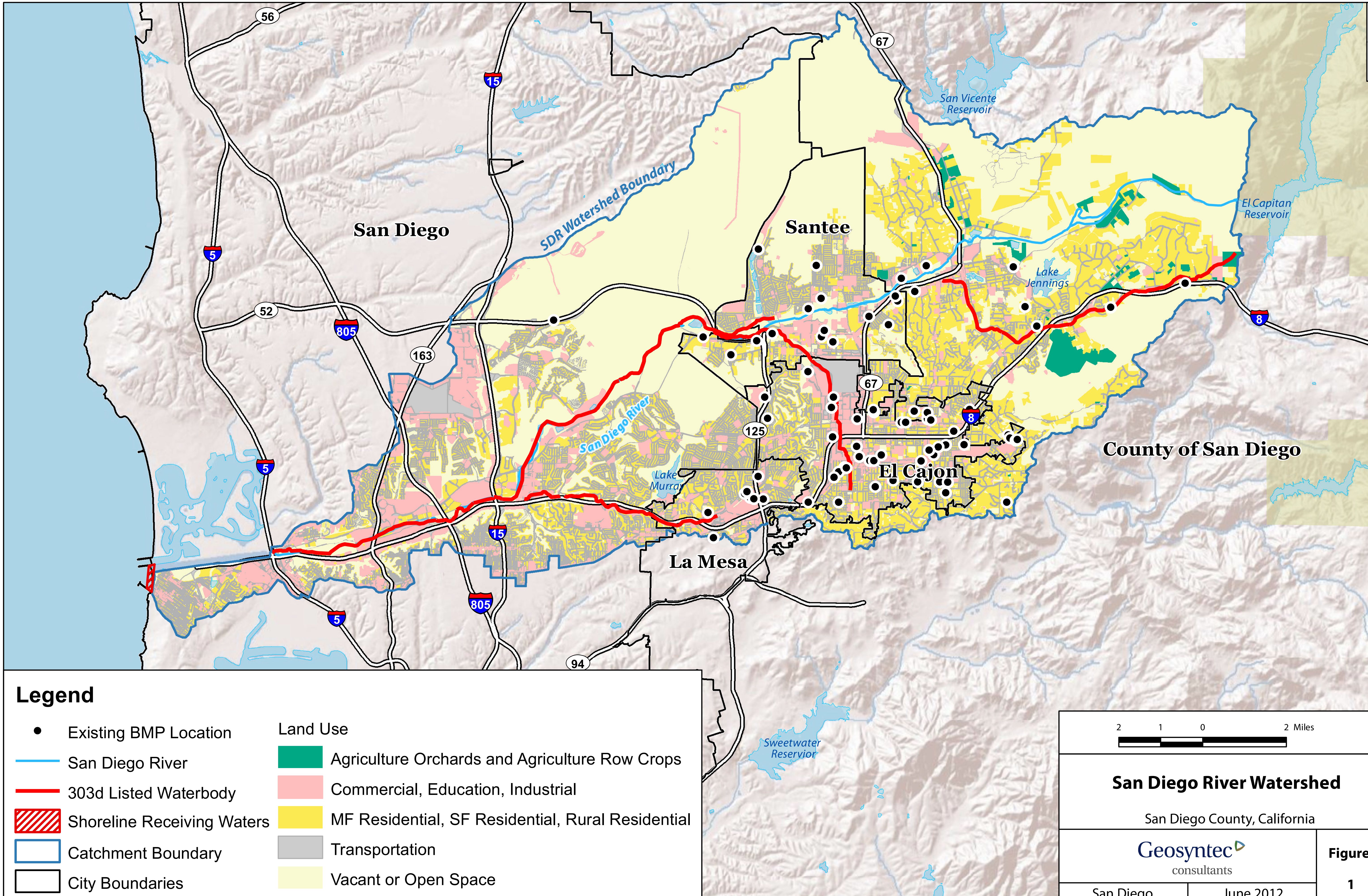
Appendix A


San Diego
Santee
El Cajon
La Mesa
County of San Diego
SDR Watershed Boundary
San Diego River
San Vicente Reservoir
El Capitan Reservoir
Lake Jennings
Lake Murray
Sweetwater Reservoir
56
67
15
5
52
805
163
125
8
94
Legend
Existing BMP Location
San Diego River
303d Listed Waterbody
Shoreline Receiving Waters
Catchment Boundary
City Boundaries
Land Use
Agriculture Orchards and Agriculture Row Crops
Commercial, Education, Industrial
MF Residential, SF Residential, Rural Residential
Transportation
Vacant or Open Space
2 1 0 2 Miles
San Diego River Watershed
San Diego County, California
Geosyntec
consultants
Figure
1
San Diego
June 2012

Appendix B

Geosyntec consultants

3990 Old Town Avenue, Suite B-101
San Diego, CA 92110
PH 619.297.1530
www.geosyntec.com

Memorandum

Date: 30 June 2012

To: Todd Snyder, Stephanie Gaines, County of San Diego

From: Rita Kampalath, Ph.D., Christian Braun, Brandon Steets, P.E., Ken Susilo, P.E., and Jennifer Larson, Geosyntec Consultants

Subject: San Diego River Watershed Comprehensive Load Reduction Plan
Data Review Memo
County of San Diego Reference: Task Order 9
Geosyntec Project No. LA0228.09

1.0 INTRODUCTION

1.1 Purpose

The purpose of this memo is to summarize datasets that were used for the bacteria Total Maximum Daily Load (TMDL) Comprehensive Load Reduction Plan (CLRP) for the San Diego River (SDR) Watershed downstream of the El Capital and San Vicente reservoirs. Many of these datasets are used to support bacteria load estimation, BMP load reduction, and source area prioritization.

This memo summarizes spatial and non-spatial data that were used for GIS mapping and analysis using the Structural BMP Prioritization and Analysis Tool (SBPAT) as well as water quality data from monitoring programs within the watershed, and data analysis results using these datasets.

1.2 Terms of Reference

The work described in this memorandum was conducted by Geosyntec Consultants for the County of San Diego for the San Diego River Watershed Comprehensive Load Reduction Plan, Task Order 9, Geosyntec Project No. LA0228.07. The primary authors of this memorandum were Rita Kampalath and Venkat Gummmadi. Peer review was performed by Christian Braun and Jennifer Larson, and senior review was performed by Brandon Steets, P.E., in accordance with Geosyntec's quality assurance protocols.

2.0 DATASETS

In development of the Comprehensive Load Reduction Plan (CLRP), spatial data and non-spatial data served as the basis for the following planning-level analyses:

- Watershed rainfall-runoff modeling to assist in determination of pollutant load reductions necessary to meet TMDL requirements
- Strategic identification of structural best management practice (BMP) locations and types most appropriate for the watershed
- Determination of the potential extent of nonstructural BMP implementation
- Quantification of potential water quality benefits resulting from both structural and nonstructural BMP implementation
- Structural BMP siting and design constraints and criteria

To complete the above analyses for the SDR watershed, spatial and non-spatial data needs were discussed with and requested from the County of San Diego (County). When spatial data inputs were not available from the County, data were obtained from third party sources or in some cases, created by Geosyntec. Table 1 summarizes the spatial datasets typically used for the above analyses and the sources from which these datasets were obtained for SDR watershed. The table is organized by Structural BMP Prioritization and Analysis Tool (SBPAT) analysis step. Please see the SBPAT User's Manual for additional information on the SBPAT methodology (Geosyntec 2008).

Table 1. Spatial Datasets Obtained for Analyses Supporting CLRP Development

DATASET	SOURCE	FORMAT	DATE	REQUIRED ATTRIBUTES
Area Screening				
Step 1: Catchment Prioritization				
Catchments (~200 ac)	Geosyntec	Vector (poly)		
Land Use	SanGIS/SANDAG GISData Warehouse	Vector (poly)	2009	Land use type
Impairments (303d) & TMDLs	SanGIS/SANDAG GIS Data Warehouse	Vector (line & poly)	2007	
Digital Elevation Model (DEM)	SanGIS/SANDAG GIS Data Warehouse	Raster		Elevation and % slope
Soils	NRCS SSURGO	Vector (poly)		Ksat, soil hydrologic group, others
Aerial imagery	NAIP, ESRI Imagery, Microsoft Bing Maps	Raster		
Precipitation (85th percentile 24-hr isohyets)	SanGIS/SANDAG GIS Data Warehouse	Vector (poly)	2003	Isohyet value
Step 2: Project Area (Parcel) Screening				
Parcels	SanGIS/SANDAG GIS Data Warehouse	Vector (poly)	2011	Owner name & address only, site address
Roads	SanGIS/SANDAG GIS	Vector (line)		

DATASET	SOURCE	FORMAT	DATE	REQUIRED ATTRIBUTES
	Data Warehouse			
Municipal Boundary	SanGIS/SANDAG GIS Data Warehouse	Vector (poly)	2011	Jurisdiction
Public Land Ownership	SanGIS/SANDAG GIS Data Warehouse	Vector (poly)	2008	Ownership
Storm drains	SanGIS/SANDAG GIS Data Warehouse, City of Santee, City of El Cajon, City of La Mesa, County of SD	Vector (line)	2011	MS4 Layer
NHD Streams	SanGIS/SANDAG GIS Data Warehouse	Vector (line)	2000	
BMP Screening				
Step 3: General BMP Evaluation				
Step 4: Site-Specific BMP Evaluation				
RARE Beneficial Use waters	SanGIS/SANDAG GIS Data Warehouse	Vector (line & poly)	2007	WBID, waterbody name
Wetlands	NWI	Vector (poly)		Type
Flood hazard		Vector (poly)		Flood zone type
BMP Modeling				
Precipitation gages	Hydromodification Management Plan Rainfall dataset	Vector (point)		Name, location, elevation, start date, yrs of record
Precipitation gage influence zones	Geosyntec	Vector (poly);		Representative hourly precipitation record (one each zone)
Soils/Ksat, Soil Suction Head, Soil Moisture Deficit	Modified by Geosyntec	Vector (poly)		
ET	DWR CIMIS	Vector (poly)		Monthly Normal ET values for each month

In addition to the spatial data, the following non-spatial data was used in SBPAT analysis. The data sources as well as assumptions made are described in the sections below.

2.1 Precipitation data

The long-term hourly rainfall dataset developed for the County of San Diego (2011) by Brown and Caldwell as part of the Hydromodification Management Plan is used in this analysis.

Sources of the rainfall data include ALERT data from the County of San Diego (which extend back to 1982), the California Climatic Data Archive, National Oceanic and Atmospheric Administration (NOAA), the National Climatic Data Center, and the Western Regional Climate Center. The length of the overall rainfall station record for each rainfall data source is 35 years or the overall length of the rainfall record, whichever was longer.

2.2 Soil Parameters

Spatial soils data from the Soil Survey Geographic database (SSURGO 2.2) were downloaded from the Natural Resources Conservation Service (NRCS) website. The SSURGO dataset categorizes each soil type by a Hydrologic Soil Group. The following table provides the Green-Ampt soil parameters attributed to each Hydrologic Soil Group for this analysis. Saturated hydraulic conductivity, soil suction head and initial moisture deficit were determined from the Storm Water Management Model (SWMM v5.0) User's Manual (EPA, 2010).

Table2. Soil Parameter Assumptions

Hydrologic Soil Group	Saturated Hydraulic Conductivity (in/hr)	Soil Suction Head (in)	Initial Moisture Deficit (in)
A	0.375	2.90	0.32
B	0.225	5.04	0.29
C	0.10	8.60	0.21
D	0.025	10.47	0.17

2.3 Pollutant Group Weights

Pollutant group weights used in the analysis to estimate the CPI scores for the catchments are presented in Table 3 below. These pollutant weights are based on Responsible Parties' consensus on relative pollutant "importance".

Table 3. Pollutant Group Weights for Normalized Pollutant CPI Calculation

Pollutant	Weight
Trash	0
Nitrogen (Nitrate)	10
Bacteria (Fecal Coliform)	20
Total Metals (Total Copper, Total Lead, Total Zinc) (5 points each)	0
Total Suspended Solids (representing Phosphorous)	10

2.4 BMP Effluent Concentrations

BMP effluent concentrations were used to estimate annual load reductions for each BMP. BMP effluent concentrations from the SBPAT User's manual were updated with the new quality assured, BMP performance data from the International Stormwater BMP Database, so that the water quality modeling efforts utilize the most current BMP performance summary statistics. The analysis used the November 2011 interim version of the International Stormwater BMP Database.

To account for the multiple detection limits in the censored data sets, a robust regression-on-order statistics (ROS) method was used to provide probabilistic estimates of non-detects before computing descriptive statistics (Helsel and Cohn, 1988). ROS is a category of robust methods for estimating descriptive statistics of censored datasets that utilize the normal scores for the order statistics (Shumway et al. 2002). In this method, plotting positions are based on conditional probabilities and ranks, where the ranks of the censored (below detection) and uncensored data (above detection) related to each detection limit are ranked independently. The ROS method was only used for data sets with less than 80% non-detects and greater than 2 detects. Otherwise, ½ the detection limit (DL) is used.

After the censored data were estimated (or for datasets without non-detects), descriptive statistics were computed using the standard bootstrap method suggested by Singh, Singh, and Engelhardt (1997). The bootstrap method samples from the dataset with replacement several thousand times and calculates the desired descriptive statistics from the sampled data. The following descriptive statistics of the influent and effluent concentrations were computed:

- Log mean
- Median (90th Percent Conf. Int.)
- Standard Deviation about the Mean
- 10th and 90th percentiles

The arithmetic mean and standard deviation effluent concentrations estimated with this method for use in SBPAT are provided in Table 4 and Table 5, respectively.

Table 4. Updated Arithmetic Mean Effluent Concentrations for Use in SBPAT.

	TSS	TP	DP	NH3	NO3	TKN	DCu	TCu	TPb	DZn	TZn	FC
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	#/100 mL
Bioretention	18.1	0.14	0.07	0.18	0.37	0.98	8.3	8.8	4.2	34.7	37.6	5.89E+03
Cistern	Volume reductions only											
Constructed Wetland / Wetpond (with Extd Detention)	38.3	0.19	0.11	0.18	0.42	1.20	5.3	6.7	7.2	22.1	35.3	1.01E+04
Constructed Wetland / Wetpond (without Extd Detention)	32.9	0.17	0.09	0.17	0.38	1.20	5.3	6.2	12.0	22.6	38.0	9.89E+03
Dry Extended Detention Basin	42.3	0.37	0.26	0.16	0.61	2.40	6.5	11.4	14.4	33.7	78.4	1.41E+04
Green Roof	Volume reductions only											
HydroDynamic Separator	98.1	0.50	0.06	0.30	0.67	2.07	13.1	16.7	12.7	78.4	107.4	2.68E+04
HydroDynamic Separator-Dist	98.1	0.50	0.06	0.30	0.67	2.07	13.1	16.7	12.7	78.4	107.4	2.68E+04
Infiltration Basin	Volume reductions only											
Media Filter	22.3	0.14	0.07	0.18	0.74	0.98	8.3	11.0	4.6	34.7	37.6	5.89E+03
Porous Pavement	Volume reductions only											
Sub-surface Flow Wetland	18.1	0.06	0.06	0.09	0.27	0.87	4.6	4.6	0.7	20.9	25.8	PR=90%
Treatment Plant	2.0	0.00	0.00	0.00	0.27	0.01	1.0	1.0	4.4	5.0	5.0	2.00E+00
Vegetated Swale	18.1	0.14	0.07	0.18	0.37	0.98	8.3	8.8	4.2	34.7	37.6	5.89E+03

PR = percent removal used instead of effluent quality.

Table 5. Updated Arithmetic Standard Deviation Effluent Concentrations for Use in SBPAT.

	TSS	TP	DP	NH3	NO3	TKN	DCu	TCu	TPb	DZn	TZn	FC
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	#/100 mL
Bioretention	30.7	0.17	0.10	0.38	0.55	1.21	13.7	11.1	4.8	100.3	100.3	1.27E+04
Cistern												
Constructed Wetland / Wetpond (with Extd Detention)	76.8	0.25	0.25	0.23	0.79	0.69	4.3	9.7	13.0	42.5	62.0	3.23E+04
Constructed Wetland / Wetpond (without Extd Detention)	71.1	0.23	0.23	0.38	0.75	0.85	4.2	8.8	123.0	41.9	85.6	3.08E+04
Dry Extended Detention Basin	87.4	0.67	0.44	0.18	1.17	5.03	6.7	20.0	56.0	64.7	137.9	4.15E+04
Green Roof												
HydroDynamic Separator	236.5	1.24	0.09	0.88	1.20	3.74	13.7	12.0	25.7	182.1	137.4	2.16E+05
HydroDynamic Separator-Dist	236.5	1.24	0.09	0.88	1.20	3.74	13.7	12.0	25.7	182.1	137.4	2.16E+05
Infiltration Basin												
Media Filter	40.7	0.17	0.10	0.38	0.85	1.21	13.7	17.2	10.0	100.3	100.3	1.27E+04
Porous Pavement												
Sub-surface Flow Wetland	30.7	0.09	0.09	0.15	0.55	0.59	1.7	3.5	1.8	12.8	17.2	na
Treatment Plant	2.0	0.00	0.00	0.01	0.55	0.03	3.0	3.0	11.0	15.0	15.0	1.00E+00
Vegetated Swale	30.7	0.17	0.10	0.38	0.55	1.21	13.7	11.1	4.8	100.3	100.3	1.27E+04

PR = percent removal used instead of effluent quality.

2.1 Imperviousness and EMC grouping

Land use imperviousness is another required input for SBPAT. This dataset was based on information provided in the San Diego County Imperviousness study (County of San Diego 2010).

Non-residential land use imperviousness inputs for SBPAT were calculated by area-weighting County imperviousness values from subwatersheds within the SDR Watershed. Since County data included only one residential land use type, imperviousness estimates for the three residential types used in SBPAT (single family, multi-family and rural) were determined by randomly choosing several parcels within the watershed of each of these residential types. Imperviousness percentages for these parcels were estimated using GIS digitization, and a single value for each of the three land uses was assigned based on these estimates. These values were found to be consistent with impervious percentages used in the L.A. County Hydrology Manual (LACDPW 2006). In order to validate these estimates further, they were area-weighted and then compared to the area-weighted value provided by the County. Since these values were found to be very close (39.4% versus 38.6% respectively) the estimates were considered valid, and incorporated into the model.

For the purposes of assigning EMCs (which have many fewer categories) to these land uses, the land uses were grouped based on the load anticipated to stem from them based on similarity of land use activities and land cover.

Imperviousness percentages for each land use and their EMC groups are summarized in Table 6 below.

Table 6. Imperviousness and EMC group for land uses.

LU	Detailed Land Use	EMC LU Group	SDR Specific Impervious Estimate
1000	Spaced Rural Residential	Rural Residential	0.10
1110	Single Family Detached	SF Residential	0.42
1120	Single Family Multiple-Units	SF Residential	0.42
1190	Single Family Residential Without Units	SF Residential	0.42
1200	Multi-Family Residential	MF Residential	0.74
1290	Multi-Family Residential Without Units	MF Residential	0.74
1300	Mobile Home Park	MF Residential	0.74
1401	Jail/Prison	MF Residential	0.56
1402	Dormitory	MF Residential	0.49
1404	Monastery	Education/Institutional	0.17
1409	Other Group Quarters Facility	MF Residential	0.47

LU	Detailed Land Use	EMC LU Group	SDR Specific Impervious Estimate
1501	Hotel/Motel (Low-Rise)	MF Residential	0.50
1502	Hotel/Motel (High-Rise)	MF Residential	0.72
1503	Resort	MF Residential	0.59
2001	Heavy Industry	Industrial	0.80
2101	Industrial Park	Industrial	0.82
2103	Light Industry - General	Industrial	0.84
2104	Warehousing	Industrial	0.84
2105	Public Storage	Industrial	0.84
2201	Extractive Industry	Industrial	0.73
2301	Junkyard/Dump/Landfill	Industrial	0.62
4103	General Aviation Airport	Transportation	0.45
4111	Rail Station/Transit Center	Transportation	0.77
4112	Freeway	Transportation	0.58
4113	Communications and Utilities	Vacant-Open Space	0.40
4114	Parking Lot - Surface	Transportation	0.75
4115	Parking Lot - Structure	Transportation	0.61
4116	Park and Ride Lot	Transportation	0.87
4117	Railroad Right of Way	Transportation	0.52
4118	Road Right of Way	Transportation	0.60
4119	Other Transportation	Transportation	0.55
5001	Wholesale Trade	Industrial	0.94
5002	Regional Shopping Center	Commercial	0.94
5003	Community Shopping Center	Commercial	0.83
5004	Neighborhood Shopping Center	Commercial	0.85
5005	Specialty Commercial	Commercial	0.83
5006	Automobile Dealership	Commercial	0.89
5007	Arterial Commercial	Commercial	0.83
5008	Service Station	Commercial	0.94
5009	Other Retail Trade and Strip	Commercial	0.80
6001	Office (High-Rise)	Commercial	0.61
6002	Office (Low-Rise)	Commercial	0.65
6003	Government Office/Civic Center	Commercial	0.80
6101	Cemetery	Education/Institutional	0.44
6102	Religious Facility	Education/Institutional	0.48
6103	Library	Education/Institutional	0.57
6104	Post Office	Commercial	0.78
6105	Fire/Police Station	Commercial	0.63

LU	Detailed Land Use	EMC LU Group	SDR Specific Impervious Estimate
6108	Mission	Vacant-Open Space	0.05
6109	Other Public Services	Commercial	0.56
6501	UCSD/VA Hospital/Balboa Hospital	Commercial	0.53
6502	Hospital - General	Commercial	0.74
6509	Other Health Care	Commercial	0.68
6701	Military Use	Education/Institutional	0.62
6702	Military Training	Vacant-Open Space	0.09
6703	Weapons Facility	Industrial	0.62
6801	SDSU/CSU San Marcos/UCSD	Education/Institutional	0.53
6802	Other University or College	Education/Institutional	0.54
6803	Junior College	Education/Institutional	0.51
6804	Senior High School	Education/Institutional	0.56
6805	Junior High School or Middle School	Education/Institutional	0.55
6806	Elementary School	Education/Institutional	0.56
6807	School District Office	Education/Institutional	0.72
6809	Other School	Education/Institutional	0.51
7202	Stadium/Arena	Commercial	0.93
7204	Golf Course	Vacant-Open Space	0.05
7205	Golf Course Clubhouse	Commercial	0.52
7206	Convention Center	Commercial	0.67
7210	Other Recreation - High	Education/Institutional	0.34
7211	Other Recreation - Low	Education/Institutional	0.14
7601	Park - Active	Education/Institutional	0.14
7603	Open Space Park or Preserve	Vacant-Open Space	0.06
7604	Beach - Active	Vacant-Open Space	0.08
8001	Orchard or Vineyard	Agriculture-Orchard	0.03
8002	Intensive Agriculture	Agriculture	0.12
8003	Field Crops	Agriculture	0.09
9101	Vacant and Undeveloped Land	Vacant-Open Space	0.08
9200	Water	Water	0.08
9201	Bay or Lagoon	Water	0.08
9202	Lake/Reservoir/Large Pond	Water	0.08
9501	Residential Under Construction	SF Residential	0.42
9502	Commercial Under Construction	Commercial	0.83
9504	Office Under Construction	Commercial	0.62
9507	Freeway Under Construction	Transportation	0.58

3.0 WATER QUALITY MONITORING DATASETS

Monitoring in the SDR Watershed has been conducted through a number of different programs, many of which are currently required by the San Diego Region Municipal Separate Storm Sewer System (MS4) permit, Order No. R9-2007-0001 (RWQCB Permit). The results of many of these monitoring activities are summarized in annual reports prepared by Weston Solutions (Weston). A brief summary of these programs is included below, as well as a description of how some of the datasets (primarily data taken within receiving waters) were used to support CLRP analyses.

3.1 Mass Loading Station and Temporary Watershed Assessment Stations

Monitoring at the San Diego River Mass Loading Station (MLS) has been performed since 2001. Starting in 2007, monitoring at this location was used for compliance assessment in accordance with the Receiving Waters and Urban Runoff Monitoring Program, per the San Diego Regional Water Quality Control Board (RWQCB) Order R9-2007-0001. In addition to monitoring at the MLS, permit compliance monitoring activities also included monitoring at three Temporary Watershed Assessment Stations (TWAS), which began in the 2009-2010 season.

The MLS is located in the City of San Diego along a natural channel adjacent to the Fashion Valley Mall. The majority of this area consists of residential (29%), parks (24%) and undeveloped (21%) land uses (Weston). The three TWAS sites are located on the mainstem of SDR. TWAS-1 is a few miles upstream of the MLS within the City of San Diego. TWAS-2 is located in the City of Santee, close to mouth of Forester Creek. TWAS-3 is in the Lakeside Hydrologic Subarea (HSA). The MLS and TWAS monitoring locations are shown in Figure 1 (Weston).

Wet weather sampling at the MLS has been done from 2001 until present, with three samples taken annually from 2001 to 2007. Sampling in the 2008-2009 season and the 2009-2010 season consisted of collection of one and two samples respectively, with no samples collected in the 2007-2008 and 2010-2011 seasons. In accordance with the RWQCB Permit, wet and dry weather sampling in the SDR Watershed now occurs every other year, with the 2010-2011 season the off-season for both the MLS and TWAS sites. A total of three wet samples were collected at TWAS-1 and two each at TWAS-2 and -3 in the 2009-2010 sampling season.

started in the 2009-2010 season, with a total of two sample results reported so far for each site
(sampling is scheduled to occur in the current season, however, since the sampling season is not
Dry weather sampling at the MLS and TWAS sites as part of the regional monitoring program
finished, reports have not been released as yet).

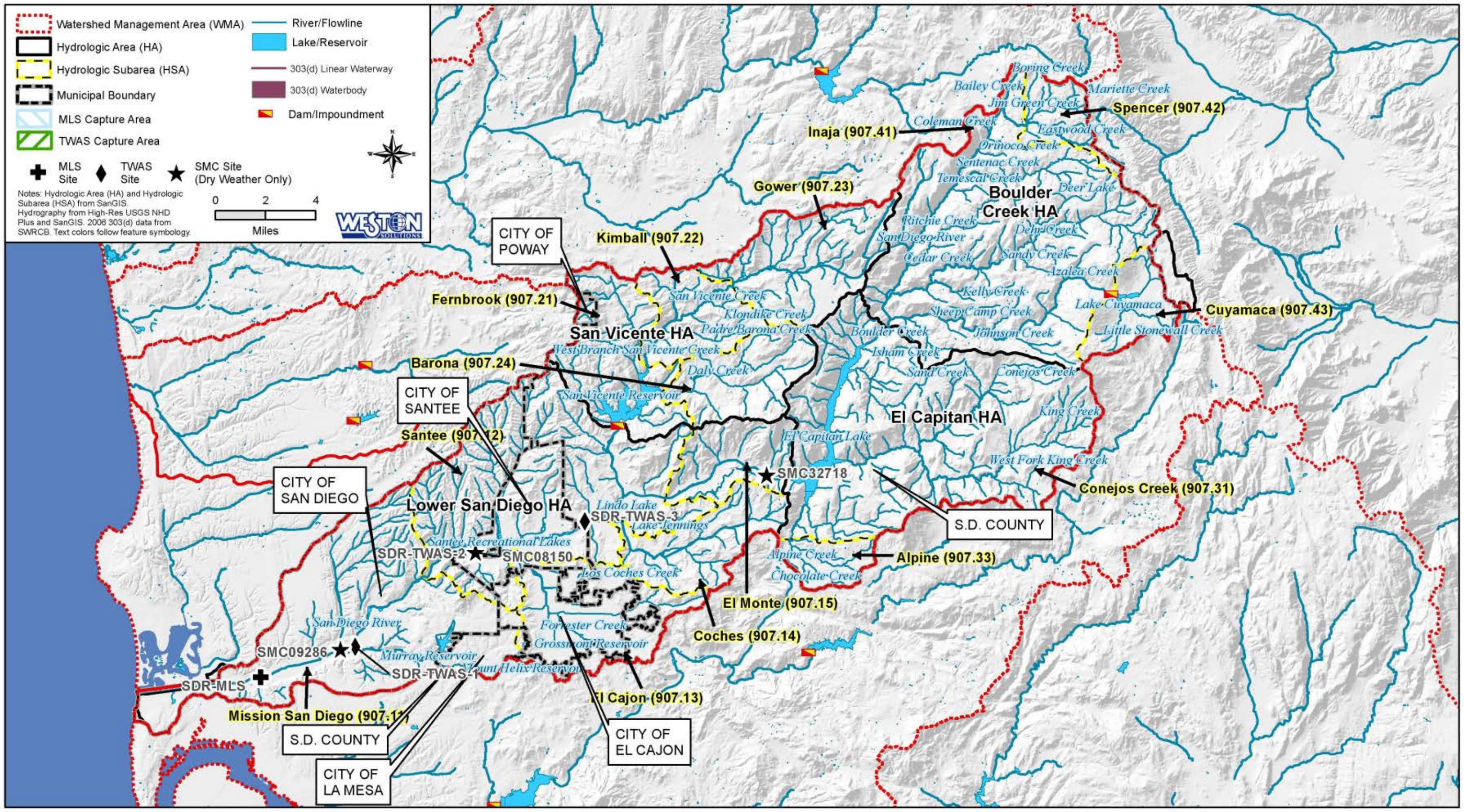


Figure 1. Receiving water sampling locations for San Diego WMA. MLS and TWAS stations were sampled during wet and dry weather, while SMC sites and third party sites were sampled only during dry weather (Weston).

3.1.1 Wet Weather

Over the monitoring period, concentrations at the MLS and TWAS sites were frequently elevated during wet weather. Fecal coliform and enterococcus have benchmarks for creeks in the San Diego Basin Plan (400 MPN/100 mL and 61 MPN/100 mL respectively), (SDRWQCB 1994). Based on comparisons with these benchmarks, the majority of samples at the MLS have had exceedances for fecal coliform and all of them have exceeded the enterococcus standards. All TWAS samples exceeded benchmarks for both fecal coliform and enterococcus.

3.1.2 Dry Weather

Dry weather monitoring at the MLS and TWAS stations as part of the regional monitoring program began in the 2009-2010 season, and as such, the dataset is more limited because of the short duration of the study data. Based on the Basin Plan benchmarks for enterococcus and fecal coliform described in the previous section (61 and 400 MPN/100 mL, respectively), one of the two samples taken at the MLS exceeded benchmarks for enterococcus. Both TWAS-2 samples and one TWAS-3 sample also exceeded for enterococcus. There were no exceedances during dry weather for fecal coliform.

3.2 MS4 Sampling

The MS4 Outfall monitoring program in the SDR watershed includes both random and targeted sampling activities which occur during both wet and dry weather. Random sampling is designed to provide statistically valid inferences about the region as a whole without having to sample every MS4 location. Targeted sampling then focuses monitoring on those outfalls that are considered most likely to contribute to receiving water issues. Dry weather sampling at MS4 outfalls began in the summer of 2008 and wet weather sampling began in the 2008-2009 rainy season.

3.2.1 Wet Weather

The wet weather MS4 monitoring program consists of random and targeted sampling. Bacterial indicator results from random sampling of MS4s were similar to the consistently high results from the MLS and TWAS sites, with consistent exceedances of fecal coliform and enterococcus benchmarks.

Weston summarized MS4 sampling data for the hydrologic sub-areas (HSAs) in which they were located (HSAs are shown in Figure 1), and also compared data from the MS4 sampling program with data from the receiving water locations which they drained to (MLS, TWAS-1 or TWAS-2). The results of this analysis for the 2009-2010 monitoring season are summarized in Table 7 below (Weston 2011). The constituents listed are those that were identified as high priority wet weather constituents for receiving waters. These results show that fecal coliform is high priority in both receiving waters and MS4s.

Table 7. Summary of Spatial Distribution of Priority Wet Weather Constituents (Weston 2011)

Station Type	HA	HSA	Parameter	Total Suspended Solids (estimated)	Total Dissolved Solids	Fecal Coliforms	Biochemical Oxygen Demand	Turbidity	MBAS	Bifenthrin	Permethrin
MS4 by HSA	*Lower San Diego (907.1)*	*Mission San Diego (907.11)*	*n*	3	3	3	1*	1*	0	0	0
			% > Criteria	33%	0%	100%	0%	100%	NA	NA	NA
		Santee (907.12)	*n*	2	2	2	0	0	0	0	0
			% > Criteria	0%	0%	100%	NA	NA	NA	NA	NA
		El Cajon (907.13)	*n*	1*	1*	1*	0	0	0	0	0
			% > Criteria	0%	0%	100%	NA	NA	NA	NA	NA
		Coches (907.14)	*n*	1*	1*	1*	0	0	0	0	0
			% > Criteria	0%	0%	100%	NA	NA	NA	NA	NA
		El Monte (907.15)	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
SDR-MLS (MS4 vs Receiving Water Comparison)			*MS4 (n)*	7	7	7	1*	1*	0	0	0
			MS4 (%) > Criteria	14%	0%	100%	0%	100%	NA	NA	NA
			*RW Score***	Low	Med	High	Med	Med	Med	Low	Low
SDR-TWAS-1 (MS4 vs Receiving Water Comparison)			*MS4 (n)*	5	5	5	1*	1*	1*	0	0
			MS4 (%) > Criteria	0%	0%	100%	0%	100%	100%	NA	NA
			*RW Score***	Low	Med	High	Low	High	Med	High	Low
SDR-TWAS-2 (MS4 vs Receiving Water Comparison)			*MS4 (n)*	4	4	4	0	0	0	0	0
			MS4 (%) > Criteria	0%	0%	100%	NA	NA	NA	NA	NA
			*RW Score***	High	Low	High	Med	High	Low	High	High
SDR-TWAS-3 (MS4 vs Receiving Water Comparison)			*MS4 (n)*	3	3	3	0	0	0	0	0
			MS4 (%) > Criteria	0%	0%	100%	NA	NA	NA	NA	NA
			*RW Score***	Low	Low	High	Low	High	Low	High	Low

*One station was used in the summary.

