PSOMAS

Los Angeles Valley College

Measure J Stormwater Master Plan

Prepared for

Yang Management

Prepared

April 15, 2011

LACCD Project No. 38V.5870.01
Psomas Project No. 1LOS151304

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LOS ANGELES VALLEY COLLEGE

MEASURE J STORMWATER MASTER PLAN

LACCD Project No. 38V.5870.01
Psomas Project No. 1LOS151304

April 15, 2011

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1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

Located in the Valley Glen neighborhood in the City of Los Angeles, Los Angeles Valley College (LAVC) is one the largest of the nine Los Angeles Community College District (LACCD) campuses and consists of a total area of approximately 105 acres. The LAVC campus provides education and support facilities housed within permanent buildings and temporary structures.

With the passage of Measure J in 2008, LAVC has adopted a new campus master plan, the Los Angeles Valley 2010 Update to the 2003 Facilities Master Plan – Horizon 1 (referred herein as the Measure J Master Plan), prepared by Steinberg Architects, dated April 2010 and included herein as Exhibit 1.0.

1.2 PROJECT SCOPE

Psomas has been asked to complete a Stormwater Master Plan based on previously constructed infrastructure and future development proposed in the Measure J Master Plan. Scope of work includes:

- Summarize the overall effects of the future development to the campus stormwater system, including hydrology, conveyance and water quality impacts.
- Evaluate the future development according to proposed construction phases.
- Evaluate the existing on campus storm drain infrastructure.
- Provide recommendations for improvements that will serve the future development shown in the Measure J Master Plan.

1.3 OBJECTIVE

The Stormwater Master Plan report presented herein is developed consistent with the layout and goals for the proposed LAVC expansion as presented in the Measure J Master Plan. The main objectives of this report include the following:

- Identify relevant information regarding drainage on the campus.
- Provide a base map of existing hydrology and future hydrology to conceptualize specific stormwater control features.
- Identify applicable stormwater regulations and guidelines.
- Identify applicable drainage computation methodologies and design standards.
- Assess the existing storm drainage system.
- Identify potential drainage issues as related to future development depicted in the Measure J Master Plan.
- Propose Best Management Practices (BMPs) in compliance with stormwater regulations to help minimize and/or eliminate potential pollutant impacts.

The Stormwater Master Plan addresses improvements to both stormwater drainage and water quality based on the future development. The overall hydrologic and stormwater quality issues presented in this report provide a preliminary assessment of the campus and are based on criteria and guidelines as presented herein.

1.4 OVERVIEW OF REGULATIONS AND POLICIES

1.4.1 Development Permits

The design and construction of onsite improvements are subject to review and approval of the California State Division of the State Architect (DSA). DSA is the permitting jurisdiction applicable to LAVC. DSA offers minimal review of storm drainage facilities and does not review hydrology, hydraulic or water quality calculations.

Offsite improvements, such as those within the local city or county property, are subject to review and approval by the local municipality holding jurisdiction of the area. Local permits shall be required for storm drainage improvements located in the public right-of-ways and connections to existing public systems.

1.4.2 Water Quality Regulations

LAVC is required to comply with Federal and State Stormwater Regulations, including the NPDES permit program, which is administered for the State of California by the State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Boards (RWQCB).

Los Angeles Regional Water Quality Control Board (LARWQCB) has issued Order No. 01-182 and adopted NPDES Permit No.CAS004001 for municipal stormwater and urban runoff discharges within the County of Los Angeles and the incorporated cities therein, except the City of Long Beach. In compliance with the Permit, Los Angeles County has implemented a stormwater quality management program, entitled the Standard Urban Stormwater Mitigation Plan (SUSMP), with the ultimate goal of accomplishing the requirements of the Permit and reducing the amount of pollutants in stormwater and urban runoff.

The City of Los Angeles is currently regulated by the LARWQCB Permit and adheres to stormwater quality requirements of the Los Angeles County SUSMP. Since LAVC currently discharges stormwater to the City and County of Los Angeles storm drain systems, we recommend that LAVC follow the City and County of Los Angeles stormwater quality requirements and comply with the regulations of Los Angeles County SUSMP.

A detailed overview of relevant regulations can be found in Section 3.0 of this report. Refer to Appendix A for a recent *Clarification to the Los Angeles County Municipal Stormwater Permit, Order No. 01-182; NPDES Permit No. CAS004001*. Refer to Appendix B for *SWRCB Water Quality Order No. 2003-0005-DWQ; NPDES General Permit No. CAS000004, the Waste Discharge Requirements for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4) - General Permit*.

1.4.3 Standard Urban Stormwater Mitigation Plan (SUSMP)

As part of the Los Angeles Region NPDES Permit, the Los Angeles Regional Water Quality Control Board (LARWQCB) requires new development and redevelopment projects to incorporate stormwater mitigation measures into site design. Los Angeles County requires submission of a Standard Urban Stormwater Mitigation Plan (SUSMP) by new development and redevelopment projects to reduce the quantity and improve the quality of stormwater runoff. SUSMPs designate Best Management Practices (BMPs) to be used in specified categories of development projects.

As of March 8, 2000, the LARWQCB has approved the Los Angeles County SUSMP, which requires new development and redevelopment projects to implement stormwater BMPs. The SUSMP was developed by Los Angeles County as part of the municipal stormwater program to address stormwater pollution with the objective of accomplishing the following:

- Effectively prohibit non-stormwater discharges and,

- Reduce the discharge of pollutants from stormwater conveyance systems to the Maximum Extent Practicable statutory standard.

The SUSMP numerical sizing criteria states that all post construction structural or treatment control BMPs shall collectively be designed to comply with the following:

a) Mitigate (infiltrate or treat) stormwater runoff from either:

- the 85^{th} percentile 24-hour runoff event determined as the maximized capture stormwater 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

- the volume of runoff based on unit basin storage water quality volume, to achieve 80 percent or more volume treatment by the method recommended in California Stormwater Best Management Practices Handbook – Industrial/Commercial (1993), or

- the volume of runoff produced from a 0.75 inch storm event, prior to its discharge to a stormwater conveyance system, or

- the volume of runoff produced from a historical-record based reference 24-hour rainfall criterion for "treatment" (0.75 inch average for the Los Angeles County area) that achieves approximately the same reduction in pollutant loads achieved by the 85th percentile 24-hour runoff event,

b) Control peak flow discharge to provide stream channel and over bank flood protection, based on flow design criteria selected by the local agency.

Local flow based design criteria outlined in the General MS4 Permit is as follows:

- The flow of runoff produced from a rain event equal to at least 0.2 inches per hour intensity; or

- The flow of runoff produced from a rain event equal to at least two times the 85^{th} percentile hourly rainfall intensity for Los Angeles County; or

- The flow of runoff produced from a rain event that will result in treatment of the same portion of runoff as treated using volumetric standards above.

The SUSMP requirements are used to help establish appropriate mitigation measures for the project. Water quality mitigation measures shall include structural BMPs for post-construction conditions. By effectively treating stormwater runoff, pollutants can be greatly reduced before being discharged. Pollutants of concern would be effectively mitigated through the proposed BMPs. Further information regarding potential pollutants of concern can be found in Section 4.0 of this report.

Pollutants that are typically expected to be present in stormwater include sediment, nutrients, trash, metals, bacteria, oil and grease, organics and pesticides. BMPs effective in treating pollutants of concern are recommended for the LAVC future development illustrated in the Measure J Master Plan. Information regarding general stormwater BMP types and descriptions can be found in Section 5.0 of this report.

Neither the County or City of Los Angeles, nor the NPDES permit regulations require permitees to treat offsite run-on to their property. It is the intent of the regulations to require each permit holder to treat runoff within their respective boundaries prior to discharging to downstream permit holders.

1.4.4 General Permit

In addition to the Los Angeles County SUSMP, the State Water Resources Control Board has also approved a new General Permit which was adopted September 2, 2009 and becomes effective July 1,

2010. The majority of the General Permit affects construction activities including Stormwater Pollution Prevention Plan (SWPPP) preparation, monitoring, etc, which is beyond the scope of this report. However, Section XIII, Post-Construction Standards, in the General Permit (included herein as Appendix C) specifically identifies all sites which do not currently fall within the jurisdiction of an existing MS4 permit holder. LAVC qualifies as a site which does not fall under an existing MS4's jurisdiction. However, we expect that LAVC and other LACCD campuses will be specifically identified to generate their own small MS4 permit in the near future and at that time the regulations of the Section XIII shall no longer apply.

The intent of Section XIII, Post-Construction Standards is similar to the intent in the Los Angeles County SUSMP in that it targets the 85th percentile storm for detention and treatment. The difference is that the General Permit provides alternative means to calculate the storage volume. The General Permit identifies the following BMPs for volume credits:

- Porous Pavement
- Tree Planting
- Downspout Disconnection
- Impervious Area Disconnection
- Green Roof
- Stream Buffer
- Vegetated Swales
- Rain Barrels and Cisterns
- Landscaping Soil Quality

Utilizing the spreadsheet provided by the SWRCB in Appendix 2 of the General Permit, some of the above BMPs can be incorporated into the site design and fulfill the requirements of Section XIII.

The provisions of Section XIII do not take effect until three years from the adoption date of the permit (effective on September 2, 2012). Since LAVC does not currently fall under an existing MS4's jurisdiction, we encourage LAVC to incorporate these site design measures into future site planning where possible but recognize that in some instances they may not be feasible.

2.0 STORMWATER MASTER PLAN

2.1 EXISTING SITE DESCRIPTION

2.1.1 Existing Site Layout

Los Angeles Valley College (LAVC) is located west of the Tujunga Wash which is a tributary to the Los Angeles River Watershed. Annual rainfall in this area is typically low and occurs generally in the winter months. Runoff sources occur mainly on-site. The combination of soil characteristics and high magnitude low frequency storms, which are typical of the region, produce conditions conducive to rapid accumulation of surface water and high storm peak runoff.

The LAVC Campus is surrounded on the south, west and north by residential neighborhoods separated by Burbank Blvd., Fulton Ave., Oxnard St., respectively. Stormwater runoff from the residential areas is intercepted by drainage facilities located on public streets. The Tujunga Wash borders the eastern boundary of campus. Grant High School is located adjacent to the north-east corner of campus and is separated by Ethel Ave. and Hatteras St.

According to the Federal Flood Hazard Boundary/Flood Insurance Rate Map (FIRM), the LAVC Campus is not located within a 100-year flood plain. Thus, the future development as illustrated in the Measure J Master Plan will not be located within a 100-year flood plain, or impede or redirect flood flows within a 100-year flood hazard area.

2.1.2 Existing Storm Drain System

The LAVC campus stormwater system is conveyed primarily by surface flow to the surrounding public streets. Stormwater from the campus discharges to the City of Los Angeles (LA) storm drain system within Oxnard St., Fulton Ave., Burbank Blvd. and Hatteras St. and is ultimately discharged to the Tujunga Wash. The Tujunga Wash is operated by the County of Los Angeles (LA).

The LAVC campus does not contain a large storm drain pipe network typical to most campuses. The campus system consists of small, individual networks of onsite catch basins and appurtenant piping which convey stormwater from small storm events and nuisance flows to the curb face along the campus roadways and the surrounding public streets. The existing storm drain network does not provide flood protection for the 25-year storm event. The campus is dependent on surface flow for flood protection.

2.1.3 Soil Characteristics

The following geotechnical investigation reports have been prepared for the LAVC Campus:

1 Updated Report of Geotechnical Investigation – Proposed Athletic Complex, prepared by MACTEC (January 22, 2009)

2 Geotechnical Engineering Investigation – Proposed Media Arts / Performing Arts Center, prepared by Geotechnologies, Inc. (February 5, 2010)

3 Addendum II – Stormwater Infiltration – Proposed Media Arts / Performing Arts Center, prepared by Geotechnologies, Inc. (June 23, 2010)

4 Geotechnical Engineering Investigation – Proposed Parking Structure, prepared by Geotechnologies, Inc. (October 4, 2010)

5 Geotechnical Engineering Investigation – Proposed Photo Voltaic System, prepared by Geotechnologies, Inc. (October 28, 2010)

6 Geotechnical Engineering Investigation – Proposed Multi-Purpose Community Services Center, prepared by Geotechnologies, Inc. (November 12, 2010)

7 Soil Infiltration Testing for Proposed Stormwater Infiltration System - LA Valley College - Campus Center/Sustainable Mall Project, prepared by MTGL (March 1, 2011)

Subsurface exploration was performed using conventional, truck-mounted hollow-stem auger drilling equipment. Exploratory boring depths vary between reports and the depths range from approximately 15 to 60 feet. Groundwater was not encountered in the borings at the time of drilling to a maximum depth of 50 feet and Geotechnologies, Inc. indicates that during 2004 explorations groundwater was not encountered to a maximum depth of 100 feet. Investigation associated with the listed geotechnical investigation reports also included percolation testing. The following table provides a summary of the percolation test results.

Table 2.1: Percolation Test Results

Report (Listed above)	Report Date	Percolation Test Depth	Percolation Test Results
1	January 22, 2010	4.5 inches	0.75 in/hour
3	June 23, 2010	4 feet and 9.5 feet	3 in/hour
4	October 4, 2010	5 feet	5 in/hour
5	October 28, 2010	15 feet	1 in/hour
6	November 12, 2010	5 feet	9 in/hour
7	March 1, 2011	10 FT	9.138 ft./day, 14.878 ft./day, 1.51 ft./day

2.2 FUTURE SITE DESCRIPTION

2.2.1 Future Site Layout

Future development of the LAVC Campus as depicted in the Measure J Master Plan will consist of new buildings, renovated parking lots, new athletic fields and associated site work and landscape. The various projects indicated in the Measure J Master Plan have been categorized in to the following future development projects:

Table 2.2: Future Development Projects

Future Development	Measure J Project
FP-1	Athletic Training Facility
FP-2	Multi-Purpose Community Services Center
FP-3	Parking Lots J and H
FP-4	Planetarium Building Expansion
FP-5	Parking Lot A (MTA Parking Lot)
FP-6	Workforce Development Center / Administration Building
FP-7	Media Arts / Performing Arts (MAPA) Center
FP-8	Monarch Center and Parking Structure
FP-9	Campus-wide Stormwater Infrastructure Project (CSWIP)
FP-10	Parking Lot B
FP-11	Parking Lot D

The future development projects and project limits are depicted in the Future Development Map included as Exhibit 2.3. The site layouts and building configurations shown are based on the Measure J Master Plan with the exception of the Athletic Training Facility (FP-1) which is based on the 100% Construction Documents (prepared by Cannon Design; dated September 20, 2010).

Future building renovation and tenant improvement projects which have no planned effect on the existing building foot print are not considered in the stormwater quality analysis included herein. According to the Los Angeles County BMP Handbook, if the building foot print is not increased by 5,000 square feet or more, stormwater quality mitigation shall not be required. Based on the Measure J Master Plan and available design documents, the listed future development projects are assumed to be the Measure J projects which shall require stormwater quality mitigation measures. However, it shall be the responsibility of each project design team to confirm their stormwater quality requirements based on final project scope of work.

2.2.2 Future Storm Drain System

Design responsibilities for site specific storm drainage systems and water quality mitigation shall be included in the scope of work for the future development projects. This approach will require each project to examine and consider the upstream and downstream effects for pre-construction and post-construction conditions.

In addition to project specific stormwater treatment systems, the College wishes to construct a stormwater treatment system (identified as the Campus-wide Stormwater Infrastructure Project (CSWIP)) located within Campus Dr., east of the existing Campus Center building. The CSWIP will act as the primary campuswide stormwater collection and treatment system and will intercept existing campus roadways and storm drain piping to collect stormwater from adjacent areas.

2.2.3 Construction Phasing

Based on the construction timeline for the future development provided by the LAVC Construction Project Manager (CPM), the future development projects have been divided in to two phases. Phase 1 includes all future development scheduled prior to the CSWIP and Phase 2 is considered the final build-out of the Measure J Master Plan. The following table illustrates which future development projects are constructed in each phase.

Table 2.3: Construction Phasing

Phase	Description
Phase 0	Existing Conditions
Phase 1	Athletic Training Facility
	Multi-Purpose Community Services Center
	Parking Lots J and H
	Parking Lot A (MTA Parking Lot)
	Workforce Development Center / Administration Building
	Media Arts / Performing Arts (MAPA) Center
	Monarch Center and Parking Structure
	Parking Lot B
	Parking Lot D
Phase 2 (Final)	Planetarium Building Expansion
	Campus-wide Stormwater Infrastructure Project (CSWIP)

2.3 CONCEPT HYDROLOGY ANALYSIS

LAVC stormwater system discharges to the surrounding streets owned and operated by the City of LA, which combined with the City of LA storm drain system are designed to convey the 25-year storm event per County of LA guidelines. Accordingly, LAVC shall follow the City's hydrology and hydraulic methodology. City of LA requires all hydrology and hydraulic calculations to follow the Los Angeles County Department of Public Works (LACDPW) Hydrology Manual (2006).

2.3.1 Methodology

The LACDPW hydrology guidelines and methodology, presented in the Los Angeles County Department of Public Works Hydrology Manual (2006), are used to calculate the 25-year peak flow rates for the project site. The 25-year storm event was used as the design storm to allow for comparison with allowable Q as given by the LACDPW Hydrology Manual. Runoff from the 25-year storm event was estimated for existing and future conditions and the watershed of the campus was divided into several drainage areas that are identified and characterized for both existing and future conditions. The existing and future hydrology maps are presented as Exhibit 2.0 thru Exhibit 2.2.

Rainfall data was obtained from the LACDPW Hydrology Manual (2006) Hydrologic Maps; 50-year, 24-hour Isohyet map. The campus is located on Isohyet Map 1-H1.27. A copy is included in Appendix D. The 50-year 24-hour rainfall Isohyet nearest to the campus is 7.2. According to the Isohyet reduction factor located on Isohyet Map 1-H1.27, the 25-year; 24-hour Isohyet would be 6.3. The soil types within the campus are Type 5 and Type 15, Hanford Fine Sandy Loam and Tujunga Fine Sandy Loam, respectively.

The LACDPW TC (TC_calc_depth.xls, July 2006) computer program, which utilizes the Rational Method, was used to calculate the time of concentration (Tc) for existing and future drainage sub-areas, as well as stormwater runoff flow rates for individual drainage sub-areas independent of all adjacent sub-areas. This program uses the area, length and slope of longest path of flow, isohyet, soil type and percent of impervious cover for each sub-area to determine both the time of concentration and the calculated peak flow rate. The Tc calculation results are provided in Appendix E.

The LAR04 modeling program, which uses the Modified Rational Method, is used to calculate stormwater runoff flow rates for drainage sub-areas which are tributary to adjacent drainage sub-areas. The Modified Rational Equation is an extension of the Rational Method used to create runoff hydrographs from a watershed of any size over a specific time period. The Rational Method is limited to considering storms with duration equal to the time of concentration and provides only a peak flow. However, the Modified Rational Method can consider single storm events with changing intensities and longer durations. The Modified Rational Method was developed as a means to provide hydrographs for storage design based on the rational method. The LAR04 calculation results are provided in Appendix F.

For the existing and future hydrology analysis, percent imperviousness was estimated based on the distribution of land uses and land use-specific percent impervious values presented in LACDPW Hydrology Manual (2006) – Appendix D.

2.3.2 Existing Hydrology

The Existing Hydrology Map (Phase 0) included as Exhibit 2.0 provides a summary of pre-development drainage conditions at the LAVC Campus. The hydrology map shows drainage sub-areas within the project site, direction of flow, downstream points of discharge, and the calculated existing 25-year peak flow rates. Stormwater from the campus currently discharges to the surrounding public streets and ultimately to the Tujunga Wash. The drainage areas are illustrated to identify the discharge point for each area.

The following table summarizes the calculated flow rates for the existing conditions and the information correlates with Exhibit 2.0; Hydrology Map – Construction Phase 0 (Existing).

TABLE 2.4: 25-Year Existing Hydrology Summary

SUB-AREA	**AREA** (acres)	**PEAK FLOW** **Q** (cfs)	**CUMULATIVE FLOW** **ΣQ** (cfs)
Discharge to Hatteras St. & Tujunga Wash			
1-1A	3.3	5.34	--
1-2A	6.8	14.62	--
1-3A	0.3	0.86	--
1-4B	8.0	17.81	--
1-5B	4.3	10.96	--
1-6B	12.8	18.12	--
Confluence Point	35.5	--	57.46
1-8A	0.8	1.66	--
1-9A	10.8	6.08	--
Discharge Point	47.1	--	65.22
2-1A	0.7	1.43	--
2-2A	0.5	1.12	--
Discharge Point	1.2	--	2.42
3-1A	12.2	6.64	6.64
Discharge to Burbank Blvd.			
4-1A	6.2	13.33	13.33
5-1A	2.3	4.59	--
5-2A	9.5	12.39	--
5-3A	2.4	3.13	--
5-4A	2.7	4.17	--
5-5A	3.5	5.12	--
Discharge Point	20.4	--	25.28
6-1A	1.1	2.04	2.04
7-1A	5.5	7.79	7.79
8-1A	2.5	6.14	6.14
9-1A	1.7	4.39	4.39
Discharge to Fulton Ave.			
10-1A	3.5	7.92	7.92
11-1A	5.1	11.36	11.36
12-1A	0.3	1.13	1.13
Discharge to Oxnard St.			
13-1A	0.7	1.91	1.91

2.3.3 Future Hydrology

Utilizing the *LACDPW TC* and *LAR04* modeling programs as described in Section 2.3.1, 25-year peak flow rates for each drainage sub-area were calculated for construction Phase 1 and Phase 2. The following tables summarize the calculated flow rates for each phase of construction. The following information correlates to the Future Hydrology Maps per Construction Phase (Exhibit 2.1 and Exhibit 2.2)

TABLE 2.5: 25-Year Future Hydrology Summary – Construction Phase 1

SUB-AREA	**AREA** (acres)	**PEAK FLOW** **Q** (cfs)	**CUMULATIVE FLOW** **ΣQ** (cfs)
Discharge to Hatteras St. & Tujunga Wash			
1-1A	3.3	5.34	--
1-2A	5.6	13.14	--
1-3B	8.2	18.30	--
1-4B	4.7	12.06	--
Confluence Point	21.8	--	43.74
1-6A	0.3	0.86	--
1-7B	8.0	16.04	--
1-8B	1.2	3.36	--
1-9B	4.2	10.97	--
Confluence Point	35.5	--	77.10
1-11A	0.5	1.12	--
1-12A	7.6	11.30	--
Discharge Point	43.6	--	92.90
2-1A	0.7	1.43	--
2-2A	0.5	1.12	--
Discharge Point	1.2	--	2.42
3-1A	0.8	2.14	
3-2A	0.5	0.86	
Discharge Point	1.3	--	3.00
Discharge to Burbank Blvd.			
4-1A	20.5	18.84	18.84
5-1A	2.3	4.59	--
5-2A	9.5	12.78	--
5-3A	3.8	4.95	--
5-4A	2.4	3.78	--
5-5A	4.8	11.35	--
Discharge Point	22.8	--	37.34
7-1A	1.1	3.29	3.29
9-1A	8.6	17.18	17.18

TABLE 2.5: 25-Year Future Hydrology Summary – Construction Phase 1 *(CONTINUED)*

SUB-AREA	AREA (acres)	PEAK FLOW Q (cfs)	CUMULATIVE FLOW ΣQ (cfs)
Discharge to Fulton Ave.			
10-1A	2.0	4.96	4.96
11-1A	5.1	11.36	11.36
12-1A	0.3	1.13	1.13
Discharge to Oxnard St.			
13-1A	0.6	1.52	1.52

TABLE 2.6: 25-Year Future Hydrology Summary – Construction Phase 2 (Final)

SUB-AREA	AREA (acres)	PEAK FLOW Q (cfs)	CUMULATIVE FLOW ΣQ (cfs)
Discharge to Hatteras St. & Tujunga Wash			
1-1A	3.3	5.34	--
1-2A	5.6	13.14	--
1-3B	8.2	18.30	--
1-4B	4.7	12.06	--
Confluence Point	21.8	--	43.74
1-6A	0.3	0.86	--
1-7B	3.8	4.95	--
1-8B	4.7	7.65	--
1-9B	8.0	16.04	--
1-10B	1.2	3.36	--
1-11B	4.2	10.97	--
Confluence Point	44.0	--	92.65
1-13A	0.5	1.12	--
1-14A	7.6	11.30	--
Discharge Point	52.1	--	108.54
2-1A	0.7	1.43	--
2-2A	0.5	1.12	--
Discharge Point	1.2	--	2.42
3-1A	0.8	2.14	
3-2A	0.5	0.86	
Discharge Point	1.3	--	3.00
Discharge to Burbank Blvd.			
4-1A	20.5	18.84	18.84
5-1A	2.3	4.59	--
5-2A	4.9	9.69	--

TABLE 2.6: 25-Year Future Hydrology Summary – Construction Phase 2 (Final) *(CONTINUED)*

SUB-AREA	AREA (acres)	PEAK FLOW Q (cfs)	CUMULATIVE FLOW ΣQ (cfs)
5-3A	2.4	3.78	--
5-4A	4.8	11.35	--
Discharge Point	14.4	--	29.56
7-1A	0.5	1.77	1.77
9-1A	9.2	18.46	18.46
Discharge to Fulton Ave.			
10-1A	2.0	4.96	4.96
11-1A	5.1	11.36	11.36
12-1A	0.3	1.13	1.13
Discharge to Oxnard St.			
13-1A	0.6	1.52	1.52

2.4 IMPERVIOUS COVER

According to the Letter of Clarification to part 4.D. Development Planning Program of the Los Angeles County Municipal Stormwater Permit (Appendix A), Permitees must minimize the percentage of additional impervious area to a generally accepted standard of 5% or less of the total project area. The Low Impact Designs (LIDs) and Best Management Practices (BMPs) presented in Sections 2.5 and 5.0, respectively are intended provide additional mitigation against any unforeseen increases in impervious cover.

Based on the Measure J Master Plan layout and Athletic Training Facility design documents, the following tables summarize the approximate percent impervious cover per future development project at the existing condition and final phase of construction; Phase 2. The Athletic Training Facility project is utilizing artificial turf for the athletic fields. For the purposes of this study, artificial turf is considered a pervious material.

TABLE 2.7: Existing Percent Impervious

FUTURE DEVELOPMENT	TOTAL AREA (acres)	EXISTING IMPERVIOUS AREA (acres)	% EXISTING IMPERVIOUS
FP-1	16.40	8.79	54%
FP-2	4.72	4.40	93%
FP-3	3.80	3.22	85%
FP-4	0.53	0.30	56%
FP-5	5.87	5.06	86%
FP-6	2.11	1.07	51%
FP-7	5.00	2.97	59%
FP-8	7.44	3.45	46%
FP-9	2.67	2.10	79%
FP-10	3.50	3.50	100%
FP-11	4.00	4.00	100%

TABLE 2.8: Future Percent Impervious

FUTURE DEVELOPMENT	TOTAL AREA (acres)	FUTURE IMPERVIOUS AREA (acres)	% FUTURE IMPERVIOUS
FP-1	16.40	6.40	39%
FP-2	4.72	2.42	51%
FP-3	3.80	2.80	74%
FP-4	0.53	0.36	68%
FP-5	5.87	4.64	79%
FP-6	2.11	1.16	55%
FP-7	5.00	3.80	76%
FP-8	7.44	5.58	75%
FP-9	2.67	1.34	50%
FP-10	3.50	3.50	100%
FP-11	4.00	4.00	100%

2.5 STORMWATER TREATMENT

LAVC has elected to utilize the County of LA SUSMP criteria as a guide for compliance with the State Water Resources Control Board (SWRCB) and Los Angeles Regional Water Quality Control Board (LARWQCB) requirements and regulations as described in Sections 1.4 and 3.0. As stated in Section 1.0, County of LA SUSMP requirements shall be used to help establish appropriate water quality mitigation measures including Best Management Practices (BMPs) for post-construction conditions.

2.5.1 Standard Urban Stormwater Mitigation Plan (SUSMP) Methodology

Volume-based or flow-based design standards may be used separately or in combination. Volume-based criteria are used in the sizing of infiltration structures while flow-based criteria are used on swales. The SUSMP requirements, approved by the Regional Water Quality Control Board (RWQCB), call for the treatment of the peak mitigation flow rate or volume of runoff produced by a 0.75 inch 24-hour rainfall event. Further description of flow-based and volume-based BMPs is provided in Section 5.0.

The SUSMP calculation methodology was used to calculate the required treatment flows and volumes for each of the future development projects. The equations, referenced from the LACDPW SUSMP Manual, for calculating the required treatment flow rate (i.e. peak mitigation flow rate) and treatment volume (i.e. mitigation volume) are shown below.

$$Q_{PM} = C_D * I_X * A_{Total} * (1.008333 \text{ ft}^3\text{-hour / acre-inches-seconds})$$

$$V_M = (2722.5 \text{ ft}^3 \text{ / acre}) * [(A_{Impervious}) * (0.9) + ((A_{Pervious}) * (C_U)]$$

Q_{PM} = Peak Mitigation Flow Rate (cfs)

V_M = Mitigation Volume (ft^3)

$A_{Impervious}$ = Impervious Area of Development (acres)

$A_{Pervious}$ = Pervious Area of Development (acres)

A_{Total} = Total Area of Development and Contributing Undeveloped Upstream Area (acres)

C_U = Undeveloped Runoff Coefficient*

C_D = Developed Runoff Coefficient

I_X = Rainfall Intensity (in / hour)

*The runoff coefficient curve for Soil Type 5 and Type 15 is included in Appendix D.

2.5.2 Concept Stormwater Treatment Analysis: Mitigation Flow Rate and Volume

The Future Development Map included as Exhibit 2.3 illustrates the main impervious and pervious areas of each future development project.

Utilizing the methodology described above, he following table summarizes the estimated treatment flow rates and volumes for the future development projects based on the Measure J Master Plan layout and Athletic Training Facility design documents.

TABLE 2.9: Mitigation Flow Rate and Volume

Future Development	A_T (acres)	A_I (acres)	A_p (acres)	C_U	C_D	Q_{PM} (cfs)	V_M (ft^3)
FP-1	16.40	6.40	10.00	0.1	0.61	**1.9**	**18,404**
FP-2	4.72	2.42	2.30	0.1	0.66	**0.6**	**6,556**
FP-3	3.80	2.80	1.00	0.1	0.74	**0.5**	**7,133**
FP-4	0.53	0.36	0.17	0.1	0.72	**0.2**	**928**
FP-5	5.87	4.64	1.23	0.1	0.75	**0.9**	**11,704**
FP-6	2.11	1.16	0.95	0.1	0.67	**0.6**	**3,101**
FP-7	5.00	3.80	1.20	0.1	0.74	**0.7**	**9,638**
FP-8	7.44	5.58	1.86	0.1	0.74	**2.5**	**14,179**
FP-9	2.67	1.34	1.33	0.1	0.65	**0.8**	**3,645**
FP-10	3.50	3.50	0.00	0.1	0.83	**1.3**	**8,576**
FP-11	4.00	4.00	0.00	0.1	0.83	**0.6**	**9,801**

To provide the most conservative results, a minimum Time of Concentration (Tc) of 5 minutes was used in the concept stormwater treatment analysis for the future development projects. For future development projects currently in design by others, the Tc was determined based on the longest flowpath shown in design documents provided by the CPM.

2.5.3 Infiltration

Soil infiltration effectively removes soluble and particulate pollutants. Infiltration is only feasible on permeable soils and where the water table and bedrock are situated well below the bottom of the percolation level. Infiltration systems include infiltration basins, infiltration trenches and bio-retention areas. An infiltration BMP is designed to capture a defined volume of storm runoff, retain it, and infiltrate all or part of that volume into the ground.

The following is a list of limitations for infiltration trenches from the LA County SUSMP Manual.

1. Slope of contributing watershed needs to be less than 20 percent.

2. Soil should have an infiltration rate greater than 0.3 inches per hour and clay content less than 30 percent.

3. The bottom of the infiltration trench should be at least 4 feet above the underlying bedrock and the season high water table.

4. Drainage area should be between 1 and 10 acres in size.

5. Infiltration trench cannot be located within 100 feet of local drinking water wells.

6. Infiltration trench needs to be located a minimum of 10 feet down gradient and 100 feet up gradient from building foundations because of seepage problems.

Design criteria for infiltration are provided in the LA County SUSMP Manual and shall be used as a guideline for design and implementation.

In the case that the specific development and/or project site can not meet the conditions and limitations suitable for stormwater infiltration as listed above, the stormwater treatment system shall be designed as a filtration system. By utilizing the landscape and soil surface, soil filtration will effectively remove soluble and particulate pollutants and treat stormwater similar to an infiltration system. However, stormwater is collected by a sub surface drainage system that discharges the treated water to the downstream storm drain system. A filtration BMP is designed to capture the same defined volume of storm runoff as an infiltration BMP, retain it, and filtrate all or part of that volume through the surface to the designed subsurface collection system.

2.5.4 Low Impact Design (LID)

Low Impact Design is a design approach which tries to minimize the impacts that a proposed project has on its surroundings by attempting to mimic the site's natural state as closely as possible. The basic principals are for the site design to capture, store, filter, evaporate, detain and/or infiltrate runoff as close to the source as possible. This concept deviates from the traditional mind set of drainage control devices which attempt to capture surface runoff into subsurface pipes as soon as possible. Conversely, LIDs attempt to keep runoff on the surface, in vegetated areas, to allow for detention, evaporation, and infiltration. The 5 basic design principals of LIDs are:

- Conserve Natural Areas and Vegetation
- Minimize and Disconnect Impervious Surfaces
- Direct Runoff to Natural and Landscaped Areas
- Use Integrated Management Practices (IMPs)
- Stormwater Education

Some LIDs are not practical for project sites due to poor soil permeability, high soil contamination, steep slopes, and shallow water tables. However, the ideas behind LIDs should be maintained wherever possible during the project's preliminary design process.

2.6 STORMWATER TREATMENT FINDINGS AND RECOMMENDATIONS

Based on the concept stormwater treatment analysis presented herein, the following summarizes recommended best Management Practices (BMPs) and water quality mitigation measures for each future development project. The future development projects shall also incorporate pre-treatment systems and LIDs into the individual project drainage designs. Graphic locations of the future stormwater treatment systems are illustrated on the Stormwater Treatment Map included as Exhibit 2.4. Additional information and descriptions of various types of BMPs can be found in Section 5.0 and Appendix G of this report.

Approximate locations of existing stormwater treatment systems constructed with Bond A/AA development projects are also shown on Exhibit 2.4. Analysis of the existing stormwater treatment systems was not included as part of this report.

The following table provides a summary of anticipated treatment totals to be considered by the future development projects.

TABLE 2.10: Stormwater Treatment Summary

FUTURE DEVELOPMENT	TREATMENT TOTAL		CONTRIBUTING FUTURE DEVELOPMENT
	Q_{PM} (cfs)	V_M (ft^3)	
FP-1	1.9	18,404	FP-1
FP-2	0.6	6,556	FP-2
FP-3	0.5	7,133	FP-3
FP-5	1.5	17,805	FP-4, FP-5, Existing Student Services
FP-7	0.7	9,638	FP-7
FP-8	2.68	17,119	FP-8, 30% FP-11
FP-9	1.8	13,000	FP-6, FP-9, 15.9 acres of Exist. Site
FP-10	1.3	8,576	FP-10
FP-11	0.42	6,861	70% FP-11

FP-1 (Athletic Training Facility)

The Athletic Training Facility (ATF) project will develop 16.4 acres of campus property east of Ethel Ave. and includes a new building, athletic fields and associated site improvements. The ATF 100% Construction Documents (prepared by Cannon Design; dated 9/20/10) specify a filter cartridge system as the project's stormwater treatment system and as identified on the design documents, it has capacity to treat a peak flow rate of 1.4 cfs. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 1.9 cfs and 18,404 ft^3, respectively. However, according to the detailed analysis provided by the ATF design team the project has a mitigated flow rate and volume of 1.42 cfs and 20,089 ft^3, respectively. The filter cartridge system, as shown in the 100% Construction Documents has sufficient capacity to treat the minimum requirement.

FP-2 (Multi-Purpose Community Services Center)

The Multi-Purpose Community Services Center project will develop 4.72 acres of campus property east of Ethel Ave. and includes a new building, athletic field and associated site improvements. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 0.6 cfs and 6,556 ft^3, respectively.

The athletic practice field, currently part of the project program, shall be designed to serve as a stormwater treatment facility, utilizing the landscape boundary and grass turf to filter stormwater prior to discharge. At the College's request, stormwater shall be collected within either the south or east portions of the field, standing water shall be mitigated and the draw-down time shall be limited to a maximum 4 hours.

FP-3 (Parking Lots H and J)

Parking Lots H and J project includes demolition of the existing bungalow buildings and development of new parking lots within a 3.8 acre site at the south end of campus, adjacent to Burbank Blvd. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 0.5 cfs and 7,133 ft^3, respectively.

Stormwater BMPs such as vegetated swales shall be incorporated in to the parking lot design to treat stormwater runoff from the project site and prior to discharge.

FP-4 (Planetarium Building Expansion)

The Planetarium Building Expansion project includes expansion of the existing Planetarium building at the south-west corner of campus, north of the MTA Parking Lot. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 0.2 cfs and 928 ft^3, respectively.

Due to the size of the project and unavailable space surrounding the building area, the Planetarium Expansion project shall utilize Parking Lot A stormwater treatment system to treat stormwater runoff from the project site.

FP-5 (Parking Lot A (MTA Parking Lot))

Parking Lot A project includes renovation to an existing parking lot at the south-west corner of campus adjacent to the intersection of Burbank Blvd. and Fulton Ave. The Parking Lot A 100% Construction Documents (prepared by Berliner and Associates; dated 1/29/07) specify vegetated swales as the project's stormwater treatment system and as identified on the design documents, they have capacity to treat 15.7 cfs of stormwater. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 0.9 cfs and 11,704 ft^3, respectively. According to the concept analysis presented herein, the stormwater treatment system, as shown in the 100% Construction Documents has sufficient capacity to treat the minimum requirement.

The stormwater treatment system shall also be used to treat stormwater from a recently constructed Student Services Center and the future Planetarium Building Expansion project (reference future development project FP-4). According to the LAVC Campus Facilities Department, the infiltration wells installed with the Student Services Center have not been functioning properly during the 2010/2011 storm events. To avoid future problems such as building flooding, the College plans to provide a storm drain connection from the Student Services Center to Parking Lot A stormwater treatment system. Based on a concept analysis, the Student Services Center has an estimated mitigated flow rate and volume of 0.4 cfs and 5,173 ft^3.

FP-6 (Workforce Development Center / Administration Building)

The Workforce Development Center / Administration Building project includes demolition of the existing Administration Building, construction of a new building and associated site improvements at west side of campus, adjacent to Fulton Ave. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 0.6 cfs and 3,101 ft^3, respectively.

Stormwater runoff from the project site shall be treated by the CSWIP via a connection to the existing underground storm drain east of the project site. Pre-treatment and LIDs shall be provided prior to discharge to the existing storm drain system.

FP-7 (Media Arts / Performing Arts (MAPA) Center)

The MAPA Center project includes a new building and associated site improvements at the north end of campus. The MAPA Center 75% Construction Documents (prepared by Ehrlich Architects; dated 12/20/10) specify a Storm Tech Chamber system as the project's stormwater treatment system and as illustrated in the design documents, it has capacity to treat 13,777 ft^3 of stormwater. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 0.7 cfs and 9,638 ft^3, respectively. According to the concept analysis presented herein, the future stormwater treatment system as shown in the 75% Construction Documents has sufficient capacity to treat the minimum requirement.

FP-8 (Monarch Center and Parking Structure)

The Monarch Center and Parking Structure project includes construction of a new building, parking structure and associated site improvements at west of Ethel Ave. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 2.5 cfs and 14,179 ft^3, respectively.

Stormwater BMPs such as vegetated swales and infiltration basins shall be provided within the project limits to treat stormwater runoff from the project site and prior to discharge. In addition to treating stormwater runoff from its own project site, the Monarch Center and Parking Structure project shall be designed to treat stormwater runoff from a portion of the Parking Lot D Renovation project (reference future development project FP-11).

FP-9 (Campus-wide Stormwater Infrastructure Project (CSWIP))

The CSWIP includes new site improvements surrounding the existing Campus Center building and a campus-wide stormwater treatment system. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 0.8 cfs and 3,645 ft^3, respectively.

In addition to treating stormwater runoff from its own project site, the CSWIP shall be designed to treat stormwater runoff from the Workforce Development Center / Administration Building project (reference future development project FP-6). There shall also be additional capacity to treat a minimum 20% of stormwater runoff from 15.9 acres of the existing campus which shall not be development as part of the Measure J Master Plan and is tributary to the CSWIP.

FP-10 (Parking Lot B)

Parking Lot B project includes renovation of approximately 3.50 acres of an existing parking lot at the north-west corner of campus. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 1.3 cfs and 8,576 ft^3, respectively.

Stormwater BMPs such as vegetated swales shall be incorporated in to the parking lot design to treat stormwater runoff from the project site and prior to discharge.

