁽¹⁾	X	P ⁽¹⁾	X
Streets, Highways & Freeways		X	P ⁽¹⁾	P ⁽¹⁾	X ⁽⁴⁾	X	X	P ⁽¹⁾	X

X = anticipated.

P = potential

(1) A potential pollutant if landscaping or open area exist on-site.

(2) A potential pollutant if the project includes uncovered parking areas.

(3) A potential pollutant if land use involves food or animal waste products.

(4) Including petroleum hydrocarbons.

(5) Including solvents.

Table A-7.VI - 3
Summary of the 2002 303(d) Listed Water Bodies and Associated Pollutants of Concern for Orange County

Region	Water Body	Watershed	Pollutant							
			Bacteria Indicators/ Pathogens	Metals	Nutrients	Pesticides	Toxicity	Trash	Salinity/TDS/ Chlorides	Turbidity
Region 8 Santa Ana	Anaheim Bay	C		X		X				
	Bolsa Chica			X						
	Buck Gully Creek	H	X							
	Huntington Beach State Park	C	X							
	Huntington Harbour	D	X	X		X				
	Los Trancos Creek (Crystal Cove Creek)	H	X							
	Newport Bay, Lower	G		X		X				
	Newport Bay, Upper (Ecological Reserve)	G		X		X				
	Orange County Beaches	Varies						X		
	San Diego Creek, Reach 1	F	X			X				
	San Diego Creek, Reach 2	F		X			X			
	Seal Beach	A	X							
	Silverado Creek	E	X						X	
Region 9 San Diego	Aliso Creek (Mouth)	J	X							
	Aliso Creek (20 Miles)	J	X		X		X			
	Dana Point Harbor	K	X	X						
	Pacific Ocean Shoreline, Aliso Beach HSA	J	X							
	Pacific Ocean Shoreline, Dana Point HSA	K	X							
	Pacific Ocean Shoreline, Laguna Beach and San Joaquin Hills HSAs	I	X							
	Pacific Ocean Shoreline, Lower San Juan HSA	L	X							
	Pacific Ocean Shoreline, San Clemente, San Mateo, and San Onofre HSAs	M	X							
	Prima Deshecha Creek	M			X					X
	San Juan Creek (Lower one Mile)	L	X							
	San Juan Creek (Mouth)	L	X							
Segunda Deshecha Creek	M				X				X	

A-7.VI - 3.2.4 Identify Hydrologic Conditions of Concern

Common impacts to the hydrologic regime resulting from development typically include increased runoff volume and velocity; reduced infiltration; increased flow frequency, duration, and peaks; faster time to reach peak flow; and water quality degradation. Under certain circumstances, changes could also result in the reduction in the amount of available sediment for transport; storm flows could fill this sediment-carrying capacity by eroding the downstream channel. These changes have the potential to permanently impact downstream channels and habitat integrity.

A change to a priority project site's hydrologic regime would be considered a condition of concern if the change would have a significant impact on downstream natural channels and habitat integrity. Because of these potential impacts, the following steps shall be followed by each priority project:

1. Determine if the downstream stream channel is fully natural or partially improved with a significant potential for erosive conditions or alteration of habitat integrity to occur as a result of upstream development. If either of these conditions exists, continue with the following steps.
2. Evaluate the project's conditions of concern in a drainage study report prepared by a registered civil engineer in the State of California, with experience in fluvial geomorphology and water resources management. The report shall consider the project area's location (from the larger watershed perspective), topography, soil and vegetation conditions, percent impervious area, natural and infrastructure drainage features, and any other relevant hydrologic and environmental factors to be protected specific to the project area's watershed.
3. Review watershed plans, drainage area master plans or other planning documents to the extent available to identify if any specific implementation requirements for new development exist that address hydrologic conditions of concern.
4. As part of the drainage study, the civil engineer shall conduct a field reconnaissance to observe and report on representative downstream conditions, including undercutting erosion, slope stability, vegetative stress (due to flooding, erosion, water quality degradation, or loss of water supplies) and the area's susceptibility to erosion or habitat alteration as a result of an altered flow regime or change in sediment transport.
5. The drainage study shall compute rainfall runoff characteristics from the project area including, at a minimum, peak flow rate, flow velocity, runoff volume, time of concentration, and retention volume. These characteristics shall be developed for the two-year and 10-year frequency, Type I storm, of six-hour or 24-hour duration (whichever is the closer approximation of the site's time of concentration), during critical hydrologic conditions for soil and vegetative cover².

² Design storms can be found at <http://www.wrcc.dri.edu/pcpnfreq.html>. The County may calculate the storm events using local rain data. In addition, isopluvial maps contained in the Orange County Hydrology Manual may be used to extrapolate rainfall data to

The drainage study shall report the project's conditions of concern based on the hydrologic and downstream conditions discussed above. Where downstream conditions of concern have been identified, the drainage study shall establish, with documentation deemed adequate by the County, that pre-project hydrologic conditions affecting downstream conditions of concern would be maintained by the proposed project, satisfactory to the County, by incorporating the site design, source control, and treatment control requirements identified in **Section A-7.VI - 3.3.4**. For conditions where a reduction in sediment transport from the project development and features would significantly impact downstream erosion, the Treatment Control BMPs proposed should be evaluated to determine if use of the BMPs would result in reducing beneficial sediment (i.e. sand and gravel) significantly below pre-development levels. Under such conditions alternative BMPs (such as watershed based approaches for erosional sediment control) may need to be considered.

A-7.VI - 3.3 BMP Selection

All Priority Projects shall consider, incorporate and implement urban runoff and stormwater BMPs into the project design, in the following progression:

- Site Design BMPs
- Source Control BMPs (routine non-structural and routine structural)
- Treatment Control BMPs either on-site or off-site shared BMPs, or participation in a regional or watershed program

At a minimum, Priority Projects must implement Source Control BMPs (routine non-structural and routine structural) and must implement Treatment Control BMPs either on-site or off-site shared BMPs or participate in a regional or watershed program unless a waiver is granted based on the infeasibility of all Treatment Control BMPs as discussed in **Section A-7.VI - 6.0**. BMPs must also achieve the performance standards set out in **Section A-7.VI - 3.3.4**. Upon completion, for Public Agency projects will become subject to the Municipal Activities Program. Therefore it is not necessary to identify routine non-structural BMPs in the WQMP provided that such BMPs already been identified as part of the Municipal Activities Program (see **DAMP Section 5**).

A number of the Site Design and Treatment Control BMPs rely on infiltration of runoff to reduce the volume and load of pollutants to surface receiving waters. While such approaches can be very effective, there are potential limitations with respect to both soil stability and groundwater quality that are discussed in **Section A-7.VI - 3.3.4** under *RESTRICTIONS ON USE OF INFILTRATION BMPs*.

areas where insufficient data exists. If isopluvial maps are selected, the County shall describe its method for using isopluvial maps in its Local Implementation Plan.

A-7.VI - 3.3.1 Site Design BMPs

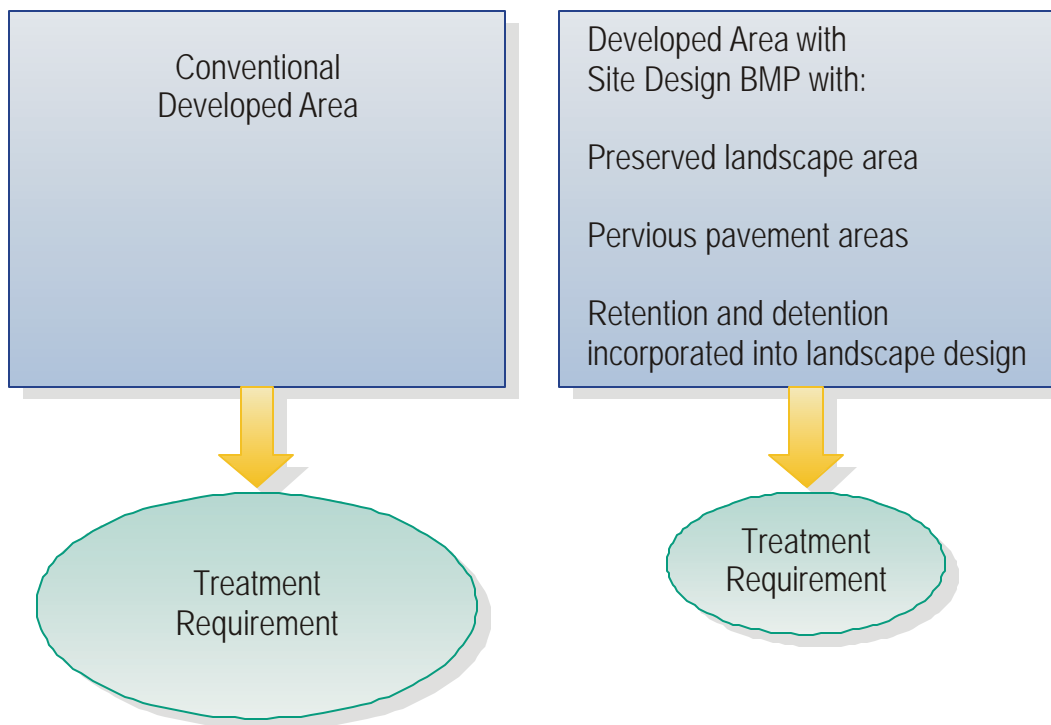
Priority Projects (as well as Non-Priority Projects - see **Section A-7.VI - 4.0**) shall be designed to minimize the introduction of pollutants that may result in significant impacts, generated from site runoff to the municipal storm drain system through a combination of BMPs that may include Site Design, Source Control, and Treatment Control BMPs. Priority Projects for which hydrologic conditions of concern have been identified shall also control post-development peak stormwater runoff discharge rates and velocities to maintain or reduce pre-development downstream erosion rates and to protect stream habitat. Priority Projects can address these objectives by considering the incorporation of Site Design BMPs that are intended to create a hydrologically functional project design that attempts to mimic the natural hydrologic regime. Mimicking a site's natural hydrologic regime can be pursued by:

- Reducing imperviousness, conserving natural resources and areas, maintaining and using natural drainage courses in the municipal storm drain system, and minimizing clearing and grading.
- Providing runoff storage measures dispersed uniformly throughout a site's landscape with the use of a variety of detention, retention, and runoff practices.
- Implementing on-lot hydrologically functional landscape design and management practices.

Runoff from developed areas may be reduced by using alternative materials or surfaces with a lower Coefficient of Runoff, or "C Factor". The C Factor is a representation of the ability of a surface to produce runoff. Surfaces that produce higher volumes runoff are represented by higher C Factors. By incorporating more pervious, lower C Factor surfaces into a development, lower volumes of runoff will be produced. Lower volumes and rates of runoff translate directly to lowering treatment requirements.

Detention and retention areas incorporated into landscape design provide areas for retaining and detaining stormwater flows, resulting in lower runoff rates and reductions in volume due to limited infiltration and evaporation. Such Site Design BMPs may reduce the size of Treatment Control BMPs,

Figure A-7.VI -2
Reduction of Treatment by Incorporation of Site Design BMPs



These design principles offer an innovative approach to urban stormwater management, one that does not rely on the conventional end-of-pipe or in-the-pipe structural methods but instead uniformly or strategically integrates stormwater controls throughout the urban landscape. Useful resources for applying these principles, referenced in **Section A-7.VI - 8.0 and Attachment B**, include Start at the Source (1999), and Low -Impact Development Design Strategies (1999).

DESIGN CONCEPT 1: MINIMIZE STORMWATER RUNOFF, MINIMIZE PROJECT'S IMPERVIOUS FOOTPRINT AND CONSERVE NATURAL AREAS

Minimize and/or control the post-development peak stormwater runoff discharge rates, velocities and volumes by utilizing measures that reduce runoff rates and volumes, and increase infiltration. A reduction in the stormwater runoff from a development project using properly designed BMPs, can yield a corresponding reduction in the amount of pollutants transported from the site. The undeveloped runoff volume should be determined by considering the project site to be in a natural condition with surface vegetation in place.

The following site design options shall be considered and incorporated where applicable and feasible, during the site planning and approval process consistent with applicable General Plan policies, other development standards and regulations and with any Site Design BMPs included in an applicable regional or watershed program.

1. Minimize impervious footprint. This can be achieved in various ways, including, but not limited to increasing building density (number of stories above or below ground) and developing land use regulations seeking to limit impervious surfaces. Decreasing the project's footprint can substantially reduce the project's impacts to water quality and hydrologic conditions
2. Conserve natural areas. This can be achieved by concentrating or clustering development on the least environmentally sensitive portions of a site while leaving the remaining land in a natural, undisturbed condition. Where available, the County shall also refer to its Multiple Species Conservation Plans or other biological regulations, as appropriate to assist in determining sensitive portions of the site.

Within each of the previous categories, areas containing hillsides (as defined in this County WQMP) should be considered more sensitive than the same category without hillsides.

3. Construct walkways, trails, patios, overflow parking lots, alleys, driveways, low-traffic streets and other low-traffic areas with open-jointed paving materials or permeable surfaces, such as pervious concrete, porous asphalt, unit pavers, and granular materials
4. Construct streets, sidewalks and parking lot aisles to the minimum widths necessary, provided that public safety and a walk able environment for pedestrians are not compromised³. Incorporate landscaped buffer areas between sidewalks and streets
5. Reduce widths of street where off-street parking is available⁴
6. Maximize canopy interception and water conservation by preserving existing native trees and shrubs, and planting additional native or drought tolerant trees and large shrubs
7. Minimize the use of impervious surfaces, such as decorative concrete, in the landscape design
8. Use natural drainage systems if feasible.
9. Where soils conditions are suitable, use perforated pipe or gravel filtration pits for low flow infiltration⁵
10. Construct onsite ponding areas or retention facilities to increase opportunities for infiltration
11. Other site design options that are comparable, and equally effective

³ Sidewalk widths must still comply with Americans with Disabilities Act regulations and other life safety requirements.

⁴ However, street widths must still comply with life safety requirements for fire and emergency vehicle access.

⁵ However, projects must still comply with hillside grading ordinances that limit or restrict infiltration of runoff.

DESIGN CONCEPT 2: MINIMIZE DIRECTLY CONNECTED IMPERVIOUS AREAS (DCIAs)

Priority Projects shall consider and incorporate the following design characteristics, where determined applicable and feasible and with any Site Design BMPs included in an applicable regional or watershed program.

1. Where landscaping is proposed, drain rooftops into adjacent landscaping prior to discharging to the storm drain
2. Where landscaping is proposed, drain impervious sidewalks, walkways, trails, and patios into adjacent landscaping
3. Increase the use of vegetated drainage swales in lieu of underground piping or imperviously lined swales
4. Use one or more of the following (for further guidance, see Start at the Source [1999]):
 - a. Rural swale system: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings
 - b. Urban curb/swale system: street slopes to curb; periodic swale inlets drain to vegetated swale/biofilter
 - c. Dual drainage system: First flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to municipal storm drain systems
 - d. Other design concepts that are comparable and equally effective
5. Use one or more of the following features for design of driveways and private residential parking areas:
 - a. Design driveways with shared access, flared (single lane at street) or wheel strips (paving only under tires); or, drain into landscaping prior to discharging to the municipal storm drain system
 - b. Uncovered temporary or guest parking on private residential lots may be: paved with a permeable surface; or, designed to drain into landscaping prior to discharging to the municipal storm drain system
 - c. Other design concepts that are comparable and equally effective
6. Use one or more of the following design concepts for the design of parking areas:
 - a. Where landscaping is proposed in parking areas, incorporate landscape areas into the drainage design

- b. Overflow parking (parking stalls provided in excess of the County's minimum parking requirements) may be constructed with permeable paving
 - c. Other design concepts that are comparable and equally effective
7. Other design characteristics that are comparable and equally effective

A-7.VI - 3.3.2 Source Control BMPs

The following Source Control BMPs (routine non-structural BMPs, routine structural BMPs and BMPs for individual categories/project features) are required within all new development and significant redevelopment projects regardless of their priority, including an applicable regional or watershed program, unless they do not apply due to the project characteristics. If any of the following Source Control BMP that would otherwise apply to the project is not included in the project, an explanation of why must be included in the Project WQMP or the regional or watershed program.

INCLUDE ROUTINE NON-STRUCTURAL SOURCE CONTROL BMPs:

- *N1 Education for Property Owners, Tenants and Occupants*

For developments with no Property Owners Association (POA) or with POAs of less than fifty (50) dwelling units, practical information materials will be provided to the first residents/occupants/tenants on general housekeeping practices that contribute to the protection of stormwater quality. These materials will be initially developed and provided to first residents/occupants/tenants by the developer. Thereafter such materials will be available through the Permittees' countywide education program. Different materials for residential, office commercial, retail commercial, vehicle-related commercial and industrial uses will be involved.

For developments with POA and residential projects of more than fifty (50) dwelling units, project conditions of approval will require that the POA provide environmental awareness education materials, made available by the municipalities, to all member periodically. Among other things, these materials will describe the use of chemicals (including household type) that should be limited to the property, with no discharge of wastes via hosing or other direct discharge to gutters, catch basins and storm drains.

- *N2 Activity Restrictions*

If a POA is formed, conditions, covenants and restrictions (CCRs) shall be prepared by the developer for the purpose of surface water quality protection. An example would be not allowing car washing outside of established community car wash areas in multi-unit complexes. Alternatively, use restrictions may be developed by a building operator through lease terms, etc. These restrictions must be included in the Project WQMP.

- *N3 Common Area Landscape Management*

On-going maintenance consistent with County Water Conservation Resolution, plus fertilizer and/or pesticide usage consistent with Management Guidelines for Use of Fertilizers (**DAMP Section 5.5**). Statements regarding the specific applicable guidelines must be included in the Project WQMP.

- *N4 BMP Maintenance*

Identify responsibility for implementation of each non-structural BMP and scheduled cleaning and/or maintenance of all structural BMP facilities.

- *N5 Title 22 CCR Compliance*

Compliance with Title 22 of the California Code of Regulations and relevant sections of the California Health & Safety Code regarding hazardous waste management shall be enforced by County Environmental Health on behalf of the State. The Project WQMP must describe how the development will comply with the applicable section(s) of Title 22.

- *N6 Local Water Quality Permit Compliance*

The County, under its Water Quality Ordinance, may issue permits to ensure clean stormwater discharges from fuel dispensing areas and other areas of concern to public properties.

- *N7 Spill Contingency Plan*

Prepared by building operator for use by specified types of building or suite occupancies and which mandates stockpiling of cleanup materials, notification of responsible agencies, disposal of cleanup materials, documentation, etc.

- *N8 Underground Storage Tank Compliance*

Compliance with State regulations dealing with underground storage tanks, enforced by County Environmental Health on behalf of State.

- *N9 Hazardous Materials Disclosure Compliance*

Compliance with County ordinances typically enforced by respective fire protection agency for the management of hazardous materials. The Orange County, health care agencies, and/or other appropriate agencies (i.e. Department of Toxics Substances Control or Agricultural Department) are typically responsible for enforcing hazardous waste handling and disposal regulations.

- *N10 Uniform Fire Code Implementation*

Compliance with Article 80 of the Uniform Fire Code enforced by fire protection agency.

- *N11 Common Area Litter Control*

For industrial/commercial developments and for developments with POAs, the owner/POA shall be required to implement trash management and litter control procedures in the common areas aimed at reducing pollution of drainage water. The owner/POA may contract with their landscape maintenance firms to provide this service during regularly scheduled maintenance, which should consist of litter patrol, emptying of trash receptacles in common areas, and noting trash disposal violations by tenants/homeowners or businesses and reporting the violations to the owner/POA for investigation.

- *N12 Employee Training*

Education program (see N1) as it would apply to future employees of individual businesses. Developer either prepares manual(s) for initial purchasers of business site or for development that is constructed for an unspecified use makes commitment on behalf of POA or future business owner to prepare.

- *N13 Housekeeping of Loading Docks*

Loading docks typically found at large retail and warehouse-type commercial and industrial facilities shall be kept in a clean and orderly condition through a regular program of sweeping and litter control and immediate cleanup of spills and broken containers. Cleanup procedures should minimize or eliminate the use of water. If washdown water is used, it must be disposed of in an approved manner and not discharged to the storm drain system. If there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only if allowed by the local sewerage agency through a permitted connection.

- *N14 Common Area Catch Basin Inspection*

For industrial/commercial developments and for developments with privately maintained drainage systems, the owner is required to have at least 80 percent of drainage facilities inspected, cleaned and maintained on an annual basis with 100 percent of the facilities cleaned in a two-year period prior to the storm season, no later than October 15th each year. Drainage facilities include catch basins (storm drain inlets) detention basins, retention basins, sediment basins, open drainage channels and lift stations.

- *N15 Street Sweeping Private Streets and Parking Lots*

Streets and parking lots are required to be swept prior to the storm season, no later than October 15 each year.

- *N16 Commercial Vehicle Washing*

This BMP Has Been Removed.

- *N17 Retail Gasoline Outlets*

Retail gasoline outlets (RGOs) are required to follow operations and maintenance best management practices shown in the California Stormwater Quality Association (CASQA, formerly California Stormwater Quality Task Force) Best Management Practice Guide for Retail Gasoline Outlets. This document may be obtained by downloading from the CASQA website at <http://www.stormwatertaskforce.org/swqtf/RGOGuide.htm> or from forthcoming CASQA website.

INCLUDE ROUTINE STRUCTURAL SOURCE CONTROL BMPs

Provide Storm Drain System Stenciling and Signage

Storm drain stencils are highly visible source control messages, typically placed directly adjacent to storm drain inlets. The stencils contain a brief statement that prohibits the dumping of improper materials into the municipal storm drain system. Graphical icons, either illustrating anti-dumping symbols or images of receiving water fauna, are effective supplements to the anti-dumping message. Stencils and signs alert the public to the destination of pollutants discharged into stormwater. The following requirements shall be included in the project design and shown on the project plans:

1. Provide stenciling or labeling of all storm drain inlets and catch basins, constructed or modified, within the project area with prohibitive language (such as: “NO DUMPING-DRAINS TO OCEAN”) and/or graphical icons to discourage illegal dumping.
2. Post signs and prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points along channels and creeks within the project area.
3. Maintain legibility of stencils and signs.

Design Outdoor Hazardous Material Storage Areas To Reduce Pollutant Introduction

Improper storage of materials outdoors may increase the potential for toxic compounds, oil and grease, fuels, solvents, coolants, wastes, heavy metals, nutrients, suspended solids, and other pollutants to enter the municipal storm drain system. Where the plan of development includes outdoor areas for storage of hazardous materials that may contribute pollutants to the municipal storm drain system, the following stormwater BMPs are required:

1. Hazardous materials with the potential to contaminate urban runoff shall either be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the municipal storm drain system; or (2)

protected by secondary containment structures (not double wall containers) such as berms, dikes, or curbs.