HAs with no MS4 data are not shown in table and include San Vincente (907.2), El Capitan (907.3) and Boulder Creek (907.4).

Key

- High: > 50% Above benchmark
- Medium: > 25% and ≤ 50% Above benchmark
- Low: ≤ 25% Above benchmark
- No Data

HA - hydrologic area
HSA - hydrologic subarea
MBAS - methylene blue active substance
MLS - mass loading station
MS4 - municipal separate storm sewer system
NA – not available
RW – receiving water
SDR - San Diego River
TWAS – temporary watershed assessment station

3.2.2 Dry Weather

Dry weather random and targeted sample results at MS4s showed elevated levels of bacterial indicators, with the majority of samples exceeding benchmarks (from the Basin Plan) for enterococcus, and consistent (though fewer) exceedances of fecal coliform.

Exceedances of total nitrogen and total phosphorus benchmarks occurred in the majority of samples. There were also several benchmark exceedances for nitrate.

Similar to what was done for wet weather, Weston summarized dry weather MS4 sampling data for the HSAs in which they were located (HSAs are shown in Figure 1), and also compared data from the MS4 sampling program to data from the receiving water locations which they drained to (MLS, TWAS-1 or TWAS-2). The results of this analysis for the 2009-2010 monitoring season are summarized in Table 8 below (Weston 2011). The constituents listed are those that were identified as high priority dry weather constituents for receiving waters. These results show that fecal coliform and enterococcus are generally identified as higher priority constituents in MS4 outflows as compared to receiving waters. Total nitrogen and total phosphorus were identified as high priority as well.

Table 8. Summary of Spatial Distribution of Priority Dry Weather Constituents (Weston 2011)

Station Type	HA	HSA	Parameter	Total Nitrogen (calculated)	Dissolved Phosphorus	Total Phosphorus	Total Dissolved Solids	Fecal Coliform	Entero-coccus
MS4 by HSA	*Lower San Diego (907.1)*	*Mission San Diego (907.11)*	*n*	13	0	13	13	13	13
			% > Criteria	85%	NA	69%	85%	31%	69%
		Santee (907.12)	*n*	8	0	8	8	8	8
			% > Criteria	88%	NA	63%	75%	25%	75%
		El Cajon (907.13)	*n*	6	0	6	6	6	6
			% > Criteria	100%	NA	83%	100%	67%	67%
		Coches (907.14)	*n*	1*	0	1*	1*	1*	1*
			% > Criteria	100%	NA	100%	100%	0%	100%
		El Monte (907.15)	*NA*	NA	NA	NA	NA	NA	NA
	San Vicente (907.2)	*Fernbrook (907.21)*	*NA*	NA	NA	NA	NA	NA	NA
		Kimball (907.22)	*NA*	NA	NA	NA	NA	NA	NA
		Gower (907.23)	*n*	1*	0	1*	1*	1*	1*
			% > Criteria	0%	NA	100%	100%	0%	0%
		Barona (907.24)	*NA*	NA	NA	NA	NA	NA	NA
	El Capitan (907.3)	*Conejos Creek (907.31)*	*NA*	NA	NA	NA	NA	NA	NA
		Alpine (907.33)	*n*	2	0	2	2	2	2
			% > Criteria	100%	NA	100%	100%	100%	100%
	Boulder Creek (907.4)	*Inaja (907.41)*	*NA*	NA	NA	NA	NA	NA	NA
		Spencer (907.42)	*NA*	NA	NA	NA	NA	NA	NA
		Cuyamaca (907.43)	*NA*	NA	NA	NA	NA	NA	NA
SDR-MLS Summary (MS4 to RW Comparison)			*MS4 (n)*	28	0	28	28	28	28
			MS4 (%) > Criteria	89%	NA	71%	86%	36%	71%
			RW Score	Low	High	Med	Low	Low	Low
SDR-TWAS-1 Summary (MS4 to RW Comparison)			*MS4 (n)*	18	0	18	18	18	18
			MS4 (%) > Criteria	94%	NA	72%	89%	50%	72%
			RW Score	Low	High	High	Low	Low	Low
SDR-TWAS-2 Summary (MS4 to RW Comparison)			*MS4 (n)*	15	0	15	15	15	15
			MS4 (%) > Criteria	93%	NA	73%	87%	40%	73%
			RW Score	High	Med	High	High	Low	Med
SDR-TWAS-3 Summary (MS4 to RW Comparison)			*MS4 (n)*	5	0	5	5	5	5
			MS4 (%) > Criteria	100%	NA	100%	80%	20%	60%
			RW Score	Med	Med	Med	High	Low	Med

*One station was used in the summary.

HAs with no MS4 data are not shown in table and include Boulder Creek (907.4).

Key

High	> 50% Above benchmark
Medium	> 25% and ≤ 50% Above benchmark
Low	≤ 25% Above benchmark
No Data	

HA - hydrologic area
HSA- hydrologic subarea
MLS - mass loading station
MS4 - municipal separate storm sewer system
NA – not available
RW – receiving water
SDR - San Diego River
TWAS – temporary watershed assessment station

3.3 Urban Runoff Management Programs

In addition to dry weather monitoring at the MLS and TWAS sites, dry weather monitoring was also conducted through the Jurisdictional Urban Runoff Management Program (JURMP) and the Watershed Urban Runoff Management Program (WURMP). The purpose of these programs is to identify areas and sources of contamination in the watershed. Monitoring for the JURMP is conducted by individual jurisdictions. The goal of this program is to identify water quality problems that may result from non-storm water discharges to or from municipal separate storm sewer systems (MS4s). Some of the sample sites for this program are receiving water bodies in unincorporated areas of the watershed, since these often serve as conduits for urban runoff. The WURMP is intended to identify areas of contamination across the San Diego River Watershed.

Results from these monitoring programs are incorporated into Figures 7 and 8 below.

3.4 Third Party Datasets

Third party data from the SDR Watershed were collected by a number of entities, including the Surface Water Ambient Monitoring Program (SWAMP), Padre Dam Municipal Water District, the Cities of La Mesa and Santee, Stormwater Monitoring Coalition (SMC), and Coastkeeper.

The Padre Dam Municipal Water District has collected samples in the SDR Watershed since 2004. From 2004 to 2009, six locations upstream of the MLS were sampled during both wet and dry weather. FIB samples had frequent exceedances of Basin Plan Standards. Starting in the 2009-2010 season, samples were collected from seven locations during dry weather only (in the 2010-2011 season, this was done on a monthly basis as part of their NPDES permit). E. Coli and fecal coliforms were identified as high or medium priorities at several of these sites. Nutrients were identified as high or medium priority in all of the sites.

The City of Santee conducted monitoring within the SDR Watershed at five sites in SDR, Sycamore Creek and Forester Creek during the 2009-2010 season in dry weather. Nutrients were identified as high or medium priority in all of the sites. As part of the Forester Creek Restoration Project, the City of Santee did additional monitoring, which is detailed below.

The City of La Mesa conducted dry and wet weather monitoring in 2007 in order to evaluate land use contributions within the City's jurisdiction. Two locations were sampled in Alvarado Channel during both wet and dry weather. Fecal coliforms were found above benchmarks in both locations.

Sampling by Coastkeeper occurred on a monthly basis during dry weather at two locations (one in the Mission San Diego HSA, and the other in the Santee HSA) during the 2010-2011 season, as part of a Regional Board approved Quality Assurance Project Plan. Enterococcus and E. Coli sample results were found to be above benchmarks.

The SWAMP data were collected from four locations in the SDR Watershed: Boulder Creek, Los Coches Creek, Forester Creek and SDR. A number of parameters were measured, including nutrients, metals and pesticides, however bacterial indicators were not analyzed.

Data from within the SDR Watershed were collected as a part of the Stormwater Monitoring Coalition (SMC) Program at four sites in the 2010-2011 sampling season during dry weather. Total phosphorus and total nitrogen were identified as high priority constituents at some of the sites. Samples were not tested for bacterial indicators.

3.5 AB411 Data

Per Assembly Bill 411 (AB 411), which mandated testing for bacterial indicators at public beaches, monitoring was conducted at the Pacific Ocean Shoreline at the SDR outlet during both wet and dry weather starting in 1999. These data were used to estimate Target Load Reductions (TLR) for the CLRP as well as to assess historic or current exceedance rates for comparison with interim targets and final WLAs. This analysis is discussed in more detail in Section 4.

3.1 Microbial Source Identification Studies

In response to frequent exceedances of bacterial standards at the SDR AB411 site at Dog Beach, studies were initiated to identify possible sources of bacterial loads. The San Diego River-Ocean Beach Water Quality Improvement Project (Weston 2007) was undertaken in order to address these continuing exceedances. Based on previous studies, Phase I of the project assumed that bird and dog feces were not the primary source of contamination, and targeted infrastructure issues (such as leaking sanitary sewers or storm drain systems), urban runoff, and human inputs in the SDR Watershed as potential sources of bacterial loads to the beach.

During Phase I, three potential areas of chronic bacterial inputs to SDR were identified. Possible sources identified in these areas included aging infrastructure (though follow-up investigations on sewers did not reveal evidence of leaks), homeless populations, wildlife, discharge from a pump station east of I-5, and two outfalls that drain the community of Ocean Beach. These outfalls, Outfalls 13 and 14, were also identified as having the greatest potential to influence water quality during dry weather conditions at Dog Beach, since observations of flow from these Outfalls confirmed that their discharge could reach the beach. During wet weather, it was noted that increased flow from SDR did impact water quality at the beach, though wet weather sources were not thoroughly investigated since the focus of this study was dry weather.

Based on the results of the source tracking work as well as follow-up surveys, it was concluded that the River may not be the primary source of dry weather bacterial loading to Dog Beach and that local sources, such as kelp and sand berms located on Ocean Beach (south of Dog Beach), which are made up of a mix of sand and kelp, may be significant contributors.

Phase II of the project was designed based on the results of Phase I, with the goals of implementing infrastructure improvements in the SDR Watershed, conducting water quality monitoring to track the effectiveness of improvement projects, and developing a Kelp and Dog Waste Management Plan.

Water quality monitoring for Phase II consisted of dry weather sampling in five locations within SDR, four locations on Dog Beach, Outfalls 13 and 14, and at low flow diversion boxes for the two Outfalls, which connect the storm and sanitary sewer systems. With the exception of sampling on Dog Beach which occurred over a time period slightly longer than a year (July 2006-September 2007), sampling occurred over a period of approximately a year and a half (November 2004-April 2006). Results were compared to AB411 standards, and it was noted that exceedances seemed to decrease in several locations post-construction of infrastructure improvements.

Phase I of the study also included source identification investigations on MS4s near Dog Beach in order to test for the presence of human sewage contamination. Of the 18 samples tested, only one was found to have a weak human fecal signal, so it was concluded that human fecal contamination was not a significant source of bacterial inputs.

Further source tracking work was presented in the San Diego River Source Tracking Investigation, which was also conducted in two phases (Weston 2009a and b). Phase I of the San Diego Source Tracking study sought to determine if there was evidence of human fecal contamination in the San Diego River by testing samples collected during two dry weather events, and, similar to the San Diego River-Ocean Beach study, found no evidence of human-specific fecal waste. Phase II of the study found human contributions during wet weather sampling of SDR. Review of this work, however, was unable to confirm the reliability of these source identification results due to a lack of available data on quality assurance and control (see CLRP Appendix H).

3.2 Forester Creek Study

Forester Creek is a tributary of SDR located in eastern San Diego County. Forester Creek begins in the City of El Cajon and flows north through the City of Santee eventually discharging to the SDR just north of Mission Gorge Road. Prior to 2006, the lower portion of Forester Creek was an earthen hydromodified channel that was often inundated by flooding and provided little to no natural habitat or water quality benefit. The Forester Creek Improvement Project (Project) involved the widening and naturalization of the downstream 1.2 mile segment of the Forester Creek channel within the City of Santee, beginning at Prospect Avenue.

The goals of the Project included enhancing natural habitat, improving water quality, and increasing the channel's flood control capacity. The new channel was designed to handle a one hundred-year flood event, which required widening the channel by 200 feet. Construction on the Project began in January 2006 and was completed in June 2008. The channel is earthen throughout the Project with the exception of a concrete conveyance under Mission Gorge Road where the channel makes a sharp left turn. Native vegetation was planted and has become established since construction was completed. A trail system was established on the west bank of the creek for recreation.

The City of Santee and their consultant, D-MAX, monitored for fecal coliform upstream and downstream of the project, during both wet and dry weather conditions. Monitoring during dry weather was conducted before, during, and after construction. Monitoring during wet weather was conducted before and during construction. Dry weather monitoring has been occurring since 2002 and wet weather monitoring has been occurring since 2005. Monitoring has found significant improvements in fecal coliform during dry weather, increased Index of Biological Integrity (IBI) scores for bioassessment, as well as increased flood control capacity.

Water quality benefits for this and other stream restoration benefits were quantified for the CLRP. This quantification involved review of a number of studies and documents (including those from Earth Tech, D-Max, Polaris, Helix, Poutney Psomas, and Google Earth Pro) as well as information provided by the Responsible Parties (primarily the City of Santee), which are included in the References section of this document.

3.3 Riverford Road Study

Water quality sampling in SDR at Riverford Road was conducted from 2006 to 2008 in order to document FIB counts and determine baseline levels at this one location. Most samples were taken during dry weather, though samples were also collected during several storms.

Average results from these monitoring results are reflected in Figures 5 through 8 below.

4.0 ANALYSIS OF MONITORING DATA

Analysis of monitoring data primarily relied on data collected through the AB411 program, since a robust dataset was available for this location. Additional SDR mainstem and tributary datasets were also compiled to create maps of monitoring data. These analyses are described below.

4.1 Target Load Reduction Estimate

A Total Maximum Daily Load (TMDL) for bacteria in twenty beaches and creeks in the San Diego Region (Resolution No. R9-2010-0001) was adopted on February 10, 2010 and went into effect on April 4, 2011 (SDRWQCB 2010). This TMDL applies to the Pacific Ocean shoreline at the SDR outlet, as well as two additional sites in both SDR and Forester Creek.

The TMDL numeric targets for beaches and creeks consist of REC-1 Water Quality Objectives (WQO) for fecal indicator bacteria (FIB) concentrations, as well as dry and wet weather allowable exceedance frequencies (AEF), which are the percentage of samples which may exceed the WQOs annually. The TMDL sets WQOs in terms of single sample maximums (SSMs) and 30-day geometric means (GMs). The WQOs and AEFs are listed in Tables 10 and 11.

For wet weather, concentrations cannot exceed the single sample maximum numeric targets more often than the AEF of 22%. In other words, no more than 22% of the wet weather samples collected on an annual basis, assuming daily sampling, may exceed the numeric targets listed in Tables 10 and 11. 30-day geometric means have an AEF of 0%, meaning they may not exceed the numeric targets.

For the SDR watershed, TMDL required load reductions for wet and dry weather are apportioned solely to MS4 sources.

Table 10: TMDL single sample maximum WQOs

Indicator Bacteria	WQO (MPN/100 mL)	Allowable Exceedance Frequency (wet/dry)
Fecal Coliform	400	22% / 0%
Total Coliform	10,000	22% / 0%
Enterococci	104/61[1]	22% / 0%

[1] 104 MPN/100 mL is the limit for beaches, and 61 MPN/100 mL is the limit for creeks, including SDR and Forester Creek.

Table 11: TMDL geometric mean WQOs

Indicator Bacteria	WQO (MPN/100 mL)	Allowable Exceedance Frequency
Fecal Coliform	200	0%
Total Coliform	1,000	0%
Enterococci	35/33[1]	0%

[1] 35 MPN/100 mL is the limit for beaches, and 33 MPN/100 mL is the limit for creeks, including SDR and Forester Creek.

The AB411 dataset was used to estimate total load reductions necessary in the SDR watershed in order to meet TMDL requirements. The dataset was split into wet weather and dry weather days using data from the Lindbergh CCDA rain gauge, and applying the TMDL definition of a wet day as a day with greater than 0.2 inches of precipitation, in addition to the 72 hour period following that day.

For wet weather, the AB411 data was compared to the TMDL numeric limits to determine the exceedance rate over the monitoring period. A reduction percentage was then applied to the whole dataset to determine what reduction would be necessary to lower the exceedance rate to the allowable 22%.

For the wet and dry weather geometric mean limits, as well as the dry weather single sample limits, there are no allowable exceedances (in other words, the allowable frequency is 0%). Therefore, the reduction was calculated as the reduction required to lower the maximum value of each dataset to the WQO.

Since this TMDL in SDR apply only to MS4s sources, the load reduction percentages calculated for the whole watershed were scaled to determine a percent load reduction required just from MS4 sources using load estimates from the TMDL. When the load was apportioned this way, the required TLR for MS4s was over 100%. Results of this analysis (for the whole watershed) are presented in Table 12.

Table 12. Summary of Total Load Reduction Analysis using AB411 data

	Wet		Dry	
	Single Sample Max	Geo Mean	Single Sample Max	Geo Mean
Exceedance Days	9	80	43	65
No. Days Analyzed	29	1254	357	1254
Exceedance Percentage	31.0%	6.4%	12.0%	5.2%
Allowable Exceedance Frequency (AEF)	22%	0%	0%	0%
Concentration Reduction % Necessary to Meet Target AEF on Average	28%	72%	95%	85%

4.2 Monitoring Data Correlations

AB411 monitoring datasets were also used to investigate correlations in order to guide overall CLRP approaches as described below.

4.2.1 Tidal Fluctuations in AB411 Data

Trends in AB411 data during rising high tides and falling low tides were investigated in order to determine if there was evidence to support significant sources of bacteria on the beach itself (for instance, from beach wrack). Box plots illustrating this data for each FIB are shown in Figures 2 through 4. Tidal data for this analysis was taken from the National Oceanic and Atmospheric Administration Tides and Currents website.

The three FIB were generally higher during wet weather as compared to dry weather, however, based on these graphs, no consistent trends were observed between tides and AB411 bacteria concentrations, indicating that beach sources of FIB are likely not the primary contributors to exceedances at the beach. It should be noted that this analysis does not take into account diurnal variations, which has been shown to be a significant factor due to photoinactivation of FIB.

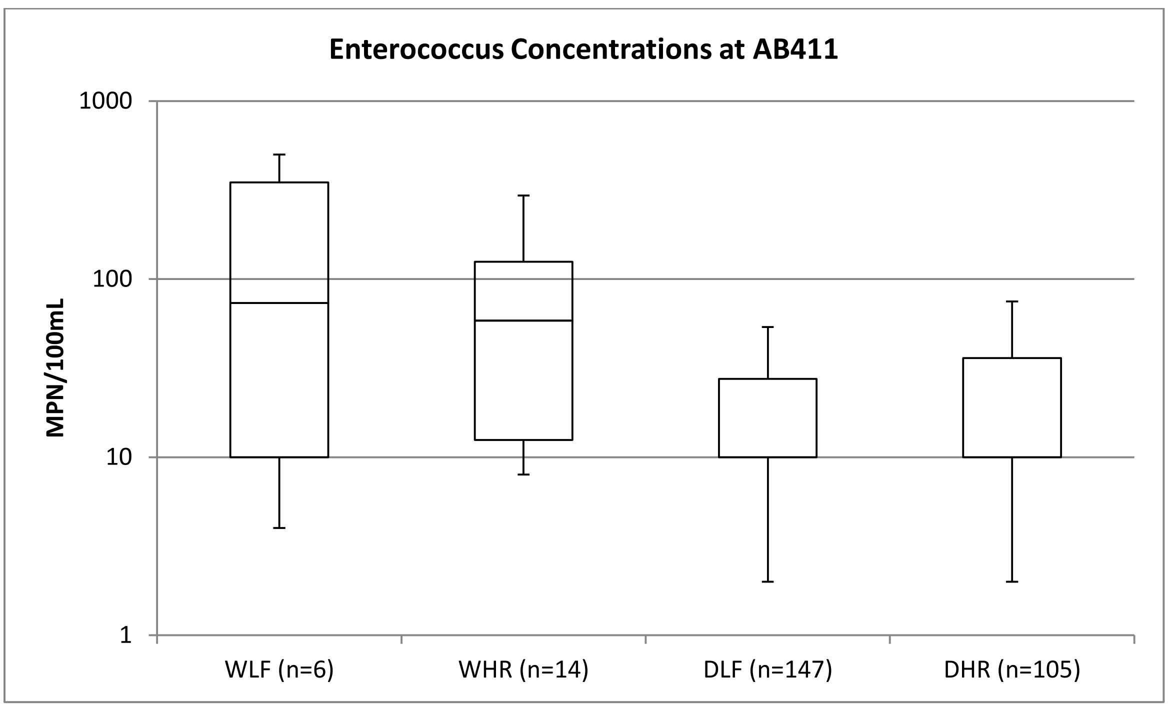


Figure 2. Enterococcus data shown during different tidal conditions at the AB411 site. Data is split into wet low falling tide (WLF), wet high rising tide (WHR), dry low falling tide (DLF) and dry high rising tide (DHR). Boxplots show median, 1st and 3rd quartiles, and whiskers show 1.5IQR or min/max point. The number of data points for each box plot is shown in the x-axis.

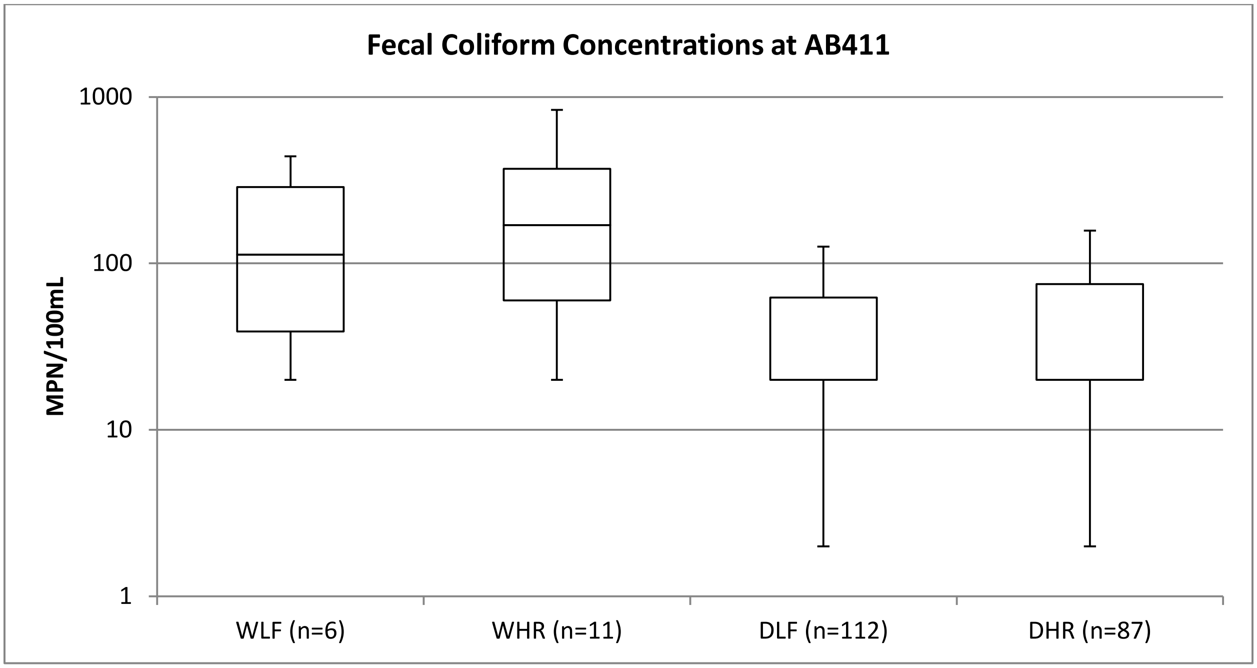


Figure 3. Fecal coliform data shown during different tidal conditions at the AB411 site. Data is split into wet low falling tide (WLF), wet high rising tide (WHR), dry low falling tide (DLF) and dry high rising tide (DHR). Boxplots show median, 1st and 3rd quartiles, and whiskers show 1.5IQR or min/max point. The number of data points for each box plot is shown in the x-axis.

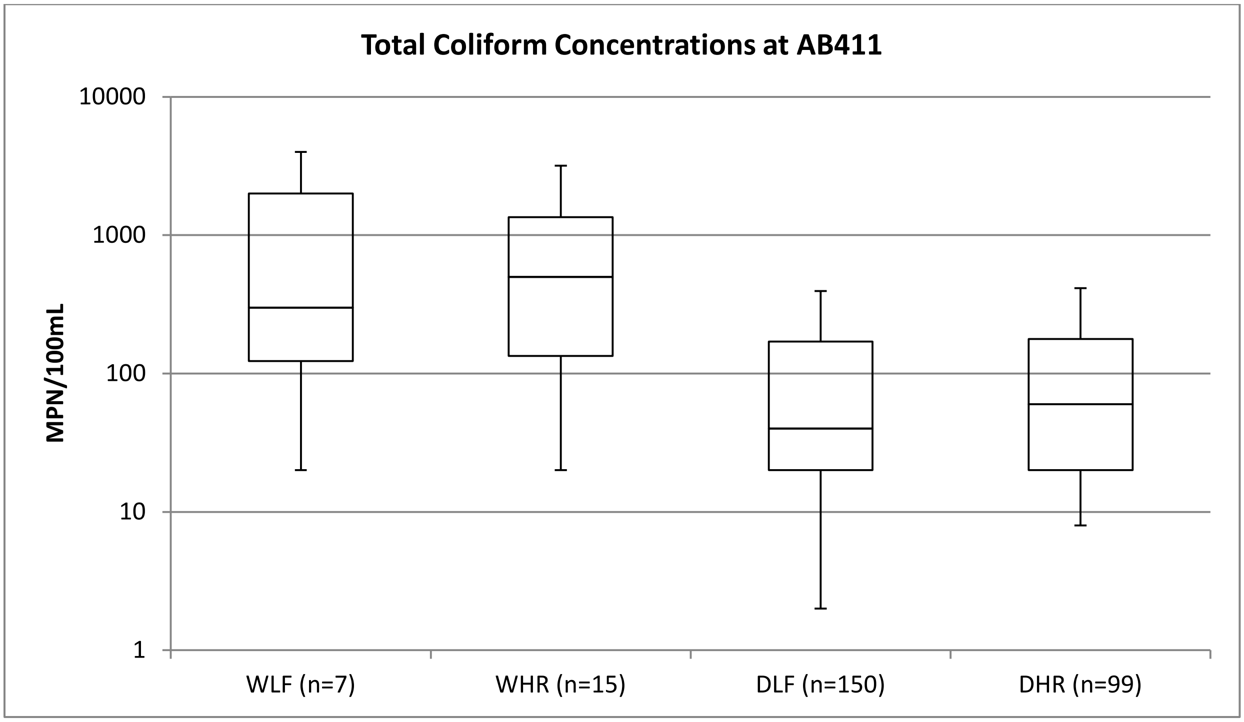


Figure 4. Total coliform data shown during different tidal conditions at the AB411 site. Data is split into wet low falling tide (WLF), wet high rising tide (WHR), dry low falling tide (DLF) and dry high rising tide (DHR). Boxplots show median, 1st and 3rd quartiles, and whiskers show 1.5IQR or min/max point. The number of data points for each box plot is shown in the x-axis.

4.2.2 Seasonal AB411 Data Trends

AB411 data were also used to investigate if there were seasonal trends in dry weather data. The dataset was split into summer-dry (April through October) and winter-dry (November through March) months and exceedance days during these periods were counted.

When the number of exceedances in each season was compared to the total number of dry weather samples taken during that period, summer-dry was found to have a higher exceedance rate than winter-dry (13% versus 7% respectively).

4.3 Spatial Analysis of Data

Fecal coliform and enterococcus data from the MLS and TWAS sampling, the Urban Runoff Management Programs, the Forester Creek study and the AB411 monitoring program were compiled and the points with at least three sample results (with the exception of the MLS and TWAS-1 sites during dry weather, and the TWAS-2 and -3 sites during both wet and dry, the three of which had 2 sample results) were mapped in order to determine hot spots within the watershed. Dry weather data was graphed over a GIS land use layer while wet weather data was graphed over results of the SBPAT analysis CPI scores. These maps are shown in Figures 5 through 8.

These analyses provided limited ability to develop correlations due to the high percentage monitoring results that were above water quality objectives. Generally speaking, higher average concentrations of both enterococcus and fecal coliforms during wet weather were found in areas with higher CPI scores (indicating greater need for water quality treatment), with the highest concentrations occurring in areas with CPI scores of 3 or 4.

In dry weather, there was a greater range of results in relation to WQOs, however more data was available in the upper portions of the Watershed. Higher concentrations tended to be located in the upper portions of the Watershed, primarily in residential and commercial land use areas.

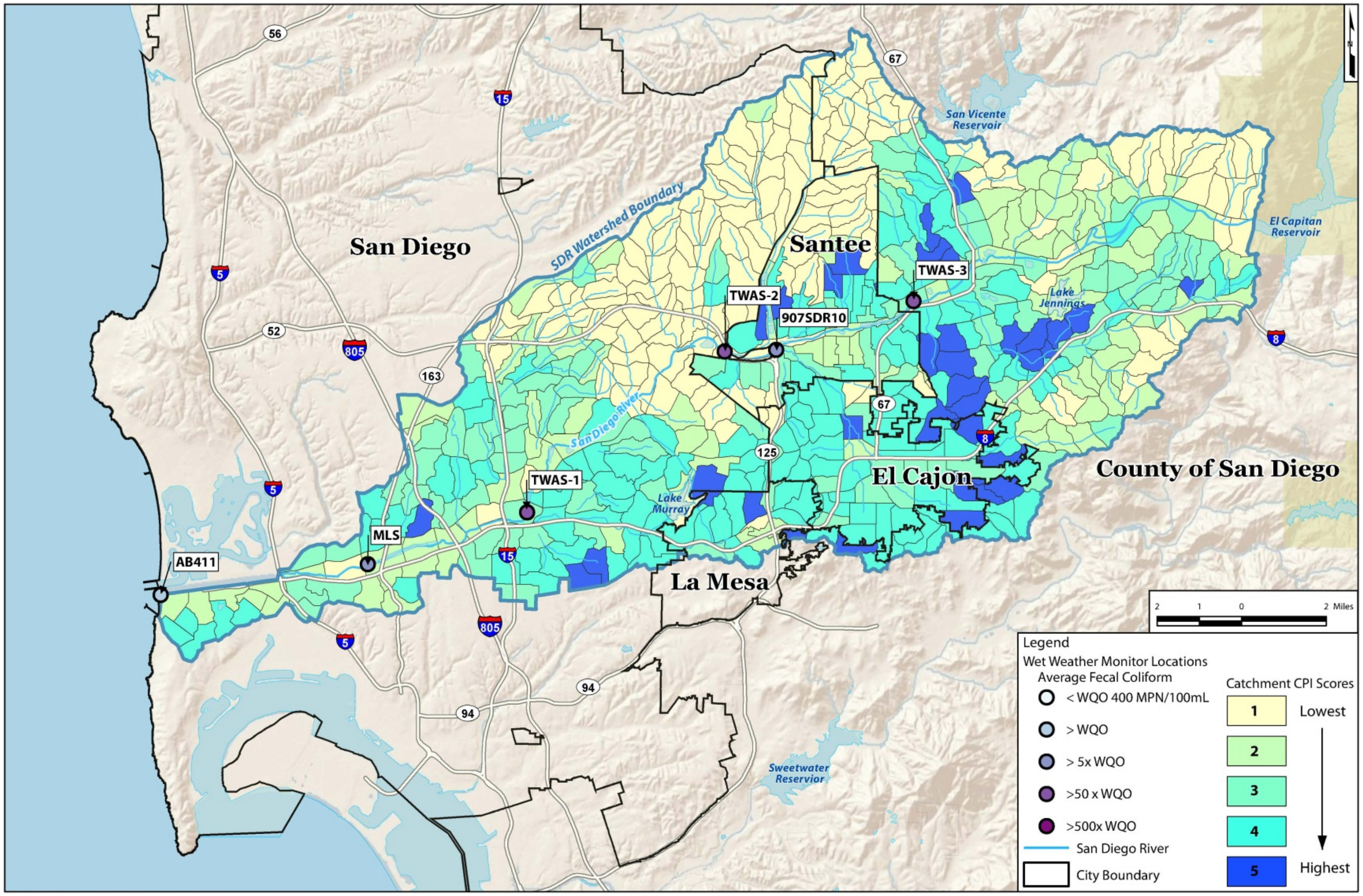


Figure 5. Average fecal coliform results during wet weather in SDR Watershed.