FP-11 (Parking Lot D)

Parking Lot D project will renovate 4.00 acres of an existing parking lot, including new solar photo voltaic system west of Ethel Ave. Based on the concept stormwater treatment analysis presented herein, the project has an anticipated mitigated flow rate and volume of 0.6 cfs and 9,801 ft^3, respectively.

Stormwater runoff from the south-west portion of the parking lot (approximately 1.2 acres) shall be treated by the Monarch Center and Parking Structure project. Stormwater BMPs such as vegetated swales shall be incorporated along the eastern boundary of the parking lot to treat the remaining stormwater runoff.

2.7 CONCEPT STORM DRAIN SYSTEM ANALYSIS

The capacity of the existing and future storm drain system has been estimated based on initial evaluation of the systems. Only main storm drain lines with a diameter larger than 8-inches were considered in the analysis. Since a majority of the campus depends on surface flow to convey and discharge stormwater during large storm events, the storm drain systems' ability to collect and convey the entire 25-year storm event was not evaluated. The concept analysis merely provides an estimated capacity for the existing and future pipe networks and may be used as necessary by the campus and future design teams to determine system improvements based on project specific parameters.

2.7.1 Methodology

Partially full storm drain pipes, culverts, and weirs were modeled as open channel flow. Water surfaces, and velocities, were computed by using Flowmaster (Haestad, Inc.).

2.7.2 Existing Storm Drain System

The existing campus stormwater primarily surface flows to the surrounding campus roads and City of LA streets. The existing storm drainage system collects small storm events, low flows, and nuisance flows, but does not provide flood protection for the 25-year storm event. Refer to Section 2.1 for further description of the existing campus storm drain system.

The existing storm drain system modeling results are provided in the table below and the associated pipes and nodes are shown on the Storm Drain Pipe and Node Map included as Exhibit 2.5.

TABLE 2.11: Existing Storm Drain System Analysis

UPSTREAM NODE	**DOWNSTREAM NODE**	**SIZE** (in)	**SLOPE**	**MATERIAL**	**ROUGHNESS COEFFICIENT**	**FULL FLOW CAPACITY** (cfs)
C-001	C-000	30"	0.005 *	PVC	0.010	37.7
C-002	C-001	12"	0.005 *	PVC	0.010	3.3
C-003	C-002	12"	0.005 *	PVC	0.010	3.3
C-004	C-003	12"	0.005 *	PVC	0.010	3.3
C-005	C-004	12"	0.005 *	PVC	0.010	3.3
E-001	E-000	12"	0.020	PVC	0.010	6.6
E-002	E-001	12"	0.020	PVC	0.010	6.6
E-003	E-002	12"	0.020	PVC	0.010	6.6
F-002	F-001	15"	0.005 *	VCP	0.010	5.9
F-003	F-002	15"	0.005 *	VCP	0.010	5.9
G-002	G-001	15"	0.003	RCP	0.013	3.5
H-002	H-001	15"	0.008	VCP	0.010	7.5
H-003	H-002	12"	0.008	VCP	0.010	4.1

* = Minimum slope of .005 assumed. Existing invert data not available

The existing storm drain system information was obtained from campus record and survey information collected by Psomas as part of the Utility Master Plan (Psomas, April 26, 2010).

2.7.3 Future Storm Drain System

The future storm drain system modeling results are provided in the table below and the associated pipes and nodes are shown on the Storm Drain Pipe and Node Map included as Exhibit 2.5.

TABLE 2.12: Future Storm Drain System Analysis

UPSTREAM NODE	DOWNSTREAM NODE	SIZE (in)	SLOPE	MATERIAL	ROUGHNESS COEFFICIENT	FULL FLOW CAPACITY (cfs)
A-001	A-000	18"	0.010 [1]	RCP	0.013	10.5
A-003	A-002	12"	0.005 [1]	HDPE	0.010	3.3
A-004	A-003	12"	0.005 [1]	HDPE	0.010	3.3
A-005	A-004	12"	0.005 [1]	HDPE	0.010	3.3
A-101	A-002	12"	0.005 [1]	HDPE	0.010	3.3
A-102	A-101	12"	0.005 [1]	HDPE	0.010	3.3
B-001	B-000	27"	0.010 [2]	PVC	0.010	40.3
B-002	B-001	24"	0.003 [2]	PVC	0.010	16.1
B-003	B-002	24"	0.003 [2]	PVC	0.010	16.1
B-004	B-003	24"	0.003 [2]	PVC	0.010	16.1
B-005	B-004	21"	0.003 [2]	PVC	0.010	11.3
B-006	B-005	21"	0.003 [2]	PVC	0.010	11.3
B-007	B-006	21"	0.003 [2]	PVC	0.010	11.3
B-008	B-007	18"	0.003 [2]	PVC	0.010	7.5
B-101	B-001	18"	0.005 [2]	PVC	0.010	9.7
B-102	B-101	15"	0.005 [2]	PVC	0.010	5.9
B-103	B-102	12"	0.005 [2]	PVC	0.010	3.3
B-104	B-103	12"	0.006 [2]	PVC	0.010	3.6
D-001	C-000	30"	0.005 *	RCP	0.013	29.0
D-002	D-001	30"	0.005 *	RCP	0.013	29.0
D-003	D-002	30"	0.005 *	RCP	0.013	29.0
F-001	F-000	7'wx5"h	0.005 *	RCB	0.013	12.0
G-001	G-000	18"	0.005 *	RCP	0.013	9.8
H-001	H-000	18"	0.005 *	VCP	0.010	9.5
I-001	I-000	8"	0.005 [3]	PVC	0.010	1.1
J-001	J-000	8"	0.005 *	PVC	0.010	1.1
K-001	K-000	12"	0.020 *	PVC	0.010	6.6

* = Pipe slope and size assumed based on preliminary concept analysis. Final pipe slope and size shall be determined from detailed hydraulic analysis of the final design.

[1] = Storm drain system information based on MTA Bus Station Extension; 100% Construction Documents; prepared by Berliner and Associates; dated January 29, 2007.

[2] = Storm drain system information based on Athletic Training Facility; 100% Construction Documents; prepared by Cannon Design; dated September 20, 2010.

[3] = Storm drain system information based on Media Arts & Performing Arts Complex; 75% Construction Documents; prepared by Ehrlich Architects; dated December 20, 2010.

2.8 STORM DRAIN SYSTEM FINDINGS AND RECOMMENDATIONS

The existing and future storm drain system capacity concept analysis results are provided in Section 2.7. The storm drain system locations are illustrated on the Storm Drain Pipe and Node Map, included as Exhibit 2.5.

The following summarizes findings and recommendations to the existing storm drain system and recommendations for improvements to support future development. The following also includes review of the storm drain system design provided in the design documents prepared by others.

Storm Drain Line “A”

Based on review of the 100% Construction Documents (prepared by Berliner and Associates; dated 1/29/07) and analysis included herein, Line “A” has sufficient capacity for the project area, but the stormwater treatment system shall also treat stormwater from adjacent projects. This is anticipated to increase the flow rate within the project site. As specified in the design documents the project stormwater treatment system has capacity to treat 15.7 cfs; however the pipe system is estimated to have capacity for 10.5 cfs. We recommend that the design team re-evaluate the storm drain system design to ensure capacity for the adjacent projects.

Storm Drain Line “B”

Based on review of the 100% Construction Documents (prepared by Cannon Design; dated 9/20/10) and analysis included herein, we recommend that the design consider providing additional capacity for the 25-year peak flow rate and for the Multi-Purpose Community Services Center (FP-2). Also the project is diverting all stormwater to the existing catch basin in Burbank Blvd. Pre-development conditions show that the project site was split with a portion draining to Burbank Blvd. and the remainder draining to a catch basin which discharges east directly to the Tujunga Wash. We recommend that the design team verifies whether the existing catch basin and storm drain system in Burbank Blvd. has capacity for the additional stormwater.

Storm Drain Line “C”

Future development shown in the Measure J Master Plan is not anticipated to affect Storm Drain Line “C”.

Storm Drain Line “D”

As part of the CSWIP (FP-9), a new discharge pipe shall be provided to discharge stormwater from the CSWIP directly to the Tujunga Wash. The discharge pipe shall be installed in the City of LA right of way and in a City of LA easement within Ethel Ave. and Hatteras St., respectively. Catch basins shall be installed at the intersection of Ethel Ave. and Hatteras St. to collect stormwater and reduce flooding at the intersection during large storm events. The storm drain improvements will require approval by the City of LA. A direct connection to the Tujunga Wash would require approval with the County of LA.

The pipe size shown for Line “D” in the concept system analysis included herein is assumed based on the size of the existing storm drain system at the down stream connection within Hatteras St. It is not anticipated that the entire 25-year storm event will be contained within the underground system and Ethel Ave. will still be used for stormwater conveyance. The intent for Line “D” is to assist with discharge of stormwater from the campus, specifically the Campus-wide Stormwater Infrastructure Project (CSWIP) and alleviate surface runoff and flooding at the Hatteras and Ethel Ave. intersection. The project design team shall perform detailed hydrology and hydraulic calculations to determine final storm drain design including pipe size, pipe slope, catch basin sizing and catch basin locations.

Storm Drain Line “E”

Future development shown in the Measure J Master Plan is not anticipated to affect Storm Drain Line “E”.

Storm Drain Line “F”, “G”, and “H”

Campus flood protection for the 25-year storm is dependent on surface flow. Existing storm drain lines “F”, “G”, and “H” do not provide flood protection. Most of the stormwater surface flows east to Campus Dr. and does not make it in to the pipe system. During large storm events this causes flooding of

Campus Dr. which is primarily used by students and staff as a pedestrian walkway. The following are two options to address this issue:

1. The College may consider replacing the existing storm drain system to increase size and capacity, thus reducing surface water. This option was not considered in the concept analysis included herein due to the anticipated cost and disruption to the campus.

2. Maintain the existing storm drain system and provide improvements at the downstream ends to collect and intercept additional surface flow. There are opportunities with future development projects such as the CSWIP and the Monarch Center and Parking Structure project to provide the storm drain system improvements necessary to minimize surface flow and alleviate campus flooding. This option was considered in the concept analysis included herein.

Existing storm drain line "H" shall be extended to provide a pipe connection to the southern/upstream end of the CSWIP. This will allow the CSWIP to collect and treat stormwater currently draining in Line "H", including the future Workforce Development Center / Administration Building (FP-6). A storm drain catch basin shall be installed adjacent to Node H-001 to collect additional surface flow.

Storm Drain Line "I"

Based on review of the 75% Construction Documents (prepared by Ehrlich Architects; dated 12/20/10) and analysis included herein, Line "I" has sufficient capacity for the project area. However we recommend that the design team consider providing additional capacity for the 25-year peak flow rate and for potential overflow from Parking Lot B north of the project site.

Storm Drain Line "J"

Storm Drain Line "J" shall be provided to allow the Planetarium Building Expansion project to discharge stormwater to the Parking Lot A stormwater treatment system for conveyance and treatment.

Storm Drain Line "K"

Storm Drain Line "K" shall be provided to discharge stormwater from the south-west portion of Lot D to the Monarch Center and Parking Structure stormwater treatment system for conveyance and treatment.

General

- Near the south end of Campus Dr., stormwater currently flows off the roof of existing pedestrian canopies creating a waterfall affect. To prevent this condition and provide increased personal safety, improved maintenance of the existing canopy downspouts shall be required and the College has requested that additional downspouts with direct connection from the canopy roof to Line "H" shall be provided.

- The selected design teams for the future development projects described herein shall comply with the requirements and recommendations presented in this report. The College would like each design team to provide stormwater calculations at each design deliverable to illustrate compliance with this report and current local and state stormwater quality regulations.

- According to the geotechnical reports listed in Section 2.1.3, the percolation tests identified in each report were performed by using varying testing methods. However none of the tests were performed using a double ring infiltrometer test (per ASTM D3385), which is the preferred method for stormwater infiltration design. We recommend that additional percolation tests be performed using a double ring infiltrometer test when stormwater infiltration is considered in project design.

2.9 STORMWATER POLLUTION PREVENTION PLAN

Runoff from construction sites can have a significant impact on water quality since it may be contaminated with pollutants. Sediment is usually the main pollutant of concern, and excessive erosion from construction sites and discharge of sediment into receiving waters are usually the most visible water quality impacts due to construction activities. Per the LACCD specifications, contractors are required to submit a Stormwater Pollution Prevention Plan (SWPPP) prior to construction. As outlined in the LACCD specifications, the SWPPP is developed for the purpose of preventing the discharge of pollutants from the construction site to the receiving waters during construction, including elimination of non-stormwater pollution discharges such as improper dumping, spills or leakage from storage tanks or transfer areas. The new General Permit, which took effect on July 1, 2010, has significant changes to SWPPP requirements, processing, monitoring, etc. It is recommended that LAVC, their representatives and contractors review the new General Permit so that existing SWPPPs can be revised accordingly.

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3.0 REGULATIONS

The Los Angeles County Standard Urban Stormwater Mitigation Plan (SUSMP), described in Section 1.0 is the primary medium for permit compliance for the County and City of Los Angeles. This section gives more detail on the Federal and State regulations which led to the development of the Los Angeles County SUSMP.

3.1 FEDERAL POLLUTION CONTROL ACT – CLEAN WATER ACT

The Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA) establishes a permitting framework under the NPDES program to address stormwater discharges associated with urban areas and certain industrial activities. The objective is to restore and maintain the chemical, physical, and biological integrity of the nation's waters by preventing point and non-point pollution sources, providing assistance to publicly owned treatment works for the improvement of wastewater treatment, and maintaining the integrity of wetlands.

Pollutants regulated under the CWA include "priority" pollutants, including various toxic pollutants; "conventional" pollutants, such as biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, oil and grease, and pH; and "non-conventional" pollutants, including any pollutant not identified as either conventional or priority. The CWA regulates both direct (point source) and indirect (non-point source) discharges.

The following are sections of the CWA which are relevant to this project:

- Section 303(d): Total Maximum Daily Loads (TMDLs)
- Section 319: Non-point Source Prevention and Control Program
- Section 402: NPDES Program

3.2 TOTAL MAXIMUM DAILY LOADS (TMDLs)

Section 303(d) of the 1972 CWA requires that jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. A TMDL is a regulatory method for establishing the amount of pollutants that a water body can accept before beneficial uses are adversely impacted. TMDLs are implemented for impaired waters to help restore the beneficial uses of those waters. In California, the SWRCB is responsible for preparing a list of impaired waters (known as the 303(d) list) that serves as the basis for establishing TMDLs. This report considers 303(d) listed waters and the reason for their impairment, as well as any TMDLs that have been completed for 303(d) listed waters, in selection and implementation of control measures and BMPs.

The campus discharges to a City owned MS4 storm drain which eventually discharges to Reach 6 of the Los Angeles River. Reach 6 is included on the 2008 CWA Section 303(d) List of Water Quality Limited Sections, approved by the LARWQCB on July 16, 2009, for coliform bacteria.

A Consent Decree issued on March 23, 1999 and signed by Heal the Bay, Santa Monica BayKeeper, and the USEPA mandates a schedule for the development of TMDLs for the LA River for the following constituents:

- Trash
- Nutrients
- Metals

- Bacteria
- Organics
- Oils

TMDLs for trash, nutrients and metals have already been developed. The City of Los Angeles is in the process of implementing requirements in order to meet these TMDLs thresholds.

3.3 NON-POINT SOURCE PREVENTION AND CONTROL PROGRAM

Congress amended the CWA in 1987 to establish the Section 319 Non-point Source Management Program to control pollution added from non-point sources to the navigable waters within the State and improve the quality of such waters.

Non-point source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. Examples of NPS pollutants include:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff and energy production;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks;
- Salt from irrigation practices and acid drainage from abandoned mines;
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems;
- Atmospheric deposition and hydro modification are also sources of nonpoint source pollution.

In December 1999, the State Water Resources Control Board (SWRCB), in its continuing efforts to control NPS pollution in California, adopted the Plan for California's Non-point Source Pollution Control Program (NPS Program Plan). The NPS Program Plan upgraded the State's first Non-point Source Management Plan adopted by the SWRCB in 1988. Upgrading the 1988 Plan with the NPS Program Plan brought the State into compliance with the requirements of section 319 of the Clean Water Act (CWA) and section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA).

In May 2004, the SWRCB adopted the "Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program" (Nonpoint Source Program). The purpose of the Nonpoint Source Program is to improve the State's ability to effectively manage nonpoint source pollution and conform to the requirements of the federal Clean Water Act and the federal Coastal Zone Management Act. The plan describes three options for addressing nonpoint source pollution: waste discharge requirements, conditional waivers of waste discharge requirements, and discharge prohibitions. The plan also describes elements of nonpoint source control implementation programs, including anti-degradation requirements, management practices, time schedules, feedback to Regional Board to evaluate the program progress and appropriate Board actions to correct program deficiencies, if appropriate.

3.4 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT PROGRAM

CWA Section 402 prohibits the discharge of pollutants into waters of the United States from any point source without an NPDES permit. To regulate stormwater (non-point source) discharges, EPA developed a two-phased NPDES permit program as discussed below.

In November 1990, under Phase I of its stormwater program, the EPA published NPDES permit requirements for municipal and industrial stormwater discharges, which included the following:

- Municipalities that own and operate separate storm drain systems serving populations of 100,000 or more, or that contribute significant pollutants to waters of the United States, must obtain municipal stormwater NPDES permits.
- A municipality must develop and implement a stormwater management program to obtain a permit.
- The municipal stormwater management program must address how to reduce pollutants in industrial stormwater discharges and other discharges that are contributing a substantial pollutant load to their systems.
- Facilities that are discharging stormwater associated with industrial activity, including construction activities that disturb 5 or more acres, must acquire industrial stormwater NPDES permit coverage.

The City of Los Angeles falls under this Phase 1 permit coverage.

On August 7, 1995, the EPA amended the NPDES permit requirements in order to focus on Phase II stormwater discharges, such as discharges caused by:

- Commercial, light industrial, and institutional activities;
- Construction activities under 5 acres and greater than one acre; and
- Regulated municipal storm drain systems serving populations under 100,000. (Regulated Small MS4s)

Similar to Phase I requirements, the NPDES Phase II permit program also required the development and implementation of stormwater management plans to reduce such discharges. The Phase II program went into effect in early 2003, after which affected agencies were required to obtain NPDES Phase II permit coverage.

3.5 PORTER-COLOGNE WATER QUALITY CONTROL ACT

The Porter-Cologne Water Quality Control Act (Porter-Cologne; California Water Code Section 13000) is California's equivalent to the Federal CWA. Under the Porter-Cologne Water Quality Control Act, the State Water Resources Control Board (SWRCB) is provided with the ultimate authority over state water rights and water quality policy. The Regional Water Quality Control Boards (RWQCBs) provide oversight on water quality issues at a regional and local level. Los Angeles Valley College (LAVC) lies within the jurisdiction of the Los Angeles RWQCB (Region 4) (LARWQCB).

3.6 LOS ANGELES NPDES PERMIT

The RWQCBs implement the municipal stormwater NPDES permit program through area-wide permits for urbanized areas that are considerable sources of pollutants or contribute to water quality standard violations. Regardless of population, the area-wide permits cover all municipalities within the defined urban area. The Municipal Stormwater Permitting Program of the SWRCB regulates stormwater discharges from MS4s. The MS4 permit program was implemented in two phases as noted previously, where:

- Phase I covers medium municipalities (serving between 100,000 and 250,000 people) and large municipalities (serving 250,000 people). These permits are typically issued to a group of co-permitees encompassing an entire metropolitan area. The co-permittees are required to implement a regional stormwater management to reduce discharges of pollutants in stormwater to the Maximum Extent Practicable (MEP).

- Phase II covers smaller municipalities, including non-traditional Small MS4s, which are stormwater systems serving public campuses (including universities, community colleges, primary schools, and other publicly owned learning institutions with campuses), military bases, and prison and hospital complexes within or adjacent to other regulated MS4s, or which pose significant water quality threats. The SWRCB adopted a statewide General Permit for the Discharge of Stormwater from Small MS4s (WQ Order No. 2003-0005-DWQ, referred to as the “Small MS4 General Permit”) to provide permit coverage for these smaller municipalities and non-traditional Small MS4s. MS4 permits require the discharger to develop and implement a Stormwater Management Plan/Program (SWMP) with the goal of reducing the discharge of pollutants to the Maximum Extent Practicable (MEP). The management programs specify what BMPs will be used to address certain program areas. The permit requires that the SWMP be developed to address six “minimum control measures,” or program areas, including public education and outreach; public participation and involvement, illicit discharge detection and elimination; construction site runoff control, post-construction runoff control, and good housekeeping for municipal operations.

On December 13, 2001, the Los Angeles RWQCB adopted Order No. 01-182. This Order is the NPDES Permit (NPDES No.CAS004001) for municipal stormwater and urban runoff discharges within the County of Los Angeles. As adopted in December 2001, the requirements of Order No. 01-182 (the “Permit”) covers 84 cities (including the City of Los Angeles) and the unincorporated areas of Los Angeles County, with the exception of the portion of Los Angeles County in the Antelope Valley including the cities of Lancaster and Palmdale, the City of Long Beach, and the City of Avalon. Under the Permit, the Los Angeles County Flood Control District is designated as the Principal Permittee and the County of Los Angeles along with the 84 incorporated cities are designated as Co-Permittees.

In compliance with the Permit, the Permittees have implemented a stormwater quality management program (SQMP) with the ultimate goal of accomplishing the requirements of the Permit and reducing the amount of pollutants in stormwater and urban runoff. The SQMP is broken up into six separate programs. These programs are Public Information and Participation, Industrial/Commercial Facilities, Development Planning, Development Construction, Public Agency Activities, and Illicit Connection/Illicit Discharge. One specific requirement of the Development Planning Program is the Standard Urban Stormwater Mitigation Plan (SUSMP). The SUSMP outlines the necessary Best Management Practices (BMPs) which must be incorporated into design plans.

Section D. of the LA County MS4 Permit states that the permittees may lack legal jurisdiction over entities outside of the Permittees’ boundaries under state and federal constitutions. Under this permit, the LA County MS4 permit does not have jurisdictional authority over LAVC. A letter from the SWRCB clarifying the Part 4.D. Development Planning Program of the LA County MS4 Permit (Appendix A) describes the requirements for LACCD college campuses, including LAVC. There are three provisions that serve as essential requirements for compliance with the Los Angeles County MS4 permit, which include maximizing the percentage of permeable surfaces to allow percolation of stormwater into the ground; Minimize the quantity of stormwater directed to impermeable surfaces and the public storm drain system; and Minimize pollution emanating from parking lots through the use of appropriate treatment control BMPs and good housekeeping practices.

The LACCD college campuses have not been automatically designated for permit coverage under Phase II, and therefore are currently not required to obtain permit coverage. However, Attachment 3 of the Small MS4 General Permit (SWRCB Order No. 2003-0005-DWQ, NPDES General Permit No. CAS000004, included in Appendix B) identifies LAVC, along with the other LACCD college campuses, in anticipation for future permit coverage in the category Non-traditional Small MS4.

Once designated by SWRCB or RWQCB, regulated Small MS4s that are non-traditional MS4s must submit to the appropriate RWQCB, an NOI, a complete SWMP (one hard copy and one electronic copy in

Word or PDF format), and an appropriate fee within 180 days of notification of designation (or at a later date stated by SWRCB or RWQCB).

Although we have not seen documentation it is our understanding that the LACCD may have already received a notification from the LARWQCB requiring them to obtain permit coverage. The report herein does not go into the level of detail that is required for permit issuance; however it is geared toward the implementation of the anticipated requirements that would arise from permit coverage.

For additional information on the Phase II General Permit for the Discharge of Stormwater from Small MS4s (WQ Order No. 2003-0005-DWQ), refer to the following website: http://www.swrcb.ca.gov

3.7 LOS ANGELES REGIONAL WATER QUALITY CONTROL BOARD BASIN PLAN

On June 13, 1994, the LARWQCB adopted a Water Quality Control Plan (Basin Plan) for the Los Angeles County region. The Basin Plan specifies the beneficial uses for both existing water bodies and receiving waters within their jurisdiction. Beneficial uses of the water bodies are protected by both narrative and numeric water quality objectives and the State's Anti-degradation policy.

Receiving waters are defined as designated bodies of water that receive discharge from surrounding lands within a watershed. The Los Angeles Basin Plan defined receiving waters according to hydrologic unit basin numbers. The LAVC campus falls within the jurisdiction of the Los Angeles RWQCB (LARWQCB) as defined herein. The project site stormwater discharges to the Los Angeles River Reach 6 (above Sepulveda Flood Control Basin). According to the LARWQCB Basin Plan, the Los Angeles River Reach 6 Hydrologic Unit is identified as HU 405.21. Reach 6 of the Los Angeles River is included on the 2006 CWA Section 303(d) List of Water Quality Limited Segments, approved by the LARWQCB on July 16, 2009, for the following: 1,1-Dichloroethane (1,1-DCE)/Vinylidene chloride, Coliform Bacteria, Selenium, Tetrachloroethylene/PCE, Trichloroethylene/TCE A.

** This section is intended to summarize the regulatory and policy history of the existing stormwater quality requirements. The regulations and requirements are constantly changing in this ever evolving field. This report is our interpretation of the applicable laws and regulations pertinent to County and City of Los Angeles and LAVC at the time of issuance of this report.

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4.0 POLLUTANTS

4.1 POLLUTANTS OF CONCERN

Pollutants that are typically expected to be present in stormwater include sediment, nutrients, trash, metals, bacteria, oil and grease, organics and pesticides. Table 4.1 lists these pollutants and typical activities that are expected to generate them.

Sediment

Sediments are soils or other surface 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.

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.

Trash

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. Also, 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.

Metals

Metals are raw material components in non-metal products such as fuels, adhesives, paints, and other coatings. The primary sources 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. 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.

Bacteria

Viruses are a common pollutant in water, however they are difficult to identify in a reasonable time frame. Bacteria is easy to identify, and is an indicator of the presence of viruses. Common sources of bacteria are sanitary sewer overflows, animal excrement, food particles, and restaurants. An over abundance of bacteria and viruses could cause human illness, the death of aquatic organisms, and the impairment of beneficial use of waterways.

Oil & Grease

Oil and grease are characterized as high-molecular weight organic compounds. The 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.

Organics

Organic compounds are carbon-based (commercially available or naturally occurring) substances 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.

Pesticides

Pesticides (including herbicides) are chemical compounds commonly used to control nuisance growth of organisms. Excessive application of a pesticide may result in runoff containing toxic levels of its active component.

TABLE 4.1: Potential Pollutants of Concern

Activity	**Potential Pollutants of Concern**							
	Sediment	**Nutrients**	**Trash**	**Metals**	**Bacteria**	**Oil & Grease**	**Organics**	**Pesticides**
Building Maintenance & Repair	✓		✓	✓			✓	
Equipment Maintenance & Repair				✓		✓	✓	
Food Service Operations			✓		✓	✓	✓	
Fueling						✓	✓	
Landscape Maintenance	✓	✓	✓		✓			✓
Material Loading & Unloading		✓	✓	✓		✓	✓	✓
Material Storage, Handling & Disposal	✓		✓			✓	✓	✓
Minor Construction	✓		✓					
Parking Lot Maintenance	✓		✓	✓		✓		
Spill Prevention Control		✓	✓			✓	✓	✓
Vehicle & Equipment Cleaning	✓	✓	✓	✓		✓	✓	
Vehicle & Equipment Storage				✓		✓	✓	
Waste Handling & Disposal		✓	✓	✓	✓	✓	✓	

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5.0 BEST MANAGEMENT PRACTICES (BMPs)

The U.S. EPA guidance states that in order to meet the goals of post-development peak discharge rate, volume and pollutant loading to receiving waters being the same as pre-development values, BMPs should be implemented to achieve three main objectives:

1. Flow control
2. Pollutant removal
3. Pollutant source reduction.

Similarly, Section 2.4 of the California Stormwater BMP Handbook for Development and Redevelopment (2003), states that planning and design principles promote three basic strategies in the following order of preference based on effectiveness and costs:

1. Reduce or eliminate post-project runoff.
2. Control sources of pollutants.
3. Treat contaminated stormwater runoff before discharging it to natural water bodies.

Structural BMPs shall be provided for pre-construction and post-construction stormwater quality mitigation. Post-construction stormwater quality mitigation measures also include treatment control and source control BMPs. The Standard Urban Stormwater Mitigation Plan (SUSMP) as described herein may be used to help establish appropriate mitigation levels.

5.1 TREATMENT CONTROL BMPS

There are several treatment control BMPs that may be implemented to effectively treat the identified pollutants of concern, as shown in Table 5.1 below. Both flow based and volume based BMPs are shown in the table and described in detail below. The primary parameter for designing Treatment Control BMPs is to treat the stormwater quality design flow (QBMP) or the stormwater quality design volume (VBMP) of the stormwater runoff. Flow-based BMP design standards apply to BMPs whose primary mode of pollutant removal depends on the rate of flow of runoff through the BMP. Volume-based BMP design standards apply to BMPs whose primary mode of pollutant removal depends on the volumetric capacity of the BMP. Volume-based Treatment Control BMPs shall be designed to infiltrate or treat the design volume of runoff. Detailed descriptions of treatment control BMPs are provided below.

TABLE 5.1: Treatment Control BMP Selection Matrix [1]

Pollutant of Concern	Biofilters (2)	Detention Basins (3)	Infiltration BMPs (4)	Wet Ponds or Wetlands (5)	Filtration Systems (6)	Water Quality Inlets	Hydrodynamic Separator Systems (7)	Manufactured or Proprietary Devices (8)
Sediment/Turbidity	H/M	M	H/M	H/M	H/M	L	H/M (L for Turbidity)	U
Nutrients	L	M	H/M	H/M	L/M	L	L	U
Organic Compounds	U	U	U	U	H/M	L	L	U
Trash & Debris	L	M	U	U	H/M	M	H/M	U
Bacteria & Viruses	U	U	H/M	U	H/M	L	L	U
Oil & Grease	H/M	M	U	U	H/M	M	L/M	U
Pesticides (non-soil bound)	U	U	U	U	U	L	L	U
Metals	H/M	M	H	H	H	L	L	U

Abbreviations:

L = Low Removal Efficiency

H/M = High or Medium Removal Efficiency

U = Unknown Removal Efficiency

Notes:

(1) Excerpted, with minor revision, from the Riverside County Water Quality Control Plan (September 17, 2004), Orange County Water Quality Management Plan dated September 26, 2003 and the San Bernardino Water Quality Management Plan dated April 14, 2004.

(2) Includes grass swales, grass strips, wetland vegetation swales, and bioretention.

(3) Includes extended/dry detention basins with grass lining and extended/dry detention basins with impervious lining. Effectiveness based upon minimum 36-48-hour drawdown time.

(4) Includes infiltration basins, infiltration trenches, and pervious pavements.

(5) Includes permanent pool wet ponds and constructed wetlands.

(6) Includes sand filters and media filters.

(7) Also known as hydrodynamic devices, baffle boxes, swirl concentrators, or cyclone separators.

(8) Includes proprietary stormwater treatment devices as listed in the CASQA Stormwater Best Management Practices Handbooks, other stormwater treatment BMPs not specifically listed in this WQMP, or newly developed/emerging stormwater treatment technologies.

5.2 FLOW-BASED TREATMENT CONTROL BMPS

Vegetated Swales

A vegetated swale is a wide, shallow densely vegetated channel that treats Urban Runoff as it is slowly conveyed into a downstream system. These swales have very shallow slopes in order to allow maximum contact time with the vegetation. The depth of the design flow should be less than the height of the vegetation. Contact with vegetation improves water quality by plant uptake of pollutants, removal of sediment, and an increase in infiltration. Overall the effectiveness of grass swales is limited and they are recommended in combination with other BMPs.

Vegetated swales require a thick vegetative cover to function properly. They usually require normal landscape maintenance activities such as irrigation and mowing to maintain pollutant removal efficiency. The application of fertilizers and pesticides should be minimized. Consider use of duplicate facilities such that one one-half of the facility can be taken out of service to allow for maintenance without reducing the required level of treatment performance. This is especially helpful for vegetated swales that need to be dry before they can be mowed.

Vegetated Filter Strips

Vegetated filter strips are uniformly graded areas of dense vegetation designed to treat sheet flow Urban Runoff. Pollutants are removed by filtering and through settling of sediment and other solid particles as the design flow passes through (not over) the vegetation. Filter strips are usually as wide as the tributary area and must be long enough in the flow direction to adequately treat the runoff. Concentrated flows are redistributed uniformly across the top of the strip with a level spreader. A grass swale, sand filter, or infiltration BMP is recommended in conjunction with a filter strip.

Vegetated filter strips require frequent landscape maintenance. Maintenance requirements typically include grass or shrub-growing activities such as irrigation, mowing, trimming, removal of invasive species, and replanting when necessary. Consider use of duplicate facilities such that one one-half of the facility can be taken out of service to allow for maintenance without reducing the required level of treatment performance. This is especially helpful for vegetated filter strips that need to be dry before they can be mowed.

Water Quality Inlet

A water quality inlet is a device that removes oil and grit from Urban Runoff before the water enters the MS4. It consists of one or more chambers that promote sedimentation of coarse materials and separation of free oil from Urban Runoff. Manufacturers have created a variety of configurations to accomplish this. A specific model can be selected from the manufacturer based on the design flow rate. A water quality inlet is generally used for pretreatment before discharging into another type of BMP.

Water quality inlet (WQI) maintenance is site-specific due to variations in sediment and hydrocarbon by-products, which may require disposal as hazardous waste. Establishment of a maintenance schedule is helpful for ensuring proper maintenance, because the WQIs are underground and can easily be neglected. High sediment loads can interfere with the ability of the WQI to effectively separate oil and grease from the runoff.

Other BMPs

In some cases, other flow-based BMPs, proprietary BMPs or combinations of BMPs may be appropriate for a development. Such BMPs or combinations of BMPs may be employed on a site-specific basis as approved by the Co-Permittee. The appropriate BMP(s) for a Project should be determined based on the size of the project area and the types of pollutants that will be found in the development runoff.

5.3 VOLUME-BASED TREATMENT CONTROL BMPs

Extended Detention Basin

An extended detention Basin is a permanent basin sized to detain and slowly release the design volume of Urban Runoff, allowing particles and associated pollutants to settle out. The basin outlet is designed to slowly release this runoff over a set drawdown period. An inlet forebay section and an inlet energy dissipater minimize erosion from entering flows, while erosion protection at the outlet prevents damage from exiting flows. The bottom of the basin slopes towards the outlet at an approximate grade of two percent, and a low flow channel conveys incidental flows directly to the outlet end of the basin. The basin should be vegetated earth in order to allow some infiltration to occur, although highly pervious soils may require an impermeable liner to prevent groundwater contamination. Proper turf management is also required to ensure that the vegetation does not contribute to water pollution through pesticides, herbicides, or fertilizers. A permanent micro-pool should not be included due to vector concerns. Extended detention basins can also be used to reduce the peaks of small run-off events for flood control purposes.

Extended detention basins require inspection semi-annually and after significant storm events to identify potential problems early. Most maintenance efforts will need to be directed toward vegetation management and vector control, which may focus on basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely, within the set drawdown time, to prevent creating vector habitats.

Infiltration Basin

Infiltration basins perform better in well-drained permeable soils. Infiltration basins in areas of low permeability can clog within a couple of years, and require more frequent inspection and maintenance. The use and regular maintenance of pretreatment BMPs will significantly minimize maintenance requirements for the basin. Spill response procedures and controls should be implemented to prevent spills from reaching the infiltration basin. Particular care is required where the area upstream of the infiltration BMP may not be fully stabilized, or in existing developments where upstream areas may become destabilized due to construction work, lack of maintenance, fire, or other actions. In these cases, measures to prevent sediment from entering and clogging the BMP are necessary until the tributary area is stabilized. This BMP may require groundwater monitoring. Basins should not be put into operation until the upstream tributary area is stabilized.

Infiltration Trench

An infiltration trench is an excavated trench that has been refilled with a gravel and sand bed capable of holding the design volume of Urban Runoff. The runoff is stored in the trench over a period of time during which it slowly infiltrates back into the naturally pervious surrounding soil. This infiltration process effectively removes soluble and particulate pollutants; however it is not intended to trap coarse sediments. These trenches also include a bypass system for volumes greater than the design capture volume, and a perforated pipe observation well to monitor water depth.

Infiltration trenches require an effective pretreatment, such as vegetated buffer strips, to remove sediment and minimize clogging. If the trench clogs, it may be necessary to remove and replace all or part of the filter fabric and possibly the coarse aggregate. Maintenance should be concentrated on the pretreatment practices, such as buffer strips and swales upstream of the trench to ensure that sediment does not reach the infiltration trench. Particular care is required where the area upstream of the infiltration BMP may not be fully stabilized, or in existing developments where upstream areas may become destabilized due to construction work, lack of maintenance, fire, or other actions. In these cases, measures to prevent sediment from entering and clogging the BMP are necessary until the tributary area is stabilized. Regular inspection should determine if the sediment removal structures require routine maintenance. Infiltration basins should not be put into operation until the upstream tributary area is stabilized.

Sand Filter

Sand filters clog easily when subjected to heavy sediment loads. Sediment reducing pretreatment practices, such as vegetated buffer strips or vegetated swales, placed upstream of the filter should be maintained properly to reduce sediment loads into the filter. Media filters should drain within the set drawdown time to minimize vector habitat. Maintenance will need to focus on basic housekeeping practices such as removal of debris accumulations and vegetation management (within media filter) to prevent clogs and/ or standing water. Materials such as sand, gravel, filter cloth, or filter media must be disposed of properly and in accordance with all applicable laws.

Pervious Pavement

Pervious Pavement is an infiltration BMP that consists of pervious pavement blocks placed over a shallow recharge bed of sand and gravel. It is typically restricted to low volume parking areas that do not receive significant offsite runoff. The modular pavement blocks allow water to seep into the recharge bed, where the sand and gravel layers percolate the design volume into the natural surrounding soils. Pervious Pavement can be used for areas of up to 10 acres.

Other BMPs

In some cases, other volume-based BMPs, proprietary BMPs or combinations of BMPs may be appropriate for a development. Such BMPs or combinations of BMPs may be employed on a site-specific basis as approved by the Co-Permittee. The appropriate BMP(s) for a Project should be determined based on the size of the project area and the types of pollutants that will be found in the development runoff.

5.4 SOURCE CONTROL BMPs

It is recommended that the future developments incorporate one or more of the following source control BMPs:

1. Peak Stormwater Runoff Discharge Rates
2. Conserve Natural Areas
3. Minimize Stormwater Pollutants of Concern
4. Protect Slopes and Channels
5. Provide Storm Drain System Stenciling and Signage
6. Properly Design Trash Storage Areas
7. Provide Proof of Ongoing BMP Maintenance
8. Properly Design Loading/Unloading Dock Areas
9. Properly Design Repair/Maintenance Bays
10. Properly Design Vehicle/Equipment/Accessory Wash Areas

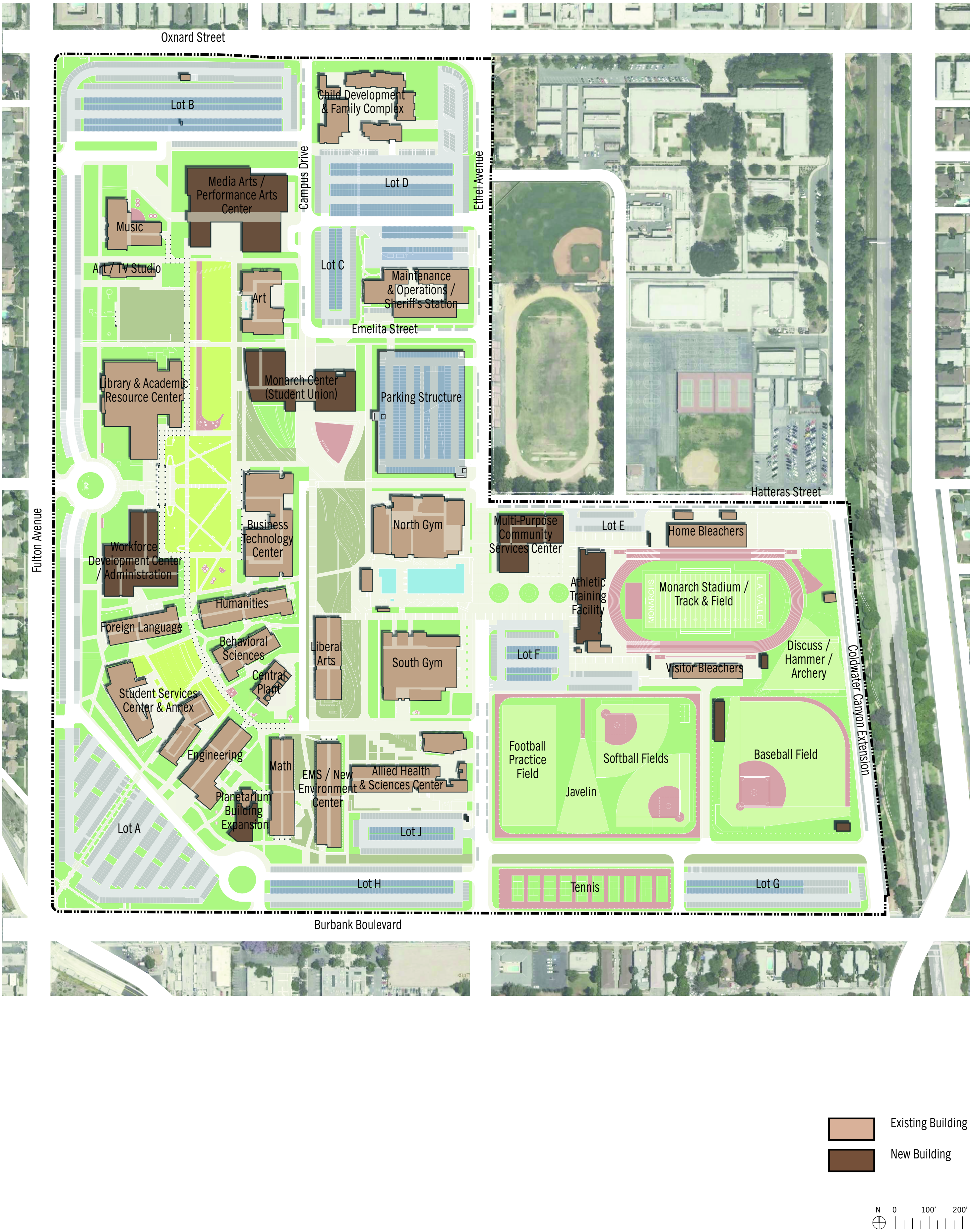
5.5 MAINTENANCE

The College shall be aware of the required maintenance for various types of BMPs. The following Table 5.2 provides examples of maintenance requirements for different BMP types. The information presented below is from Part B of the City of Los Angeles BMP Handbook, 3rd edition.