2. The storage area shall be paved and sufficiently impervious to contain leaks and spills.
3. The storage area shall have a roof or awning to minimize direct precipitation and collection of stormwater within the secondary containment area.
4. Any stormwater retained within the containment structure must not be discharged to the street or storm drain system.

Location(s) of installations of where these preventative measures will be employed must be included on the map or plans identifying BMPs.

Design Trash Storage Areas To Reduce Pollutant Introduction

All trash container areas shall meet the following requirements (limited exclusion: detached residential homes):

1. Paved with an impervious surface, designed not to allow run-on from adjoining areas, designed to divert drainage from adjoining roofs and pavements diverted around the area, screened or walled to prevent off-site transport of trash; and
2. Provide attached lids on all trash containers that exclude rain, or roof or awning to minimize direct precipitation.
3. Connection of trash area drains to the municipal storm drain system is prohibited.

Use Efficient Irrigation Systems and Landscape Design

Projects shall design the timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the municipal storm drain system. (Limited exclusion: detached residential homes.) The following methods to reduce excessive irrigation runoff shall be considered, and incorporated on common areas of development and other areas where determined applicable and feasible by the County:

1. Employing rain shutoff devices to prevent irrigation after precipitation.
2. Designing irrigation systems to each landscape area's specific water requirements.
3. Using flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.
4. Implementing landscape plan consistent with County Water Conservation Resolution, which may include provision of water sensors, programmable irrigation times (for short cycles), etc.

5. The timing and application methods of irrigation water shall be designed to minimize the runoff of excess irrigation water into the municipal storm drain system.
6. Employing other comparable, equally effective, methods to reduce irrigation water runoff.
7. Group plants with similar water requirements in order to reduce excess irrigation runoff and promote surface filtration. Choose plants with low irrigation requirements (for example, native or drought tolerant species). Consider other design features, such as:
 - Use mulches (such as wood chips or shredded wood products) in planter areas without ground cover to minimize sediment in runoff.
 - Install appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant material where possible and/or as recommended by the landscape architect.
 - Leave a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible.
 - Choose plants that minimize or eliminate the use of fertilizer or pesticides to sustain growth.

Protect Slopes and Channels

Project plans shall include Source Control BMPs to decrease the potential for erosion of slopes and/or channels, consistent with County codes and ordinances and with the approval of all agencies with jurisdiction, e.g., the U.S. Army Corps of Engineers, the Regional Boards and the California Department of Fish and Game. The following design principles shall be considered, and incorporated and implemented where determined applicable and feasible by the County:

1. Convey runoff safely from the tops of slopes.
2. Avoid disturbing steep or unstable slopes.
3. Avoid disturbing natural channels.
4. Stabilize disturbed slopes as quickly as possible.
5. Vegetate slopes with native or drought tolerant vegetation.
6. Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems.
7. Stabilize channel crossings as quickly as possible, and ensure that increases in runoff velocity and frequency caused by the project do not erode the channel.

8. Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion. Energy dissipaters shall be installed in such a way as to minimize impacts to receiving waters.
9. Onsite conveyance channels should be lined, where appropriate, to reduce erosion caused by increased flow velocity due to increases in tributary impervious area. The first choice for linings should be grass or some other vegetative surface, since these materials not only reduce runoff velocities, but also provide water quality benefits from filtration and infiltration. If velocities in the channel are large enough to erode grass or other vegetative linings, riprap, concrete soil cement or geo-grid stabilization may be substituted or used in combination with grass or other vegetation stabilization.
10. Other design principles that are comparable and equally effective.

INCORPORATE REQUIREMENTS APPLICABLE TO INDIVIDUAL PROJECT FEATURES:

All projects, regardless of priority, shall adhere to each of the individual project category requirements that apply to the project (e.g., a restaurant would be required to incorporate the requirements for Equipment Wash Areas into the project design). Where identified in **Table A-7.VI - 4**, the following requirements shall be incorporated into applicable priority projects.

**Table A-7.VI - 4
Source Control and Site Design Stormwater BMP Selection Matrix**

Priority Project Category	Source Control BMPs ⁽¹⁾	Requirements Applicable to Individual Project Features (or Priority Project Categories) ⁽²⁾							Site Design BMPs ⁽³⁾
		Loading Dock Areas	Maintenance Bays	Vehicle Wash Areas	Outdoor Processing Areas	Equipment Wash Areas	Fueling Areas	Hillside Landscaping	
Detached Residential Development	R							R	C
Attached Residential Development	R			R				R	C
Commercial/Industrial Development >100,000 ft ²	R	R	R	R	R	R	R	R	C
Automotive Repair Shop	R	R	R	R		R	R		C
Restaurants	R	R				R		R	C
Hillside Development >5,000 ft ² in SDRWQCB	R							R	C
Hillside Development >10,000 ft ² in SARWQCB	R							R	C
Parking Lots	R							R	C
Streets, Highways & Freeways	R							R	C
<p>R = Required; select BMPs as required from the applicable steps in Section A-7.VI - 3.3.2 or equivalent. C = Consider and select one or more applicable BMPs (1) Required for all projects regardless of priority. Refer to Section A-7.VI - 3.3.2. (2) Priority project categories must apply specific stormwater BMP requirements, where applicable. Projects are subject to the requirements of all priority project categories that apply. (3) Refer to Section A-7.VI - 3.3.1.</p>									

Loading Dock Areas

Loading/unloading dock areas shall include the following:

1. Cover loading dock areas, or design drainage to preclude urban run-on and runoff.
2. Direct connections to the municipal storm drain system from below grade loading docks (truck wells) or similar structures are prohibited. Stormwater can be discharged through a permitted connection to the storm drain system with a Treatment Control BMP applicable to the use.
3. Other features which are comparable and equally effective, that prevent unpermitted discharges to the municipal storm drain system.
4. Housekeeping of loading docks shall be consistent with N13.

Maintenance Bays

Maintenance bays shall include the following:

1. Repair/maintenance bays shall be indoors; or, designed to preclude urban run-on and runoff.
2. Design a repair/maintenance bay drainage system to capture all wash water, leaks and spills. Provide impermeable berms, drop inlets, trench catch basins, or overflow containment structures around repair bays to prevent spilled materials and wash-down waters from entering the storm drain system. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the municipal storm drain system is prohibited. If there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only allowed by the local sewerage agency through a permitted connection.
3. Other features which are comparable and equally effective that prevent unpermitted discharges to the municipal storm drain system.

Vehicle Wash Areas

Projects that include areas for washing/steam cleaning of vehicles shall use the following:

1. Self-contained or covered with a roof or overhang.
2. Equipped with a wash racks constructed in accordance with the guidelines in **Attachment C**, and with the prior approval of the sewerage agency (Note: Discharge monitoring may be required by the sewerage agency).
3. Equipped with a clarifier or other pretreatment facility.

4. If there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only if allowed by the local sewerage agency through a permitted connection.
5. Other features which are comparable and equally effective that prevent unpermitted discharges to the municipal storm drain system.

Outdoor Processing Areas

Outdoor process equipment operations, such as rock grinding or crushing, painting or coating, grinding or sanding, degreasing or parts cleaning, landfills, waste piles, and wastewater and solid waste handling, treatment, and disposal, and other operations determined to be a potential threat to water quality by the County shall adhere to the following requirements.

1. Cover or enclose areas that would be the sources of pollutants; or, slope the area toward a sump that will provide infiltration or evaporation with no discharge; or, if there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only if allowed by the local sewerage agency through a permitted connection
2. Grade or berm area to prevent run-on from surrounding areas.
3. Installation of storm drains in areas of equipment repair is prohibited.
4. Other features which are comparable or equally effective, that prevent unpermitted discharges to the municipal storm drain system.
5. Where wet material processing occurs (e.g. Electroplating), secondary containment structures (not double wall containers) shall be provided to hold spills resulting from accidents, leaking tanks or equipment, or any other unplanned releases (Note: If these are plumbed to the sanitary sewer, the structures and plumbing shall be in accordance with **Section A-7.VI - 8, Attachment D**, and with the prior approval of the sewerage agency). See also **Section A-7.VI - 3.4.2, N10**. Design of secondary containment structures shall be consistent with "Design of Outdoor Material Storage Areas To Reduce Pollutant Introduction".

Some of these land uses (e.g. landfills, waste piles, wastewater and solid waste handling, treatment and disposal) may be subject to other permits including Phase I Industrial Permits that may require additional BMPs.

Equipment Wash Areas

Outdoor equipment/accessory washing and steam cleaning activities shall use the following:

1. Be self-contained or covered with a roof or overhang.

2. Be equipped with a clarifier, grease trap or other pretreatment facility, as appropriate and discharge. If there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only allowed by the local sewerage agency through permitted connection to a sanitary sewer, through an approved connection.
3. Other features which are comparable or equally effective that prevent unpermitted discharges to the municipal storm drain system.

Fueling Areas

Fuel dispensing areas shall contain the following:

1. At a minimum, the fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.
2. The fuel dispensing area shall be paved with Portland cement concrete (or equivalent smooth impervious surface). The use of asphalt concrete shall be prohibited.
3. The fuel dispensing area shall have an appropriate slope (2% - 4%) to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of stormwater.
4. An overhanging roof structure or canopy shall be provided. The cover's minimum dimensions must be equal to or greater than the area of the fuel dispensing area in #1 above. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area. The fueling area shall drain to the project's Treatment Control BMP(s) prior to discharging to the municipal storm drain system.

Hillside Landscaping

Hillside areas that are disturbed by project development shall be landscaped with deep-rooted, drought tolerant plant species selected for erosion control, satisfactory to the County.

Wash Water Controls For Food Preparation Areas

Food establishments (per State Health & Safety Code 27520) shall have either contained areas, sinks, each with sanitary sewer connections for disposal of wash waters containing kitchen and food wastes. If located outside, the contained areas, sinks shall also be structurally covered to prevent entry of stormwater. Adequate signs shall be provided and appropriately placed stating the prohibition of discharging of washwater to the storm drain system.

Community Car Wash Racks

In complexes larger than 100 dwelling units where car washing is allowed, a designated car wash area that does not drain to a storm drain system shall be provided for common usage.

Wash waters from this area may be directed to the sanitary sewer (in accordance with **Attachment C**, and with the prior approval of the sewerage agency); to an engineered infiltration system; or to an equally effective alternative. Pre-treatment may also be required. Signage shall be provided prohibiting discharges of washwater outside of the designated area.

A-7.VI - 3.3.3 Selection of Regional or Project-Based Approach to Treatment Control BMPs

Regional and/or watershed management programs as described below that address runoff from New Development/Significant Redevelopment are encouraged to be considered as alternatives to Project WQMPs within the Santa Ana Regional Board permit area. Regional and/or watershed management programs, as described in this Local WQMP, are not allowed within the San Diego Regional Board permit area. However, under certain conditions within the San Diego Regional Board permit area, as described further under “Locate Treatment Control BMPs Near Pollutant Sources” (**Section A-7.VI – 3.3.4**), offsite shared controls can be considered. It is anticipated that the County individually or in conjunction with other Permittees may approve offsite shared BMPs, or regional or watershed programs that will be utilized within their respective jurisdictions. Offsite, regional or watershed programs are meant to provide comprehensive water quality solutions for the new development or significant projects they are meant to serve. To this end, all BMPs applicable to individual projects served by the approved offsite shared BMPs or a regional or watershed program as well as details of applicable Site Design BMPs and offsite (as well as any on-site) Treatment Control BMPs will be predetermined in the approved offsite shared BMPs, or regional or watershed program.

If a regional or watershed program approach is allowed by the current NPDES permit (e.g. by Santa Ana Regional Board Order R8-2002-0010) the program may be approved if the following criteria are met:

- The project incorporates all appropriate routine Source Control BMPs and any applicable Site Design BMPs.
- The regional program incorporates Treatment Control BMPs that are sized to treat at a minimum the volume or flow for the water quality design storm for the runoff from the project and other new development or significant redevelopment projects served by the regional or watershed BMP(s) as determined by the planning for the regional or watershed program. The water quality design storm runoff volume or flow obligation for project participation in the regional or watershed program may be reduced based on the incorporation of any Site Design BMPs that offset treatment requirements for pollutants of concern.
- An implementation plan is identified including funding, timing, ability to implement and responsible parties. The implementation plan can rely on an adopted Regional or Watershed Master Plan. If a project is in a watershed where a regional or watershed program can be considered or has already been adopted, the Project WQMP will describe or reference the regional or watershed program and describe how the project will participate in or contribute to the program. The implementation plan will also identify an appropriate

level of either project-specific monitoring or coordination with regional monitoring programs.

- The County may conduct and adopt a master plan to determine where on-site and offsite community-wide facilities are appropriate. Where it is determined by the County that on-site facilities are necessary, the County will either define the performance standards to be consistent with or more stringent than this County WQMP. When regional or watershed treatment controls are determined to be most practical, the developer may need to construct these facilities (for larger development projects), or pay a share of these facilities' cost through an equitable fee-in-lieu-of method. The County will work with the other Permittees to establish an overall performance standard to allow developers to select the appropriate Treatment Control BMPs given site conditions, costs, and performance.

When deciding to implement a regional or watershed management program, specific performance criteria should be evaluated. These performance criteria are listed as follows:

- The degree of pollution control provided under typical operating conditions.
- Variability of efficiency from pollutant to pollutant
- Variability of efficiency with storm characteristics
- The effect of design variables on performance
- Stability of efficiency over time
- Effectiveness relative to other BMPs
- Reduction of toxicity
- Improvement in, or protection of, downstream biotic communities
- Potential downstream negative impacts

Several factors affect whether a regional or watershed or project-based (on-site) structural approach is more feasible. Among these are removal effectiveness, cost, maintenance and construction timing:

Pollutant Removal Effectiveness

A variety of pollutant removal methods have been utilized in BMP monitoring studies to evaluate efficiency. The following are six methods typically used by investigators:

- Efficiency ratio
- Summation of loads

- Regression of loads
- Mean concentration
- Efficiency of individual storm loads
- Reference watersheds and before/after studies

Equations and example calculations are provided in the ASCE/EPA Technical Memorandum titled "Development of Performance Measures", which can be found in **Attachment D** of this Exhibit.

Cost

As with the selection of all BMPs, cost effectiveness is an important criterion to consider. When evaluating regional or watershed programs, it must be determined who will be responsible for funding the construction and/or upkeep of the regional or watershed control measures.

It is often most cost effective to utilize an existing treatment control near the development site. For instance, many Treatment Control BMPs can be incorporated into regional flood control detention/retention facilities with modest design refinements, and limited increased land requirements and cost. However, this type of alternative should be reviewed by the Orange County Flood Control District to check that both flood control and pollution control objectives are met.

Other potential issues that may affect cost include filling, dredging, and streambed alteration conditions; in which case, the project should be reviewed by the Army Corps of Engineers, the Regional Board, and the Department of Fish and Game.

Maintenance

Proper maintenance is crucial for all BMPs. It is necessary to clearly state who will be responsible for the maintenance and upkeep of the regional or watershed Treatment Control BMPs, as the responsible party in a regional or watershed program is not as apparent as with an on-site treatment control.

Construction Timing

Participation in a regional or watershed program may be approved provided construction of the regional or watershed structural Treatment Control BMP is completed (or an equivalent temporary alternative is put in place) prior to the post-construction use of the regional or watershed BMP by the new development or significant redevelopment project being approved. The regional or watershed BMPs shall only be required to have capacity to treat the dependent developments or phases of development that are in use.

Interim stormwater BMPs that provide equivalent or greater treatment than is required by the County WQMP may be implemented until each regional or watershed Treatment Control BMP

is operational. If interim BMPs are selected, the BMPs shall remain in use until permanent BMPs are operational.

A-7.VI - 3.3.4 Treatment Control BMPs

For Priority Projects, minimizing a development's detrimental effects on water quality can be most effectively achieved using a combination of Site Design, Source Control and Treatment Control BMPs. Where projects have been designed to reduce, the introduction of anticipated pollutants of concern that may result in significant impacts to the receiving waters through the implementation of Site Design and Source Control stormwater BMPs, the development may still have the potential for pollutants of concern to enter the municipal storm drain system or receiving waters.

Where acceptable offsite shared BMPs, or regional or watershed management programs are available within the downstream watershed⁶ to address the pollutants of concern from new development and significant redevelopment, a project may participate in offsite shared BMPs or a regional or watershed program provided the program meets the criteria discussed in **Section A-7.VI - 3.3.3**. Otherwise, Priority Projects shall be designed to remove pollutants of concern from the municipal storm drain system through the incorporation and implementation of Treatment Control BMPs.

In meeting the requirements in this section, Priority Projects shall implement a single or combination of stormwater Treatment Control BMPs that will remove anticipated pollutants of concern, as identified by the procedure in **Section A-7.VI - 3.2**, in site runoff. Treatment Control BMPs must be implemented unless a waiver is granted to the project by the County, based on the infeasibility of any Treatment Control BMP (see **Section A-7.VI - 6.0**).

QUANTITY DESIGN STANDARD FOR TREATMENT CONTROL BMPs

All Priority Projects shall design, construct and implement structural Treatment Control BMPs that meet the design standards of this section, unless specifically exempted by the limited exclusions listed at the end of this section or the project is participating in acceptable offsite shared BMPs, or a regional or watershed management program. Structural Treatment Control BMPs required by this section shall be operational prior to the use of any dependent development, and shall be located and designed in accordance with the requirements here in this section.

Unlike flood control measures that are designed to handle peak flows, stormwater Treatment Control BMPs are designed to treat the more frequent, lower-flow storm events, or the first flush portions of runoff from larger storm events (typically referred to as the first-flush events). Small, frequent storm events represent most of the total average annual rainfall for the area. The flow and volume from such small events is targeted for treatment. There is marginal water

⁶ Regional/Watershed BMPs and off-site BMPs downstream of a project are not in compliance with San Diego Regional Board Order No. R9-2002-001. Multiple projects may share structural BMPs provided they are installed prior to discharge to receiving waters supporting beneficial uses.

quality benefit gained by sizing treatment facilities to handle flows or volumes greater than the ones generated by small events.

The primary control strategy for designing Treatment Control BMPs is to treat the Stormwater Quality Design Flow (SQDF) or the Stormwater Quality Design Volume (SQDV) of the stormwater runoff. **Table A-7.VI - 5** lists BMPs along with the basis of design, SQDF or SQDV, to be used for designing the BMP. **Attachment A** to this Exhibit provides detailed guidance and tools for determining the SQDV and SQDF for a project.

Table A-7.VI - 5 Basis of Design for Treatment Control BMPs

Treatment Control BMP	Design Basis
Vegetated (Grass) Strips	SQDF
Vegetated (Grass) Swales	
Proprietary Control Measures	
Dry Detention Basin	SQDV
Wet Detention Basin	
Constructed Wetland	
Detention Basin/Sand Filter	
Porous Pavement Detention	
Porous Landscape Detention	
Infiltration Basin	
Infiltration Trench	
Media Filter	
Proprietary Control Measures	

Stormwater Quality Design Volume (SQDV)

Volume-based BMPs shall be designed to mitigate (infiltrate, filter, or treat) either:

1. The volume of runoff produced from a 24-hour 85th percentile storm event, as determined from the local historical rainfall record;
2. The volume of runoff produced by the 85th percentile 24-hour runoff event, determined as the maximized capture urban runoff volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ ASCE Manual of Practice No. 87, (1998); or

3. The volume of annual runoff based on unit basin storage volume, to achieve 90 percent or more volume treatment by the method recommended in California Stormwater Best Management Practices Handbook – Industrial/ Commercial, (1993), or
4. The volume of runoff, as determined from the local historical rainfall record, that achieves approximately the same reduction in pollutant loads and flows as achieved by mitigation of the 85th percentile 24-hour runoff event,⁷

OR

Stormwater Quality Design Flow (SQDF)

Flow-based BMPs shall be designed to mitigate (infiltrate, filter, or treat) either:

1. The maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour for each hour of a storm event; or
2. The maximum flow rate of runoff produced by the 85th percentile hourly rainfall intensity, as determined from the local historical rainfall record, multiplied by a factor of two; or
3. The maximum flow rate of runoff, as determined from the local historical rainfall record, that achieves approximately the same reduction in pollutant loads and flows as achieved by mitigation of the 85th percentile hourly rainfall intensity multiplied by a factor of two.

Limited Exclusions:

1. Proposed restaurants, where the land area for development or redevelopment is less than 5,000 square feet, are excluded from the Treatment Control BMP and numerical sizing criteria requirements.
2. Where significant redevelopment results in an increase of less than 50 percent of the impervious surfaces of a previously existing development, and the existing development was not subject to Project WQMP requirements, the Treatment Control BMP and numeric sizing criteria discussed in this section apply only to the addition, and not to the entire development.

⁷ This volume is not a single volume to be applied to all of Orange County. The size of the 85th percentile storm event is different for various parts of the County. The County may calculate the 85th percentile storm event using local rain data pertinent to their particular jurisdiction (the 0.8 inch standard is a rough average for the County and should only be used where appropriate rain data is not available). In addition, isopluvial maps may be used to extrapolate rainfall data to areas where insufficient data exists in order to determine the volume of the local 85th percentile storm event in such areas. Where the County will use isopluvial maps to determine the 85th percentile storm event in areas lacking rain data, the County shall describe their method for using isopluvial maps in their Local Implementation Plan prepared as Appendix A of the 2003 DAMP.

SELECTION OF TREATMENT CONTROL BMPs

1. To select a structural Treatment Control BMP, each Priority Project shall compare the list of pollutants for which the downstream receiving waters are impaired (if any), with the pollutants anticipated to be generated by the project (as identified in **Table A-7.VI - 2**).

Any pollutants identified by **Table A-7.VI - 2**, which are also causing a Clean Water Act section 303(d) impairment of receiving waters of the project, shall be considered primary pollutants of concern. Priority Projects shall select a single or combination of stormwater Treatment Control BMPs, which address the particular primary pollutant(s) of concern. The Treatment Control BMP Selection Matrix (**Table A-7.VI - 6**) should be used as a guide to assist in the selection of BMPs. BMPs are indicated in **Table A-7.VI - 6** that are presumed to be adequate to address their specific pollutant(s) of concern, as these BMPs have been shown to have either medium or high effectiveness in removing these particular pollutants. The selected Treatment Control BMP(s) will address other pollutants in addition to the primary pollutant(s) as shown in **Table A-7.VI - 6**.

If during the CEQA process a more refined evaluation of the project identifies that impacts on receiving waters may not be significant and that the project will not cause further exceedance of water quality objectives related to the pollutant(s) for which the receiving water is impaired, the project shall not be required to use pollutant-specific treatment BMP(s) but may use any Treatment Control BMP or combination of stormwater Treatment Control BMPs that are designed to mitigate pollution.