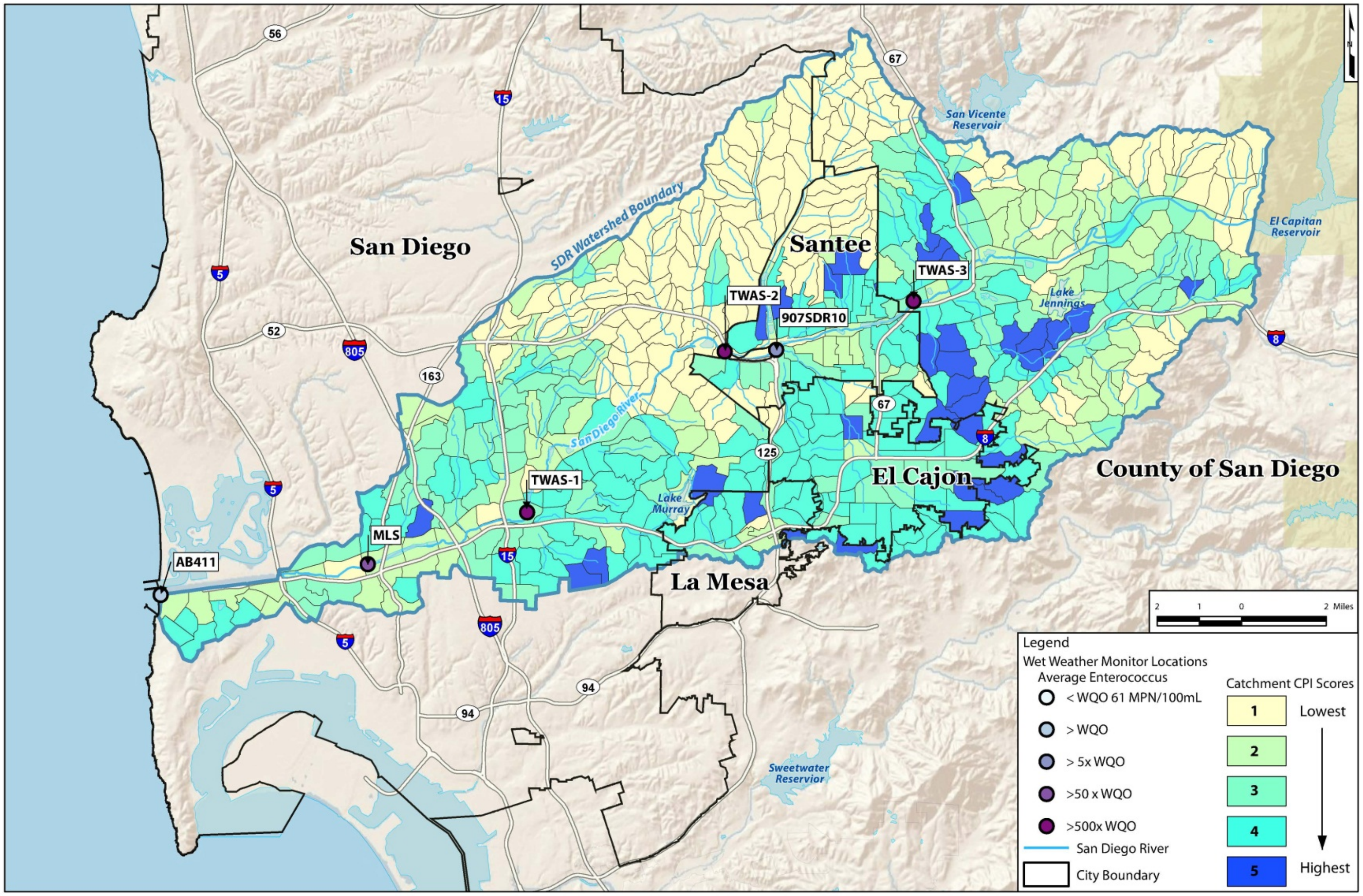


Figure 6. Average enterococcus results during wet weather in SDR Watershed.

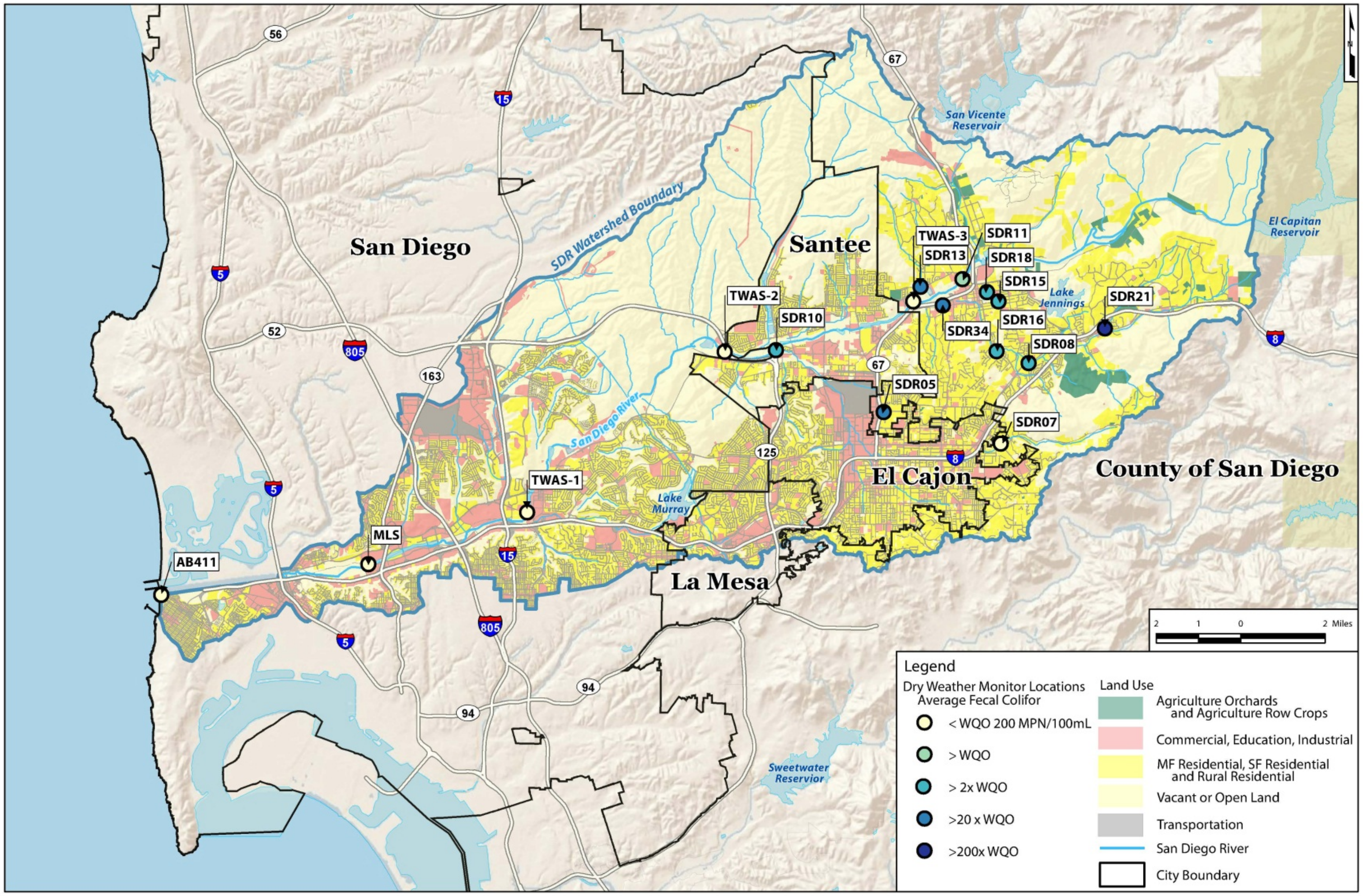


Figure 7. Average fecal coliform results during dry weather in SDR Watershed.

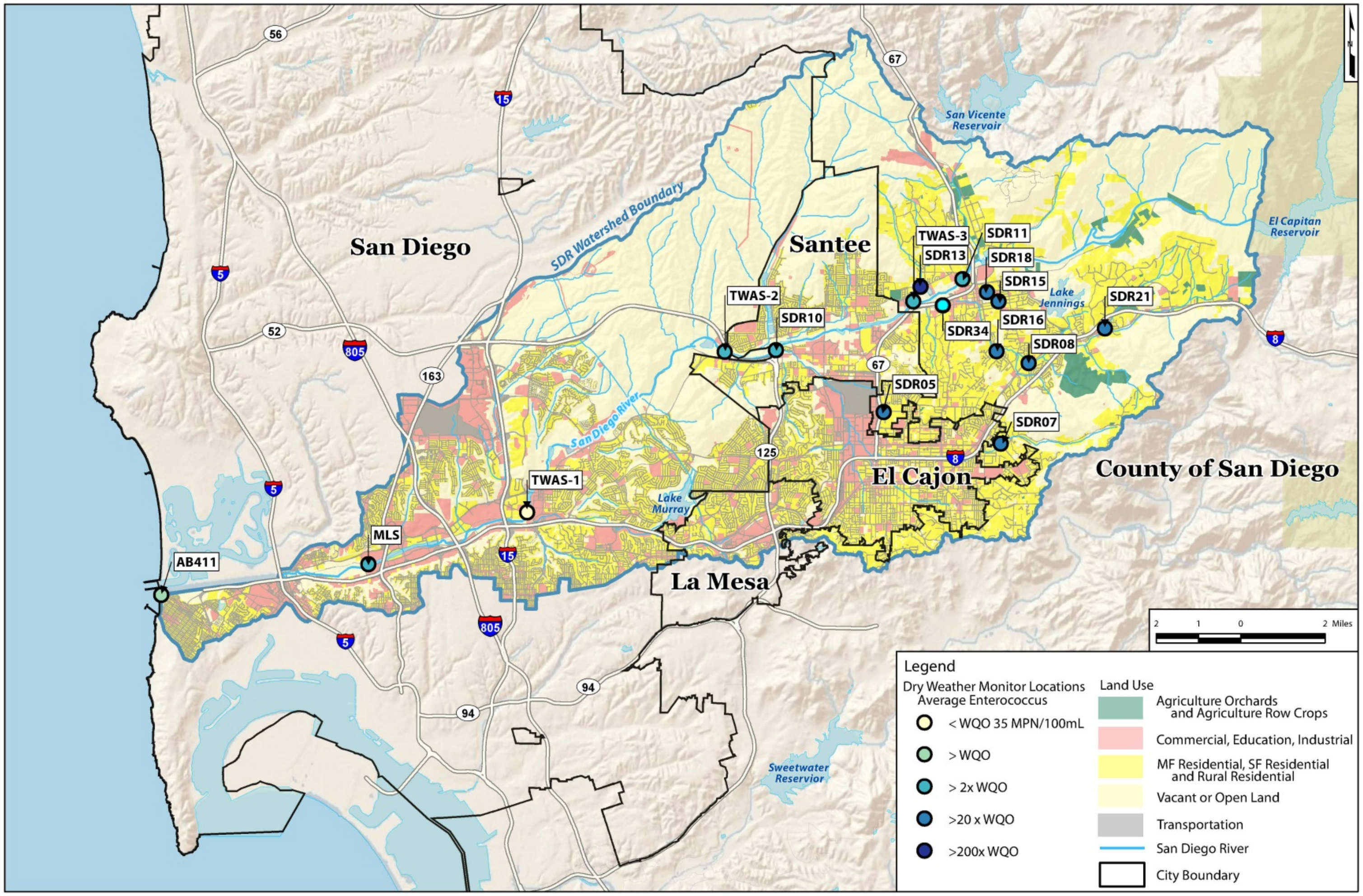


Figure 8. Average enterococcus results during dry weather in SDR Watershed.

5.0 REFERENCES

County of San Diego, "Impervious Surface Coefficients for General Land Use Categories for Application within San Diego County", 2010.

County of San Diego, Hydromodification Management Plan. Prepared by Brown and Caldwell, 2011.

D-Max Engineering, 2008. City of Santee Forester Creek Improvement Project Water Quality Monitoring Summary Report.

D-MAX Engineering, Inc., "Creek Restoration Water Quality Improvement Potential." Memo. December 16, 2010.

Earth Tech, 1999. Hydrologic Analysis Report for the City of Santee Forester Creek Project.

Earth Tech, 2008. Request for letter of Map Revision, Forester Creek from Prospect Avenue to Mission Gorge Road. Volume I

Earth Tech, 2008. Request for letter of Map Revision, Forester Creek from Prospect Avenue to Mission Gorge Road. Volume II

Earth Tech, 2009. Drainage Calculations for Forester Creek Improvement Project.

Email from Julie Procopio, P.E., Principal Civil Engineer, City of Santee. To Christian Braun, Geosyntec. February 16, 2012. Email summarizes design features for forester Creek..

EPA, Storm Water Management Model User's Manual Version 5.0, EPA/600/R-05/040, July 2010.

Forester creek monitoring data received from Helen Davies, M.S., CPSWQ, Stormwater Program Manager, City of Santee.

Geosyntec Consultants, "A User's Guide for the Structural BMP Prioritization and Analysis Tool (SBPAT v1.0)", December 2008

Geosyntec Consultants, "San Luis Rey and San Diego River Watershed Comprehensive Load Reduction Plans – San Diego Land Use EMCs", November 2011

Google Earth Pro, historic aerial imagery, pre-construction, during construction, and post-construction for both Forester Creek and Woodglen Vista Creek.

Helix, 2011. Wetland restoration area drawings for Woodglen Vista Creek.

Helsel, D.R. and Cohn, T.A. (1988). "Estimation of Descriptive Statistics for Multiply Censored Water Quality Data." Wat. Res. Research, 24(12): 1997-2004.

Los Angeles County Department of Public Works (LACDPW), "Hydrology Manual", January 2006

MACTEC, Noble R, Griffith J, Fuhrman J, "Lower San Luis Rey River Bacterial Source Identification Project", Final Project Report, September 2011

Polaris, 2011. Woodglen Vista As-built and information on River walk development.

Poutney Psomas, 2006. Rough Grading Plan For Santee Town Center Park. Used for Woodglen Vista Creek. Paper Maps received from Helen Davies, M.S., CPSWQ, Stormwater Program Manager, City of Santee

San Diego Regional Water Quality Control Board (SDRWQCB), "A Resolution Amending the Water Quality Control Plan for the San Diego Basin (9) to Incorporate Revised Total Maximum Daily Loads for Indicator Bacteria, Project I – Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek)", Resolution No. R9-2010-0001, February 2010

SDRWQCB, "Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds of the County of San Diego, the Incorporated Cities of San Diego County, the San Diego Unified Port District, and the San Diego County Regional Airport Authority", Order No. R9-2007-0001, January 2007

SDRWQCB, "Water Quality Control Plan for the San Diego Basin (9)" (Basin Plan), September 1994

Shumway, R.H., Azari, R.S., and Kayhanian, M. (2002). "Statistical Approaches to Estimating Mean Water Quality Concentrations with Detection Limits." Environ. Sci. Technol., 36: 3345-3353.

Singh, A.K., A. Singh, and M. Engelhardt, 1997. "The lognormal distribution in environmental applications." EPA Technology Support Center Issue, EPA 600-R-97-006

Weston Solutions, Receiving Waters and Urban Runoff Monitoring Reports, 2004-2011 sampling seasons.

Weston Solutions. 2007. Phase II San Diego River – Ocean Beach Water Quality Improvement Project Report. December

Weston Solutions. 2009. San Diego River Source Tracking Investigation – Phase 1, Final Report, Revision 1. December

Weston Solutions. 2009b. San Diego River Source Tracking Investigation – Phase II, Final Report Revision 1. Prepared for City of San Diego Storm Water Department. San Diego, CA.

* * * * *

Appendix C

Geosyntec consultants

3990 Old Town Avenue, Suite B-101
San Diego, CA 92110
PH 619.297.1530
www.geosyntec.com

Memorandum

Date: 14 November 2011

To: Todd Snyder, Scott Norris, County of San Diego

From: Christian Braun, Brandon Steets, Ken Susilo, Aklilu Tesfamichael, Geosyntec Consultants

Subject: San Luis Rey and San Diego River Watershed Comprehensive Load Reduction Plans – San Diego Land Use EMCs
Solicitation for Input from Stakeholders
County of San Diego Reference: Task Orders 5, 7, 9 and 11
Geosyntec Projects: LA0228.05, 07, 09 and 11

The San Luis Rey (SLR) and San Diego River (SDR) Watershed Comprehensive Load Reduction Plans (CLRP) will include source area assessment, BMP prioritization, and pollutant load modeling. The Strategic BMP Prioritization and Analysis Tool (SBPAT) is a model that is being used as part of this process. SBPAT relies on land use Event Mean Concentrations (EMCs) to estimate wet weather watershed loading using a Monte Carlo stochastic process, so that (log) distributional statistics are required for each land use (LU) - pollutant of concern (POC) combination (e.g., single family residential – bacteria). SBPAT contains a pre-populated default LU EMC dataset based on data from the Los Angeles region, however San Diego specific LU EMC data are available for augmenting this dataset and SLR and SDR stakeholders have expressed a preference to use San Diego EMC data wherever possible. This memo summarizes the San Diego LU EMC datasets and their log summary statistics for stakeholder review and approval.

I. San Diego County EMC Datasets

The San Diego County EMC datasets are compiled primarily from two sources:

- Two County of San Diego studies involving wet weather water quality sampling from rural residential, orchard, and single family residential LUs in SLR, SDR and Los Peñasquitos watersheds; and
- City of San Diego LU based stormwater quality monitoring programs for residential, commercial, industrial and municipal/education LUs in Los Peñasquitos and Pueblo San Diego watersheds.

The goal of the water quality monitoring studies was to collect wet weather LU runoff data to support regional source area pollutant concentration assessments. The stormwater monitoring programs were conducted between December-2009 and March-2010, and stormwater quality samples were collected and analyzed from a total of 16 stations capturing six LU categories including single family residential, rural residential, orchard, commercial, industrial and municipal/education. Individual sample results, drainage area descriptions, and information on sample collection procedures can be found in the County of San Diego and City of San Diego reports (*County of San Diego, Wet Weather Water Quality Sampling Report, 2009-2010. April 2011 and City of San Diego Projects titled Chollas and B Street-Broadway*).

The location of the monitoring stations and the major contributing watershed areas are shown in Figure 1 (see final page). Summary information of the monitoring sites is presented in Table 1.

Blossom Valley, Couser Canyon, Oceanside and Del Mar samples were collected as automated flow-weighted composite samples, or a composite of discrete aliquots that are collected at pre-defined intervals during each storm event, and analyzed as a single composite sample. The City of San Diego MS4 samples however were collected as discrete grab samples at approximately 15 minute intervals and analyzed individually by the lab; these results were subsequently mathematically composited through flow weighting calculations to create flow-weighted composite EMCs.

Table 1: County of San Diego Stormwater Quality Monitoring Sites Used in the EMC Evaluation

Site	Stat. ID	Watershed	Drainage Area (acres)	Primary Land Use	Percent Primary Land use	Month / Year	Sample Type	# of Samp-ling Events
Blossom Valley	--	San Diego River	185	Rural Residential	91%	Feb/Mar-2010	Flow Weighted Composite	2
Couser Canyon	--	San Luis Rey	1155	Orchards (avocado)	75%	Feb- 2010	Flow Weighted Composite	2
City of Del Mar	DM-SID-1	Los Peñasquitos	38	Single Family Residential	78%	Dec-2009 & Jan-2010	Composite	3
City of Oceanside	OC-SID-1	San Luis Rey	52	Single Family Residential	67%	Dec-2009 & Jan-2010	Composite	3
Tecolote Creek	CHR03	Los Peñasquitos	56	Single Family Residential [1]	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Tecolote Creek	CHR04	Los Peñasquitos	44	Single Family Residential [1]	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Mission San Diego	CHR06	San Diego River	31	Single Family Residential [1]	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2

Site	Stat. ID	Watershed	Drainage Area (acres)	Primary Land Use	Percent Primary Land use	Month / Year	Sample Type	# of Samp-ling Events
Chollas Creek	CHR10	Pueblo San Diego	7	Single Family Residential [1]	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Switzer Creek	DBR01	Pueblo San Diego	4	Single Family Residential [1]	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Mission San Diego	CHM05	San Diego River	5	Education [2]	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Switzer Creek	CHI08	Pueblo San Diego	6	Industrial	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Chollas Creek	CHI09	Pueblo San Diego	8	Industrial	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Chollas Creek	CHI11	Pueblo San Diego	4	Industrial	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Switzer Creek	CHC07	Pueblo San Diego	3	Commercial	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
Chollas Creek	CHC12	Pueblo San Diego	6	Commercial	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2
B St./ Broadway Piers	DBC02	Pueblo San Diego	5	Commercial	NA	Dec-2009 & Jan-2010	Flow Weighted Composite	2

[1] City of San Diego and TetraTech reported this as “residential” however we are assuming SFR based on review of the sampling location in Google earth.
[2] City of San Diego and TetraTech reported this as “municipal” however we are assuming education (school) based on review of the sampling location in Google earth and based on the local SANDAG LU classification.
NA = Not available.

Data Screening and Assumptions

The City of San Diego EMC database contains a large number of entries where the data were collected as grab samples at about 15 to 30 minute interval during selected storm events. The EMC samples were first screened by eliminating field blank (FB) and matrix spikes (MS) from the dataset. Field duplicates (FD) and laboratory replicates were averaged, and non-detects were replaced by one-half the method detection level (MDL). After the screening, EMC grab measurements were composited using a flow weighting method. Flow weighted composite EMCs are considered better parameters because they capture the storm-wide flow and pollutant concentration variability during the rise and fall of the storm hydrograph. If the flow weighted EMC of a storm event was less than MDL, the sample was considered non-detect, otherwise the sample was considered detected.

Combining datasets

Single family residential EMC datasets are available both in the city of San Diego (n=10) and the County of San Diego (n=6) for several pollutants including total suspended solids, total phosphorous, dissolved Cu, dissolved Zn and Fecal Coliform. The two datasets were combined to create a larger pool of 16 residential EMCs. The datasets were evaluated using population tests including Mann-Whitney and *t*-test to compare if they were significantly different. The tests showed that all the single family residential POCs that were sampled both in the City and County of San Diego are not statistically different at the alpha significance level of 0.05, with p-values ranging from 0.073 for Dissolved Zn and Fecal Coliform to 0.91 for TSS and Dissolved Cu. We also evaluated if both datasets arise from similar population distributions and were combinable using visual pointers such as inflection points, breaks and linearity on log probability plots. The probability plots of the combined datasets showed single populations with a fairly strong normal (TSS) or lognormal (TP, Dissolved Cu, Dissolved Zn and Fecal Coliform) background distribution indicating that the combined residential EMCs underlie a common population distribution. Based on this analysis, the SFR datasets were considered appropriate for combining because the probability plots of the combined datasets indicate that the data are similarly distributed while the tests indicate that they are not statistically different. The combined data are considered representative of the range of EMCs likely to be observed for the various SFR neighborhoods in the SLR and SDR watersheds.

The number of samples and percent non-detects for the default SBPAT and proposed San Diego EMCs are summarized in Table 2. As shown in the table, there are many more samples in the SBPAT default data sets (except for Fecal Coliform), but the percent non-detects are much higher.

Table 2: County of San Diego Stormwater Quality Monitoring Sites Used in the EMC Evaluation and SBPAT Default LA County Datasets

Land Use		TSS	TP	DP	NH3	NO3	TKN	Diss Cu	Tot Cu	Tot Pb	Diss Zn	Tot Zn	Fecal Col.
San Diego Region EMC Summary (2009-2010)													
Rural Residential[1]	Count	2	2	2	2	2	2	2	NA	2	2	NA	2
	% ND	0%	0%	0%	0%	0%	0%	0%	NA	0%	0%	NA	0%
Orchard[1]	Count	2	2	2	2	2	2	NA	NA	NA	NA	NA	2
	% ND	0%	0%	0%	0%	0%	0%	NA	NA	NA	NA	NA	0%
Single Family Residential[2]	Count	16	16	6	NA	6	6	16	10	10	16	10	16
	% ND	0%	0%	0%	NA	0%	0%	0%	0%	0%	0%	0%	0%
Commercial[3]	Count	6	6	NA	NA	NA	NA	6	6	6	6	6	6
	% ND	0%	0%	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%

Land Use		TSS	TP	DP	NH3	NO3	TKN	Diss Cu	Tot Cu	Tot Pb	Diss Zn	Tot Zn	Fecal Col.
Industrial[3]	Count	6	6	NA	NA	NA	NA	6	6	6	6	6	6
	% ND	0%	0%	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%
Municipal[3]	Count	2	2	NA	NA	NA	NA	2	2	2	2	2	2
	% ND	0%	0%	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%
Los Angeles Region Based Default SBPAT EMC Summary (1996-2001)													
Commercial[4]	Count	31	32	33	33	33	36	40	40	40	40	40	5
	% ND	0%	3%	3%	21%	21%	3%	15%	0%	45%	10%	0%	20%
Industrial[4]	Count	53	55	56	57	56	57	61	61	61	61	61	6
	% ND	0%	5%	9%	19%	5%	0%	15%	0%	43%	7%	0%	0%
Transportation[4]	Count	75	71	71	74	75	75	77	77	77	77	77	2
	% ND	0%	1%	4%	27%	20%	0%	1%	0%	52%	6%	0%	0%
Education[4]	Count	51	49	49	52	51	51	54	54	54	54	54	NA
	% ND	0%	0%	2%	35%	24%	0%	19%	0%	76%	39%	9%	NA
Multi-Family Residential[4]	Count	45	38	38	46	46	50	54	54	54	54	54	7
	% ND	2%	3%	3%	24%	26%	0%	37%	7%	72%	41%	9%	0%
Single Family Residential[4]	Count	41	42	42	44	43	46	48	48	48	48	48	4
	% ND	0%	0%	0%	16%	30%	0%	40%	4%	52%	81%	44%	0%
Agriculture (row crop)[5]	Count	20	18	18	21	19	17	18	21	21	21	21	5
	% ND	0%	0%	0%	0%	5%	0%	0%	0%	0%	10%	0%	0%
Vacant / Open Space[4]	Count	48	46	44	48	50	50	52	52	57	52	52	2
	% ND	2%	41%	57%	67%	2%	0%	90%	38%	88%	96%	77%	0%

[1] SD County land use monitoring data (*source: County of San Diego, Wet Weather Water Quality Sampling from Rural Residential, Rural, and Single Family Residential Land Uses, 2009-2010. April 2011*) (Blossom Canyon for rural residential and Couser Canyon for orchard) were used to estimate log means, while Los Angeles and Ventura County COVs were used to estimate log standard deviations. This "blended" approach (i.e., use of both San Diego and Los Angeles data to develop the San Diego EMC distributional statistics) was approved by SLR stakeholders and is described in the EMC memo dated August 31, 2011.

[2] Combination of SD County (Del Mar & Oceanside) and City of SD land use monitoring data were used to estimate log means, while Los Angeles County log COVs were used to estimate log standard deviations

[3] City of SD land use monitoring data (*City of San Diego Projects titled Chollas and B Street-Broadway*) were used to estimate log means, while Los Angeles County log COVs were used to estimate log standard deviations

[4] Based on Los Angeles County MS4 EMCs (*Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report. July 31, 2000.*), except for FC which are based on SCCWRP data (*Stein, E.D., Tiefenthaler, L.L., and Schiff, K.C., 2007. "Sources, Patterns and Mechanisms of Storm Water Pollutant Loading From Watersheds and Land Uses of the Greater Los Angeles Area, California, USA." Southern California Research Project (SCCWRP), Technical Report 510, March.*)

[5] Based on Ventura County MS4 EMCs (*Ventura County Flood Control District stormwater monitoring report, 1997-2003*), except for FC which are based on SCCWRP data

II. EMC Approach for San Diego County Land Uses

The number of samples available for San Diego County LU EMC evaluation ranges from 2 to 6 except single family residential with 6 to 16 samples (see Table 2).

The following describes the approach used to develop San Diego-specific LU EMCs for use in modeling the SDR and SLR Watersheds.

<u>SBPAT Default EMC Values</u>

SBPAT default EMC values are based on larger, more robust Southern California LU stormwater monitoring datasets from Los Angeles (LA) County, Ventura County, and Southern California Coastal Water Research Program (SCCWRP) (typically with sample sizes from 20-50[1] for the LA and Ventura County data, and covering multiple monitoring seasons and storm sizes). However, these datasets, while larger and tested, may be less representative of San Diego County land uses than smaller local datasets. For example, the single family residential (SFR) land use dataset from LA County was obtained from one SFR subcatchment in the City of Glendale in the San Fernando Valley. The LA County SFR land use monitoring station (which is used for all SBPAT SFR EMCs with the exception of fecal coliform) does not include any rural residential areas, such as those found in the SLR watershed; however, the SCCWRP low density residential land use monitoring station, which is used for the SBPAT SFR fecal coliform EMCs, does include some rural residential land use in its drainage area.

<u>San Diego County Specific EMC Values</u>

Alternatively, very small to medium (samples sizes from 2 to 16) but locally representative EMC datasets are available for rural residential, orchard, SFR, commercial, industrial and municipal land uses based on stormwater monitoring data from unincorporated San Diego County, and the cities of San Diego, Oceanside, and Del Mar. These data may better represent runoff quality from San Diego area land uses and it may be appropriate to perform reasonable summary statistics using 6 samples or more. However, a closer look at the specifics of the sampling location drainage areas and span of time over which the samples were collected shows that the San Diego County EMC datasets are based on fewer storms and smaller drainage areas (and

---

[1] The exception is the SCCWRP-based Fecal Coliform EMCs which are based on smaller datasets (n = 2 to 7 per land use).

therefore a smaller diversity of sites within each LU category) but multiple monitoring sites within each LU category. Additionally, the samples were collected over a three month period of time within a single season, and therefore may not adequately capture the full variability across multiple storm sizes, antecedent conditions, and wet seasons. Moreover, some of the LUs including commercial, industrial and municipal do not have EMCs for a complete list of SBPAT pollutants. Many of the datasets also have small sample sizes and it is highly unlikely that they represent the true spread of the underlying populations (see Table 1).

Blended SBPAT and San Diego County Data Sets

As a blend of these two EMC values, Geosyntec developed San Diego County-specific EMCs based on stormwater monitoring data collected in the aforementioned studies by 1) the City of San Diego, and 2) the County of San Diego and the Copermittees of the San Diego Municipal Stormwater Permit. The mean statistics were evaluated using San Diego County datasets, but in order to capture variability and spread the standard deviation statistics were also evaluated using the coefficients of variation (COV = standard deviations divided by the means) from the LA County SBPAT default datasets.

For POCs where no San Diego County specific EMC data are available, SBPAT default EMC statistics were used.

Stormwater quality datasets often follow positively skewed population distributions that may be represented by the lognormal distribution (with few exceptions that better fit the normal distribution). In this evaluation, all land use EMC datasets were assumed to follow a log-normal distribution. This assumption is discussed in more detail in the SBPAT technical appendices which can be downloaded at www.sbpat.net.

The proposed EMC distributional statistics for use in the SLR and SDR CLRPs are summarized in Table 3. These are log distributional statistics that are shown here in arithmetic space for ease of review (i.e., they are converted from log space values). There were no San Diego EMC data for transportation, multi-family residential, agriculture (non-orchard), and open space land uses, and therefore SBPAT default EMC statistics are used for these LUs.