TABLE 5.2: Example Maintenance Requirements of Select BMPs

BMP Type	Example Maintenance
Wet Detention Basins/Ponds	Inspect after the first rain event during the first few months after construction, and annually thereafter. Inspect, clean, and remove litter and floating materials after each rain event. Provide supplement water supply during dry season. Inspect condition of aquatic life, if any.
Vegetated Swales and Strips	Trim vegetation regularly to avoid woody growth and increase of vegetation density. Excessive vegetation may hinder infiltration.
Dry Ponds	Inspect regularly during rainy season and remove trash, litter, debris, and other solid materials that hinder infiltration. Re-vegetate any eroded areas.
Infiltration Trenches	Inspect infiltration trench surface if evidence of clogging exists. Clear and remove litter and debris from the trench surface after each rain event. If an observation well is installed, measure groundwater depth before and after rain season.
Catch Basin Inserts	Inspect before rain season starts, remove trash and debris, inspect filter media and replace before start of rain season or as necessary. Service or replace defective system parts. Inspect after the first rain event and perform similar steps as above. After rain season, remove trash, debris, or oil accumulation from the insert manifold.
Media Filtration	Replace filter media/material at the beginning of rain season or as necessary when saturated with pollutants.
Pervious Pavement	Prevent soil from being washed onto pavement and keep landscape areas well maintained Inspect pavement at least twice per year. Inspect outlets annually. Vacuum/Pressure wash clogged surfaces.
Continuous Separation Systems	Inspect system for clogging before rain season starts and remove trash, debris, and other solids. Service or replace defective system parts. Inspect after the first rain event and perform similar steps as above. After rain season, remove trash, debris, or oil accumulation from the system.

*** Further descriptions and detailed information of stormwater BMPs may be found in the California Stormwater BMP Handbook; New Development and Redevelopment (www.cabhandbooks.com). Copies of Fact Sheets for select BMPs relative to the LAVC campus are provided in Appendix G of this report and at www.cabhandbooks.com



Los Angeles Valley College
Measure J Stormwater Master Plan

Exhibit 1.0
Measure J Master Plan - Horizon 1

April 15, 2011

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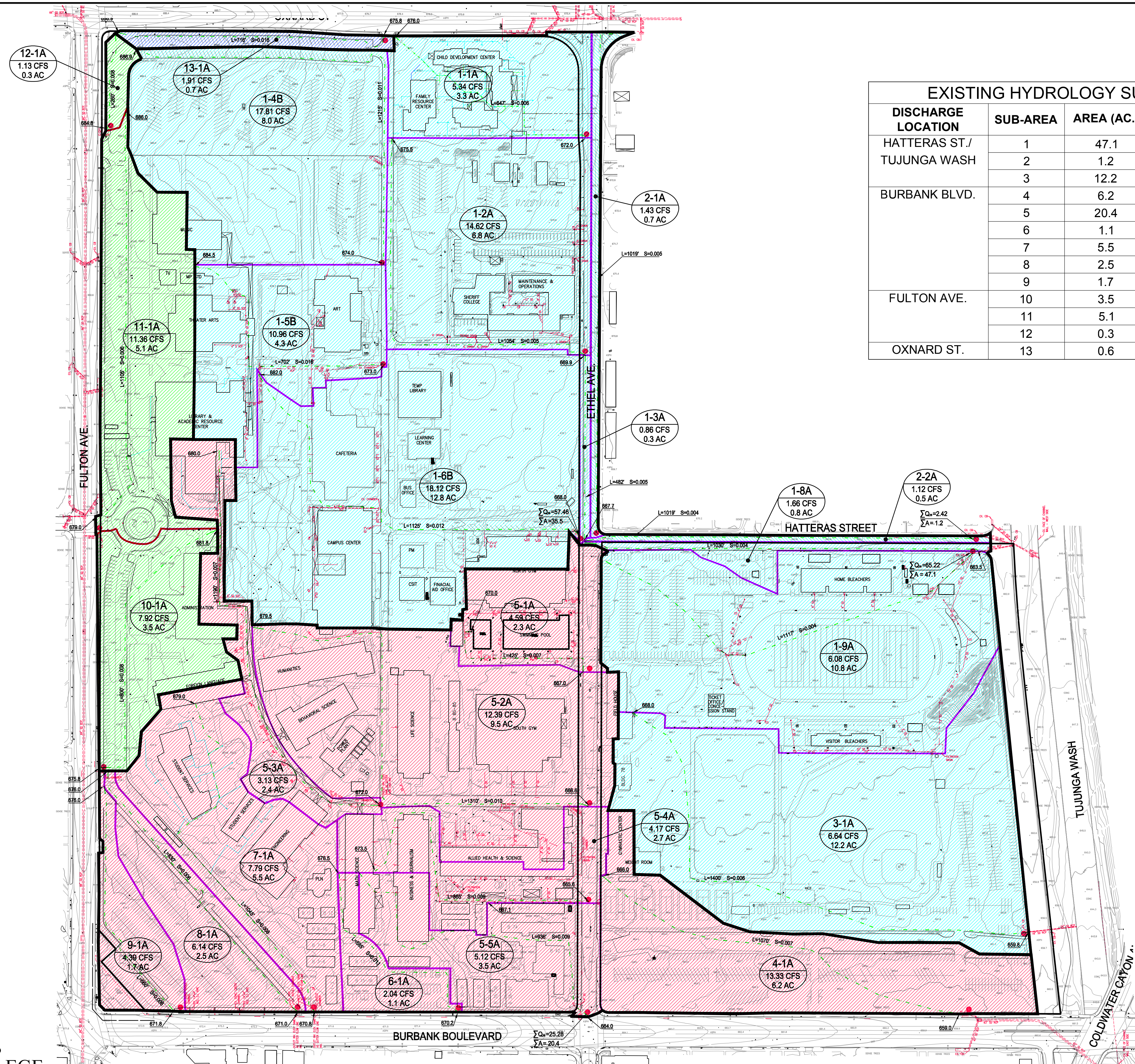

EXISTING HYDROLOGY SUMMARY

DISCHARGE LOCATION	SUB-AREA	AREA (AC.)	EXISTING PEAK Q_{25} (CFS)
HATTERAS ST./ TUJUNGA WASH	1	47.1	65.22
	2	1.2	2.42
	3	12.2	6.64
BURBANK BLVD.	4	6.2	13.33
	5	20.4	25.28
	6	1.1	2.04
	7	5.5	7.79
	8	2.5	6.14
	9	1.7	4.39
FULTON AVE.	10	3.5	7.92
	11	5.1	11.36
	12	0.3	1.13
OXNARD ST.	13	0.6	1.91

LEGEND

- AREA DISCHARGE TO HATTERAS ST./ TUJUNGA WASH
- AREA DISCHARGE TO BURBANK BLVD.
- AREA DISCHARGE TO FULTON AVE.
- AREA DISCHARGE TO OXNARD ST.
- DRAINAGE AREA BOUNDARY
- DRAINAGE SUB-AREA BOUNDARY
- EXISTING STORM DRAIN
- FLOWPATH
- POINT OF DISCHARGE
- $\sum Q_{25}$=2.61 — CUMULATIVE PEAK FLOW RATE, Q_{25} (CFS)
- $\sum A$= 1.2 — TOTAL TRIBUTARY AREA (ACRES) AREA
- 5-2A — AREA; 22 CFS — PEAK FLOW RATE, Q_{25}; 0.4 AC — AREA (AC.)

LOS ANGELES VALLEY COLLEGE
Measure J Stormwater Master Plan

Exhibit 2.0
Existing Hydrology Map

PSOMAS

April 15, 2011

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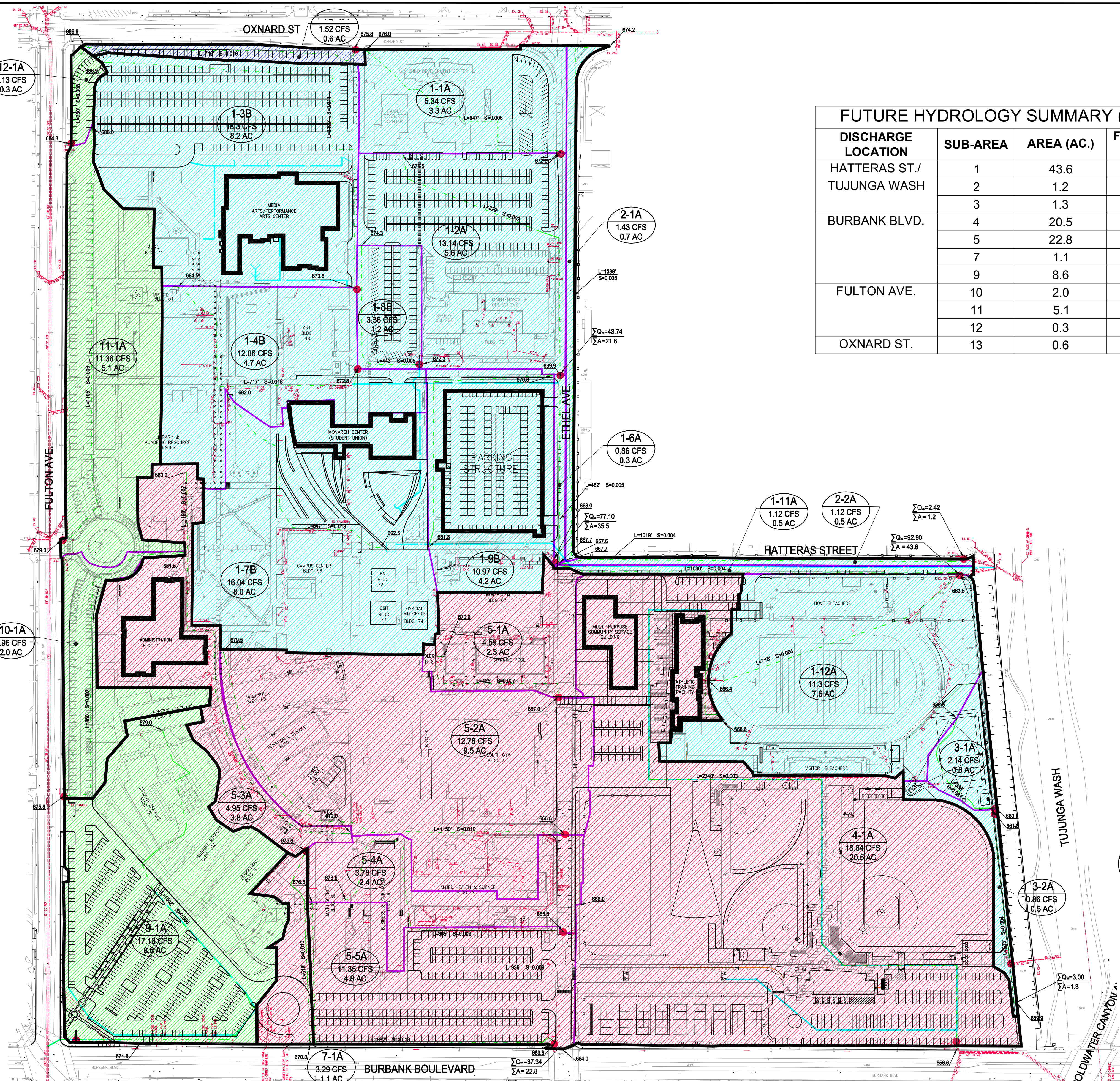


FUTURE HYDROLOGY SUMMARY (PHASE 1)

DISCHARGE LOCATION	SUB-AREA	AREA (AC.)	FUTURE PEAK Q_{25} (CFS)
HATTERAS ST./ TUJUNGA WASH	1	43.6	92.90
	2	1.2	2.42
	3	1.3	3.00
BURBANK BLVD.	4	20.5	18.84
	5	22.8	37.34
	7	1.1	3.29
	9	8.6	17.18
FULTON AVE.	10	2.0	4.96
	11	5.1	11.36
	12	0.3	1.13
OXNARD ST.	13	0.6	1.52

LEGEND

- FUTURE MEASURE J BUILDING
- AREA DISCHARGE TO HATTERAS ST./ TUJUNGA WASH
- AREA DISCHARGE TO BURBANK BLVD.
- AREA DISCHARGE TO FULTON AVE.
- AREA DISCHARGE TO OXNARD ST.
- DRAINAGE AREA BOUNDARY
- DRAINAGE SUBAREA BOUNDARY
- FUTURE STORM DRAIN
- EXISTING STORM DRAIN
- FLOWPATH
- POINT OF DISCHARGE
- $\sum Q_{25}=2.61$ — CUMULATIVE PEAK FLOW RATE, Q_{25} (CFS)
- $\sum A= 1.2$ — TOTAL TRIBUTARY AREA (ACRES) AREA
- 5-2A — AREA
- 22 CFS — PEAK FLOW RATE, Q_{25}
- 0.4 AC — AREA (AC.)

NTS

LOS ANGELES VALLEY COLLEGE
Measure J Stormwater Master Plan

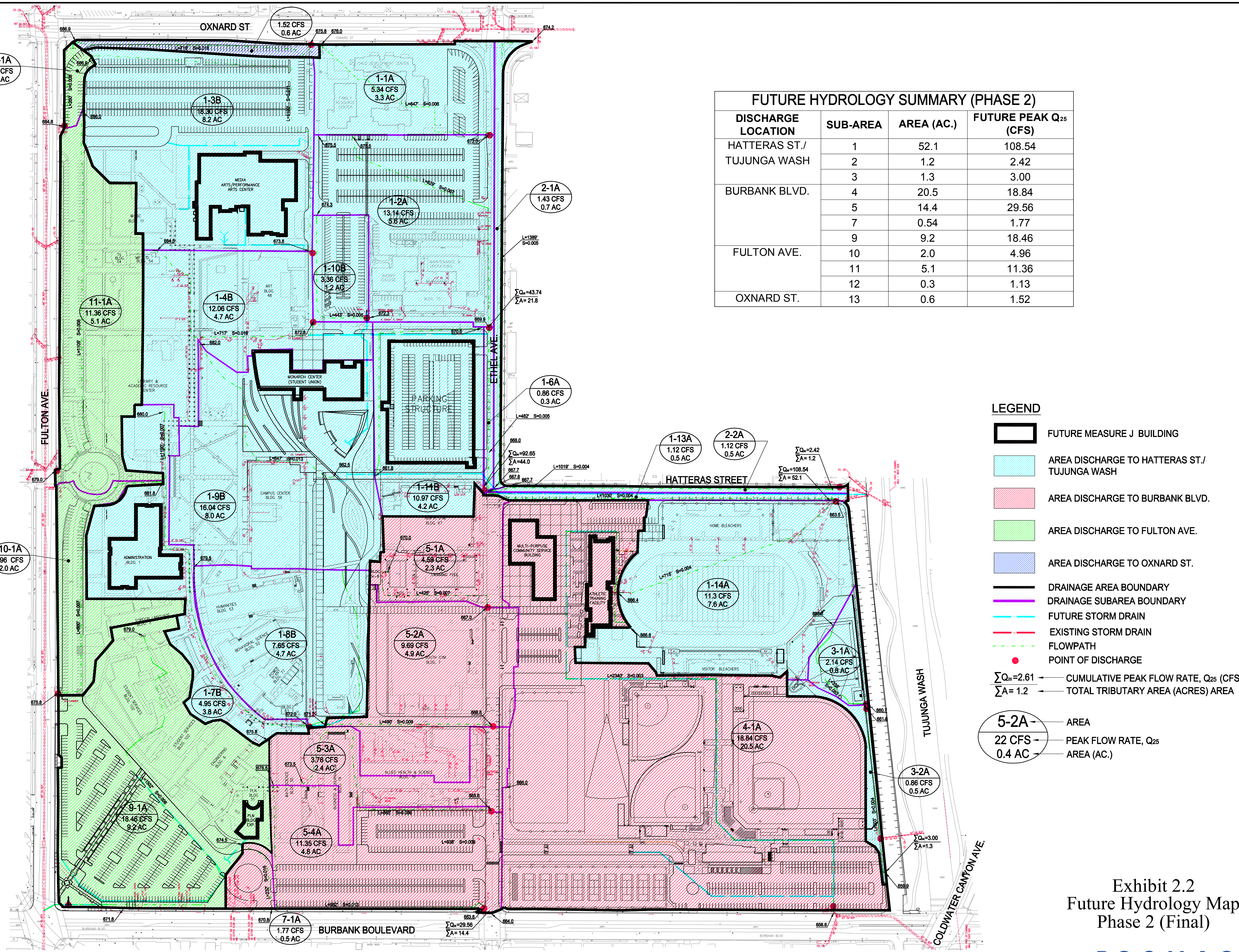
Exhibit 2.1
Future Hydrology Map
Phase 1

PSOMAS

April 15, 2011

FUTURE HYDROLOGY SUMMARY (PHASE 2)

DISCHARGE LOCATION	SUB-AREA	AREA (AC.)	FUTURE PEAK Q_{25} (CFS)
HATTERAS ST./ TUJUNGA WASH	1	52.1	108.54
	2	1.2	2.42
	3	1.3	3.00
BURBANK BLVD.	4	20.5	18.84
	5	14.4	29.56
	7	0.54	1.77
	9	9.2	18.46
FULTON AVE.	10	2.0	4.96
	11	5.1	11.36
	12	0.3	1.13
OXNARD ST.	13	0.6	1.52



LOS ANGELES VALLEY COLLEGE
Measure J Stormwater Master Plan

Exhibit 2.2
Future Hydrology Map
Phase 2 (Final)

PSOMAS

April 15, 2011

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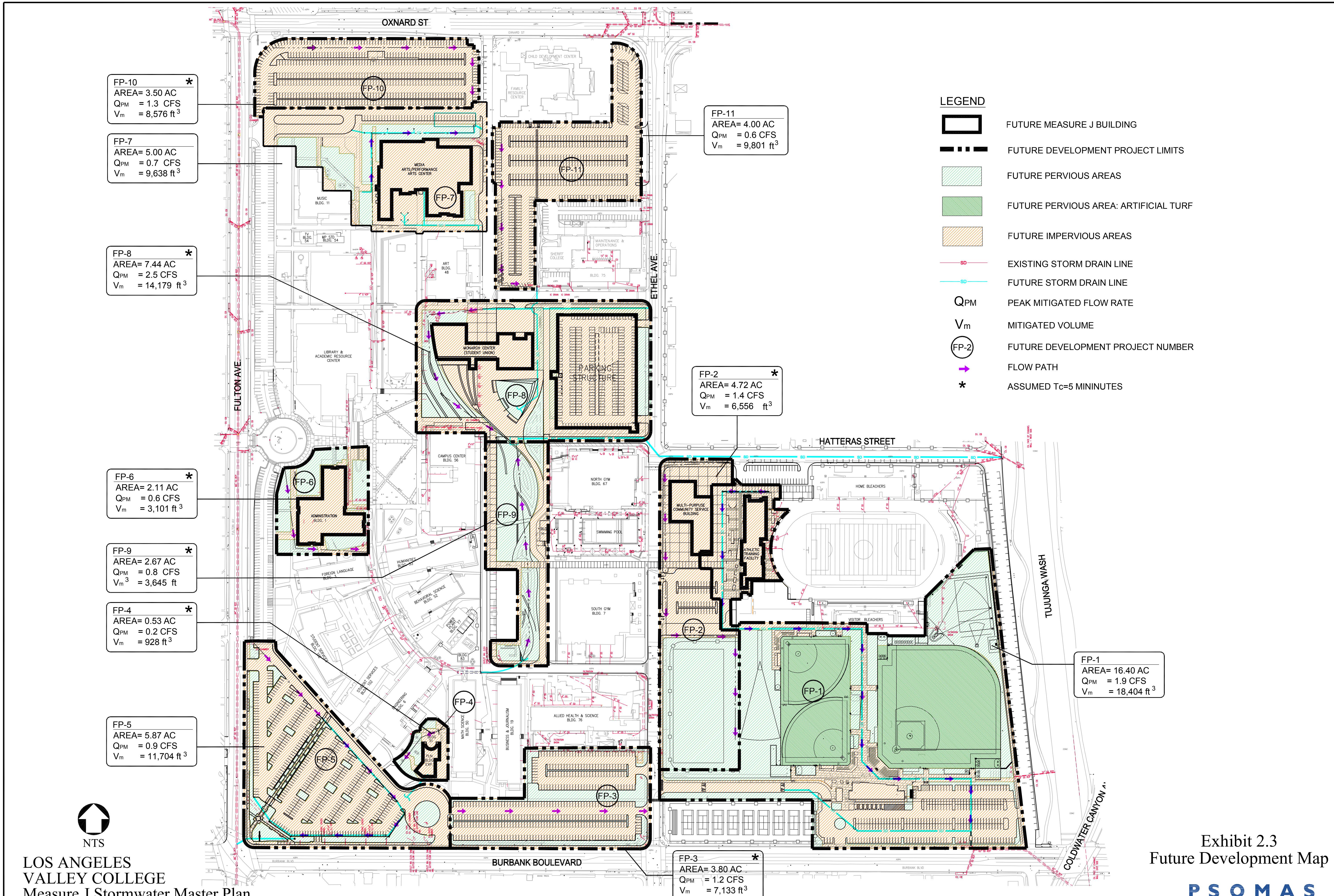

Exhibit 2.3
Future Development Map

April 15, 2011

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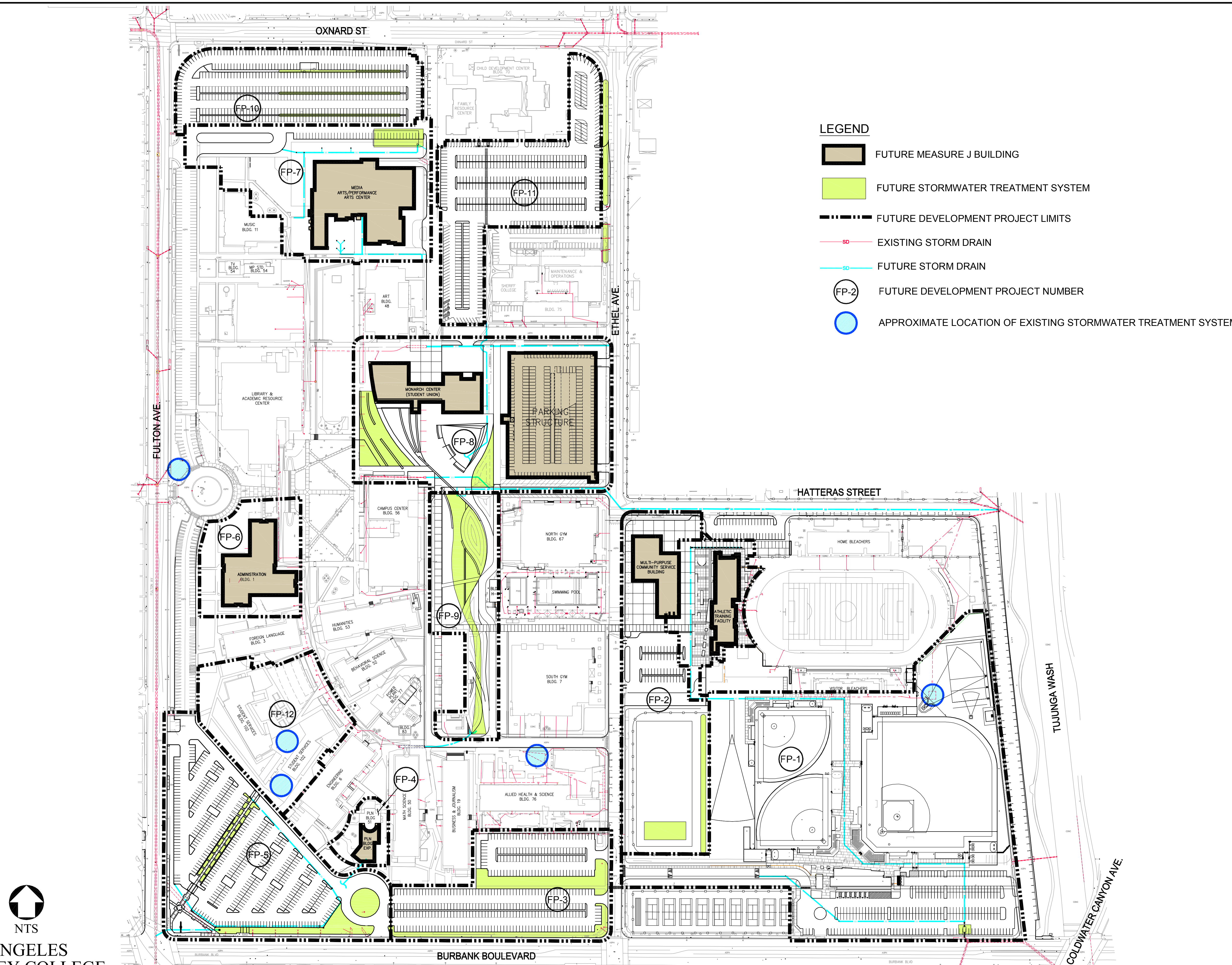
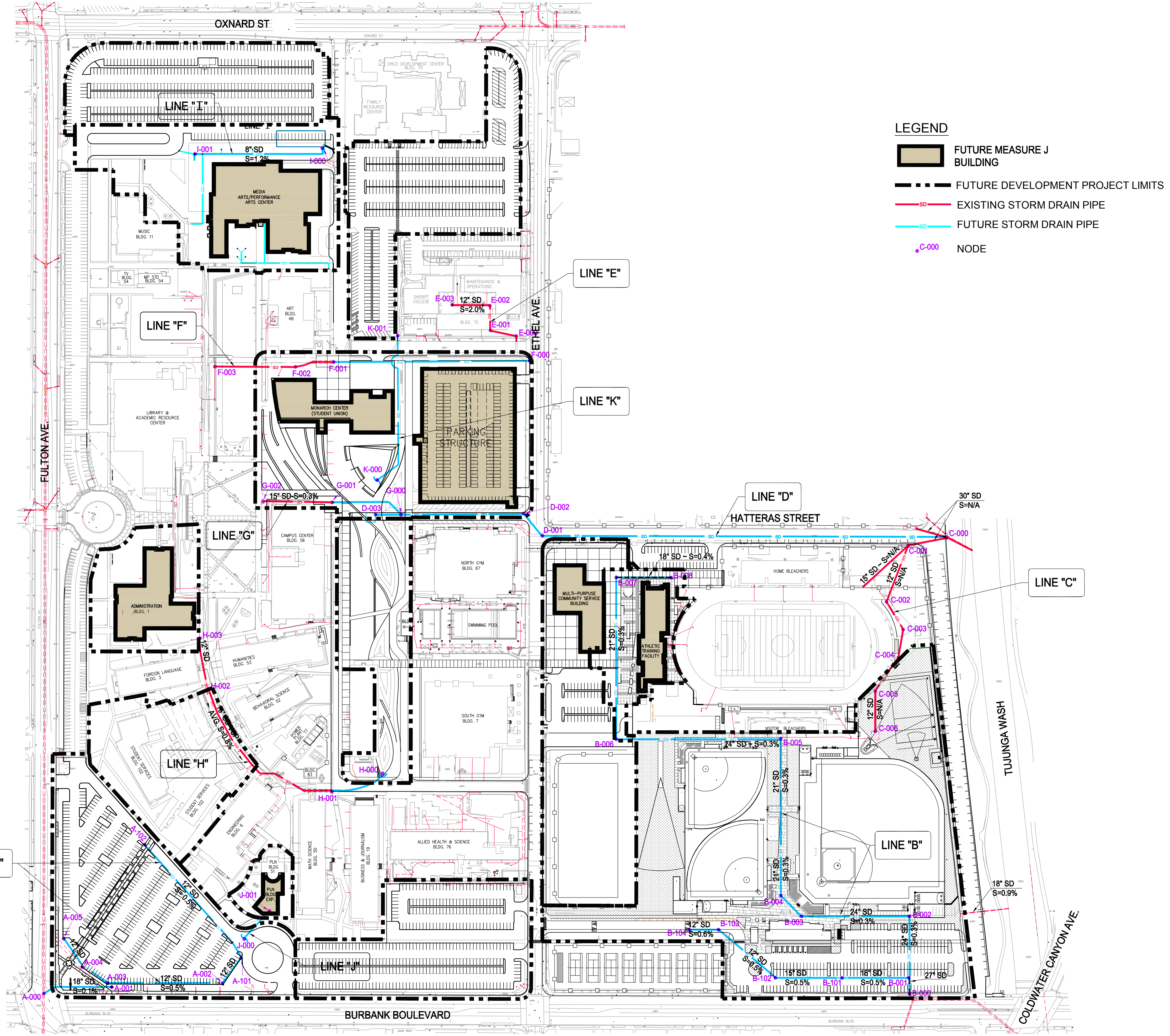


LOS ANGELES VALLEY COLLEGE
Measure J Stormwater Master Plan

Exhibit 2.4
Stormwater Treatment Map

PSOMAS

April 15, 2011



LOS ANGELES VALLEY COLLEGE
Measure J Stormwater Master Plan

Exhibit 2.5
Storm Drain Pipe and Node Map

PSOMAS

April 15, 2011

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APPENDIX A

LETTER OF CLARIFICATION TO PART 4.D. DEVELOPMENT PLANNING PROGRAM, THE LOS ANGELES COUNTY MUNICIPAL STROM WATER PERMIT, ORDER NO. 01-182, NPDES PERMIT NO. CAS004001

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California Regional Water Quality Control Board

Los Angeles Region

Recipient of the 2001 *Environmental Leadership Award* from Keep California Beautiful

Linda S. Adams
Agency Secretary

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Arnold Schwarzenegger
Governor

December 15, 2006

Mark Pestrella, Assistant Deputy Director
Department of Public Works
County of Los Angeles
700 South Fremont Ave.
Alhambra, CA 91803

Directors, Department of Public Works and
Directors, Department of Planning
Municipal Permittees within County of Los Angeles

CLARIFICATION TO PART 4.D. DEVELOPMENT PLANNING PROGRAM, THE LOS ANGELES COUNTY MUNICIPAL STORM WATER PERMIT, ORDER No. 01-182, NPDES PERMIT No. CAS004001

Dear Mr. Pestrella and Municipal Directors:

Thank you for requesting clarification on the Development Planning requirements of the Los Angeles County Municipal Storm Water Permit (L.A. County MS4 Permit).

This letter restates the compliance expectation of the California Regional Water Quality Control Board, Los Angeles Region (L.A. Water Board), when it adopted the requirements in 'Part 4 §D, Development Planning' of the L.A. County MS4 Permit. Part 4.D contains specific provisions that are fully enforceable, and which were also contained in the Development Planning Model Program submitted by the L.A. County Permitees, and which was approved in 2000.

Our evaluation of the implementation of the Development Planning and Standard Urban Stormwater Mitigation Plan (SUSMP) requirements on land development projects in Los Angeles County has revealed that many Permittees' planning and public works departments and their associated staff, including architects, planners and engineers have failed to integrate SUSMP implementation adequately with other storm water quality management strategies required in the L.A. County MS4 permit. The L.A. Water Board has identified several instances of inadequate or uncoordinated implementation by Permitttes for 'Part 4.D Development Planning'.

U.S. EPA Guidance

In areas undergoing new development or redevelopment, the most effective method of controlling impacts from storm water discharges is to limit the amount of rainfall that is converted to runoff. By utilizing design techniques that incorporate on-site storage and infiltration, and minimizing the amount of directly connected impervious surfaces, the amount of runoff generated from the site can be significantly reduced (*Preliminary Data Summary of Urban Storm Water Best Management Practices*, EPA 821-R-99-012, August 1999).

The three provisions in Part 4.D are consistent with guidance in Chapter 5 of *Preliminary Data Summary of Urban Storm Water Best Management Practices*. The U.S. EPA guidance states that in order to meet the goals of post-development peak discharge rate, volume and pollutant loading to receiving waters being the same as pre-development values, BMPs should be implemented to achieve three main objectives: flow control, pollutant removal and pollutant source reduction.

California BMP Manual

Similarly, Section 2.4 of the California Stormwater Quality Association (CASQA) BMP Handbook for Development and Redevelopment (2003), in its discussion on planning and design principles, reiterates the provisions in Part 4.D. These principles promote three basic strategies in the following order of preference based on effectiveness and costs: (1) reduce or eliminate post-project runoff; (2) control sources of pollutants; and (3) treat contaminated storm water runoff before discharging it to natural water bodies.

Groundwater Quality Protection Concern

Some Permittees have expressed a concern that infiltration of storm water may present risks to groundwater aquifers. Generally, the common pollutants in storm water are filtered or adsorbed by soil, and unlike hydrophobic solvents and salts, do not cause groundwater contamination. In any case, infiltration of 1-2 inches of rainfall in semi-arid areas like Southern California where there is a high rate of evapo-transpiration, presents minimal risks.

The Water Augmentation Study conducted by the Los Angeles and San Gabriel Rivers Watershed Council, in partnership with several agencies including water districts, municipalities, and the U.S. Bureau of Reclamation, indicates that the infiltration of storm water, with appropriate pretreatment, does not adversely impact groundwater quality (*Los Angeles Basin Water Augmentation Study, August 2005*). You may view the study at www.lasgrwc.org/WAS.htm

Infiltration of storm water discharges from heavy industrial areas is seldom appropriate. Where there is a real concern on the risk of groundwater contamination from preexisting soil contamination or heavy vehicular traffic when installing infiltration systems such as extended detention basins, the L.A. Water Board and the California Department of Transportation (Caltrans) developed guidance to ensure an adequate analysis for proper siting. See, *Infiltration Basin -Site Selection Study, Volumes I, II, and III* June 2003, CTSW-RT-03-025**,** http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/index.htm

Caltrans research indicates that infiltration basins and biofiltration BMPs are technically feasible if site site-specific considerations are taken into account (Caltrans CTSW-RT-01-050, *BMP Retrofit Pilot Program, January 2004*).

Background of MS4 Development Planning Requirements

Standard Urban Storm Water Mitigation Plan

On March 8, 2000, the L.A. Water Board adopted the SUSMP, and required that municipalities incorporate into the planning and design phases post-construction storm water mitigation controls for specified development and redevelopment projects. Although the SUSMP action was petitioned by some municipalities to the State Water Resources Control Board (State Water Board), the State Water Board directed in Water Quality Order 2000-11 that, *"the Permittees shall amend codes, if necessary, not later than **January 15, 2001**, to give legal effect to the SUSMP requirements. The SUSMP requirements shall take effect not later than **February 15, 2001**."*

On November 7, 2003, the L.A. Water Board transmitted the Development Planning Program Review Report after auditing four Permittee Programs (the Planning Review Report). The Planning Review Report presented and described discernible permit violations, deficiencies, and notable elements observed during the audit. Notably, the MS4 Development Planning program contained in Board Order No. 01-182 is built upon programs already established in previous Board Orders (90-079 and 96-054), after undergoing a very long process of public hearings and meetings before permit adoption.

Nearly six years later after the SUSMP was adopted, most Permittees' implementation of SUSMPs is deficient, because Permittees have not focused nor emphasized water quality pollution mitigation to protect the beneficial uses of receiving waters.

Consequently, the L.A. Water Board provides the following clarification consistent with the L.A. Water Board's mission of protecting water quality and preserving water resources:

A. Essential Post Construction Control Requirements

1. The three provisions in Part 4.D are the essential requirements for compliance with the Development Planning requirements of the L.A. County MS4 Permit. The three provisions are to: (1) maximize the percentage of pervious surfaces to allow percolation of storm water into the ground; (2) minimize the quantity of storm water directed to impervious surfaces and the MS4; and (3) minimize pollution emanating from parking lots through the use of appropriate treatment control BMPs and good housekeeping practices.

The basic site design planning considerations for post-construction storm water BMP implementation are to:

a. Preserve the natural drainage system, protect slopes and provide controls for stream protection. These controls are achieved through the basic control measures that include infiltration, retention/detention, bioretention and biofilters;

b. Integrate fully the opportunities to maximize the percentage of pervious surfaces and minimize the volume of storm water runoff;

c. Utilize a BMP treatment-train that (i) captures and infiltrates using infiltration basins, infiltration trenches, retention and/or detention BMPs; and/or (ii) provide flow through treatment in the order of preference for the prescribed storm water quality runoff volume **(Q_{wv})** based on the numerical mitigation criteria in Part 4.D;

d. Identify the combination of BMP treatment trains that are to be sized, designed and constructed based on **Q_{wv}** required for water quality. Using **Q_P** from 10, 20, or 50-year return-period for flood management is inappropriate for water quality purposes and not cost effective. Capturing and treating a larger percentage of the annual storm water runoff volume greater than **Q_{wv}** provides only a small increase in additional removal of pollutants and considerably increases the sizing and cost of the structural and treatment storm water controls; and

e. Establish in addition, for downstream channel protection, instead of **Q_P** a flow control criteria (Q_{HMC}) which takes into consideration flow volume, duration, and frequency to maintain the predevelopment distribution of in-stream flows above the critical flow for streambed erosion, thus preserving the pre-development capacity to transport sediment, while not accelerating down stream erosion. An appropriate hydromodification flow duration control criteria might be to set the Q_{HMC} such that the post-construction discharge rates and duration match the ranges from 10 percent of the pre-development 2-year 24 hour peak flow up to the pre-development 10 year 24 hour peak flow, unless an alternative criterion can be demonstrated as equally protective using hydrodynamic modeling.

2. <u>Measures and Approaches for Minimizing Impervious Surface Area</u>

a. Permittees must minimize the percentage of impervious surfaces to support the percolation and infiltration of storm water into the ground and/or minimize pollutants emanating from impervious surfaces by reducing the percentage of effective impervious area to a generally accepted standard of 5 percent or less of total project area.

The U.S. EPA storm water technology fact sheet for bioretention recommends that sizing criterion should be 5 to 7 percent of the drainage area multiplied by the rational method runoff coefficient "C" determined for the site (*Storm Water Technology Fact Sheet, Bioretention*, U.S. EPA Document No. EPA 832-F-99-012, September 1999). However, a lower sizing criterion may be more appropriate for

Southern California. A recent study determined that physical degradation of stream channels in semi-arid climates such as in Southern California may be detectable with watershed impervious cover between 3 and 5 percent (*Effects of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Stream,* SCCWRP, April 2005).

b. Permittees must also control pollution emanating from impervious surfaces such as roof-tops, parking lots, and roadways through the use of appropriate source controls such as the use of low impact development (LID) and integrated water resources management strategies that:

1. Emphasize conservation and the use of on-site natural features;
2. Integrate engineered small-scale hydrologic controls to more closely reflect pre-development hydrologic functions. Small-scale hydrologic controls are BMPs that create green infrastructure and spaces such as park-like open space, rainwater collection barrels, planter boxes, and garden-like areas that promote community awareness and improve storm water quality; and
3. Implement primarily a source control and minimize the need for large sub-regional and regional treatment control BMPs.

B. <u>Plan Preparation/ Review Procedures and Guidelines</u>

1. Permittees must possess clear and adequate legal authority in municipal storm water ordinances to address post-construction requirements in the L.A. County MS4 Permit. The legal authority must direct land developers to review and mitigate the adverse storm water quality impacts in the Environmental Impact Report (EIR), and to ensure that adequate post-construction control measures are incorporated during the development project's site planning and design phases. In addition, clear instructions should be provided on how to illustrate on plans the BMPs selected, adequate sizing, and BMP siting;

2. The selection of the treatment train of BMPs must be conducted through a methodical selection process that matches the type of BMP with the type and nature of pollutants that are expected to be generated from the site. For example, vortex separation devices installed in high commerce areas for removing trash and gross solids are not suitable for removing pollutants in dissolved state or smaller size/lighter weight fractions from vehicular traffic areas;

3. Permittees should also prescribe guidelines for the submittal of standard final SUSMP plans so that relevant storm water BMP locations and specifications in design sheets are clearly identified. Separate SUSMP detail plan sheets will facilitate technical review.