2. Priority Projects that are not anticipated to generate a primary pollutant of concern, shall select a single or combination of stormwater Treatment Control BMPs from **Table A-7.VI - 6**, that are designed to be effective in reducing pollutants of concern.
3. Alternative stormwater Treatment Control BMPs not identified in **Table A-7.VI - 6** may be approved at the discretion of the County, provided the alternative Treatment Control BMP is as effective in removal of pollutants of concern as other feasible BMPs listed in **Table A-7.VI - 6**.

LOCATE TREATMENT CONTROL BMPs NEAR POLLUTANT SOURCES

Project-based (on-site) structural Treatment Control BMPs should be implemented close to pollutant sources to minimize costs and maximize pollutant removal prior to runoff entering receiving waters. Such Treatment Control BMPs may be located on- or off-site, used singly or in combination, or shared by multiple new developments, pursuant to the following requirements:

1. All structural Treatment Control BMPs shall be located so as to infiltrate, filter, and/or treat the required runoff volume or flow prior to its discharge to any receiving water.
2. Multiple post-construction structural Treatment Control BMPs for a single Priority Project shall collectively be designed to comply with the design standards of this section;

**Table A-7.VI - 6
Treatment Control BMP Selection Matrix⁽¹⁾**

Pollutant of Concern	Treatment Control BMP Categories					
	Biofilters	Detention Basins	Infiltration Basins ⁽²⁾	Wet Ponds or Wetlands	Filtration	Hydrodynamic Separator Systems ⁽³⁾
Sediment Turbidity	H/M	H/M	H/M	H/M	H/M	H/M
Nutrients	L	H/M	H/M	H/M	H/M	L
Organic Compounds	U	U	U	U	H/M	L
Trash & Debris	L	H/M	U	U	H/M	H/M
Oxygen Demanding Substances	L	H/M	H/M	H/M	H/M	L
Bacteria & Viruses	U	U	H/M	U	H/M	L
Oil & Grease	H/M	H/M	U	U	H/M	L/M
Pesticides (non-soil bound)	U	U	U	U	U	L
<p>(1) Cooperative periodic performance assessment may be necessary. This Treatment Control BMP table will be updated as needed and as knowledge of stormwater treatment BMPs improves.</p> <p>(2) Including trenches and porous pavement.</p> <p>(3) Also known as hydrodynamic devices and baffle boxes.</p> <p>L: Low removal efficiency H/M: High or medium removal efficiency U: Unknown removal efficiency</p> <p>Sources: Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993), National Stormwater Best Management Practices Database (2001), and Guide for BMP Selection in Urban Developed Areas (2001).</p>						

Biofilters include:

- Grass swales
- Grass strips
- Wetland vegetation swales
- Bioretention

Detention Basins include:

- Extended/dry detention basins with grass lining
- Extended/dry detention basins with impervious lining

Infiltration Basins include:

- Infiltration basins
- Infiltration trenches

Wet Ponds and Wetlands include:

- Wet ponds (permanent pool)
- Constructed wetlands

Filtration Systems include:

- Media filtration
- Sand filtration

Hydrodynamic Separation Systems include:

- Swirl Concentrators
- Cyclone Separators

3. Shared stormwater Treatment Control BMPs shall be operational prior to the use of any dependent development or phase of development. The shared BMPs shall only be required to treat the dependent developments or phases of development that are in use;
4. Interim stormwater Treatment Control BMPs that provide equivalent or greater treatment than is required by this section may be implemented by a dependent development until each shared BMP is operational. If interim BMPs are selected, the BMPs shall remain in use until permanent BMPs are operational.

For projects participating in offsite shared BMPs, or a regional or watershed program in lieu of project-based BMPs, the offsite BMPs must be located in accordance with the above requirements or the regional or watershed program

RESTRICTIONS ON USE OF INFILTRATION BMPS

Grading permits may limit or prohibit the use of infiltration BMPs in hillside or other special situations where slope stability and subsurface stability are of concern. Over time, infiltration may affect pre or post-development subsurface conditions, creating potential for instability.

It is also important to note that any drainage feature that infiltrates runoff poses some risk of potential groundwater contamination. Three factors significantly influence the potential for urban runoff to contaminate ground water. They are (i) pollutant mobility, (ii) pollutant abundance in urban runoff, (iii) and soluble fraction of pollutant. The risks associated with groundwater infiltration can be managed by:

- Designing landscape drainage features so that they promote infiltration of runoff, but do not inject runoff so that it bypasses the natural processes of filtering and transformation that occur in the soil. Taking reasonable steps to prevent the illegal discharge of wastes to drainage systems.

In general, designs that disperse runoff over landscaped areas or through permeable surfaces are the most effective, easiest to maintain and have the lowest initial cost. These designs also minimize the risk of illegal disposal because the surface is visible and the infiltration rate per unit area is relatively low.

- For some sites, it may be feasible to use detention basins to infiltrate additional runoff in a more compact area, but the designer must consider the potential for illegal disposal of chemical spills. Detention basins should not drain to, or be located near, work areas where wash-water or liquid wastes are generated or where hazardous chemicals are stored. Detention basins should be clearly marked with “no dumping” signs and should be inspected regularly.
- The Orange County Groundwater Basin and the San Juan Groundwater Basin are the primary managed drinking water basins for the county residents and must be protected as a source of safe drinking water. The Orange County Water District (OCWD) and the San Juan Basin Authority (SJBA) are the agencies responsible for managing the Orange County Groundwater Basin and the San Juan Groundwater Basin. Planning and possible

implementation of infiltration facilities must always be coordinated with OCWD and SJBA to make sure that proposed solutions to stormwater quality do not cause groundwater quality problems.

- The risk of contamination of groundwater may be reduced by pretreatment of urban runoff. A discussion of limitations and guidance for infiltration practices is contained in Potential Groundwater Contamination from Intentional and Non-Intentional Stormwater Infiltration, Report No. EPA/600/R-94/051, USEPA (1994).

To protect groundwater quality, the County shall apply restrictions to the use of any Treatment Control BMPs that are designed to primarily function as infiltration devices (such as infiltration trenches and infiltration basins). As additional ground water basin data is obtained, The County in coordination with OCWD and SJBA, may develop additional restrictions on the use of any BMPs that allow incidental infiltration.

At a minimum, use of structural Treatment Control BMPs that are designed to primarily function as infiltration devices shall meet the following conditions⁸:

1. Use of structural infiltration treatment BMPs shall not cause or contribute to an exceedance of groundwater water quality objectives.
2. Pollution prevention and Source Control BMPs shall be implemented at a level appropriate to protect groundwater quality at sites where infiltration structural Treatment Control BMPs are to be used.
3. Structural infiltration Treatment Control BMPs shall not cause a nuisance or pollution, as defined in Water Code Section 13050.
4. Urban runoff from commercial developments shall undergo pretreatment to remove both physical and chemical contaminants, such as sedimentation or filtration, prior to infiltration.
5. All dry weather flows shall be diverted from infiltration devices except for those non-stormwater discharges authorized pursuant to 40 CFR 122.26(d)(2)(iv)(B)(1): diverted stream flows, rising ground waters, uncontaminated ground water infiltration [as defined at 40 CFR 35.2005(20)] to municipal storm drain systems, uncontaminated pumped ground water, foundation drains, springs, water from crawl space pumps, footing drains, air conditioning condensation, flow from riparian habitats and wetlands, water line flushing, landscape irrigation, discharges from potable water sources other than water main breaks, irrigation water, individual residential car washing, and dechlorinated swimming pool discharges.
6. The vertical distance from the base of any infiltration structural Treatment Control BMP to the seasonal high groundwater mark shall be at least 10 feet or as determined on an

⁸ These conditions do not apply to structural Treatment Control BMPs which allow incidental infiltration and are not designed to primarily function as infiltration devices (such as grassy swales, detention basins, vegetated buffer strips, constructed wetlands, etc.)

individual, site-specific basis by the County. Where groundwater does not support beneficial uses, this vertical distance criterion may be reduced, provided groundwater quality is maintained. Reduction of vertical criterion should always be coordinated with OCWD and SJBA

7. The soil through which infiltration is to occur shall have physical and chemical characteristics (such as appropriate cation exchange capacity, organic content, clay content, and infiltration rate) that are adequate for proper infiltration durations and treatment of urban runoff for the protection of groundwater beneficial uses.
8. Infiltration structural Treatment Control BMPs shall not be used for areas of industrial or light industrial activity; areas subject to high vehicular traffic (25,000 or greater average daily traffic on main roadway or 15,000 or more average daily traffic on any intersecting roadway); automotive repair shops; car washes; fleet or RV storage areas (bus, truck, etc.); nurseries; and other high threat to water quality land uses and activities as designated by the County in its Local Implementation Plan (see **2003 DAMP Appendix A**).
9. The horizontal distance between the base of any infiltration structural Treatment Control BMP and any water supply wells shall be 100 feet or as determined on an individual, site-specific basis by the County.
10. Any entity that implements a structural infiltration Treatment Control BMP shall be required to mitigate any groundwater contamination caused by the infiltration system.

Where infiltration Treatment Control BMPs are authorized, their performance shall be evaluated for impacts on groundwater quality. The County may develop additional restrictions on the use of Treatment Control BMPs that are designed to primarily function as infiltration devices. The County shall also consider Permit Section D.1.g. requirements to control the contribution of pollutants from one portion of the watershed to another portion of the watershed through interagency agreements among the Permittees. In those instances where the implementation of proposed infiltration Treatment Control BMPs within the County has a potential impact to groundwater quality in another jurisdiction, the County may include a notification requirement be placed upon those proposing such use in addition to the above protection measures.

A-7.VI - 4.0 NON-PRIORITY PROJECTS

Non-Priority Projects for new development or significant redevelopment covered under this program shall perform the following steps for Project WQMP preparation using a process similar to described for Priority Projects:

- Incorporate all applicable Source Control BMPs (routine non-structural and routine structural, including requirements applicable to individual project features). See **Section A-7.VI - 3.3.2** for more details.
- Consider Site Design BMPs

All non-priority new development and significant redevelopment projects shall consider, and incorporate and implement Site Design BMPs, where determined applicable and feasible during the site planning and approval process. See **Section A-7.VI - 3.3.1** for details.

A-7.VI - 5.0 PROVIDE PROOF OF ONGOING STORMWATER BMP MAINTENANCE

The County shall not accept stormwater structural BMPs as meeting the WQMP requirements standard, unless an Operation and Maintenance Plan (O&M Plan) is prepared (see **DAMP Section 7.6.6**) and a mechanism is in place that will ensure ongoing long-term maintenance of all structural and non-structural BMPs. This mechanism can be provided by the County or by the project proponent. As part of project review, if a project proponent is required to include interim or permanent structural and non-structural BMPs in project plans, and if the County does not provide a mechanism for BMP maintenance, the County shall require that the applicant provide verification of maintenance requirements through such means as may be appropriate, at the discretion of the County, including, but not limited to covenants, legal agreements, maintenance agreements, conditional use permits and/or funding arrangements.

A-7.VI - 5.1 Maintenance Mechanisms

1. **Public entity maintenance:** The County may approve a public or acceptable quasi-public entity (e.g., the County Flood Control District, or annex to an existing assessment district, an existing utility district, a state or federal resource agency, or a conservation conservancy) to assume responsibility for operation, maintenance, repair and replacement of the BMP. Unless otherwise acceptable to the County, public entity maintenance agreements shall ensure estimated costs are front-funded or reliably guaranteed, (e.g., through a trust fund, assessment district fees, bond, letter of credit or similar means). In addition, the County may seek protection from liability by appropriate releases and indemnities.

The County shall have the authority to approve stormwater BMPs proposed for transfer to any other public entity within its jurisdiction before installation. The County shall be involved in the negotiation of maintenance requirements with any other public entities accepting maintenance responsibilities within their respective jurisdictions; and in

negotiations with the resource agencies responsible for issuing permits for the construction and/or maintenance of the facilities. The County must be identified as a third party beneficiary empowered to enforce any such maintenance agreement within their respective jurisdictions.

2. **Project proponent agreement to maintain stormwater BMPs:** The County may enter into a contract with the project proponent obliging the project proponent to maintain, repair and replace the stormwater BMP as necessary into perpetuity. Security or a funding mechanism with a “no sunset” clause may be required.
3. **Assessment districts:** The County may approve an Assessment District or other funding mechanism created by the project proponent to provide funds for stormwater BMP maintenance, repair and replacement on an ongoing basis. Any agreement with such a District shall be subject to the Public Entity Maintenance Provisions above.
4. **Lease provisions:** In those cases where the County holds title to the land in question, and the land is being leased to another party for private or public use, the County may assure stormwater BMP maintenance, repair and replacement through conditions in the lease.
5. **Conditional use permits:** For discretionary projects only, the County may assure maintenance of stormwater BMPs through the inclusion of maintenance conditions in the conditional use permit. Security may be required.
6. **Alternative mechanisms:** The County may accept alternative maintenance mechanisms if such mechanisms are as protective as those listed above.

A-7.VI - 5.2 Permit Closeout Requirements

For discretionary and ministerial projects, the County-approved method of stormwater BMP maintenance shall be incorporated into the project's permit, and shall be consistent with permits issued by resource agencies, if any. Just as with all other aspects of a project's approved plans and designs, the County will make a determination that all requirements of the Project WQMP have been satisfactorily completed prior to closeout of permits and issuance of certificates of use and occupancy (see **DAMP Section 7.6.6**).

In all instances, the project proponent shall provide proof of execution of a County-approved method of maintenance, repair, and replacement (O&M Plan – See **Section A-7.VI - 5.3**) before the issuance of construction approvals, permit closeout and issuance of certificates of use and occupancy. The County in carrying out public projects that are not required to obtain permits shall be responsible for ensuring that a County-approved method of stormwater BMP maintenance repair and replacement is in place prior to the completion of construction. For all properties, the verification mechanism will include the project proponent's signed statement, as part of the project application, accepting responsibility for all structural BMP maintenance, repair and replacement, until a County-approved entity agrees to assume responsibility for

structural BMP maintenance, repair and replacement or an alternative mechanism is approved by the County regarding maintenance, repair and replacement of the structural BMP.

A-7.VI - 5.3 Maintenance Requirements

1. Operation & Maintenance (O&M) Plan: The County shall ensure that a copy of an O&M Plan, prepared by the project proponent satisfactory to the County, is received prior to permit closeout and the issuance of certificates of use and occupancy. The O&M Plan describes the designated responsible party to manage the stormwater BMP(s), employee's training program and duties, operating schedule, maintenance frequency, routine service schedule, specific maintenance activities, copies of resource agency permits, and any other necessary activities. At a minimum, maintenance agreements shall require the inspection and servicing of all structural BMPs on an annual basis.

The project proponent or County-approved maintenance entity shall complete and maintain O&M forms to document all maintenance requirements. Parties responsible for the O&M Plan shall retain records for at least 5 years. These documents shall be made available to the County for inspection upon request at any time.

2. Access Easement/Agreement: As part of the maintenance mechanism selected above, the County shall require the inclusion of a copy of an executed access easement that shall be binding on the land throughout the life of the project, until such time that the stormwater BMP requiring access is replaced, satisfactory to the County.

A-7.VI - 6.0 WAIVER OF STRUCTURAL TREATMENT BMP REQUIREMENTS

The County may provide for a Priority Project to be waived from the requirement of implementing structural Treatment Control BMPs (see **Section A-7.VI - 3**) if infeasibility can be established. The County shall only grant a waiver of infeasibility when all available structural Treatment Control BMPs have been considered and rejected as infeasible. The burden of proof is on the project proponent to demonstrate that all available measures are infeasible. The County shall notify the Executive Officer of the San Diego or Santa Ana Regional Board by Certified Mail (with Return Receipt) within five (5) days of each waiver issued and a copy of the waiver documentation shall include the name of the person granting each waiver and a copy of the Project WQMP.

Waivers may only be granted for structural Treatment Control BMP sizing requirements. Priority Projects, whether or not granted a waiver, may not cause or contribute to an exceedance of water quality objectives. Pollutants in runoff from projects granted a waiver must still be reduced through the use of Source Control and consideration of Site Design BMPs.

In considering a waiver the County will review the CEQA documentation for the project to identify whether a significant unmitigatable impact was identified that was subject to a statement of overriding considerations.

The County may, at its option, also develop a WQMP waiver impact fee program to require project proponents who have received waivers to transfer the savings in cost, or a proportionate share thereof, as determined by the County, to a stormwater mitigation fund. The County shall notify the Regional Board if a WQMP waiver impact fee program is developed. Further, details for any WQMP waiver impact fee program may be set out in the Local Implementation Plan (DAMP Appendix A), or in supplemental submissions if the County joins with other Permittees to establish a joint mitigation fund program for a region or watershed.

The County WQMP does not preclude the County individually or in conjunction with other Permittees from imposing any other fees or charges on development projects that are permitted by law, or from managing or expending the monies received from such non-WQMP programs in any manner authorized by law.

A-7.VI - 7.0 ALTERNATIVE APPROACHES FOR TREATMENT CONTROLS

A-7.VI - 7.1 Site Design Stormwater Treatment Credits

The County may develop and submit for public review and Regional Board approval, a regional Model Site Design Stormwater Treatment Credits program that allows reductions in the volume or flow of stormwater that must be captured or treated on a project in return for the inclusion of specified project design features in the project. The Model Site Design Stormwater Treatment Credits program shall be deemed part of this County WQMP following Regional Board approval.

Any such model program shall specify the conditions under which project proponents can be credited for the use of Site Design BMPs and low impact development techniques that can reduce the volume of stormwater runoff, preserve natural areas, and minimize the pollutant loads generated and potentially discharged from the site. Any Site Design Stormwater Treatment Credits program implemented by the County within its jurisdiction shall be consistent and compliant with this model approved by the Regional Board.

A-7.VI - 8.0 RESOURCES AND REFERENCES

A list of resources for information is provided in **Attachment B**.

ATTACHMENT A

DESIGN OF TREATMENT CONTROL BMPs USING THE STORMWATER QUALITY DESIGN FLOW (SQDF) OR THE STORMWATER QUALITY DESIGN VOLUME (SQDV)

Unlike flood control measures that are designed to handle peak flows, stormwater Treatment Control BMPs are designed to treat the more frequent, lower-flow storm events, or the first flush portions of runoff from larger storm events (typically referred to as the first-flush events). Small, frequent storm events represent most of the total average annual rainfall for the area. The flow and volume from such small events is targeted for treatment.

The primary control strategy for designing Treatment Control BMPs is to treat the Stormwater Quality Design Flow (SQDF) or the Stormwater Quality Design Volume (SQDV) of the stormwater runoff. This section explains how to calculate the SQDF or the SQDV of the stormwater runoff. In addition, Treatment Control BMPs must be designed to safely convey or bypass peak design storms.

Hydrology/Hydraulics

Hydrologic calculations for determining peak design storm flows in Orange County shall be in accordance with the latest edition of the Orange County Hydrology Manual produced in January 1986, together with the procedure set forth herein. Where jurisdictions within Orange County have approved alternative hydrologic calculation methods, the alternative methods may be utilized if they have been approved by the jurisdiction for use in design of flow-based stormwater quality BMPs.

The Orange County Hydrology Manual requires that storm drains with tributary areas of less than 640 acres be designed for a minimum of 10-year frequency below the top of the curb elevation using a combination of street and storm drain flow. In sump conditions, catch basin and connecting storm drains must be designed to a 25-year frequency. Habitable structures shall have 100-year flood protection.

Stormwater Quality Design Flow (SQDF) Calculations

The Stormwater Quality Design Flow (SQDF) is defined as the maximum flow rate of runoff produced from a rainfall intensity of 0.2-inch of rainfall per hour⁹.

Calculation Procedure

1. The Stormwater Quality Design Flow in Orange County is defined as $Q_{P, SQDF}$.
2. Calculate the peak rate stormwater quality design flow for the site (or each sub-drainage area that will discharge to a separate BMP) produced by 0.2-inch/hour rainfall by using the rational method equation:

$$Q_{P, SQDF} = C * I * A$$

Where:

C = runoff coefficient obtained from **Table A-1**.

I = rainfall intensity (0.2 in/hr)

A = area of the site or sub-drainage area in acres

Note: An alternate but less conservative method of computing the peak rate stormwater quality design flow ($Q_{P, SQDF}$) is to use the formula given in section D.6 of the Orange County Hydrology Manual, for I less than or equal than the lowest infiltration rate F_p for soil group D. This formula is:

$$Q_{P, SQDF} = 0.90 * a_i * I * A$$

Where:

a_i = ratio of impervious area to total area (decimal fraction)

⁹ As defined in Section XII.B.3.B of the California Regional Water Quality Control Board, Santa Ana Region, Waste Discharge Requirements for the County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County within the Santa Ana Region, Urban Stormwater Runoff Management Program, Orange County, Order No. R8-2002-0010, NPDES Permit No. CAS618030; and in Section F.1.b.(2)(c) of the California Regional Water Quality Control Board, San Diego Region, Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds of the County of Orange, the Incorporated Cities of Orange County and the Orange County Flood Control District within the San Diego Region, Board Order No. R9-2002-0001, NPDES CAS0108740

Table A-1
C Values Based on Impervious/Pervious Area Ratios

% Impervious	% Pervious	C
0	100	0.15
5	95	0.19
10	90	0.23
15	85	0.26
20	80	0.30
25	75	0.34
30	70	0.38
35	65	0.41
40	60	0.45
45	55	0.49
50	50	0.53
55	45	0.56
60	40	0.60
65	35	0.64
70	30	0.68
75	25	0.71
80	20	0.75
85	15	0.79
90	10	0.83
95	5	0.86
100	0	0.90

Example Stormwater Quality Design Flow (SQDF) Calculation

The steps below show an example calculation for a 30-acre site with runoff coefficient of 0.45 (40% impervious).

Step 1:

$$\text{Design Flow} = Q_{P, SQDF} = C * I * A$$

Step 2:

Calculate the peak rate of flow

$$Q_{P, SQDF} = 0.45 \times 0.2 \times 30 = 2.7 \text{ cfs} = \text{Stormwater Quality Design Flow for the BMP.}$$

Stormwater Quality Design Storm Volume (SQDV) Calculations

Hydrologic calculations for design of volumetric-based stormwater quality BMPs in Orange County shall be in accordance with one of the four following approaches specified in the permits:

- i. The volume of runoff produced from a 24-hour 85th percentile storm event, as determined from the local historical rainfall record (0.8 inch approximate average for the Orange County area)¹⁰; or
- ii. The volume of runoff produced by the 85th percentile 24-hour runoff event, determined as the maximized capture urban runoff volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual and Report on Engineering Practice No. 87, (1998); or
- iii. The volume of annual runoff based on unit basin storage volume, to achieve 80 percent (Santa Ana Permit area), or 90 percent (San Diego Permit area) or more volume treatment by the method recommended in California Stormwater Best Management Practices Handbooks (1993), or
- iv. The volume of runoff, as determined from the local historical rainfall record, that achieves approximately the same reduction in pollutant loads and flows as achieved by mitigation of the 85th percentile 24-hour runoff event.¹¹

Individual projects may evaluate and select any of the above approaches. Procedures, data specific to Orange County, and examples for applying approaches (i), (ii), and (iii) are presented herein.