Geosyntec consultants

3990 Old Town Avenue, Suite B-101
San Diego, CA 92110
PH 619.297.1530
www.geosyntec.com

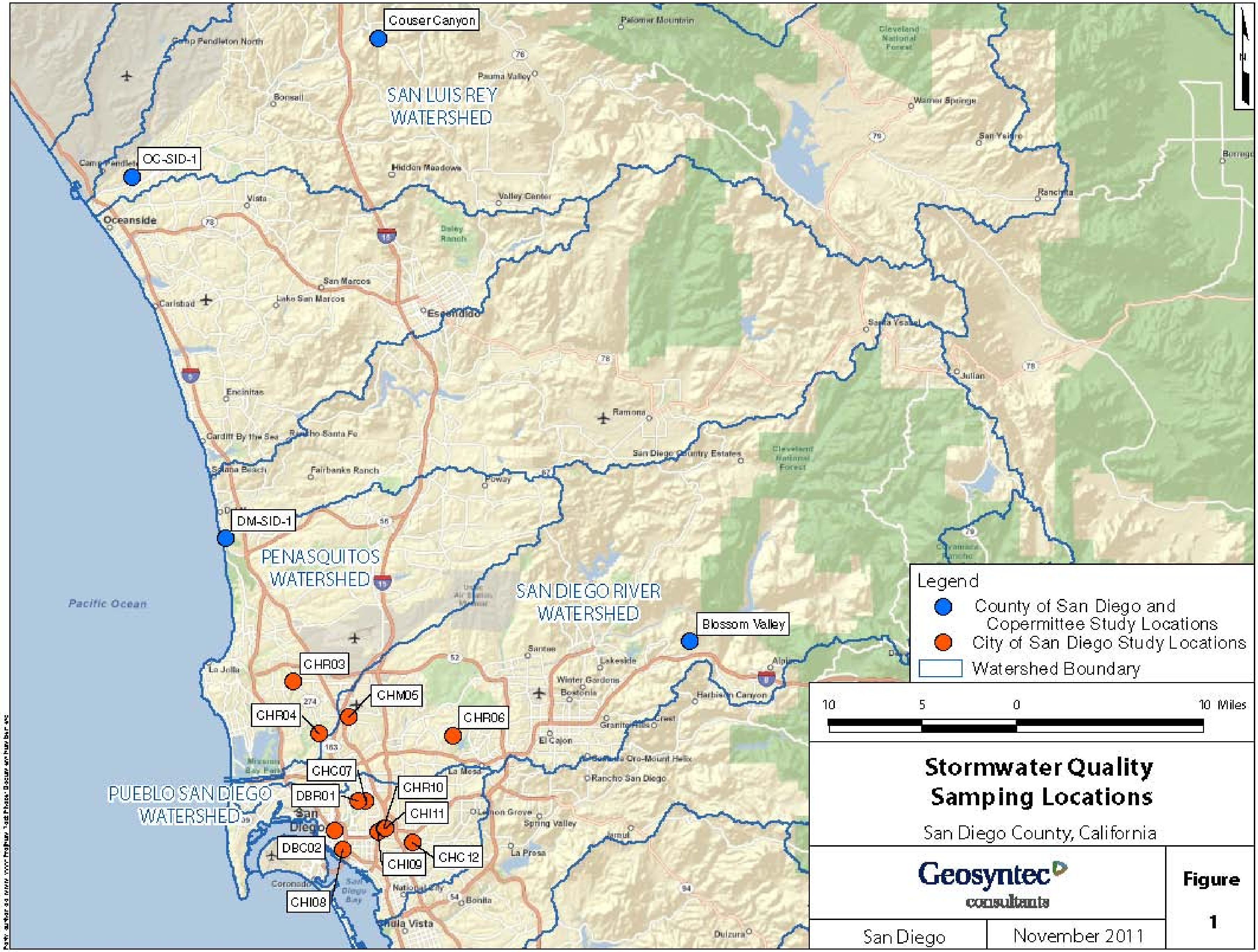
Table 3: Proposed SBPAT EMCs for SLR and SDR Watersheds – Arithmetic Estimates of the Lognormal Summary Statistics (means with standard deviations in parentheses)

Land Use	TSS	TP	DP	NH3	NO3	TKN	Diss Cu	Tot Cu	Tot Pb	Diss Zn	Tot Zn	Fecal Col.
Rural Residential	2,523.76 (3,757.19)	1.59 (1.19)	0.12 (0.08)	0.11 (0.14)	1.50 (3.40)	2.65 (2.45)	4.20 (4.02)	8.36 (5.99)[1]	21.38 (31.41)	14.99 (30.63)	39.19 (34.01)[1]	6,684 (20,245)
Orchard	252.64 (163.89)	0.36 (0.16)	0.13 (0.10)	0.04 (0.04)	26.11 (88.27)	2.31 (1.09)	22.50 (17.50)	100.10 (74.8)	30.20 (34.30)	40.10 (49.10)	274.80 (147.30)	1,344 (3,410)
Single Family Residential	123.41 (183.72)	0.49 (0.37)	0.45 (0.29)	0.49 (0.64)	1.58 (3.59)	2.51 (2.33)	11.42 (10.93)	25.96 (18.6)	13.03 (19.15)	50.02 (102.22)	153.29 (133.04)	35,557 (107,700)
Commercial	127.68 (89.75)	0.32 (0.27)	0.29 (0.25)	1.21 (4.18)	0.55 (0.55)	3.44 (4.78)	16.62 (13.78)	54.84 (44.88)	14.40 (39.60)	224.40 (140.58)	483.7 (306.62)	791 (22,846)
Industrial	125.18 (118.15)	0.45 (0.47)	0.26 (0.25)	0.6 (0.95)	0.87 (0.96)	2.87 (2.33)	21.35 (20.78)	53.54 (56.95)	20.52 (58.92)	214.58 (271.47)	428.39 (388.85)	26,703 (34,515)
Education (Municipal)	132.11 (162.75)	0.46 (0.26)	0.26 (0.2)	0.4 (0.99)	0.61 (0.67)	1.71 (1.13)	5.58 (5.03)	12.02 (8.21)	7.43 (10.11)	73.13 (50.73)	174.1 (123.02)	2,148 (6,506)[2]
Transportation	77.80 (83.80)	0.68 (0.94)	0.56 (0.82)	0.37 (0.68)	0.74 (1.05)	1.84 (1.44)	32.40 (25.5)	52.20 (37.5)	9.20 (14.5)	222 (201.7)	292.90 (215.8)	1,680 (456)
Multi-family Residential	39.90 (51.3)	0.23 (0.21)	0.20 (0.19)	0.50 (0.74)	1.51 (3.06)	1.80 (1.24)	7.40 (5.70)	12.10 (5.60)	4.50 (7.80)	77.5 (84.1)	125.10 (101.10)	11,800 (23,700)
Agriculture (row crop)	999.2 (648.2)	3.34 (1.53)	1.41 (1.04)	1.65 (1.67)	34.40 (116.30)	7.32 (3.44)	22.50 (17.50)	100.10 (74.8)	30.20 (34.3)	40.10 (49.10)	274.80 (147.30)	60,300 (153,000)
Vacant / Open Space	216.60 (1482.8)	0.12 (0.31)	0.09 (0.27)	0.11 (0.25)	1.17 (0.79)	0.96 (0.9)	0.60 (1.90)	10.60 (24.4)	3.00 (13.10)	28.10 (12.90)	26.30 (69.50)	6,310 (1,310)

[1] SBPAT default SFR dissolved:total concentration ratio was applied to the Blossom Valley dissolved mean value to estimate Blossom Valley total mean value

[2] FC EMC COV is based on SFR SCCWRP datasets

Mean EMCs in shaded area are based on LA region default SBPAT datasets due to a lack of available San Diego data.



Couser Canyon
SAN LUIS REY WATERSHED
OC-SID-1
PENASQUITOS WATERSHED
DM-SID-1
SAN DIEGO RIVER WATERSHED
Blossom Valley
PUEBLO SAN DIEGO WATERSHED
CHR03
CHM05
CHR04
CHR06
CHC07
DBR01
CHR10
CHI11
DBC02
CHI09
CHC12
CHI08
Pacific Ocean
Oceanside
Carlsbad
Escondido
Encinitas
Vista
San Marcos
Ramona
Julian
Poway
La Jolla
El Cajon
Santee
Lakeside
La Mesa
Spring Valley
National City
Chula Vista
Coronado
Legend
County of San Diego and Copermittee Study Locations
City of San Diego Study Locations
Watershed Boundary
10 5 0 10 Miles
Stormwater Quality Samping Locations
San Diego County, California
Geosyntec consultants
Figure 1
San Diego
November 2011

Appendix D

Memorandum

Date: 07 June 2012

To: Todd Snyder, Scott Norris, County of San Diego

From: Rachel T. Noble, Ph. D

Subject: San Luis Rey Watershed Comprehensive Load Reduction Plan
Data Review Memo
County of San Diego Reference: Task Order 9
Geosyntec Project No. LA0228.09

1.0 INTRODUCTION

1.1 Purpose

The purpose of this technical memorandum is to support the San Luis Rey (SLR) and San Diego River (SDR) bacteria TMDL Combined Load Reduction Plans (CLRPs) for the MS4 co-permittees by providing technical information to support:

1. The estimation of a percentage ranges of dry and wet weather instream indicator bacteria that are from human fecal sources (e.g., homeless and leaking sewers), for use in estimating non-structural Best Management Practices (BMP) load reductions, based on the interpretation of available historical data and knowledge of the watersheds; and
2. Guidance on the selection and scoping of special studies to support CLRP implementation planning and TMDL reopener efforts.

1.2 Terms of Reference

The work described in this memorandum was conducted by Rachel Noble, Ph. D for the County of San Diego for the San Luis Rey Watershed Comprehensive Load Reduction Plan, Task Order 9, Geosyntec Project No. LA0228.09, as well as the San Diego River Watershed Comprehensive Load Reduction Plan, Geosyntec Project No. La0228.07. Geosyntec staff provided a review for consistency with CLRP objectives.

2.0 MICROBIAL SOURCE TRACKING METHODS

Microbial source tracking (MST) is the use of microbial markers (including bacteriophage, bacteria, viruses, protozoans, etc.) to determine the type of fecal pollution present in an aquatic system based upon source (i.e., human, pet, livestock). The MST field continues to advance rapidly and much that has been published ten years ago is now obsolete. In recent years, there has been a dramatic movement away from library-based methods (such as fingerprinting) and toward truly quantitative molecular methods for a range of markers of specific types of contamination, often incorporating the use of Quantitative PCR (QPCR). There currently does not exist a specific widely-accepted approach for calculating the percent human contribution in a watershed. Towards this end, a recent Source Identification Pilot Project (SCCWRP, 2012) funded by the State of CA involves study of a range of molecular source tracking methods, with major goals of assessing methods across a range of fecal source types and standardization of methods for users. A SIPP study endproduct will be a manual of standardized protocols and approaches, many of which that are likely to be directly applicable to work in the San Diego region.

Previous work has been conducted in Los Angeles, CA (Noble et al. 2006) and Oceanside, CA using a tier of Bacteroidales based markers as the foundation of MST. The tiered approach relied on quantification of Fecal Bacteroides spp. (Converse et al. 2009), BacHum (Kildare et al. 2007), and HF183 (Seurinck et al. 2005), to characterize and quantify the presence of human fecal contamination. Enterovirus quantification (Gregory et al. 2006) and community analysis were also conducted with limited results. The tier of Bacteroidales assays chosen were selected because they are highly sensitive, the target bacteria that are enumerated have been shown to be a predictor of human health (Wade et al. 2010), and the assays follow a gradient of sensitivity and specificity; Fecal *Bacteroides* spp. is the most sensitive (found ubiquitously in high concentrations in human feces), but is also the least specific (can be found at low concentrations in other types of animal feces), whereas the HF183 marker is relatively difficult to find and exists at much lower concentrations, but is known to be highly specific for human fecal contamination (94-99% ability to discriminate between animal and human feces). The BacHum marker's specificity and sensitivity is between that of the Fecal Bacteroides spp. and the HF183 marker. It is more specifically associated with human fecal contamination than the Fecal *Bacteroides* spp., but less specific than HF183 (previous studies have noted a 82-96% ability to discriminate between human and animal feces). The BacHum marker tends to be found in concentrations that are higher than those of HF183 in sewage influent, but lower than the concentrations of Fecal *Bacteroides* spp.. It should be noted that relationships exist between Fecal *Bacteroides* spp. concentrations and adverse human health outcomes as measured during epidemiology studies (e.g. Wade et al. 2010). Similar relationships have been observed, of course, with the fecal indicator bacteria group, Enterococcus spp., creating a theoretical linkage among the populations. This type of epidemiological study has not been conducted, however, in the coastal waters of the San Luis Rey or San Diego Rivers, so it is not known whether these relationships exist there. This trio of fully quantitative QPCR-based assays are being used in an array of studies in stormwater contaminated areas across the country with success, and can be used to both identify hot spots of human fecal contamination and predict the presence and concentration of human-specific fecal pollution (Converse et al., 2009).

3.0 SUMMARY OF RECENT SLR AND SDR MST STUDIES

Previous MST conducted in the City of Oceanside portion of lower SLR River has indicated the presence of human fecal contamination during both dry and wet weather (MACTEC, 2012). During dry weather, human fecal contamination was noted primarily in the River Mouth areas. During wet weather, the River Mouth again showed evidence of human fecal contamination, in addition to upstream locations such as Douglas Bridge, Pilgrim Creek, and the site noted as "Critical Point".

In the SDR watershed, only presence/absence information is available for human fecal contamination as found at sampling locations during dry and wet weather. The QPCR methods utilized in a recent study of the San Diego Watershed (Weston 2010) did not include full quantification of the *Bacteroides* based markers. In stormwater and creek/river samples, it is vital that assessments of inhibition are made on the success of the QPCR. Naturally found compounds, such as humic and fulvic acids, and other high molecular weight compounds found in decaying plant litter, sediment and silt, can severely inhibit the QPCR success. In these types of samples, quantification of inhibition is necessary to rule out false negatives, i.e. negative results for QPCR that were simply the result of inadequate primer binding, polymerase function, or dNTP or other chemical availability. Previous work in the Tijuana River and other small coastal creeks and rivers in San Diego County have reported the presence of human fecal contamination during dry weather in most of the creeks and rivers of the South Bay in the past decade (Jiang et al. 2001, Noble et al. 2001). Jiang et al. (2001) specifically noted the need to conduct an extensive additional Guanidine Thioisocyanate extraction step on the samples from San Diego River in the 2001 work. Of a serial dilution of 6 decreasing concentrations of samples spiked with adenovirus from the San Diego River, only the highest two concentrations of adenovirus spike resulted in a measurable result by nested PCR (Jiang et al. 2001). While this study is nearly a decade removed from the study conducted in the San Diego River in 2009, it clearly documents the need to use spiking or specimen processing control based protocols to assess inhibition in both QPCR and PCR reactions when working in stormwater environments in southern California.

Work conducted by Weston, Inc. during 2009 for *Bacteroides* based source tracking in the SDR revealed no quantified human fecal contamination during dry weather. There is no data presented or indication of procedures conducted (such as spiking samples with known amounts of *Bacteroides*) to assess inhibition (false negative results). Therefore, it is difficult to interpret the findings presented in the report for dry weather. During wet weather in the SDR, two locations were identified as being contaminated with human fecal contamination. There were also no estimates of loading or flux presented for the *Bacteroides* based markers. Because no assessment of inhibition was made during the studies conducted on the SDR Watershed, results from the SLR watershed are being extrapolated given the locational and geographic similarities, as well as the similar types of expected sources of fecal contamination (homeless populations, illicit connections/discharges, aging infrastructure, to name a few). While extrapolations from watershed to watershed are difficult to make, the similarities in likely sources and the greater urbanization and levels of impervious surface coverage within the SDR watershed make this extrapolation conservative in nature..

4.0 HUMAN SOURCE ALLOCATION IN THE SAN LUIS REY AND SAN DIEGO RIVERS

4.1 Limitations

Calculating a percent of indicator bacteria in surface water samples that are derived from human fecal sources is not a simple task, especially when considering markers that are measured using a range of methods (culture-based versus molecular), and the natural variability observed in the native populations of organisms found in the guts of warm-blooded animals, the range of persistence characteristics observed across markers (e.g. Noble et al. 2003, Seurinck et al. 2005), natural processes such as settling/sinking of bacteria attached to particles, the impact of sunlight and temperature, and dilution and mixing. There are extremely high levels of variability observed in molecular marker concentrations across humans, sewage, and septic system sample types. Concentrations of molecular markers of the *Bacteroidales* are often highest in sewage influent, which is an integration of samples collected across a broad population. At this time, the science to link the *Bacteroidales* based molecular marker quantities to their respective FIB concentrations observed for Enterococcus and E. coli is not available. Correlations exist between the anaerobic *Bacteroidales* and the gram-positive *Enterococcus* sp. in human feces and sewage influent. That is, the populations are coupled. When material is discharged in the environment, however, the physiological differences begin to expand, with observations of contrasting persistence and behavior in receiving water environments, often with *Enterococcus* sp. outlasting members of the *Bacteroidales* in real world conditions (e.g. Balleste and Blanch, 2010, Green et al. 2011, Cao et al. 2012). The bottom line is that the FIB concentrations rarely are correlated to *Bacteroides* based marker concentrations in recreational waters. If the populations are significantly correlated, then it has been postulated that changes in the flux of the populations can be used with a series of source specific markers to imply contributions from different sources (Kinzelman et al. 2011). Some of the host-specific markers have been used to develop real-time quantitative PCR (qPCR) methods for determining the concentrations of host-specific bacterial

DNA in environmental samples. qPCR has been used to measure the concentrations of a range of microbial targets, including members of the *Bacteroidales* (e.g. Kildare et al. 2007), *Escherichia coli* and *Enterococcus* (e.g. Noble et. al. 2010). However, it still remains that the relative contributions from sources of fecal contamination cannot be calculated based upon the quantities of FIB measured, that is, it is difficult to extrapolate the quantitative information produced by qPCR across Bacteroidales based (or other MST) markers to the FIB bacterial concentrations that are the subject of monitoring and compliance actions (Santo Domingo, 2007). Some extrapolation can be made using Bacteroidales based quantifications, given that they are a significant portion of the bacteria found in the human gut (Van Tongerent et al. 2005). Kinzelman et al. (2011) suggested that assuming the users understand the limitations and caveats associated with linking FIB concentrations to MST marker concentrations for management purposes, these caveats should not detract from use as exploratory tools for water quality management.

Therefore, knowing the caveats, some calculations can be made to estimate the range of percentages of human fecal contamination in water samples. During dry weather in the San Luis Rey Watershed, concentrations of the Fecal Bacteroides sp. marker as published by Converse et al. (2009) ranged from 1.6×10^6 to 1.6×10^8 cells/100 ml. The highest concentrations of the Fecal *Bacteroides* sp. marker that were quantified alongside the human specific HF183 *Bacteroides* based marker were from River Mouth sampling locations, indicating the presence of human fecal contamination. In all of the samples, the accompanying *Enterococcus* concentration determined was relatively low (<100 CFU/100 ml). For example, Converse et al. (2009) presented concentrations of Fecal Bacteroides spp. per 100 ml of human sewage influent of 1×10^9 – using this value alone the highest percentage represented in real-world samples collected in the River Mouth of the San Luis Rey would be roughly 10%. Srnivasan et al. (2011) reported concentrations of the Fecal Bacteroides spp. marker in raw sewage of roughly 10^7 copies/100 ml, making the estimated values of human fecal contribution during dry weather roughly 10% based upon our observed data. Using the lower range of values reported in the literature, a value of 0.5-1% would be calculated for the Fecal *Bacteroides* spp. marker. HF183 marker is known to be more specific to human fecal contamination than the BacHum marker, for which more cross reactivity has been observed with other animal species. Using values extrapolated from curves presented by Green et al. (2011) for sewage influent seeded water samples at the beginning of their experiment, the concentration of the HF183 marker observed was roughly $4\text{-}5 \times 10^5$ copies/100 ml. Other experiments conducted by Van De Werfhorst et al. (2011) with the HF183 marker have presented mean concentrations in sewage influent of 8.6×10^7 copies/100 ml, 2 orders of magnitude higher than those presented by Green et al. (2011). We observed mean concentrations during dry weather in the San Luis Rey River Mouth sampling locations of roughly 3×10^4 per 100 ml equating to roughly 1-10% human fecal contamination as determined by the HF183 marker when combining information from the publications mentioned. However, inhibition of the qPCR was noted in several of these real world analyses, making the quantification of HF183 likely a conservative estimate. Silkie et al. 2009 estimated concentrations of the BacHum marker at 10^8 copies/100 ml sewage, with relatively low percentages of *Enterococcus* sp. calculated per *Bacteroides* marker concentration (1-2%). Silkie et al. 2009 also reported a very high percentage of the BacHum marker to total Bacteroidales marker, at 82%. This value has ranged in previous studies from 2-100% for sewage samples as observed by Layton et al. (2006) and Kildare et al. (2007). Others have reported BacHum concentrations that are lower in human sewage, ranging from 10^5 - 10^7 copies/100 ml (California based samples, VA based samples, unpublished data). Based upon the range of available published data for concentrations of the BacHum marker in human feces, and the data collected during the dry weather portion of the SLR Study, the range of human fecal contamination present based solely upon the BacHum marker would be roughly 0.1-10%. Using all of the markers together to create an estimate of the percentage of human fecal contamination based upon marker concentrations, the estimate would be 1-10% human contribution during dry weather. This is a speculated value using the best possible published information, and further specific studies to attribute human fecal contamination to either individuals or integrated sewage contamination will be necessary to formalize this number, along with ongoing source identification and quantification studies and microbial risk assessments being conducted by the Southern California Coastal Water Research Project and collaborators (SIPP Study, 2012, QMRA Study, 2012).

During wet weather in the San Luis Rey River watershed, concentrations of Bacteroidales based markers, as described previously, were generally significantly higher than those during dry weather. Generally, concentrations of the Fecal Bacteroides spp. when extrapolated in relation to published concentrations of Fecal Bacteroides spp. in raw sewage, could be used to estimate the percentage human fecal contamination at 1-5%, whereas HF183 concentration based estimates would range from roughly 1-50%. Examining the data in a slightly different light, the calculated average concentration of the BacHum marker for the whole system during the second storm sampled was 1×10^5 copies/100 ml, equating to 1-100% of human fecal contamination based solely upon this marker and considering only reported BacHum concentrations from sewage and human samples. *Enterococcus* concentrations were also an order of magnitude higher throughout the SLR during wet weather, indicating both that the system was experiencing increased microbial contaminant contributions, and that loading of materials to the open ocean was dramatically increased during this period. During wet weather, human pathogenic enteroviruses were also quantified in one sample from the River Mouth area, with a relatively high concentration reported, further confirming the presence of human fecal contamination during wet weather. Previously published concentrations of enterovirus in sewage samples ranges from 200-242,500 PFU per liter, based upon cell culture quantification (Dahling et al. 1989). The value for the single positive result observed in the River Mouth during wet weather in the San Luis Rey River is within this reported range (9.8 x 10^3 PFU/100 ml). According to values reported in Ballona Creek, CA water samples by Gregory et al. 2006, this value observed in the San Luis Rey River was on the higher end of the spectrum. Based upon quantification of molecular markers, but still considering the lack of science to link source attributions, it can be reasonably estimated that the molecular markers indicate a human fecal contribution during wet weather of 5-20%. It has been previously noted that source attributions may be possible where FIB concentrations correlate to molecular marker concentrations, thereby permitting assessments during periods of contamination. For the SLR study, there is a relatively small sample size, but a significant relationship between the HF183 human specific marker and *E. coli* concentrations has been noted. This relationship may be important in the future for assessment of the relative rates of change of these populations over the course of a contamination event. Further study of the system is necessary to verify these attributions empirically through the use of the approach published by Kinzelman et al. 2011.

5.0 RECOMMENDED SPECIAL STUDIES

5.1 <u>Fecal Indicator Bacteria/Pathogen Contribution to Surface Waters from Septic Systems</u>

Septic systems are widely used across rural residential areas such as those found in the SLR watershed. Previous studies have suggested that wastewater leaking from failing septic systems, and even from successfully functioning septic during periods of high surface runoff could potentially represent a significant source of loading of microbial contaminants to receiving waters, and therefore a public health risk to those using nearby contaminated waters for recreation (Lipp et al. 2001). Even though a completely different environment from southern California, the speed with which septic related microbial contamination can travel was illustrated well through a study in the Florida Keys that used viral tracers to demonstrate that viral pathogens can travel from septic systems to nearby coastal surface and groundwater over short time periods (Paul et al. 2000). Bacteriophages (viruses) seeded into septic tanks in Boot Key Harbor were detected in adjacent canals within a few hours time (3 hr and 15 min). Under local conditions, bacteriophages had migrated at rates that ranged from 1.7 m hr^{-1} to an astounding 57.5 m hr^{-1}. Similarly, other studies (e.g., Scandura and Sobsey 1997; DeBorde 1998) employed viral tracers to show that septic systems can contribute viral pollutants to receiving waters.

Potential microbial contamination to nearby waters from septic systems can be exacerbated both during and after storm events, when the groundwater levels are still rising and impacted by upstream flow storm events (Conn et al. 2012). Studies on microbial contamination from septic systems have not been conducted within the SLR watershed, and for a range of reasons, many of the already published studies cited for septic system assessments are not directly applicable to this region. Temperature, precipitation, solar radiation, and soil types affect the treatment of microbial pathogens in septic systems due to sorption, predation and die-off in the soil (Sobsey et al. 1980; Crane and Moore 1986; Scandura and Sobsey 1997; Meschke and Sobsey 1998; Chu et al. 2003). The goal of this study will be to determine the bacterial contribution of septic systems to SLR during summer-dry, winter-dry, and wet weather periods. It is assumed that this study will be conducted using MST molecular marker approaches using an informed placement of upstream and downstream sampling locations to assess septic systems in the upper reaches of the SLR. During this study, it will be vital to assess the function of septic systems during both dry weather and wet weather, using human specific source markers that have been verified to be present in distribution box material from these specific septic systems, and to conduct flux assessments of septic system contributions over the course of storms. Previously published approaches like that by Conn et al. (2012), combining molecular, culture-based, and dye based approaches to study fate and transport may be particularly useful. If septic systems can be ruled out as a significant contributor of the microbial contaminants to the SLR River, increased focus can be placed on other human sources such as instream homeless and sources to/within the MS4s. The data gathered in this study will be critical in establishing more precise criteria for successfully functioning septic systems in the SLR WMA, permitting more accurate definition of important parameters, including the setback distance recommended for the systems, the persistence and travel time of the contaminants through the systems and the unsaturated zone of the absorption field to the surrounding water bodies. If desired, the data can be incorporated into models of fate and transport of fecal contamination developed for TMDL implementation.

5.2 <u>MS4 Bacteria and Human Fecal Source Investigation</u>

This study will build upon previously conducted work in the SLR watershed by the City and Oceanside/MACTEC (MACTEC 2012). It is anticipated that this study would begin with development of GIS geodatabases of the MS4s and sewage collection systems including information such as pipe elevations, types and ages. Additional on the ground field assessments of potential sources of contamination will be made. MST source quantification will be conducted, but with this application the rapidity of the methods will be used to a direct advantage. That is, most source tracking studies currently conducted rely on batch analysis of molecular markers. This study will incorporate the rapid methods used "on the ground", that is during specific focused periods, sanitary survey type field work will be conducted to quantify and verify specific sources of contamination, through continued work upstream until sources are specifically found. To do this appropriately, a large expenditure on detailed, frequent FIB measurements to guide the selection of a subset of locations, all combined with flow assessments, will be necessary. The study design will include attention to Minimum Information for Publication of Quantitative Real-Time PCR Experiments (MIQE) guidelines for QPCR, and special attention to inhibition issues including a range of quality assurance and quality control steps to deliver fully quantitative data. Note: Given previous success in mid Atlantic source tracking studies of a similar nature, it may be of interest to use Human Polyoma Virus as a marker for human specific contamination, along with sequence analysis, which may permit discrimination between sewage, septic, and homeless population fecal samples. Human polyomavirus (HPyV) quantification, reported by McQuaig et al. (2009) has been successfully used in the Hampton Roads, VA region to assist in the confirmation of human fecal contamination, in combination with the use of the previously specified trio of Bacteroidales based markers. These viruses are double-stranded DNA viruses frequently isolated from the urine, and in some cases feces, of both healthy and immunocompromised individuals (Zhong et al. 2007; Bialasiewicz et al. 2009). It has been suggested that HpyVs are spread via the urine-oral route (Kunitake et al. 1995; Bofill-Mas et al. 2001), and therefore they are considered a "non-traditional enteric virus".

5.3 Other Non-Structural BMP Pilot Project Monitoring Studies or Non-Human Anthropogenic Source Studies

To assess the success of non-structural BMPs that target non-human anthropogenic bacteria sources such as dogs and horses, it may be necessary to conduct additional MST in the SLR and SDR watersheds. This study may include multiple source marker types (not just focusing on humans), with some specific attention paid to potential contributions by seagulls (already noted as an ephemeral input to the SLR during previous studies), dogs and horses. Quantification over seasons and during dry and wet weather periods will permit formal assessment of the efficacy of non-structural BMPs.

5.4 Site Specific REC-1 Objective Study

If pursued, the goal of this study will be to conduct a state of the art study to investigate the alteration of existing reference-based TMDL waste load allocation given microbial risk assessments that demonstrate that illness rates for recreational users are below EPA's acceptable risk levels. The best way to do this will be to formally understand transport and delivery of FIB and microbial contaminants (here human pathogenic virus quantification will be vital, as these are the causative agents for a majority of recreational water-borne disease) over the course of both dry and wet weather epidemiological studies or QMRA based studies. Ongoing work in Ventura County in the coming year (2012) will provide vital information on this approach, as the science is currently being developed for this type of approach. It may be possible to use a budgeting approach like that presented by Noble et al. (2006) which was conducted in a highly urbanized watershed comprising most of the populated area that is west of downtown Los Angeles and at about 85% impervious surface coverage. The researchers used a tiered approach combining a mass-based design at six mainstem sites and four major tributaries was used to quantify the flux of enterococcus and E. coli by measurements using culture-based FIB methods and simultaneous assessments of flow. The three tiers were (1) spatially and temporally rich FIB analysis, (2) analysis for human specific Bacteroides markers and (3) and human pathogenic enterovirus quantification by QPCR and genetic sequence analysis. Sources and concentrations of FIB were ubiquitously high throughout Ballona Creek and no single tributary appeared to dominate the fecal inputs. The flux of enterococcus and E. coli averaged 10^9 to 10^{10} cells per hour and were as high at the head of watershed as they were at the mouth prior to its discharge into SMB. Using this type of approach, it will be possible to quantify and model the fate and transport of material from the SLR across the beaches of Oceanside during both dry and wet weather. A similar study design could be implemented in the San Luis Rey River with full flow measurements made and upstream and downstream sites designed specifically to capture inputs from 1) homeless encampments, 2) septic systems, and 3) sewage systems. Pathogen quantification can be conducted to assess the relative associated risk with discharge from the SLR.

Assuming success of the implemented human fecal contamination control measures, microbial source tracking work during the REC-1 study will also need to focus more on other sources of fecal contamination, i.e. animal fecal contamination. If human sources are effectively eliminated, then an application for natural source exclusion would be a main focus of the study, that is, it will be vital to quantify specific animal fecal contamination sources and to assess the potential human health risk stemming from each, along with concominant studies for the potential of reservoir populations of FIB to exist in the natural environments of each watershed.

6.0 REFERENCES

Ahmed, W., A. Goonetilleke, D. Powell and T. Gardner. 2009. Evaluation of multiple sewage-associated Bacteroides PCR markers for sewage pollution tracking. Water Research 43(19):4872-4877.

Balleste, E., and A. R. Blanch. 2010. Persistence of *Bacteroides* Species Populations in a River as Measured by Molecular and Culture Techniques. Appl. Environ. Microbiol. 76 (22): 7608-7616.

Bernhard, A.E. and K. G. Field. 2000. A PCR assay to discriminate human and ruminant feces on the basis of host differences in Bacteroides-Prevotella genes encoding 16S rRNA. Applied and environmental microbiology. 66(10):4571-4574.

Converse, R. R., Griffith, J. F. and R. T. Noble. 2009. Rapid QPCR-Based Assays for Fecal Bacteroides and Enterococcus Speciation as Tools for Assessing Fecal Contamination in Recreational Waters. Journal of Water Research. 43(19):4828-37.

Converse, R. R. Bridging the Gap between Molecular and Traditional Assessments of Recreational Water Quality. 2009. PhD Dissertation. University of North Carolina at Chapel Hill, UNC Press, Chapel Hill, North Carolina.

Dahling, D. R., Safferman, R. S., and Wright, B. A. 1989. Isolation of Enterovirus and Reovirus from Sewage and Treated Effluents in Selected Puerto Rican Communities. Appl. Environ. Microbiol. 55 (2):503-506.

Fong, Theng-Theng, Griffin, Dale W. and E. K. Lipp. 2005. Molecular Assays for Targeting Human and Bovine Enteric Viruses in Coastal Waters and Their Application for Library-Independent Source Tracking. Appl. Environ. Microbiol. 71: 2070-2078.

Fong, T. T. and E. K. Lipp. 2005. Enteric viruses of humans and animals in aquatic environments: Health risks, detection and potential water quality assessment tools. Microbiology and Molecular Biology Reviews.69:357.

Fuhrman, J.A., Liang, X. and R. T. Noble. 2005. Rapid detection of enteroviruses from small volumes of natural waters by real time RT-PCR. Appl. Environ. Microbiol. 71 (8):4523-4530.

Green, H. C., Shanks, O. C., Sivaganesan, M., Haugland, R. A., and K. G. Field. 2011. Differential decay of human faecal *Bacteroides* in marine and freshwater. Environmental Microbiology. 13(12):3235–3249

Gregory, J. B., Litaker, W. A. and R. T. Noble. 2006. A Rapid One-Step Quantitative Reverse Transcriptase PCR Assay for Enterovirus with a Competitive Internal Positive Control. Applied and Environmental Microbiology. 72 (6): 3960-3967.

Griffith, J. F., Weisberg, S. B. and C. D. McGee. 2003. Evaluation of microbial source tracking methods using mixed fecal sources in aqueous test samples. J. Water Health. 01:141-151.

Kildare, B.J., C.M. Leutenegger, B.S. McSwain, D.G. Bambic, V.B. Rajal and S. Wuertz. 2007. 16S rRNA-based assays for quantitative detection of universal, human-, cow- and dog-specific fecal Bacteroidales: a Bayesian approach. Water Research. 41(16):3701–3715.