   Delineation of drainage area and/or sub-areas, natural drainage systems, storm drains, and other relevant parameters at pre-development and post-development water flow paths, outfall (drainage) locations, BMP detail plans, and other relevant information should be presented. Simply inserting post-development plans within the grading plans, storm drain plans, or civil plans with unrelated detail drawings, numbers, and construction notes makes it difficult to review and evaluate. Small-scale controls may be combined with the landscaping plans;

4. Plan view and sectional plans for small-scale hydrologic controls for a lot size and sub-drainage area of the sites should be prescribed; and

5. BMP design specifications must be incorporated in the SUSMP report together with hydrologic calculations for sizing BMPs. This report should support and show how criteria were adequately utilized in sizing BMPs (e.g., infiltration, retention/detention BMPs, bioretention facilities, etc.);

If you have any questions, please call Dr. Xavier Swamikannu at (213) 620-2094 or Carlos D. Santos at (213) 620-2093.

Sincerely,

Original Signed

Jonathan Bishop, P.E.
Executive Officer

cc: Michael Levy, Office of the Chief Counsel, State Water Board
Darrin Polhemus, Division of Water Quality, State Water Board
Bruce Fujimoto, Division of Water Quality, State Water Board

APPENDIX B

STATE WATER RESOURCES CONTROL BOARD WATER QUALITY ORDER NO. 2003-0005-DWQ, NPDES GENERAL PERMIT NO. CAS000004

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STATE WATER RESOURCES CONTROL BOARD (SWRCB)
WATER QUALITY ORDER NO. 2003 – 0005 – DWQ

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
GENERAL PERMIT NO. CAS000004

WASTE DISCHARGE REQUIRMENTS (WDRS)
FOR
STORM WATER DISCHARGES FROM
SMALL MUNICIPAL SEPARATE STORM SEWER SYSTEMS (GENERAL PERMIT)

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FACT SHEET
FOR
STATE WATER RESOURCES CONTROL BOARD (SWRCB)
WATER QUALITY ORDER NO. 2003 – 0005 – DWQ

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
GENERAL PERMIT NO. CAS000004

WASTE DISCHARGE REQUIREMENTS (WDRS)
FOR
STORM WATER DISCHARGES FROM
SMALL MUNICIPAL SEPARATE STORM SEWER SYSTEMS (GENERAL PERMIT)

BACKGROUND

In 1972, the federal Water Pollution Control Act (also referred to as the Clean Water Act [CWA]) was amended to provide that the discharge of pollutants to waters of the United States from any point source is unlawful unless the discharge is in compliance with a NPDES permit. The 1987 amendments to CWA added section 402(p), which established a framework for regulating storm water discharges under the NPDES Program. Subsequently, in 1990, the U.S. Environmental Protection Agency (U.S. EPA) promulgated regulations for permitting storm water discharges from industrial sites (including construction sites that disturb five acres or more) and from municipal separate storm sewer systems (MS4s) serving a population of 100,000 people or more. These regulations, known as the Phase I regulations, require operators of medium and large MS4s to obtain storm water permits. On December 8, 1999, U.S. EPA promulgated regulations, known as Phase II, requiring permits for storm water discharges from Small MS4s and from construction sites disturbing between one and five acres of land. This General Permit regulates storm water discharges from Small MS4s.

An “MS4” is a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) designed or used for collecting or conveying storm water; (ii) which is not a combined sewer; and (iii) which is not part of a Publicly Owned Treatment Works (POTW). [See Title 40, Code of Federal Regulations (40 CFR) §122.26(b)(8).]

A “Small MS4” is an MS4 that is not permitted under the municipal Phase I regulations, and which is “owned or operated by the United States, a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity….” (40 CFR §122.26(b)(16)). Small MS4s *include systems similar to separate storm sewer systems in municipalities, such as systems at military bases, large hospital or prison complexes, and highways and other thoroughfares, but do not include separate storm sewers in* *very discrete areas, such as individual buildings*. This permit refers to MS4s that operate throughout a community as "traditional MS4s" and MS4s that are similar to traditional MS4s but operated at a separate campus or facility as "non-traditional MS4s."

Federal regulations allow two permitting options for storm water discharges (individual permits and general permits). SWRCB elected to adopt a statewide general permit for Small MS4s in order to efficiently regulate numerous storm water discharges under a single permit. In certain situations a storm water discharge may be more appropriately and effectively regulated by an individual permit, a region-specific general permit, or by inclusion in an existing Phase I permit. In these situations, the Regional Water Quality Control Board (RWQCB) Executive Officer will direct the Small MS4 operator to submit the appropriate application, in lieu of a Notice of Intent (NOI) to comply with the terms of this General Permit. In these situations, the individual or regional permits will govern, rather than this General Permit.

NINTH CIRCUIT COURT RULING

On January 14, 2003, the Ninth Circuit Court issued its decision in *Environmental Defense Center v. EPA*. This ruling upheld the Phase II regulations on all but three of the 20 issues contested. In summary, the court determined that applications for general permit coverage (including the NOI and Storm Water Management Program [SWMP]) must be made available to the public, the applications must be reviewed and determined to meet the Maximum Extent Practicable standard by the permitting authority before coverage commences, and there must be a process to accommodate public hearings. This General Permit is consistent with the ruling. Should the ruling be revised or vacated in the future, SWRCB may modify the General Permit.

ENTITIES SUBJECT TO THIS GENERAL PERMIT

This General Permit regulates discharges of storm water from "regulated Small MS4s." A "regulated Small MS4" is defined as a Small MS4 that discharges to a water of the United States (U.S.) or to another MS4 regulated by an NPDES permit, and which is designated in one of the following ways:

1. Automatically designated by U.S. EPA pursuant to 40 CFR section 122.32(a)(1) because it is located within an urbanized area defined by the Bureau of the Census (see Attachment 1); or

2. Traditional Small MS4s that serve cities, counties, and unincorporated areas that are designated by SWRCB or RWQCB after consideration of the following factors:

    a. High population density – High population density means an area with greater than 1,000 residents per square mile. Also to be considered in this definition is a high density created by a non-residential population, such as tourists or commuters.

    b. High growth or growth potential – If an area grew by more than 25 percent between 1990 and 2000, it is a high growth area. If an area anticipates a growth rate of more than 25 percent over a 10-year period ending prior to the end of the first permit term, it has high growth potential.

c. Significant contributor of pollutants to an interconnected permitted MS4 – A Small MS4 is interconnected with a separately permitted MS4 if storm water that has entered the Small MS4 is allowed to flow directly into a permitted MS4. In general, if the Small MS4 discharges more than 10 percent of its storm water to the permitted MS4, or its discharge makes up more than 10 percent of the other permitted MS4's total storm water volume, it is a significant contributor of pollutants to the permitted MS4. In specific cases, the MS4s involved or third parties may show that the 10 percent threshold is inappropriate for the MS4 in question.

d. Discharge to sensitive water bodies – Sensitive water bodies are receiving waters, which are a priority to protect. They include the following:

- those listed as providing or known to provide habitat for threatened or endangered species;

- those used for recreation that are subject to beach closings or health warnings; or

- those listed as impaired pursuant to CWA section 303(d) due to constituents of concern in urban runoff (these include biochemical oxygen demand [BOD], sediment, pathogens, petroleum hydrocarbons, heavy metals, floatables, polycyclic aromatic hydrocarbons [PAHs], trash, and other constituents that are found in the MS4 discharge).

Additional criteria to qualify as a sensitive water body may exist and may be determined by SWRCB or RWQCB on a case-by-case basis.

e. Significant contributor of pollutants to waters of the U.S. – Specific conditions presented by the MS4 may lead to significant pollutant loading to waters of the U.S. that are otherwise unregulated or inadequately regulated. An example of such a condition may be the presence of a large transportation industry.

These factors are to be considered when evaluating whether a Small MS4 should be regulated pursuant to this General Permit. An MS4 and the population that it serves need not meet all of the factors to be designated. SWRCB designates a number of Small MS4s according to these criteria through this General Permit (see Attachment 2).

Non-traditional Small MS4s may also be designated to seek permit coverage. These include non-traditional MS4s that are located within or discharge to a permitted MS4 and those that pose significant water quality threats. In general, these are storm water systems serving public campuses (including universities, community colleges, primary schools, and other publicly owned learning institutions with campuses), military bases, and prison and hospital complexes within or adjacent to other regulated MS4s, or which pose significant water quality threats. SWRCB considered designating non-traditional Small MS4s when adopting this General Permit. However, the *Environmental Defense Center* ruling requires that SWRCB and RWQCBs change their procedures for implementing this General Permit. In compliance with that decision, each

NOI and SWMP must be reviewed and approved, and in some cases considered in a public hearing, prior to the Small MS4 obtaining coverage under the General Permit. Therefore, SWRCB is delaying making these designations and the General Permit does not designate any non-traditional MS4s. A list of non-traditional MS4s that are anticipated to be designated within this permit term is included in Attachment 3 of this General Permit. These or other non-traditional MS4s may be designated by SWRCB or RWQCB at any time subsequent to the adoption of this General Permit.

The criteria selected to designate Small MS4s to be regulated are based on the potential to impact water quality due to conditions influencing discharges into their system or due to where they discharge. Some of the definitions provide "cut-off numbers." Although there is no regulatory standard that mandates which numbers to use, dividing lines must be established in order to effectively use them as criteria.

Specifically, the high growth factor uses 25 percent growth over ten years. The average growth (based on county data from the Census) in California between 1990 and 2000 was 15.8 percent. The standard deviation was 9.9. Growth rates outside one standard deviation are more than 25.7 percent. The standard deviation is generally an indication of the spread of data. In defining the high growth factor, the standard deviation was used because it sets the limits within which most areas of California fall. County data was used because it was consistently available, whereas 1990 populations for several of the cities and places were not readily available. Additionally, county data gives a broader picture of the growth dynamics in California. Because the data is not normally distributed, 68 percent of the data points do not necessarily fall within one standard deviation of the mean. It does, however, provide a number in which to compare city and place growth rates to the average growth rate of California. The number was rounded to 25 percent for ease of application and with the understanding that it is an approximation.

The significant contributor of pollutants to an interconnected permitted MS4 definition uses a volume value of 10 percent, with the assumption that storm water contains pollutants. This is meant to capture flows that may affect water quality or the permit compliance status of another MS4, but exclude incidental flows between communities.

APPLICATION REQUIREMENTS

Regulated Small MS4s, automatically designated because they are within an urbanized area (Attachment 1), must submit to the appropriate RWQCB by August 8, 2003 a complete application package. A complete package includes an NOI (Attachment 7), a complete SWMP (one hard copy and one electronic copy in Word or PDF format), and an appropriate fee.

The August 8, 2003 deadline is an administrative deadline to comply with the General Permit. Section 122.33(c)(1) of 40 CFR required automatically designated Small MS4s to submit an application by March 10, 2003. Those applications received from Small MS4s that submitted applications to comply with the federal deadline will be considered as an application to meet the requirements of this General Permit. If the application package is deemed complete by the RWQCB staff, it will be posted on the internet and made available for public review and public hearing if requested subsequent to permit adoption.

Regulated Small MS4s that are traditional MS4s designated by the SWRCB or RWQCB must submit to the appropriate RWQCB, within 180 days of notification of designation (or at a later date stated by SWRCB or RWQCB), an NOI (Attachment 7), a complete SWMP (one hard copy and one electronic copy in Word or PDF format), and an appropriate fee. Those traditional MS4s identified in Attachment 2 of this General Permit are being notified of their designation by SWRCB upon adoption of this General Permit. They must, therefore, submit their NOI and SWMP by October 27, 2003.

Regulated Small MS4s that are non-traditional MS4s designated by SWRCB or RWQCB, including those in Attachment 3, must submit to the appropriate RWQCB, within 180 days of notification of designation (or at a later date stated by SWRCB or RWQCB), an NOI (Attachment 7), a complete SWMP (one hard copy and one electronic copy in Word or PDF format), and an appropriate fee.

Regulated Small MS4s relying entirely on Separate Implementing Entities (SIEs) that are also permitted, to implement their entire storm water programs are not required to submit a SWMP if the SIE being relied on has an approved SWMP. Proof of SWMP approval, such as a copy of the RWQCB letter, must be submitted to the RWQCB by the applying Small MS4, along with the NOI and an appropriate fee.

Regulated Small MS4s that fail to obtain coverage under this General Permit or another NPDES permit for storm water discharges will be in violation of the CWA and the Porter-Cologne Water Quality Control Act.

Receipt of applications deemed complete by RWQCB staff will be acknowledged on SWRCB's website at http://www.swrcb.ca.gov/stormwtr/index.html for a minimum of 60 days. When a SWMP is received by an RWQCB, those members of the public that have indicated they would like to receive notice, will receive an email from RWQCB staff that a SWMP has been received. During this 60-day public review period, a member of the public may request a copy of the SWMP and request that a public hearing be held by RWQCB. If a public hearing is requested, the hearing itself will be public noticed for a minimum of 30 days. If no hearing is requested, the RWQCB Executive Officer will notify the regulated MS4 that it has obtained permit coverage only after RWQCB staff has reviewed the SWMP and has determined that the SWMP meets the MEP standard established in this permit.

Attachment 8 lists RWQCB contact information for questions and submittals.

GENERAL PERMIT REQUIREMENTS

Prohibitions

This General Permit effectively prohibits the discharge of materials other than storm water that are not "authorized non-storm water discharges" (see General Permit § D.2.c) or authorized by a separate NPDES permit. This General Permit also incorporates discharge prohibitions contained in Statewide Water Quality Control Plans and Regional Water Quality Control Plans (Basin Plans).

Effluent Limitations

Permittees must implement Best Management Practices (BMPs) that reduce pollutants in storm water runoff to the technology-based standard of Maximum Extent Practicable (MEP) to protect water quality. In accordance with 40 CFR section 122.44(k)(2), the inclusion of BMPs in lieu of numeric effluent limitations is appropriate in storm water permits.

Discharges shall not contain reportable quantities of hazardous substance as established at 40 CFR section 117.3 or 40 CFR section 302.4.

Preparation of SWMP

This General Permit requires regulated Small MS4s to:

1. Develop and implement a SWMP that describes BMPs, measurable goals, and timetables for implementation in the following six program areas (Minimum Control Measures):

Public Education
The Permittee must educate the public in its permitted jurisdiction about the importance of the storm water program and the public's role in the program.

Public Participation
The Permittee must comply with all State and local notice requirements when implementing a public involvement/participation program.

Illicit Discharge Detection and Elimination
The Permittee must adopt and enforce ordinances or take equivalent measures that prohibit illicit discharges. The Permittee must also implement a program to detect illicit discharges.

Construction Site Storm Water Runoff Control
The Permittee must develop a program to control the discharge of pollutants from construction sites greater than or equal to one acre in size within its permitted jurisdiction. The program must include inspections of construction sites and enforcement actions against violators.

Post Construction Storm Water Management
The Permittee must require long-term post-construction BMPs that protect water quality and control runoff flow, to be incorporated into development and significant redevelopment projects. Post-construction programs are most efficient when they stress (i) low impact design; (ii) source controls; and (iii) treatment controls.

For non-traditional MS4s that seek coverage under this Permit, implementation of this control measure will not require redesign of projects under active construction at the time of designation or for K-12 school or community college facilities that have been submitted to the Department of General Services, Division of the State Architect before adoption of the permit, and which receive final approval from the State Allocation Board or the Public Works Board, as appropriate on or before December 31, 2004. SWMP must, however, specify how the control measure will be implemented within five years of designation.

Pollution Prevention/Good Housekeeping for Municipal Operations

The Permittee must examine its own activities and develop a program to prevent the discharge of pollutants from these activities. At a minimum, the program must educate staff on pollution prevention, and minimize pollutant sources.

2. Reduce its discharge of pollutants to the MEP.

3. Annually report on the progress of SWMP implementation.

<u>Development and Implementation of SWMP</u>

SWMP must describe how pollutants in storm water runoff will be controlled and describe BMPs that address the six Minimum Control Measures. Each BMP must have accompanying measurable goals that will be achieved during the permit term, or within five years of designation if designated subsequent to permit adoption, as a means of determining program compliance and accomplishments and as an indicator of potential program effectiveness. The measurable goals should be definable tasks such as number of outreach presentations to make, number of radio spots to purchase, or percentage of pollutant loading to reduce (other examples of measurable goals can be found on U.S. EPA's web-site at http://cfpub.epa.gov/npdes/stormwater/measurablegoals/index.cfm). This approach provides the flexibility to target an MS4's problem areas while working within the existing organization.

It is not anticipated that the SWMP be fully implemented upon submittal with the NOI. It is the intent of this General Permit that SWMPs submitted with the NOI contain sufficient information such that RWQCB staff and interested parties understand the BMPs that will be implemented or will be developed and implemented over the course of the General Permit term or, for Small MS4s designated subsequent to permit adoption, over a five–year period from designation. It is also expected that SWMPs will protect water quality, contain measurable goals and schedules, and assign responsible parties for each BMP. It is anticipated that the SWMP initially submitted may be revised or modified based on review of RWQCB staff or on comments provided by interested parties in accordance with Provisions G and H.19 of the General Permit.

For example, it may be proposed that a storm water logo be developed (or an existing one modified) by the end of the first year; an ordinance prohibiting non-storm water discharges be adopted by the end of the second year; a survey of non-storm water discharges throughout the city be completed by the end of the second year; a brochure targeting the restaurant community regarding proper practices to eliminate non-storm water discharges be developed or obtained by the end of the fourth year; and the brochure be distributed to 25 percent of the restaurants within the city during health department inspections by the end of the fifth year. (This example mentions only one activity each year. In fact, numerous activities will occur throughout the permit term that ensure that a SWMP addressing all six Minimum Control Measures is implemented by the end of the permit term, or within five years of designation for Small MS4s designated subsequent to adoption of the Permit.)

The main goal of this General Permit is to protect water quality from the impacts of storm water runoff from Small MS4s. The intent is that storm water quality impacts will be considered in all aspects of a municipality's activities and that multiple departments within the municipality will work together to implement storm water BMPs. For instance, the planning department may work with the public works department when considering projects and their potential storm water impacts. Also, the health department can work with public works in a complementary manner to spread a consistent message about illicit discharges.

Many of the activities that a municipality already does can be recognized as a benefit to storm water or can be modified to add a storm water quality twist. A critical element of SWMP development is an assessment of activities already being conducted. For example, many communities already have a household hazardous waste program, which can be assumed to reduce illicit discharges to the MS4. Likewise, they examine potential flooding impacts of new development. This process can be modified to also examine water quality impacts as well as quantity.

Similarly, the Minimum Control Measures emphasize working with the public to prevent pollution during their everyday activities as well as to gain support for program funding. The MS4 has the flexibility to target specific segments of its residential or employee population in ways that are most appropriate for that particular segment. Taken together, the suite of public education approaches an MS4 takes can create a robust multimedia campaign that has a single message, which is threaded throughout the community through implementation of BMPs in the six program areas.

For links to information on how to implement each of the Minimum Control Measures, including sample ordinances that address the respective Minimum Control Measures, please see SWRCB's internet site at http://www.swrcb.ca.gov/stormwtr/municipal.html. Additionally, in accordance with 40 CFR section 122.34(d)(2), SWRCB provides U.S. EPA's menu of BMPs to consider when developing a SWMP. This menu is available on U.S. EPA's internet site at http://cfpub1.epa.gov/npdes/stormwater/swphase2.cfm?program_id=6. The menu provides examples of BMPs and associated measurable goals; however, other BMPs and measurable goals may be used.

MEP

MEP is the technology-based standard established by Congress in CWA section 402(p)(3)(B)(iii) that municipal dischargers of storm water must meet. Technology-based standards establish the level of pollutant reductions that dischargers must achieve. MEP is generally a result of emphasizing pollution prevention and source control BMPs as the first lines of defense in combination with structural and treatment methods where appropriate serving as additional lines of defense. The MEP approach is an ever evolving, flexible, and advancing concept, which considers technical and economic feasibility. As knowledge about controlling urban runoff continues to evolve, so does that which constitutes MEP. The individual and collective activities elucidated in the MS4's SWMP become its proposal for reducing or eliminating pollutants in storm water to the MEP. The way in which MEP is met may vary between communities.

The MEP standard applies to all regulated MS4s, including those in Phase I and Small MS4s regulated by this General Permit. Consistent with U.S. EPA guidance, the MEP standard in California is applied so that a first-round storm water permit requires BMPs that will be expanded or better-tailored in subsequent permits. In choosing BMPs, the major focus is on technical feasibility, but cost, effectiveness, and public acceptance are also relevant. If a Permittee chooses only the most inexpensive BMPs, it is likely that MEP has not been met. If a Permittee employs all applicable BMPs except those that are not technically feasible in the locality, or whose cost exceeds any benefit to be derived, it would meet the MEP standard. MEP requires Permittees to choose effective BMPs, and to reject applicable BMPs only where other effective BMPs will serve the same purpose, the BMPs are not technically feasible, or the cost is prohibitive. (See SWRCB Order WQ 2000-11, http://www.swrcb.ca.gov/resdec/wqorders/2000/00wqo.html.)

Generally, in order to meet MEP, communities that have greater water quality impacts must put forth a greater level of effort. Alternatively, for similar water quality conditions, communities should put forth an equivalent level of effort. However, because larger communities have greater resources (both financial resources as well as existing related programs that can help in implementing storm water quality programs), it may appear that they have more robust storm water programs. Additionally, because storm water programs are locally driven and local conditions vary, some BMPs may be more effective in one community than in another. A community that has a high growth rate would derive more benefit on focusing on construction and post-construction programs than on an illicit connection program because illicit connections are more prevalent in older communities.

In accordance with the Ninth Circuit Court ruling, prior to obtaining permit coverage, SWMPs will be evaluated for compliance with the MEP standard by the RWQCB Executive Officer or, if requested, considered for approval in a public hearing conducted by RWQCB.

Many Phase I MS4s have been permitted under storm water regulations for more than ten years and have had that time to develop programs intended to reduce pollutants in their storm water discharge to MEP. It is understood that storm water quality programs and regulations are new to the entities that will be regulated under this General Permit. Therefore, it is anticipated that this General Permit term will serve as a "ramping-up" period and that programs implemented by Phase II communities will not necessarily conform to programs implemented by Phase I communities. Despite this understanding, however, many of the lessons learned and information developed by Phase I communities is available to smaller communities as a guide and may be used by Phase II communities.

Supplemental Provisions for Larger and Fast Growing Regulated Small MS4s

By the expiration date of this General Permit, traditional and non-traditional Small MS4s serving a population of 50,000 people or more, or that are subject to high growth, must require specific design standards as part of their post-construction program (as outlined in Attachment 4 of this General Permit, or a functionally equivalent program that is acceptable to the appropriate RWQCB), and they must comply with water quality standards through implementing better-tailored BMPs in an iterative process. These more stringent requirements are applied to communities that are larger and, therefore, capable of a more extensive storm water program, and to communities that are fast growing, and therefore may have greater impacts on storm water runoff associated with construction and the loss of pervious lands. Studies have found the amount of impervious surface in a community is strongly correlated with the community's water quality. New development and redevelopment result in increased impervious surfaces in a community. The design standards in Attachment 4 focus on mitigating the impacts caused by increased impervious surfaces through establishing minimum BMP requirements that stress (i) low impact design; (ii) source controls; and (iii) treatment controls. The design standards include minimum sizing criteria for treatment controls and establish maintenance requirements.

BMPs that may be used to comply with the design standards can be found in U.S. EPA's Toolbox of BMPs at http://cfpub1.epa.gov/npdes/stormwater/swphase2.cfm?program_id=6. Additionally, some RWQCBs may have lists of approved references and resources.

Small MS4s designated subsequent to permit adoption have five years from designation to achieve compliance with the Supplemental Provisions. Attachment 5 provides a list of communities that SWRCB anticipates being subject to the provisions in Attachment 4.

Receiving Water Limitations

Attachment 4 establishes receiving water limitations that apply to larger and fast-growing regulated Small MS4s that are required to comply with Supplemental Provisions of this General Permit. This permit allows regulated Small MS4s up to five years to fully implement their SWMPs. Therefore, regulated Small MS4s must begin to comply with the receiving water limitations iterative process once their plans are fully implemented. The receiving water limitation language provided in this General Permit is identical to the language established in SWRCB Water Quality Order WQ-99-05 adopted by SWRCB on June 17, 1999. As interpreted in SWRCB Water Quality Order WQ-2001-15, adopted by SWRCB on November 15, 2001, the receiving water limitations in this General Permit do not require strict compliance with water quality standards. SWRCB language requires that SWMPs be designed to achieve compliance with water quality standards over time, through an iterative approach requiring improved BMPs. Upon full implementation of the SWMP, exceedances of water quality standards must be addressed through the iterative process.

Reporting Requirements

The Permittee must track and assess its program to ensure BMP effectiveness and must conform to other monitoring requirements that may be imposed by RWQCB.

The Permittee is required to submit annual reports to the appropriate RWQCB by September 15th of each year (for Small MS4s designated with the adoption of this permit, the first annual report is to be submitted in 2004), or as otherwise required by the RWQCB Executive Officer. Among other things, the Permittee shall evaluate its compliance with permit conditions, evaluate and assess the effectiveness of its BMPs, summarize the results of any monitoring performed, summarize the activities planned for the next reporting cycle, and, if necessary, propose changes to SWMP.

Monitoring

Inspections, as a form of visual monitoring, are important to a storm water program. Inspections of storm water runoff and infrastructure (such as drop inlets, basins, and gutters) can say a lot about the effectiveness and needs of a storm water program. Through inspections, non-storm water discharges can be discovered and subsequently stopped, maintenance needs can be identified, and visual pollutants and erosion problems can be detected. Inspections of facilities are also important for public education and outreach, to ensure proper BMP implementation and maintenance, and to detect non-storm water discharges. Additionally, chemical monitoring can be used to involve the public through citizen monitoring groups, detect pollutants, identify and target pollutants of concern, illustrate water quality improvements and permit compliance, and participate in total maximum daily load (TMDL) development and implementation.

Monitoring environmental indicators through bio-assessments or other less technical methods may also be a key component of a program. Although it may be more challenging, it is also very valuable because it is the "final product," not just for a storm water program but for the broader environmental health of a community.

More specifically, the objectives of a monitoring program may include:

- Assessing compliance with this General Permit;
- Measuring and improving the effectiveness of SWMP;
- Assessing the chemical, physical, and biological impacts on receiving waters resulting from urban runoff;
- Characterizing storm water discharges;
- Identifying sources of pollutants; and
- Assessing the overall health and evaluating long-term trends in receiving water quality.

While only inspections of construction sites, as part of the Construction Site Storm Water Runoff Control Minimum Control Measure, are specifically required, as elucidated above, other monitoring tasks may be appropriate in a storm water program. Also, the RWQCB can require additional monitoring.

Termination of Coverage

A Permittee may terminate coverage if: a new operator has assumed responsibility for the regulated Small MS4; the Permittee has ceased operation of its MS4; or all discharge of runoff from the Small MS4 has been eliminated. To terminate coverage, the Permittee must submit to RWQCB a written request for permit termination.

Reliance on a SIE

A Permittee may rely on a separate entity to implement one or more of the six Minimum Control Measures, if the separate entity can appropriately and adequately address the storm water issues of the Permittee. To do this, both entities must agree to the arrangement, and the Permittee must comply with the applicable parts of the SIE's program. The arrangement is subject to the approval of the RWQCB Executive Officer.

In accordance with section 122.35(a)(3), the Permittee remains responsible for compliance with its permit obligations if SIE fails to implement the control measure(s) (or component thereof). Therefore, the entities are encouraged to enter into a legally binding agreement to minimize any uncertainty about compliance with the permit.

If the Permittee relies on an SIE to implement all six Minimum Control Measures and SIE also has a storm water permit, the Permittee relying on SIE must still submit an NOI, appropriate fee, proof that SIE's SWMP has been approved by RWQCB or its staff, and certification of the arrangement. However, the Permittee is not required to develop or submit a SWMP or annual reports, unless requested to do so by the RWQCB Executive Officer. The arrangement is subject to the approval of the RWQCB Executive Officer.

School districts present an example of where an SIE arrangement may be appropriate, either by forming an agreement with a city or with an umbrella agency, such as the County Office of Education. Because schools provide a large audience for storm water education, as part of the agreement, the two entities may coordinate an education program. An individual school or a school district may agree to provide a one-hour slot for all the second and fifth grade classes during which the city would bring in its own storm water presentation. Alternatively, the school could agree to teach a lesson in conjunction with an outdoor education science project, which may also incorporate a public involvement component. Additionally, the school and the city or Office of Education may arrange to have the school's maintenance staff attend the other entity's training sessions.

Retention of Records

The Permittee is required to retain records of all monitoring information and copies of all reports required by this General Permit for a period of at least five years from the date generated. This period may be extended by request of SWRCB or RWQCB.

Role of RWQCBs

RWQCBs and their staff will review and decide whether to approve SWMPs and, where requested, conduct public hearings on NOIs and SWMPs. Upon approval, they will notify Permittees that they have obtained permit coverage. They will also oversee implementation and compliance with this General Permit. As appropriate, they will review reports, require modification to SWMPs and other submissions, impose region-specific monitoring requirements, conduct inspections, take enforcement actions against violators of this General Permit, and make additional designations of regulated Small MS4s pursuant to this General Permit. They may also issue individual permits to regulated Small MS4s, and alternative general permits to categories of regulated Small MS4s. Upon issuance of such permits by an RWQCB, this General Permit shall no longer regulate the affected Small MS4s.

The Permittee and RWQCB are encouraged to work together to accomplish the goals of the storm water program. Specifically, they can coordinate the oversight of construction and industrial sites. For example, Permittees are required to implement a construction program. This program must include procedures for construction site inspection and enforcement. Construction sites disturbing an acre of land or more are also subject to inspections by RWQCB under the Statewide General Permit for Discharges of Storm Water Associated with Construction Activity. U.S. EPA intended to provide a structure that requires permitting through the federal CWA while at the same time achieving local oversight of construction projects. A structured plan review process and field enforcement at the local level, which is also required by this General Permit, were cited in the preamble to the Phase II regulations as the most effective components of a construction program.

Similarly, as part of the illicit discharge detection and elimination program, the Permittee may inspect facilities that are permitted by the Statewide General Permit for Discharges of Storm Water Associated with Industrial Activity and subject to RWQCB inspections.

The Small MS4 and RWQCB are encouraged to coordinate efforts and use each of their enforcement tools in the most effective manner. For instance, the Small MS4 may identify a construction site operator that is not in compliance with the local requirements and the Construction General Permit. The Small MS4 may establish a fee for re-inspection if a site is out of compliance. If education efforts and the inspection fee fail to bring the site into compliance, the Small MS4 may contact RWQCB and arrange a dual inspection and start enforcement procedures under the CWA if compliance is not achieved.

Relationship Between the Small MS4 Permit and the General Permit for Discharges of Storm Water Associated with Industrial Activity (Industrial Permit)

Some MS4 operators may also have facilities that are subject to the Industrial Permit. While the intent of both of these permits is to reduce pollutants in storm water, neither permit's requirements totally encompass the other. This General Permit requires that MS4 operators address six Minimum Control Measures, while the Industrial Permit requires the development and implementation of Storm Water Pollution Prevention Plans (SWPPP) for certain "industrial" activities as well as requiring specific visual and chemical monitoring. In the Preamble to the Phase II regulations, U.S. EPA notes that for a combination permit to be acceptable, it must contain all of the requirements for each permit. Further, "when viewed in its entirety, a combination permit, which by necessity would need to contain all elements of otherwise separate industrial and MS4 permit requirements, and require NOI information for each separate industrial activity, may have few advantages when compared to obtaining separate MS4 and industrial general permit coverage."

Where the permits do overlap, one program may reference the other. More specifically, the Good Housekeeping for Municipal Operations Minimum Control Measure requires evaluation of municipal operations, some of which may be covered under the Industrial Permit. The development and implementation of SWPPP under the Industrial Permit will likely satisfy the Good Housekeeping requirements for those industrial activities. SWMP may incorporate by reference the appropriate SWPPP.

There may be instances where a non-traditional MS4 has, under the Industrial Permit, obtained coverage for the entire facility (rather than only those areas where industrial activities occur) and has developed a SWPPP that addresses the six Minimum Control Measures required by this General Permit. In these instances, the non-traditional Small MS4 is not required to obtain coverage under this General Permit. The entity should, in such cases, provide to the appropriate RWQCB documentation that its SWPPP addresses the six Minimum Control Measures.

STATE WATER RESOURCES CONTROL BOARD (SWRCB)
WATER QUALITY ORDER NO. 2003 - 0005 – DWQ

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
GENERAL PERMIT NO. CAS00000X

WASTE DISCHARGE REQUIREMENTS (WDRs)
FOR
STORM WATER DISCHARGES FROM SMALL MUNICIPAL SEPARATE STORM SEWER SYSTEMS (MS4s) (GENERAL PERMIT)

SWRCB finds that:

1. Urban runoff is a leading cause of pollution throughout California.

2. Pollutants of concern found in urban runoff include sediments, non-sediment solids, nutrients, pathogens, oxygen-demanding substances, petroleum hydrocarbons, heavy metals, floatables, polycyclic aromatic hydrocarbons (PAHs), trash, and pesticides and herbicides.

3. During urban development, two important changes occur. First, where no urban development has previously occurred, natural vegetated pervious ground cover is converted to impervious surfaces such as paved highways, streets, rooftops, and parking lots. Natural vegetated soil can both absorb rainwater and remove pollutants providing a very effective purification process. Because pavement and concrete can neither absorb water nor remove pollutants, the natural purification characteristics of the land are lost. Second, urban development creates new pollutant sources as human population density increases and brings with it proportionately higher levels of vehicle emissions, vehicle maintenance wastes, municipal sewage, pesticides, household hazardous wastes, pet wastes, trash, etc., which can be washed into the MS4. As a result of these two changes, the runoff leaving a developed urban area may be significantly greater in volume, velocity, and/or pollutant load than pre-development runoff from the same area.

4. A higher percentage of impervious area correlates to a greater pollutant loading, resulting in turbid water, nutrient enrichment, bacterial contamination, organic matter loads, toxic compounds, temperature increases, and increases of trash or debris.

5. Pollutants present in storm water can have damaging effects on both human health and aquatic ecosystems. In addition, the increased flows and volumes of storm water discharged from impervious surfaces resulting from development can significantly impact beneficial uses of aquatic ecosystems due to physical modifications of watercourses, such as bank erosion and widening of channels.

6. When water quality impacts are considered during the planning stages of a project, new development and many redevelopment projects can more efficiently incorporate measures to protect water quality.

7. On December 8, 1999, the U.S. Environmental Protection Agency (EPA) promulgated regulations under authority of the Clean Water Act (CWA) section 402(p)(6). These regulations require SWRCB to issue NPDES storm water permits to operators of small municipal separate storm sewer systems (Small MS4s) that discharge to waters of the U.S.

8. Of the Small MS4s defined by federal regulations, only "regulated Small MS4s" must obtain a permit. Title 40 of the Code of Federal Regulations (40 CFR) section 122.32(a) describes regulated Small MS4s as those traditional Small MS4s located within an urbanized area as determined by the latest Decennial Census by the Bureau of the Census and other Small MS4s that are designated by the permitting authority in accordance with designation criteria in Findings 10 and 11 below. Traditional Small MS4s within urbanized areas (Attachment 1) are automatically designated and are not subject to the designation criteria provided in Finding 10.

9. Section 123.35(b) of 40 CFR requires SWRCB to develop a process, as well as criteria, to designate Small MS4s as regulated Small MS4s.

10. In developing the designation criteria, factors were chosen to include parameters that may affect water quality. The following criteria will be considered in designating Small MS4s operated within a city or county as regulated Small MS4s.

    a. <u>High population density</u> – High population density means an area with greater than 1,000 residents per square mile. Also to be considered in this definition is a high density created by a non-residential population, such as tourists or commuters.

    b. <u>High growth or growth potential</u> – If an area grew by more than 25 percent between 1990 and 2000, it is a high growth area. If an area anticipates a growth rate of more than 25 percent over a 10-year period ending prior to the end of the first permit term, it has high growth potential.

    c. <u>Significant contributor of pollutants to an interconnected permitted MS4</u> – A Small MS4 is interconnected with a separately permitted MS4 if storm water that has entered the Small MS4 is allowed to flow directly into a permitted MS4. In general, if the Small MS4 discharges more than 10 percent of its storm water to the permitted MS4, or its discharge makes up more than 10 percent of the other permitted MS4's total storm water volume, it is a significant contributor of pollutants to the permitted MS4. In specific cases, the MS4s involved or third parties may show that the 10 percent threshold is inappropriate for the MS4 in question.

    d. <u>Discharge to sensitive water bodies</u> – Sensitive water bodies are receiving waters, which are a priority to protect. They include the following:

- those listed as providing or known to provide habitat for threatened or endangered species;

- those used for recreation that are subject to beach closings or health warnings; or

- those listed as impaired pursuant to CWA section 303(d) due to constituents of concern in urban runoff (these include biochemical oxygen demand (BOD), sediment, pathogens, oil and grease, and other constituents that are found in the MS4 discharge).

Additional criteria to qualify as a sensitive water body may exist and may be used by SWRCB or RWQCB on a case-by-case basis.

e. Significant contributor of pollutants to waters of the United States (U.S.) – Specific conditions presented by the MS4 may lead to significant pollutant loading to waters of the U.S. that are otherwise unregulated or inadequately regulated. An example of such a condition may be the presence of a large transportation industry.

This General Permit serves as notice to those Small MS4s on Attachment 2 that they are designated as regulated Small MS4s by the SWRCB at the time of permit adoption.

11. Section 122.26(b)(16)(iii) of 40 CFR defines systems that are similar to separate storm sewer systems in cities and counties, such as systems at military bases, large hospital or prison complexes, and highways and other thoroughfares as Small MS4s. In this General Permit these types of Small MS4s are referred to as non-traditional MS4s that may be designated as regulated Small MS4s and required to seek coverage under this General Permit or coverage under a separate permit. Non-traditional MS4s often operate storm sewers that are similar to traditional MS4s operated by cities or counties and discharge the same types of pollutants that are typically associated with urban runoff.

12. This permit does not designate any non-traditional MS4s. SWRCB or RWQCB may designate non-traditional MS4s at any time subsequent to the adoption of this General Permit. Non-traditional MS4s that may be designated at a future date include, but are not limited to, those listed in Attachment 3 of this General Permit.

13. Non-traditional Small MS4 entities that are designated, but whose entire facilities are subject to the NPDES General Permit for the Discharge of Storm Water Associated with Industrial Activities and whose Storm Water Pollution Prevention Plan (SWPPP) addresses all six Minimum Control Measures described in this General Permit, are not required to obtain coverage under this General Permit. Such entities must present documentation to the appropriate RWQCB, showing that they meet the requirements for exclusion from coverage.

14. This General Permit requires regulated Small MS4s (Permittees) to develop a Storm Water Management Program (SWMP) designed to reduce the discharge of pollutants to the Maximum Extent Practicable (MEP) and to protect water quality. Upon approval of SWMP by the Regional Water Quality Control Board (RWQCB) or its Executive Officer,

the Permittees obtain coverage under this General Permit. This General Permit requires implementation of SWMP.

15. SWMP will be available for public review and comment and may be subject to a public hearing if requested prior to approval.

16. Permittees can satisfy the requirements through effective implementation of a SWMP, which must contain Best Management Practices (BMPs) that address six Minimum Control Measures. SWMP must incorporate measurable goals and time schedules of implementation.

17. The MEP standard is an ever-evolving, flexible, and advancing concept, which considers technical and economic feasibility. As knowledge about controlling urban runoff continues to evolve, so does that which constitutes MEP. Reducing the discharge of storm water pollutants to MEP in order to protect beneficial uses requires review and improvement, which includes seeking new opportunities. To do this, the Permittee must conduct and document evaluation and assessment of each relevant element of its program and revise activities, control measures, BMPs, and measurable goals, as necessary to meet MEP.

18. This General Permit includes Supplemental Provisions that apply to traditional and non-traditional Small MS4s serving a population of 50,000 people or more, or that are subject to high growth. These requirements address post-construction requirements and compliance with water quality standards. These Supplemental Provisions are similar to requirements for Medium and Large MS4s (Phase I), and are appropriate because larger Small MS4s are able to have more robust storm water programs and fast-growing Small MS4s may cause greater impacts to water quality.

19. The Receiving Water Limitations language contained in Attachment 4 is identical to the language established in SWRCB Water Quality Order WQ-99-05 adopted by the SWRCB on June 17, 1999. As interpreted in SWRCB Water Quality Order WQ-2001-15, adopted by the SWRCB on November 15, 2001, the receiving water limitations in this General Permit do not require strict compliance with water quality standards, but instead require compliance with water quality standards over time, through an iterative approach requiring improved BMPs.

20. The post-construction requirements, or Design Standards, contained in Attachment 4 are consistent with Order WQ-2000-11 adopted by SWRCB on October 5, 2000.

21. The purpose of the annual performance review is to evaluate (1) SWMP's effectiveness; (2) the implementation of SWMP (3) status of measurable goals; (4) effectiveness of BMPs; and (5) improvement opportunities to achieve MEP.