The project used to demonstrate the calculations has the following characteristics:

- Located in the City of Irvine
- 400 ft above sea level
- Total project area, A_t , is 10 acres
- Impervious area, A_i , is 6 acres

¹⁰ This volume is not a single volume to be applied to all of Orange County. The size of the 85th percentile storm event is different for various parts of the County. The County may calculate the 85th percentile storm event using local rain data (the 0.8 inch standard is a rough average for the County and should only be used where appropriate rain data is not available). In addition, isopluvial maps may be used to extrapolate rainfall data to areas where insufficient data exists in order to determine the volume of the local 85th percentile storm event in such areas. Where the County uses isopluvial maps to determine the 85th percentile storm event in areas lacking rain data, the County shall describe its method for using isopluvial maps in the LIP and/or County WQMP.

¹¹ Under this volume criterion, hourly rainfall data may be used to calculate the 85th percentile storm event, where each storm event is identified by its separation from other storm events by at least six hours of no rain. If hourly rainfall data is selected, the County shall describe the method for using hourly rainfall data to calculate the 85th percentile storm event in the LIP and/or County WQMP.

Method (I):

The volume of runoff produced from a 24-hour 85th percentile storm event, as determined from the local historical rainfall record (0.8 inch approximate average for the Orange County area below elevation of 1,000 feet and 0.95 in for projects above 1,000 feet elevation). The procedure is as follows:

1. **Review the area draining to the proposed BMP.** Determine the percentage of the drainage area that is considered impervious. Impervious area includes paved areas, roofs, and other developed, non-vegetated areas. Non-vegetated, compacted soil areas shall be considered as impervious area.
2. **Use Table A-1 to determine the Runoff Coefficient “C” for the drainage area** The runoff coefficients from this table are intended only for use in this procedure for design of volumetric-based stormwater quality BMPs.
3. **Find the depth of rainfall in inches of the 85th percentile storm event.**
Use 0.80 inch for projects with 1,000 ft or less in elevation.
Use 0.95 inch for projects with 1,000 ft or more in elevation.
4. **Calculate the Water Quality Design Volume of the BMP.** The Water Quality Design Volume of the BMP is then calculated by multiplying the total rainfall by the BMP’s drainage area and runoff coefficient. Due to the mixed units that result (e.g., acre-inches, acre-feet) it is recommended that the resulting volume be converted to cubic feet for use during design.

Example Use of Unit Basin Storage Volume Curves Sizing a Dry Detention Basin

$$(A_i/A_t) * 100 = (6/10) * 100 = 60\%$$

From Table A-1, for 60% impervious, $C = 0.60$

$$V_b = C * I * A_t$$

$$V_b = 0.60 * (0.8 \text{ in}) * (10 \text{ ac}) * (1 \text{ ft}/12 \text{ in}) * (43,560 \text{ ft}^2/\text{acre})$$

Size the BMP for $V_b = 17,424 \text{ ft}^3$ and 48-hr drawdown

Note that this result is greater than that calculated using the 80% annual capture volume approach below (Method (iii)). This is in part because the capture volume method is based on a continuous simulation model using actual rainfall data and accounts for drawdown affects in the detention basin.

Method (II)

The volume of runoff produced by the 85th percentile 24-hour runoff event, determined as the maximized capture urban runoff volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual and Report on Engineering Practice No. 87, (1998).

From WEF MOP 23/ASCE MREP 87:

$$P_0 = (a * C) * P_6$$

Where:

C = Runoff Coefficient = $0.858 i^3 - 0.78 i^2 + 0.774 i + 0.04$

i = Watershed imperviousness ratio; namely, percent total imperviousness divided by 100 = 0.60

P₆ = mean storm precipitation volume, watershed inches. Using **Figure 5-3** in the manual, P₆ = 0.65 inches

a = Regression constant from least-square analysis. Using **Table 5-4** in the manual for 48-hours drain time, a = 1.963

P₀ = Maximized detention volume using either the volume capture ratio as its basis, watershed inches

$$C = 0.858 (0.60)^3 - 0.78 (0.60)^2 + 0.774 (0.60) + 0.04 = 0.409$$

$$P_0 = (1.963 * 0.409) * 0.65$$

$$P_0 = 0.522 \text{ inches}$$

$$V_b = 0.522 (10 \text{ acre}) (1 \text{ ft}/12 \text{ in}) (43,560 \text{ ft}^2/\text{acre})$$

Size the BMP for V_b = 18,949 ft³ and 48-hour drawdown

Note that this result is greater than that calculated using the 80% annual capture volume approach below (Method (iii)). This is in part because the capture volume method is based on a continuous simulation model using actual rainfall data and accounts for drawdown affects in the detention basin.

Method (III) – Annual Runoff or Unit Basin Storage Volume Method

1. **Review the area draining to the proposed BMP.** Determine the percentage of the drainage area that is considered impervious. Impervious area includes paved areas, roofs, and other developed, non-vegetated areas. Non-vegetated, compacted soil areas shall be considered as impervious area.
2. **Use Table A-1 to determine the Runoff Coefficient “C” for the drainage area.** The runoff coefficients from this table are intended only for use in this procedure for design of volumetric-based stormwater quality BMPs. Alternately, obtain the Runoff Coefficient from the drainage design calculations for the project.
3. **Find the Unit Basin Storage Volume¹².**

Use **Figure A-1** for projects with elevations less than 1,000 ft.

Use **Figure A-2** for projects with 1,000 ft or more in elevation.

Enter **Figure A-1** or **A-2** on the vertical axis at 80% Annual Capture for projects in the Santa Ana Regional Board region or 90% Annual Capture for projects in the San Diego Regional Board region.

Move horizontally to the right across the figure until the curve corresponding to the drainage area’s runoff coefficient (“C”) determined in Step 2 is intercepted. Interpolation between curves may be necessary. Move vertically down the figure for this point until the horizontal axis is intercepted. Read the Unit Basin Storage Volume along the horizontal axis. Recommended drawdown time for dry detention basins is 48 hours as discussed in the fact sheet.

OR

Figure A-3 provides a direct reading of Unit Basin Storage Volumes required for 80% (Santa Ana Regional Board region) and 90% (San Diego Regional Board region) annual capture of runoff for values of “C” determined in Step 2 for projects with elevations less than 1000 ft.

Figure A-4 provides a direct reading of Unit Basin Storage Volumes required for 80% (Santa Ana Regional Board region) and 90% (San Diego Regional Board region) annual capture of runoff for values of “C” determined in Step 2 for projects with elevations 1000 ft or higher.

¹² Figures A-1 – A-4 are based on Precipitation Gages 4650 and 8243, located at Laguna Beach and Silverado Ranger Station, respectively. Both of these gages have data records of approximately fifty years of hourly readings and are maintained by the National Weather Service. Figures A-1 through A-4 are for use only in the permit areas specified in Santa Ana Regional Board Order No. R8-2002-0010, NPDES Permit No. CAS618030; and San Diego Regional Board Order No. R9-2002-0001, NPDES CAS0108740.

Enter the vertical axis of **Figure A-3** (or **Figure A-4**) with the “C” value from Step 2. Move horizontally across the figure until the line is intercepted. Move vertically down the figure from this point until the horizontal axis is intercepted. Read the Unit Basin Storage Volume along the horizontal axis.

4. **Calculate the BMP volume.** The basin volume or basic volume of the BMP is then calculated by multiplying the Unit Basin Storage Volume by the BMP’s drainage area. Due to the mixed units that result (e.g., acre-inches, acre-feet) it is recommended that the resulting volume be converted to cubic feet for use during design.

Example Use of Unit Basin Storage Volume Curves Sizing a Dry Detention Basin

$$(A_i/A_t) * 100 = (6/10) * 100 = 60\%$$

From **Table A-1**, for 60% impervious, $C = 0.60$

Use **Figure A-3**, and the line that provides a direct reading of Unit Basin Storage Volumes required for 80% (Santa Ana Regional Board region) annual capture of runoff for values of “C” determined from **Table A-1**, and for projects with elevations less than 1000 ft.

Enter the vertical axis of **Figure A-3** with $C = 0.60$. Move horizontally across the figure until the line is intercepted. Move vertically down the figure from this point until the horizontal axis is intercepted. Read the Unit Basin Storage Volume (V_u) along the horizontal axis.

$$V_u = 0.46 \text{ inches}$$

The volume of the basin is then $V_u \times A_t$

$$V_b = V_u \times A_t = (0.46 \text{ in}) (10\text{ac}) (1 \text{ ft}/12 \text{ in}) (43,560 \text{ ft}^2/\text{ac})$$

Size the BMP for $V_b = 16,698 \text{ ft}^3$ and 48-hour drawdown

Figure A-1
Volumetric BMP Sizing Curves for
Orange County Stormwater Quality Management Program
Use for Elevations <1,000 Feet

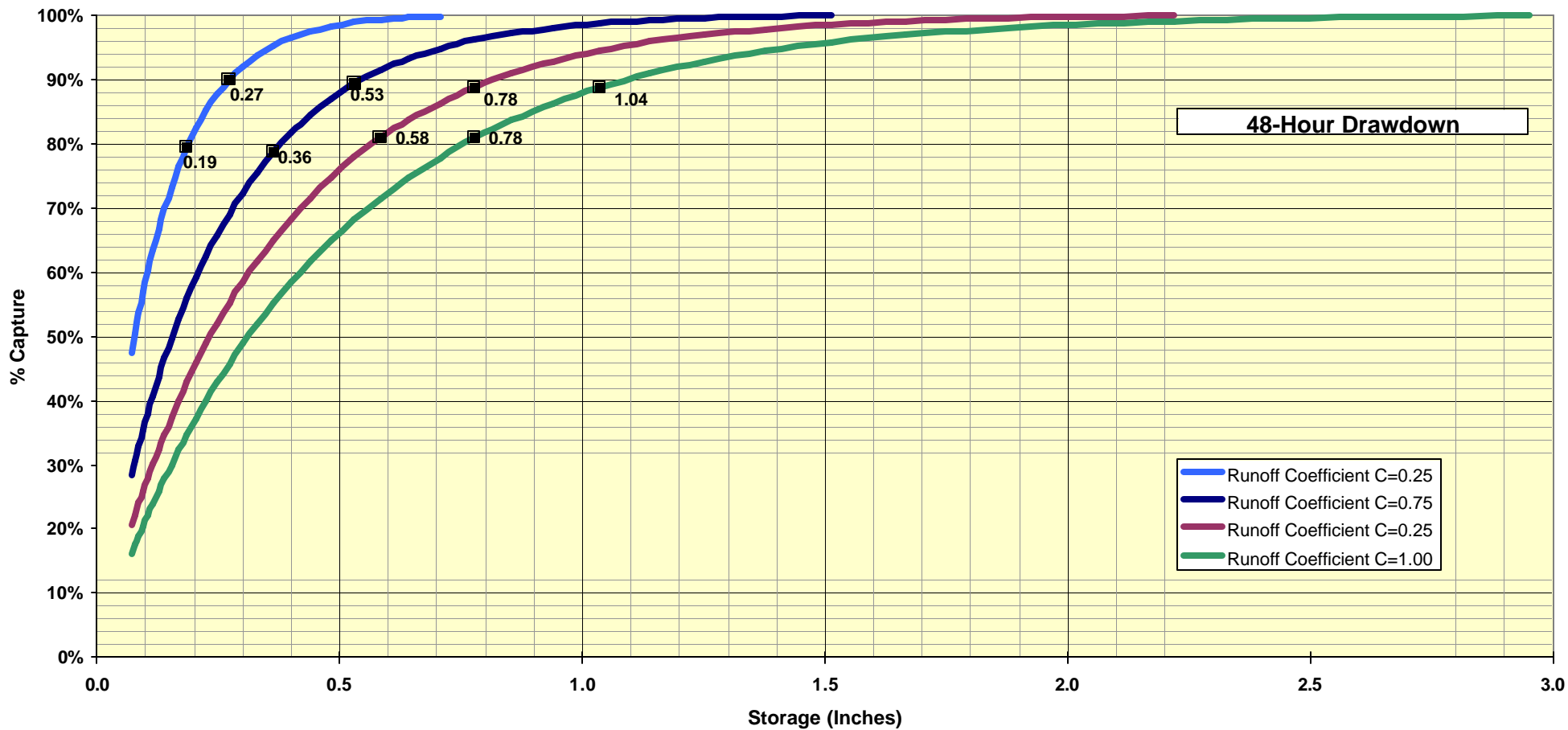


Figure A-2
Volumetric BMP Sizing Curves for
Orange County Stormwater Quality Management Program
Use for Elevations >1,000 Feet

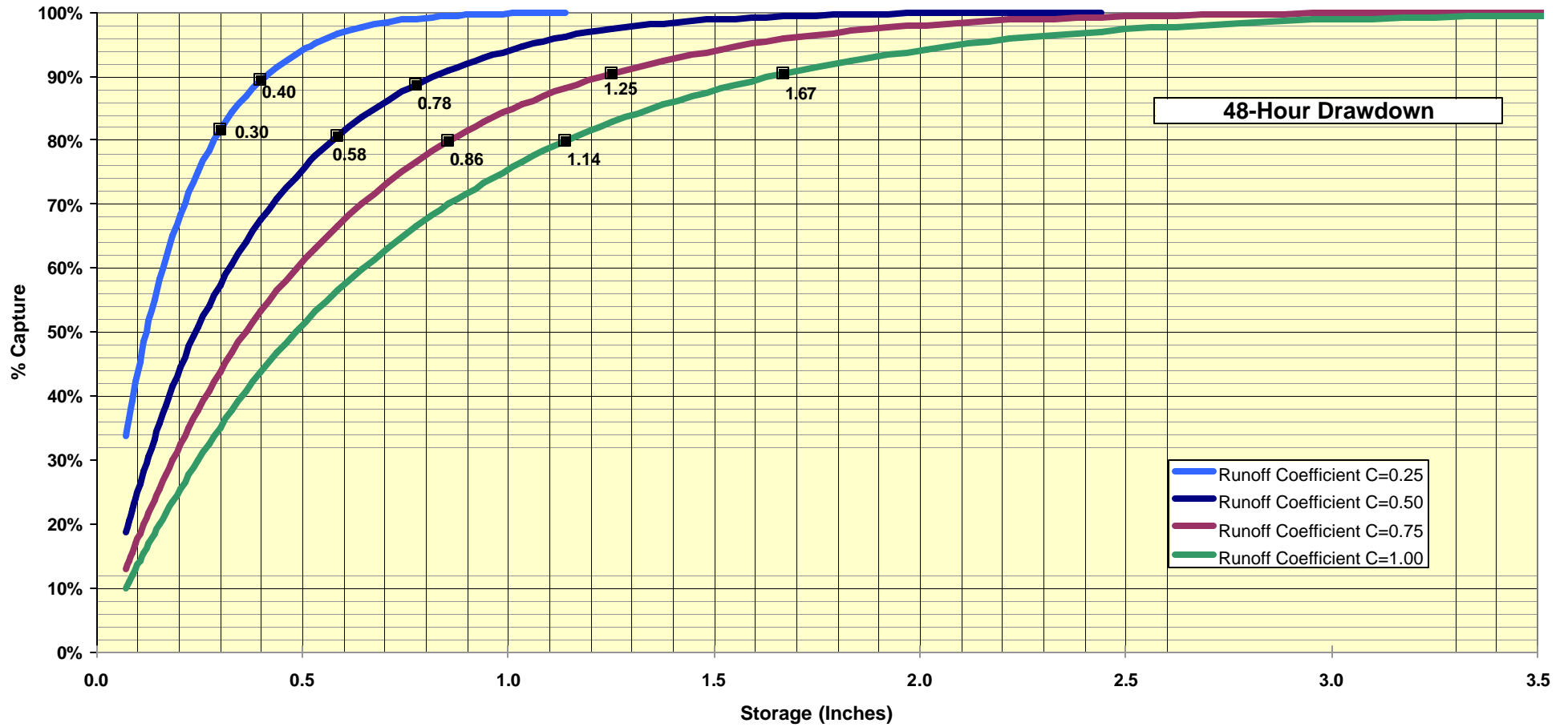


Figure A-3
Volumetric BMP Sizing Curves for
Orange County Stormwater Quality Management Program
Use for Elevations < 1,000 Feet

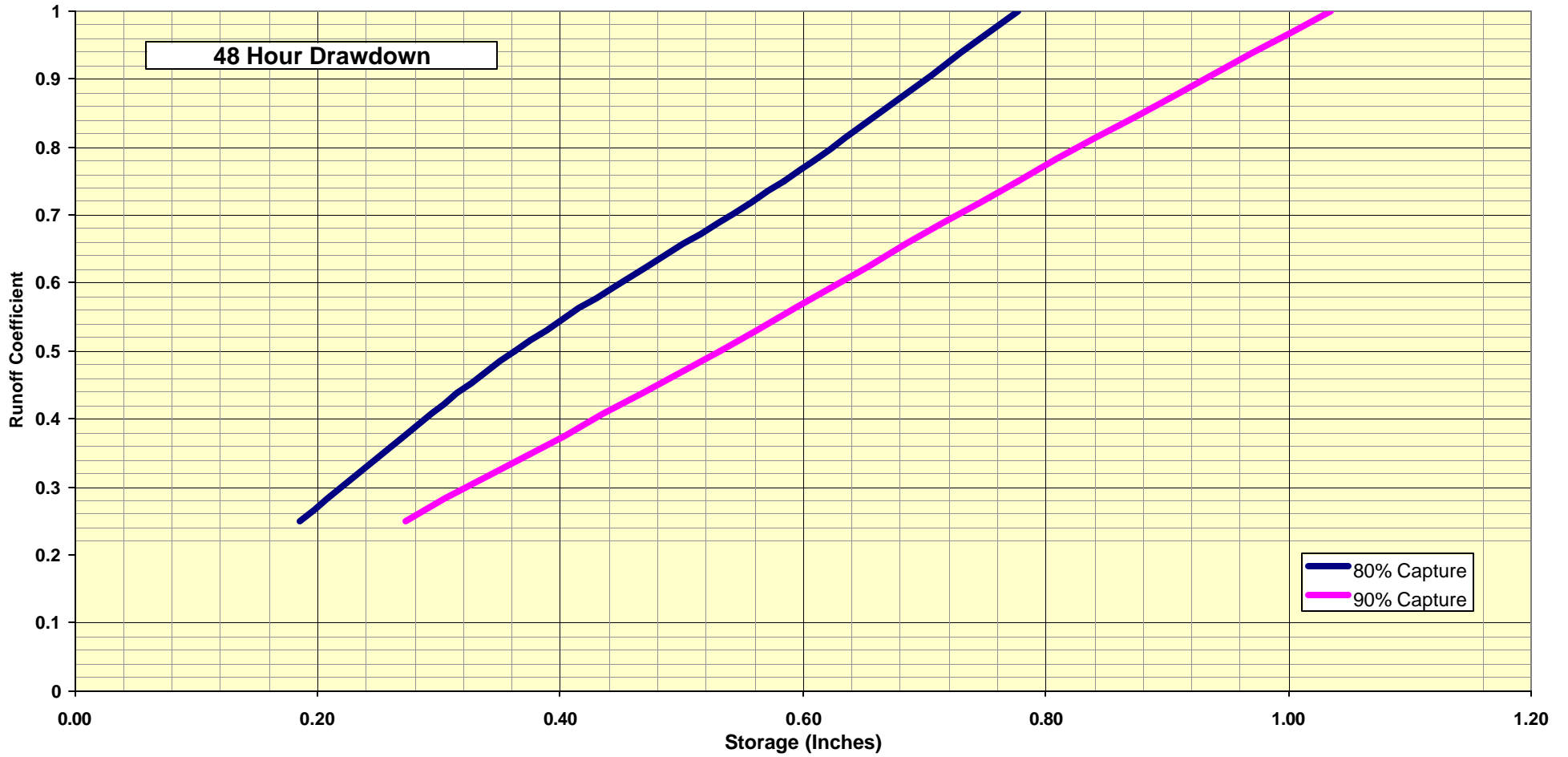
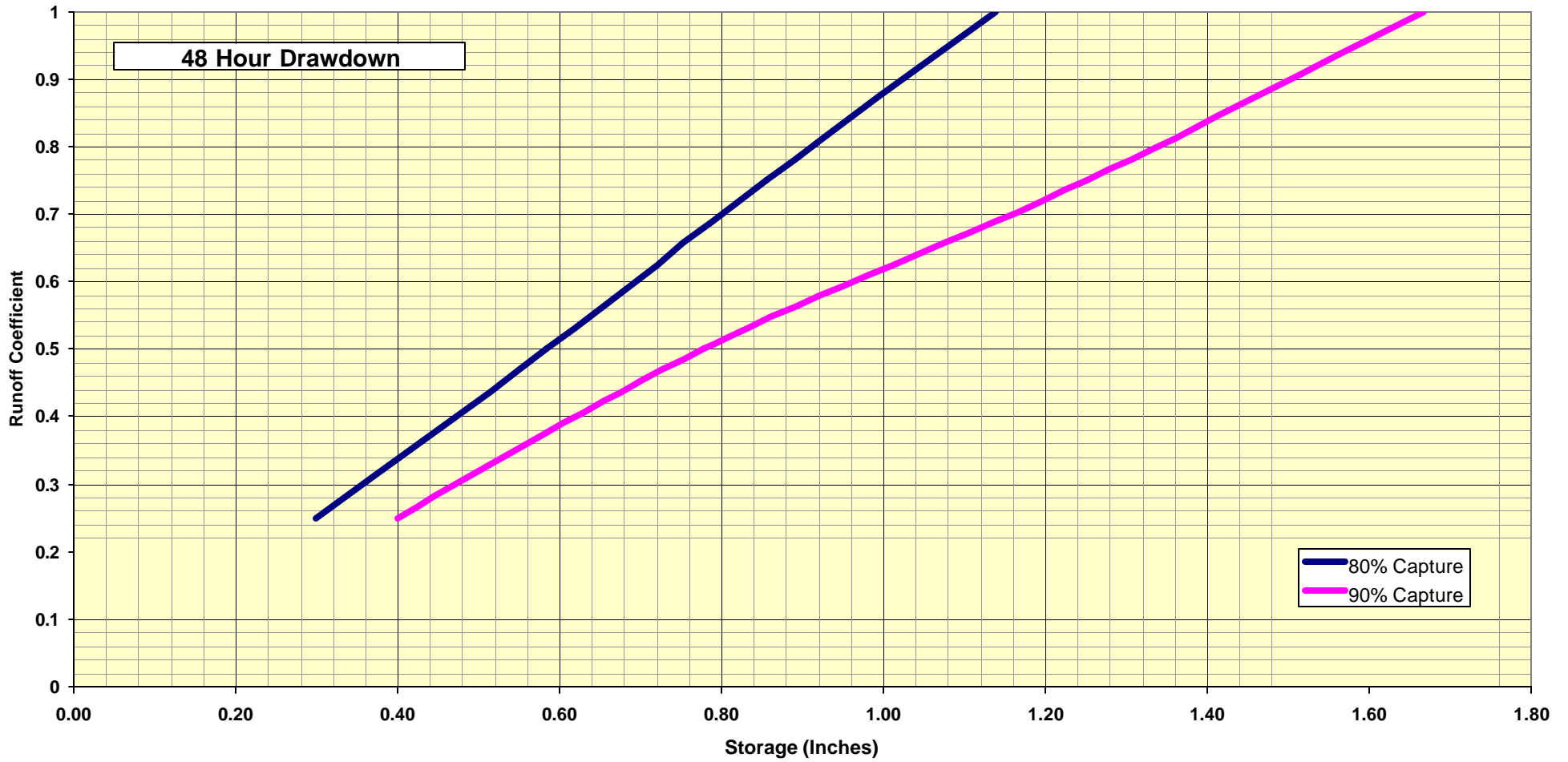