MACTEC, Noble R, Griffith J, Fuhrman J. 2011. Lower San Luis Rey River Bacterial Source Identification Project, Final Project Report. September.

McQuaig, S. M., Scott, T. M., Harwood, V. J., Farrah, S. R., J. O. Lukasik. 2006. Detection of Human-Derived Fecal Pollution in Environmental Waters by Use of a PCR-Based Human Polyomavirus Assay. Appl. Environ. Microbiol. 72:7567-7574.

Noble, R. T. J.F. Griffith, A.D. Blackwood, J.A. Fuhrman, J.B. Gregory, X. Hernandex, X. Liang,A.A. Bera, and K. Schiff. 2006. Multi-tiered approach using QPCR for Tracking Sources of Fecal Pollution to Santa Monica Bay, CA. Appl. Environ. Microbiol. 72 (2): 1604-1612.

Noble, R. T. and S. B. Weisberg. 2005. A review of technologies being developed for rapid microbial detection in recreational waters. Review Article. Journal of Water and Health. 03: 381-392.

Noble, R. T., S. M. Allen, A. D. Blackwood, W.-P. Chu, S. C. Jiang, G. L. Lovelace, M. D. Sobsey, J. R. Stewart and D. A. Wait. 2003. Use of viral pathogens and indicators to differentiate between human and non-human fecal contamination in a microbial source tracking comparison study. Journal of Water and Health. 1: 195-207.

Parker, J. P., D. A. McIntyre and R. T. Noble. 2010. Characterizing fecal contamination in stormwater runoff in coastal North Carolina, USA. In revision. Water Research.

Rajal,V. B., B.S. McSwain, D.E. Thompson, C.M. Leutenegger, S. Wuertz. 2007. Molecular quantitative analysis of human viruses in California stormwater. Water Research. 41(19):4287-4298.

Reischer, G. H., Haider, J. M., Sommer, R., Stadler, H., Keiblinger, K. M., Hornek, R., Zerobin, W., Mach, R. L., and A. H. Farnleitner. 2008. Quantitative microbial faecal source tracking with sampling guided by hydrological catchment dynamics. Environ Microbiol. 10(10): 2598–2608.

Seurinck, S. Defoirdt, T.,Verstraete, W. and S. D. Siciliano. 2005. Detection and quantification of the human-specific HF183 Bacteroides 16S rRNA genetic marker with real-time PCR for assessment of human faecal pollution in freshwater. Environmental Microbiology. 7(2), 249–259

Silkie, S. S., Nelson, K. L. 2009. Concentrations of host-specific and generic fecal markers measured by quantitative PCR in raw sewage and fresh animal feces. Water Research. 43 (19):4860-4871.

US Environmental Protection Agency. 2005. Microbial Source Tracking Guide Document. EPA/600/R-05/064 June 2005.

Van De Werfhorst, L. C., Sercu, B., and P. A. Holden. 2011. *Comparison of the Host Specificities of Two Bacteroidales Quantitative PCR Assays Used for Tracking Human Fecal Contamination. Appl. Environ. Microbiol. 77 (17) 6258-6260.*

Wade, T., Sams, E., Brenner, K., Haugland, R., Chern, E., Beach, M., Wymer, L., Rankin, C., Love, D., Li, Q., Noble, R. & Dufour, A. *Rapidly measured indicators of recreational water quality and swimming-associated illness at marine beaches: a prospective cohort study*Environmental Health, **2010**, Vol. 9(1), pp. 66-72

Weston Solutions. 2010. San Diego River Source Tracking Investigation, Phase II. June.

Wong, M., L. Kumar, T. M. Jenkins, I. Xagoraraki, M. S. Phanikumar and J. B. Rose. 2009. Evaluation of public health risks at recreational beaches in Lake Michigan via detection of enteric viruses and a human-specific bacteriological marker. Water Research 43:1137-1149.

* * * * *

Appendix E

Geosyntec consultants

3990 Old Town Avenue, Suite B-101
San Diego, CA 92110
PH 619.297.1530
www.geosyntec.com

Memorandum

Date: 17 May 2012

To: Todd Snyder, Stephanie Gaines, County of San Diego

From: Christian Braun, Brandon Steets, P.E., Ken Susilo, P.E., Erica Meyers, and Avery Blackwell, Geosyntec Consultants

Subject: San Diego River Watershed Comprehensive Load Reduction Plan
Identification of Nonstructural BMP Types
County of San Diego Reference: Task Order 7
Geosyntec Project No. LA0228.07

1.0 INTRODUCTION

1.1 Purpose and Objectives

The purpose of this memorandum is to identify and describe new or enhanced nonstructural Best Management Practices (BMPs) that can be effective at reducing concentrations of bacteria and nutrients, the priority pollutants addressed by the San Diego River (SDR) Watershed Comprehensive Load Reduction Plan (CLRP). Nonstructural BMPs are just one element of the CLRP. The CLRP also includes an assessment of pollutant sources, identification of potential structural BMP opportunities, and pollutant load modeling components with the objective of achieving compliance with watershed Total Maximum Daily Loads (TMDLs). This memorandum is a reference document intended to provide support and justification for the nonstructural BMPs, both wet and dry weather, that are included as part of the SDR CLRP strategy. Table 1 summarizes the prioritized nonstructural BMPs for the watershed, some of which are enhancements to current programs, others which would be new initiatives. The table also identifies the land uses targeted and the pollutant-generating activities addressed by each BMP. The BMPs listed in Table 1 were specifically selected as a result of their ability to address the high priority sources that were identified in the *San Diego County Bacteria Source Prioritization Process* (Ruby, 2011). BMPs will be deployed based on the best professional judgment of the Responsible Parties and as resources allow. Not all of these BMPs will be implemented by all Responsible Parties.

The memorandum is organized as follows: Section 1 provides an introduction; Section 2 contains brief watershed and regulatory background information; Section 3 describes the method of identification, prioritization, and quantification of nonstructural BMPs; Section 4 provides descriptions and potential effectiveness of the identified nonstructural BMPs; and Section 5 concludes the document. This memorandum is intended to supplement, not duplicate, efforts by the Responsible Parties Program Planning Subcommittee and its consultants to summarize and evaluate current and planned nonstructural practices in San Diego County.

Table 1: Priority Nonstructural BMPs in the San Diego River Watershed

Nonstructural BMP	Enhanced	Targeted Land Use	Pollutant Generating Activities
1st Priority (Human Sources or Dry Weather Sources)			
Identification and control of sewage discharge to MS4 of Responsible Parties	X	MS4 conveyance system	Leaking sewers, illegal discharges, illicit connections, illegal dumping, RVs
Homelessness Waste Management Program	X	Urban areas	Homeless encampments
Onsite Wastewater Treatment System Source Reduction	X	Rural residential	Leaky, failing septic systems
Irrigation Runoff Reduction and Good Landscaping Practices	X	Residential and commercial	Irrigation runoff, fertilizers/compost, soil and decaying plant matter, green waste
Commercial/Industrial Good Housekeeping	X	Commercial and industrial	Dumpsters, outdoor garbage areas, garbage trucks, grease bins, outdoor dining/fast food, washwater

Table 1 (continued): Priority Nonstructural BMPs in the San Diego River Watershed

Nonstructural BMP	Enhanced	Targeted Land Use	Pollutant Generating Activities
2nd Priority (Non-Human Anthropogenic Wet Weather Sources)			
Residential/Small-Scale Low Impact Development (LID) Incentive Program	X	Residential	Residential roofs
Pet Waste Program	X	Parks, recreational areas and residential	Pets
Animal Facilities Management	X	Commercial and rural residential	Livestock, manure
Street and Median Sweeping	X	Residential and commercial	Littering, sedimentation, aerial deposition, leaf litter
MS4 Cleaning	X	MS4 drain inlets	Biofilm/regrowth, trash, organic matter, sediment
Redevelopment and LID Implementation	Existing, unchanged program	All land uses covered under SUSMP	Urban land development planning and design

1.2 Terms of Reference

The work described in this memorandum was conducted by Geosyntec Consultants for the County of San Diego for the San Diego River Watershed Comprehensive Load Reduction Plan, Task Order 7, Geosyntec Project No. LA0228.07. The primary authors of this memorandum were Erica Meyers and Avery Blackwell. Peer review was performed by Chris Wessel, P.E. and Julie Stephenson, and senior review was performed by Brandon Steets, P.E., Michael Bloom, P.E., and Ken Susilo, P.E. in accordance with Geosyntec's quality assurance protocols.

2.0 BACKGROUND

Nonstructural BMPs are management programs designed to reduce or eliminate pollutant loading by addressing their sources. Nonstructural BMPs can be municipal programmatic or regulatory measures, public education and outreach, financial incentives, or other source management programs designed to effect behavior change. The nonstructural BMPs described in this memo are proposed as part of the SDR CLRP. Detailed descriptions of the SDR Watershed and the regulations necessitating the development of the CLRP are included in the CLRP itself, and brief overviews are contained below.

2.1 Geographic Setting

The San Diego River Watershed covers approximately 440 square miles in southern San Diego County. From the headwaters to the ocean the river runs for approximately 52 miles, however the SDR CLRP will address only the lower San Diego River Hydrologic Unit. The Cities of San Diego, El Cajon, La Mesa, and Santee along with the unincorporated communities of Lakeside and Alpine are the major population centers of the lower watershed. 30% of the lower watershed land use is residential and rural residential, while 25% is parks/open space and recreational.

2.2 Regulatory Setting

On February 10, 2010, the San Diego Regional Water Quality Control Board adopted a revised Bacteria TMDL into the San Diego Basin Plan. The TMDL establishes numeric waste load allocations (targets) for bacteria loading to impaired water bodies. A plan to attain and maintain the targets must be developed and implemented. The lower San Diego River Watershed is listed as an impaired shoreline and an impaired creek and is therefore required to fulfill the requirements of the TMDL.

3.0 NONSTRUCTURAL BMP IDENTIFICATION AND PRIORITIZATION STRATEGY

Nonstructural BMPs were identified and prioritized for inclusion in this memorandum as options for further evaluation and inclusion into the SDR CLRP through the following process:

1. Develop list of potential new or enhanced nonstructural BMPs to address bacteria and nutrients

2. Identify potential bacteria sources to or within the MS4 of Responsible Parties

3. Prioritize and rank sources using the *San Diego County Bacteria Source Prioritization Process* (Ruby, 2011)

4. Identify new or enhanced nonstructural BMPs that would be effective in targeting priority sources

5. Quantify the bacteria load reduction benefits and costs of implementing the identified nonstructural BMPs

6. Finalize BMP list based on return-on-investment and feedback from responsible parties listed in the TMDL

Step one of the selection process began by reviewing information on regional nonstructural BMP implementation programs for potential enhancements; including Jurisdictional Urban Runoff Management Plans (JURMP) (County of San Diego, 2008) and JURMP annual report documents (City of San Diego, 2010; County of San Diego, 2011), the SDR Watershed Urban Runoff Management Plan (WURMP) annual reports (WURMP, 2011a). Other TMDL implementation plans were also reviewed along with the Nonstructural BMP Fact Sheets prepared for the San Diego Responsible Parties' Program Planning Subcommittee (RBF, 2011). Additional preferences were also established through interviews with agency representatives.

The second step of the selection process involved a review of bacteria source studies including the *San Diego County Bacteria Source Prioritization Process* (Ruby, 2011), the *San Diego River Source Tracking Investigation – Phase I and II* (Weston 2009 a&b) and the *Lower San Luis Rey River Bacterial Source Identification Project* (Oceanside, 2011). This review identified categories of possible human and anthropogenic non-human bacteria sources in the SDR Watershed.

The third step prioritized the bacteria sources to be addressed by nonstructural BMPs in the SDR Watershed using the methodology presented in the *San Diego County Bacteria Source Prioritization Process* (Ruby, 2011). The first priority for selection of nonstructural BMPs are those that address human bacteria sources due to the inherently greater threat they pose to public health risk. Dry weather sources of bacteria are also considered a first priority due to the more accelerated dry weather TMDL compliance schedule and the fact that body contact recreation in the watershed is more common during dry weather conditions. Second priority nonstructural BMPs are those that address wet weather, non-human anthropogenic sources, given their assumed lower public health risk and the longer TMDL compliance schedule identified in the CLRP. Non-anthropogenic sources, and sources beyond the responsibility of the Responsible Parties, are not targeted for control in the CLRP.

Step four refined the candidate list of nonstructural BMPs, based on the findings of literature and data review, to options that addressed first and second priority bacteria sources. Many existing nonstructural BMPs could be enhanced or adapted to better address the priority sources, while others would require the development of new programs or approaches.

In step five, first and second priority BMPs were quantified for their potential bacteria load reduction range and estimated implementation costs. The estimated load reductions achieved through BMP implementation along with capital and operations and maintenance (O&M) costs are described in Attachment E: SDR Summary of Nonstructural BMPs and Quantification of Water Quality (as Fecal Indicator Bacteria – Fecal Coliform, FIB-FC) Benefits. Due to the availability of limited studies and significant information gaps, not all selected nonstructural BMPs are able to be quantified for load reductions; however, based on the Responsible Parties experience and best professional judgment, these BMPs are still included and assumed to add value toward compliance.

The concluding step is the creation of a final nonstructural BMP list based on discussions, including implementation feasibility and return-on-investment, with the Responsible Parties of the selected BMPs. Copermittees of the San Diego River Watershed TMDL CLRP include the incorporated Cities of El Cajon, San Diego, Santee, and La Mesa, the unincorporated communities of the County of San Diego, and Caltrans jurisdiction.

4.0 ENHANCED AND NEW NONSTRUCTURAL BMPS

This section describes potential enhancements and new nonstructural BMPs based on the process defined in section 3. The specific sources addressed by each BMP, the land uses targeted, and their potential effectiveness within the SDR Watershed are also discussed.

4.1 Identification and control of sewage discharge to MS4 of Responsible Parties

Description

Aging and leaking sanitary sewer and stormwater conveyance pipes can introduce pollutants to the MS4 through sanitary sewer overflows (SSO) caused by blockages, line breaks, or other sewer defects; exfiltration of sewage from sanitary sewers; and infiltration of groundwater when the MS4 lies below the water table. Upgrading, repairing, or slip-lining faulty sanitary sewer pipes will reduce pollutant loads by eliminating the leaks in those pipes and, therefore, the sources of the pollutants to the Responsible Parties. However, it should be noted that not all sanitary sewer systems in the SDR Watershed are managed by the entities named as responsible parties in the TMDL. For example, sanitary sewer systems in portions of the unincorporated County are operated by special districts not identified in the TMDL.

Upgrading or repairing storm drain pipes can prevent the infiltration of contaminated groundwater into the MS4. Additional illicit discharges listed in the MS4 permit include sanitary sewer cross-connections, industrial and commercial cross-connections, transitory discharges from spills or illegal dumping (e.g., boats and RVs), private lateral sewer overflows, wash water resulting from property or vehicle cleaning, discharges from pool or fountain draining, and discharges of food-related wastes (RWQCB, 2007). Illicit discharges can be sources of bacteria or nutrients. Many of the sources addressed through the above BMPs ranked highly as dry weather sources in the *San Diego County Bacteria Source Prioritization Process* (Ruby, 2011), including the highest and third highest ranked: SSOs and leaky sewer pipes.

Potential load reductions from a robust sewage discharge control program will depend on the current controllable pollutant loads from illicit discharges. Beyond targeted sewer discharge control programs, other Illicit Discharge Detection and Elimination (IDDE) program components could include water quality monitoring for indicators of human sewage constituents, MS4 inspections to identify locations with persistent dry weather flows, an IDDE hotline for citizens to report spills or suspicious discharges, or the use of cameras or continuous automated flowmeters in storm drains to identify or measure infiltration and/or illicit connections. Finally, special studies such as dye tracing, canine source tracking, and/or microbial source tracking may be employed to answer specific, targeted questions.

The Responsible Parties' IDDE program currently undertakes significant efforts to detect and respond to illegal connections and illicit discharges (IC/IDs). These efforts include public reporting hotlines; spill reporting, response, and prevention programs; urban runoff monitoring; and follow-up investigations and enforcement. Caltrans currently trains maintenance staff to be able to investigate and report IC/IDs to their storm drains. Caltrans also operates IC/ID detection and reporting programs at all Caltrans construction sites.

The Responsible Parties are also currently implementing significant BMP measures to address SSOs. The City of San Diego conducts field inspections and televised sewer lines, which can reveal blockages from debris to roots to grease and show pipeline cracks, breaks, or deterioration.

Potential Effectiveness

If human sources are determined to be a significant source of pollutant loading within the SDR Watershed, accelerated repair or upgrade of sanitary sewer and stormdrain systems would encourage proactive mitigation of bacteria and nutrient pollution resulting from the sanitary sewer system and/or groundwater. The location and design of upgrades could be optimized to decrease pollutant loads using information gathered in IDDE programs, GIS analysis of high-risk sewers, and/or special source tracking studies. Strategically planning upgrades to older, clay sanitary sewer laterals that cross or run next to and above storm drains is cost-effective and would offer multiple benefits, including benefits to water quality and reduced operations and maintenance costs from newer infrastructure. For example, the City of Santa Barbara identified four locations through the use of a dye tracer and microbial source tracking study that together contribute roughly 1,500 gallons of raw sewage each day via infiltration into the local MS4 (Murray et al., 2011).

To increase the effectiveness of IDDE, current programs could be expanded to include a tiered dry weather source investigation including: (1) visual surveys of MS4s to identify dry weather flow locations, (2) GIS-based prioritization where aging sewer laterals are above and near storm drains that are observed to occasionally flow during dry weather, (3) video survey of the storm drains to identify leaks from the top of the pipe and/or sewer dye tracing studies, and (4) fecal source tracking studies that use canine scent tracking and/or microbial source tracking.

4.2 Homelessness Waste Management Program

Description

Encampments of homeless and transient persons both within the river channel and the Responsible Parties' MS4 systems can be sources of bacteria and trash during wet weather, as rainwater mobilizes waste and transports it to the MS4 and receiving waters. According to the Regional Task Force on the Homeless 2011 Point-In-Time Count, there are more than 3,800 homeless people living in vehicles or hand-built structures (not a regional shelter, safe haven facility or transitional housing) in the Cities of San Diego, El Cajon, La Mesa, Santee and the unincorporated Communities of Alpine and Lakeside, combined. When combined with the number of homeless living in shelters or transitional housing are included, the estimate increases to over 6,400 persons living as homeless. (RTHF, 2011) Because these numbers reflect the cities' entire count for homeless, some areas of which lie outside of the SDR Watershed, the counts may tend toward the higher estimate when including "sheltered" homeless individuals. It would be safe to assume that for the SDR Watershed the number of homeless ranges between the number of homeless counted as "unsheltered" and those counted as living within a shelter.

The Responsible Parties ranked Homeless Encampments as the third highest wet weather bacteria source in the prioritization process (Ruby, 2011). In areas of the SDR Watershed where homeless encampments are determined to be a significant pollutant source, effective programs may include establishing ordinances that reduce encampments, enhancing programs to reduce the number of homeless people in encampments, and enforcing new and existing laws to decrease the negative impact on water quality. Enforcement during the night hours is of special importance, in order to cite and fine those caught camping illegally.

Options to reduce water quality impacts of homeless encampments can also be combined with efforts to reduce homelessness. One example is a grant-funded pilot program on Coyote Creek in San José, CA that employs homeless persons living in creek encampments to remove trash and litter and to engage in peer-to-peer outreach with others living in the encampment. Participants are housed temporarily and given food vouchers, case management services, employment skills, and assistance at transitioning to permanent housing (USEPA, 2011). Partnering with non-profit organizations to inspect and remove trash generated by encampments leverages existing social programs, watershed volunteer programs, and water quality programs to address a common concern.

Existing projects in the San Diego River Watershed include the Forester Creek Homeless Encampment Removal Project, which involved police sweeps of transient camps and subsequent cleanup. This activity removed 14 cubic yards of debris during fiscal year 2009-2010. Similar sweeps and cleanup events are conducted in the City of Santee in the San Diego Riverbed and have removed 5,000 lbs. of trash. The San Diego River Park Foundation works collaboratively with local park rangers, police, and volunteers to identify and remove homeless encampments, and document activities.

Potential Effectiveness

Results from a bacteria source identification project by the City of Oceanside suggest that 5-20% of fecal bacteria throughout the lower SLR River during wet weather and winter dry weather may be attributed to human sources. Results also suggest that during summer dry weather only about 1-10% of fecal bacteria at the river mouth are from human sources (Oceanside, 2011). These percentages were derived with rough accuracy by comparing concentrations of the human-specific HF183 bacteroides marker to order of magnitude thresholds (shown in Table 2) provided by Dr. Noble, who led the Oceanside study. This method was only used when all three human fecal markers (Fecal *Bacteroides*, BacHum, and HF183) were detected in the sample, therefore human sources were considered probable.

Table 2: Rough Estimate of Percent Human Contribution of Fecal Bacteria based on HF183 Marker (from Noble, Personal Communication)

HF183/100mL	% Human
$>10^3$	~1
$>10^4$	~10
$>10^5$	~50

Based on the large number of homeless within the lower watershed, it is expected that similar homeless contributions are found in the SDR. The high percentage of fecal bacteria from human sources during the winter months is consistent with the human waste being washed from streambanks, floodplain areas, and ephemeral channel tributaries where it was deposited. This suggests that reducing loads from homeless encampments or transients near SDR is likely to offer significant opportunities for load reduction.

4.3 <u>Onsite Wastewater Treatment Source Reduction</u>

Description

Without proper maintenance, onsite wastewater treatment systems (OWTSs or septic systems) can fail, primarily during wet weather, and become a source of bacteria to MS4s and receiving waters. Even when properly sited and maintained, OWTSs can be a source of nutrients transported directly to receiving waters or through ground water interactions. Because the source of bacteria is human fecal matter, control of bacteria and pathogens from OWTSs is high priority. Leaky and failing OWTSs are the tenth highest ranked wet weather bacteria source assessed during the County prioritization process (Ruby, 2011).

The State Water Resources Control Board has released the final draft State Policy for Water Quality Control for Siting, Design, and Operation and Management of Onsite Wastewater Treatment Systems (SWRCB, 2012). As a response to Assembly Bill 885, the policy would establish a statewide, risk-based, five tiered approach for the management of OWTSs installations and replacements and set a level of performance and protection expected from OWTSs. Tier 0 includes existing OWTSs that are properly functioning. Tiers 1 and 2 only apply to new or replacement OWTSs, where Tier 1 OWTSs meet State specified low risk siting and design requirements and Tier 2 OWTSs will include coverage under a local agency management program for greater risk OWTSs. Existing OWTSs fall into Tier 3 if they are located near (within 600 feet) an impaired water body or a water body addressed by a TMDL implementation plan. Tier 3 OWTSs would require an Advanced Protection Management Program including additional inspection, and possibly advanced treatment upgrades. Tables 4 and 5 of attachment 2 to the State policy list impaired water bodies for pathogens and nitrogen as identified by the State for determining Tier 3 OWTSs. Those OWTSs that are failing are moved to Tier 4 until repair or upgrade can occur.

Potential Effectiveness

As the TMDL for the SDR Watershed does not assign load allocations to septic and since Tables 4 and 5 of the final draft State Policy do not include any impaired water bodies in San Diego County, no OWTS will categorized as Tier 3 within in the SDR Watershed. As a result no significant changes affecting bacteria or nutrient load reductions will be required of the local agencies or OWTS owners as a result of the new State Policy.

Based on the results of the San Diego River source tracking study, Phase II (Weston, 2009), human fecal bacteroides markers at the SDR upstream monitoring station (where we would expect to capture bacteria contributions from OWTSs in the less urbanized area of the watershed) contained some human markers representing the possibility of OWTS loading. The influence of

OWTS was not a focus of this study, and the data mentioned above was minimal, therefore a special study is recommended to better inform the contribution of OWTSs to the surface water bacteria load in the watershed during summer-dry, winter-dry, and wet periods.

4.4 Irrigation Runoff Reduction and Good Landscaping Practices

Description

Irrigation runoff from lawns, gardens, parks, and other vegetated areas can result in dry-weather nuisance flows with high concentrations of nutrients and also mobilize and transport pollutants accumulated on ground surfaces. The contribution of dry weather inflows from irrigation runoff to a stagnant pool has also been known to foster in-situ bacterial growth (Geosyntec, 2010a). This bacteria growth or regrowth was ranked as the 7th highest dry weather anthropogenic non-human bacteria source in the SDR by the Responsible Parties in the prioritization process (Ruby, 2011). Effective methods to reduce irrigation runoff could include development of educational outreach, increased inspections, punitive measures for overwatering, tiered water rates, or distribution of smart irrigation controllers and/or other financial incentive programs that decrease watering volume. These BMPs can address bacteria loading from residential, commercial, industrial, parks, transportation and educational land uses.

As a result of the California Water Conservation in Landscaping Act of 2006, each Responsible Party updated their landscape ordinances, effective the beginning of 2010 (City of El Cajon, 2009; City of La Mesa, 2009; City of San Diego, 2009b; City of Santee, 2009a, County of San Diego 2010b). These ordinances are based on the California Model Water Efficient Landscape Ordinance and similar San Diego Region Model and provide rules and guidelines for landscape design, installation, maintenance and management. The new components of these ordinances apply to industrial, commercial, educational, multi-family residential, or public agency projects with landscaped area greater than 1,000 (2,500 in some jurisdictions) square feet and single family residential landscape areas over 5,000 square feet. The irrigation plans required within the ordinance must be designed to prevent runoff.

The San Diego County Water Authority has previously offered rebate programs for smart irrigation controllers during periods of water scarcity (i.e., drought). A similar program, although expanded in scope and including additional outreach and education, could lead to measurable reductions in dry-weather flows to MS4s. The conversion of traditional irrigation systems to advanced systems incorporates weather-based irrigation controllers, drip irrigation, and pressure drop sensors.

Irrigation runoff reduction programs can also be integrated with BMPs that encourage landscaping and smart gardening practices that reduce the load of fertilizers and chemicals that end up in stormwater. The natural environment of San Diego is unique; therefore, utilization of natural ecological interactions in the landscaped areas will help to reduce pollution in stormwater. Some techniques that seek to create this natural interaction are integrated pest management, reducing fertilizer and pesticide use, xeriscaping, and turf conversion. Promotion of existing programs encouraging these practices and the establishment of new programs such as "Green Gardener" training and certification can integrate these principles and reach homeowners and business owners that hire caretakers to tend their landscapes. To facilitate the use of these natural approaches, ordinances, education and outreach, and financial incentives can be implemented.

Potential Effectiveness

Two studies in Orange County measured the effectiveness of advanced irrigation systems for reducing irrigation runoff. A residential runoff study conducted in five neighborhoods found dry-weather runoff decreased by 50% in areas where weather-based irrigation controllers were installed (IRWD and OCMWD, 2004). Berg et al. (2009) found dry-weather runoff reductions of 25% to 50% for a similar study of 4,100 Smart Timers installed in residential and commercial areas. The San Diego River source tracking study (Weston, 2009a) found average concentrations of fecal coliforms in dry-weather residential runoff at levels between 100 and 120 MPN/100ml. Besides these concentrations within the irrigation runoff, the increased flows also allow for regrowth in the MS4 and mobilization of pollutants in the MS4 to the receiving waters. Based on these studies, it is believed that increased irrigation runoff controls in the SDR Watershed, such as inspection, enforcement, and incentives in commercial and residential land uses will generate pollutant load reductions.

4.5 Residential/Small-Scale LID Incentive Program

Description

This wet weather nonstructural control is an incentive program that encourages residents and businesses to capture or redirect runoff from roofs using LID principles to reduce flow to storm drains. Downspouts can be redirected to lawns, specially designed rain gardens or swales; or rain barrels or cisterns can be installed to collect roof runoff for later use.

A comprehensive residential rain barrel and downspout retrofit program could include public education and outreach, as well as significant financial incentives such as offering rain barrels at no or reduced cost or rebate programs for downspout retrofits and conversion to sustainable landscapes. These programs are also effective nonstructural BMPs for commercial, industrial, and public buildings. A pilot program could determine the level of incentive necessary to achieve the desired number of renovations.

The City of San Diego conducted a rain barrel and downspout disconnect pilot project in 2009 at eight City-owned sites. The study found that individual systems were able to attenuate and infiltrate up to six times the cistern volume for a single storm event. These flow reductions resulted in decreased pollutant mobilization and transport to storm drains (Weston, 2010b).

In 2010, the County of San Diego implemented a pilot program that offered subsidized rain barrels to County Unincorporated residents. A total of 186 residents participated in the program and of those, 27 participants reside in the SDR Watershed. In addition to the provision of rain barrels, County staff cooperated with non-profit agencies to provide educational materials to participants and answer questions related to installation and maintenance.

Potential Effectiveness

If widely implemented, a downspout disconnection and rain barrel program could reduce stormwater runoff and associated pollutant loads from areas discharging into the MS4, particularly during small, frequently occurring storms. The City of Portland has been implementing an effective downspout retrofit incentives program since 1996, and more than 56,000 property owners have disconnected downspouts (City of Portland Website). Given that in the SDR Watershed the typical rooftop sheds approximately 14,500 gallons of water over an average winter (assuming an average 2,100 square-foot roof and 11.13 inches of rain per year), the reduction in potential pollutant loading to storm drains from urban runoff is substantial.

4.6 Commercial/Industrial Good Housekeeping

Description

Requiring good housekeeping practices involves establishing and enforcing ordinances for commercial, industrial, and multi-family residential facilities. Programs that address wet weather load reductions may include increased inspection and enforcement of grease removal equipment for restaurants, monitoring trash enclosures for proper waste disposal, and cleaning of private catch basins and drain inlets. The wet weather sources targeted by these BMPs include several of the highly ranked anthropogenic non-human sources, such as dumpsters and grease traps, from the bacteria prioritization process (Ruby, 2011). Dry weather controls can also include discouraging vehicle washing, power washing and other wash down activities that produce nuisance flows to MS4s. Wash water was ranked as the 7th highest rank dry weather anthropogenic non-human bacteria source during the prioritization process (Ruby, 2011).

A source tracking study performed in the San Diego River Watershed found that approximately 20% of all dumpsters or grease traps had evidence of liquid leaks. These leaking containers are of especially high importance as a result of the significant concentrations of bacteria in the leaking liquid (Weston 2009a).

Catch basins and drain inlets play an important role in the prevention of trash and other sediment from entering the storm drain system. A survey conducted as part of the San Diego River source study found that 46% of commercial catch basins had moderate buildup and 34% had ponded water. Signs of washdown and food scraps were frequently associated with catch basins near restaurants (Weston 2009a).

Potential Effectiveness

Commercial, industrial, and multi-family residential facilities represent a small portion of overall pollutant loading in the SDR Watershed. However, focused attention on high priority activities, as mentioned above, may produce sizeable pollutant reductions. Water quality benefits of these programs are expected to be very cost-effective at reducing pollutants, including bacteria, trash, oils and grease, and sediments. Enhanced inspection and enforcement of the above listed categories could be carried out on a facility and property wide basis to ensure complete coverage and would yield increased results when directed by past experiences. Requiring catch basin cleaning prior to the wet season could also successfully generate bacteria load reductions, especially for restaurants and other food outlets. An ordinance requiring covered trash enclosures and frequent cleaning could efficiently keep the load of dumpster bacteria to a minimum. Requirements for street sweeping of commercial and multi-family residential parking lots may also yield effective pollutant load reductions from these sources.

4.7 Pet Waste Program

Description

Pet waste is a potentially significant source of bacteria during wet weather to the SDR Watershed. BMPs for pet waste pick-up and disposal could include both educational outreach and enforcement to encourage residents and pet owners to clean up after their pets. The bacteria prioritization process found pets to be the top ranked wet weather anthropogenic non-human source (Ruby, 2011). A survey of Chesapeake Bay residents indicated that about 60 percent of dog owners pick up after their pets; and a survey in Washington indicated that about 70 percent of dog owners pick up pet waste (Schueler, 2000).

Results from the City of Oceanside's *Barriers to Picking up Dog Waste Survey*, (Oceanside, 2009) reveal that 83 percent of dog walkers never leave their dog's waste behind. The City of Santee's pet waste pickup survey (Santee, 2009b) recorded that 80 percent of dog walkers responded as always picking up after their pet. The survey also connected the importance of water quality knowledge to a dog owner's decision to pick up after their dog. According to the survey, owners stating that pet waste left in parks contaminates streams were about seven times more likely to pick up after their pet than not. Conversely, an owner who believed pet waste dissolves and fertilizes the grass was only about five times more likely to pick up after their pet.

Options to control pet waste include park signage, receptacles for pet waste, waste bag distribution stations, designated dog parks, strict ordinances to regulate pet waste clean-up, and educational outreach at pet stores, animal shelters, veterinary offices, and other sites frequented by pet owners. Pet waste management practices may also include BMPs relating to horseback riding activities. These will be developed as needed as riverside trails develop, and/or as source investigation studies or other data indicate that they are necessary. A potential mechanism to fund and maintain this program is a stormwater charge on animal licenses. Most commonly applied in parks, recreation areas, and open spaces, pet waste programs in residential areas could also be an effective application.