22. To apply for permit coverage authorizing storm water discharges to surface waters pursuant to this General Permit, the Permittees must submit a complete application package to the appropriate RWQCB. An application package includes a Notice of Intent

(NOI) to comply with the terms of this General Permit, appropriate fee (in accordance with the most recent fee schedule[1]), and SWMP. Permittees relying entirely on separately permitted Separate Implementing Entities (SIEs) to implement their entire programs are not required to submit a SWMP if the SIE being relied on has an approved SWMP. Attachment 8 gives contact information for each RWQCB.

23. Upon receipt of a complete permit application, the application will be public noticed for thirty days on SWRCB's website. During the public notice period, a member of the public may request that a public hearing be conducted by RWQCB. If no public hearing is requested, the application may be approved by the RWQCB Executive Officer. Permittees obtain coverage under the General Permit only after the SWMP has been approved.

24. Each Permittee is individually responsible for adoption and enforcement of ordinances and/or policies, implementation of identified control measures/BMPs needed to prevent or reduce pollutants in storm water, and for allocation of funds for the capital, operation and maintenance, and enforcement expenditures necessary to implement and enforce such control measures/BMPs within its jurisdiction. Enforcement actions concerning this General Permit will be pursued only against the individual Permittee responsible for specific violations of this General Permit.

25. In accordance with 40 CFR section 122.28(b)(3), a RWQCB may issue an individual MS4 NPDES Permit to a Permittee otherwise subject to this General Permit, or adopt an alternative general permit that covers storm water discharges regulated by this General Permit. The applicability of this General Permit is automatically terminated on the effective date of the individual permit or the date of approval for coverage under the alternative general permit.

26. Certain BMPs implemented or required by Permittees for urban runoff management may create a habitat for vectors (e.g., mosquitoes and rodents) if not properly designed or maintained. Close collaboration and cooperative effort between the Permittees, local vector control agencies, RWQCB staff, and the State Department of Health Services is necessary to identify and implement appropriate vector control measures that minimize potential nuisances and public health impacts resulting from vector breeding.

27. This General Permit may be reopened and modified if the decision *in Environmental Defense Center v. EPA* is revised or vacated.

28. This NPDES Permit is consistent with the antidegradation policies of 40 CFR section 131.12, SWRCB Resolution 68-16, and RWQCBs' individual Basin Plans. Implementing storm water quality programs that address the six Minimum Control Measures in previously unregulated areas will decrease the pollutant loading to the receiving waters and improve water quality.

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[1] California Code of Regulations. Title 23. Division 3. Chapter 9 Waste Discharge Reports and Requirements. Article 1 Fees.

29. Following public notice in accordance with State and federal laws and regulations, SWRCB, in public hearings on December 2, 2002 and April 30, 2003, heard and considered all comments. SWRCB has prepared written responses to all significant comments.

30. This action to adopt an NPDES Permit is exempt from the provisions of the California Environmental Quality Act (Public Resources Code § 21100, et seq.) in accordance with section 13389 of the Porter-Cologne Water Quality Control Act (Porter-Cologne) (Division 7 of the California Water Code).

31. This NPDES Permit is in compliance with Part 402 of CWA and shall take effect 100 days after adoption by SWRCB. Once in effect, RWQCBs shall enforce the provisions herein.

IT IS HEREBY ORDERED that operators of Small MS4s subject to this General Permit shall comply with the following:

A. APPLICATION REQUIREMENTS

1. Deadlines for Application

a. By August 8, 2003, all Permittees automatically designated (see Attachment 1) must either apply for coverage under this General Permit (either individually or as a co-permittee), submit an application for an individual or alternative general Small MS4 permit (if applicable), or submit a joint application for modification of an existing large or medium MS4 permit (40 CFR §122.33(c)(1)).

Permittees that submitted complete application packages prior to the adoption of this General Permit to meet the federal regulation March 10, 2003 deadline have complied with this requirement and are not required to submit a duplicate application package.

b. By October 27, 2003, traditional Small MS4s designated according to Finding 10 (see Attachment 2), must either apply for coverage under this General Permit (either individually or as a co-permittee), submit an application for an individual or alternative general Small MS4 permit, or submit a joint application for modification of an existing large or medium MS4 permit (40 CFR §122.33(c)(2)). Written notices will be sent to designated parties subsequent to adoption of this General Permit.

c. Non-traditional Small MS4s, or other Small MS4s, which are designated by RWQCB or SWRCB after adoption of this General Permit must apply for coverage under this General Permit (either individually or as a co-permittee), submit a complete application for an individual or alternative general Small MS4 permit, or submit a joint application for modification of an existing large or medium MS4 permit (40 CFR §122.33(c)(2)). Applications must be submitted within 180 days of designation unless a later date is provided in the designation letter.

2. General Permit Application

To obtain coverage under this General Permit, submit to the appropriate RWQCB a completed NOI (Attachment 7), a complete SWMP (one hard copy and one electronic copy in Word or PDF format), and appropriate fee. SWMP shall meet all the requirements of Section D of this General Permit. Permittees relying entirely on SIEs pursuant to Provision D.6 and permitted under the NPDES program are not required to submit a SWMP.

3. General Permit Coverage

Permit coverage will be in effect upon the completion of the following:

a. The Permittee has submitted a complete permit application to the appropriate RWQCB,

b. Receipt of a complete application is noticed for a minimum of 60 days and copies provided to the public for review and comment upon request,

c. The proposed SWMP has been reviewed by RWQCB staff, and

d. SWMP has been approved by the RWQCB Executive Officer, or approved by RWQCB in a public hearing, if requested.

B. DISCHARGE PROHIBITIONS

1. Discharges of waste that are prohibited by Statewide Water Quality Control Plans or applicable Regional Water Quality Control Plans (Basin Plans) are prohibited.

2. Discharges from the MS4s regulated under this General Permit that cause or threaten to cause nuisance are prohibited.

3. Discharges of material other than storm water to waters of the U.S. or another permitted MS4 must be effectively prohibited, except as allowed under Provision D.2.c, or as otherwise authorized by a separate NPDES permit.

C. EFFLUENT LIMITATIONS

1. Permittees must implement BMPs that reduce pollutants in storm water to the technology-based standard of MEP.

2. Storm water discharges regulated by this General Permit shall not contain a hazardous substance in amounts equal to or in excess of a reportable quantity listed in 40 CFR Part 117 or 40 CFR Part 302.

D. STORM WATER MANAGEMENT PROGRAM REQUIREMENTS

The Permittee shall maintain, implement, and enforce an effective SWMP, and develop adequate legal authority to implement and enforce the SWMP, designed to reduce the discharge of pollutants from the permitted MS4 to MEP and to protect water quality. SWMP shall serve as the framework for identification, assignment, and implementation of control measures/BMPs. The Permittee shall implement SWMP and shall subsequently demonstrate its effectiveness and provide for necessary and appropriate revisions, modifications, and improvements to reduce pollutants in storm water discharges to the MEP. SWMP shall be fully implemented by the expiration of this General Permit, or within five years of designation for Small MS4s designated subsequent to Permit adoption, with reasonable progress made towards implementation throughout the term of the General Permit. Existing programs that have storm water quality benefits can be identified in the SWMP and be a part of a Permittee's storm water program.

SWMP shall be revised to incorporate any new or modified BMPs or measurable goals developed through the Permittee's annual reporting process. The Permittee shall incorporate changes required by or acceptable to the RWQCB Executive Officer into applicable annual revisions to SWMP and adhere to its implementation.

1. The Permittee shall maintain, implement, and enforce an effective SWMP designed to reduce the discharge of pollutants from the regulated Small MS4 to the MEP and to protect water quality.

2. SWMP must describe BMPs, and associated measurable goals, that will fulfill the requirements of the following six Minimum Control Measures.

   a. **Public Education and Outreach on Storm Water Impacts**
   The Permittee must implement a public education program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of storm water discharges on water bodies and the steps that the public can take to reduce pollutants in storm water runoff. For non-traditional Permittees, the employee/user population may serve as "the public" to target for outreach and involvement.

Non-traditional Small MS4s that discharge into medium and large MS4 may integrate public education and outreach program with the existing MS4 public education and outreach programs.

b. **Public Involvement/Participation**
The Permittee must at a minimum comply with State and local public notice requirements when implementing a public involvement/participation program.

c. **Illicit Discharge Detection and Elimination**
The Permittee must:

1) Develop, implement, and enforce a program to detect and eliminate illicit discharges (as defined at 40 CFR §122.26(b)(2)) into the regulated Small MS4;

2) Develop, if not already completed, a storm sewer system map, showing the location of all outfalls and the names and locations of all waters of the U.S. that receive discharges from those outfalls;

3) To the extent allowable under State or local law, effectively prohibit, through ordinance, or other regulatory mechanism, non-storm water discharges into the MS4 and implement appropriate enforcement procedures and actions;

4) Develop and implement a plan to detect and address non-storm water discharges, including illegal dumping, to the system that are not authorized by a separate NPDES permit;

5) Inform public employees, businesses, and the general public of the hazards that are generally associated with illegal discharges and improper disposal of waste; and

6) Address the following categories of non-storm water discharges or flows (i.e., authorized non-storm water discharges) only where they are identified as significant contributors of pollutants to the Small MS4:

1. water line flushing;
2. landscape irrigation;
3. diverted stream flows;
4. rising ground waters;
5. uncontaminated ground water infiltration (as defined at 40 CFR §35.2005(20)) to separate storm sewers;
6. uncontaminated pumped ground water;
7. discharges from potable water sources;
8. foundation drains;
9. air conditioning condensation;
10. irrigation water;
11. springs;
12. water from crawl space pumps;
13. footing drains;
14. lawn watering;
15. individual residential car washing;
16. flows from riparian habitats and wetlands; and
17. dechlorinated swimming pool discharges.

Discharges or flows from fire fighting activities are excluded from the effective prohibition against non-storm water and need only be addressed where they are identified as significant sources of pollutants to waters of the U.S.

If a RWQCB Executive Officer determines that any individual or class of non-storm water discharge(s) listed above may be a significant source of pollutants to waters of the U.S. or physically interconnected MS4, or poses a threat to water quality standards (beneficial uses), the RWQCB Executive Officer may require the appropriate Permittee(s) to monitor and submit a report and to implement BMPs on the discharge.

d. **Construction Site Storm Water Runoff Control**

The Permittee must develop, implement, and enforce a program to reduce pollutants in any storm water runoff to the Small MS4 from construction activities that result in a land disturbance of greater than or equal to one acre. Reduction of storm water discharges from construction activity disturbing less than one acre must be included in your program if that construction activity is part of a larger common plan of development or sale that would disturb one acre or more. The program must include the development and implementation of, at a minimum:

1) An ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions, or other effective mechanisms, to ensure compliance, to the extent allowable under State, or local law;

2) Requirements for construction site operators to implement appropriate erosion and sediment control BMPs;

3) Requirements for construction site operators to control waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site that may cause adverse impacts to water quality;

4) Procedures for site plan review which incorporate consideration of potential water quality impacts;

5) Procedures for receipt and consideration of information submitted by the public; and

6) Procedures for site inspection and enforcement of control measures.

e. **Post-Construction Storm Water Management in New Development and Redevelopment**

The Permittee must:

1) Develop, implement, and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the Small MS4 by ensuring that controls are in place that would prevent or minimize water quality impacts;

2) Develop and implement strategies, which include a combination of structural and/or non-structural BMPs appropriate for your community;

3) Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State or local law For those Small MS4s described in Supplemental Provision E below, the requirements must at least include the design standards contained in Attachment 4 of this General Permit or a functionally equivalent program that is acceptable to the appropriate RWQCB; and

4) Ensure adequate long-term operation and maintenance of BMPs.

The General Permit does not require redesign of K-12 school or community college facilities that have been submitted to the Department of General Services, Division of the State Architect before adoption of the permit, and which receive final approval from the State Allocation Board or the Public Works Board, as appropriate, on or before December 31, 2004.

f. **Pollution Prevention/Good Housekeeping for Municipal Operations**
The Permittee must:

1) Develop and implement an operation and maintenance program that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations; and

2) Using training materials that are available from U.S. EPA, the State, or other organizations, the program must include employee training to prevent and reduce storm water pollution from activities such as park and open space maintenance, fleet building maintenance, new construction and land disturbances, and storm water system maintenance.

3. SWMP must identify the measurable goals for each of the BMPs, including, as appropriate, the months and years for scheduled actions, including interim milestones and the frequency of the action.

4. SWMP must identify the person or persons who will implement or coordinate SWMP, as well as each Minimum Control Measure.

5. Termination of coverage

A Permittee may terminate coverage if a new operator has assumed responsibility for the MS4, the Permittee has ceased operation of the MS4, or the Permittees has eliminated discharges from the MS4. To terminate coverage, the Permittee must submit a written request to the RWQCB.

6. Reliance on a SIE

The Permittee may rely on a SIE to satisfy one or more of the permit obligations, if the separate entity can appropriately and adequately address the storm water issues of the Permittee. The Permittee must describe the arrangement in the SWMP and the arrangement is subject to the approval of the RWQCB Executive Officer. The other entity must agree to implement the control measure(s), or components thereof, to achieve compliance with the General Permit. The Permittee remains responsible for compliance with this General Permit if the SIE fails to implement the control measure(s).

If the Permittee relies on an SIE to implement all six Minimum Control Measures and the SIE also has a storm water permit issued by SWRCB or RWQCB, the Permittee relying on the SIE must still submit an NOI, appropriate fee, and certification of the arrangement. The Permittee must note this fact in the NOI and provide proof that the SIE has an approved SWMP, but is not required to maintain a SWMP nor submit annual reports.

7. Outfalls not identified in the storm sewer system map required by Provision D.2.c.2), but constructed within the permitted area during the term of this General Permit to receiving waters identified in the NOI, shall not be considered a material change in character, location, or volume of the permitted discharge, and shall be allowed under the terms of this General Permit without permit application or permit modification, provided that the following information be provided in the subsequent annual report:

   a. Receiving water name;

   b. Storm sewer system map of added area;

   c. Certification that SWMP shall be amended to include the drainage area.

E. SUPPLEMENTAL PROVISIONS

Those regulated traditional and non-traditional Small MS4s serving a population over 50,000 or that are subject to high growth (at least 25 percent over ten years) must comply with the requirements in Attachment 4 of this General Permit. Compliance is required upon full implementation of the Small MS4s' storm water management plan.

Attachment 5 provides a list of communities that SWRCB anticipates being subject to the provisions in Attachment 4.

F. REPORTING REQUIREMENTS AND MONITORING

1. Reporting

The Permittee must submit annual reports to the appropriate RWQCB by September 15th of each year (for Small MS4s designated with the adoption of this permit, the first annual report is to be submitted in 2004), or as otherwise required by the RWQCB Executive Officer, unless exempted under Provision D.6. The report shall summarize the activities performed throughout the reporting period (July 1 through June 30) and must include:

   a. The status of compliance with permit conditions;

   b. An assessment of the appropriateness and effectiveness of the identified BMPs;

   c. Status of the identified measurable goals;

   d. Results of information collected and analyzed, including monitoring data, if any, during the reporting period;

e. A summary of the storm water activities the Permittee plans to undertake during the next reporting cycle;

f. Any proposed change(s) to SWMP along with a justification of why the change(s) are necessary; and

g. A change in the person or persons implementing and coordinating SWMP.

2. RWQCB may impose additional monitoring requirements, which may include a reporting component. RWQCBs may adopt such requirements on an individual or group basis.

3. Recordkeeping

The Permittee must keep records required by this General Permit for at least five years or the duration of the General Permit if continued. The RWQCB Executive Officer may specify a longer time for record retention. The Permittee must submit the records to the RWQCB Executive Officer upon request. The Permittee must make the records, including the permit and SWMP, available to the public during regular business hours.

G. RWQCB AUTHORITIES

RWQCBs will review and approve SWMPs prior to permit coverage being in effect and will conduct public hearings of individual permit applications upon request. Where there is no hearing, the Executive Officer may approve the SWMP. RWQCBs will also oversee compliance with this General Permit. Oversight may include, but is not limited to, reviewing reports, requiring modification to SWMPs and other submissions, imposing region-specific monitoring requirements, conducting inspections, taking enforcement actions against violators of this General Permit, and making additional designations of Permittees pursuant with the criteria described in this General Permit and Fact Sheet. The RWQCBs may also issue individual permits to regulated Small MS4s, and alternative general permits to categories of regulated Small MS4s. Upon issuance of such permits by an RWQCB, this General Permit shall no longer regulate the affected Small MS4(s).

H. STANDARD PROVISIONS

1. General Authority

Three of the minimum control measures (illicit discharge detection and elimination, and the two construction-related measures) require enforceable controls on third party activities to ensure successful implementation of the measure. Some non-traditional operators, however, may not have the necessary legal regulatory authority to adopt these enforceable controls. As in the case of local governments that lack such authority, non-traditional MS4s are expected to utilize the authority they do possess and to seek cooperative arrangements.

2. Duty to Comply

The Permittee must comply with all of the conditions of this General Permit. Any permit noncompliance constitutes a violation of CWA and the Porter-Cologne and is grounds for enforcement action and/or removal from General Permit coverage. In the event that the Permittee is removed from coverage under the General Permit, the Permittee will be required to seek coverage under an individual or alternative general permit.

3. General Permit Actions

This General Permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the Permittee for a General Permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not nullify any General Permit condition.

If any toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is promulgated under section 307(a) of CWA for a toxic pollutant which is present in the discharge and that standard or prohibition is more stringent than any limitation on the pollutant in this General Permit, this General Permit shall be modified or revoked and reissued to conform to the toxic effluent standard or prohibition and Permittee so notified.

4. Noncompliance Reporting

Permittees who cannot certify compliance and/or who have had other instances of noncompliance shall notify the appropriate RWQCB within 30 days. Instances of noncompliance resulting in emergencies (i.e., that endanger human health or the environment) shall be reported orally to the RWQCB within 24 hours from the time the discharger becomes aware of the circumstance and in writing to the RWQCB within five days of the occurrence. The notification shall identify the noncompliance event and an initial assessment of any impact caused by the event, describe the actions necessary to achieve compliance, and include a time schedule indicating when compliance will be achieved. The time schedule and corrective measures are subject to modification by the RWQCB Executive Officer.

5. Need to Halt or Reduce Activity Not a Defense

It shall not be a defense for the Permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this General Permit.

6. Duty to Mitigate

The Permittee shall take all responsible steps to minimize or prevent any discharge in violation of this General Permit that has a reasonable likelihood of adversely affecting human health or the environment.

7. Proper Operation and Maintenance

The Permittee shall at all times properly operate and maintain any facilities and systems of treatment and control (and related appurtenances) which are installed or used by the Permittee to achieve compliance with the conditions of this General Permit and with the requirements of SWMP. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. Proper operation and maintenance may require the operation of backup or auxiliary facilities or similar systems installed by the Permittee when necessary to achieve compliance with the conditions of this General Permit.

8. Property Rights

This General Permit does not convey any property rights of any sort or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor does it authorize any infringement of federal, State, or local laws or regulations.

9. Duty to Provide Information

The Permittee shall furnish RWQCB, SWRCB, or U.S. EPA, during normal business hours, any requested information to determine compliance with this General Permit. The Permittee shall also furnish, upon request, copies of records required to be kept by this General Permit.

10. Inspection and Entry

The Permittee shall allow RWQCB, SWRCB, U.S. EPA, or an authorized representative of RWQCB, SWRCB, or U.S. EPA, upon the presentation of credentials and other documents as may be required by law, to:

a. Enter upon the Permittee's premises during normal business hours where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this General Permit;

b. Access and copy, during normal business hours, any records that must be kept under the conditions of this General Permit within a reasonable time from notification;

c. Inspect during normal business hours any municipal facilities; and

d. Sample or monitor at reasonable times for the purpose of assuring General Permit compliance.

11. Signatory Requirements

All NOIs, SWMPs, certifications, reports, or other information prepared in accordance with this General Permit submitted to SWRCB or RWQCB shall be signed by either a principal executive officer, ranking elected official, or duly authorized representative. The principal executive officer of a Federal agency includes the chief executive officer of the agency or the senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrator of U.S. EPA).

12. Certification

Any person signing documents under Section H.11 above shall make the following certification:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, to the best of my knowledge and belief, the information submitted is true, accurate, and complete.

I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

13. Anticipated Noncompliance

The Permittee will give advance notice to the RWQCB and local storm water management agency of any planned changes in the regulated Small MS4 activity that may result in noncompliance with General Permit requirements.

14. Penalties for Falsification of Reports

Section 309(c)(4) of CWA provides that any person who knowingly makes any false material statement, representation, or certification in any record or other document submitted or required to be maintained under this General Permit, including reports of compliance or noncompliance, shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than two years or by both.

15. Penalties for Violations of Permit Conditions

    a. Part 309 of CWA provides significant penalties for any person who violates a permit condition implementing Parts 301, 302, 306, 307, 308, 318, or 405 of CWA or any permit condition or limitation implementing any such section in a permit issued under Part 402. Any person who violates any permit condition of this General Permit is subject to a civil penalty not to exceed $27,500 per calendar day of such violation, as well as any other appropriate sanction provided by Part 309 of CWA.

    b. Porter-Cologne also provides for administrative, civil, and criminal penalties, which in some cases are greater than those under CWA.

16. Oil and Hazardous Substance Liability

    Nothing in this General Permit shall be construed to preclude the institution of any legal action against the Permittee or relieve the Permittee from any responsibilities, liabilities, or penalties to which the Permittee is or may be subject to under Part 311 of CWA.

17. Severability

    The provisions of this General Permit are severable; and, if any provision of this General Permit or the application of any provision of this General Permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this General Permit shall not be affected thereby.

18. Reopener Clause

    This General Permit may be modified, revoked and reissued, or terminated for cause due to promulgation of amended regulations, or otherwise in accordance with 40 CFR sections 122.62, 122.63, 122.64, and 124.5.

19. Availability

    A copy of this General Permit and SWMP shall be made available for public review.

20. Transfers

    This General Permit is not transferable. A Permittee must submit written notification to the appropriate RWQCB to terminate coverage of this General Permit.

21. Continuation of Expired Permit

This General Permit expires five years from the date of adoption. This General Permit continues in force and in effect until a new General Permit is issued or the SWRCB rescinds this General Permit. Only those Small MS4s authorized to discharge under the expiring General Permit are covered by the continued General Permit.

CERTIFICATION

The undersigned, Clerk to the Board, does hereby certify that the foregoing is a full, true, and correct copy of an order duly and regularly adopted at a meeting of SWRCB held on April 30, 2003.

AYE: Arthur G. Baggett, Jr.
Peter S. Silva
Richard Katz
Gary M. Carlton

NO: None

ABSENT: None

ABSTAIN: None

Maureen Marché
Clerk to the Board

APPENDIX C

STATE WATER RESOURCES CONTROL BOARD WATER QUALITY ORDER NO. 2009-0009-DWQ, NPDES GENERAL PERMIT NO. CAS000002, SECTION XIII

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Linda S. Adams
Secretary for Environmental Protection

State Water Resources Control Board

Arnold Schwarzenegger
Governor

Division of Water Quality
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NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
GENERAL PERMIT FOR
STORM WATER DISCHARGES
ASSOCIATED WITH CONSTRUCTION AND LAND DISTURBANCE ACTIVITIES

ORDER NO. 2009-0009-DWQ
NPDES NO**. CAS000002**

This Order was adopted by the State Water Resources Control Board on:	**September 2, 2009**
This Order shall become effective on:	**July 1, 2010**
This Order shall expire on:	**September 2, 2014**

IT IS HEREBY ORDERED, that this Order supersedes Order No. 99-08-DWQ except for enforcement purposes. The Discharger shall comply with the requirements in this Order to meet the provisions contained in Division 7 of the California Water Code (commencing with section 13000) and regulations adopted thereunder, and the provisions of the federal Clean Water Act and regulations and guidelines adopted thereunder.

I, Jeanine Townsend, Clerk to the Board, do hereby certify that this Order with all attachments is a full, true, and correct copy of an Order adopted by the State Water Resources Control Board, on September 2, 2009.

AYE: Vice Chair Frances Spivy-Weber
Board Member Arthur G. Baggett, Jr.
Board Member Tam M. Doduc

NAY: Chairman Charles R. Hoppin

ABSENT: None

ABSTAIN: None

Jeanine Townsend
Clerk to the Board

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XIII. POST-CONSTRUCTION STANDARDS

A. All dischargers shall comply with the following runoff reduction requirements unless they are located within an area subject to post-construction standards of an active Phase I or II municipal separate storm sewer system (MS4) permit that has an approved Storm Water Management Plan.

1. This provision shall take effect three years from the adoption date of this permit, or later at the discretion of the Executive Officer of the Regional Board.

2. The discharger shall demonstrate compliance with the requirements of this section by submitting with their NOI a map and worksheets in accordance with the instructions in Appendix 2. The discharger shall use non-structural controls unless the discharger demonstrates that non-structural controls are infeasible or that structural controls will produce greater reduction in water quality impacts.

3. The discharger shall, through the use of non-structural and structural measures as described in Appendix 2, replicate the pre-project water balance (for this permit, defined as the volume of rainfall that ends up as runoff) for the smallest storms up to the 85^{th} percentile storm event (or the smallest storm event that generates runoff, whichever is larger). Dischargers shall inform Regional Water Board staff at least 30 days prior to the use of any structural control measure used to comply with this requirement. Volume that cannot be addressed using non-structural practices shall be captured in structural practices and approved by the Regional Water Board. When seeking Regional Board approval for the use of structural practices, dischargers shall document the infeasibility of using non-structural practices on the project site, or document that there will be fewer water quality impacts through the use of structural practices.

4. For sites whose disturbed area exceeds two acres, the discharger shall preserve the pre-construction drainage density (miles of stream length per square mile of drainage area) for all drainage areas within the area serving a first order stream[14] or larger stream and ensure that post-project time of runoff concentration is equal or greater than pre-project time of concentration.

[14] A first order stream is defined as a stream with no tributaries.

B. All dischargers shall implement BMPs to reduce pollutants in storm water discharges that are reasonably foreseeable after all construction phases have been completed at the site (Post-construction BMPs).

APPENDIX D

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS HYDROLOGY MANUAL, WATER RESOURCES DIVISION 2006, JANUARY 2006

- 50 YEAR 24 HOUR ISOHYET MAP 1-H1.27
- RUNOFF COEFFICIENT CURVE (SOIL TYPES 5 AND 15)

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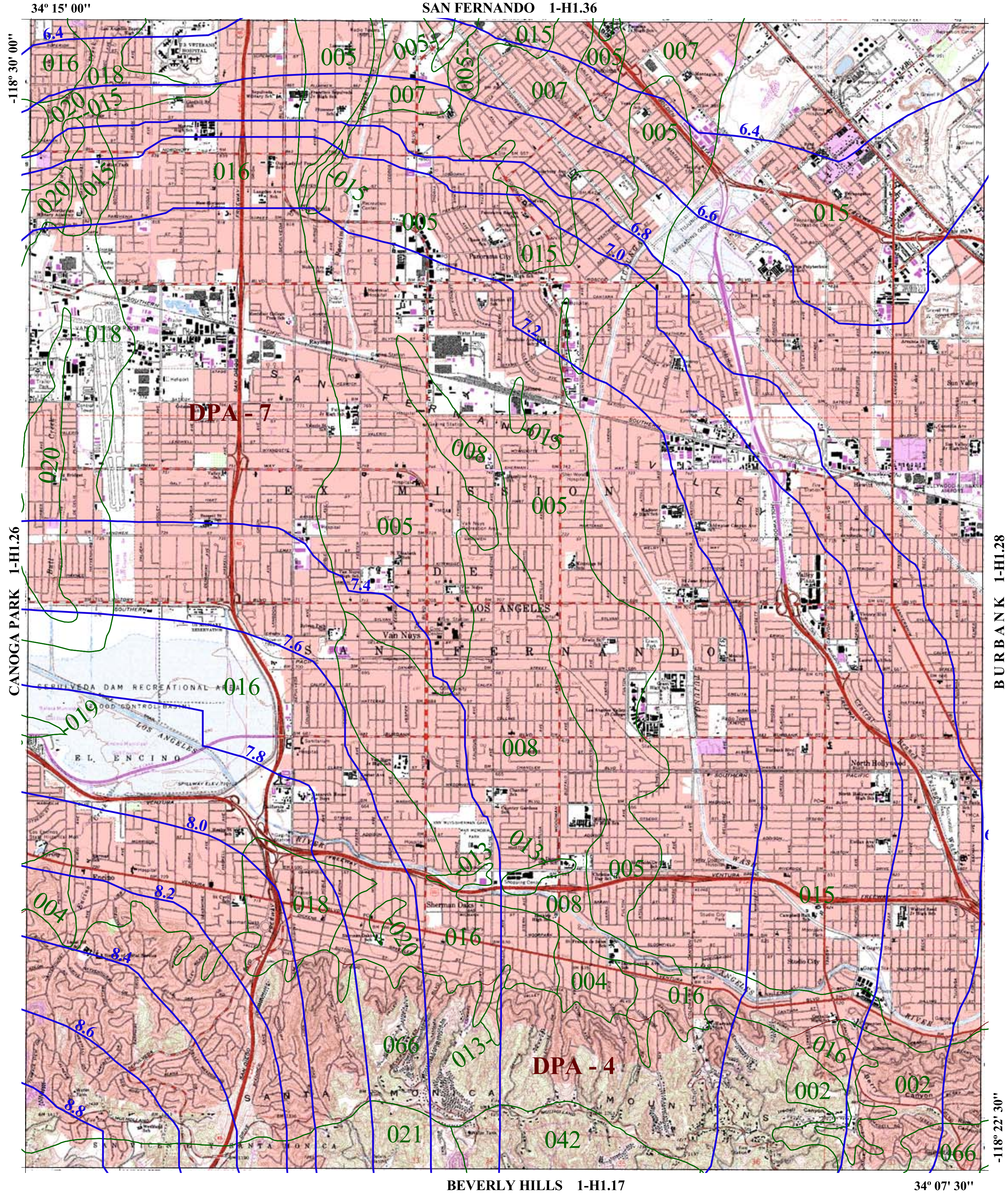


1	0	1	2 Miles

016 SOIL CLASSIFICATION AREA

7.2 INCHES OF RAINFALL

DPA - 6 DEBRIS POTENTIAL AREA

N S E W

25-YEAR 24-HOUR ISOHYET REDUCTION FACTOR: 0.878
10-YEAR 24-HOUR ISOHYET REDUCTION FACTOR: 0.714

VAN NUYS
50-YEAR 24-HOUR ISOHYET

1-H1.27

$C_D = (0.9 * IMP) + (1.0 - IMP) * C_U$

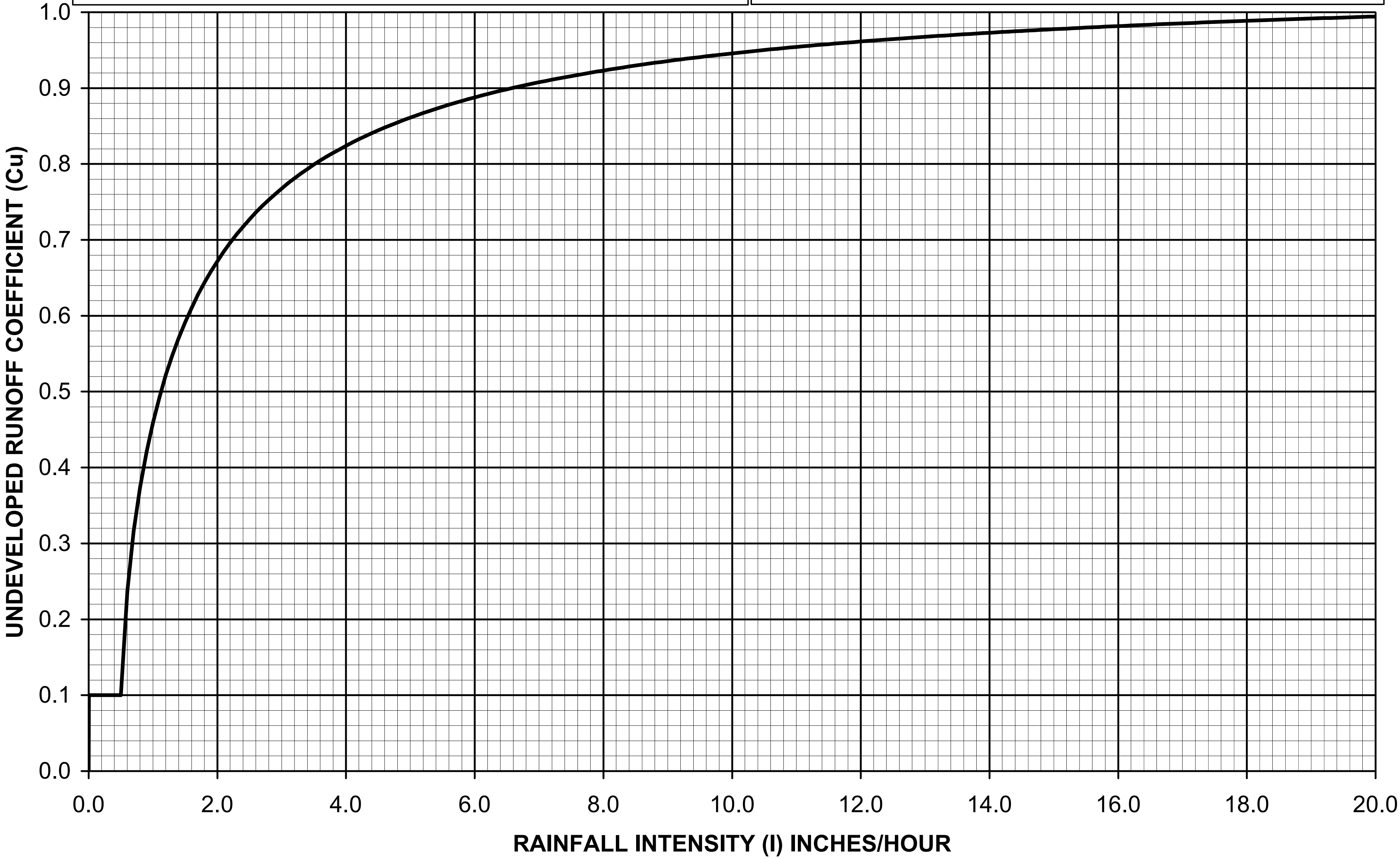
Where: C_D = Developed Runoff Coefficient

IMP = Proportion Impervious

C_U = Undeveloped runoff coefficient

Los Angeles County Department of Public Works

RUNOFF COEFFICIENT CURVE
SOIL TYPE NO. 005



$C_D = (0.9 * IMP) + (1.0 - IMP) * C_U$

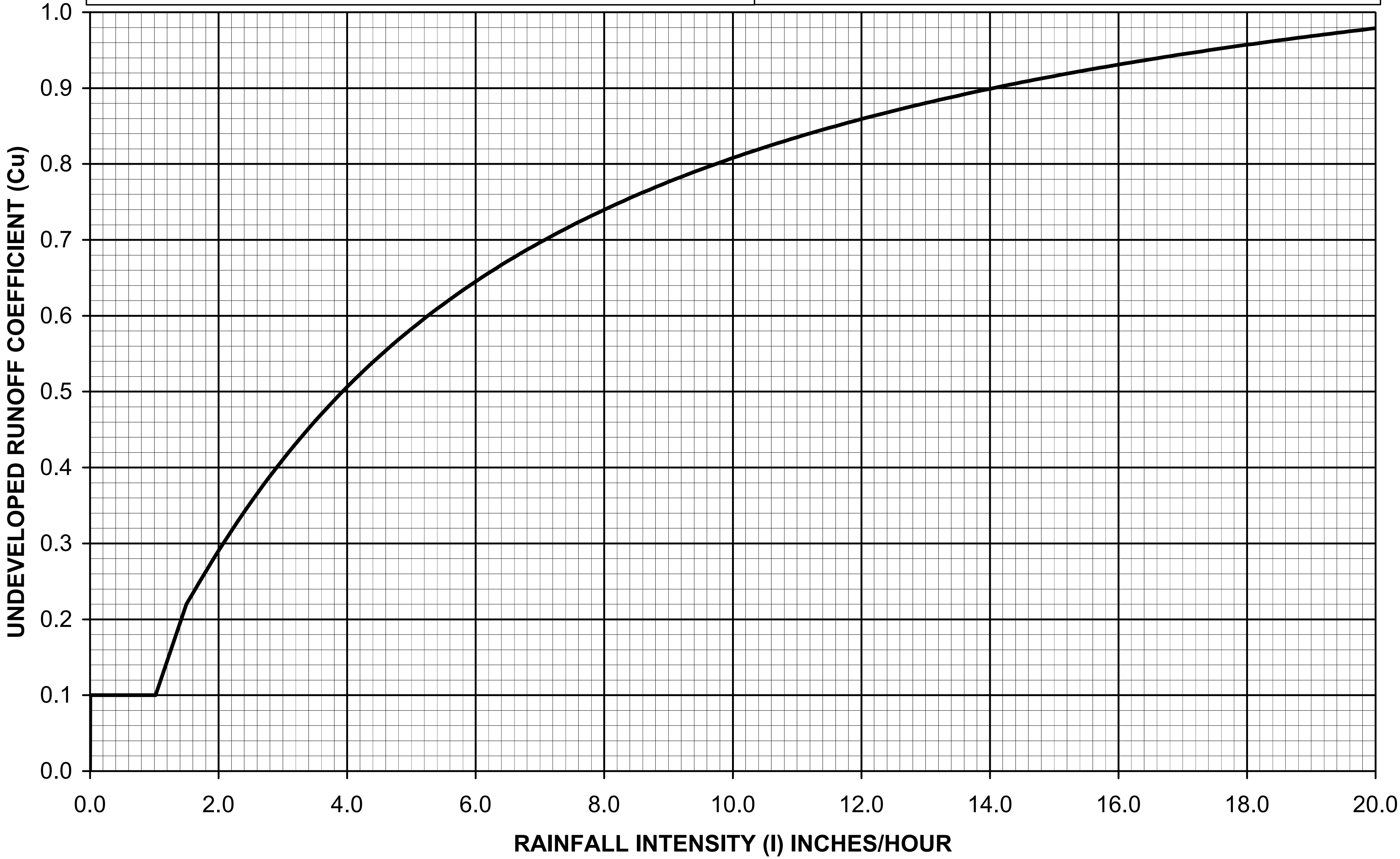
Where: C_D = Developed Runoff Coefficient

IMP = Proportion Impervious

C_U = Undeveloped runoff coefficient

Los Angeles County Department of Public Works

RUNOFF COEFFICIENT CURVE
SOIL TYPE NO. 015



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APPENDIX E

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS TC PROGRAM RESULTS

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Los Angeles Valley College
Psomas Project No. 1LOS151304
25-Year Hydrology Tc Calculations (Existing)
By: Cesar Moran, P.E.
Date: 4/11/11

Area #	Subarea	Area (acres)	%imp	Frequency	Soil Type	Length (ft)	Slope (ft/ft)	Isohyet (in.)	Tc-calculated (min.)	Intensity (in./hr)	Cu	Cd	Flowrate (cfs)
AREA 1	1-1A	3.3	0.47	25	15	647	0.006	6.4	11	2.64	0.37	0.6	5.34
AREA 1	1-2A	6.8	0.91	25	15	1054	0.005	6.4	12	2.53	0.35	0.9	14.62
AREA 1	1-3A	0.3	0.91	25	15	482	0.005	6.4	8	3.07	0.42	0.9	0.86
AREA 1	1-4B	8.0	0.91	25	5	1215	0.011	6.4	12	2.53	0.73	0.9	17.81
AREA 1	1-5B	4.3	0.47	25	5	702	0.016	6.4	8	3.07	0.77	0.8	10.96
AREA 1	1-6B	12.8	0.47	25	15	1125	0.012	6.4	14	2.36	0.33	0.6	18.12
AREA 1	1-8A	0.8	0.91	25	15	1030	0.004	6.4	13	2.44	0.34	0.9	1.66
AREA 1	1-9A	10.8	0.1	25	15	1117	0.004	6.4	26	1.76	0.26	0.3	6.08
AREA 2	2-1A	0.7	0.91	25	15	1389	0.005	6.4	15	2.28	0.32	0.9	1.43
AREA 2	2-2A	0.5	0.91	25	15	1019	0.004	6.4	13	2.44	0.34	0.9	1.12
AREA 3	3-1A	12.2	0.1	25	15	1400	0.006	6.4	28	1.7	0.25	0.3	6.64
AREA 4	4-1A	6.2	0.91	25	15	1070	0.007	6.4	12	2.53	0.35	0.9	13.33
AREA 5	5-1A	2.3	0.47	25	15	425	0.007	6.4	8	3.07	0.42	0.7	4.59
AREA 5	5-2A	9.5	0.47	25	15	1310	0.01	6.4	16	2.21	0.32	0.6	12.39
AREA 5	5-3A	2.4	0.47	25	15	1190	0.007	6.4	16	2.21	0.32	0.6	3.13
AREA 5	5-4A	2.7	0.47	25	15	865	0.009	6.4	12	2.53	0.35	0.6	4.17
AREA 5	5-5A	3.5	0.47	25	15	936	0.009	6.4	13	2.44	0.34	0.6	5.12
AREA 6	6-1A	1.1	0.47	25	15	585	0.011	6.4	9	2.9	0.4	0.6	2.04
AREA 7	7-1A	5.5	0.47	25	15	1045	0.008	6.4	14	2.36	0.33	0.6	7.79
AREA 8	8-1A	2.5	0.91	25	5	830	0.006	6.4	10	2.76	0.75	0.9	6.14
AREA 9	9-1A	1.7	0.91	25	5	680	0.006	6.4	9	2.9	0.76	0.9	4.39
AREA 10	10-1A	3.5	0.47	25	5	800	0.008	6.4	10	2.76	0.75	0.8	7.92
AREA 11	11-1A	5.1	0.91	25	5	1105	0.006	6.4	12	2.53	0.73	0.9	11.36
AREA 12	12-1A	0.3	0.91	25	5	260	0.008	6.4	5	3.82	0.81	0.9	1.13
AREA 13	13-1A	0.7	0.91	25	5	716	0.016	6.4	8	3.07	0.77	0.9	1.91