Figure A-4
Volumetric BMP Sizing Curves for
Orange County Stormwater Quality Management Program
Use for Elevations >1,000 Feet



ATTACHMENT B – Suggested Resources

SUGGESTED RESOURCES	HOW TO GET A COPY
<p>Better Site Design: A Handbook for Changing Development Rules in Your Community (1998)</p> <p>Presents guidance for different model development alternatives.</p>	<p>Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323 www.cwp.org</p>
<p>California Urban runoff Best Management Practices Handbooks (1993) for Construction Activity, Municipal, and Industrial/Commercial</p> <p>Presents a description of a large variety of Structural BMPs, Treatment Control, BMPs and Source Control BMPs</p>	<p>Los Angeles County Department of Public Works Cashiers Office 900 S. Fremont Avenue Alhambra, CA 91803 626-458-6959</p>
<p>Caltrans Urban runoff Quality Handbook: Planning and Design Staff Guide (Best Management Practices Handbooks (1998)</p> <p>Presents guidance for design of urban runoff BMPs</p>	<p>California Department of Transportation P.O. Box 942874 Sacramento, CA 94274-0001 916-653-2975</p>
<p>Design and Construction of Urban Stormwater Management Systems, American Society of Civil Engineers (ASCE) Manuals and Reports on Engineering Practice No. 77/ Water Environment Federation (WEF) Manual of Practice FD-20, 1992.</p>	
<p>Design Manual for Use of Bioretention in Stormwater Management (1993)</p> <p>Presents guidance for designing bioretention facilities.</p>	<p>Prince George's County Watershed Protection Branch 9400 Peppercorn Place, Suite 600 Landover, MD 20785</p>
<p>Design of Stormwater Filtering Systems (1996) by Richard A. Claytor and Thomas R. Schuler</p> <p>Presents detailed engineering guidance on ten different urban runoff-filtering systems.</p>	<p>Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323</p>
<p>Development Planning for Stormwater Management, A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), (May 2000)</p>	<p>Los Angeles County Department of Public Works http://dpw.co.la.ca.us/epd/ or http://www.888cleanLA.com</p>
<p>Florida Development Manual: A Guide to Sound Land and Water Management (1988)</p> <p>Presents detailed guidance for designing BMPs</p>	<p>Florida Department of the Environment 2600 Blairstone Road, Mail Station 3570 Tallahassee, FL 32399 850-921-9472</p>

SUGGESTED RESOURCES	HOW TO GET A COPY
Guidance Manual for On-Site Stormwater Quality Control Measures, Sacramento Stormwater Management Program.	City of Sacramento Department of Utilities and County of Sacramento Water Resources Division. January 2000.
Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993) Report No. EPA-840-B-92-002. Provides an overview of, planning and design considerations, programmatic and regulatory aspects, maintenance considerations, and costs.	National Technical Information Service U.S. Department of Commerce Springfield, VA 22161 800-553-6847
Guide for BMP Selection in Urban Developed Areas (2001)	ASCE Envir. and Water Res. Inst. 1801 Alexander Bell Dr. Reston, VA 20191-4400 (800) 548-2723
Low-Impact Development Design Strategies - An Integrated Design Approach (June 1999)	Prince George's County, Maryland Department of Environmental Resource Programs and Planning Division 9400 Peppercorn Place Largo, Maryland 20774 http://www.co.pg.md.us/Government/DER/PPD/pgcounty/lidmain.htm
Maryland Stormwater Design Manual (1999) Presents guidance for designing urban runoff BMPs	Maryland Department of the Environment 2500 Broening Highway Baltimore, MD 21224 410-631-3000
Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality, Environmental Protection Agency (EPA-440/5-87-001).	
National Stormwater Best Management Practices (BMP) Database, Version 1.0 Provides data on performance and evaluation of urban runoff BMPs	American Society of Civil Engineers 1801 Alexander Bell Drive Reston, VA 20191 703-296-6000
National Stormwater Best Management Practices Database (2001)	Urban Water Resources Research Council of ASCE Wright Water Engineers, Inc. (303) 480-1700
Operation, Maintenance and Management of Stormwater Management (1997) Provides a thorough look at stormwater practices including, planning and design considerations, programmatic and regulatory aspects, maintenance considerations, and costs.	Watershed Management Institute, Inc. 410 White Oak Drive Crawfordville, FL 32327 850-926-5310
Potential Groundwater Contamination from Intentional and Non-Intentional Stormwater Infiltration	Report No. EPA/600/R-94/051, USEPA (1994).

SUGGESTED RESOURCES	HOW TO GET A COPY
Preliminary Data Summary of Urban runoff Best Management Practices (August 1999) EPA-821-R-99-012	http://www.epa.gov/ost/stormwater/
Reference Guide for Stormwater Best Management Practices (July 2000)	City of Los Angeles Urban runoff Management Division 650 South Spring Street, 7th Floor Los Angeles, California 90014 http://www.lacity.org/san/swmd/
Second Nature: Adapting LA's Landscape for Sustainable Living (1999) by Tree People Detailed discussion of BMP designs presented to conserve water, improve water quality, and achieve flood protection.	Tree People 12601 Mullholland Drive Beverly Hills, CA 90210 (818) 623-4848 Fax (818) 753-4625
Site Planning for Urban Stream Protection, Department of Environmental Programs, Metropolitan Washington Council of Governments	
Start at the Source (1999) Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
Stormwater, Grading and Drainage Control Code, Seattle Municipal Code Section 22.800-22.808, and Director's Rules, Volumes 1-4. (Ordinance 119965, effective July 5, 2000)	City of Seattle Department of Design, Construction & Land Use 700 5th Avenue, Suite 1900 Seattle, WA 98104-5070 (206) 684-8880 http://www.ci.seattle.wa.us/dclu/Codes/sgdcode.htm
Stormwater Management in Washington State (1999) Vols. 1-5 Presents detailed guidance on BMP design for new development and construction.	Department of Printing State of Washington Department of Ecology P.O. Box 798 Olympia, WA 98507-0798 360-407-7529
The Stormwater Manager's Resource Center. This is a comprehensive site with information on BMP design and sizing. http://www.stormwatercenter.com	
Stormwater Pollution Control, Municipal, Industrial and Construction NPDES Compliance, Second Edition. Roy D. Dodson, P.E., 1999.	
Texas Nonpoint Source Book – Online Module (1998) www.txnpsbook.org Presents BMP design and guidance information on-line	Texas Statewide Urban runoff Quality Task Force North Central Texas Council of Governments 616 Six Flags Drive Arlington, TX 76005 817-695-9150

SUGGESTED RESOURCES	HOW TO GET A COPY
The Practice of Watershed Protection by Thomas R. Shchuler and Heather K. Holland	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323 www.cwp.org
Urban Runoff Quality Management, American Society of Civil Engineers (ASCE) Manual and Report on Engineering Practice No. 87/Water Environment Federation (WEF) Manual of Practice No.23, 1998.	
Urban Storm Drainage, Criteria Manual – Volume 3, Best Management Practices (1999) Presents guidance for designing BMPs	Urban Drainage and Flood Control District 2480 West 26th Avenue, Suite 156-B Denver, CO 80211 303-455-6277

ATTACHMENT C

Orange County Sanitation District, Guidelines for Preventing Sewer Discharge of Surface Runoff through Wash Pads

Purpose and Scope

These guidelines are established pursuant to Section 203 of the Districts' Wastewater Discharge Regulations (Ordinance) as amended February 7, 1992. Section 203 provides that

No person shall discharge groundwater, surface runoff, or subsurface drainage to the Districts' sewerage facilities except as provided herein. Pursuant to section 305, et. Seq., the Districts may approve the discharge of such water only when no alternate method of disposal is reasonably available or to mitigate an environmental risk or health hazard.

The Guidelines presented herein are intended for the implementation of this policy as it applies to preventing surface runoff from entering the Districts' sewerage system through exposed wash pads.

Application

Two sources from which surface runoff can potentially enter the Districts' sewerage system are the exposed area around the wash pad and the wash pad itself.

Exposed Area Around the Wash Pad: Appropriate measures must be taken to insure that surface runoff from the exposed area around the wash pad (e.g. parking lot, storage areas) does not enter the sewer. Surface runoff must be directed away from the sewer. Appropriate measures include grading the open area to redirect surface runoff to the storm drain; berming around the wash pad; or trenching around the wash pad with grating over the trench, and directing the collected water to a storm drain in accordance with stormwater discharge requirements.

The Wash Pad: Appropriate measures must be taken to insure that surface runoff from the wash pad itself does not enter the sewer. Provided that local regulations are satisfied, roofing will be required for all exposed wash pads, which have a total area exceeding 150 square feet. If the roof structure does not include walls, then the roofs overhang must extend a minimum of 20 percent of the roofs height. All roof drains must be routed to a storm drain.

Where roofing of exposed areas is infeasible or prohibited by local regulations, the Districts may accept the use of an automated surface runoff diversion system. [Note: This diversion system will not substitute for the appropriate measures cited above for surface runoff from the exposed area around the wash pad]. In cases where a diversion system is installed, only the first 0.1-inch of rainwater will be allowed to enter the sewer. After the first 0.1 inch of rainfall, excess rainwater must be diverted to an appropriate drainage system by use of an automated diversion system. The diversion system is subject to acceptance by the Districts. Manual methods of diversion (e.g. manual gates, removable plugs) are not acceptable. Companies are responsible for maintaining the automated diversion system in proper operating condition to ensure that no excess surface runoff from the wash pad is discharged to the sewer.

ATTACHMENT D

ASCE/EPA Technical Memorandum titled “Development of Performance Measures”

Development of Performance Measures

Task 3.1 – Technical Memorandum

Determining Urban Stormwater Best Management Practice (BMP) Removal Efficiencies

Prepared by

**URS Greiner Woodward Clyde
Urban Drainage and Flood Control District**

and

Urban Water Resources Research Council (UWRRC) of ASCE

In cooperation with

**Office of Water
US Environmental Protection Agency
Washington, DC 20460**

July, 2 1999



Acknowledgements

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Scope of Memorandum

This memorandum is intended for use in this cooperative research effort as an outline and description of the methodology for Task 3.0, Data Exploration and Evaluation. Although the memorandum describes, in detail, methods to be used for analysis of stormwater best management practices, the discussion included here is not inclusive of all of the issues relevant to the subject and is not intended as a "guidance manual" of analysis techniques. The application of the approach should be limited to the current scope of this project until the methods and issues described have been further explored and reviewed by the Team, ASCE(UWRRC), and EPA.

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**ASCE/EPA
Determining Urban Stormwater Best Management Practice (BMP) Removal
Efficiencies
May, 14 1999**

**TECHNICAL MEMORANDUM - TASK 3.1
Development of Performance Measures**

1 Overview

The purpose of this cooperative research effort between EPA and the American Society of Civil Engineers (ASCE) is to develop a more useful set of data on the performance and effectiveness of individual best management practices (BMPs), specifically by assessing the relationship between measures of effectiveness and BMP design. BMP monitoring data should not only be useful for a particular site, but should also be useful for comparing data collected in studies of both similar and different types of BMPs in other locations and with different design attributes. Almost all past BMP monitoring studies have provided very limited data that is useful for comparing BMP design and selection. This technical memorandum provides an overview of methods for evaluating the efficiency, performance, and effectiveness of best management practices (BMPs) through analysis of water quality, flow, and precipitation data for monitored storm events as well as BMP design attributes collected and stored in the National Stormwater (NSW) Best Management Practices Database. Furthermore, it provides a specific description of the methods that will be used to conduct the data exploration and evaluation, described under Tasks 3.2-3.4 of this project. These methods provide the basic techniques for analyzing data manually and a preliminary basis for integrated analysis tools to be built into the database in the future.

1.1 Definition of Terms

In order to better clarify the terminology used to describe the level of treatment achieved and how well a device, system, or practice meets its goals, definitions of some terms, often used loosely in the literature, are provided here. These terms help to better specify the scope of monitoring studies and related analyses.

- Best Management Practice (BMP) - A device, practice, or method for removing, reducing, retarding, or preventing targeted stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters.
- BMP System - A BMP system includes the BMP and any related bypass or overflow. For example, the efficiency (see below) can be determined for a offline retention (Wet) Pond either by itself (as a BMP) or for the BMP system (BMP including bypass)
- Performance - measure of how well a BMP meets its goals for stormwater that the BMP is designed to treat.
- Effectiveness - measure of how well a BMP system meets its goals in relation to all stormwater flows
- Efficiency - measure of how well a BMP or BMP system removes pollutants.

The primary focus of the data exploration and evaluation will be to determine efficiency of BMPs and BMP systems and to elucidate relationships between design and efficiency. In addition, effectiveness and performance will be evaluated, acknowledging the limitations of existing information about the goals of specific BMP projects. Quantification of efficiency only evaluates a portion of the overall performance or effectiveness of a BMP or BMP system. Calculation of the efficiency, however, does help to determine additional measures of performance and effectiveness, for example the ability of a BMP to meet any regulatory goals based on percent removal. A list of typical goals and the current ability of the ASCE/EPA project to help evaluate them is shown in Table 1.1.

Table 1.1 Goals of BMP Projects and the Ability of the National Stormwater BMP Database to Provide Information Useful for Determining Performance and Effectiveness

Goals of BMP Projects		Ability to Evaluate Performance and Effectiveness
Category		
Hydraulics	<ul style="list-style-type: none"> Improve flow characteristics upstream and/or downstream of BMP 	-
Hydrology	<ul style="list-style-type: none"> Flood mitigation, improve runoff characteristics (peak shaving) 	✓
Water Quality (Efficiency)	<ul style="list-style-type: none"> Reduce downstream pollutant loads and concentrations of pollutants Improve/minimize downstream temperature impact Achieves desired pollutant concentration in outflow 	✓ ✓ ✓
	<ul style="list-style-type: none"> Removal of litter and debris 	-
Toxicity	<ul style="list-style-type: none"> Reduce acute toxicity of runoff Reduce chronic toxicity of runoff 	✓ ¹ ✓ ¹
Regulatory	<ul style="list-style-type: none"> Compliance with NPDES permit Meet local, state, or federal water quality criteria 	- ✓ ²
Implementation Feasibility	<ul style="list-style-type: none"> For non-structural BMPs, ability to function within management and oversight structure 	-
Cost	<ul style="list-style-type: none"> Capital, operation, and maintenance costs 	✓ ¹
Aesthetic	<ul style="list-style-type: none"> Improve appearance of site 	-
Maintenance	<ul style="list-style-type: none"> Operate within maintenance, and repair schedule and requirements Ability of system to be retrofit, modified or expanded 	✓ ¹ ✓
Longevity	<ul style="list-style-type: none"> Long term functionality 	✓ ¹
Resources	<ul style="list-style-type: none"> Improve downstream aquatic environment/erosion control Improve wildlife habitat Multiple use functionality 	- - -
Safety, Risk and Liability	<ul style="list-style-type: none"> Function without significant risk or liability Ability to function with minimal environmental risk downstream 	- -
Public Perception	<ul style="list-style-type: none"> Information is available to clarify public understanding of runoff quality, quantity and impacts on receiving waters 	✓

✓ can be evaluated using the ASCE/EPA Database as information source

✓¹ will be able to be evaluated using the database as primary source of information after enough studies have been submitted

✓² can be evaluated using the database as the primary source of information combined with a secondary source of comparative data

- can be evaluated only qualitatively through included comments by reviewer or author, or are unable to be evaluated at this time

The term event mean concentration (EMC) is used throughout this memorandum. The EMC is a statistical parameter used to represent the flow-proportional average concentration of a given parameter during a storm event. It is defined as the total constituent mass divided by the total runoff volume. It is often estimated via the collection of multiple flow volume triggered grab samples that are composited for analysis. When combined with flow measurement data, the EMC can be used to estimate the pollutant loading from a given storm.

1.3 BMPs Types and Implications for Calculation of Efficiency

The issues involved in selection of methods for quantifying efficiency, performance, and effectiveness are complex. It would be difficult, at best, to find one method that would cover the data analysis requirements for the widely varied collection of BMP types and designs found in the NSW Database. When analyzing efficiency, it is convenient to classify BMPs according to one of the following four distinct categories:

- BMPs with well-defined inlets and outlets whose primary treatment depends upon extended detention storage of stormwater, (e.g., wet and dry ponds, wetland basins, underground vaults)
- BMPs with well-defined inlets and outlets that do not depend upon significant storage of water, (e.g., sand filters, swales, buffers, structural “flow-through” systems)
- BMPs that do not have a well defined inlet and/or outlet (e.g., retention, infiltration, porous pavement)
- Widely distributed BMPs that use reference watersheds to evaluate effectiveness, (e.g., catch basin retrofits; education programs)

Any of the above can also include evaluations where the BMP's efficiency was measured using before and after or paired watershed comparisons of water quality.

The difficulty in selection of measures of efficiency stems not only from the desire to compare a wide range of BMPs, but also from the large number of methods currently in use. There is much variation and disagreement in the literature about what measure of efficiency is best applied.

1.4 Relationship Between Monitoring Study Objective and Data Analysis

In developing a method for quantifying BMP performance or effectiveness, it is helpful to look at the objectives of previous studies seeking such a goal. BMP studies usually are conducted to obtain information regarding one or more of the following objectives:

- What degree of pollution control does the BMP provide under typical operating conditions?
- How does efficiency vary from pollutant to pollutant?
- How does efficiency vary with various input concentrations?
- How does efficiency vary with storm characteristics such as rainfall amount, rainfall density, antecedent weather conditions?
- How do design variables affect performance?
- How does efficiency vary with different operational and/or maintenance approaches?
- Does efficiency improve, decay, or remain stable over time?
- How does the BMP's efficiency, performance, and effectiveness compare relative to other BMPs?
- Does the BMP reduce toxicity to acceptable levels?
- Does the BMP cause an improvement or protect in downstream biotic communities?
- Does the BMP have potential downstream negative impacts?

The monitoring efforts implemented most typically seek to answer a small subset of the above questions. This often leaves larger questions about the efficiency, performance and effectiveness of the BMP, and the relationship between design and efficiency, unanswered. The goal of this document is to develop a recommended approach to utilize the National Stormwater BMP Database to evaluate BMP data that have been entered such that some or all of the above questions about BMP efficiency can be assessed where sufficient data is available.

1.5 Physical Layout and Its Effect on Efficiency and Its Measure

The estimation of the efficiency of BMPs is often approached in different ways based on the goals of the researcher. A BMP can be evaluated by itself or as part of an overall BMP system. The efficiency of a BMP not including bypass or overflow may be dramatically different than the efficiency of an overall system. Bypasses and overflows can have significant effects on the ability of a BMP to remove constituents and appreciably reduce the efficiency of the system as a whole. Researchers who are interested in comparing the efficiency of an offline wet pond and an offline wetland may not be concerned with the effects of bypass on a receiving water. On the other hand, another researcher who is comparing offline wet ponds with online wet ponds would be very interested in the effects of the bypass. Often detailed information about the bypass of the BMP is not available for analysis. In some cases, comprehensive inflow and outflow measurements allow for the calculation of a mass balance that can be used to estimate bypass flow volumes. Estimations of efficiency of a BMP system can be based on these mass balance calculations coupled with sampling data.

The efficiency of a BMP system or a BMP can be directly affected by the way in which an operator chooses to manage the system. This is the case where parameters of a design can be adjusted, (e.g., adjustments to the height of an overflow/bypass weir or gate). These adjustments can vary the efficiency considerably. In order to analyze a BMP or BMP system thoroughly, all static and state variables of the system must be known.

1.6 Relevant Period of Impact

The period of analysis used in an efficiency calculation is important. The period used should take into account how the parameter of interest varies with time. This allows for observation of relevant changes in the efficiency of the BMP on the time scale in which these changes occur. For example, in a wetland it is often observed that during the growing season removal efficiency increases for nutrients. The opposite effect may be observed during the winter months or during any period where decaying litter and plant material may contribute significantly to export of nutrients and, potentially, other

contaminants. Therefore, the efficiency calculations may need to be made based on data collected over a few months or seasonally. This variation of efficiency on a temporal scale is extremely important in understanding how BMPs function.

In addition to observing how factors, such as climate, affect efficiency as a function of time, it is important to relate the calculation period to the potential impact a given constituent would have on the receiving water. For example, it may not be useful to study the removal of a chlorinated organic for a short period of record when the negative impacts of such a contaminant are generally expressed over a long time scale. Likewise, some parameters (e.g., temperature, BOD, DO, pH, TSS and metals) may have a significant impact in the near term.

Toxicity plays a major role in evaluating what time period should be used to analyze efficiency. Specific constituents that are acutely toxic require a short-term analysis on an “intra-storm” basis. Where dilution is significant and/or a constituent is toxic on a chronic basis, long-term analysis that demonstrates removal of materials on a sum of loads or average EMC basis may be more appropriate. Many contaminants may have both acute and chronic effects in the aquatic environment. These contaminants should be evaluated over both periods of time. Similarly, hydraulic conditions merit both short and long term examination. Event peak flows are examples of short-term data, while seasonal variations of the hydrologic budget due to the weather patterns are examples of long-term data. Examples of water quality parameters and their relationship to the time scale over which they act are given in Table 1.2.