The Responsible Parties have installed pet waste bag dispensers and educational signage within park facilities, recreational areas, and other popular do walking areas in the SDR Watershed. The municipalities also complete continuing educational outreach to residents via regional and jurisdiction specific programs.

Potential Effectiveness

The Phase I Report for the San Diego River Kelp and Dog Waste Management Plan for Dog Beach and Ocean Beach found that public compliance with the “scoop the poop” policy was highly dependent on awareness of the policy and availability of waste disposal bags and trash cans (Weston, 2004). Public surveys in the City of Austin indicated their educational campaign resulted in a 9% improvement in the number of pet owners who claim to regularly pick up waste (City of Austin, 2008). Studies in San Diego have shown that installation of pet waste stations have resulted in a 37% reduction in the total amount of pet waste in city parks (City of San Diego, 2011a).

Source tracking studies have found that generally 6% to 16% of fecal bacteria have DNA matching canine sources, based on studies in Mission Bay in San Diego and elsewhere in California (including Ventura County, Morro Bay, Rincon Coast, and the San Lorenzo River) (City of San Diego, 2004; Geosyntec, 2010b; Kitts et al., 2002; Santa Barbara County, 1999; and County of Santa Cruz, 2006). It is important to note that the analytical methods used in these older bacteria tracking studies have since been deemed unreliable. However, the similar ranges of percent canine contribution for these five studies improve confidence in these estimates.

Assuming that SDR Watershed has similar contributions from canine sources, an enhanced pet waste program may result in significant total reduction in fecal indicator bacteria loads in the

SDR Watershed. Advancing implementation beyond parks and open space into residential areas could be a useful step towards creating a comprehensive program.

4.8 Animal Facilities Management

Description

Animal facilities for large and small animals can be sources of bacteria, nutrients and sediment in both wet and dry weather. An effective source control program could contain with an inventory and frequent inspection of horse ranches, livestock areas, kennels and other pet service areas. Community outreach tools would include education materials that stress manure and washwater management, directing drainage away from and/or around exposed stalls, and watershed awareness. These BMPs would address both commercial and private facilities.

In addition, policies for manure management may be introduced, requiring large animal owners to clean up manure, for compost or storage prior to proper disposal. This BMP could also require soil bedding and manure to be removed from stalls frequently and stored in seepage-free containers prior to disposal. Exclusion fences to prevent grazing from occurring in or directly adjacent to water courses may also result in load reductions. This BMP prevents not only the direct deposition of livestock waste from occurring within waterways, but also prevents the tracking of waste by animals into the water courses. This BMP could be enacted by modifying zoning regulations on lands that permit grazing. Other potentially effective BMPs may include equestrian peer-mentoring programs, BMP demonstration sites, and property assessments for livestock land uses. Equestrian manure management along trails could be control by signage and increased maintenance.

Within San Diego County a pilot program is being implemented that conducts workshops to educate equestrian and livestock facilities in manure management, composting, land use regulations and protection of local water sources.

Potential Effectiveness

The SDR Watershed supports an active equestrian community, especially in the communities of Lakeside and Alpine. However, the potential contribution of equine or other livestock sources is unquantifiable at this time. Prior to implementing expanded programs, it is suggested that additional studies be conducted to assess the importance of these sources and prioritize areas of equine and livestock land use. If determined to be a significant source, enhancement of the County pilot program would increase outreach and education to the significant number of private residences maintaining horses and other livestock on their property.

4.9 Redevelopment and LID Implementation

Description

The San Diego County Copermittees' Standard Urban Stormwater Mitigation Plans (SUSMP) require advanced stormwater treatment through LID implementation for all development and redevelopment that affects a minimum of 5,000 square feet of impervious area in specific project categories. In 2007 the current County SUSMP requirements went into effect replacing the 2002 requirements. The SUSMP requirements apply to residential, commercial, industrial, educational, and transportation land uses for wet weather. The SUSMP guides applicants through the design and submittal process to ensure the necessary stormwater features are being implemented. Project designs must show runoff being infiltrated or else treated by bioretention facilities, planter boxes, filters, settling ponds, or constructed wetlands (County of San Diego, 2011b).

Potential Effectiveness

The LID SUSMP requirements, when appropriately implemented to address pollutants of concern, have been an effective stormwater management technique since their inception and no enhancements are recommended at this time. To quantify the potential bacteria and nutrient load reductions from redevelopment and LID implementation, SBPAT was used to model a hypothetical BMP from different land uses. Credit for pollutant load reductions are granted in redevelopment conditions, where an existing developed land use is functionally retrofitted as part of redevelopment. Table 3 shows the assumed effective load reduction per acre of redevelopment. For simplicity, it was assumed that a standard SUSMP sized bioretention area with underdrain would treat runoff from each land use. In addition to reducing pollutant loads, the hypothetical BMP captures approximately 80% of average annual runoff volume. Based on this analysis, the highest bacteria and nitrate load reductions can be gained through redevelopment-triggered stormwater mitigation in SFR and industrial land uses. Total phosphorus loads will be reduced most per acre for the transportation land use, once treated by LID.

Table 3: Bacteria (as FC) and Nutrient Unit Load Reduction per Redevelopment Acre applying LID

Land Use	Modeled % Impervious	Load Reduction per Land Use Acre via Application of SUSMP Biofiltration BMPs		
		FC (10^12 MPN/ac/yr)	TP (lb/ac/year)	NO3 (lb/ac/year)
Commercial	80%	.007	0.42	0.70
Education	56%	0.010	0.46	0.50
Industrial	81%	0.309	0.62	1.20
Residential (SFR)	55%	0.203	0.50	1.75
Transportation	90%	0.004	1.14	1.10

4.10 Street and Median Sweeping

Description

The collection of bacteria in street sediments during dry weather conditions creates concerns for the transport of pollutants—including bacteria, nutrients, and metals—to water bodies during wet weather events. Street and median sweeping is a common practice for reducing street sediment and therefore urban runoff pollutant loads from transportation land uses. The major factors that impact the effectiveness of a street sweeping program in reducing pollutant loads are frequency and timing of cleaning and the type of street sweeping equipment used. Effectiveness is also dependent on the speed the sweeper travels, the amount of sediment on the street, and how much of the street is swept (e.g., whether parked cars prevent sweepers from accessing the curb).

High-efficiency street sweeping equipment, such as regenerative air sweepers or vacuum assisted sweepers can significantly increase the amount of sediment removed from roadways. Several studies comparing mechanical broom sweepers to newer high efficiency alternative equipment have shown increases in sediment removal of 35% (Pitt, 2002), 15 to 60% (Minton, 1998), and up to 140% (Schwarze Industries). Additionally regenerative air and vacuum sweepers were designed specifically to better capture fine particles. Bacteria, as well as metals and other pollutants, on sediments are typically associated with smaller sized particles due to a larger surface-to-volume ratio and greater adsorption properties of clay particles (Xanthopoulos and Hahn, 1990; Krumgalz et al, 1992).

Potential Effectiveness

Concentrations of bacteria in street sediments and sediment accumulation rates provide an estimate of annual bacteria loading attributable to accumulated street sediment. The concentration of fecal coliform bacteria on sediment collected from street surfaces has been measured in a number of studies (Bannerman et al., 1993; Steuer et al, 1997; and Pitt and

Maclean, 1986), and ranges from 5 x 10^6 to 5 x 10^8 colonies per pound of sediment, calculated as constituent concentration divided by the total sediment concentration (assumes pollutant concentration in rainwater is negligible and 100% of pollutant mass is from land surfaces). Sediment and pollutant accumulation on streets depends on many factors, including surrounding land use, traffic patterns, and climate. The rate of sediment accumulation per length of street has been studied in numerous watersheds and typically ranges from 43 to 74 lbs per curb mile per day (Sartor and Gaboury, 1984; Rosselot, 2007). Given this range of sediment accumulation and bacteria concentrations, and assuming sediment is mobilized by runoff at a rate of 10-20% (Pitt et al., 2004), a rough estimate of bacteria load would be in the range of 9 x 10^7 to 2 x 10^{10} colonies per mile roadway per day.

The street and median sweeping within the SDR Watershed appears to be an effective program for managing the sediment transport of bacteria into the MS4. Further improvements to existing programs could occur with newer, high efficiency street sweepers replacing older equipment or additional targeted routes.

4.11 MS4 Cleaning

Description

Cleaning sediment and trash from storm drain inlets and conveyance systems can reduce pollutant loads of bacteria, nutrients, trash, metals, and sediments in receiving waters. Load reductions that can be gained by the cleaning of drain inlets and storm drains will depend on the extent, timing and frequency of cleaning. A literature review conducted by the Center for Watershed Protection (CWP) found that cleaning catch basins semi-annually can reduce total suspended solids (TSS) by 56%, total phosphorus by 2%, and total nitrogen by 10% (CWP, 2009), assuming catch basin sumps are less than 50% full when cleaned. Pitt estimated that semi-annual catch basin cleaning can reduce total solids by 25%, and nutrients and metals (such as zinc) by 5 to 10% (Pitt et al, 1985).

Drain inlets in San Diego County are not designed with catch basin sumps, therefore material is not generally stored in inlets after even a small storm. However, data from the County of San Diego JURMP Annual Report show that almost 700 conveyances were inspected and 60 cleaned during fiscal year 2010-2011, removing over 900 cubic yards of material using street sweepers and other means of cleaning (County of San Diego, 2011c). In the City of San Diego approximately 3,000 catch basins and drain inlets are cleaned per year, resulting in 1400 tons of material removed. As technology continues to advance, high efficiency MS4 cleaning equipment allows for improved bacteria load reductions and therefore could be phased in to replace older equipment.

Potential Effectiveness

A study of sediment accumulation in storm drains found that pipes and channels with significant sediment accumulation had low slopes (less than 1.5%) or were located near sediment sources (Pitt and Field, 2004). This suggests that storm drain cleaning in areas of known sediment accumulation can provide additional pollutant removal benefit. Large, open concrete-lined channels can be cleaned using street sweeping equipment to increase sediment and pollutant pickup efficiency.

A source tracking study performed by Weston for the San Diego River (Weston 2009 a&b) found that catch basins contained a noteworthy concentration of FIB during dry weather periods (Fecal coliform concentrations as high as 7,936 MPN/100mL). In phase 2 of the study they found that standard cleaning of catch basins didn't significantly affect the dry weather runoff FIB concentrations downstream; however the data are limited.

The MS4 cleaning administered in the SDR Watershed appears to be an effective program for managing the sediment transport of bacteria in the MS4. Further improvements to existing programs could occur with newer, high efficiency cleaning machines replacing older equipment or targeted inspections.

5.0 CONCLUSIONS

The process of nonstructural BMP prioritization for development of the SDR Watershed CLRP will involve evaluation of institutional and source control programs currently being implemented by the Responsible Parties that could be expanded or improved; assessment of additional programs likely to provide substantial reductions of bacteria, nutrients, and other pollutants; and knowledge of effective nonstructural BMP options, with preference for those that provide the greatest water quality benefits. This memorandum has outlined a list of potentially cost-effective BMPs to be assessed and considered for implementation.

In addition to this assessment, cost-efficiencies for nonstructural BMP programs can be introduced by increasing stakeholder collaboration and expanding current practices across jurisdictional lines. For example, regional coordination between agencies, environmental groups, and other stakeholders can reduce expenses associated with staff training, program administration, and operations costs.

6.0 REFERENCES

Bannerman, R., D. Owen, R. Dodds, and N. Hornewer. 1993. "Sources of Pollutants in Wisconsin Stormwater." *Water Science and Technology*. 28(3-5): 241-259.

Berg, J.M., S.C. Hedges, and S.D. Jakubowski. 2009. "Evaluating Irrigation Effectiveness – Effects of runoff-reducing weather based irrigation (Smart Timers)." *Water Efficiency*. July-August. < www.waterefficiency.net/july-august-2009/evaluating-irrigation-effectiveness >

California Department of Transportation (Caltrans). 2012. Statewide Stormwater Management Program Annual Report 2010-2011. Sacramento, CA. April 1, 2012.

Caltrans. 2003a. Assessment of Drain Inlet Cleaning and Waste Disposal. CTSW-RT-03-091.51.43, California Dept. of Transportation, Sacramento, CA. November.

Caltrans. 2003b. Assessment of Drain Inlet Efficacy Study-Final Report. CTSW-RT-03-57.36.1, California Dept. of Transportation. Sacramento, CA. June.

California Regional Water Quality Control Board (RWQCB), San Diego Region. 2007. Waste discharge requirements for discharges of urban runoff from the municipal separate storm sewer systems (ms4s) draining the watersheds of the County of San Diego, the incorporated Cities of San Diego County, the San Diego Unified Port District, and the San Diego County Regional Airport Authority. ORDER NO. R9-2007-0001. January 24, 2007.

California State Water Resources Control Board (SWRCB). 2010. 2010 Integrated Report - Clean Water Act Section 303(d) List / 305(b) Report. Updated 2 December, 2011. <http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml>

California State Water Resources Control Board (SWRCB). 2012. Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems, Final Draft. March 20, 2012.

California Stormwater Quality Association (CASQA). 2003. "Animal Care and Handling Facilities." California Stormwater BMP Handbook. January. <www.cabmphandbooks.com/Documents/Industrial/AnimalCareandHandlingFacilities.pdf>

Center for Watershed Protection (CWP). 2006. Technical Memorandum 1 – Literature Review. Research in support of an interim pollutant removal rate for street sweeping and stormdrain cleanout activities. Funded by USEPA Grant CG-97322201-0. October.

City of Austin. 2008. Scoop the Poop Education Campaign, Summary Report.

City of El Cajon. 2009. El Cajon Municipal Code. Chapter 17.94 Water Efficient Landscaping. 2009.

City of La Mesa, 2009. La Mesa Municipal Code. Chapter 14.29 Water Efficient Landscape Regulations. 2009.

City of Los Angeles. 2010. Total Maximum Daily Load for Metals in Ballona Draft Implementation Plan. January.

City of Los Angeles. 2009a. Total Maximum Daily Load for Bacterial Indicator Densities in Ballona Creek, Ballona Estuary, and Sepulveda Channel Draft Implementation Plan. November.

City of Los Angeles. 2009b. Water Quality Compliance Master Plan for Urban Runoff. Clean Stormwater/Urban Runoff Master Plan. Watershed Protection Division, Bureau of Sanitation, Department of Public Works. May.

City of Oceanside. 2011. Lower San Luis Rey River Bacterial Source Identification Project. Final Project Report. September 2011.

City of Oceanside Website. 2011. Street Sweeping. Accessed on 15 December, 2011. <http://www.ci.oceanside.ca.us/gov/pw/maintops/sweeping.asp>

City of Oceanside. 2010. Jurisdictional Urban Runoff Management Program Annual Report 2009-2010. September 30, 2010.

City of Oceanside. 2009. Barriers to Picking up Dog Waste Survey. 2009.

City of San Diego. 2011a. Phase II Pet Waste Bag Dispenser Station Design and Implementation Report. Final Report. Doc ID# CSD-RT-11-URS31-02. 17 June.

City of San Diego. 2011b. Storm Water Standards. January.

City of San Diego. 2010. Jurisdictional Urban Runoff Management Program Annual Report 2009-2010. September 30, 2010.

City of San Diego. 2010a. Chollas Creek and Paleta Creek Stormdrain Characterization Study – Final Report. July.

City of San Diego. 2010b. Municipal Park Irrigation Runoff Minimization – Technical Memorandum. Doc ID# CSD-TM-10-URS21-10. June 2010.

City of San Diego. 2010c. Preliminary Stormwater Reuse Best Management Practices and Artificial Turf Feasibility Study – Technical Memorandum. Doc ID# CSD-TM-10-URS21-02. 22 September.

City of San Diego. 2009. Characterization and Assessment of Stormdrain Sediments from Switzer Creek – Final. 20 March.

City of San Diego. 2009b. San Diego Municipal Code. Chapter 14, Article 2, Division 4 Landscape Regualtions. November 2009.

City of San Diego. 2004. Mission Bay Clean Beaches Initiative Bacterial Source Identification Study Final Report. 15 September.

City of Santee. 2009a. Santee Municipal Code. Title 17, Chapter 17.36 Landscape and Irrigation Regulations.

City of Santee. 2009b. Baseline Assessment of Current Residential Activities and Behavior Towards Pet Waste. Prepared by Deven O'Neil. 2009.

City of Tacoma. 2008. Summary, Measurement, and Assessment of Education and Outreach Programs – Attachment B16.

City of Vista. 2010. Jurisdictional Urban Runoff Management Program Annual Report 2009-2010. September, 2010.

Clean Water Education Program (CWEP). 2008. Pre- and Post-TV Campaign Surveys of Stormwater Awareness & Behavior in the CWEP Service Area: Comparisons and Findings, North Carolina.

County of San Diego. 2011. Jurisdictional Urban Runoff Management Program Annual Report 2009-2010. 2011.

County of San Diego. 2011a. Draft MS4 Cleaning BMP/Control Description. November.

County of San Diego. 2011b. Standard Urban Stormwater Mitigation Plan (SUSMP) Requirements for Development Applications. 8 January.

County of San Diego. 2010. San Luis Rey Watershed Septic Inventory Analysis Methodology and Results.

County of San Diego. 2010b. San Diego County Code Title 8, Division 6, Chapter 7 Water Conservation in Landscaping. 13 January 2010.

County of San Diego. 2008. Jurisdictional Urban Runoff Management Program.

County of San Diego. 2007. Low Impact Development Handbook, Stormwater Management Strategies. Department of Planning and Land Use. December.

County of Santa Cruz. 2006. Assessment of Sources of Bacteria Contamination at Santa Cruz County Beaches. March.

Davis, S.L., M.D. Dukes, G.L. Miller. 2008. Irrigation by Evapotranspiration-Based Irrigation Controllers in Florida. 29th Annual International Irrigation Show, Anaheim, CA. November.

Dudek, 2008. Supplemental Environmental Project- Quantifying threat to water quality from sewage spills from private properties and laterals and proposed control measures in the Santa Ana region of Orange County. Prepared for the Orange County Sanitation District. June 2008.

EOA, Inc. and Geosyntec Consultants. 2011. Sediment Management Practices: Clean Watershed for a Clean Bay Task 4 Literature Review. Prepared for the Bay Area Stormwater Management Agencies Association, June.

Ferguson, T., R. Gignac, M. Stoffan, A. Ibrahim, and H. Aldrich. 1997. Rouge River National Wet Weather Demonstration Project Cost Estimating Guidelines: Best Management Practices and Engineered Controls. Rouge River National Wet Weather Demonstration Project, Wayne County, MI.

Geosyntec Consultants. 2010a. Dry Weather Source Characterization and Control Summary, Santa Monica Bay Beaches Bacteria TMDL Implementation. Revised June, 2011.

Geosyntec Consultants. 2010b. Harbor Beaches of Ventura County (Kiddie Beach and Hobie Beach) Wet- Weather Bacteria Total Maximum Daily Load Implementation Plan for Unincorporated Ventura County. June.

Geosyntec Consultants. 2007. Quantitative Assessment Santa Monica Bay Bacteria TMDL Implementation Plan. Jurisdictional Groups 1 & 4. 8 January.

German, J. and G. Svensson. 2002. "Metal Content and Particle Size Distribution of Street Sediments and Street Sweeping Waste." *Water Science and Technology*, 46(6-7):191-198.

Grant, S.B., S.C. Jiang, B.F. Sanders, K. McLaughlin, J.H. Ahn, R. Litton, and L. Ho. 2009. Newport Bay Fecal Indicator Bacteria Source Identification Project. Submitted to the County of Orange and the California Santa Ana Regional Water Quality Control Board. 26 July.

Hardwick, N. 1997. Lake Sammamish Watershed Water Quality Survey. King County Water and Land Resources Division. Seattle, WA.

Haver, D.L. 2004. Mitigation efforts to protect natural environments in highly urbanized watersheds. 227th ACS National Meeting, Anaheim, CA, United States, March 28-April 1.

Herrera Environmental Consultants. 2006. Technical Memorandum: Nonstructural Stormwater BMP Assessment. Prepared for the City of Portland Bureau of Environmental Services. May.

Home and Garden Information Center (HGIC). 1996. Residential Fertilizer Use Survey. University of Maryland Cooperative Extension. College Park, MD. Unpublished.

Irvine, K., M. Perrelli, R. Ngoen-klan, and I. Droppo. 2009. Metal Levels in Street Sediment from an Industrial City: Spatial Trends, Chemical Fractionation, and Management Implications, J. Soils Sediments. 9:328-341.

Irvine Ranch Water District (IRWD). 2005. Orange County Green Vision Presentation. September 15. < www.lgc.org/freepub/docs/community_design/presentations/ huntington_bch2005/jones.pdf>

IRWD and Orange County Metropolitan Water District (OCMWD). 2004. Residential Runoff Reduction Study. Irvine Ranch Water District and Municipal Water District of Orange County. July. < www.irwd.com/alwayswatersmart/resources/research-technology/tabs/research-studies >

Imperial, M. and L. Jones. 2005. Evaluation of the Burnt Mill Creek Outreach and Demonstration Project: Final Report, Prepared for the City of Wilmington, NC.

Jang, Y.C., P. Jain, T. Tolaymat, B. Dubey, S. Singh, and T. Thownsend. 2010. "Characterization of Roadway Stormwater System Residuals for Reuse and Disposal Options." *Science of the Total Environment*. 408(8): 1878-1887. 15 March.

Kang, J., S. Debats, and M. Stenstrom. 2009. "Storm-Water Management Using Street Sweeping." *ASCE Journal of Environmental Engineering*, 135(7): 479-489.

Kitts, C., M.A. Moline, A. Schaffner, M. Samadpour, C. McNeil, and S. Duffield. 2002. Identifying the Sources of *Escherichia coli* Contamination to the Shellfish Growing Areas of the Morro Bay Estuary. March.

Kurahashi & Associates, Inc. 1997. Port of Seattle, Stormwater Treatment BMP Evaluation.

Law, N., K. DiBlasi, and U. Ghosh. 2008. Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Stormdrain Cleanout Programs in the Chesapeake Bay Basin. Prepared for the Center for Watershed Protection. University of Maryland Baltimore County.

Malcolm Pirnie, Inc. and Geosyntec Consultants, 2009. Dry-Weather Bacteria TMDL Implementation Plan for the Harbor Beaches of Ventura County (Kiddie Beach and Hobie Beach). June.

Minton, G.R., B. Lief, and R. Sutherland. 1998. "High efficiency sweeping or Clean a Street, Save a Salmon!" *Stormwater Treatment Northwest.* 4(4). November.

Minton, G. and R. Sutherland. 2010. "Street Dirt: A Better Way of Measuring BMP Effectiveness," *Stormwater Magazine*. p. 12-22. March/April.

Montgomery County Department of Environmental Protection. 2002. Street Sweeping for Pollutant Removal. Montgomery County, MD. February. <http://h2o.enr.state.nc.us/nps/documents/MDstreetsweepingreview.pdf>

Murray, J., P. Holden, B. Sercu, and L. Van De Werfhorst. 2011. Protocol for Source Tracking Sewage Contamination in Coastal California Urban Drains and Creeks. Presentation at StormCon. August 23.

Pitt, R. 2002. "Emerging stormwater controls for critical source areas." *Management of Wet-Weather Flow in the Watershed*. Sullivan, D. & Field R. (Eds). p. 14-16. CRC Press, Boca Raton, FL.

Pitt, R. 1979. Demonstration of Nonpoint Pollution Abatement through Improved Street Cleaning Practices, EPA Report EPA-600/2-79-161. August.

Pitt, R. and P. Bissonette. 1985. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. Bellevue Urban Runoff Program. U.S. Environmental Protection Agency. Washington, D.C. EPA/600/S2-85/038.

Pitt, R. and S. Clark. 2006. Interactions between Catchbasin and Street Cleaning in Urban Drainages and Sediment Transport in Stormdrain Systems. Chapter 6, BMP Technology Symposium: Current and Future Directions, ASCE. pp. 94-125. May.

Pitt, R. and R. Field. 2004. Catch Basins and Inserts for the Control of Gross Solids and Conventional Stormwater Pollutants. ASCE World Water and Environmental Resources Congress, Salt Lake City, Utah. June 27 – July 1.

Pitt, R. and J. McLean. 1986. Toronto Area Watershed Management Strategy Study - Humber River Pilot Watershed Project. Ontario Ministry of the Environment, Toronto, Ontario, June.

Pitt, R., D. Williamson, J. Voorhees, and S. Clark. 2004. "Review of Historical Street Dust and Dirt Accumulation and Washoff Data." *Effective Modeling of Urban Water Systems.* W. James, K.N. Irvine, E.A McBean, and R.E. Pitt, (Eds.). ISBN 0-9736716-0-2. Chicago, IL.

RBF Consulting. 2011. Nonstructural BMP Fact Sheets. Prepared for the County of San Diego. 2011.

Regional Task Force on the Homeless (RTFH). 2011. The Regional Homeless Assessment Profile (RHAP) for San Diego County. Report and Presentation. 2011.

Roberts, G. 2009. Further Understanding of the Bacteria Dynamic – Lessons from Microbial Source Tracking, Presentation at the CASQA 2009 Annual Conference, November 2009.

Rokes, K. 2012, ChannelKeepers, city of Santa Barbara settle dirty water lawsuit; city to spend $26 million to updated sewage system. Santa Barbara Daily Sound. March 28, 2012.

Rosselot, K. 2007. Copper and Solids Removed via Street Sweeping. Report prepared for the Brake Pad Partnership. March.

Rosselot, K. 2006. Copper Released from Brake Pad Lining Wear in the San Francisco Bay Area. Report prepared for the Brake Pad Partnership. January.

Ruby, A. 2011. Source Prioritization Process for Bacteria, Draft. Report prepared for the County of San Diego. December 21, 2011.

San Diego River Watershed Urban Runoff Management Program (WURMP). 2011a. Annual Report. Appendix A Program Activity Summary Descriptions for Fiscal Year 2009-2010. January.

San Luis Rey River Watershed Urban Runoff Management Program (WURMP). 2011b. Urban Runoff Management Program Annual Report for Fiscal Year 2009-2010. January.

Santa Barbara County Environmental Health Services Division. October 1999. Lower Rincon Creek Watershed Study: A Field Investigation into the Sources of Fecal Contamination in the Lower Rincon Creek Watershed and Ocean Interface (Surfzone).

Schilling, J.G. 2005. Street Sweeping – Report No. 1, State of the Practice. Prepared for Ramsey-Washington Metro Watershed District. North St. Paul, Minnesota. June.

Schueler, T.R. 2000. "Microbes and Urban Watersheds: Concentrations, Sources, and Pathways." *The Practice of Watershed Protection*. Eds, T. Schueler and H. Holland. Center for Watershed Protection. Ellicott City, MD.

Schwarze Industries. 2004. "Virginia test further documents pickup of high efficiency sweepers." *American Sweeper*. 8(1).

Selbig, W.R. and R.T. Bannerman. 2007. Evaluation of Street Sweeping as a Stormwater Quality Management Tool in Three Residential Basins in Madison, Wisconsin. U.S. Geological Survey Scientific Investigations Report 2007-5156.

Stein, E.D., L.L. Tiefenthaler, and K.C. Schiff. 2007. Sources, Patterns and Mechanisms of Storm Water Pollutant Loading From Watersheds and Land Uses of the Greater Los Angeles Area, California, USA. Southern California Research Project (SCCWRP), Technical Report, 510. March 2007.

Steuer, J., W. Selbig, N. Hornewer, and J. Prey. 1997. Sources of Contamination in an Urban Basin in Marquette, Michigan and an Analysis of Concentrations, Loads, and Data Quality. U.S. Geological Survey, Water-Resources Investigations Report 97-4242.

Sutherland, R.C. 2011. "Street Sweeping 101: Using Street Sweepers to Improve Water and Air quality. *Stormwater Magazine*." Jan/Feb.

Sutherland, R.C. and S.L. Jelen. 2002. A Technique for Accurate Urban Runoff Load Estimation. Water Environment Federation. National TMDL Science and Policy 2002 Specialty Conference, November 13 –16. Phoenix, AZ.

Sutherland, R.C. and S.L. Jelen. 2002. Quantifying the Optimum Urban Runoff Pollutant Load Reductions Associated with Various Street and Catchbasin Cleaning Practices. Proc. 9th Int. Conf. Urban Drainage – Global Solutions for Urban Drainage.

Swann, C. 1999. A Survey of Residential Nutrient Behaviors in the Chesapeake Bay. Widener-Burrows, Inc. Chesapeake Research Consortium. Center for Watershed Protection, Ellicott City, Maryland.

Tetra Tech, 2012. Memo: CLRP Task 4 Initial Development of Non-Structural Solutions. February 7, 2012

URS Corporation. 2011. Targeted Aggressive Street Sweeping Pilot Program: Phase IV Speed Efficiency Study, prepared for the City of San Diego Stormwater Department. 31 May.

URS Corporation. 2010. Targeted Aggressive Street Sweeping Pilot Program: Phase III Median Sweeping Study, prepared for the City of San Diego Stormwater Department, San Diego, CA. 104 pp.

USEPA. 2011. A grant-funded pilot program focusing on cleaning up Coyote Creek. Clean Creeks, Healthy Communities Program Snapshot. 31 May.

Van der Wel, 1995. Dog Pollution. *The Magazine of the Hydrological Society of South Australia*.

Watershed Management Services of Anchorage. 2010. Anchorage MS4 Street Sweeping Report for 2010. WMP CPr11001. January.

Watershed Management Services of Anchorage. 2003. Fecal Coliform in Anchorage Streams: Sources and Transport Processes. Department of Public Works. APg03001. September.

Weston Solutions. 2010a. City of San Diego Targeted Aggressive Street Sweeping Pilot Study Assessment Final Report, Prepared for City of San Diego Stormwater Department. San Diego, CA. 77 pp.

Weston Solutions. 2010b. Rain Barrel Downspout Disconnect BMP Effectiveness Monitoring and Operations Program Final Report. Prepared for City of San Diego Storm Water Department. San Diego, CA. 62 pp.

Weston Solutions. 2009a. San Diego River Source Tracking Investigation – Phase I, Final Report Revision 1. Prepared for City of San Diego Storm Water Department. San Diego, CA. 132 pp.

Weston Solutions. 2009b. San Diego River Source Tracking Investigation – Phase II, Final Report Revision 1. Prepared for City of San Diego Storm Water Department. San Diego, CA.

Weston Solutions. 2004. San Diego River – Ocean Beach Water Quality Improvement Project – Phase II Kelp and Dog Waste Management Plan, Prepared for the City of San Diego. San Diego, CA. September.

* * * * *

Appendix F

3990 Old Town Avenue, Suite B-101
San Diego, CA 92110
PH 619.297.1530
www.geosyntec.com

Memorandum

Date: 1 December 2011

To: Todd Snyder, Stephanie Gaines, County of San Diego

From: Christian Braun, Brandon Steets, P.E., Ken Susilo, P.E., and Erica Meyers, Geosyntec Consultants

Subject: San Diego River Watershed Comprehensive Load Reduction Plan
Identification of Structural BMP Types
County of San Diego Reference: Task Order 7
Geosyntec Project No. LA0228.07

1.0 INTRODUCTION

1.1 Purpose and Objectives

The San Diego River (SDR) Watershed Comprehensive Load Reduction Plan (CLRP) will include source area assessment, Best Management Practices (BMP) prioritization, and pollutant load modeling. Centralized and distributed structural BMP alternatives will be identified based on: (1) known bacteria and nutrient sources identified in existing studies, including the bacteria source identification project being led by the Copermittee Monitoring Workgroup; (2) receiving water and MS4 monitoring data; (3) BMP performance data, including data on structural BMPs from the American Society of Civil Engineers/U.S. Environmental Protection Agency International BMP Database (2010) and nonstructural BMPs from the Copermittee Program Planning Subcommittee project to evaluate nonstructural control measures; and 4) experience with other southern California bacterial Total Maximum Daily Load (TMDL) Implementation Plans (IPs) and CLRPs. The Structural BMP Prioritization and Analysis Tool (SBPAT) is a model and decision support tool that is being used as part of the overall CLRP development process.

The objective of this memorandum is to describe the structural BMP options that will be considered in the CLRP; a subsequent memo will address nonstructural BMPs. Section 2 provides a summary of expected BMP bacteria and nutrient reduction performance by BMP type, based on data on fecal indicator bacteria (FIB), nitrogen, and phosphorus concentrations in BMP influent and effluent from the International BMP Database. Section 3 is an overview of structural BMP types that will be considered in the evaluation due to their effectiveness at reducing concentrations of FIB, nutrients, and other pollutants of concern (POCs). Section 4 summarizes the general and site-specific BMP evaluation steps that will contribute to the identification of structural BMP alternatives.

The strategy used to identify acceptable BMPs for reducing bacteria and other pollutant concentrations in the SDR watershed includes assessment of:

(1) ***BMP Performance:*** Which BMP types (or combinations of types) are most effective at reducing concentrations of FIB, nutrients, and other POCs?
(2) ***Site-specific Constraints:*** Which BMP types are feasible given the location, parcel ownership, and physical characteristics of the site?
(3) ***Costs:*** Which BMP types are most cost-effective, both in capital expenditures and expected annual operations and maintenance costs?