Los Angeles Valley College
Psomas Project No. 1LOS151304
25-Year Hydrology Tc Calculations (Phase 1)
By: Cesar Moran, P.E.
Date: 4/12/11

Area #	Subarea	Area (acres)	%imp	Frequency	Soil Type	Length (ft)	Slope (ft/ft)	Isohyet (in.)	Tc-calculated (min.)	Intensity (in./hr)	Cu	Cd	Flowrate (cfs)
Area 1	1-1A	3.3	0.47	25	15	647	0.006	6.4	11	2.64	0.37	0.6	5.34
Area 1	1-2A	5.6	0.91	25	15	829	0.007	6.4	10	2.76	0.38	0.9	13.14
Area 1	1-3B	8.2	0.91	25	5	1190	0.011	6.4	12	2.53	0.73	0.9	18.3
Area 1	1-4B	4.7	0.47	25	5	717	0.016	6.4	8	3.07	0.77	0.8	12.06
Area 1	1-6A	0.3	0.91	25	15	482	0.005	6.4	8	3.07	0.42	0.9	0.86
Area 1	1-7B	8.0	0.47	25	15	647	0.03	6.4	8	3.07	0.42	0.7	16.04
Area 1	1-8B	1.2	0.91	25	15	443	0.005	6.4	7	3.26	0.44	0.9	3.36
Area 1	1-9B	4.2	0.91	25	15	728	0.012	6.4	8	3.07	0.42	0.9	10.97
Area 1	1-11A	0.5	0.91	25	15	1030	0.004	6.4	13	2.44	0.34	0.9	1.12
Area 1	1-12A	7.6	0.47	25	15	715	0.004	6.4	13	2.44	0.35	0.6	11.3
Area 2	2-1A	0.7	0.91	25	15	1389	0.005	6.4	15	2.28	0.32	0.9	1.43
Area 2	2-2A	0.5	0.91	25	15	1019	0.004	6.4	13	2.44	0.34	0.9	1.12
Area 3	3-1A	0.8	0.47	25	15	335	0.083	6.4	5	3.82	0.49	0.7	2.14
Area 3	3-2A	0.5	0.47	25	15	503	0.004	6.4	10	2.76	0.38	0.6	0.86
Area 4	4-1A	20.5	0.47	25	15	2340	0.004	6.4	29	1.67	0.24	0.6	18.84
Area 5	5-1A	2.3	0.47	25	15	425	0.007	6.4	8	3.07	0.42	0.7	4.59
Area 5	5-2A	9.5	0.47	25	15	1184	0.01	6.4	15	2.28	0.32	0.6	12.78
Area 5	5-3A	3.8	0.47	25	15	1191	0.008	6.4	16	2.21	0.32	0.6	4.95
Area 5	5-4A	2.4	0.47	25	15	865	0.009	6.4	12	2.53	0.35	0.6	3.78
Area 5	5-5A	4.8	0.91	25	15	982	0.013	6.4	10	2.76	0.38	0.9	11.35
Area 7	7-1A	1.1	0.91	25	15	518	0.018	6.4	6	3.51	0.46	0.9	3.29
Area 9	9-1A	8.6	0.91	25	5	1502	0.005	6.4	15	2.28	0.7	0.9	17.18
Area 10	10-1A	2.0	0.91	25	5	860	0.007	6.4	10	2.76	0.75	0.9	4.96
Area 11	11-1A	5.1	0.91	25	5	1105	0.006	6.4	12	2.53	0.73	0.9	11.36
Area 12	12-1A	0.3	0.91	25	5	260	0.008	6.4	5	3.82	0.81	0.9	1.13
Area 13	13-1A	0.6	0.91	25	5	716	0.016	6.4	8	3.07	0.77	0.9	1.52

Los Angeles Valley College
Psomas Project No. 1LOS151304
25-Year Hydrology Tc Calculations (Phase 2)
By: Cesar Moran, P.E.
Date: 4/12/11

Area #	Subarea	Area (acres)	%imp	Frequency	Soil Type	Length (ft)	Slope (ft/ft)	Isohyet (in.)	Tc-calculated (min.)	Intensity (in./hr)	Cu	Cd	Flowrate (cfs)
Area 1	1-1A	3.3	0.47	25	15	647	0.006	6.4	11	2.64	0.37	0.6	5.34
Area 1	1-2A	5.6	0.91	25	15	829	0.007	6.4	10	2.76	0.38	0.9	13.14
Area 1	1-3B	8.2	0.91	25	5	1190	0.011	6.4	12	2.53	0.73	0.9	18.3
Area 1	1-4B	4.7	0.47	25	5	717	0.016	6.4	8	3.07	0.77	0.8	12.06
Area 1	1-6A	0.3	0.91	25	15	482	0.005	6.4	8	3.07	0.42	0.9	0.86
Area 1	1-7B	3.8	0.47	25	15	1191	0.008	6.4	16	2.21	0.32	0.6	4.95
Area 1	1-8B	4.7	0.47	25	15	580	0.005	6.4	11	2.64	0.37	0.6	7.65
Area 1	1-9B	8.0	0.47	25	15	647	0.03	6.4	8	3.07	0.42	0.7	16.04
Area 1	1-10B	1.2	0.91	25	15	443	0.005	6.4	7	3.26	0.44	0.9	3.36
Area 1	1-11B	4.2	0.91	25	15	728	0.012	6.4	8	3.07	0.42	0.9	10.97
Area 1	1-13A	0.5	0.91	25	15	1030	0.004	6.4	13	2.44	0.34	0.9	1.12
Area 1	1-14A	7.6	0.47	25	15	715	0.004	6.4	13	2.44	0.35	0.6	11.3
Area 2	2-1A	0.7	0.91	25	15	1389	0.005	6.4	15	2.28	0.32	0.9	1.43
Area 2	2-2B	0.5	0.91	25	15	1019	0.004	6.4	13	2.44	0.34	0.9	1.12
Area 3	3-1A	0.8	0.47	25	15	335	0.083	6.4	5	3.82	0.49	0.7	2.14
Area 3	3-2A	0.5	0.47	25	15	503	0.004	6.4	10	2.76	0.38	0.6	0.86
Area 4	4-1A	20.5	0.47	25	15	2340	0.004	6.4	29	1.67	0.24	0.6	18.84
Area 5	5-1A	2.3	0.47	25	15	425	0.007	6.4	8	3.07	0.42	0.7	4.59
Area 5	5-2A	4.9	0.47	25	15	490	0.009	6.4	8	3.07	0.42	0.7	9.69
Area 5	5-3A	2.4	0.47	25	15	865	0.009	6.4	12	2.53	0.35	0.6	3.78
Area 5	5-4A	4.8	0.91	25	15	982	0.013	6.4	10	2.76	0.38	0.9	11.35
Area 7	7-1A	0.5	0.91	25	15	232	0.016	6.4	5	3.82	0.49	0.9	1.77
Area 9	9-1A	9.2	0.91	25	5	1502	0.005	6.4	15	2.28	0.7	0.9	18.46
Area 10	10-1A	2.0	0.91	25	5	860	0.007	6.4	10	2.76	0.75	0.9	4.96
Area 11	11-1A	5.1	0.91	25	5	1105	0.006	6.4	12	2.53	0.73	0.9	11.36
Area 12	12-1A	0.3	0.91	25	5	260	0.008	6.4	5	3.82	0.81	0.9	1.13
Area 13	13-1A	0.6	0.91	25	5	716	0.016	6.4	8	3.07	0.77	0.9	1.52

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APPENDIX F

LAR04 PROGRAM RESULTS

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```
  Program Package Serial Number:  2033
 04/11/11   FILE: LAV25A   INPUT DATA: English Units  RAINFALL SOIL FILE: English
(In) OUTPUT DATA: English Units     PAGE     1
                                                       LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                        PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LOS ANGELES VALLEY COLLEGE - 25 YEAR STORM ANALYSIS - AREA 1
                                STORM DAY 4
                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL       RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
           1304    1A    3.3       5.50       3.3      5.50   3     566.   .00400
   .00   .00        0.   15  11   A37   .47
           1304    2A    6.8      14.81      10.1     18.06   0       0.   .00000
   .00   .00        0.   15  12   A37   .91
           1304    3A     .3        .79      10.4     18.72   0       0.   .00000
   .00   .00        0.   15   8   A37   .91
           1304    4B    8.0      18.09       8.0     18.09   3     267.   .00400
   .00   .00        0.    5  12   A37   .91
           1304    5B    4.3      10.99      12.3     28.00   3     946.   .00500
   .00   .00        0.    5   8   A37   .47
           1304    6B   12.8      18.52      25.1     39.57   0       0.   .00000
   .00   .00        0.   15  14   A37   .47
           1304    7AB  25.1      39.57      35.5     57.46   0       0.   .00000
   .00   .00        0.   15   0   A37   .00
           1304    8A     .8       1.68      36.3     58.97   0       0.   .00000
   .00   .00        0.   15  13   A37   .91
           1304    9A   10.8       6.33      47.1     65.22   0       0.   .00000
   .00   .00        0.   15  26   A37   .10
```

```
  Program Package Serial Number:  2033
 04/11/11   FILE: LAVC-2   INPUT DATA: English Units  RAINFALL SOIL FILE: English
(In) OUTPUT DATA: English Units     PAGE     1
                                                    LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                        PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LAVC - 25 YEAR HYDROLOGY - AREA 2 (EXISTING)
                                STORM DAY 4
                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL      RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
           1304    1A      .7       1.38        .7      1.38   0       0.   .00000
   .00   .00        0.   15  15   A37   .91
           1304    2A      .5       1.05       1.2      2.42   0       0.   .00000
   .00   .00        0.   15  13   A37   .91
```

```
  Program Package Serial Number:  2033
 04/11/11   FILE: LAVC-5   INPUT DATA: English Units  RAINFALL SOIL FILE: English
(In) OUTPUT DATA: English Units     PAGE     1
                                                 LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                     PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LAVC - 25 YEAR HYDROLOGY - AREA 5 (EXISTING)
                                STORM DAY 4
                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL      RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
           1403    1A     2.3       4.55      2.3      4.55   3     350.   .01000
   .00   .00        0.   15   8   A37   .47
           1403    2A     9.5      12.73     11.8     16.83   3     250.   .00400
   .00   .00        0.   15  16   A37   .47
           1403    3A     2.4       3.22     14.2     19.70   3     545.   .01000
   .00   .00        0.   15  16   A37   .47
           1403    4A     2.7       4.27     16.9     22.04   3     296.   .00500
   .00   .00        0.   15  12   A37   .47
           1403    5A     3.5       5.29     20.4     25.28   0       0.   .00000
   .00   .00        0.   15  13   A37   .47
```

```
  Program Package Serial Number:  2033
 04/12/11   FILE: LAVC-A   INPUT DATA: English Units  RAINFALL SOIL FILE: English
(In) OUTPUT DATA: English Units     PAGE     1
                                                   LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                     PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LAVC - 25 YEAR STORM ANALYSIS - AREA 1  (PHASE 1)
                                   STORM DAY 4
                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL      RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
           1304    1A     3.3       7.19       3.3      7.19   3     569.   .00350
   .00   .00        0.    5  11   A37   .47
           1304    2A     5.6      13.89       8.9     18.14   3     490.   .00600
   .00   .00        0.    5  10   A37   .91
           1304    3B     8.2      18.54       8.2     18.54   3     482.   .00500
   .00   .00        0.    5  12   A37   .91
           1304    4B     4.7      12.01      12.9     27.67   3     209.   .00500
   .00   .00        0.    5   8   A37   .47

**************************************************************************************
****************************************
      *                                                        CONFLUENCE Q'S
                                             *
      *   1304    5A  TA 1160 QA    17.52 QAB    42.70 QB    25.18    1304    5B
TB 1158 QB    27.05 QBA    43.74 QA    16.69   *
      *                                1304    5AB TAB 1158 QAB    43.74 QA    16.69
QB    27.05                                  *

**************************************************************************************
****************************************
                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL      RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
           1304    5AB   12.9      27.05      21.8     43.74   0       0.   .00000
   .00   .00        0.    5   0   A37   .00
           1304    6A      .3        .82      22.1     44.32   0       0.   .00000
   .00   .00        0.    5   8   A37   .91
           1304    7B     8.0      20.45       8.0     20.45   4     130.   .00500
  2.25   .00        0.    5   8   A37   .47
           1304    8B     1.2       3.49       9.2     23.84   4     550.   .02000
  1.00   .00        0.    5   7   A37   .91
           1304    9B     4.2      11.45      13.4     35.07   4     325.   .00500
  2.50   .00        0.    5   8   A37   .91

**************************************************************************************
****************************************
      *                                                        CONFLUENCE Q'S
                                             *
      *   1304   10A  TA 1158 QA    44.32 QAB    76.50 QB    32.18    1304   10B
TB 1156 QB    35.04 QBA    76.64 QA    41.60   *
      *                                1304   10AB TAB 1157 QAB    77.01 QA    43.55
QB    33.45                                  *

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                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL      RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
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   .00   .00         0.     5   13   A37    .91
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(In) OUTPUT DATA: English Units     PAGE     1
                                              LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                    PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LAVC - 25 YEAR STORM ANALYSIS - AREA 3 (PHASE 1)
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 CONV   CONV   CONTROL SOIL      RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
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(In) OUTPUT DATA: English Units     PAGE     1
                                                   LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                        PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LAVC - 25 YEAR HYDROLOGY - AREA 5 (PHASE 1)
                                STORM DAY 4
                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL       RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
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   .00   .00        0.    5  16   A37   .47
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   .00   .00        0.    5  12   A37   .47
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(In) OUTPUT DATA: English Units     PAGE     1
                                                       LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                      PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LAVC - 25 YEAR STORM ANALYSIS - AREA 1 (PHASE 2)
                                    STORM DAY 4
                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL       RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
SIZE(Ft)   Z      Q(CFS) NAME  TC  ZONE  IMPV
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           1304    3B     8.2      18.54       8.2     18.54   3     482.   .00500
   .00   .00        0.    5  12   A37   .91
           1304    4B     4.7      12.01      12.9     27.67   3     209.   .00500
   .00   .00        0.    5   8   A37   .47

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TB 1158 QB    27.05 QBA    43.74 QA    16.69   *
       *                                       1304    5AB TAB 1158 QAB    43.74 QA    16.69
QB    27.05                                          *

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 CONV   CONV   CONTROL SOIL       RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
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           1304    7B     3.8       6.77       3.8      6.77   0       0.   .00000
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  2.50   .00        0.    5   8   A37   .91

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                                                     *
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TB 1156 QB    49.47 QBA    91.07 QA    41.60   *
       *                                       1304   12AB TAB 1157 QAB    92.65 QA    43.55
QB    49.10                                          *

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 CONV   CONV   CONTROL SOIL       RAIN  PCT
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SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
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 04/13/11   FILE: LAVC-3   INPUT DATA: English Units  RAINFALL SOIL FILE: English
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                                                       LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                    PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LAVC - 25 YEAR STORM ANALYSIS - AREA 3 (PHASE 2)
                                    STORM DAY 4
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 CONV   CONV   CONTROL SOIL      RAIN  PCT
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SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
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           1304    2A      .5        .88       1.3      3.00   0       0.   .00000
   .00   .00        0.   15  10   A37   .47
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 03/31/11   FILE: LAVC-5   INPUT DATA: English Units  RAINFALL SOIL FILE: English
(In) OUTPUT DATA: English Units     PAGE     1
                                               LOS ANGELES COUNTY FLOOD CONTROL
DISTRICT                     PROG F0601M

           Version 11, MODIFIED RATIONAL METHOD HYDROLOGY - STORM YEAR = 25  SOIL
DATA FILE: C:\Civild\lasoilx.dat
           LAVC - 25 YEAR HYDROLOGY - AREA 5 (PHASE 2)
                                STORM DAY 4
                        SUBAREA   SUBAREA     TOTAL   TOTAL  CONV   CONV     CONV
 CONV   CONV   CONTROL SOIL      RAIN  PCT
           LOCATION     AREA(Ac)  Q(CFS)    AREA(Ac)  Q(CFS) TYPE  LNGTH(Ft) SLOPE
SIZE(Ft)   Z     Q(CFS) NAME  TC  ZONE  IMPV
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           1304    2A     4.9      12.53      7.2     15.33   3     250.   .00400
   .00   .00         0.    5   8   A37   .47
           1304    3A     2.4       4.97      9.6     19.74   3     300.   .00500
   .00   .00         0.    5  12   A37   .47
           1304    4A     4.8      11.91     14.4     29.56   0       0.   .00000
   .00   .00         0.    5  10   A37   .91
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APPENDIX G

CALIFORNIA STORMWATER QUALITY ASSOCIATION (CASQA) BMP FACT SHEETS

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Site Design & Landscape Planning SD-10

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Each project site possesses unique topographic, hydrologic, and vegetative features, some of which are more suitable for development than others. Integrating and incorporating appropriate landscape planning methodologies into the project design is the most effective action that can be done to minimize surface and groundwater contamination from stormwater.

Approach

Landscape planning should couple consideration of land suitability for urban uses with consideration of community goals and projected growth. Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for site design and landscapes planning should conform to applicable standards and specifications of agencies with jurisdiction and be consistent with applicable General Plan and Local Area Plan policies.

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Designing New Installations

Begin the development of a plan for the landscape unit with attention to the following general principles:

- Formulate the plan on the basis of clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.

- Map and assess land suitability for urban uses. Include the following landscape features in the assessment: wooded land, open unwooded land, steep slopes, erosion-prone soils, foundation suitability, soil suitability for waste disposal, aquifers, aquifer recharge areas, wetlands, floodplains, surface waters, agricultural lands, and various categories of urban land use. When appropriate, the assessment can highlight outstanding local or regional resources that the community determines should be protected (e.g., a scenic area, recreational area, threatened species habitat, farmland, fish run). Mapping and assessment should recognize not only these resources but also additional areas needed for their sustenance.

Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Conserve Natural Areas during Landscape Planning

If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Cluster development on least-sensitive portions of a site while leaving the remaining land in a natural undisturbed condition.

- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.

- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.

- Promote natural vegetation by using parking lot islands and other landscaped areas.

- Preserve riparian areas and wetlands.

Maximize Natural Water Storage and Infiltration Opportunities Within the Landscape Unit

- Promote the conservation of forest cover. Building on land that is already deforested affects basin hydrology to a lesser extent than converting forested land. Loss of forest cover reduces interception storage, detention in the organic forest floor layer, and water losses by evapotranspiration, resulting in large peak runoff increases and either their negative effects or the expense of countering them with structural solutions.

- Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Develop and implement policies and regulations to discourage the clearing, filling, and channelization of these features. Utilize them in drainage networks in preference to pipes, culverts, and engineered ditches.

- Evaluating infiltration opportunities by referring to the stormwater management manual for the jurisdiction and pay particular attention to the selection criteria for avoiding groundwater contamination, poor soils, and hydrogeological conditions that cause these facilities to fail. If necessary, locate developments with large amounts of impervious surfaces or a potential to produce relatively contaminated runoff away from groundwater recharge areas.

Protection of Slopes and Channels during Landscape Design

- Convey runoff safely from the tops of slopes.
- Avoid disturbing steep or unstable slopes.
- Avoid disturbing natural channels.
- Stabilize disturbed slopes as quickly as possible.
- Vegetate slopes with native or drought tolerant vegetation.
- Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems.
- Stabilize temporary and permanent channel crossings as quickly as possible, and ensure that increases in run-off velocity and frequency caused by the project do not erode the channel.
- 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.
- Line on-site conveyance channels 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 high enough to erode grass or other vegetative linings, riprap, concrete, soil cement, or geo-grid stabilization are other alternatives.
- Consider other design principles that are comparable and equally effective.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define “redevelopment” in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of “ redevelopment” must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under “designing new installations” above should be followed.

Redevelopment may present significant opportunity to add features which had not previously been implemented. Examples include incorporation of depressions, areas of permeable soils, and swales in newly redeveloped areas. While some site constraints may exist due to the status of already existing infrastructure, opportunities should not be missed to maximize infiltration, slow runoff, reduce impervious areas, disconnect directly connected impervious areas.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Stormwater Management Manual for Western Washington, Washington State Department of Ecology, August 2001.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Roof Runoff Controls SD-11

Rain Garden

Design Objectives

☑ Maximize Infiltration

☑ Provide Retention

☑ Slow Runoff

Minimize Impervious Land Coverage

Prohibit Dumping of Improper Materials

☑ Contain Pollutants

Collect and Convey

Description

Various roof runoff controls are available to address stormwater that drains off rooftops. The objective is to reduce the total volume and rate of runoff from individual lots, and retain the pollutants on site that may be picked up from roofing materials and atmospheric deposition. Roof runoff controls consist of directing the roof runoff away from paved areas and mitigating flow to the storm drain system through one of several general approaches: cisterns or rain barrels; dry wells or infiltration trenches; pop-up emitters, and foundation planting. The first three approaches require the roof runoff to be contained in a gutter and downspout system. Foundation planting provides a vegetated strip under the drip line of the roof.

Approach

Design of individual lots for single-family homes as well as lots for higher density residential and commercial structures should consider site design provisions for containing and infiltrating roof runoff or directing roof runoff to vegetative swales or buffer areas. Retained water can be reused for watering gardens, lawns, and trees. Benefits to the environment include reduced demand for potable water used for irrigation, improved stormwater quality, increased groundwater recharge, decreased runoff volume and peak flows, and decreased flooding potential.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Designing New Installations

Cisterns or Rain Barrels

One method of addressing roof runoff is to direct roof downspouts to cisterns or rain barrels. A cistern is an above ground storage vessel with either a manually operated valve or a permanently open outlet. Roof runoff is temporarily stored and then released for irrigation or infiltration between storms. The number of rain barrels needed is a function of the rooftop area. Some low impact developers recommend that every house have at least 2 rain barrels, with a minimum storage capacity of 1000 liters. Roof barrels serve several purposes including mitigating the first flush from the roof which has a high volume, amount of contaminants, and thermal load. Several types of rain barrels are commercially available. Consideration must be given to selecting rain barrels that are vector proof and childproof. In addition, some barrels are designed with a bypass valve that filters out grit and other contaminants and routes overflow to a soak-away pit or rain garden.

If the cistern has an operable valve, the valve can be closed to store stormwater for irrigation or infiltration between storms. This system requires continual monitoring by the resident or grounds crews, but provides greater flexibility in water storage and metering. If a cistern is provided with an operable valve and water is stored inside for long periods, the cistern must be covered to prevent mosquitoes from breeding.

A cistern system with a permanently open outlet can also provide for metering stormwater runoff. If the cistern outlet is significantly smaller than the size of the downspout inlet (say ¼ to ½ inch diameter), runoff will build up inside the cistern during storms, and will empty out slowly after peak intensities subside. This is a feasible way to mitigate the peak flow increases caused by rooftop impervious land coverage, especially for the frequent, small storms.

Dry wells and Infiltration Trenches

Roof downspouts can be directed to dry wells or infiltration trenches. A dry well is constructed by excavating a hole in the ground and filling it with an open graded aggregate, and allowing the water to fill the dry well and infiltrate after the storm event. An underground connection from the downspout conveys water into the dry well, allowing it to be stored in the voids. To minimize sedimentation from lateral soil movement, the sides and top of the stone storage matrix can be wrapped in a permeable filter fabric, though the bottom may remain open. A perforated observation pipe can be inserted vertically into the dry well to allow for inspection and maintenance.

In practice, dry wells receiving runoff from single roof downspouts have been successful over long periods because they contain very little sediment. They must be sized according to the amount of rooftop runoff received, but are typically 4 to 5 feet square, and 2 to 3 feet deep, with a minimum of 1-foot soil cover over the top (maximum depth of 10 feet).

To protect the foundation, dry wells must be set away from the building at least 10 feet. They must be installed in solids that accommodate infiltration. In poorly drained soils, dry wells have very limited feasibility.

Infiltration trenches function in a similar manner and would be particularly effective for larger roof areas. An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. These are described under Treatment Controls.

Pop-up Drainage Emitter

Roof downspouts can be directed to an underground pipe that daylights some distance from the building foundation, releasing the roof runoff through a pop-up emitter. Similar to a pop-up irrigation head, the emitter only opens when there is flow from the roof. The emitter remains flush to the ground during dry periods, for ease of lawn or landscape maintenance.

Foundation Planting

Landscape planting can be provided around the base to allow increased opportunities for stormwater infiltration and protect the soil from erosion caused by concentrated sheet flow coming off the roof. Foundation plantings can reduce the physical impact of water on the soil and provide a subsurface matrix of roots that encourage infiltration. These plantings must be sturdy enough to tolerate the heavy runoff sheet flows, and periodic soil saturation.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Supplemental Information

Examples

- City of Ottawa's Water Links Surface –Water Quality Protection Program
- City of Toronto Downspout Disconnection Program
- City of Boston, MA, Rain Barrel Demonstration Program

Other Resources

Hager, Marty Catherine, Stormwater, "Low-Impact Development", January/February 2003. www.stormh2o.com

Low Impact Urban Design Tools, Low Impact Development Design Center, Beltsville, MD. www.lid-stormwater.net

Start at the Source, Bay Area Stormwater Management Agencies Association, 1999 Edition

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Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Pervious paving is used for light vehicle loading in parking areas. The term describes a system comprising a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface can itself be porous such that water infiltrates across the entire surface of the material (e.g., grass and gravel surfaces, porous concrete and porous asphalt), or can be built up of impermeable blocks separated by spaces and joints, through which the water can drain. This latter system is termed 'permeable' paving. Advantages of pervious pavements is that they reduce runoff volume while providing treatment, and are unobtrusive resulting in a high level of acceptability.

Approach

Attenuation of flow is provided by the storage within the underlying structure or sub base, together with appropriate flow controls. An underlying geotextile may permit groundwater recharge, thus contributing to the restoration of the natural water cycle. Alternatively, where infiltration is inappropriate (e.g., if the groundwater vulnerability is high, or the soil type is unsuitable), the surface can be constructed above an impermeable membrane. The system offers a valuable solution for drainage of spatially constrained urban areas.

Significant attenuation and improvement in water quality can be achieved by permeable pavements, whichever method is used. The surface and subsurface infrastructure can remove both the soluble and fine particulate pollutants that occur within urban runoff. Roof water can be piped into the storage area directly, adding areas from which the flow can be attenuated. Also, within lined systems, there is the opportunity for stored runoff to be piped out for reuse.

Suitable Applications

Residential, commercial and industrial applications are possible. The use of permeable pavement may be restricted in cold regions, arid regions or regions with high wind erosion. There are some specific disadvantages associated with permeable pavement, which are as follows:

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- Permeable pavement can become clogged if improperly installed or maintained. However, this is countered by the ease with which small areas of paving can be cleaned or replaced when blocked or damaged.

- Their application should be limited to highways with low traffic volumes, axle loads and speeds (less than 30 mph limit), car parking areas and other lightly trafficked or non-trafficked areas. Permeable surfaces are currently not considered suitable for adoptable roads due to the risks associated with failure on high speed roads, the safety implications of ponding, and disruption arising from reconstruction.

- When using un-lined, infiltration systems, there is some risk of contaminating groundwater, depending on soil conditions and aquifer susceptibility. However, this risk is likely to be small because the areas drained tend to have inherently low pollutant loadings.

- The use of permeable pavement is restricted to gentle slopes.

- Porous block paving has a higher risk of abrasion and damage than solid blocks.

Design Considerations

Designing New Installations

If the grades, subsoils, drainage characteristics, and groundwater conditions are suitable, permeable paving may be substituted for conventional pavement on parking areas, cul de sacs and other areas with light traffic. Slopes should be flat or very gentle. Scottish experience has shown that permeable paving systems can be installed in a wide range of ground conditions, and the flow attenuation performance is excellent even when the systems are lined.

The suitability of a pervious system at a particular pavement site will, however, depend on the loading criteria required of the pavement.

Where the system is to be used for infiltrating drainage waters into the ground, the vulnerability of local groundwater sources to pollution from the site should be low, and the seasonal high water table should be at least 4 feet below the surface.

Ideally, the pervious surface should be horizontal in order to intercept local rainfall at source. On sloping sites, pervious surfaces may be terraced to accommodate differences in levels.

Design Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and their required operational life. To provide satisfactory performance, the following criteria should be considered:

- The subgrade should be able to sustain traffic loading without excessive deformation.

- The granular capping and sub-base layers should give sufficient load-bearing to provide an adequate construction platform and base for the overlying pavement layers.

- The pavement materials should not crack of suffer excessive rutting under the influence of traffic. This is controlled by the horizontal tensile stress at the base of these layers.

There is no current structural design method specifically for pervious pavements. Allowances should be considered the following factors in the design and specification of materials:

- Pervious pavements use materials with high permeability and void space. All the current UK pavement design methods are based on the use of conventional materials that are dense and relatively impermeable. The stiffness of the materials must therefore be assessed.

- Water is present within the construction and can soften and weaken materials, and this must be allowed for.

- Existing design methods assume full friction between layers. Any geotextiles or geomembranes must be carefully specified to minimize loss of friction between layers.

- Porous asphalt loses adhesion and becomes brittle as air passes through the voids. Its durability is therefore lower than conventional materials.

The single sized grading of materials used means that care should be taken to ensure that loss of finer particles between unbound layers does not occur.

Positioning a geotextile near the surface of the pervious construction should enable pollutants to be trapped and retained close to the surface of the construction. This has both advantages and disadvantages. The main disadvantage is that the filtering of sediments and their associated pollutants at this level may hamper percolation of waters and can eventually lead to surface ponding. One advantage is that even if eventual maintenance is required to reinstate infiltration, only a limited amount of the construction needs to be disturbed, since the sub-base below the geotextile is protected. In addition, the pollutant concentration at a high level in the structure allows for its release over time. It is slowly transported in the stormwater to lower levels where chemical and biological processes may be operating to retain or degrade pollutants.

The design should ensure that sufficient void space exists for the storage of sediments to limit the period between remedial works.

- Pervious pavements require a single size grading to give open voids. The choice of materials is therefore a compromise between stiffness, permeability and storage capacity.

- Because the sub-base and capping will be in contact with water for a large part of the time, the strength and durability of the aggregate particles when saturated and subjected to wetting and drying should be assessed.

- A uniformly graded single size material cannot be compacted and is liable to move when construction traffic passes over it. This effect can be reduced by the use of angular crushed rock material with a high surface friction.

In pollution control terms, these layers represent the site of long term chemical and biological pollutant retention and degradation processes. The construction materials should be selected, in addition to their structural strength properties, for their ability to sustain such processes. In general, this means that materials should create neutral or slightly alkaline conditions and they should provide favorable sites for colonization by microbial populations.

Construction/Inspection Considerations

- Permeable surfaces can be laid without cross-falls or longitudinal gradients.
- The blocks should be lain level
- They should not be used for storage of site materials, unless the surface is well protected from deposition of silt and other spillages.
- The pavement should be constructed in a single operation, as one of the last items to be built, on a development site. Landscape development should be completed before pavement construction to avoid contamination by silt or soil from this source.
- Surfaces draining to the pavement should be stabilized before construction of the pavement.
- Inappropriate construction equipment should be kept away from the pavement to prevent damage to the surface, sub-base or sub-grade.

Maintenance Requirements

The maintenance requirements of a pervious surface should be reviewed at the time of design and should be clearly specified. Maintenance is required to prevent clogging of the pervious surface. The factors to be considered when defining maintenance requirements must include:

- Type of use
- Ownership
- Level of trafficking
- The local environment and any contributing catchments

Studies in the UK have shown satisfactory operation of porous pavement systems without maintenance for over 10 years and recent work by Imbe et al. at 9th ICUD, Portland, 2002 describes systems operating for over 20 years without maintenance. However, performance under such regimes could not be guaranteed, Table 1 shows typical recommended maintenance regimes:

Table 1 Typical Recommended Maintenance Regimes

Activity	Schedule
■ Minimize use of salt or grit for de-icing ■ Keep landscaped areas well maintained ■ Prevent soil being washed onto pavement	Ongoing
■ Vacuum clean surface using commercially available sweeping machines at the following times: - End of winter (April) - Mid-summer (July / August) - After Autumn leaf-fall (November)	2/3 x per year
■ Inspect outlets	Annual
■ If routine cleaning does not restore infiltration rates, then reconstruction of part of the whole of a pervious surface may be required. ■ The surface area affected by hydraulic failure should be lifted for inspection of the internal materials to identify the location and extent of the blockage. ■ Surface materials should be lifted and replaced after brush cleaning. Geotextiles may need complete replacement. ■ Sub-surface layers may need cleaning and replacing. ■ Removed silts may need to be disposed of as controlled waste.	As needed (infrequent) Maximum 15-20 years

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 1 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Cost Considerations

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 2 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Table 2 Engineer's Estimate for Porous Pavement

Porous Pavement														
Item	**Units**	**Price**	**Cycles/ Year**	**Quant. 1 Acre WS**	**Total**	**Quant. 2 Acre WS**	**Total**	**Quant. 3 Acre WS**	**Total**	**Quant. 4 Acre WS**	**Total**	**Quant. 5 Acre WS**	**Total**
Grading	SY	$2.00		604	$1,208	1209	$2,418	1812	$3,624	2419	$4,838	3020	$6,040
Paving	SY	$19.00		212	$4,028	424	$8,056	636	$12,084	848	$16,112	1060	$20,140
Excavation	CY	$3.60		201	$724	403	$1,451	604	$2,174	806	$2,902	1008	$3,629
Filter Fabric	SY	$1.15		700	$805	1400	$1,610	2000	$2,300	2800	$3,220	3600	$4,140
Stone Fill	CY	$16.00		201	$3,216	403	$6,448	604	$9,664	806	$12,896	1008	$16,128
Sand	CY	$7.00		100	$700	200	$1,400	300	$2,100	400	$2,800	500	$3,500
Sight Well	EA	$300.00		2	$600	3	$900	4	$1,200	7	$2,100	7	$2,100
Seeding	LF	$0.05		644	$32	1288	$64	1932	$97	2576	$129	3220	$161
Check Dam	CY	$35.00		0	$0	0	$0	0	$0	0	$0	0	$0
Total Construction Costs					**$10,105**		**$19,929**		**$29,619**		**$40,158**		**$49,798**
Construction Costs Amortized for 20 Years					**$505**		**$996**		**$1,481**		**$2,008**		**$2,490**
Annual Maintenance Expense													
Item	**Units**	**Price**	**Cycles/ Year**	**Quant. 1 Acre WS**	**Total**	**Quant. 2 Acre WS**	**Total**	**Quant. 3 Acre WS**	**Total**	**Quant. 4 Acre WS**	**Total**	**Quant. 5 Acre WS**	**Total**
Sweeping	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Washing	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Inspection	MH	$20.00	5	5	$100	5	$100	5	$100	5	$100	5	$100
Deep Clean	AC	$450.00	0.5	1	$225	2	$450	3	$675	3.9	$878	5	$1,125
Total Annual Maintenance Expense					**$3,960**		**$7,792**		**$11,651**		**$15,483**		**$19,370**

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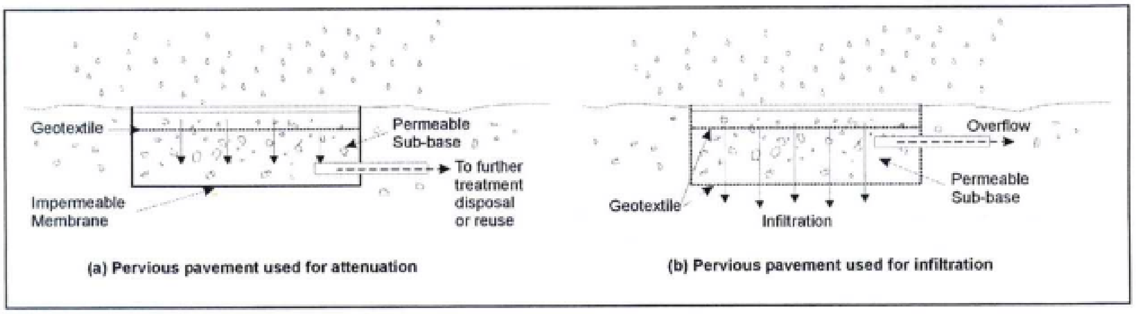

Schematics of a Pervious Pavement System

Alternative Building Materials SD-21

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Source Control
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutant
- Collect and Convey

Description

Alternative building materials are selected instead of conventional materials for new construction and renovation. These materials reduce potential sources of pollutants in stormwater runoff by eliminating compounds that can leach into runoff, reducing the need for pesticide application, reducing the need for painting and other maintenance, or by reducing the volume of runoff.

Approach

Alternative building materials are available for use as lumber for decking, roofing materials, home siding, and paving for driveways, decks, and sidewalks.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Designing New Installations

Decking

One of the most common materials for construction of decks and other outdoor construction has traditionally been pressure treated wood, which is now being phased out. The standard treatment is called CCA, for chromated copper arsenate. The key ingredients are arsenic (which kills termites, carpenter ants and other insects), copper (which kills the fungi that cause wood to rot) and chromium (which reacts with the other ingredients to bind them to the wood). The amount of arsenic is far from trivial. A deck just 8 feet x 10 feet contains more than 1 1/3 pounds of this highly potent poison. Replacement materials include a new type of pressure treated wood, plastic and composite lumber.

There are currently over 20 products in the market consisting of plastic or plastic-wood composites. Plastic lumber is made from 100% recycled plastic, # 2 HDPE and polyethylene plastic milk jugs and soap bottles. Plastic-wood composites are a combination of plastic and wood fibers or sawdust. These materials are a long lasting exterior weather, insect, and chemical resistant wood lumber replacement for non structural applications. Use it for decks, docks, raised garden beds and planter boxes, pallets, hand railings, outdoor furniture, animal pens, boat decks, etc.

New pressure treated wood uses a much safer recipe, ACQ, which stands for ammoniacal copper quartenary. It contains no arsenic and no chromium. Yet the American Wood Preservers Association has found it to be just as effective as the standard formula. ACQ is common in Japan and Europe.

Roofing

Several studies have indicated that metal used as roofing material, flashing, or gutters can leach metals into the environment. The leaching occurs because rainfall is slightly acidic and slowly dissolved the exposed metals. Common traditional applications include copper sheathing and galvanized (zinc) gutters.

Coated metal products are available for both roofing and gutter applications. These products eliminate contact of bare metal with rainfall, eliminating one source of metals in runoff. There are also roofing materials made of recycled rubber and plastic that resemble traditional materials.

A less traditional approach is the use of green roofs. These roofs are not just green, they're alive. Planted with grasses and succulents, low- profile green roofs reduce the urban heat island effect, stormwater runoff, and cooling costs, while providing wildlife habitat and a connection to nature for building occupants. These roofs are widely used on industrial facilities in Europe and have been established as experimental installations in several locations in the US, including Portland, Oregon. Their feasibility is questionable in areas of California with prolonged, dry, hot weather.

Paved Areas

Traditionally, concrete is used for construction of patios, sidewalks, and driveways. Although it is non-toxic, these paved areas reduce stormwater infiltration and increase the volume and rate of runoff. This increase in the amount of runoff is the leading cause of stream channel degradation in urban areas.

There are a number of alternative materials that can be used in these applications, including porous concrete and asphalt, modular blocks, and crushed granite. These materials, especially modular paving blocks, are widely available and a well established method to reduce stormwater runoff.

Building Siding

Wood siding is commonly used on the exterior of residential construction. This material weathers fairly rapidly and requires repeated painting to prevent rotting. Alternative “new” products for this application include cement-fiber and vinyl. Cement-fiber siding is a masonry product made from Portland cement, sand, and cellulose and will not burn, cup, swell, or shrink.

Pesticide Reduction
A common use of powerful pesticides is for the control of termites. Chlordane was used for many years for this purpose and is now found in urban streams and lakes nationwide. There are a number of physical barriers that can be installed during construction to help reduce the use of pesticides.

Sand barriers for subterranean termites are a physical deterrent because the termites cannot tunnel through it. Sand barriers can be applied in crawl spaces under pier and beam foundations, under slab foundations, and between the foundation and concrete porches, terraces, patios and steps. Other possible locations include under fence posts, underground electrical cables, water and gas lines, telephone and electrical poles, inside hollow tile cells and against retaining walls.