Table 1.2

Time Scale for Analysis	Water Quality Parameter
Short Term	BOD, DO
Long Term	Organics, Carcinogens
Both Short and Long Term	Metals, TSS, Nitrogen, Phosphorous, Temperature, pH, Pesticides

2 Example Study for Examination of Efficiency Calculation Methods

In order to discuss and contrast the various methods that have been employed for estimating the efficiency of BMPs, an example data set was utilized. The examples taken from this data set are based upon data from *Three Design Alternatives for Stormwater Detention Ponds*, (Rushton, Miller, Hull and Cunningham, 1997). The study was conducted by the Southwest Florida Water Management District (SWFWMD). The single pond studied with different design attributes was located at the SWFWMD Service office in Tampa. The following quote from the executive summary of the report describes the site:

The drainage basin is 6.5 acres with about 30 percent of the watershed covered by roof tops and asphalt parking lots, 6 percent by a crushed limestone storage compound and the remaining 64 percent as a grassed storage area. The impervious surfaces discharge to ditches which provide some pre-treatment before stormwater enters the pond. During the first year of the study (1990), the pond was shallow and completely vegetated with a permanent pool less than one foot deep and an average wet season residence time of two days. In the second year (1993), the vegetated littoral zone covered 35 % of the pond area and the volume of the permanent pool was increased to include a five-day residence time by excavating the pond to five feet. For the final year (1994), the vegetated littoral zone was planted with desirable species, the depth of the pond was kept at five feet and the area of the permanent pool was enlarged for a calculated wet season residence time of 14 days.

This example study was chosen due its comprehensive data set and its ability to demonstrate the effects of changes in efficiency based on design variations. The pond study also demonstrates the potential effects of average wet season residence time on the calculated performance of the BMP. All calculations included in this memorandum are based on the raw data provided in the report as stored in the National Stormwater Best Management Practices Database at this time. The values reported in the SWFWMD report are given in Table 2.1 for comparison. Two methods were used by SWFWMD to enumerate effectiveness, 1) the *Summation of Loads* and, 2) the *Efficiency Ratio*. Both of these methods are described in more detail in Section 3 of this memorandum.

Table 2.1

Method	TSS Percent Removal Reported by SWFWMD		
	1990	1993-1994	1994-1995
Efficiency Ratio (EMC)	61	69	95
Summation of Loads	71	67	94
Other Information			
Number of Rain Events (>0.05 in)	53	60	83
Percent Monitored	43	50	56
Average Depth of Monitored Storms	0.53 inch	0.57 inch	0.53 inch
Total Rainfall During Monitoring Period	28 inch	34 inch	44 inch

Differences between the values calculated for the examples given in this memo and the values reported in the SWFWMD report were checked thoroughly and it was determined that the cause for the difference in reported efficiencies is due to rounding of each flow weighted sample value in the SWFWMD report. All of the calculations in this memo were based on the digital data provided by SWFWMD, which were not rounded. SWFWMD also excluded some of the values in their final analysis of the BMP during the 1993-1994 water year due to a leaking water main and problems with the rain collector used on site. This change to the data set used for calculating performance had no net effect on the efficiency reported for TSS. The examples in this document use the entire data set.

3 Review of Commonly Used Efficiency Calculation Methods

A variety of pollutant removal methods have been utilized in BMP monitoring studies to evaluate efficiency. This section describes and gives examples of methods employed by different investigators. One of five methods are typically used by investigators for the calculation of BMP efficiency:

- Efficiency ratio
- Summation of loads
- Regression of loads
- Mean concentration
- Efficiency of individual storm loads
- Reference watersheds and before/after studies

Although these methods do present a summary of efficiency, they do not look at removal statistically, and thus, do not provide enough information to determine if the differences in inflow and outflow water quality measures are statistically significant. Previous studies comparing BMP efficiency for a number of BMPs statistically examined reported removal efficiencies that were based upon various efficiency calculation methods. The National Stormwater Best Management Practices Database allows for the consistent calculation of efficiencies for each of the BMPs based on event data. Calculating efficiency on this basis makes detailed statistical analysis possible. Section 4 of this memorandum describes and gives examples of the methodology that will be used in Tasks 3.2-3.4 of the project. This selected methodology, the Lognormal Statistical Efficiency (LSE) is an expansion of the efficiency ratio method (ER). The LSE method fully describes the statistical distribution of water quality upstream and downstream of BMPs and determines if differences in water quality are statistically significant.

3.1 Efficiency Ratio

Definition

The efficiency ratio is defined in terms of the average event mean concentration (EMC) of pollutants over some time period:

$$ER = 1 - \frac{\text{average outlet EMC}}{\text{average inlet EMC}} = \frac{\text{average inlet EMC} - \text{average outlet EMC}}{\text{average inlet EMC}}$$

EMCs can be either collected as flow weighted composite samples in the field or calculated from discrete measurements. The EMC for an individual event or set of field measurements, where discrete samples have been collected, is defined as:

$$EMC = \frac{\sum_{i=1}^n V_i C_i}{\sum_{i=1}^n V_i}$$

where,

- V: volume of flow during period i
- C: average concentration associated with period i
- n: total number of measurements taken during event

The arithmetic average EMC is defined as,

$$\text{average EMC} = \frac{\sum_{j=1}^m EMC_j}{m}$$

where,

- m: number of events measured

In addition, the log mean EMC can be calculated using the logarithmic transformation of each EMC. This transformation allows for normalization of the data for statistical purposes.

$$\text{Mean of the Log EMCs} = \frac{\sum_{j=1}^m \text{Log}(EMC_j)}{m}$$

Estimates of the arithmetic summary statistics of the population (mean, median, standard deviation, and coefficient of variation) should be based on their theoretical relationships (Appendix A) with the mean and standard deviation of the transformed data. Computing the mean and standard deviation of log transforms of the sample EMC data and then converting them to an arithmetic estimate often obtains a better estimate of the mean of the population due to the more typical distributional characteristics of water quality data. This value will not match that produced by the simple arithmetic average of the data. Both provide an estimate of the population mean, but the approach utilizing the log-transformed data

tends to provide a better estimator, as it has been shown in various investigations that pollutant, contaminant and constituent concentration levels have a log-normal distribution (NURP, 1983). As the sample size increases, the two values converge.

Assumptions

This method

- Weights EMCs from all storms equally regardless of relative magnitude of storm. For example a high concentration/high volume event has equal weight in the average EMC as a low concentration/low volume event. The logarithmic approach tends to minimize the difference between the EMC and mass balance calculations.
- Is most useful when loads are directly proportional to storm volume. For work conducted on nonpoint pollution (i.e., inflows), the EMC has been shown to not vary significantly with storm volume. This lends credence to using the average EMC value for the inflow but does not provide sufficient evidence that outflows are well represented by average EMC. Accuracy of this method will vary based on the BMP type.
- Minimizes the impacts of smaller/cleaner storm events on actual performance calculations. For example, in a storm by storm efficiency approach, a low removal value for such an event is weighted equally to a larger value.
- Allows for the use of data where portions of the inflow or outflow data are missing, based on the assumption that the inclusion of the missing data points would not significantly impact the calculated average EMC.

Comments

This method

- Is taken directly from non-point pollution studies and does a good job characterizing inflows to BMPs but fails to take into account some of the complexities of BMP design. For example, some BMPs may not have outflow EMCs that are normally distributed (e.g., a media filter that treats to a relatively constant level that is independent on inflow concentrations).
- Assumes that if all storms at the site had been monitored, the average inlet and outlet EMCs would be similar to those that were monitored.

Example

The example calculations given below are for the Tampa Office Pond using arithmetic average EMCs in the efficiency ratio method.

Period of Record	Average EMC In	Average EMC Out	Efficiency Ratio
1990	27.60	11.18	0.59
1993-1994	34.48	12.24	0.64
1994-1995	131.43	6.79	0.95

3.2 Summation of Loads

Definition

The summation of loads method defines the efficiency based on the ratio of the summation of all incoming loads to the summation of all outlet loads, or:

$$SOL = 1 - \frac{\text{sum of outlet loads}}{\text{sum of inlet loads}}$$

The sum of outlet loads are calculated as follows:

$$\text{sum of loads} = \sum_{j=1}^m \left(\sum_{i=1}^n C_i V_i \right) = \sum_{j=1}^m EMC_j \cdot V_j$$

Assumptions

- Removal of material is most relevant over entire period of analysis.
- Monitoring data accurately represents the actual entire total loads in and out of the BMP for a period long enough to overshadow any temporary storage or export of pollutants.
- Any significant storms that were not monitored had a ratio of inlet to outlet loads similar to the storms that were monitored.
- No materials were exported during dry periods, or if they were, the ratio of inlet to outlet loads during these periods is similar to the ratio of the loads during the monitored storms.

Comments

- A small number of large storms typically dominate efficiency.
- If toxics are a concern then this method does not account for day to day releases, unless dry weather loads in and out are also accounted for.
- Based on mass balance.

Example of Summation of Loads for TSS Using the Tampa Office Pond

Period of Record	Sum of Loads In (kg)	Sum of Loads Out (kg)	SOL Efficiency
1990	134.60	39.67	0.71
1993-1994	404.19	138.44	0.66
1994-1995	2060.51	130.20	0.94

3.3 Regression of Loads (ROL), Martin and Smoot (1986)

Definition

The regression of loads method defines the regression efficiency as the slope of a least squares linear regression of inlet loads and outlet loads of pollutants, with the intercept constrained to zero. The equation for the ROL efficiency is:

$$\text{Loads out} = \mathbf{b} \cdot \text{Loads in} = \mathbf{b} - \frac{\text{Loads out}}{\text{Loads in}}$$

The percent reduction in loads across the BMP is estimated as:

$$\text{Percent Removal} = 1 - \mathbf{b} = 1 - \frac{\text{Loads out}}{\text{Loads in}}$$

Assumptions

- The assumptions for this method are identical to the assumptions for the *Summation of Loads* method.

Comments

- A few data points often control the slope of line due to clustering of loads about the mean storm size. Regressions are best used where data is equally populous through the range to be examined. This is readily observed in the examples that follow (See Figures 3.1 and 3.3).
- The process of constraining the intercept of the regression line to the origin is questionable and in some cases could significantly misrepresent the data. It may be more useful to apply the *Regression of Loads* method over some subset of the data without requiring that the intercept be constrained to the origin. The problem with this alternative approach is that a large number of data points are required in order to get a good fit of the data. Often (See Figure 3.1) a meaningful regression cannot be made using the data that was collected. This is well illustrated by the very low R^2 values in the table below. Forcing the line through the origin, in these cases, provides a regression line even where no useful trend is present.
- There is sufficient evidence that this first order polynomial (straight line) fit is not appropriate over a large range of loadings. Very small events are much more likely to demonstrate low efficiency where larger events may demonstrate better overall efficiency depending on the design of the BMP.

Example of ROL Efficiency Results for TSS in the Tampa Office Pond

Period of Record	Slope of Regression Line	R^2	Percent Removal
1990	0.21	0.06	0.79
1993-1994	0.18	-0.06	0.82
1994-1995	0.05	0.46	0.95

The regressions used to arrive at the above slopes are given in Figures 3.1-3.3.

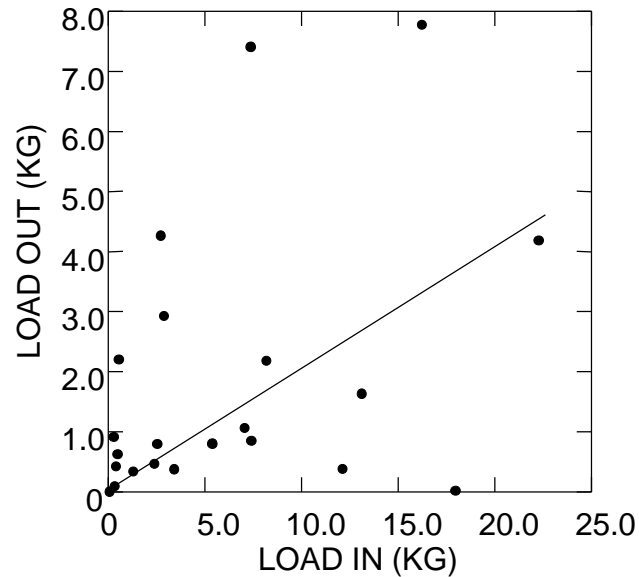


Figure 3.1 ROL Plot for use in Calculating Efficiency for TSS using the Tampa Office Pond (1990) (Slope = 0.2135, $R^2 = 0.0563$, Standard Error in Estimate = 2.176, one point is considered an outlier with a Studentized Residual of 3.304). All points were used for regression.

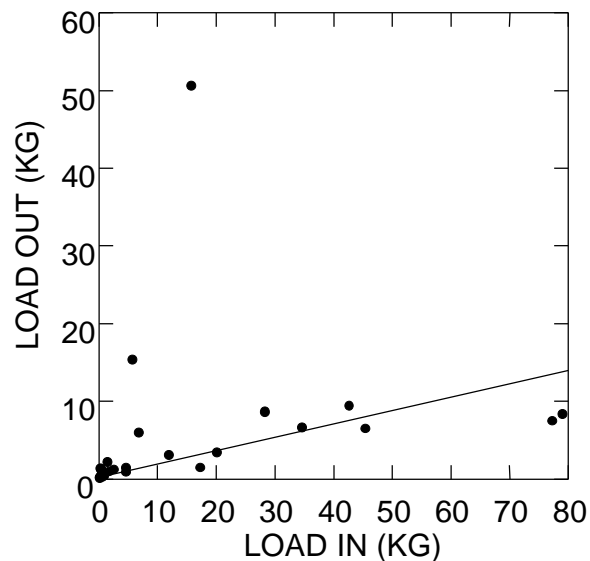


Figure 3.2 ROL Plot for use in Calculating Efficiency for TSS using the Tampa Office Pond (1993-1994) (Slope = 0.1801, $R^2 = -0.0562$, Standard Error in Estimate = 10.440, One point is considered an outlier with a Studentized Residual of 13.206 and one point has a high Leverage of 0.323). All points were used for regression.

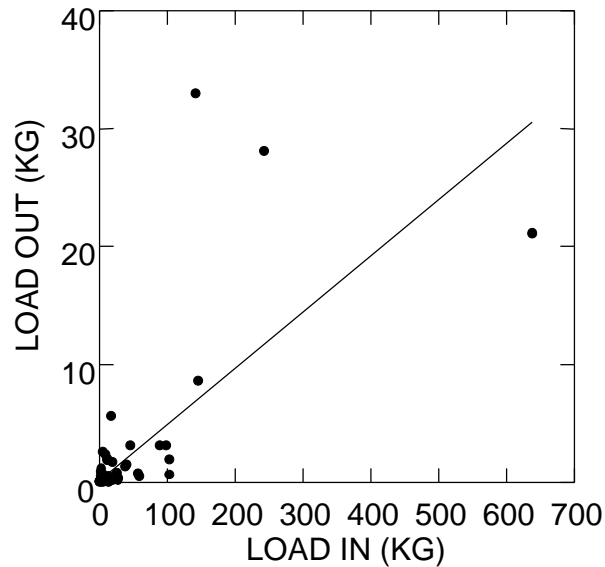


Figure 3.3 ROL Plot for use in Calculating Efficiency for TSS using the Tampa Office Pond (1994-1995) (Slope = 0.0492, $R^2 = 0.4581$, Standard Error in Estimate = 5.260, three points are considered outliers (Studentized Residuals of 3.724, 8.074, and -4.505, The point to the far right on the graph has large Leverage (0.724) and Influence, Cook Distance = 36.144). All points were used for regression.

3.4 Mean Concentration

Definition

The mean concentration method defines the efficiency as unity minus the ratio of the average outlet to average inlet concentrations. The equation using this method is, thus:

$$MC = 1 - \frac{\text{average outlet concentration}}{\text{average inlet concentration}}$$

This method does not require that concentrations be flow weighted. This method might have some value for evaluating grab samples where no flow weighted data is available or where the period of record does not include the storm volume.

Assumptions

- The flows from which the samples were taken are indicative of the overall event.

Comments

- This method may be useful for calculating BMP's effectiveness in reducing acute toxicity immediately downstream of the BMP. This is due to the fact that acute toxicity is measured as a threshold concentration value of a specific

constituent in the effluent at or near the point of discharge. If more than one sample per event is analyzed, this method would result in more information on potential toxicity reduction.

- Weights individual samples equally. Biases could occur due to variations in sampling protocols or sporadic sampling (i.e., collectively many samples close in time and others less frequently. The sample collection program specifics are not accounted for in the method and estimated efficiencies are often not comparable between studies.
- This method does not account for storage capacity. Typically BMP's will have an equal or lesser volume of outflow than of inflow, on a mass basis this affects removal, since volume (or flow) is used with concentration to determine mass for a storm event,

$$1 - \frac{C_{out} V_{out}}{C_{in} V_{in}} \geq 1 - \frac{\text{average outlet concentration}}{\text{average inlet concentration}}$$

where:

C_{in} : Concentration In
 C_{out} : Concentration Out
 V_{in} : Volume In
 V_{out} : Volume Out

In this respect, it is often more conservative (i.e., lower removal efficiency stated) to use concentration rather than mass-based removal.

3.5 Efficiency of Individual Storm Loads

Definition

The Efficiency of Individual Storm Loads (ISL) method calculates a BMP's efficiency for each storm event based on the loads in and the loads out. The mean value of these individual efficiencies can be taken as the overall efficiency of the BMP. The efficiency of the BMP for a single storm is given by:

$$\text{Storm Efficiency} = 1 - \frac{\text{Load}_{out}}{\text{Load}_{in}}$$

The average efficiency for all monitored storms is thus:

$$\text{Average Efficiency} = \frac{\sum_{j=1}^m \text{Storm Efficiency}_j}{m}$$

where,

m: number of storms

Assumptions

- Storm size or other storm factors do not play central roles in the computation of average efficiency of a BMP.
- Storage and later release of constituents from one storm to the next is negligible.
- The selection of storms monitored does not significantly skew the performance calculation.

Comments

- The weight of all storms is equal. Large storms do not dominate the efficiency in this scenario. The efficiency is viewed as an average performance regardless of storm size.
- Some data points are not able to be used due to the fact that there is not a corresponding measurement at either the inflow or the outflow for a particular storm, and thus an efficiency cannot always be calculated on a storm by storm basis. This is not true for the ER method, however it is a limitation of the Summation of Load Method.
- Storm by storm analysis neglects the fact that the outflow being measured may have a limited relationship to inflow in BMPs that have a permanent pool. For example, if a permanent pool is sized to store a volume equal to the average storm, about 60 to 70 percent of storms would be less than this volume [from studies conducted using SYNOP (EPA, 1989)].

Example of Efficiency of Individual Storm Loads for TSS in the Tampa Office Pond

Period of Record	Efficiency
1990	0.29
1993-1994	-0.02
1994-1995	0.89

3.6 Reference Watershed Methods

Discussion

Many BMPs do not allow for comparison between inlet and outlet water quality parameters. In addition it is often difficult or costly, where there are many BMPs being installed in a watershed (e.g., retrofit of all catch basins), to monitor a large number of specific locations. Often a reference watershed is used to evaluate the effectiveness of a given BMP or multiple BMPs of the same type. The database allows for a watershed and all associated data to be identified for use as a reference watershed. One of the primary reasons for using a reference watershed is that there is no clearly defined inlet or outlet point at which to monitor water quality. Such is the case with many non-structural BMPs, porous pavements, and infiltration practices.

The difficulty in determining the effectiveness of a BMPs using reference watersheds stems from the large number of variables typically involved. When setting up a BMP monitoring study, it is advantageous to keep the watershed characteristics of the reference watershed and the test watershed as similar as possible. Unfortunately, finding two watersheds that are similar is often quite difficult and the usefulness of the data can be compromised as a result. In order to attempt to determine the effectiveness of a BMP based on a reference watershed, an accurate accounting of the variations between the watersheds, operational, and environmental conditions is needed. The database explicitly stores some of the key parameters required for normalization of watershed and environmental conditions.

The most obvious parameter used to normalize watershed characteristics is area. If the ratio of land uses and activities within each watershed is identical in both watersheds then the watershed area can be scaled linearly. Additionally, the loads found at each downstream monitoring station, for each event, can be scaled linearly with area as well. Difficulty arises when land use in the reference watershed is not found in the same ratio. In this case, either the effects of land use must be ignored or a portion of the load found for each event must be allocated to a land use and then scaled linearly as a function of the area covered by that land use. In many cases, the differences in land use can be ignored, (e.g., between parking lots with relatively small, but different unpaved areas). The effect of the total impervious area is relevant and provided in the database in all cases and can be used to normalize the water quality data collected. The ratio of the total impervious areas can be used to scale event loads. Scaling the loads based on impervious areas would be best used where it is determined that the majority of pollutants are from runoff from the impervious areas (e.g., parking lots), or the contaminant of interest primarily results from deposition on impervious surfaces, (e.g., TSS in a highly urban area). Methods that attempt to determine BMP performance from poorly matched watersheds yield poor results at best. As the characteristics of the two watersheds diverge, the effect of the BMP is masked by the large number of variables in the system; the noise in the data becomes greater than the signal.

The analysis of BMPs utilizing reference watersheds also requires incorporation of operational details of the system, (e.g., frequency of street sweeping, type of device used, device setup). The database asks users to provide the frequency, extent, and other operational parameters for nonstructural BMPs. If the BMP is an alteration of the frequency of a certain practice, the system can be viewed in two ways, (1) as a control/test system, or (2) as a series of data aimed at quantifying the continuous effect of increasing or decreasing BMP frequency. In the first case the BMP can be analyzed in a manner similar to other BMPs with reference watersheds. In the second case, the loads realized at the monitoring stations need to be correlated with the frequency using some model for the effectiveness of the practice per occurrence.

3.7 Summary and Comparison of Methods from the Examples

The table below shows the results of the various methods shown above for calculation of efficiency for the Tampa Office Pond. It can be seen that the four methods demonstrated (mean concentration method was not applicable to data available from the Tampa Office Pond study) vary widely in their estimates of percent removal depending on the assumptions of each method as discussed above.

Design	Method			
	Efficiency Ratio (ER)	Summation of Loads (SOL)	Regression of Loads (ROL)	Efficiency of Individual Storms
1990	0.59	0.71	0.79	0.29
1993-1994	0.64	0.66	0.82	-0.02
1994-1995	0.95	0.94	0.95	0.89

4 Proposed Methods for Calculation of Efficiency

This section describes methods that will be used in Task 3.2 of the project to quantify efficiency of each BMP currently stored in the database. In order to assess efficiency, water quality data needs to be analyzed in a consistent manner. Background information on data preparation is provided in Section 4.1, procedures and techniques that will be used for graphical exploration of the data are demonstrated in Section 4.2, the proposed primary method for quantification of efficiency (the Lognormal Statistical Efficiency, LSE) is outlined in Section 4.3, and Section 4.4 describes an alternative method (the Relative Outflow Efficiency) for quantification of efficiency where outflow EMCs do not vary with respect to inflow concentrations.