1.2 Terms of Reference

The work described in this memorandum was conducted by Geosyntec Consultants for the County of San Diego for the San Diego River Watershed Comprehensive Load Reduction Plan, Task Order 7, Geosyntec Project No. LA0228.07. The primary author of this memorandum was Erica Meyers. Review was contributed by Brandon Steets, P.E., and Ken Susilo, P.E. in accordance with Geosyntec's quality assurance protocols.

2.0 BMP PEFORMANCE

In development of the CLRP, structural BMP identification will focus on measures that are most likely to significantly reduce FIB and nutrient concentrations. This section compares the performance of different BMP types for FIB and nutrient removal, based on analyses of the International Stormwater BMP Database conducted by Geosyntec and Wright Water Engineers, Inc. (2010).

Table 1 compares exceedance frequency of primary contact standards for influent and effluent from five treatment BMP categories—dry extended detention basins, retention (wet) ponds, media filters (e.g., sand filters), grass swales, and manufactured (i.e., proprietary) devices—based on measured inflow and outflow concentrations for all BMPs in each category that met data quality and quantity criteria (Wright Water Engineers, Inc. and Geosyntec Consultants, 2010). Performance of individual BMPs varies and may be higher or lower depending on BMP design and other factors. Disinfection systems, which would consistently achieve recreational standards, are not included in Table 1 as they are primarily used for treating dry weather flows.

Table 1: Percent Inflow/Outflow Values Greater than Primary Contact Recreation Standard (200MPN/100mL) for Fecal Coliform* (adapted from Wright Water Engineers, Inc. and Geosyntec Consultants, 2010)

	Detention Basin	Grass Swale	Manufactured Device	Media Filter	Retention Pond	Capture and Use	Infiltration
Influent Concentration	83 % (77-90)	85 % (77-94)	98 % (94-100)	74 % (65-83)	61 % (49-74)	No Data	No Data
Effluent Concentration	65 % (57-73)	93 % (87-99)	99 % (97-100)	59 % (49-69)	36 % (24-48)	0 %**	0 %**

* Percent exceedance 95 percent confidence intervals given in parentheses
**Assumed no exceedances due to full capture; capture/use and infiltration BMPS not included in BMP database

Of the BMPs included in the International Stormwater BMP Database, media filters (e.g., sand filters), retention (wet) ponds, and bioretention (not shown in the figure, but data are currently being added to the database) BMPs have proven to be most effective at reducing FIB concentrations, based on analysis of mean effluent fecal coliform concentrations (Wright Water Engineers, Inc. and Geosyntec Consultants, 2010).

BMPs that are effective at reducing FIB concentrations are typically also highly effective at reducing nutrient concentrations. BMPs most effective at removing nutrients include those with wet pools and/or filtration unit processes, including bioretention, wet ponds, constructed wetlands, media filters (e.g., sand filters), biofilters, (e.g., bioswales), and combinations of these. Design of specific BMPs or treatment trains for nutrient removal requires particular attention to nitrification/denitrification processes and removal of particulates for phosphorus reductions (Geosyntec and Wright Water Engineers, 2010).

Additionally, BMPs that reduce runoff volume, such as infiltration (e.g., basins, trenches, dry wells, and permeable pavements) or capture and use (e.g., cisterns and rainwater harvesting) BMPs, are expected to significantly reduce FIB and nutrient loading from urban runoff due to reduced mobilization and transport to storm drains and receiving waters.

Note that while no BMP *categories* shown in Table 1 produce effluent quality that meets the reference watershed allowed wet weather exceedance frequency (22%, as required by the TMDL reference watershed approach) for fecal coliform, exceedance percentages for *individual BMPs or combinations of BMPs* can meet requirements. Incorporating siting choices and design characteristics of the most effective BMPs will reduce exceedance percentages for TMDL compliance. No discharge (below a design flowrate or volume) BMPs such as infiltration and capture/use systems will achieve this threshold, in addition to carefully designed filtration BMPs and subsurface wetlands. Maximizing effectiveness of structural BMPs will involve choosing BMP types that will be most effective at reducing FIB concentrations, designing BMPs for site-specific conditions to maximize effectiveness, capturing or infiltrating stormwater when possible to reduce bacteria and nutrient loads, combining multiple BMPs into treatment trains, and/or using advanced treatment techniques.

3.0 BMP TYPES

The BMP types discussed in this memorandum include those BMPs that are likely to achieve, either alone or as part of a treatment train, the bacteria concentration reductions necessary to comply with the TMDL. BMPs are classified in this memorandum as infiltration, capture and use, natural treatment (i.e., biotreatment) or filtration, advanced treatment or proprietary, infrastructure improvements, and pretreatment BMPs. BMPs in each group are likely to have similar treatment processes, pollution reduction benefits, and site constraints. Each classification includes centralized (regional or subregional stormwater systems that treat stormwater from large areas) and/or distributed (stormwater devices dispersed throughout a catchment that treat relatively small drainage areas) BMP types. For the purpose of BMP selection, the threshold for distinguishing between centralized and distributed treatment controls is a footprint of one acre.

Distributed BMPs typically have fewer implementation constraints, which are specific to site characteristics and land ownership. Constraints for centralized systems are more common and include the distance to storm drain or drainage channel, parcel size and land ownership, and BMP-specific constraints such as soil type or geotechnical constraints. A description of each BMP, constraints to implementation, design considerations, and figures showing examples are included in the sections below.

3.1 Infiltration BMPs

Infiltration BMPs are typically highly effective at reducing bacteria and nutrient loadings in stormwater either alone or as part of a treatment train (which would include filtration and/or settling of solids prior to infiltration). Constraints preventing implementation of infiltration BMPs include shallow depth to groundwater, soil infiltration rates less than 0.52 in/hr, geotechnical hazards, soil or groundwater contamination, proximity (within 100 feet) to an onsite septic system or drinking water well, and slopes greater than 25 percent (County of San Diego, 2007). Examples of infiltration BMPs are discussed below and shown in Figure 1.

- *Infiltration Basins, Trenches, and Galleries (Centralized or Distributed)*
  An infiltration basin consists of an earthen basin constructed in naturally pervious soils with a flat bottom typically vegetated with dry-land grasses. The basin functions by retaining the design runoff volume and allowing it to percolate into the underlying soils over a specified period of time. Infiltration trenches, which are similar to basins, are long, narrow, gravel-filled trenches, often vegetated, that infiltrate stormwater runoff from smaller drainage areas. Infiltration trenches may include a shallow depression at the surface, but the majority of runoff is stored in the void space within the gravel and

infiltrates through the sides and bottom of the trench. Infiltration galleries are open-bottom, subsurface vaults that store and infiltrate stormwater.

- *Bioretention (Centralized or Distributed)*
  Bioretention stormwater treatment facilities are landscaped shallow depressions that capture and filter stormwater runoff. These facilities function as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. The facilities normally consist of a ponding area, mulch layer, planting soils, plantings, and, optionally, a subsurface gravel reservoir layer.

- *Dry Wells or Hybrid Bioretention/Dry Wells (Centralized or Distributed)*
  Dry wells or bioretention facilities with dry wells are useful in areas with low surface-level hydraulic conductivities that would normally deem an infiltration BMP infeasible but have higher levels of permeability in deeper strata. By incorporating drywells, water is able to be infiltrated at deeper soil layers that are suitable for infiltration. A hybrid bioretention/dry well BMP combines the aesthetic and filtration qualities of a bioretention facility with the enhanced infiltration capabilities of a dry well.

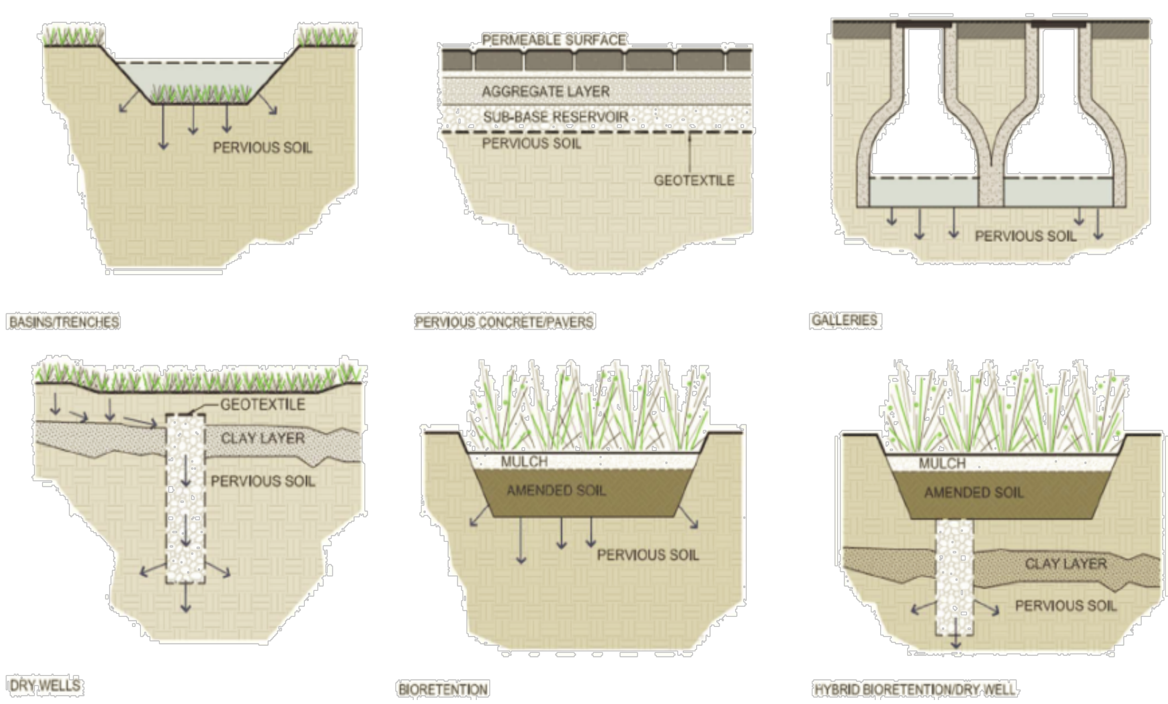


Figure 1: Infiltration BMP configurations (Susilo et al., 2011)

- *Permeable Pavements (Distributed)*
  Permeable (or pervious) pavements contain small voids that allow water to pass through to a stone base. They come in a variety of forms; they may be a modular paving system (e.g., permeable pavers, modular plastic grid pavers) or poured-in-place pavement (e.g., pervious concrete, permeable asphalt). All permeable pavements with a stone reservoir base treat stormwater and remove sediments and metals to some degree by allowing stormwater to percolate through the pavement and enter the soil below.

3.2 Capture and Use

Capture and use, or rainwater harvesting, refers to a type of distributed BMP that operates by capturing stormwater runoff and holding it for efficient use at a later time. Captured stormwater is used (versus reused) as it has not been previously utilized or consumed. On a commercial or industrial scale, capture and use BMPs are typically synonymous with cisterns, which can be implemented both above and below ground. Cisterns are sized to store a specified volume of water with no surface discharge until this volume is exceeded.

The primary use of captured runoff is currently primarily for subsurface drip irrigation purposes[1]. The temporary storage of roof runoff reduces the runoff volume from a property and may reduce the peak runoff velocity for small, frequently occurring storms. In addition, by reducing the amount of stormwater runoff that flows overland into a stormwater conveyance system, loads of FIB and other pollutants are reduced. Onsite use of the harvested water for non-potable domestic purposes conserves potable water and, where directed to unpaved surfaces, can recharge groundwater in local aquifers.

A constraint to water harvesting in Southern California is the seasonality of rainfall, with most precipitation falling during the winter months when irrigation need is lower. Depending on the drainage area and size of capture systems, as well as water requirements of vegetation at a site, rainwater harvesting can greatly reduce the need for municipal water sources for irrigation. Capture and use BMPs may be tied into real-time controller systems to increase efficiencies and cost-effectiveness (Erb et. al, 2011).

3.3 Natural Treatment or Filtration

Biofiltration BMPs are vegetated facilities that utilize natural treatment systems to capture and treat stormwater runoff through a variety of physical and biological treatment processes. Facilities may consist of a ponding area, mulch layer, planting soils, plants, and in some cases,

[1] Additional potential uses of captured stormwater are currently under evaluation by various local and regional Health Department agencies and MS4 operators within the State of California.

an underdrain. Runoff that passes through a biofiltration system is treated by the natural adsorption and filtration characteristics of the plants, soils, and microbes. Biofiltration BMPs include constructed wetlands, subsurface flow wetlands, biofiltration or bioinfiltration facilities with underdrains, planter boxes, and green streets. Biofiltration can provide multiple benefits, including significant FIB, nutrient, and other pollutant removal (Wright Water Engineers, Inc. and Geosyntec Consultants, 2010), peak flow control, aesthetic value, and low amounts of volume reduction through infiltration and evapotranspiration.

- *Constructed Wetland/Wetpond (Centralized)*
  Constructed wetlands (shown in Figure 2) include a permanent or seasonal pool of water, and can include artificial lakes or other design features that allow them to be an aesthetic water feature as well as a stormwater treatment facility. Applications include peak flow attenuation and pollutant removal, including sedimentation, dilution, and biological processes. The permanent pool of water in constructed wetlands/wetponds improves treatment of fine particulates and provides treatment of dry weather flows. Constraints to wetland or wetpond construction include siting limitations (i.e., parcel size and ownership, proximity to storm drains or drainage channels, and presence of consistent flow) and regulatory constraints (e.g., permitting).

Figure 2: Example Constructed Southern California Wetland/Wet Pond (Photo: Geosyntec Consultants)

- *Subsurface Flow Wetlands (Centralized)*
  Subsurface flow wetlands (shown in Figure 3) are engineered, below ground treatment wetlands that include many of the natural treatment processes of surface flow constructed wetlands as well as the filtration mechanisms of media filters. Water flows through a granular matrix, which typically supports the growth of emergent wetland vegetation on the surface. The matrix provides a significant surface area for the filtration of particulate bound constituents and the growth of bacteria biofilms that metabolize and degrade many pollutant types including nutrients, bacteria, dissolved metals, and organic compounds through aerobic and anaerobic processes. Due to low treatment flow rates, a treatment train that includes a detention basin is typically needed to handle peak flows and provide consistent discharge to the wetlands.

Figure 3: Example Subsurface Flow Wetlands (Photo: S. Lyon)

- *Biofiltration/Bioinfiltration with or without Underdrain (Centralized or Distributed)*
  Biofiltration facilities (shown in figures 4 and 5) capture, filter, and infiltrate stormwater runoff. As stormwater passes down through the planting soil, pollutants are filtered, adsorbed, and biodegraded by the soil and plants. Because they are not contained within an impermeable structure, they may allow for infiltration. Bioinfiltration facilities are designed for partial infiltration of runoff and partial biotreatment. These facilities are similar to bioretention devices with underdrains (described above), but include a raised underdrain above a gravel sump designed to facilitate infiltration and nitrification/denitrification. Constraints for this type of BMP include adequate sunlight for vegetation growth, irrigation requirements (depending on vegetation type), and pretreatment requirements to avoid filter clogging. If the season high groundwater table

is within 6 feet of the ground surface, an underdrain is required (County of San Diego, 2007).

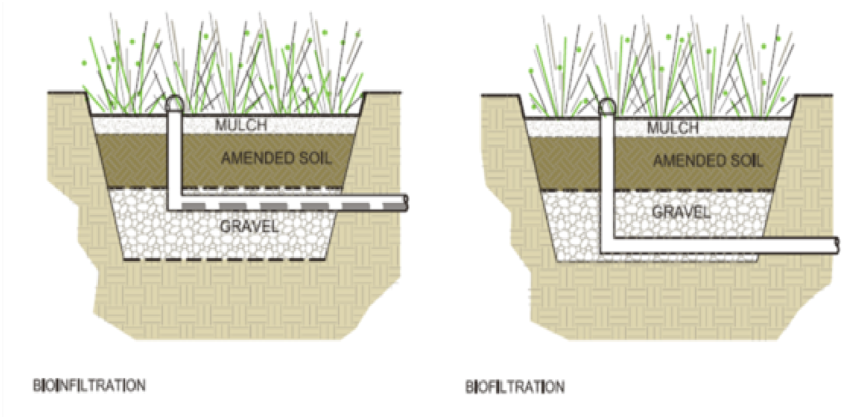


Figure 4: Example Biofiltration/Bioinfiltration Configurations (Susilo et al., 2011)

Figure 5: Bioretention with underdrain (Photo: NC State University)

- *Sand Filters (Distributed)*
  Sand filters include a pretreatment settling component and a filter bed filled with sand or a combination of absorptive filtering media over an underdrain. Sand filter design is highly adaptable to site limitations and constraints, and a number of proprietary devices exist with benefits of easy retrofit to existing storm sewer systems or inclusion of

aesthetically appealing landscaping or other biofiltration components. Well-designed sand filters can be highly effective at reducing concentrations of bacteria, phosphorus, and organic nitrogen.

- *Planter Boxes (Distributed)*
  Planter boxes (shown in Figure 6) are bioretention treatment control measures that are completely contained within an impermeable structure with an underdrain (they do not infiltrate). They are similar to bioretention facilities with underdrains except they are situated at or above ground and are bound by impermeable walls. Planter boxes may be placed adjacent to or near buildings, other structures, or sidewalks.

Figure 6: Example Planter Boxes (Susilo et al, 2011)

- *Green Streets (Distributed)*
  Green streets (shown in Figure 7) are a combination of BMPs designed to maintain pre-development hydrology and reduce pollutant loads from stormwater runoff from roadways. Green streets projects may involve treatment trains of permeable pavements, filter strips, vegetative swales, bioretention, or other distributed BMPs. An additional benefit of green streets projects is aesthetic value. Limitations to green street retrofits include local zoning standards that may determine which techniques may be applicable, including requiring wide streets, sidewalks, and/or curbed roads.

3.1 Advanced Treatment and Proprietary Devices

Advanced treatment and proprietary devices are additional options for stormwater treatment for bacteria and other pollutants. Stormwater treatment and/or disinfection can be highly effective at reducing bacteria. Additionally, many proprietary devices exist that fit into, combine, or expand on the BMP types listed above. While manufactured proprietary devices as a category were not found to reduce FIB concentrations (Wright Water Engineers, Inc. and Geosyntec Consultants, 2010), specific devices may perform effectively at reducing concentrations of FIB and other pollutants. Proof of performance for proprietary devices should be provided by adequate third party field testing.

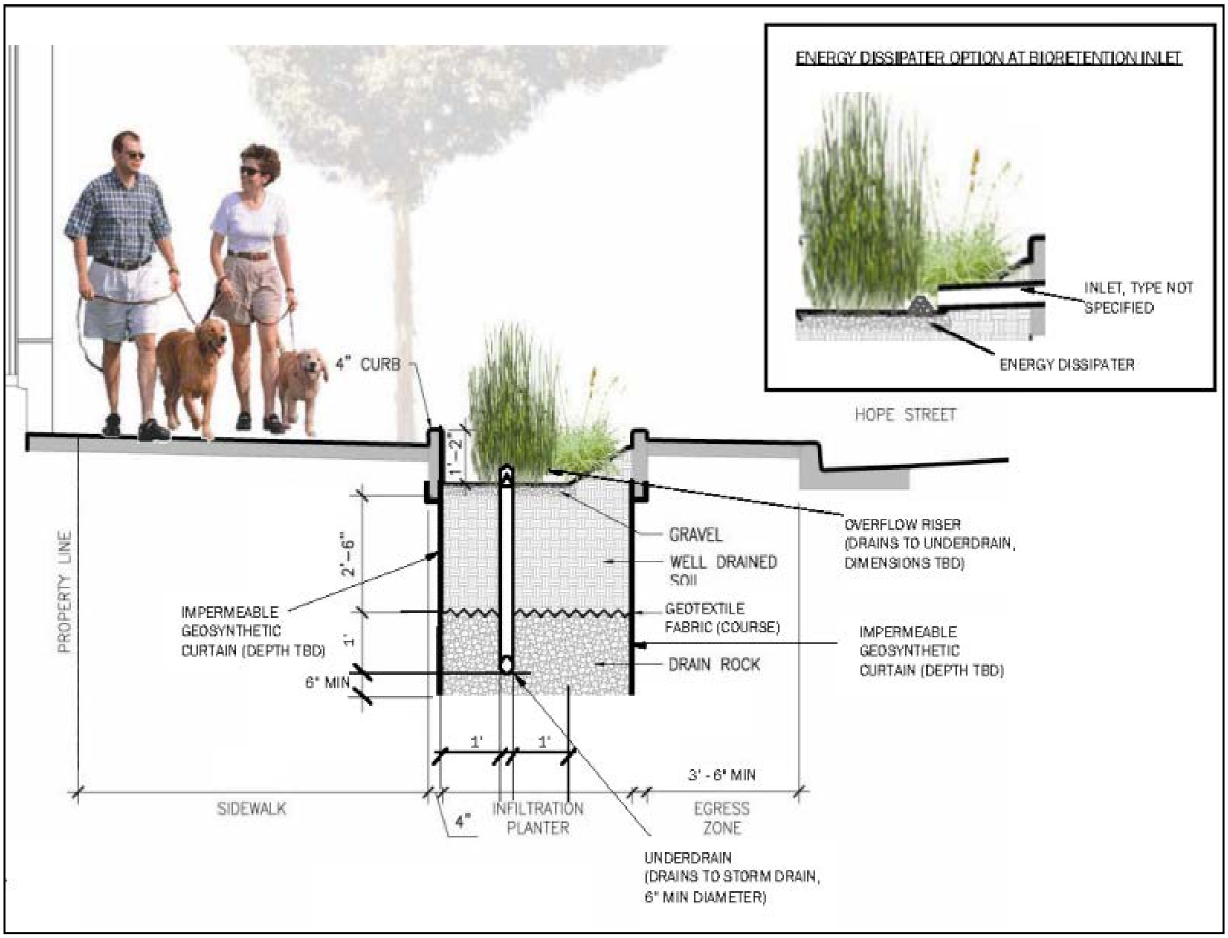


Figure 7: Example Urban Green Street Section (Susilo and Abe 2010)

Low Flow Diversion to Disinfection/Treatment Plants (Centralized)
Disinfection involves diverting runoff from the storm drain system to a conventional stormwater treatment facility that provides treatment and disinfection. Advanced treatment can be highly effective at reducing bacteria concentrations in the discharges they treat, but can be costly and is typically used to treat baseflows in locations directly proximal to beaches or swimming areas.

Proprietary Devices (Centralized and Distributed)
Proprietary devices exist that fit in many of the categories listed above and include stormwater treatment systems with technology that provides higher treatment capacity with smaller footprints. For example, a number of vendors offer prefabricated, modular

infiltration galleries in a variety of materials, shapes, and sizes that provide subsurface storage and allow for infiltration. Additionally, high-flow biotreatment devices are available that incorporate plants, soil, and microbes engineered to provide treatment at higher flow rates and with smaller footprints relative to other systems.

3.2 Infrastructure Improvement and Ancillary/Source Control BMPs

Infrastructure improvements, such as retrofitting sewer lines and repairing storm drains, are potential highly effective at reducing bacteria, nutrients, and other POCs from illicit point sources. Sanitary sewer and MS4 cross-connections, exfiltration of groundwater to MS4s, and aging sewer lines can be significant sources of bacteria and nutrients. While infrastructure improvement and retrofit is a structural solution, identification of locations for improvements would be performed as part of a nonstructural BMP. Illicit Discharge Detection and Elimination (IDDE) programs or special bacteria source tracking studies would inform the locations and design of structural repairs. These programs and their potential effectiveness will be discussed in greater detail in the nonstructural BMP technical memorandum.

3.3 Pretreatment BMPs

Additionally, “pretreatment” BMPs for use as part of a treatment train provide additional benefit of POC reduction or improve the efficiency of other structural BMPs. Functions of pretreatment BMPs include gross solids removal (e.g., hydrodynamic devices, trash racks), biofiltration (e.g., vegetated filter strips, vegetated swales), and settling and storage (e.g., extended detention basins). Pretreated stormwater is then conveyed to an infiltration, biofiltration, or other structural BMP. While expected to be very effective at reducing bacteria concentrations, quantifying the bacteria reduction benefits of pretreatment BMPs in a treatment train is unfortunately not yet possible using available data or SBPAT BMP modeling. As additional data from monitoring of treatment trains containing multiple BMPs become available in the future, it may be possible to quantify the benefits of these structural BMPs.

4.0 GENERAL AND SITE-SPECIFIC BMP EVALUATION AND SCREENING

An initial assessment of the suitability of the BMPs discussed in the previous section will be determined using the General BMP Evaluation processes in SBPAT, site-specific desktop and field screening for BMP implementability, and knowledge gained from experience with other Southern California bacteria TMDL IPs and CLRPs. Figure 8 shows the inputs that will inform which structural BMP alternatives are identified in the SDR Watershed CLRP.

The objective of the general BMP screening phase of SBPAT is to prioritize BMPs for catchment-level site-specific feasibility assessment and implementation planning by assessing the relative implementation feasibility of specific types of centralized and distributed BMPs for each watershed catchment that has been determined to have high water quality need (based on existing studies, SBPAT Catchment Prioritization Index (CPI) scores, and receiving water and MS4 monitoring data).

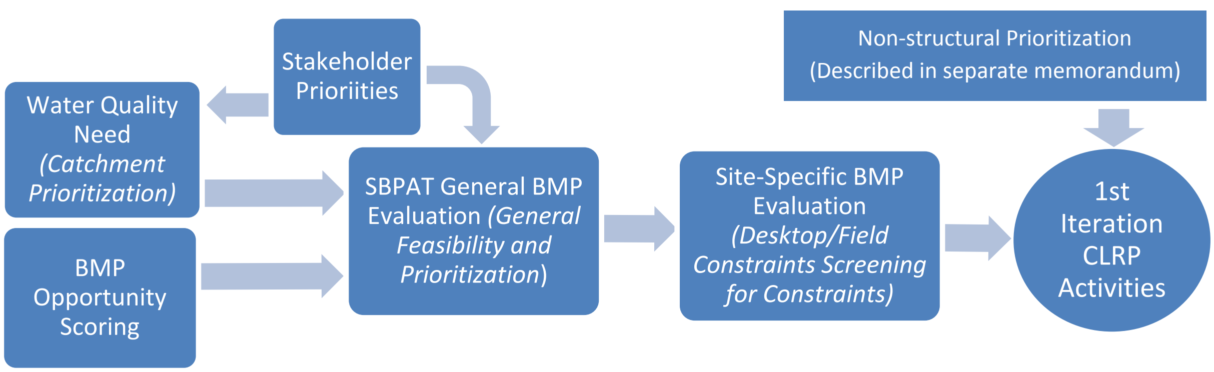


Figure 8: Structural BMP Selection Methodology

Next, a site-specific BMP evaluation of high priority sites will provide site-specific BMP implementability information, including "fatal flaw" screening, implementation constraints assessment, and identification of conditions not readily discoverable by preliminary macro-level screening of BMPs. A GIS- and desktop-level screening will be conducted using available spatial data sets, including distance to storm drains or drainage channels, land ownership information, significant ecological areas, wetlands, slopes, soils, landslide/liquefaction zones, aerial imagery, impervious surfaces, and groundwater depths. A field-level screening of land uses, available open space, runoff drainage courses, and storm drain inlets would then be conducted for all sites still in consideration (i.e. those for which no fatal flaws were identified) after desktop screening.

5.0 REFERENCES

American Society of Civil Engineers Urban Water Resources Council and United States Environmental Protection Agency (ASCE/EPA), 2010. International Stormwater Best Management Practices Database

California Stormwater Quality Association (CASQA), 2003. Stormwater Best Management Practices Handbook New Development and Redevelopment.

City of Los Angeles, 2011. Draft Development Best Management Practices Handbook. Working Draft of LID Manual. June 2011.

City of San Diego, 2011. Storm Water Standards. January 2011.

County of San Diego, 2007. Low Impact Development Handbook, Stormwater Management Strategies. Department of Planning and Land Use. December 2007.

Erb, Tam, Kharaghani, Hanna, Poresky, and Reidy, 2011. Stormwater as a Resource: Rainwater Harvesting in the City of Los Angeles. Proceedings - WEFTEC 2011. Los Angeles, CA. Oct 18.

Geosyntec Consultants, 2006. Los Angeles County-wide Structural BMP Prioritization Methodology. Appendix D: Basis for Relative BMP Cost Scores

Geosyntec Consultants, 2008. A User's Guide for the Structural BMP Prioritization and Analysis Tool (SBPAT v1.0). December 2008.

Geosyntec Consultants and Wright Water Engineers, Inc., 2010. International Stormwater BMP Database, Nutrients Technical Report. December 2010.

Susilo and Abe, 2011. Green Streets in Southern California: Transformation of basic street infrastructure to a conversation of beauty and environmental enhancements. Proceedings - 2010 International Low Impact Development Conference. San Francisco, CA. April 11-14.

Susilo, Wessel, and Scaduto, 2011. City of Los Angeles Low Impact Development Handbook. Presentation at CASQA Annual Conference. Monterey, CA. September 27.

Water Environment Research Foundation (WERF), 2005. Critical Assessment of Stormwater Treatment and Control Selection Issues. Report No. 02-SW-1. 2005.

Wright Water Engineers, Inc. and Geosyntec Consultants, 2010. International Stormwater BMP Database, Bacteria Technical Report. December 2010.

* * * * *

Appendix G

BMP Name	Wet or Dry Weather	Land Use Targeted	Pollutant Generating Activity	Quantification Assumptions			Quantification Method	Expected Annual Reduction of MS4 Baseline Load[1] by 2031 (10^12 MPN Fecal Coliform)		Estimated Implementation Cost	
				Load Assumption	Units	Citation/Assumptions		Low Range	High Range	Capital Costs Low Range High Range	O&M Costs (20 Year present value) Low Range High Range
1st Priority (Human sources or dry weather)											
Identification and Control of Sewer Discharges to MS4 (Upgrades to sanitary and stormdrain systems, inspections, enforcements, outreach)	Primarily Winter Dry Weather	MS4 Conveyance System	Leaking sewers, illegal discharges, illicit connections, illegal dumping, RVs	4.9	10 ^12 Monthly Average MS4 FIB-FC dry-weather load in watershed	Calculated by TMDL model, which was calibrated to monitoring data	(monthly bacteria load) * (months of winter dry weather) * (percent bacteria from human sources) * (percent human contribution assumed from Illicit discharge sources) * (expected behavior change)	**0.061**	**1.8**	No additional cost	**$11,000,000** **$14,000,000** [based on 7-9 employees working 80% time with an average annual cost (salary, overhead, and benefits) of $125,000/year, plus 20% contingency costs] and **$140,000,000** **$430,000,000** for annual stormdrain and/or sewer repair and replacement in addition to existing CIP budget
				5	Months during Winter dry weather						
				5-20%	Percent of dry-weather fecal bacteria having human sources	Estimate based on analysis of data for source tracking study in Oceanside					
				50-75%	Percent human contribution from sewer discharge to MS4	Best Professional Judgement					
				10-50%	Percent expected reduction from sewer discharge controls	Best Professional Judgement					
	Primarily Summer Dry Weather	MS4 Conveyance System	Leaking sewers, illegal discharges, illicit connections, illegal dumping, RVs	4.9	10 ^12 Monthly Average MS4 FIB-FC dry-weather load in watershed	Calculated by TMDL model, which was calibrated to monitoring data	(monthly bacteria load) * (months of summer dry weather) * (percent bacteria from human sources) * (percent human contribution assumed from Illicit discharge sources) * (expected behavior change)	**0.017**	**1.3**		
				7	Months during Summer dry weather						
				1-10%	Percent of dry-weather fecal bacteria having human sources	Estimate based on analysis of data for source tracking study in Oceanside					
				50-75%	Percent human contribution from sewer discharge to MS4	Best Professional Judgement					
				10-50%	Percent expected reduction from sewer discharge controls	Best Professional Judgement					
Homelessness Waste Management Program Enhancements (NGO partnerships, encampment cleanouts, and enforcements)	Primarily Wet Weather	All urban spaces where homeless encampments are found	Homeless encampments	12,422 - 14,177	10 ^12 Low and High Watershed FIB-FC wet-weather load (Baseline 1993)	Calculated in SBPAT & comparable to TMDL model load, which was calibrated to monitoring data	(annual bacteria load) * (percent bacteria from human sources) * (percent human contribution assumed from homeless) * (expected behavior change)	**6.2** (Combined load reduction from river and MS4)	**710** (Combined load reduction from river and MS4)	No additional cost	**$3,300,000** **$11,000,000** [based on program costs of 20% and 8 part-time police officers patrolling (without or with overtime) with an average annual cost (salary, overhead, and benefits) of $130,000/year]
				5-20%	Percent of wet-weather fecal bacteria having human sources in River and MS4	Estimate based on analysis of data for source tracking study in Oceanside					
				10-50%	Percent human contribution from homeless sources	Best Professional Judgement					
				10-50%	Percent expected reduction from program enhancements	Best Professional Judgement					
Onsite Wastewater Treatment Source Reduction (Septic inspection, enforcement, outreach)	Primarily Wet Weather	Rural Residential	Leaky, failing septic systems	Not sufficient data to quantify at this time						No additional cost	No additional cost (Currently being implemented)
Irrigation Runoff Reduction Enhancements (Incentatives, outreach, and education)	Dry Weather	Residential and Commercial	Irrigation runoff, fertilizers/compost, soil and decaying plant matter, green waste	4.9	10 ^12 Monthly Average MS4 FIB-FC dry-weather load in watershed	Calculated by TMDL model, which was calibrated to monitoring data	(monthly bacteria load) * (12 months per year) * (percent bacteria from runoff) * (percent of runoff from irrigation) * (expected behavior change)	**4.3**	**19**	**$4,800,000** **$15,000,000** (based on estimated $100-200 per system incentive and program costs)	**$2,000,000** **$5,900,000** [based on 1-3 employees working 100% time with an average annual cost (salary, overhead, and benefits) of $125,000/year plus 20% contingency costs]
				50-80%	Percent of MS4 dry-weather flows (and fecal bacteria loads) from commercial and residential runoff	Best Professional Judgement					
				59-80%	Percent of commercial and residential runoff load generated residential and commercial from irrigation	San Diego River Source ID study, 2009					
				25-50%	Percent reduction in irrigation runoff from irrigation control incentives	Orange County irrigation runoff study, 2004					
Commercial/Industrial Good Housekeeping Enhancements (Inspection, enforcement, outreach)	Dry Weather and Wet Weather	Commerical	Dumpsters, outdoor garbage areas, garbage trucks, grease bins, outdoor dining/fast food, washwater	4.9	10 ^12 Monthly Average MS4 FIB-FC dry-weather load in watershed	Calculated by TMDL model, which was calibrated to monitoring data	(monthly bacteria load) * (12 months per year) * (percent bacteria from runoff) * (percent of runoff from commercial activities) * (increase in inspection) * (expected behavior change)	**0.41**	**3.2**	No additional cost	**$8,800,000** **$10,000,000** [Estimate doubling current practices. Scaled from San Diego County and City of San Diego current rates]
				25-40%	Percent of MS4 dry-weather flows (and fecal bacteria loads) from commercial runoff	Best Professional Judgement					
				15-27%	Percent of commercial runoff load generated from commercial activities	San Diego River Source ID study, 2009					
				25-50%	Percent of commercial area covered by increased inspection	San Diego County JURMP					

1. The MS4 baseline load for wet weather was calculated in SBPAT and the 25th and 75th Percentiles of the annual load was used to create these ranges.
The MS4 baseline load for dry weather was calculated by the TMDL model as a monthly average load.