Metal termite shields are physical barriers to termites which prevent them from building invisible tunnels. In reality, metal shields function as a helpful termite detection device, forcing them to build tunnels on the outside of the shields which are easily seen. Metal termite shields also help prevent dampness from wicking to adjoining wood members which can result in rot, thus making the material more attractive to termites and other pests. Metal flashing and metal plates can also be used as a barrier between piers and beams of structures such as decks, which are particularly vulnerable to termite attack.

Redeveloping Existing Installations
Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of "redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Other Resources
There are no good, independent, comprehensive sources of information on alternative building materials for use in minimizing the impacts of stormwater runoff. Most websites or other references to "green" or "alternative" building materials focus on indoor applications, such as formaldehyde free plywood and low VOC paints, carpets, and pads. Some supplemental information on alternative materials is available from the manufacturers.

Fires are a source of concern in many areas of California. Information on the flammability of alternative decking materials is available from the University of California Forest Product Laboratory (UCFPL) website at: http://www.ucfpl.ucop.edu/WDDeckIntro.htm

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Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- ☑ Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

Description

Several measures can be taken to prevent operations at maintenance bays and loading docks from contributing a variety of toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to the stormwater conveyance system.

Approach

In designs for maintenance bays and loading docks, containment is encouraged. Preventative measures include overflow containment structures and dead-end sumps. However, in the case of loading docks from grocery stores and warehouse/distribution centers, engineered infiltration systems may be considered.

Suitable Applications

Appropriate applications include commercial and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for vehicle maintenance and repair are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements. The design criteria described in this fact sheet are meant to enhance and be consistent with these code requirements.

Designing New Installations

Designs of maintenance bays should consider the following:

- Repair/maintenance bays and vehicle parts with fluids should be indoors; or designed to preclude urban run-on and runoff.
- Repair/maintenance floor areas should be paved with Portland cement concrete (or equivalent smooth impervious surface).

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- Repair/maintenance bays should be designed 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 form entering the storm drain system. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.

- Other features may be comparable and equally effective.

The following designs of loading/unloading dock areas should be considered:

- Loading dock areas should be covered, or drainage should be designed to preclude urban run-on and runoff.

- Direct connections into storm drains from depressed loading docks (truck wells) are prohibited.

- Below-grade loading docks from grocery stores and warehouse/distribution centers of fresh food items should drain through water quality inlets, or to an engineered infiltration system, or an equally effective alternative. Pre-treatment may also be required.

- Other features may be comparable and equally effective.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permit.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Design Objectives

Maximize Infiltration

Provide Retention

Slow Runoff

Minimize Impervious Land Coverage

Prohibit Dumping of Improper Materials

☑ Contain Pollutants

Collect and Convey

Description

Trash storage areas are areas where a trash receptacle (s) are located for use as a repository for solid wastes. Stormwater runoff from areas where trash is stored or disposed of can be polluted. In addition, loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or creeks. Waste handling operations that may be sources of stormwater pollution include dumpsters, litter control, and waste piles.

Approach

This fact sheet contains details on the specific measures required to prevent or reduce pollutants in stormwater runoff associated with trash storage and handling. Preventative measures including enclosures, containment structures, and impervious pavements to mitigate spills, should be used to reduce the likelihood of contamination.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

Design Considerations

Design requirements for waste handling areas are governed by Building and Fire Codes, and by current local agency ordinances and zoning requirements. The design criteria described in this fact sheet are meant to enhance and be consistent with these code and ordinance requirements. Hazardous waste should be handled in accordance with legal requirements established in Title 22, California Code of Regulation.

Wastes from commercial and industrial sites are typically hauled by either public or commercial carriers that may have design or access requirements for waste storage areas. The design criteria in this fact sheet are recommendations and are not intended to be in conflict with requirements established by the waste hauler. The waste hauler should be contacted prior to the design of your site trash collection areas. Conflicts or issues should be discussed with the local agency.

Designing New Installations

Trash storage areas should be designed to consider the following structural or treatment control BMPs:

- Design trash container areas so that drainage from adjoining roofs and pavement is diverted around the area(s) to avoid run-on. This might include berming or grading the waste handling area to prevent run-on of stormwater.

- Make sure trash container areas are screened or walled to prevent off-site transport of trash.

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- Use lined bins or dumpsters to reduce leaking of liquid waste.
- Provide roofs, awnings, or attached lids on all trash containers to minimize direct precipitation and prevent rainfall from entering containers.
- Pave trash storage areas with an impervious surface to mitigate spills.
- Do not locate storm drains in immediate vicinity of the trash storage area.
- Post signs on all dumpsters informing users that hazardous materials are not to be disposed of therein.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define “redevelopment” in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of “ redevelopment” must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under “designing new installations” above should be followed.

Additional Information

Maintenance Considerations

The integrity of structural elements that are subject to damage (i.e., screens, covers, and signs) must be maintained by the owner/operator. Maintenance agreements between the local agency and the owner/operator may be required. Some agencies will require maintenance deed restrictions to be recorded of the property title. If required by the local agency, maintenance agreements or deed restrictions must be executed by the owner/operator before improvement plans are approved.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Infiltration Trench TC-10

Description

An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment entering the trench which can clog and render the trench ineffective.

California Experience

Caltrans constructed two infiltration trenches at highway maintenance stations in Southern California. Of these, one failed to operate to the design standard because of average soil infiltration rates lower than that measured in the single infiltration test. This highlights the critical need for appropriate evaluation of the site. Once in operation, little maintenance was required at either site.

Advantages

- Provides 100% reduction in the load discharged to surface waters.

- An important benefit of infiltration trenches is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated rather than flushed directly to creeks.

- If the water quality volume is adequately sized, infiltration trenches can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

Design Considerations

- Accumulation of Metals
- Clogged Soil Outlet Structures
- Vegetation/Landscape Maintenance

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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- As an underground BMP, trenches are unobtrusive and have little impact of site aesthetics.

Limitations

- Have a high failure rate if soil and subsurface conditions are not suitable.
- May not be appropriate for industrial sites or locations where spills may occur.
- The maximum contributing area to an individual infiltration practice should generally be less than 5 acres.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration trenches once clogged.

Design and Sizing Guidelines

- Provide pretreatment for infiltration trenches in order to reduce the sediment load. Pretreatment refers to design features that provide settling of large particles before runoff reaches a management practice, easing the long-term maintenance burden. Pretreatment is important for all structural stormwater management practices, but it is particularly important for infiltration practices. To ensure that pretreatment mechanisms are effective, designers should incorporate practices such as grassed swales, vegetated filter strips, detention, or a plunge pool in series.
- Specify locally available trench rock that is 1.5 to 2.5 inches in diameter.
- Determine the trench volume by assuming the WQV will fill the void space based on the computed porosity of the rock matrix (normally about 35%).
- Determine the bottom surface area needed to drain the trench within 72 hr by dividing the WQV by the infiltration rate.

$$d = \frac{WQV + RFV}{SA}$$

- Calculate trench depth using the following equation:

where:

D = Trench depth

WQV	=	Water quality volume
RFV	=	Rock fill volume
SA	=	Surface area of the trench bottom

- The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).
- Provide observation well to allow observation of drain time.
- May include a horizontal layer of filter fabric just below the surface of the trench to retain sediment and reduce the potential for clogging.

Construction/Inspection Considerations

Stabilize the entire area draining to the facility before construction begins. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction. Stabilize the entire contributing drainage area before allowing any runoff to enter once construction is complete.

Performance

Infiltration trenches eliminate the discharge of the water quality volume to surface receiving waters and consequently can be considered to have 100% removal of all pollutants within this volume. Transport of some of these constituents to groundwater is likely, although the attenuation in the soil and subsurface layers will be substantial for many constituents.

Infiltration trenches can be expected to remove up to 90 percent of sediments, metals, coliform bacteria and organic matter, and up to 60 percent of phosphorus and nitrogen in the infiltrated runoff (Schueler, 1992). Biochemical oxygen demand (BOD) removal is estimated to be between 70 to 80 percent. Lower removal rates for nitrate, chlorides and soluble metals should be expected, especially in sandy soils (Schueler, 1992). Pollutant removal efficiencies may be improved by using washed aggregate and adding organic matter and loam to the subsoil. The stone aggregate should be washed to remove dirt and fines before placement in the trench. The addition of organic material and loam to the trench subsoil may enhance metals removal through adsorption.

Siting Criteria

The use of infiltration trenches may be limited by a number of factors, including type of native soils, climate, and location of groundwater table. Site characteristics, such as excessive slope of the drainage area, fine-grained soil types, and proximate location of the water table and bedrock, may preclude the use of infiltration trenches. Generally, infiltration trenches are not suitable for areas with relatively impermeable soils containing clay and silt or in areas with fill.

As with any infiltration BMP, the potential for groundwater contamination must be carefully considered, especially if the groundwater is used for human consumption or agricultural purposes. The infiltration trench is not suitable for sites that use or store chemicals or hazardous materials unless hazardous and toxic materials are prevented from entering the trench. In these areas, other BMPs that do not allow interaction with the groundwater should be considered.

The potential for spills can be minimized by aggressive pollution prevention measures. Many municipalities and industries have developed comprehensive spill prevention control and countermeasure (SPCC) plans. These plans should be modified to include the infiltration trench and the contributing drainage area. For example, diversion structures can be used to prevent spills from entering the infiltration trench. Because of the potential to contaminate groundwater, extensive site investigation must be undertaken early in the site planning process to establish site suitability for the installation of an infiltration trench.

Longevity can be increased by careful geotechnical evaluation prior to construction and by designing and implementing an inspection and maintenance plan. Soil infiltration rates and the water table depth should be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration trench. Pretreatment structures, such as a vegetated buffer strip or water quality inlet, can increase longevity by removing sediments, hydrocarbons, and other materials that may clog the trench. Regular maintenance, including the replacement of clogged aggregate, will also increase the effectiveness and life of the trench.

Evaluation of the viability of a particular site is the same as for infiltration basins and includes:

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30 percent clay or more than 40 percent of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15 percent should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.

- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Maintenance

Infiltration trenches required the least maintenance of any of the BMPs evaluated in the Caltrans study, with approximately 17 field hours spent on the operation and maintenance of each site. Inspection of the infiltration trench was the largest field activity, requiring approximately 8 hr/yr.

In addition to reduced water quality performance, clogged infiltration trenches with surface standing water can become a nuisance due to mosquito breeding. If the trench takes more than 72 hours to drain, then the rock fill should be removed and all dimensions of the trench should be increased by 2 inches to provide a fresh surface for infiltration.

Cost

Construction Cost

Infiltration trenches are somewhat expensive, when compared to other stormwater practices, in terms of cost per area treated. Typical construction costs, including contingency and design costs, are about \$5 per ft^3 of stormwater treated (SWRPC, 1991; Brown and Schueler, 1997). Actual construction costs may be much higher. The average construction cost of two infiltration trenches installed by Caltrans in southern California was about \$50/ft^3; however, these were constructed as retrofit installations.

Infiltration trenches typically consume about 2 to 3 percent of the site draining to them, which is relatively small. In addition, infiltration trenches can fit into thin, linear areas. Thus, they can generally fit into relatively unusable portions of a site.

Maintenance Cost

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly sited or maintained, infiltration trenches have a high failure rate. In general, maintenance costs for infiltration trenches are estimated at between 5 percent and 20 percent of the construction cost. More realistic values are probably closer to the 20-percent range, to ensure long-term functionality of the practice.

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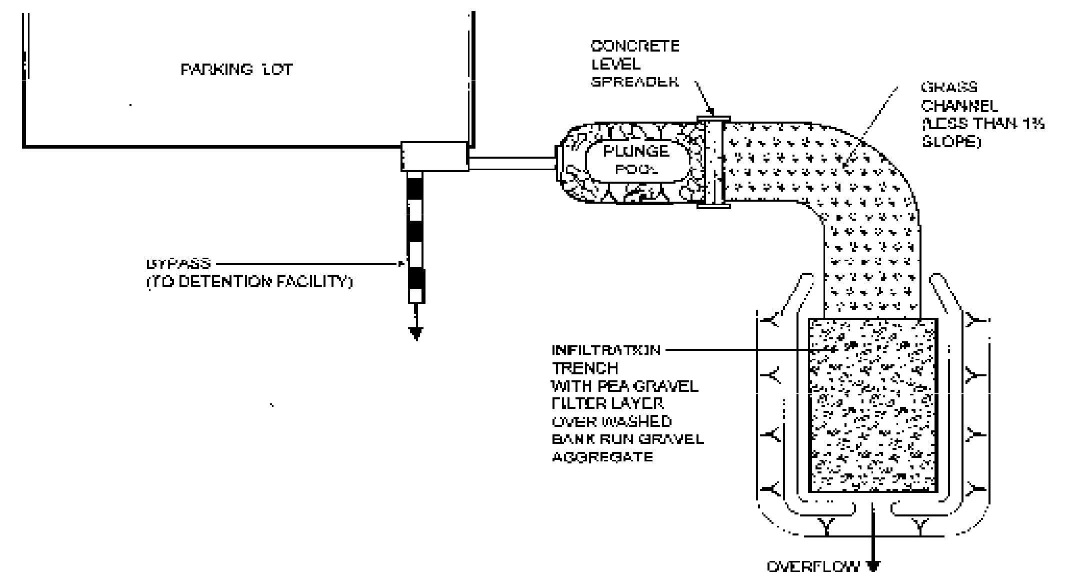
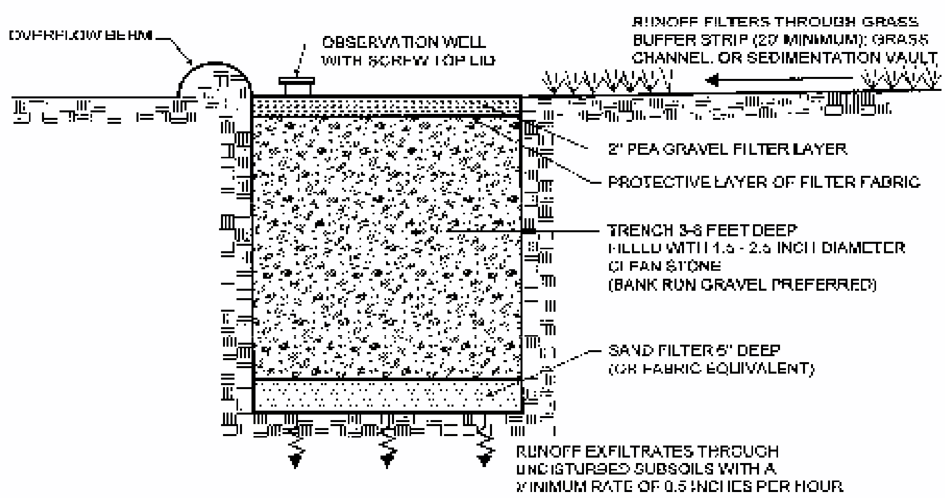


PLAN VIEW



SECTION

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Infiltration Basin TC-11

Design Considerations

- Soil for Infiltration
- Slope
- Aesthetics

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

- ● Low
- ■ High
- ▲ Medium

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Description

An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. Infiltration facilities store runoff until it gradually exfiltrates through the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge groundwater, thus helping to maintain low flows in stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

California Experience

Infiltration basins have a long history of use in California, especially in the Central Valley. Basins located in Fresno were among those initially evaluated in the National Urban Runoff Program and were found to be effective at reducing the volume of runoff, while posing little long-term threat to groundwater quality (EPA, 1983; Schroeder, 1995). Proper siting of these devices is crucial as underscored by the experience of Caltrans in siting two basins in Southern California. The basin with marginal separation from groundwater and soil permeability failed immediately and could never be rehabilitated.

Advantages

- Provides 100% reduction in the load discharged to surface waters.

- The principal benefit of infiltration basins is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated and evaporated rather than flushed directly to creeks.

- If the water quality volume is adequately sized, infiltration basins can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration basins once clogged.

Design and Sizing Guidelines

- Water quality volume determined by local requirements or sized so that 85% of the annual runoff volume is captured.
- Basin sized so that the entire water quality volume is infiltrated within 48 hours.
- Vegetation establishment on the basin floor may help reduce the clogging rate.

Construction/Inspection Considerations

- Before construction begins, stabilize the entire area draining to the facility. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction or remove the top 2 inches of soil after the site is stabililized. Stabilize the entire contributing drainage area, including the side slopes, before allowing any runoff to enter once construction is complete.
- Place excavated material such that it can not be washed back into the basin if a storm occurs during construction of the facility.
- Build the basin without driving heavy equipment over the infiltration surface. Any equipment driven on the surface should have extra-wide ("low pressure") tires. Prior to any construction, rope off the infiltration area to stop entrance by unwanted equipment.
- After final grading, till the infiltration surface deeply.
- Use appropriate erosion control seed mix for the specific project and location.

Performance

As water migrates through porous soil and rock, pollutant attenuation mechanisms include precipitation, sorption, physical filtration, and bacterial degradation. If functioning properly, this approach is presumed to have high removal efficiencies for particulate pollutants and moderate removal of soluble pollutants. Actual pollutant removal in the subsurface would be expected to vary depending upon site-specific soil types. This technology eliminates discharge to surface waters except for the very largest storms; consequently, complete removal of all stormwater constituents can be assumed.

There remain some concerns about the potential for groundwater contamination despite the findings of the NURP and Nightingale (1975; 1987a,b,c; 1989). For instance, a report by Pitt et al. (1994) highlighted the potential for groundwater contamination from intentional and unintentional stormwater infiltration. That report recommends that infiltration facilities not be sited in areas where high concentrations are present or where there is a potential for spills of toxic material. Conversely, Schroeder (1995) reported that there was no evidence of groundwater impacts from an infiltration basin serving a large industrial catchment in Fresno, CA.

Siting Criteria

The key element in siting infiltration basins is identifying sites with appropriate soil and hydrogeologic properties, which is critical for long term performance. In one study conducted in Prince George's County, Maryland (Galli, 1992), all of the infiltration basins investigated clogged within 2 years. It is believed that these failures were for the most part due to allowing infiltration at sites with rates of less than 0.5 in/hr, basing siting on soil type rather than field infiltration tests, and poor construction practices that resulted in soil compaction of the basin invert.

A study of 23 infiltration basins in the Pacific Northwest showed better long-term performance in an area with highly permeable soils (Hilding, 1996). In this study, few of the infiltration basins had failed after 10 years. Consequently, the following guidelines for identifying appropriate soil and subsurface conditions should be rigorously adhered to.

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30% clay or more than 40% of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15% should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.

- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Additional Design Guidelines

(1) Basin Sizing - The required water quality volume is determined by local regulations or sufficient to capture 85% of the annual runoff.

(2) Provide pretreatment if sediment loading is a maintenance concern for the basin.

(3) Include energy dissipation in the inlet design for the basins. Avoid designs that include a permanent pool to reduce opportunity for standing water and associated vector problems.

(4) Basin invert area should be determined by the equation:

$$A = \frac{WQV}{kt}$$

where A = Basin invert area (m^2)

WQV = water quality volume (m^3)

k = 0.5 times the lowest field-measured hydraulic conductivity (m/hr)

t = drawdown time (48 hr)

(5) The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).

Maintenance

Regular maintenance is critical to the successful operation of infiltration basins. Recommended operation and maintenance guidelines include:

- Inspections and maintenance to ensure that water infiltrates into the subsurface completely (recommended infiltration rate of 72 hours or less) and that vegetation is carefully managed to prevent creating mosquito and other vector habitats.
- Observe drain time for the design storm after completion or modification of the facility to confirm that the desired drain time has been obtained.
- Schedule semiannual inspections for beginning and end of the wet season to identify potential problems such as erosion of the basin side slopes and invert, standing water, trash and debris, and sediment accumulation.
- Remove accumulated trash and debris in the basin at the start and end of the wet season.
- Inspect for standing water at the end of the wet season.
- Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade when the accumulated sediment volume exceeds 10% of the basin.
- If erosion is occurring within the basin, revegetate immediately and stabilize with an erosion control mulch or mat until vegetation cover is established.
- To avoid reversing soil development, scarification or other disturbance should only be performed when there are actual signs of clogging, rather than on a routine basis. Always remove deposited sediments before scarification, and use a hand-guided rotary tiller, if possible, or a disc harrow pulled by a very light tractor.

Cost

Infiltration basins are relatively cost-effective practices because little infrastructure is needed when constructing them. One study estimated the total construction cost at about $2 per ft (adjusted for inflation) of storage for a 0.25-acre basin (SWRPC, 1991). As with other BMPs, these published cost estimates may deviate greatly from what might be incurred at a specific site. For instance, Caltrans spent about $18/ft^3 for the two infiltration basins constructed in southern California, each of which had a water quality volume of about 0.34 ac.-ft. Much of the higher cost can be attributed to changes in the storm drain system necessary to route the runoff to the basin locations.

Infiltration basins typically consume about 2 to 3% of the site draining to them, which is relatively small. Additional space may be required for buffer, landscaping, access road, and fencing. Maintenance costs are estimated at 5 to 10% of construction costs.

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly maintained, infiltration basins have a high failure rate. Thus, it may be necessary to replace the basin with a different technology after a relatively short period of time.

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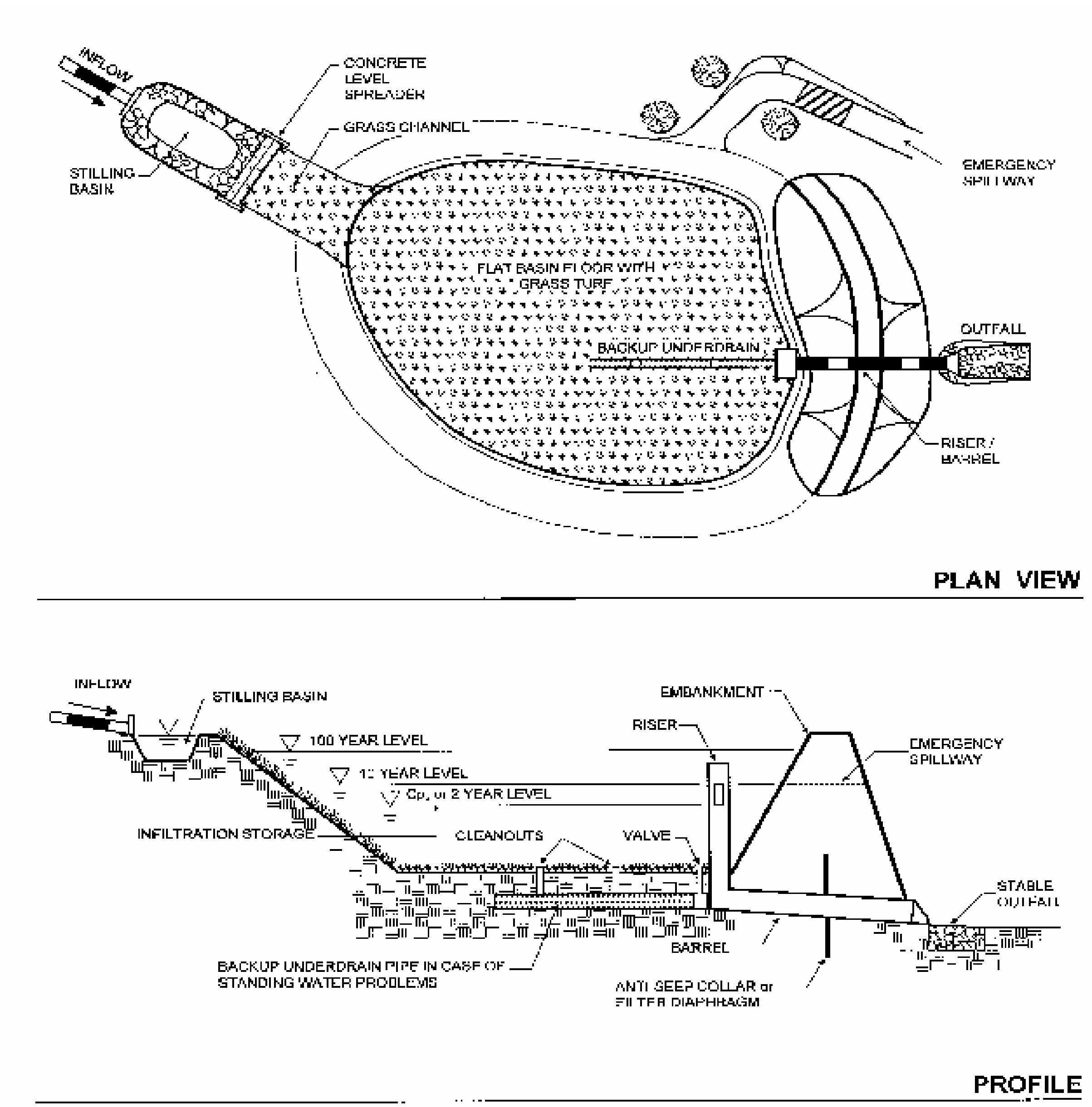

INFLOW
CONCRETE LEVEL SPREADER
GRASS CHANNEL
STILLING BASIN
EMERGENCY SPILLWAY
FLAT BASIN FLOOR WITH GRASS TURF
BACKUP UNDERDRAIN
OUTFALL
RISER / BARREL
PLAN VIEW
INFLOW
STILLING BASIN
100 YEAR LEVEL
EMBANKMENT
RISER
EMERGENCY SPILLWAY
INFILTRATION STORAGE
CLEANOUTS
VALVE
STABLE OUTFALL
BARREL
BACKUP UNDERDRAIN PIPE IN CASE OF STANDING WATER PROBLEMS
ANTI SEEP COLLAR or FILTER DIAPHRAGM
PROFILE

Design Considerations

- Soil for Infiltration
- Area Required
- Slope
- Environmental Side-effects

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

Description

Retention/irrigation refers to the capture of stormwater runoff in a holding pond and subsequent use of the captured volume for irrigation of landscape of natural pervious areas. This technology is very effective as a stormwater quality practice in that, for the captured water quality volume, it provides virtually no discharge to receiving waters and high stormwater constituent removal efficiencies. This technology mimics natural undeveloped watershed conditions wherein the vast majority of the rainfall volume during smaller rainfall events is infiltrated through the soil profile. Their main advantage over other infiltration technologies is the use of an irrigation system to spread the runoff over a larger area for infiltration. This allows them to be used in areas with low permeability soils.

Capture of stormwater can be accomplished in almost any kind of runoff storage facility, ranging from dry, concrete-lined ponds to those with vegetated basins and permanent pools. The pump and wet well should be automated with a rainfall sensor to provide irrigation only during periods when required infiltration rates can be realized. Generally, a spray irrigation system is required to provide an adequate flow rate for distributing the water quality volume (LCRA, 1998). Collection of roof runoff for subsequent use (rainwater harvesting) also qualifies as a retention/irrigation practice.

This technology is still in its infancy and there are no published reports on its effectiveness, cost, or operational requirements. The guidelines presented below should be considered tentative until additional data are available.

California Experience

This BMP has never been implemented in California, only in the Austin, Texas area. The use there is limited to watersheds where no increase in pollutant load is allowed because of the sensitive nature of the watersheds.

Advantages

- Pollutant removal effectiveness is high, accomplished primarily by: (1) sedimentation in the primary storage facility; (2) physical filtration of particulates through the soil profile; (3) dissolved constituents uptake in the vegetative root zone by the soil-resident microbial community.

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The hydrologic characteristics of this technique are effective for simulating pre-developed watershed conditions through: (1) containment of higher frequency flood volumes (less than about a 2-year event); and (2) reduction of flow rates and velocities for erosive flow events.

- Pollutant removal rates are estimated to be nearly 100% for all pollutants in the captured and irrigated stormwater volume. However, relatively frequent inspection and maintenance is necessary to assure proper operation of these facilities.

- This technology is particularly appropriate for areas with infrequent rainfall because the system is not required to operate often and the ability to provide stormwater for irrigation can reduce demand on surface and groundwater supplies.

Limitations

- Retention-irrigation is a relatively expensive technology due primarily to mechanical systems, power requirements, and high maintenance needs.

- Due to the relative complexity of irrigation systems, they must be inspected and maintained at regular intervals to ensure reliable system function.

- Retention-irrigation systems use pumps requiring electrical energy inputs (which cost money, create pollution, and can be interrupted). Mechanical systems are also more complex, requiring skilled maintenance, and they are more vulnerable to vandalism than simpler, passive systems.

- Retention-irrigation systems require open space for irrigation and thus may be difficult to retrofit in urban areas.

- Effective use of retention irrigation requires some form of pre-treatment of runoff flows (i.e., sediment forebay or vegetated filter) to remove coarse sediment and to protect the long-term operating capacity of the irrigation equipment.

- Retention/irrigation BMPs capture and store water that, depending on design may be accessible to mosquitoes and other vectors for breeding.

Design and Sizing Guidelines

- Runoff Storage Facility Configuration and Sizing - Design of the runoff storage facility is flexible as long as the water quality volume and an appropriate pump and wet well system can be accommodated.

- Pump and Wet Well System - A reliable pump, wet well, and rainfall or soil moisture sensor system should be used to distribute the water quality volume. These systems should be similar to those used for wastewater effluent irrigation, which are commonly used in areas where “no discharge” wastewater treatment plant permits are issued.

- Detention Time - The irrigation schedule should allow for complete drawdown of the water quality volume within 72 hours. Irrigation should not begin within 12 hours of the end of rainfall so that direct storm runoff has ceased and soils are not saturated. Consequently, the length of the active irrigation period is 60 hours. The irrigation should include a cycling factor of ½, so that each portion of the area will be irrigated for only 30 hours during the total of 60 hours allowed for disposal of the water quality volume. Irrigation also should not occur during subsequent rainfall events.

- Irrigation System - Generally a spray irrigation system is required to provide an adequate flow rate for timely distribution of the water quality volume.

- Designs that utilize covered water storage should be accessible to vector control personnel via access doors to facilitate vector surveillance and control if needed.

- Irrigation Site Criteria – The area selected for irrigation must be pervious, on slopes of less than 10%. A geological assessment is required for proposed irrigation areas to assure that there is a minimum of 12 inches of soil cover. Rocky soils are acceptable for irrigation; however, the coarse material (diameter greater than 0.5 inches) should not account for more than 30% of the soil volume. Optimum sites for irrigation include recreational and greenbelt areas as well as landscaping in commercial developments. The stormwater irrigation area should be distinct and different from any areas used for wastewater effluent irrigation. Finally, the area designated for irrigation should have at least a 100-foot buffer from wells, septic systems, and natural wetlands.

- Irrigation Area – The irrigation rate must be low enough so that the irrigation does not produce any surface runoff; consequently, the irrigation rate may not exceed the permeability of the soil. The minimum required irrigation area should be calculated using the following formula:

$$A = \frac{12 \times V}{T \times r}$$

where:

A = area required for irrigation (ft2)

V = water quality volume (ft3)

T = period of active irrigation (30 hr)

r = Permeability (in/hr)

- The permeability of the soils in the area proposed for irrigation should be determined using a double ring infiltrometer (ASTM D 3385-94) or from county soil surveys prepared by the Natural Resource Conservation Service. If a range of permeabilities is reported, the average value should be used in the calculation. If no permeability data is available, a value of 0.1 inches/hour should be assumed.

- It should be noted that the minimum area requires intermittent irrigation over a period of 60 hours at low rates to use the entire water quality volume. This intensive irrigation may be harmful to vegetation that is not adapted to long periods of wet conditions. In practice, a much larger irrigation area will provide better use of the retained water and promote a healthy landscape.

Performance

This technology is still in its infancy and there are no published reports on its effectiveness, cost, or operational requirements.

Siting Criteria

Capture of stormwater can be accomplished in almost any kind of runoff storage facility, ranging from dry, concrete-lined ponds to those with vegetated basins and permanent pools. Siting is contingent upon the type of facility used.

Additional Design Guidelines

This technology is still in its infancy and there are no published reports on its effectiveness, cost, or operational requirements.

Maintenance

Relatively frequent inspection and maintenance is necessary to verify proper operation of these facilities. Some maintenance concerns are specific to the type or irrigation system practice used.

BMPs that store water can become a nuisance due to mosquito and other vector breeding. Preventing mosquito access to standing water sources in BMPs (particularly below-ground) is the best prevention plan, but can prove challenging due to multiple entrances and the need to maintain the hydraulic integrity of the system. Reliance on electrical pumps is prone to failure and in some designs (e.g., sumps, vaults) may not provide complete dewatering, both which increase the chances of water standing for over 72 hours and becoming a breeding place for vectors. BMPs that hold water for over 72 hours and/or rely on electrical or mechanical devices to dewater may require routine inspections and treatments by local mosquito and vector control agencies to suppress mosquito production. Open storage designs such as ponds and basins (see appropriate fact sheets) will require routine preventative maintenance plans and may also require routine inspections and treatments by local mosquito and vector control agencies.

Cost

This technology is still in its infancy and there are no published reports on its effectiveness, cost, or operational requirements. However, O&M costs for retention-irrigation systems are high compared to virtually all other stormwater quality control practices because of the need for: (1) frequent inspections; (2) the reliance on mechanical equipment; and (3) power costs.

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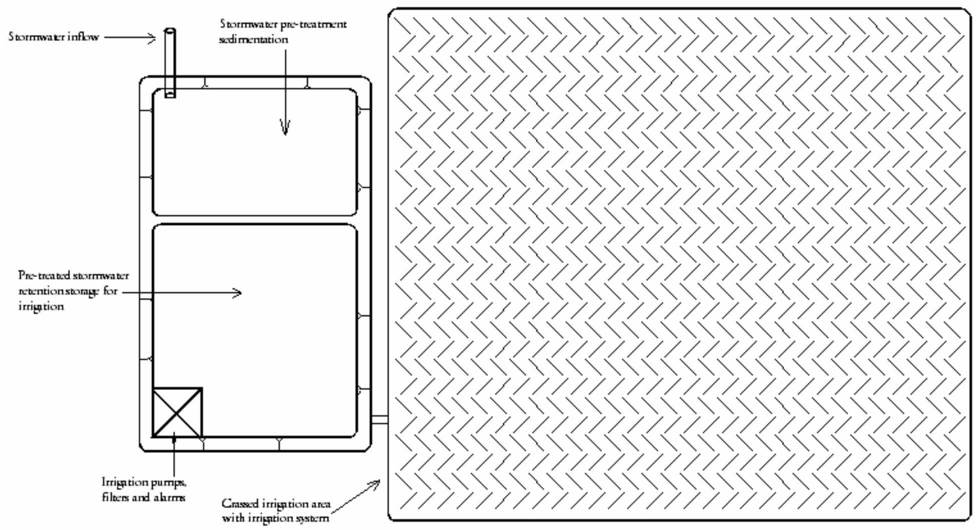

Stormwater inflow
Stormwater pre-treatment sedimentation
Pre-treated stormwater retention storage for irrigation
Irrigation pumps, filters and alarms
Grassed irrigation area with irrigation system

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Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	■
☑	Metals	▲
☑	Bacteria	▲
☑	Oil and Grease	▲
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.

- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.

- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

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relationships resulting from the increase of impervious cover in a watershed.

Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).

- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.

- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.

- Outlet designed to discharge the capture volume over a period of hours.

- Length to width ratio of at least 1.5:1 where feasible.

- Basin depths optimally range from 2 to 5 feet.

- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.

- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.

- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.

- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

Figure 1
Example of Extended Detention Outlet Structure

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_o))^{0.5}$$

where:
- Q = discharge (ft^3/s)
- C = orifice coefficient
- A = area of the orifice (ft^2)
- g = gravitational constant (32.2)
- H = water surface elevation (ft)
- H_o= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_o. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume (ft^3).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

Table 1 Estimated Average Annual Maintenance Effort

Activity	Labor Hours	Equipment & Material ($)	Cost
Inspections	4	7	183
Maintenance	49	126	2282
Vector Control	0	0	0
Administration	3	0	132
Materials	-	535	535
Total	**56**	**$668**	**$3,132**

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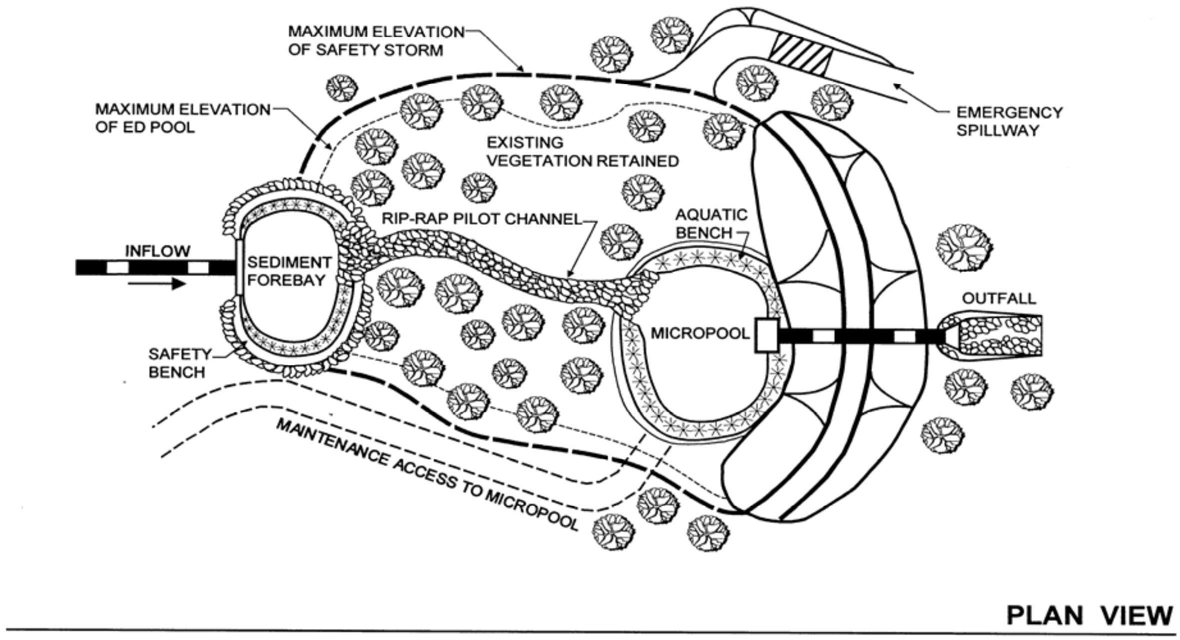

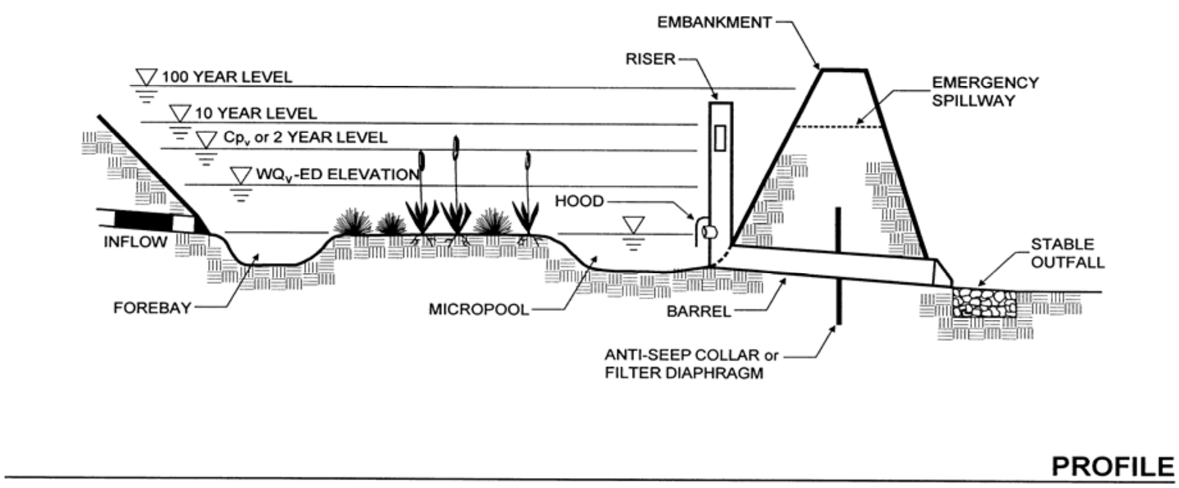

Schematic of an Extended Detention Basin (MDE, 2000)

Vegetated Swale TC-30

Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	●
☑	Metals	▲
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

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- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.

- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.

- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.

- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data

Study	TSS	TP	TN	NO_3	Metals	Bacteria	Type
	Removal Efficiencies (% Removal)						
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]...............	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c].............	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]...........	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]........	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]..	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]......................	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	–	--	–	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	–	--	–	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right)$ x swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	\$0.85 / 1,000 ft^2/ mowing	\$0.14 / linear foot	\$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	\$9.00 / 1,000 ft^2/ year	\$0.18 / linear foot	\$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	\$0.10 / linear foot / year	\$0.10 / linear foot	\$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	\$0.30 / yd^2	\$0.01 / linear foot	\$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	\$0.15 / linear foot / year, plus \$25 / inspection	\$0.15 / linear foot	\$0.15 / linear foot	Inspect four times per year
Total	--	**\$0.58 / linear foot**	**\$ 0.75 / linear foot**	--

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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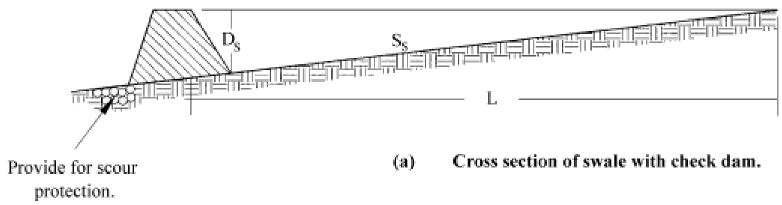
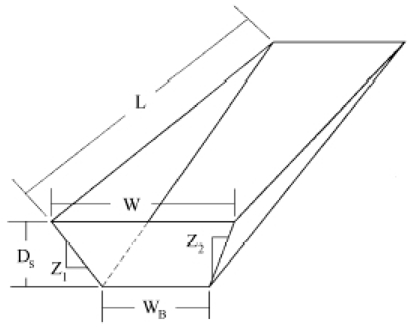


(a) Cross section of swale with check dam.