4.1 Data Preparation

There are a number of types of water quality data stored in the database due to the varying methods used to conduct monitoring studies. In order to analyze the data, some degree of preparation of the data is required.

The water quality data stored in the database can be broken down into two principal types.

1. Event Mean Concentration Data
 - Discrete (manual or automatic) Sample Flow Weighted Composite EMCs
 - Discrete Sample Time Weighted Composite EMCs
 - Discrete Sample Composite EMCs Without Flow or Time Weighting
2. Discrete Water Sample Data
 - Grab Samples

The approach described and demonstrated in Sections 4.2 and 4.3 is based on EMC monitoring data. The use of grab samples for the calculation of removal efficiencies requires additional preparation of water quality sampling data. On a study by study basis, grab sampling programs will be examined. Numerical methods will be used to approximate EMCs for certain constituents (based on flow and/or time weighting), where this is possible. If EMCs cannot be calculated for a particular study, then estimations of efficiency will be based on the grab samples themselves (i.e., a statistical analysis of concentration data will be conducted to the extent possible). For some constituents and field parameters, a discrete sample approach is required. In calculating the ability for a BMP to improve field parameters such as temperature, a "grab" sample approach will need to be utilized even where EMCs were collected in a flow or time weighted manner.

In many of the BMPs currently stored in the database, the number of inflows does not necessarily equal the number of outflows. Although many BMPs have one inflow and one outflow, many do not, and in some cases, the layout of the BMP system is quite complicated. Best management practice designs containing multiple, inflows, outflows, bypasses, and BMPs in series and/or parallel are common and all analyses of BMPs and BMP systems should take these important design details into account.

For cases where more than one inlet and outlet are present, the concentration data will be composited based on flow weighting. This will be conducted by calculating a single EMC based on the total mass flowing into or away from the BMP and the associated total flow.

In some cases the flow into or out of a BMP is not directly measured, but can be calculated from the flows that are recorded. In these cases, mass balance equations will be used and checked against work conducted by the original author. In addition, total flow volumes can be estimated from runoff coefficients and the available rainfall data, where available.

4.2 Exploratory Data Assessment

An initial exploratory data analysis will be conducted to provide a common starting point for quantification of efficiency, effectiveness and performance. Three initial sets of graphs will be produced for each BMP and constituent monitored as shown below:

1. A normal probability plot showing the log transform of both inflow and out flow EMCs for all storms for the BMP. If the log transformed data deviates significantly from normality, other transformations will be explored to determine if a better transformation exists. Examples for TSS for the three designs examined in Tampa Office Pond Study are shown in Figures 4.1-4.3

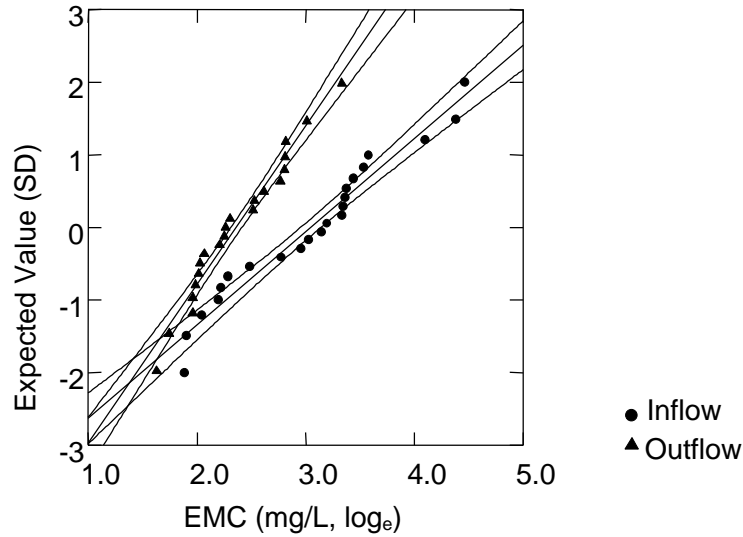


Figure 4.1 Normal Probability Plot for Log Transformed Inflow and Outflow Data for TSS for the Tampa Office Pond (1990), (0.95 confidence interval on the regression lines)

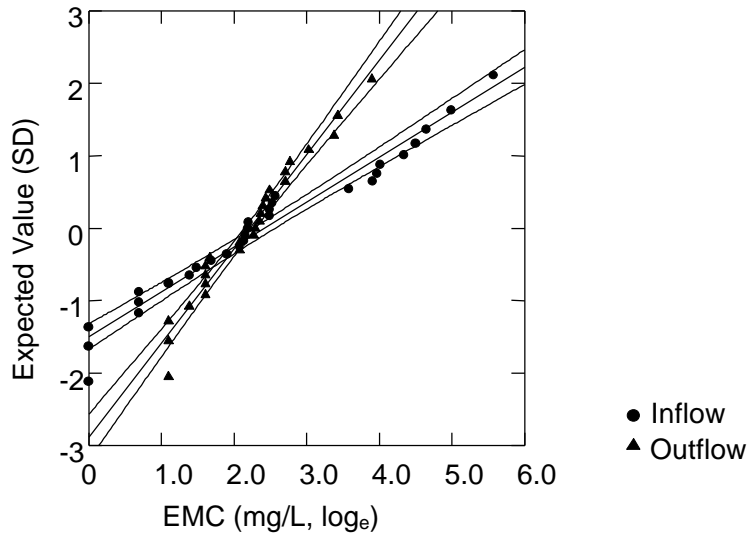


Figure 4.2 Normal Probability Plot for Log Transformed Inflow and Outflow Data for TSS for the Tampa Office Pond (1993-1994), (0.95 confidence interval on the regression lines)

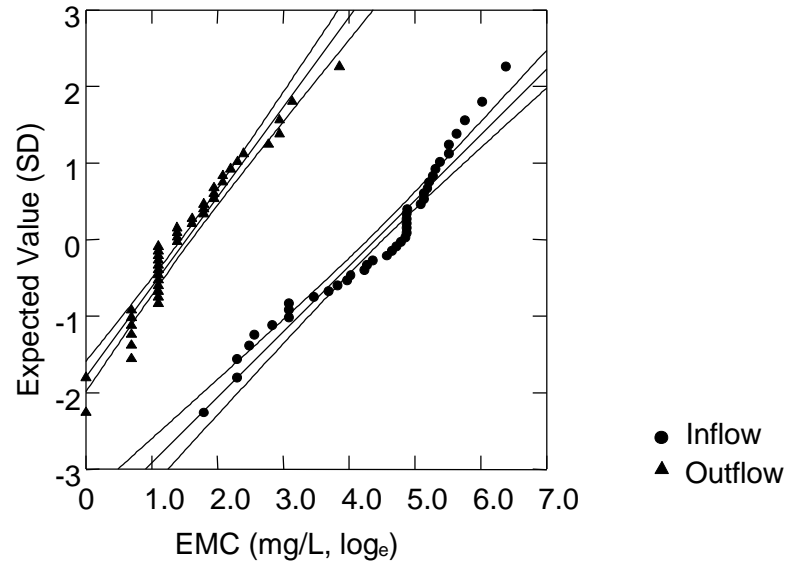


Figure 4.3 Normal Probability Plot for Log Transformed Inflow and Outflow Data for TSS for the Tampa Office Pond (1994-1995), (0.95 confidence interval on the regression lines)

2. A notched grouped box plot will be generated showing both inflow and outflow on the same plot. One plot will be generated based on transformed EMCs or grab sample concentrations and one will be generated based on transformed loads. Each box plot will include the standard deviation and selected percentiles and/or confidence intervals. Examples for TSS for the three designs examined in Tampa Office Pond Study are shown in Figure 4.4.

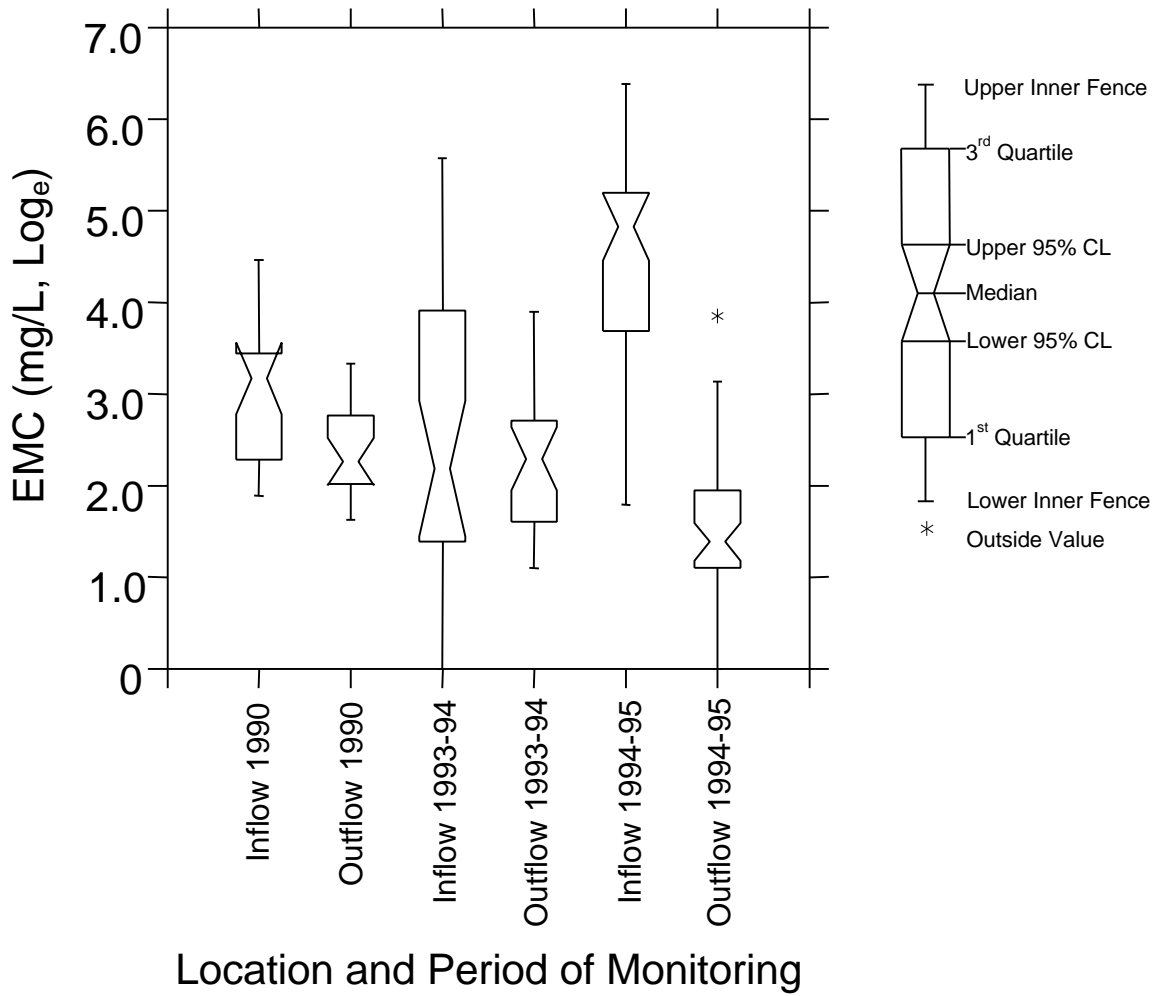
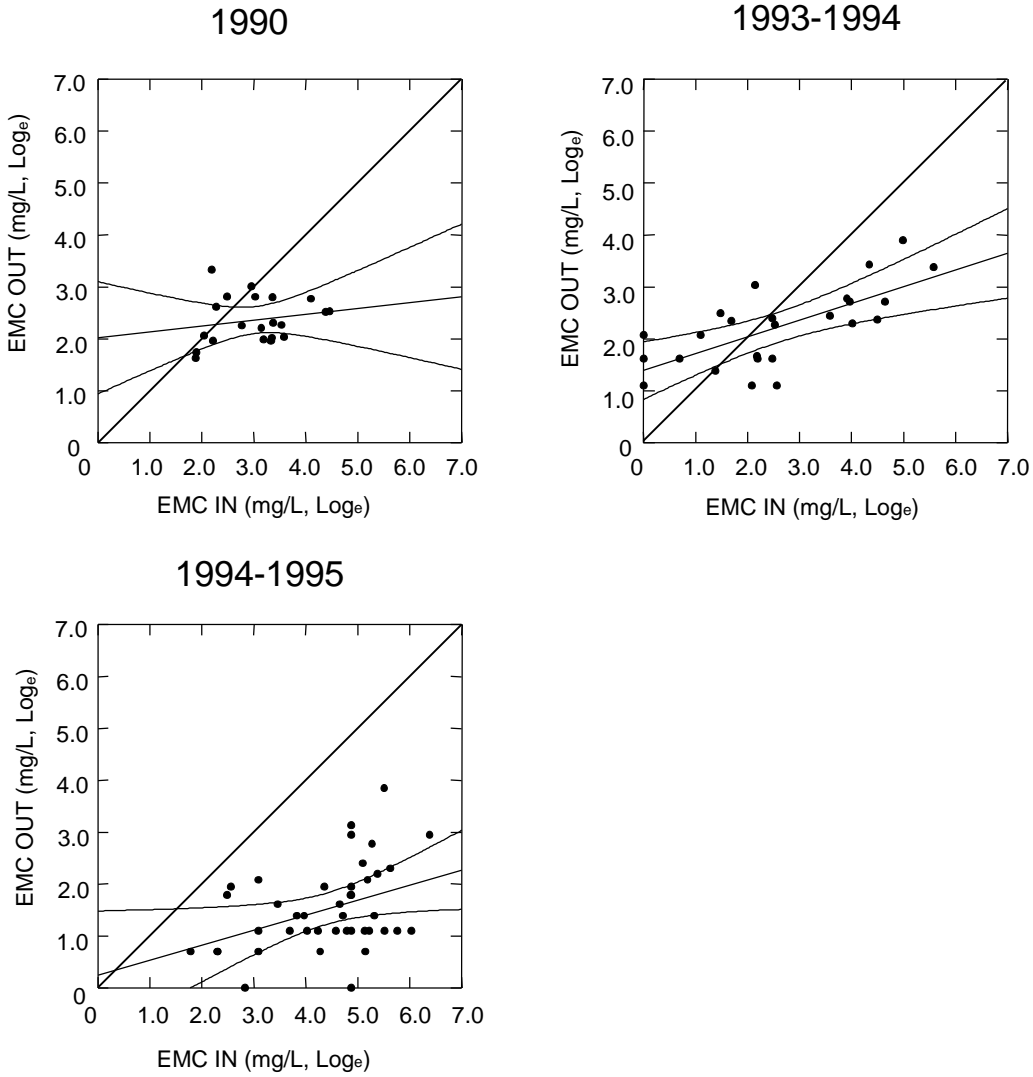


Figure 4.4 Notched Box Plot for Log Transformed Inflow and Outflow Data for TSS for the Tampa Office Pond (Boxes are narrow at the median and are full width at the lower and upper 95% confidence interval. The limits of the box show the range within which the central 50% of the values lie (also called the lower and upper hinge). The whiskers represent the upper and lower inner fences defined as: $\text{hinge} \pm (1.5 * (\text{median} - \text{hinge}))$). Outside values are labeled as an asterisk and are defined as being between the inner and outer fence.

3. A scatter plot will be generated showing EMC out as a function of EMC in. This plot will allow for the visual inspection of the degree of "pairing" of EMCs at the inflow and outflow. The scatter plot will be produced with transformed data on both axes. If appropriate, a best-fit line will be plotted.



Figures 4.5-4.7 Scatter Plot for Log Transformed Inflow and Outflow Data for TSS for the Tampa Office Pond (0.95 confidence interval on the regression lines).

After an analysis of the graphical output for each of the above methods, decisions will be made about the best way to further analyze the data on a case by case basis. The paired t-test will be used and other paired and non-paired non-parametric tests will be explored as appropriate.

4.3 Data Analysis: Lognormal Statistical Efficiency

The graphical methods shown in Section 4.2 allow for the data to be explored. These methods help determine if a statistical approach to the data is appropriate and if any transformations of the data would improve interpretation. After data for a particular BMP are deemed appropriate for further analysis (i.e., there are enough data points available for a particular study and constituent to lend statistical significance to further analysis) the water quality data will be analyzed as described in this section.

The lognormal statistical efficiency (LSE) defines efficiency, not as a single value, but as a summary of the statistical characteristics of the inflow and outflow. An example of a full analysis using this method is shown in Table 4.1.

The test of statistical significance of the results takes as its hypothesis that the inflow and outflow values are derived from the same population. This null hypothesis allows the efficiency of the BMP to be evaluated by the probability that the BMP has no statistically relevant effect on the distribution of EMCs downstream of the BMP compared to upstream values. This hypothesis is best evaluated using the results of the one-way analysis of variance (ANOVA) test. The effect of the BMP will be considered significant if the probability (P-value) that the resulting F-ratio from the ANOVA could have been generated by chance is less than a chosen significance level (to be chosen after results are examined, typically 0.05). The overall efficiency will be summarized by reporting: the P-value, the percent difference between the arithmetic estimate of the mean log transformed EMCs at the outflow and the inflow along with the related confidence limit of the means, and the percent difference between specific percentile ranges (most likely the 10th and 90th). Note that using only the difference in the mean is identical to the Efficiency Ratio method described in Section 3.1, using the log transform of the data. Additional tests of the statistical relevance of the differences in population characteristics at the inflow and outflow will also be examined depending on the usefulness of parametric methods.

If the assumptions of the parametric ANOVA cannot be met or if the proportion of non-detects in the data set exceeds 15%, a Kruskal-Wallis nonparametric ANOVA (analogous to the parametric one-way analysis of variance) will be used to examine the hypothesis regarding significant differences in constituent concentrations at the inflow and the outflow. The nonparametric ANOVA evaluates the ranks of the observed concentrations at each location. Non-detects will be treated as tied values and are assigned an average rank. The two-sample Kolmogorov-Smirnov test will also be explored. In general, nonparametric methods are less powerful than their parametric counterparts, for distributions that are approximately log normal, reducing the likelihood that a “true” significant difference between treatments will be detected.

Example of the Lognormal Statistical Efficiency for TSS in the Tampa Office Pond

All supporting graphs for the NSE method are shown in Section 4.2 of the memorandum. Table 4.1 given below shows what typical results will be presented to define efficiency of each BMP in the database.

Table 4.1 Summary of Preliminary Analysis of Tampa Office Pond Using LSE Method

BMP Name	Constituent	Location	Mean (Log EMC), [Upper CL, Lower CL]	SD	Estimate of Arithmetic Mean EMC Based on Appendix A		10 th Percentile EMC ¹		90 th Percentile EMC ¹		Analysis of Variance (ANOVA)
					Value	Diff., [%]	Value	Diff. [%]	Value	Diff. [%]	
Tampa Office Pond 1990	TSS	Inflow	3.046 [3.382, 2.711]	0.757	28.009	16.282 [58.1]	7.82	0.72 [9.2]	57.15	40.45 [70.8]	N: 43 Multiple R: 0.488 Squared Multiple R: 0.239 Sum of Squares: 5.028 Mean-Square: 5.028 F-ratio: 12.850 P-value: 0.001 Durbin-Watson D Statistic: 1.976 First Order Auto Correlation : -1.034
		Outflow	2.362 [2.566, 2.159]	0.447	11.727		7.10		16.7		
Tampa Office Pond 1993-1994	TSS	Inflow	2.413 [3.012, 1.814]	1.575	38.602	26.386 [68.4]	1.74	-1.26 [-72.4]	108.91	90.24 [82.9]	N: 54 Multiple R: 0.077 Squared Multiple R: 0.006 Sum of Squares: .500 Mean-Square: 0.500 F-ratio: 0.314 P-value: 0.578 Durbin-Watson D Statistic: 0.712 First Order Auto Correlation : 0.629
		Outflow	2.220 [2.530, 1.909]	0.752	12.216		3.00		18.67		
Tampa Office Pond 1994-1995	TSS	Inflow	4.401 [4.753, 4.050]	1.128	154.037	147.591 [95.8]	12.69	10.69 [15.8]	248.60	231.75 [93.2]	N: 84 Multiple R: 0.828 Squared Multiple R: 0.685 Sum of Squares: 173.832 Mean-Square: 173.832 F-ratio: 178.207 P-value: 0.000 Durbin-Watson D Statistic: 1.820 First Order Auto Correlation : 0.088
		Outflow	1.524 [1.781, 1.268]	0.824	6.446		2.00		16.85		

1. Calculated based on the difference between the EXP (10th percentile of the Log transformed data) for the inflow minus the outflow.

In looking at the results of the ANOVA test the criteria for the P-value (<0.05) is met in two of the three cases (1990 and 1994-1995). Inherent to the ANOVA test, the null hypothesis has been rejected, (i.e., there is less than a 5% chance that the two data sets were taken from the same population). In addition the two non-parametric tests (i.e., the Kruskal-Wallis test and the Two Sample Kolmogorov-Smirnov test) corroborate the ANOVA test (the probability for both the 1990 and 1994-1995 data are below 0.05). When looking at the 1993-1994 data (the P-value for the ANOVA test is 0.578), the criteria for all three tests), it is apparent that even though the percent difference in the estimates of the mean values is quite large (68%), this information is not statistically relevant and therefore should be identified such. Although the analysis of the difference in the mean EMC values is statistically relevant, the statistically insignificant differences provide the best estimate of the efficiency of the BMP, though there is little confidence in the 1993-1994 records should be flagged to prevent misinterpretation of any resulting “percent removal” values. The 1990 and 1994-1995 results provide a statistically significant approximation of the efficiency of the BMP (for TSS), where the 1993-1994 data fail to do so.

4.4 Relative Outflow Concentration

In addition to exploring the LSE, the relative outflow concentration will be examined as an alternative method for quantification of effectiveness where outflow EMCs do not vary significantly with respect to inflow concentrations. The relative outflow concentration examines the relationship between outflow EMCs for a number of separate BMPs, and explores the parameters that affect outflow water quality. The logarithmic transform of the EMC data will be used to statistically characterize the outflow. Descriptive statistics, identical to those methods used in Section 4.2, can be utilized to examine the relationship between outflow concentrations at a number of different BMPs of the same type. In this method, influent EMCs are viewed as one of the design parameters, along with environmental, and design factors. This focuses attention on the actual water quality levels the BMP is theoretically designed to provide and explicitly assumes that there may not be a functional, or at least an overriding, relationship between influent and effluent EMCs. Both multiple regression analysis and population testing can be used to determine the effects of each design parameter, including influent EMCs (see Section 11)

Due to the fact that the method relies on data from multiple BMPs of the same type, the data and studies used to establish the baseline information must be numerous enough to establish a reliable nationwide trend. The inflow concentration may not be the primary factor affecting the performance of a BMP. In some specific cases it is expected that outflow concentrations are independent of or only partially dependent on inflow concentrations (i.e., outflow EMCs often do not parallel inflow EMCs). Therefore, there should be less emphasis on the difference between inflow and outflow EMCs and measures, such as percent removal, when judging BMP effectiveness. In addition, the type of constituent and its associated removal mechanism are important when considering if influent EMCs have an effect on effluent EMCs.

5 Analysis of Rainfall Events

Analysis of rainfall data can often shed light on the factors that contribute to the performance of a given BMP. In order for the impact of non-structural BMPs and BMPs that lack an upstream gauging station to be properly evaluated, the rainfall for a particular event must be available for analysis. In most cases, it is sufficient to quantify the relationship between total flow at some downstream monitoring station and total rainfall depth in the BMP's tributary watershed. This can help quantify any effects the BMP may have on reducing the quantity of water that reaches the downstream monitoring location. This information is essential for comparing porous pavements, minimization of directly connected impervious areas, and many non-structural BMPs. In all cases where reference watersheds and/or temporal variation of BMP design are employed, rainfall is one of the key normalization parameters.

Analysis of storm rainfall data can also be very useful for quantifying the effects of bypass of the overall performance of a BMP. In some cases monitoring of bypass and overflows has not been conducted. In these cases, rainfall data provides the only potential means for determining the performance of the overall BMP system, where one is evaluating not only the effect on water quality of flow that pass through a BMP, but also how much the BMP can "treat". In some cases a theoretical hydrograph (which would introduce error) would be required in order to use the data stored in the database to approximate bypass or overflow for a particular event.

6 Number of Storms and Number of Samples

The number of storms used for any of the above analyses in Sections 3 and 4 directly impact the statistical relevance of the calculated performance, as evidenced in the ANOVA and confidence interval of the mean log-transformed value at a particular monitoring station. An analysis of the number of storms monitored in comparison to the number required to obtain statistically relevant results will be conducted.

7 Characteristics of Storms Monitored

In addition to confirming that the number of storms monitored is sufficient to yield statistically useful results, the types of storms monitored have a major impact on extrapolating the results obtained to determine the overall long-term performance. The relationship between storm size and storm frequency in most locations ensures that smaller storms are more prevalent in most stormwater flow records. This often presents a particular challenge. It must be ensured that the

methods inherent to the data collection effort do not unduly skew the results of the performance analysis or that this bias is taken into account or at least recognized. For many of the methods presented in Section 3 and 4, this requires restraint in extrapolation of results to areas of the record that are less populated by data. For example, the presence of a small number of large storms can dominate a summation of loads calculation.

8 Toxicity Determinations

The concentrations of both inflow and outflow EMCs can be utilized to evaluate the potential toxicity reduction of BMPs. Although instantaneous grab samples provide a more accurate picture of toxicity at any given time, the EMC comparison will provide a measure of the average concentration during an event versus criterion values. In this effort we will utilize both EMC data and grab sample data (separately) to assess a BMP's potential to reduce toxicity, comparing the frequency and magnitude of the number of both EMCs and grab samples that exceed EPA published values.

9 Net Export of Contaminants (Negative Removal Efficiencies)

In some cases, the performance of a given BMP is masked by the introduction of contaminants from within the BMP. This may be caused by significant levels of sorbed or particulate contaminants in the soil matrix, decaying matter within the BMP that exports significant quantities of nutrients, or sources such as ground water, rainwater, or airborne contaminants. If negative removal efficiencies are regularly observed during data analysis, for a contaminant, the causes for such a net export will be sought. Often net export of contaminants is observed where concentrations of the contaminant in the inflow to the BMP are quite low. When concentrations are very low, a slight shift in the quantity of contaminants could greatly affect the calculated efficiency.

10 Information Stored in the Database

For each BMP type, and indeed each BMP, there exists an intimate and complex relationship between the environmental and design parameters and the mechanism for removal. An analysis of the relationship between environmental, design, and operational parameters requires an examination of factors that are most likely to observably influence the performance of particular type of BMP. We will explore both individual design attributes and carefully selected "groups" of design attributes to look for potential factors that affect performance. In order to define what information is available through the database, a list of each BMP type along with related design, environmental, and watershed parameters are shown in Table 10. A list of the types and number of BMPs that will be part of the initial data set contained in the database is shown in Table 10.1.

Table 10.1 Parameters to Report with Water Quality Data for Various BMPs

Parameter Type	Parameter	Ret. (Wet) Pond	Extended Detention (Dry) Basin	Wetland Pond Basin	Grass Swale/ Wetland Channel	Media Filter	Oil & Sand Trap/ Hydrodyn. Device	Infil. Basins and Trenches
Tributary Watershed	Area, average slope, average runoff coeff., length, soil types, veg. types	•	•	•	•	•	•	•
	Imperv. % and % hyd. connected	•	•	•	•	•	•	•
	Details about gutter, sewer, swale, ditches, parking, roads in watershed	•	•	•	•	•	•	•
	Land use types (res., com. ind. open)	•	•	•	•	•	•	•
General Hydrology	Date and times for monitored storms	•	•	•	•	•	•	•
	Runoff volumes for monitored storms	•	•	•	•	•	•	•
	Peak 1-hr intensity	•	•	•	•	•	•	•
	Design storm/flood recurrence intervals and magnitude	•	•	•	•	•	•	•
	Peak flow rate, depth, and Manning's roughness coeff. for the 2-year storm				•			
	Depth to seasonal high groundwater/impermeable layer		•		•			•
	Saturated hydraulic conductivity, infiltration rate, soil group				•			•
Average annual values for number of storms, precipitation, snowfall, min./max. temp.	•	•	•	•	•	•	•	
Water	Pollutant and constituent EMCs, and alkalinity, hardness and pH by event	•	•	•	•	•	•	•
	Water temperature	•	•	•	•	•	•	•
	Sediment settling velocity dist.	•	•	•	•	•	•	•
	Facility on- or off-line?	•	•	•	•	•	•	•
	Bypassed flows during events	•	•	•	•	•	•	•
General Facility	Facility Location (Lat./Long.), address, city, state, country, age of BMP, etc.	•	•	•	•	•	•	•
	Type and frequency of maintenance	•	•	•	•	•	•	•
	Types and location of instruments	•	•	•	•	•	•	•
	Inlet and outlet details, and number	•	•	•	•	•	•	•
Wet Pool	Media or granular material depth, type, storage volume, and porosity					•		•
	Volume, surface area, length of permanent pool	•		•		•	•	
	Littoral zone surface area	•						
Detention Volume	Solar radiation, days of sunshine, wind speed, pan evaporation	•	•	•	•			•
	Detention (or surcharge) and flood control volumes	•	•	•		•	•	•
	Basin's surface area and length	•	•	•		•	•	•
	Brimful and half-brimful empty time	•	•	•		•	•	•
Pre-Treatment	Bottom stage/infil. surface area, type			•	•			•
	Forebay volume, surface area	•	•	•		•	•	•
Wetland Plant	Relationship to other BMPs upstream	•	•	•	•	•	•	•
	Wetland/swale type, surface area, and length, side slope, bottom width			•	•			
	Percent of wetland surface between 0-12", 12"-24", and 24"-48"			•	•			
	Plant species and age of facility	•	•	•	•			

Based on Urbonas (1994,1995) and NSW database tables

11 Parameter Evaluation

This section discusses the selection process for parameters used to evaluate the relationship between, design and environmental conditions, and efficiency. Two methods are presented. The first of these methods is multiple regression analysis. The second is BMP group testing.

11.1 Selection of Parameters and Scalability

Parameters that are selected for evaluation must be present or consistently and reliably derivable from the data in the majority of BMP reports. Parameters that relate to sizing of a BMP that are selected as indicative of performance must be scalable. This scalability allows the results obtained from one set of BMPs to be compared with results from another set. As was mentioned in the Section 3, the correlation of the results from two different locations having varied conditions cannot be compared if all significant variables that are related to sizing are not scaled appropriately. Where conditions are significantly dissimilar or a small number of data points are available, scaling can introduce significant errors in analysis.

Parameters that can be calculated from a combination of database fields will be utilized for evaluating the relationship between static and state variables and efficiency. Parameters that correlate well with efficiency should be directly linked to the removal mechanism for that particular BMP type.

For example, in all BMPs that utilize settling as a primary removal mechanism, storm detention time is a key factor. The average detention time for a BMP during a given event is dependent on the design of the BMP and flow conditions during the event. For the general case, average detention time for an event can be calculated based on the average storage volume of the BMP and flows in and out, neglecting other losses; each of these may vary with time as shown in Equations 11.1-11.4.

The volume in the BMP, $V(t)$, at time t is given by:

$$V(t) = V_o + \int_{t_0}^t [Q_{in}(t) - Q_{out}(t)] \cdot dt \quad \text{Equation 11.1}$$

where,

t:	time
V_o :	permanent pool storage volume of BMP
Q_{in} :	volume flow rate into BMP
Q_{out} :	volume flow rate out of BMP

In most cases, detention time is outflow dominated and thus can be approximated using the average volume flow rate at the outflow and the average total volume in the BMP.

The average volume flow rate, $\overline{Q_{out}(t)}$, on $[t_0, t]$ is given by:

$$\overline{Q_{out}(t)} = \frac{1}{(t - t_0)} \int_{t_0}^t Q_{out}(t) \cdot dt \quad \text{Equation 11.2}$$

The average value of the total volume in the BMP, $\overline{V(t)}$, on $[t_0, t]$ is:

$$\overline{V(t)} = \frac{1}{t - t_0} \int_{t_0}^t V(t) \cdot dt \quad \text{Equation 11.3}$$

Finally, an average detention time, $\overline{t_{det}}$, for the BMP on $[t_0, t]$, can be found from Equation 11.4:

$$\overline{t_{det}} = \frac{\overline{V(t)}}{\overline{Q_{out}(t)}} \quad \text{Equation 11.4}$$

For locations that do not have a significant change in detention volume with time during events (e.g., ponds with a large permanent pool and little surcharge detention volume) the volume of the pond can be assumed to be constant ($V(t) = V_0$, or $Q_{in}(t) = Q_{out}(t)$) and the storm average detention time can be approximated as:

$$\overline{t_{det}} = \frac{V_0}{\left(\frac{V_{out}}{t} \right)} \quad \text{Equation 11.5}$$

If ‘intra-storm’ flow rate data is not available, (the database does not currently support ‘raw’ flow data, although it can be stored in generic attached data tables) and the storage volume in the BMP changes significantly over the course of an event, either an approximate average storage volume would need to be selected based on more detailed information about the system, or some theoretical hydrograph would need to be used based on rainfall and runoff characteristics, BMP design, and design of the outflow structure.

In addition to calculating the detention time for each storm event, an average detention time can be calculated for the BMP based on the historic average wet season rainfall rate for the area (Rushton et al, 1997). This method is applicable to BMPs that have effluent flows that continue for periods well in excess of the duration of the storm event and locations that have fairly steady rainfall rates over some specified wet season. Although the actual storm detention time calculated using this alternative method is not based on data from the monitoring period, it does provide a uniform means of comparing BMP design over a wide variety of locations based on average rainfall characteristics.

It is expected that detention time will be one of the primary parameters of interest for detention based BMPs. In addition to calculating the detention time for each storm event that was monitored, it will be useful to calculate a mean detention time, and a detention time for the mean storm based on the synoptic rainfall data stored in the database. Each of these factors will be assessed to determine if there is a correlation between these factors and the efficiency of removal.

In addition to examining design parameters that are directly stored in the database (e.g., surcharge detention volume), and standard calculated parameters (e.g., detention time), additional ratios composed of more than one factor will be examined. These ‘treatment factors’ allow for examination of other possibly important ratios between design parameters. For example, a ‘treatment volume factor’, which can be defined for BMPs that use storage as the primary treatment process, is shown in Equation 11.6.

$$\frac{f(\text{design volume})}{f(\text{runoff volume})} \quad \text{Equation 11.6}$$

For BMPs that are ‘flow-through’ in nature, a ‘treatment flow factor’ (Equation 11.7), will be examined.

$$\frac{f(\text{treatment flow rate})}{f(\text{runoff flow rate})} \quad \text{Equation 11.7}$$

These two “factors” are examples taken from a larger set of combinations of parameters that will be examined. The methods outlined in Sections 11.2 and 11.3 will be used for determining the usefulness of the parameters and factors described in this section.

11.2 Multiple Linear Regression

Multiple regression analysis systematically allows for examination of any relationships between the outcome of the performance measurements discussed in Section 3 of the memorandum and some design parameter or “factor” for a type of BMP.

For example, for dry detention ponds, the relationship between the design parameters length, depth, and draw down rate could be evaluated against the efficiency of the BMP for removing TSS.

Multiple linear regression can be used to see if there is a linear relationship between the parameters or “factors” of interest and efficiency. Multiple linear regression attempts to define a continuous linear relationship between the set of parameters and the resulting efficiency of the BMP. The method first assumes that each of the variables of interest are independent. In the example we can assume, for the sake of analysis, that length and depth meet this criteria. Multiple linear regression also assumes that a linear correlation exists between each independent variable and the dependent variable. It is always advisable to plot the dependent variable as a function of each independent variable in order to determine if there may be some transformation of the independent data that may allow for a linear relationship.

After linear regression is conducted, the correlation coefficient gives a measure of the goodness of fit for the regression line. In addition the F statistic can be used to determine if the results occurred by chance and the t-statistics can be used to determine the relative usefulness of each variable in the regression equation.

11.3 BMP Group Test Methods

Group testing methods use a “cutoff” value for a design or environmental parameter and report the effects of exclusion of BMPs based on this “cutoff”. Most likely, this would be done with a set of factors; a BMP to make the “cutoff” might have to meet 4 of 6 “good” design factors. This approach does not require that a continuous relationship between some parameter and performance exists. This method can therefore be applied to yes/no factors, (e.g., forebay volume >10% of the total volume of a wet pond; length to width ratio of 3:1, etc.) or factors that have a small set of discrete values. In addition, the group testing method follows the design process, where often a required value is specified in order to meet a certain performance goal. The group testing method will probably be a more successful approach, compared to multiple regression, due to the small number of data points available for any given BMP type.

APPENDIX A

Table A.1

$T = \text{EXP}(U)$	$S = M * CV$
$M = \text{EXP}(U + 0.5 * W^2)$	$W = \text{SQRT}(\text{LN}(1 + CV^2))$
$M = T * \text{SQRT}(1 + CV^2)$	$U = \text{LN}(M / \text{EXP}(0.5 * WP))$
$CV = \text{SQRT}(\text{EXP}(W^2) - 1)$	$U = \text{LN}(M/\text{SQRT}(1 + CV^2))$

	Arithmetic	Logarithmic (ln)
Mean	M	U
Standard Deviation	S	W
Coefficient of Variation	CV	
Median	T	

Table A.1 presents transformations between logarithmic transformed population statistics and estimates of arithmetic population statistics.

ATTACHMENT E – DEFINITIONS

“Attached Residential Development” means any development that provides 10 or more residential units that share an interior/exterior wall. This category includes, but is not limited to: dormitories, condominiums and apartments.

“Automotive Repair Shop” means a facility that is categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.

“Commercial and Industrial Development” means any development on private land that is not exclusively heavy industrial or residential uses. The category includes, but is not limited to: mini-malls and other business complexes, shopping malls, hotels, office buildings, public warehouses, hospitals, laboratories and other medical facilities, educational institutions, recreational facilities, plant nurseries, car wash facilities, automotive dealerships, commercial airfields, and other light and heavy industrial complexes or facilities.

“Commercial and Industrial Development greater than 100,000 square feet” means any commercial or industrial development with a project footprint of at least 100,000 square feet.

“Detached Residential Development” means any development that provides 10 or more freestanding residential units. This category includes, but is not limited to: detached homes, such as single-family homes and detached condominiums.

“Directly Connected Impervious Area (DCIA)” means the area covered by a building, impermeable pavement, and/ or other impervious surfaces, which drains directly into the storm drain without first flowing across permeable vegetated land area (e.g., lawns).

“Environmentally Sensitive Areas” means areas that include, but are not limited to, all Clean Water Act 303(d) impaired water bodies (“303[d] water bodies”); areas designated as an “Area of Special Biological Significance” (ASBS) by the State Water Resources Control Board (1990 Water Quality Control Plan for Ocean Waters of California [Ocean Plan] and Water Quality Control Plan for the San Diego Basin (1994) and amendments); water bodies designated as having a RARE beneficial use by the State Water Resources Control Board (Water Quality Control Plan for the San Diego Basin (1994) and amendments), or areas designated as preserves or their equivalent under the Multiple Species Conservation Program (MSCP) within the Cities and County of Orange. The limits of Areas of Special Biological Significance are those defined in the 1990 Water Quality Control Plan for Ocean Waters of California (Ocean Plan) and the Water Quality Control Plan for the San Diego Basin (1994 and amendments). Environmentally sensitive area is defined for the purposes of implementing WQMP requirements, and does not replace or supplement other environmental resource-based terms, such as “Environmentally Sensitive Lands,” employed by the County in its land development review processes. As appropriate, the County will distinguish between environmentally sensitive area and other similar terms in the County WQMP.

“Hillside” means lands that have a natural gradient of 25 percent (4 feet of horizontal distance for every 1 foot of vertical distance) or greater and a minimum elevation differential of 50 feet, or a natural gradient of 200 percent (1 foot of horizontal distance for every 2 feet of vertical distance) or greater and a minimum elevation differential of 10 feet.

“Hillside development greater than 5,000 square feet” means any development that would create more than 5,000 square feet of impervious surfaces in hillsides with known erosive soil conditions.

“Infeasibility Waivers” means a County-issued waiver from requirements for Treatment BMPs. The waiver requires a project proponent demonstrate Treatment BMP infeasibility and the County to notify the Executive Officer of the applicable Regional Board of the waiver.

“Infiltration” means the downward entry of water into the surface of the soil.

“Municipal Storm Drain System” means public drainage facilities by which stormwater may be conveyed to Receiving Waters, such as: natural drainages, ditches, roads, streets, constructed channels, aqueducts, storm drains, pipes, street gutters, or catch basins.

“Natural Flow Regime” means the pre-development hydrologic conditions within a stream.

“New Development” means land disturbing activities; structural development, including construction or installation of a building or structure, the creation of impervious surfaces; and land subdivision.

“Parking Lot” means land area or facility for the temporary parking or storage of motor vehicles used personally, or for business or commerce.

“Projects Discharging to Receiving Waters within Environmentally Sensitive Areas” means all development and significant redevelopment that would create 2,500 square feet of impervious surfaces or increase the area of imperviousness of a project site to 10% or more of its naturally occurring condition, and either discharge urban runoff to a receiving water within an environmentally sensitive area (where any portion of the project footprint is located within 200 feet of the environmentally sensitive area), or discharge to a receiving water within an environmentally sensitive area without mixing with flows from adjacent lands (where the project footprint is located more than 200 feet from the environmentally sensitive area).

“Project Feature” means a project component or subpart that in and of itself, meets priority project criteria. For example, a greater than 5000 sq. ft. parking lot within a non-priority project.

“Project Footprint” means the limits of all grading and ground disturbance, including landscaping, associated with a project.

"Receiving Waters" means surface bodies of water that receive discharges from new development and redevelopment projects, either directly, or indirectly through municipal storm drain systems. Surface bodies of water include naturally occurring wetlands, streams (perennial, intermittent and ephemeral [exhibiting bed, bank, and ordinary high water mark]), creeks, rivers, reservoirs, lakes, lagoons, estuaries, harbors, bays and the Pacific Ocean. The County shall determine the definition for wetlands and the limits thereof for the purposes of this definition, provided the County definition is as protective as the Federal definition utilized by the United States Army Corps of Engineers (US COE) and the United States Environmental Protection Agency (US EPA). Constructed wetlands for treatment purposes are not considered wetlands under this definition, unless the wetlands were constructed as mitigation for habitat loss. Other constructed BMPs such as detention and retention basins are not considered receiving waters under this definition, unless the BMP was originally constructed within receiving waters.

"Residential Development" means any development on private land that provides living accommodations for one or more persons. This category includes, but is not limited to: single-family homes, multi-family homes, condominiums, and apartments.

"Restaurant" means a stand-alone facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC code 5812).

"Significant Redevelopment" means development that would create or add at least 5,000 square feet of impervious surfaces on an already developed site. Significant redevelopment includes, but is not limited to: the expansion of a building footprint; addition to or replacement of a structure; replacement of an impervious surface that is not part of a routine maintenance activity; land disturbing activities related with structural or impervious surfaces and new sidewalk construction, pedestrian ramps, or bike lane on public and private existing roads;. Replacement of impervious surfaces includes any activity that is not part of a routine maintenance activity where impervious material(s) are removed, exposing underlying soil during construction. Significant redevelopment does not include trenching and resurfacing associated with utility work; resurfacing and reconfiguring surface parking lots (if no additional impervious area is added); pedestrian ramps and replacement of damaged pavement.

"Site Design BMP" means any project design feature that reduces the creation or severity of potential pollutant sources or reduces the alteration of the project site's natural flow regime. Redevelopment projects that are undertaken to remove pollutant sources (such as existing surface parking lots and other impervious surfaces) or to reduce the need for new roads and other impervious surfaces (as compared to conventional or low-density new development) by incorporating higher densities and/or mixed land uses into the project design, are also considered Site Design BMPs.

"Source Control BMP (both structural and non-structural)" means land use or site planning practices, or structures that aim to prevent urban runoff and stormwater pollution by reducing the potential for contamination at the source of pollution. Source Control BMPs minimize the contact between pollutants and urban runoff. Examples include roof structures over trash or material storage areas, and berms around fuel dispensing areas.

“Stormwater Best Management Practice (BMP)” means any schedules of activities, prohibitions of practices, general good house keeping practices, pollution prevention and educational practices, maintenance procedures, structural treatment BMPs, and other management practices to prevent or reduce to the maximum extent practicable the discharge of pollutants directly or indirectly to receiving waters. Stormwater BMPs also include treatment requirements, operating procedures and practices to control site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. This Model WQMP groups stormwater BMPs into the following categories: Site Design, Source Control, and Treatment Control (pollutant removal) BMPs.

“Streets, Roads, Highways, and Freeways” means any project that is not part of a routine maintenance activity, and would create a new paved surface that is 5,000 square feet or greater used for the transportation of automobiles, trucks, motorcycles, and other vehicles. For the purposes of WQMP requirements, Streets, Roads, Highways, and Freeways do not include trenching and resurfacing associated with utility work; applying asphalt overlay to existing pavement; new sidewalk, pedestrian ramps, or bike lane construction on existing roads; and replacement of damaged pavement.

“Treatment Control (Structural) BMP” means any engineered system designed and constructed to remove pollutants from urban runoff. Pollutant removal is achieved by simple gravity settling of particulate pollutants, filtration, biological uptake, media adsorption or any other physical, biological, or chemical process.