Notation:

- L = Length of swale impoundment area per check dam (ft)
- D_S = Depth of check dam (ft)
- S_S = Bottom slpe of swale (ft/ft)
- W = Top width of check dam (ft)
- W_B = Bottom width of check dam (ft)
- $Z_{1\&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

(b) Dimensional view of swale impoundment area.

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Design Considerations

- Tributary Area
- Slope
- Water Availability
- Aesthetics

Targeted Constituents

☑	Sediment	■
☑	Nutrients	●
☑	Trash	▲
☑	Metals	■
☑	Bacteria	●
☑	Oil and Grease	■
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

Description

Grassed buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure. Consequently, there is little resistance to their use.

California Experience

Caltrans constructed and monitored three vegetated buffer strips in southern California and is currently evaluating their performance at eight additional sites statewide. These strips were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the southern California sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- Buffers require minimal maintenance activity (generally just erosion prevention and mowing).
- If properly designed, vegetated, and operated, buffer strips can provide reliable water quality benefits in conjunction with high aesthetic appeal.

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- Flow characteristics and vegetation type and density can be closely controlled to maximize BMP effectiveness.

- Roadside shoulders act as effective buffer strips when slope and length meet criteria described below.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.

- Buffer strips cannot treat a very large drainage area.

- A thick vegetative cover is needed for these practices to function properly.

- Buffer or vegetative filter length must be adequate and flow characteristics acceptable or water quality performance can be severely limited.

- Vegetative buffers may not provide treatment for dissolved constituents except to the extent that flows across the vegetated surface are infiltrated into the soil profile.

- This technology does not provide significant attenuation of the increased volume and flow rate of runoff during intense rain events.

Design and Sizing Guidelines

- Maximum length (in the direction of flow towards the buffer) of the tributary area should be 60 feet.

- Slopes should not exceed 15%.

- Minimum length (in direction of flow) is 15 feet.

- Width should be the same as the tributary area.

- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.

- Install strips at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be required.

- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the strip.

- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

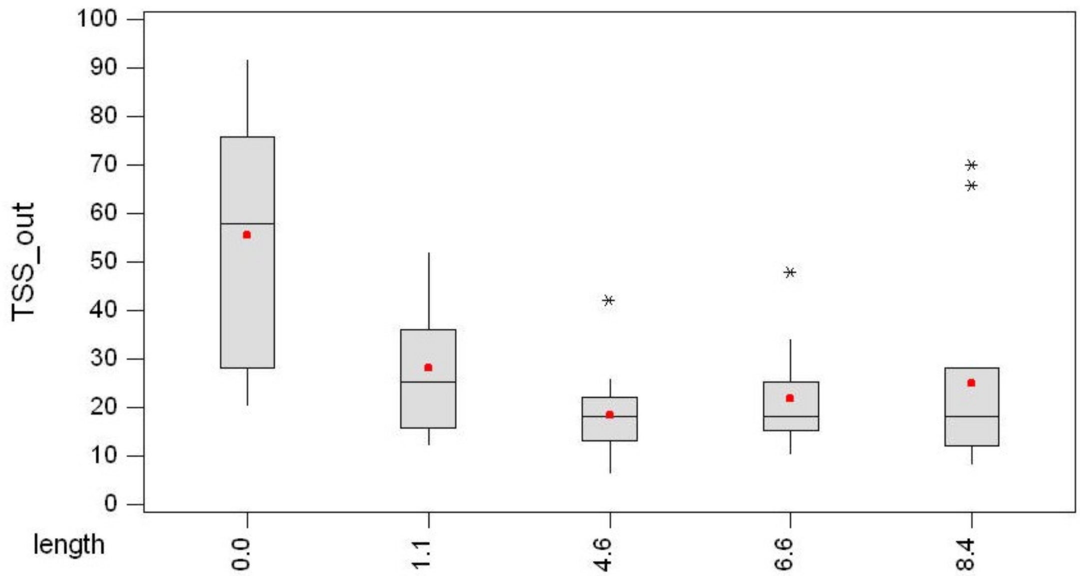
Vegetated buffer strips tend to provide somewhat better treatment of stormwater runoff than swales and have fewer tendencies for channelization or erosion. Table 1 documents the pollutant removal observed in a recent study by Caltrans (2002) based on three sites in southern California. The column labeled "Significance" is the probability that the mean influent and effluent EMCs are not significantly different based on an analysis of variance.

The removal of sediment and dissolved metals was comparable to that observed in much more complex controls. Reduction in nitrogen was not significant and all of the sites exported phosphorus for the entire study period. This may have been the result of using salt grass, a warm weather species that is dormant during the wet season, and which leaches phosphorus when dormant.

Another Caltrans study (unpublished) of vegetated highway shoulders as buffer strips also found substantial reductions often within a very short distance of the edge of pavement. Figure 1 presents a box and whisker plot of the concentrations of TSS in highway runoff after traveling various distances (shown in meters) through a vegetated filter strip with a slope of about 10%. One can see that the TSS median concentration reaches an irreducible minimum concentration of about 20 mg/L within 5 meters of the pavement edge.

Table 1 Pollutant Reduction in a Vegetated Buffer Strip

Constituent	Mean EMC		Removal %	Significance
	Influent (mg/L)	Effluent (mg/L)		P
TSS	119	31	74	<0.000
NO_3-N	0.67	0.58	13	0.367
TKN-N	2.50	2.10	16	0.542
Total N[a]	3.17	2.68	15	-
Dissolved P	0.15	0.46	-206	0.047
Total P	0.42	0.62	-52	0.035
Total Cu	0.058	0.009	84	<0.000
Total Pb	0.046	0.006	88	<0.000
Total Zn	0.245	0.055	78	<0.000
Dissolved Cu	0.029	0.007	77	0.004
Dissolved Pb	0.004	0.002	66	0.006
Dissolved Zn	0.099	0.035	65	<0.000



Filter strips also exhibit good removal of litter and other floatables because the water depth in these systems is well below the vegetation height and consequently these materials are not easily transported through them. Unfortunately little attenuation of peak runoff rates and volumes (particularly for larger events) is normally observed, depending on the soil properties. Therefore it may be prudent to follow the strips with another practice than can reduce flooding and channel erosion downstream.

Siting Criteria

The use of buffer strips is limited to gently sloping areas where the vegetative cover is robust and diffuse, and where shallow flow characteristics are possible. The practical water quality benefits can be effectively eliminated with the occurrence of significant erosion or when flow concentration occurs across the vegetated surface. Slopes should not exceed 15 percent or be less than 1 percent. The vegetative surface should extend across the full width of the area being drained. The upstream boundary of the filter should be located contiguous to the developed area. Use of a level spreading device (vegetated berm, sawtooth concrete border, rock trench, etc) to facilitate overland sheet flow is not normally recommended because of maintenance considerations and the potential for standing water.

Filter strips are applicable in most regions, but are restricted in some situations because they consume a large amount of space relative to other practices. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer or as pretreatment to a structural practice. In arid areas, however, the cost of irrigating the grass on the practice will most likely outweigh its water quality benefits, although aesthetic considerations may be sufficient to overcome this constraint. Filter strips are generally impractical in ultra-urban areas where little pervious surface exists.

Some cold water species, such as trout, are sensitive to changes in temperature. While some treatment practices, such as wet ponds, can warm stormwater substantially, filter strips do not are not expected to increase stormwater temperatures. Thus, these practices are good for protection of cold-water streams.

Filter strips should be separated from the ground water by between 2 and 4 ft to prevent contamination and to ensure that the filter strip does not remain wet between storms.

Additional Design Guidelines

Filter strips appear to be a minimal design practice because they are basically no more than a grassed slope. In general the slope of the strip should not exceed 15fc% and the strip should be at least 15 feet long to provide water quality treatment. Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion. The top of the strip should be installed 2-5 inches below the adjacent pavement, so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering.

A major question that remains unresolved is how large the drainage area to a strip can be. Research has conclusively demonstrated that these are effective on roadside shoulders, where the contributing area is about twice the buffer area. They have also been installed on the perimeter of large parking lots where they performed fairly effectively; however much lower slopes may be needed to provide adequate water quality treatment.

The filter area should be densely vegetated with a mix of erosion-resistant plant species that effectively bind the soil. Native or adapted grasses, shrubs, and trees are preferred because they generally require less fertilizer and are more drought resistant than exotic plants. Runoff flow velocities should not exceed about 1 fps across the vegetated surface.

For engineered vegetative strips, the facility surface should be graded flat prior to placement of vegetation. Initial establishment of vegetation requires attentive care including appropriate watering, fertilization, and prevention of excessive flow across the facility until vegetation completely covers the area and is well established. Use of a permanent irrigation system may help provide maximal water quality performance.

In cold climates, filter strips provide a convenient area for snow storage and treatment. If used for this purpose, vegetation in the filter strip should be salt-tolerant (e.g., creeping bentgrass), and a maintenance schedule should include the removal of sand built up at the bottom of the slope. In arid or semi-arid climates, designers should specify drought-tolerant grasses to minimize irrigation requirements.

Maintenance

Filter strips require mainly vegetation management; therefore little special training is needed for maintenance crews. Typical maintenance activities and frequencies include:

- Inspect strips at least twice annually for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall run-off to be sure the strip is ready for winter. However, additional inspection after periods of heavy run-off is most desirable. The strip should be checked for debris and litter and areas of sediment accumulation.

- Recent research on biofiltration swales, but likely applicable to strips (Colwell et al., 2000), indicates that grass height and mowing frequency have little impact on pollutant removal;

consequently, mowing may only be necessary once or twice a year for safety and aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in strip areas, particularly along highways. The need for litter removal should be determined through periodic inspection but litter should always be removed prior to mowing.

- Regularly inspect vegetated buffer strips for pools of standing water. Vegetated buffer strips can become a nuisance due to mosquito breeding in level spreaders (unless designed to dewater completely in 48-72 hours), in pools of standing water if obstructions develop (e.g. debris accumulation, invasive vegetation), and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available on the actual construction costs of filter strips. One rough estimate can be the cost of seed or sod, which is approximately 30¢ per ft^2 for seed or 70¢ per ft^2 for sod. This amounts to between $13,000 and $30,000 per acre of filter strip. This cost is relatively high compared with other treatment practices. However, the grassed area used as a filter strip may have been seeded or sodded even if it were not used for treatment. In these cases, the only additional cost is the design. Typical maintenance costs are about $350/acre/year (adapted from SWRPC, 1991). This cost is relatively inexpensive and, again, might overlap with regular landscape maintenance costs.

The true cost of filter strips is the land they consume. In some situations this land is available as wasted space beyond back yards or adjacent to roadsides, but this practice is cost-prohibitive when land prices are high and land could be used for other purposes.

Maintenance Cost

Maintenance of vegetated buffer strips consists mainly of vegetation management (mowing, irrigation if needed, weeding) and litter removal. Consequently the costs are quite variable depending on the frequency of these activities and the local labor rate.

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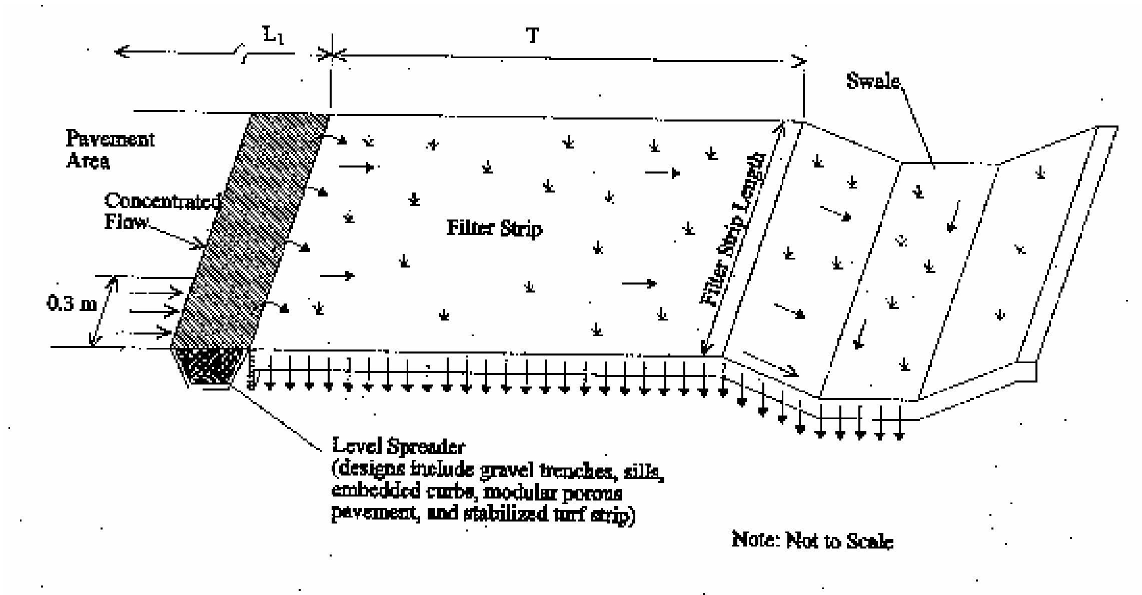
L1
T
Swale
Pavement Area
Concentrated Flow
Filter Strip
Filter Strip Length
0.3 m
Level Spreader
(designs include gravel trenches, sills, embedded curbs, modular porous pavement, and stabilized turf strip)
Note: Not to Scale

Design Considerations

- Soil for Infiltration
- Tributary Area
- Slope
- Aesthetics
- Environmental Side-effects

Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

California Experience

None documented. Bioretention has been used as a stormwater BMP since 1992. In addition to Prince George's County, MD and Alexandria, VA, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

Advantages

- Bioretention provides stormwater treatment that enhances the quality of downstream water bodies by temporarily storing runoff in the BMP and releasing it over a period of four days to the receiving water (EPA, 1999).

- The vegetation provides shade and wind breaks, absorbs noise, and improves an area's landscape.

Limitations

- The bioretention BMP is not recommended for areas with slopes greater than 20% or where mature tree removal would

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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be required since clogging may result, particularly if the BMP receives runoff with high sediment loads (EPA, 1999).

- Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
- By design, bioretention BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water.
- In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Design and Sizing Guidelines

- The bioretention area should be sized to capture the design storm runoff.
- In areas where the native soil permeability is less than 0.5 in/hr an underdrain should be provided.
- Recommended minimum dimensions are 15 feet by 40 feet, although the preferred width is 25 feet. Excavated depth should be 4 feet.
- Area should drain completely within 72 hours.
- Approximately 1 tree or shrub per 50 ft^2 of bioretention area should be included.
- Cover area with about 3 inches of mulch.

Construction/Inspection Considerations

Bioretention area should not be established until contributing watershed is stabilized.

Performance

Bioretention removes stormwater pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (EPA, 1999). Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Thus, the infiltration rate of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover, and planting soil.

Common particulates removed from stormwater include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately aerated. Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic stormwater runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals and nutrients are shown in Table 1.

Table 1 Laboratory and Estimated Bioretention Davis et al. (1998); PGDER (1993)

Pollutant	Removal Rate
Total Phosphorus	70-83%
Metals (Cu, Zn, Pb)	93-98%
TKN	68-80%
Total Suspended Solids	90%
Organics	90%
Bacteria	90%

Results for both the laboratory and field experiments were similar for each of the pollutants analyzed. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants concentrations (Davis et al, 1998).

The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

Siting Criteria

Bioretention BMPs are generally used to treat stormwater from impervious surfaces at commercial, residential, and industrial areas (EPA, 1999). Implementation of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales. Moreover, the runoff in these areas can be designed to either divert directly into the bioretention area or convey into the bioretention area by a curb and gutter collection system.

The best location for bioretention areas is upland from inlets that receive sheet flow from graded areas and at areas that will be excavated (EPA, 1999). In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized drainage areas.

Additional Design Guidelines

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered (EPA, 1999). Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil.

The use of bioretention may not be feasible given an unstable surrounding soil stratum, soils with clay content greater than 25 percent, a site with slopes greater than 20 percent, and/or a site with mature trees that would be removed during construction of the BMP.

Bioretention can be designed to be off-line or on-line of the existing drainage system (EPA, 1999). The drainage area for a bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Larger drainage areas may require multiple bioretention areas. Furthermore, the maximum drainage area for a bioretention area is determined by the expected rainfall intensity and runoff rate. Stabilized areas may erode when velocities are greater than 5 feet per second (1.5 meter per second). The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area, which is a function of the drainage area and the runoff generated from the area is sized to capture the water quality volume.

The recommended minimum dimensions of the bioretention area are 15 feet (4.6 meters) wide by 40 feet (12.2 meters) long, where the minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established. Thus replicating a natural forest and creating a microclimate, thereby enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet (7.6 meters), with a length of twice the width. Essentially, any facilities wider than 20 feet (6.1 meters) should be twice as long as they are wide, which promotes the distribution of flow and decreases the chances of concentrated flow.

In order to provide adequate storage and prevent water from standing for excessive periods of time the ponding depth of the bioretention area should not exceed 6 inches (15 centimeters). Water should not be left to stand for more than 72 hours. A restriction on the type of plants that can be used may be necessary due to some plants' water intolerance. Furthermore, if water is left standing for longer than 72 hours mosquitoes and other insects may start to breed.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.

Generally the soil should have infiltration rates greater than 0.5 inches (1.25 centimeters) per hour, which is typical of sandy loams, loamy sands, or loams. The pH of the soil should range between 5.5 and 6.5, where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. Additional requirements for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.

Soil tests should be performed for every 500 cubic yards (382 cubic meters) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area (EPA, 1999). Planting soil should be 4 inches (10.1 centimeters) deeper than the bottom of the largest root ball and 4 feet (1.2 meters) altogether. This depth will provide adequate soil for the plants' root systems to become established, prevent plant damage due to severe wind, and provide adequate moisture capacity. Most sites will require excavation in order to obtain the recommended depth.

Planting soil depths of greater than 4 feet (1.2 meters) may require additional construction practices such as shoring measures (EPA, 1999). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For instance, a 15 foot (4.6 meter) by 40 foot (12.2 meter) bioretention area (600 square feet or 55.75 square meters) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1.

Trees and shrubs should be planted when conditions are favorable. Vegetation should be watered at the end of each day for fourteen days following its planting. Plant species tolerant of pollutant loads and varying wet and dry conditions should be used in the bioretention area.

The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures, such as providing a soil breach to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities. The designers should evaluate the best placement of vegetation within the bioretention area. Plants should be placed at irregular intervals to replicate a natural forest. Trees should be placed on the perimeter of the area to provide shade and shelter from the wind. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. In cold climates, species that are more tolerant to cold winds, such as evergreens, should be placed in windier areas of the site.

Following placement of the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted at the beginning of the growing season. Mulch should be placed immediately after trees and shrubs are planted. Two to 3 inches (5 to 7.6 cm) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion.

Maintenance

The primary maintenance requirement for bioretention areas is that of inspection and repair or replacement of the treatment area's components. Generally, this involves nothing more than the routine periodic maintenance that is required of any landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell. Appropriately selected plants will aide in reducing fertilizer, pesticide, water, and overall maintenance requirements. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated as needed using preventative and low-toxic measures to the extent possible. BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water. Routine inspections for areas of standing water within the BMP and corrective measures to restore proper infiltration rates are necessary to prevent creating mosquito and other vector habitat. In addition, bioretention BMPs are susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained.

In order to maintain the treatment area's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.

New Jersey's Department of Environmental Protection states in their bioretention systems standards that accumulated sediment and debris removal (especially at the inflow point) will normally be the primary maintenance function. Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. There is also the possibility that the cation exchange capacity of the soils in the cell will be significantly reduced over time. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction (LID, 2000).

Cost

Construction Cost

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development (EPA, 1999). A general rule of thumb (Coffman, 1999) is that residential bioretention areas average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains and underdrains.

Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site in Maryland, Kettering Development, with 15 bioretention areas were estimated at $111,600.

In any bioretention area design, the cost of plants varies substantially and can account for a significant portion of the expenditures. While these cost estimates are slightly greater than those of typical landscaping treatment (due to the increased number of plantings, additional soil excavation, backfill material, use of underdrains etc.), those landscaping expenses that would be required regardless of the bioretention installation should be subtracted when determining the net cost.

Perhaps of most importance, however, the cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention areas quite attractive financially. For example, the use of bioretention can decrease the cost required for constructing stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the amount of storm drain pipe that was needed from 800 to 230 feet - a cost savings of $24,000 (PGDER, 1993). And a new residential development spent a total of approximately $100,000 using bioretention cells on each lot instead of nearly $400,000 for the traditional stormwater ponds that were originally planned (Rappahanock,). Also, in residential areas, stormwater management controls become a part of each property owner's landscape, reducing the public burden to maintain large centralized facilities.

Maintenance Cost

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

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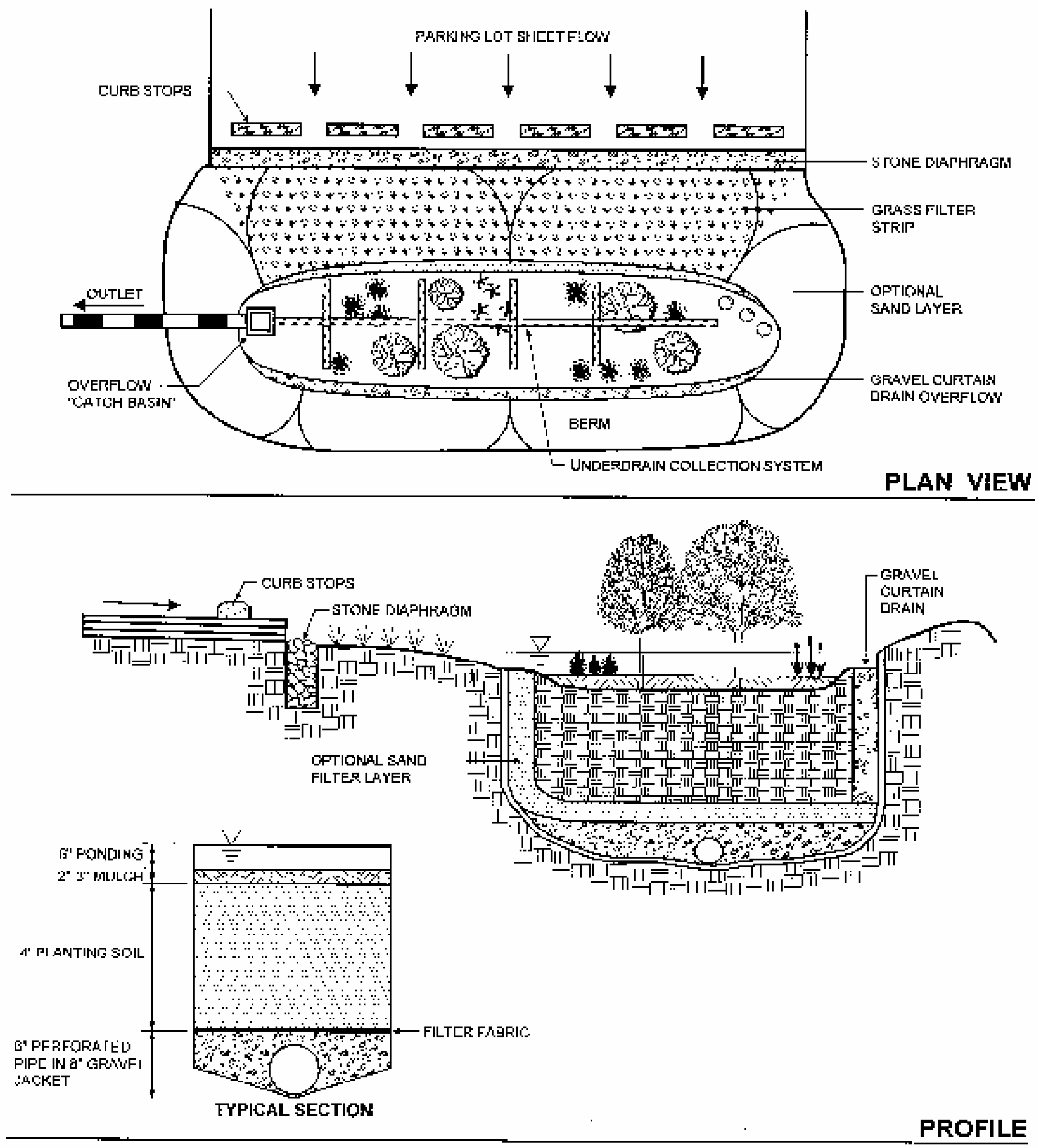

Schematic of a Bioretention Facility (MDE, 2000)

Design Considerations

- Area Required

Description

Water quality inlets (WQIs), also commonly called trapping catch basins, oil/grit separators or oil/water separators, consist of one or more chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from stormwater. Some WQIs also contain screens to help retain larger or floating debris, and many of the newer designs also include a coalescing unit that helps promote oil/water separation. A typical WQI, as shown in the schematic, consists of a sedimentation chamber, an oil separation chamber, and a discharge chamber.

These devices are appropriate for capturing hydrocarbon spills, but provide very marginal sediment removal and are not very effective for treatment of stormwater runoff. WQIs typically capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other best management practices (BMPs).

Targeted Constituents

☑	Sediment	●
☑	Nutrients	●
☑	Trash	▲
☑	Metals	●
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	●

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

Caltrans investigated the use of coalescing plate oil/water separators at maintenance stations in Southern California. Twenty-two maintenance stations were originally considered for implementation of this technology; however, only one site appeared to have concentrations that were sufficiently high to warrant installation of an oil-water separator. Concentrations of free oil in stormwater runoff observed during the course of the study even from this site were too low for effective operation of this technology, and no free oil was ever captured by the device.

Advantages

- Can provide spill control.

Limitations

- WQIs generally provide limited hydraulic and residuals storage. Due to the limited storage, WQIs do not provide substantial stormwater improvement.

- Standing water in the devices can provide a breeding ground for mosquitoes.

- Certain designs maintain permanent sources of standing water where mosquito and other vector breeding may to occur.

Design and Sizing Guidelines

- Water quality inlets are most effective for spill control and should be sized accordingly.

- Designs that utilize covered sedimentation and filtration basins should be accessible to vector control personnel via access doors to facilitate vector surveillance and controlling the basins if needed.

Performance

WQIs are primarily utilized to remove sediment from stormwater runoff. Grit and sediment are partially removed by gravity settling within the first two chambers. A WQI with a detention time of 1 hour may expect to have 20 to 40 percent removal of sediments. Hydrocarbons associated with the accumulated sediments are also often removed from the runoff through this process. The WQI achieves slight, if any, removal of nutrients, metals and organic pollutants other than free petroleum products (Schueler, 1992).

A 1993 MWCOG study found that an average of less than 5 centimeters (2 inches) of sediments (mostly coarse-grained grit and organic matter) were trapped in the WQIs. Hydrocarbon and total organic carbon (TOC) concentrations of the sediments averaged 8,150 and 53,900 milligrams per kilogram, respectively. The mean hydrocarbon concentration in the WQI water column was 10 milligrams per liter. The study also indicated that sediment accumulation did not increase over time, suggesting that the sediments become re-suspended during storm events. The authors concluded that although the WQI effectively separates oil and grease from water, re-suspension of the settled matter appears to limit removal efficiencies. Actual removal only occurs when the residuals are removed from the WQI (Schueler 1992).

A 1990 report by API found that the efficiency of oil and water separation in a WQI is inversely proportional to the ratio of the discharge rate to the unit's surface area. Due to the small capacity of the WQI, the discharge rate is typically very high and the detention time is very short. For example, the MWCOG study found that the average detention time in a WQI is less than 0.5 hour. This can result in minimal pollutant settling (API, 1990). However, the addition of coalescing units in many current WQI units may increase oil/water separation efficiency. Most coalescing units are designed to achieve a specific outlet concentration of oil and grease (for example, 10-1 5m/L oil and grease).

Pollutant removal in stormwater inlets can be somewhat improved using inserts, which are promoted for removal of oil and grease, trash, debris, and sediment. Some inserts are designed to drop directly into existing catch basins, while others may require extensive retrofit construction.

Siting Criteria

Oil/water separation units are often utilized in specific industrial areas, such as airport aprons, equipment washdown areas, or vehicle storage areas. In these instances, runoff from the area of concern will usually be diverted directly into the unit, while all other runoff is sent to the storm drain downstream from the oil/water separator. Oil/water separation tanks are often fitted with diffusion baffles at the inlets to prevent turbulent flow from entering the unit and resuspending settled pollutants.

Additional Design Guidelines

Prior to WQI design, the site should be evaluated to determine if another BMP would be more cost-effective in removing the pollutants of concern. WQIs should be used when no other BMP is feasible. The WQI should be constructed near a storm drain network so that flow can be easily diverted to the WQI for treatment (NVPDC, 1992). Any construction activities within the drainage area should be completed before installation of the WQI, and the drainage area should be revegetated so that the sediment loading to the WQI is minimized.

WQIs are most effective for small drainage areas. Drainage areas of 0.4 hectares (1 acre) or less are often recommended. WQIs are typically used in an off-line configuration (i.e., portions of runoff are diverted to the WQI), but they can be used as on-line units (i.e., receive all runoff). Generally, off-line units are designed to handle the first 1.3 centimeters (0.5 inches) of runoff from the drainage areas. Upstream isolation/diversion structures can be used to divert the water to the off-line structure (Schueler, 1992). On-line units receive higher flows that will likely cause increased turbulence and resuspension of settled material, thereby reducing WQI performance.

Oil/water separation tanks are often fitted with diffusion baffles at the inlets to prevent turbulent flow from entering the unit and resuspending settled pollutants. WQIs are available as pre-manufactured units or can be cast in place. Reinforced concrete should be used to construct below-grade WQIs. The WQIs should be water tight to prevent possible ground water contamination.

Maintenance

Typical maintenance of WQIs includes trash removal if a screen or other debris capturing device is used, and removal of sediment using a vactor truck. Operators need to be properly trained in WQI maintenance. Maintenance should include keeping a log of the amount of sediment collected and the date of removal. Some cities have incorporated the use of GIS systems to track sediment collection and to optimize future catch basin cleaning efforts.

One study (Pitt, 1985) concluded that WQIs can capture sediments up to approximately 60 percent of the sump volume. When sediment fills greater than 60 percent of their volume, catch basins reach steady state. Storm flows can then resuspend sediments trapped in the catch basin, and will bypass treatment. Frequent clean-out can retain the volume in the catch basin sump available for treatment of stormwater flows.

At a minimum, these inlets should be cleaned at least twice during the wet season. Two studies suggest that increasing the frequency of maintenance can improve the performance of catch basins, particularly in industrial or commercial areas. One study of 60 catch basins in Alameda County, California, found that increasing the maintenance frequency from once per year to twice per year could increase the total sediment removed by catch basins on an annual basis (Mineart and Singh, 1994). Annual sediment removed per inlet was 54 pounds for annual cleaning, 70 pounds for semi-annual and quarterly cleaning, and 160 pounds for monthly cleaning. For catch basins draining industrial uses, monthly cleaning increased total annual sediment collected to six times the amount collected by annual cleaning (180 pounds versus 30 pounds). These results suggest that, at least for industrial uses, more frequent cleaning of catch basins may improve efficiency.

BMPs designed with permanent water sumps, vaults, and/or catch basins (frequently installed below-ground) can become a nuisance due to mosquito and other vector breeding. Preventing mosquito access to standing water sources in BMPs (particularly below-ground) is the best prevention plan, but can prove challenging due to multiple entrances and the need to maintain the hydraulic integrity of the system. BMPs that maintain permanent standing water may require routine inspections and treatments by local mosquito and vector control agencies to suppress mosquito production. Standing water in oil/water separators may contain sufficient floating hydrocarbons to prevent mosquito breeding, but this is not a reliable control alternative to vector exclusion or chemical treatment.

Cost

A typical pre-cast catch basin costs between $2,000 and $3,000; however, oil/water separators can be much more expensive. The true pollutant removal cost associated with catch basins, however, is the long-term maintenance cost. A vactor truck, the most common method of catch basin cleaning, costs between $125,000 and $150,000. This initial cost may be high for smaller Phase II communities. However, it may be possible to share a vactor truck with another community. Typical vactor trucks can store between 10 and 15 cubic yards of material, which is enough storage for three to five catch basins. Assuming semi-annual cleaning, and that the vactor truck could be filled and material disposed of twice in one day, one truck would be sufficient to clean between 750 and 1,000 catch basins. Another maintenance cost is the staff time needed to operate the truck. Depending on the regulations within a community, disposal costs of the sediment captured in catch basins may be significant.

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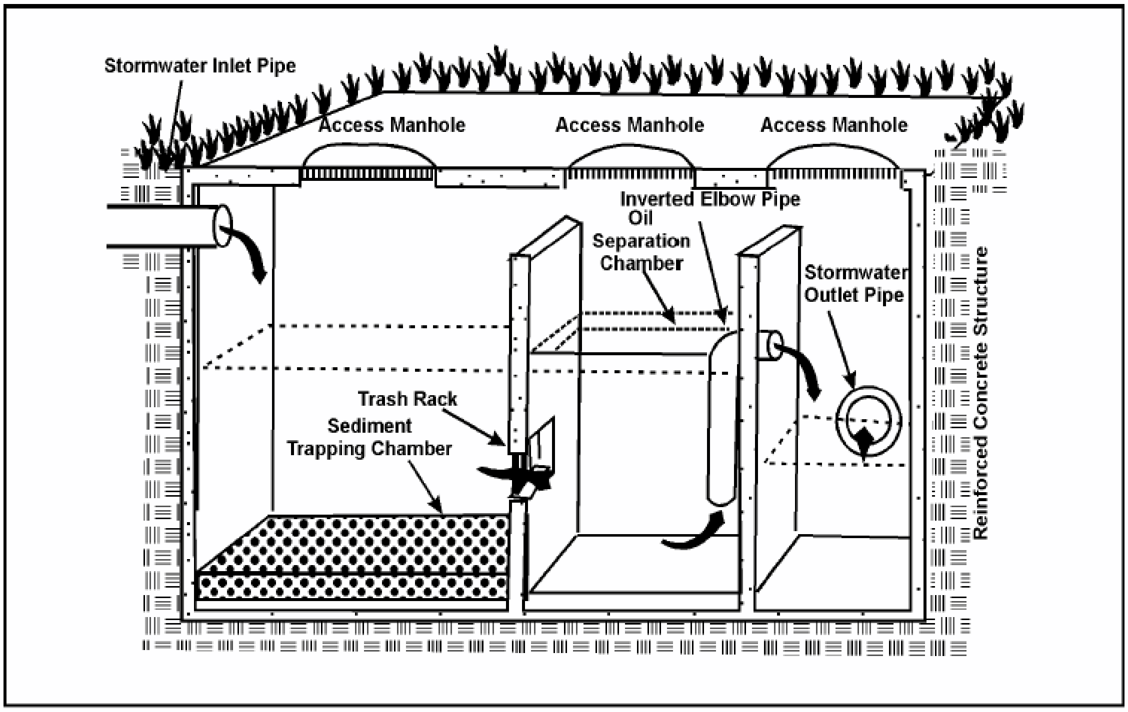
Stormwater Inlet Pipe
Access Manhole
Access Manhole
Access Manhole
Inverted Elbow Pipe
Oil
Separation
Chamber
Stormwater
Outlet Pipe
Trash Rack
Sediment
Trapping Chamber
Reinforced Concrete Structure

Multiple System Fact Sheet TC-60

Description

A multiple treatment system uses two or more BMPs in series. Some examples of multiple systems include: settling basin combined with a sand filter; settling basin or biofilter combined with an infiltration basin or trench; extended detention zone on a wet pond.

California Experience

The research wetlands at Fremont, California are a combination of wet ponds, wetlands, and vegetated controls.

Advantages

- BMPs that are less sensitive to high pollutant loadings, especially solids, can be used to pretreat runoff for sand filters and infiltration devices where the potential for clogging exists.
- BMPs which target different constituents can be combined to provide treatment for all constituents of concern.
- BMPs which use different removal processes (sedimentation, filtration, biological uptake) can be combined to improve the overall removal efficiency for a given constituent.
- BMPs in series can provide redundancy and reduce the likelihood of total system failure.

Limitations

- Capital costs of multiple systems are higher than for single devices.
- Space requirements are greater than that required for a single technology.

Design and Sizing Guidelines

Refer to individual treatment control BMP fact sheets.

Performance

- Be aware that placing multiple BMPs in series does not necessarily result in combined cumulative increased performance. This is because the first BMP may already achieve part of the gain normally achieved by the second BMP. On the other hand, picking the right combination can often help optimize performance of the second BMP since the influent to the second BMP is of more consistent water quality, and thus more consistent performance, thereby allowing the BMP to achieve its highest performance.

Design Considerations

- Area Required
- Slope
- Water Availability
- Hydraulic Head
- Environmental Side-effects

Targeted Constituents

	Constituent	Removal Effectiveness
☑	Sediment	■
☑	Nutrients	●
☑	Trash	■
☑	Metals	■
☑	Bacteria	▲
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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- When addressing multiple constituents through multiple BMPs, one BMP may optimize removal of a particular constituent, while another BMP optimizes removal of a different constituent or set of constituents. Therefore, selecting the right combination of BMPs can be very constructive in collectively removing multiple constituents.

Siting Criteria

Refer to individual treatment control BMP fact sheets.

Additional Design Guidelines

- When using two or more BMPs in series, it may be possible to reduce the size of BMPs.

- Existing pretreatment requirements may be able to be avoided when using some BMP combinations.

Maintenance

Refer to individual treatment control BMP fact sheets.

Cost

Refer to individual treatment control BMP fact sheets.

Resources and Sources of Additional Information

Refer to individual treatment control BMP fact sheets.

Drain Inserts MP-52

Description

Drain inserts are manufactured filters or fabric placed in a drop inlet to remove sediment and debris. There are a multitude of inserts of various shapes and configurations, typically falling into one of three different groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are one box; that is, the setting area and filtration through media occur in the same box. Some products consist of one or more trays or mesh grates. The trays may hold different types of media. Filtration media vary by manufacturer. Types include polypropylene, porous polymer, treated cellulose, and activated carbon.

California Experience

The number of installations is unknown but likely exceeds a thousand. Some users have reported that these systems require considerable maintenance to prevent plugging and bypass.

Advantages

- Does not require additional space as inserts as the drain inlets are already a component of the standard drainage systems.
- Easy access for inspection and maintenance.
- As there is no standing water, there is little concern for mosquito breeding.
- A relatively inexpensive retrofit option.

Limitations

Performance is likely significantly less than treatment systems that are located at the end of the drainage system such as ponds and vaults. Usually not suitable for large areas or areas with trash or leaves than can plug the insert.

Design and Sizing Guidelines

Refer to manufacturer's guidelines. Drain inserts come any many configurations but can be placed into three general groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are

Design Considerations

- Use with other BMPs
- Fit and Seal Capacity within Inlet

Targeted Constituents

- ☑ Sediment
- ☑ Nutrients
- ☑ Trash
- ☑ Metals
- Bacteria
- ☑ Oil and Grease
- ☑ Organics

Removal Effectiveness

See New Development and Redevelopment Handbook-Section 5.

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one box; that is, the setting area and filtration through media occurs in the same box. One manufacturer has a double-box. Stormwater enters the first box where setting occurs. The stormwater flows into the second box where the filter media is located. Some products consist of one or more trays or mesh grates. The trays can hold different types of media. Filtration media vary with the manufacturer: types include polypropylene, porous polymer, treated cellulose, and activated carbon.

Construction/Inspection Considerations

Be certain that installation is done in a manner that makes certain that the stormwater enters the unit and does not leak around the perimeter. Leakage between the frame of the insert and the frame of the drain inlet can easily occur with vertical (drop) inlets.

Performance

Few products have performance data collected under field conditions.

Siting Criteria

It is recommended that inserts be used only for retrofit situations or as pretreatment where other treatment BMPs presented in this section area used.

Additional Design Guidelines

Follow guidelines provided by individual manufacturers.

Maintenance

Likely require frequent maintenance, on the order of several times per year.

Cost

- The initial cost of individual inserts ranges from less than $100 to about $2,000. The cost of using multiple units in curb inlet drains varies with the size of the inlet.

- The low cost of inserts may tend to favor the use of these systems over other, more effective treatment BMPs. However, the low cost of each unit may be offset by the number of units that are required, more frequent maintenance, and the shorter structural life (and therefore replacement).

References and Sources of Additional Information

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