BMP Name	Wet or Dry Weather	Land Use Targeted	Pollutant Generating Activity	Quantification Assumptions			Quantification Method	Expected Annual Reduction of MS4 Baseline Load[1] by 2031 (10^12 MPN Fecal Coliform)		Estimated Implementation Cost	
				Load Assumption	Units	Citation/Assumptions		Low Range	High Range	Capital Costs Low Range High Range	O&M Costs (20 Year present value) Low Range High Range
				75-100%	Percent reduction in bacteria loads from enhanced inspections	San Diego County JURMP					

1. The MS4 baseline load for wet weather was calculated in SBPAT and the 25th and 75th Percentiles of the annual load was used to create these ranges.
The MS4 baseline load for dry weather was calculated by the TMDL model as a monthly average load.

BMP Name	Wet or Dry Weather	Land Use Targeted	Pollutant Generating Activity	Quantification Assumptions			Quantification Method	Expected Annual Reduction of MS4 Baseline Load[1] by 2031 (10^12 MPN Fecal Coliform)		Estimated Implementation Cost	
				Load Assumption	Units	Citation/Assumptions		Low Range	High Range	Capital Costs Low Range High Range	O&M Costs (20 Year present value) Low Range High Range
2nd Priority (Wet weather non-human sources)											
New Residential/Small-Scale LID Incentive Program (Incentives)	Wet Weather	Single Family Residential (SFR)	Residential Roofs	24,868	Acres of Single Family Residential in SDR Watershed	SANDAG Land Use Data	(residential area in watershed) * (percent of SFR that is rooftop) * [(expected percent of residential area converted to rain barrels) * (annual load reduction per acre conversion to rain barrels) + (expected percent of SFR disconnected to lawns) * (annual load reduction per acre from disconnection to lawn)]	**320**	**1300**	**$3,600,000** **$36,000,000** (based on estimated $200-500 per system incentive and program costs)	**$2,000,000** **$5,900,000** [based on 1-3 employees working 100% time with an average annual cost (salary, overhead, and benefits) of $125,000/year plus 20% contingency costs]
				35%	Percent of Single Family Residential Parcel that is Rooftop	Assumed from Ballona IP; Preliminary assessment of rooftop area in SDR showed roughly 33% rooftops, which supports this assumption					
				0.086	10 ^12 MPN reduction per impervious acre treated by rain barrels	Modeled in SBPAT, assumed 0.2 inch design storm (equates to one 55 gallon barrel for each 500 sq.-ft roof area), 10-day drain time; Would also reduce roof runoff by 18 percent on average annual basis					
				0.64	10 ^12 MPN annual reduction per impervious acre treated by disconnection to lawn	Modeled in SBPAT, assumed area receiving flow would have an infiltration rate of 0.15 in/hr. (C/B soils) and effective depression storage (including root zone) of 0.7 inches, and would be 1/4 the area of contributing flow; Would also reduce roof runoff by approximately 70 percent on an average annual basis					
				5-20%	Percent of Residential Area Converted to each downspout capture/use (i.e., rain barrels) and disconnected to pervious area.	Assumed 5-20% conversion over 15 years, based on expected effectiveness of incentives program.					
Pet Waste Program Enhancements (Signage, mutt mitts, outreach, etc.)	Wet Weather	Primarily Parks, Recreational Areas and Residential	Pets	11,162 - 12,740	10 ^12 Low and High MS4 FIB-FC wet-weather load in watershed (Baseline 1993)	Calculated in SBPAT & comparable to TMDL model load, which was calibrated to monitoring data	(annual bacteria load) * (percent bacteria from canine sources) * (expected behavior change) * (percent of contributing area)	**20**	**490**	**$130,000** **$270,000** (based on estimated $500-1000 per system installation costs and program costs)	**$290,000** **$3,500,000** (Costs to maintain dispensers range based on volunteer or agency maintenance)
				5 - 15%	Percent of indicator bacteria having canine sources	Estimate based on number of studies to be summarized in CLRP and Nonstructural Memo					
				9 - 37%	Estimated behavior change	City of Austin, 2008; City of San Diego, 2010					
				30-60%	Percent of contributing area covered by program enhancements	Best Professional Judgement					
Animal Facilities Management Enhancements (Inspection, Enforcement, Education and Outreach)	Primarily Wet Weather	Commercial and Rural Residential	Livestock, manure	Not sufficient data to quantify at this time						No additional cost	**$530,000** **$1,000,000** [Estimate doubling current practices. Scaled from San Diego County and City of San Diego current rates (assume 5-10% of commercial inspection costs)]

1. The MS4 baseline load for wet weather was calculated in SBPAT and the 25th and 75th Percentiles of the annual load was used to create these ranges.
The MS4 baseline load for dry weather was calculated by the TMDL model as a monthly average load.

BMP Name	Wet or Dry Weather	Land Use Targeted	Pollutant Generating Activity	Quantification Assumptions			Quantification Method	Expected Annual Reduction of MS4 Baseline Load[1] by 2031 (10^12 MPN Fecal Coliform)		Estimated Implementation Cost			
				Load Assumption	Units	Citation/Assumptions		Low Range	High Range	Capital Costs Low Range	Capital Costs High Range	O&M Costs (20 Year present value) Low Range	O&M Costs (20 Year present value) High Range
Programs implemented or improved since 2003													
Redevelopment and LID Implementation (SUSMP): Implementations 2003-2031 from existing SUSMP program	Wet Weather	All Land Uses covered under SUSMP	Urban development	0.183	10^12 MPN reduction per Residential Acre Converted	Modeled in SBPAT; Applied standard SUSMP-sized bioretention with underdrains to unit areas of various land uses in the Oceanside rainfall zone. The hypothetical BMP captures approximately 80% of average annual runoff volume and provides approximately 30 percent volume reduction	Sum for all land uses of (Load Reduction per Acre Converted) * (Acres Converted per Year) * (Years to 2031) * (+ or - 20%)	350	530	No additional cost (Currently being implemented)		No additional cost (Currently being implemented)	
				0.000	10^12 MPN reduction per Commercial Acre Converted								
				0.180	10^12 MPN reduction per Industrial Acre Converted								
				0.100	10^12 MPN reduction per Education Acre Converted								
				0.007	10^12 MPN reduction per Transportation Acre Converted								
				49	Acres Residential Converted per year (Land Use Redev. Rate = 0.18%)	Calculated by Extrapolating City of LA Redevelopment Rate From Ballona IP (rate shown in parentheses) to SDR by Land Use							
				5.1	Acres Commercial Converted per year (Land Use Redev. Rate = 0.15%)								
				12	Acres Industrial Converted per year (Land Use Redev. Rate = 0.34%)								
				3.9	Acres Education Converted per year (Land Use Redev. Rate = 0.16%)								
				370	Acres Transportation Converted per year (Land Use Redev. Rate = 2.7%)								
Pet Waste Program Implementations since 2003 (Signage, mutt mitts, outreach, etc.)	Wet Weather	Primarily Parks, Recreational Areas and Residential	Pets	11,162 - 12,740	10 ^12 Low and High MS4 FIB-FC wet-weather load in watershed (Baseline 1993)	Calculated in SBPAT & comparable to TMDL model load, which was calibrated to monitoring data	(annual bacteria load) * (percent bacteria from canine sources) * (expected behavior change) * (percent of contributing area)	5	210	No additional cost (Currently being implemented)		No additional cost (Currently being implemented)	
				5 - 15%	Percent of indicator bacteria having canine sources	Estimate based on number of studies to be summarized in CLRP and Nonstructural Memo							
				9 - 37%	Estimated behavior change	City of Austin, 2008; City of San Diego, 2010							
				20-40%	Percent of contributing area covered by existing program	Best Professional Judgement							
Street and Median Sweeping Implentations since 2003 and new enhancemnets (Increased routes and frequency)	Wet Weather	Residential, and Commercial Roadways	Streets, medians	25,000	additional curb miles of street swept per year	Data from the City of San Diego and La Mesa	(bacteria concentration per lb. of sediment) * (lbs of sediment removed per year) * (Rate of sediment mobilization to MS4) * (+ or - 20%)	1.1	3.2	No additional cost		$390,000	$470,000
				1,264	additional lbs. of sediment removed by street sweeping per year	Data from the City of San Diego and La Mesa						(Costs of minor enhancements to routes and frequencies)	
				10-20%	Rate street sediment assumed to mobilize by runoff to MS4	Pitt et al, 2004							
				0.00000521	10^12 colonies/lb. street sediment	Conservative estimate is minimum from Bannerman et al., 1993; Stuer et al, 1997; and Pitt and Maclean, 1986							
Drain Inlet and Conveyance System Cleaning	Primarily Wet Weather	MS4 Drain Inlets	Biofilm/Regrowth, trash, organic matter, sediment	Not sufficient data to quantify at this time						No additional cost		$550,000	$650,000
												(Costs of minor enhancements to routes and frequencies)	
Wet Weather Total							Total expected load reduction	700	3200	$3,700,000	$36,000,000	$7,100,000	$23,000,000
							% of average MS4 total load	6.3%	25%				
Dry Weather Total							Total expected load reduction	4.8	25	$4,800,000	$15,000,000	$22,000,000	$30,000,000
							% of average MS4 total load	8.1%	43%			$161,800,000	$459,900,000
												includes sewer repair & replacement	
Total								710	3300	$8,500,000	$51,000,000	$170,000,000	$480,000,000

1. The MS4 baseline load for wet weather was calculated in SBPAT and the 25th and 75th Percentiles of the annual load was used to create these ranges.
The MS4 baseline load for dry weather was calculated by the TMDL model as a monthly average load.

Appendix H

BMP Name	Caltrans						
	Water Quality (FIB-FC Load) Annual Benefits (10^12 MPN reduction/year)			Preliminary Range of Potential Costs (2011 $)			
				Potential Capital Costs		Potential O&M Costs (20 Year present value)	
	Low	High	Avg	Low	High	Low	High
Identification and Control of Illicit Discharges	Not Quantifiable			$0	$0	$140,000	$290,000
Identify and Repair Unstable Slopes	Not Quantifiable			$0	$0		
Homelessness Waste Management Program	0.34	7.9	4.1	$0	$0	$220,000	$450,000
Irrigation Runoff Reduction and Good Landscaping Practices	Not Quantifiable			$0	$0	$170,000	$340,000
Enhanced LID Implementation (Code Amendment and Training)	Not Quantifiable			$0	$0	$470,000	$940,000
Pet Waste Control and Pickup	Not Quantifiable			$0	$0	$7,300	$15,000
Good Housekeeping Programs (Washwater, Inspections, Trash Management)	0.062	0.083	0.0725	$0	$0	$820,000	$1,600,000
Land Conservation and Stewardship (Mitigation)	Not Quantifiable			$0	$0	$250,000	$490,000
Street and Median Sweeping	0.99	2.6	1.8	$0	$0	$950,000	$1,900,000
Drain Inlet and Conveyance System Cleaning	0.12	0.65	0.4	$0	$0	$110,000	$220,000
Wet Weather Total	1.5	11	6	$0	$0	$2,827,300	$5,615,000
Dry Weather Total	No Dry Weather Load			$0	$0	$310,000	$630,000
Totals	**1.5**	**11**	**6**	**$0**	**$0**	**$3,100,000**	**$6,300,000**

Appendix I

1. INTRODUCTION

1.1. Guiding Principles and Objectives:

The purpose of this Monitoring Plan (MP) is to describe the monitoring program that will be implemented within the San Diego River (SDR) Watershed in order to track the progress of Municipal Separate Storm Sewer Systems (MS4s) towards attaining compliance with the Total Maximum Daily Load (TMDL) for Indicator Bacteria (Bacteria TMDL), for beaches and creeks in the San Diego Region (SDRWQCB, 2010), and inform activities proposed and conducted as part of the SDR Comprehensive Load Reduction Plan (CLRP). This MP will describe four main types of monitoring:

1) Compliance Monitoring – this is defined here as required monitoring that is performed to meet the minimum monitoring requirements of the TMDL, for the purpose of tracking CLRP progress (in terms of water quality improvement) and assessing TMDL compliance;

2) Optional Monitoring – this is defined here as voluntary or optional monitoring that is performed based on Copermittee discretion to support compliance monitoring data collection (e.g., collection of turbidity and flow rate measurements along with bacteria samples);

3) Follow-up Monitoring – this is defined here as monitoring that is performed in response to an exceedance of interim targets or final WLAs based on compliance monitoring results (e.g., more frequent sample collection or the addition of outfall sampling), and;

4) Special Studies – this is defined here as separate voluntary monitoring studies that are performed based on Copermittee discretion to investigate specific research questions to support CLRP implementation planning and/or in preparation for the TMDL reopener.

This MP will describe such aspects of the program as monitoring locations and frequencies, analytical parameters and methods, and data analysis procedures that will be used to assess compliance with TMDL requirements.

In addition to describing monitoring activities, the MP will be used to support Comprehensive Load Reduction Plan (CLRP) adaptive management, by allowing for adjustment in compliance monitoring requirements based on sample results. This flexibility will also allow stakeholders to respond to changing conditions within the watershed that will likely occur over the course of the TMDL compliance period, for instance by implementing additional monitoring or studies to address potential sources of continuing exceedances, or by reducing or discontinuing monitoring in the case that compliance is achieved, reaches are delisted or the TMDL is modified.

1.2. TMDL Requirements Summary

1.2.1. TMDL segments being addressed

Within the SDR Watershed, the TMDL includes bacterial impairments for the Pacific Shoreline at the SDR Mouth at Dog Beach, as well as for Lower SDR and Forrester Creek. These are the locations within the SDR Watershed that are subject to the requirements of the Bacteria TMDL.

These locations are identified in the TMDL as Priority 3 (out of 3 with Priority 1 being the highest).

1.2.2. TMDL Compliance Monitoring Requirements

According to the TMDL, wet weather compliance monitoring samples should be collected "at least once within 24 hours of the end of a storm event that occurs during the rainy season", with the rainy season defined as October 1 through April 30 (SDRWQCB, 2010, p. A51).

Dry weather compliance monitoring should be conducted "at least on a monthly basis, and may be required more often during the summer months" (SDRWQCB, 2010, p. A51).

Wet weather days are defined by the TMDL as days with greater than or equal to 0.2" of precipitation, and the three following days. Dry weather days are defined as days with less than 0.1" precipitation where the previous three days had less than 0.2" precipitation.

The Lindbergh CCDA rain gauge will be used as the basis for defining wet and dry days and for triggering wet weather sampling, as discussed in Section 3.1.2 below.

1.2.3. TMDL compliance requirements

1.2.3.1. TMDL numeric targets

The TMDL numeric targets for beaches and creeks consist of REC-1 Water Quality Objectives (WQO) for fecal indicator bacteria (FIB) concentrations, as well as an allowable exceedance frequency (AEF), which is the percent of samples that may exceed the WQOs annually. The TMDL sets WQOs in terms of single sample maximums (SSMs) and 30-day geometric means (GMs). SSM limits apply to both wet and dry weather (though with different AEFs). GM limits apply to both the overall GM, including both wet and dry samples, as well as to the dry weather GM, which is calculated using only dry weather samples. The WQOs and AEFs for beaches are listed in Tables 1 and 2, and those for creeks are listed in Tables 3 and 4.[1]

The AEFs for overall and dry weather GMs are 0%, as is the dry weather SSM AEF. In other words, GMs and dry weather SSMs at the compliance monitoring point are not allowed to exceed the WQOs. For wet weather SSMs, however, the AEF is 22%.

The San Diego Regional Water Quality Control Board (SDRWQCB) set the TMDL AEF based on historic average exceedance rates observed at a reference beach, Leo Carillo Beach in Los Angeles County. This AEF was then applied to the TMDL critical year, 1993 (the 'wettest' year between 1990 and 2002, based on total number of wet days) to determine the number of allowable exceedance days (AEDs), which, in the SDR Watershed, is 19 days (based on 86 wet days during the critical year) (SDRWQCB 2010, p. A25). This AED value was then used, through modeling, to determine the mass-load based TMDLs and waste load allocations (WLAs) by discharge category, including MS4s. Since the AED was most directly used as the basis for the WLAs and is therefore considered to be protective, this CMP uses AEDs as the metric to evaluate TMDL compliance on an annual basis.[2] For the SDR Watershed, the AED is 19 days for the wet weather SSM, and 0 days for the dry weather SSM and the dry and overall GMs. Compliance with these AEDs is required by the end of the identified compliance timelines.

[1] All WQOs will be updated in the event that SDRWQCB updates the Basin Plan.

[2] Compliance will not solely be controlled by MS4 load reductions, but also by agriculture load reductions, variability in natural and/or unregulated loads, and annual hydrology (for example, if the actual number of wet days exceeds those of the TMDL critical year).

For the SDR Watershed, TMDL-required load reductions (required to meet WLAs) for wet and dry weather are apportioned entirely to MS4 sources. However, as stated above, exceedance days will be tracked based on monitoring results and will be used for comparison with the AEDs for TMDL compliance determination and progress assessment purposes.

Table 1: TMDL REC-1 SSM WQOs for beaches

Indicator Bacteria	WQO (MPN/100 mL)	Allowable Exceedance Frequency (wet/dry)
Fecal Coliform	400	22% / 0%
Total Coliform	10,000	22% / 0%
Enterococci	104	22% / 0%

Table 2: TMDL REC-1 GM WQOs for beaches

Indicator Bacteria	WQO (MPN/100 mL)	Allowable Exceedance Frequency
Fecal Coliform	200	0%
Total Coliform	1,000	0%
Enterococci	35	0%

Table 3: TMDL REC-1 SSM WQOs for creeks

Indicator Bacteria	WQO (MPN/100 mL)	Allowable Exceedance Frequency (wet/dry)
Fecal Coliform	400	22% / 0%
Enterococci	61[1]	22% / 0%

[1] A numeric objective for enterococci of 104 MPN/100 mL may be applied for creeks if they are designated in the Basin Plan as a "moderately to lightly used area." Otherwise, the more stringent target of 61 MPN/100 mL is used. Currently, neither SDR nor Forester Creek are designated in the Basin Plan as having a lower usage frequency.

Table 4: TMDL REC-1 GM WQOs for creeks

Indicator Bacteria	WQO (MPN/100 mL)	Allowable Exceedance Frequency
Fecal Coliform	200	0%
Enterococci	33	0%

1.2.3.2. TMDL compliance schedule

The following are key dates for TMDL implementation and compliance:

- April 4, 2011: TMDL effective date.
- October 2012: Submit CLRP to the RWQCB for approval.
- 2013: Compliance Monitoring start date.
- April 2016: TMDL reconsideration.
- April 2018: Interim dry weather numeric targets (50% AED reduction) become effective according to proposed Alternative Compliance Schedule.
- April 2018: Follow-up Monitoring initiated (if necessary)
- April 2021: Interim wet weather numeric targets (50% AED reduction) become effective according to proposed Alternative Compliance Schedule.
- April 2021: Compliance with final dry weather numeric targets is required.
- April 2031: Compliance with final wet weather numeric targets is required.

1.3. Summary of existing related monitoring programs

There are a number of ongoing monitoring activities in the SDR Watershed with regulatory drivers other than the TMDL, but which may be used to characterize trends of various constituents in the watershed.

Monitoring has been conducted at Dog Beach at the San Diego River outlet through the Assembly Bill 411 (AB411) beach monitoring program. Through this program, samples have been collected for enterococcus, fecal and total coliforms and E. coli since 1999.

In addition, several monitoring programs have been conducted in compliance with the San Diego County NPDES MS4 permit (RWQCB Order R9-2007-0001). A number of these programs include FIB sampling, such as:

- Wet weather monitoring in receiving water sites (i.e., Mass Loading Station and Temporary Watershed Assessment Stations)
- Annual jurisdictional dry weather monitoring (sampling in stormwater conveyances)
- MS4 outfall random and targeted monitoring
- Third-Party monitoring (i.e., City of Santee and Padre Dam Municipal Water District)

These data will be considered along with results of TMDL Compliance Monitoring and Special Studies to investigate spatial and temporal patterns of bacterial concentrations in the watershed.

1.4. Follow-up Monitoring

Follow-up Monitoring activities will be implemented as described in the following sections in the event that exceedances of WQOs continue to occur in receiving waters in order to characterize these exceedances (i.e. sources, locations, magnitude, duration, etc.) and to inform management decisions.

Specifics of Follow-up Monitoring activities will be described in detail in separate monitoring plans in the event that they are determined to be necessary, and are planned and approved by Copermittees.

1.5. Optional Monitoring

Optional Monitoring activities are not required by the TMDL and will be implemented at the discretion of the SDR Watershed Copermittees (Cities of San Diego, El Cajon, La Mesa, and Santee, County of San Diego, and Caltrans, hereafter referred to as the Copermittees), with the purpose of better understanding water quality conditions in receiving waters and supporting management decisions. At this time, no Optional Monitoring is being proposed for this watershed.

Specifics of Optional Monitoring activities will be described in detail in separate monitoring plans as these activities are planned and approved by Copermittees.

1.6. Special Studies

Special Studies will be implemented in order to fill identified knowledge gaps and provide additional data in order to support effective implementation of the Best Management Practices (BMPs) proposed in the CLRP.

2. Monitoring Location

2.1. Compliance Monitoring

The SDR beach, Lower SDR and Forrester Creek are addressed under the TMDL, which requires one compliance monitoring location per impaired beach, and two compliance monitoring locations per impaired creek. The CMP will use the existing AB411 monitoring location, Dog Beach at the SDR outlet, as the beach compliance monitoring location.

As described in the TMDL, creeks should have a minimum of two monitoring locations, one a location at or near the mouth of the creek, such as a Mass Loading Station (MLS), and at least one location upstream of the mouth, such as a Watershed Assessment Station. Based on this guidance, the SDR Watershed will contain four creek monitoring locations, two in Lower SDR and two in Forester Creek. These locations are shown in Figure 1 and are listed in Table 5 below.

Table 5: SDR Compliance Monitoring Locations

Monitoring Location	Latitude	Longitude
Dog Beach	32.75631	-117.25318
MLS	32.76515	-117.16863
Camino Del Este	32.77255	-117.14456
Forrester Creek	32.83986	-117.00395
Prospect Avenue	32.83130	-116.98572

2.2. Follow-up Monitoring

Per the TMDL, if exceedances of the numeric targets are observed in the monitoring data, additional monitoring locations and/or other source identification methods must be implemented to identify the sources causing the exceedances. Additionally, the locations and/or other source identification methods must also be used to demonstrate that the bacteria loads have been addressed.

Specific locations for Follow-up Monitoring will be detailed in a separate monitoring plan once these activities have been determined to be necessary. Options for Follow-up Monitoring that were identified in a compliance monitoring framework developed by the Copermittees (LWA 2011) include:

1) Upstream Monitoring
2) Representative Land Use Monitoring
3) Localized Outfall Monitoring, and
4) Source Identification Monitoring

2.3. Optional Monitoring

Optional Monitoring is not mandatory to meet TMDL monitoring requirements and may be suspended at any time. Locations for Optional Monitoring will be determined once these activities have been deemed necessary, planned and approved by Copermittees, and will be described in separate monitoring plans. At this time, no Optional Monitoring is being proposed for this watershed.

2.4. Special Studies

Specific special studies are not required by the TMDL. Monitoring locations for special studies will be detailed in separate monitoring plans for each study once approved by Copermittees.

3. Monitoring Frequency

3.1. Compliance Monitoring

3.1.1. Dry Weather

As described in the Bacteria TMDL, dry weather monitoring will occur monthly at a minimum. More frequent sampling may occur at the discretion of the Copermittees. This sampling will only occur on days with 0.1" or less precipitation and at least three days after a day with greater than or equal to 0.2" precipitation.

3.1.2. Wet Weather

A minimum of three (3) storms per year will be sampled, with at least one sample collected per storm. These samples will be collected according to the following schedule when possible: storm event 1, October to November; storm event 2, December to January; and, storm event 3, February to April.

Sampling will be triggered based on daily rain gauge measurements, with sampling occurring on the day after a calendar day with <0.2" that itself followed a day with >=0.2" (or the day after the daily rain total drops below 0.2"). The Lindbergh CCDA station will be used for weather tracking and triggering sampling. More frequent sampling may occur at the discretion of the Copermittees.

3.2. Other Monitoring Activities

If other monitoring activities – including Optional Monitoring, Follow-up Monitoring and Special Studies – are planned, monitoring frequencies will be described in a CMP amendment or an annual compliance monitoring report.

4. Sampling & Analysis Plan

4.1. Compliance Monitoring

4.1.1. Initiation of monitoring program

Compliance Monitoring will begin in 2013. San Diego County has submitted a request to the Regional Board to conduct a regional reference stream study in lieu of the Compliance Monitoring identified above until the reference stream study is completed.

4.1.2. Sample collection procedures

Samples will be collected using manual grab sample collection consistent with those currently used for the AB411 program.

4.1.3. Analytes

Beach samples will be analyzed for Enterococcus, Fecal and Total coliforms. Creek samples will be sampled for Enterococcus and Fecal coliforms.

4.1.4. Analytical methods

Analysis of compliance monitoring samples for FIB will be performed according to methods which are to be determined.

Laboratories performing these analyses will have up to date certification by the California Department of Health Services Environmental Laboratory Accreditation Program (ELAP). Analytical methods will be consistent with allowable methods described in the NPDES Permit, procedures used for the AB411 program, other approved EPA methods or a method from the "Standard Methods for the Examination of Water and Wastewater" (American Public Health Association 1992).

4.1.5. Quality considerations

Quality assurance and control methods (e.g., percent of samples for which duplicates will be collected, holding time limits, data management procedures, lab QA/QC practices, etc.) will be consistent with the existing AB411 monitoring plan Quality Assurance Project Plan (QAPP).

4.2. Follow-up Monitoring

If necessary, Follow-up Monitoring will be implemented after dry weather interim targets take effect, which is seven years after the effective date of the TMDL (2018), or after wet weather interim targets take effect ten years after the TMDL effective date (2021).

Follow-up Monitoring will occur when:

- Annual exceedance days have not been reduced by at least 50 percent by year seven (2018) for dry weather and year ten (2021) for wet weather.
- After the 100 percent reduction milestones for both wet and dry weather (i.e., the respective final compliance dates), the initiation criteria will be updated to reflect the most applicable 'trigger' based on the available data and possible revisions to the TMDL.

Additional details, including initiation dates, sample collection procedures, analytical methods and quality considerations will be described in a separate monitoring plan.

4.3. Optional Monitoring

Details of Optional Monitoring activities, including initiation dates, sample collection procedures, analytical methods and quality considerations will be outlined in a separate monitoring plan once those activities have been planned and approved by Copermittees.

4.4. Special Studies

Additional details, including initiation dates, sample collection procedures, analytical methods and quality considerations will be determined by Copermittees and described in separate monitoring plans for each study.

5. Provisions for Reduction of Compliance Monitoring

Though the sampling frequency and locations described in the above sections will be followed initially, this MP will be used to support the adaptive management strategy of the CLRP. In other words, the MP will be subject to adjustment based on sample results in order to best achieve TMDL requirements while at the same time avoiding unnecessary costs.

Situations which will trigger consideration of reduction of compliance monitoring requirements are described below.

5.1. TMDL numeric targets consistently achieved at compliance monitoring location

As described in the bacteria TMDL, if numeric targets are achieved at the receiving water compliance monitoring location, it will be assumed that MS4s are in compliance with the TMDL. If compliance monitoring data show that numeric targets are being met at the compliance monitoring locations for three consecutive years, reduction in monitoring will be considered.

5.2. Water bodies delisted

In the event that Dog Beach at the San Diego River outlet is delisted from the 303d list, the Bacteria TMDL will no longer be applicable and monitoring will be discontinued.

5.3. Data show MS4s are not causing or contributing to receiving water exceedances

If numeric targets are exceeded at the compliance monitoring location, MS4 compliance monitoring may be reduced or discontinued if three consecutive years of data (e.g., outfall sampling results) support the conclusion that MS4s are not causing or contributing to these exceedances.

6. Analysis of Data for Compliance Determination

Compliance with numeric targets will be assessed annually using the calculation methods described below.

6.1. Single Sample Maximum (SSM) Exceedance Day Analysis

Exceedance frequencies (EFs) for dry and wet weather are calculated by first comparing sample results to the single sample maximum WQOs defined in the TMDL and included in Table 1. For these purposes, results of all FIB are grouped together by day, so that an exceedance of any indicator counts as one exceedance day. Conversely, exceedances for more than one FIB on a single day will still count as a single exceedance day.

Once the total number of sample exceedances in the year has been determined, this number will be divided by the total number of sampling events during the year to arrive at the EF. EFs for dry and wet weather will be calculated separately.

Exceedance Days (EDs) will then be calculated by multiplying the EF by the total number of wet or dry days in the year. As described in Section 1.2.3.1 above, compliance will be determined by comparing the calculated EDs with the final AED which is 0 for dry weather and 19 for wet weather.

6.2. Geometric mean (GM) Analysis

Since dry weather sampling will be conducted monthly, the GM will be calculated monthly using the monthly sample plus the four previous samples collected.

For the dry weather GM, only dry weather samples will be used in the calculation. The overall GM will incorporate both dry weather samples as well as any wet weather samples that were collected during the sampling period covered by the five dry weather samples.

Results from the GM calculations will then be compared to the GM WQOs defined in the TMDL and included in Table 2.

6.3. Assessing Compliance with Interim Compliance Targets

As described in Section 1.2.3.2, dry weather interim compliance targets will be effective 7 years after the date when the TMDL becomes effective (2018), and 10 years after the TMDL effective date (2021) for wet weather. By these dates, exceedance days in the SDR Watershed must be reduced by 50%.

In order to establish interim target AEDs, the rate of exceedances prior to establishment of the TMDL must first be established. For dry weather, as described in the TMDL, historic data collected at the AB411 site between 2004 and 2010 were used to determine pre-TMDL average annual exceedance days. At the time of calculation, only the 2004-2010 data was available. Geometric means were calculated for each day a sample was taken using that sample plus the previous four (for a total of five samples), and these values were compared to TMDL WQOs. An annual exceedance frequency was calculated by dividing the number of exceedances by the total number of samples taken for each year. This percentage was then multiplied by the total number of dry weather days that year to arrive at an annual number of exceedance days (assuming monthly monitoring).

At the Dog Beach site, there were found to be a historic average of 41 dry weather geometric mean exceedance days per year. For the purposes of measuring compliance with interim targets then, by April 2018, the dry weather geometric mean AED should be (41-0)*0.5, or approximately 21 days.

Wet weather pre-TMDL conditions were based on the table provided in the TMDL (p. A56) showing “existing” (historic) wet weather exceedance frequencies in each watershed for the critical year, 1993. For the SDR Watershed, there were approximately 68 historic exceedance days for enterococcus, which, as is typical, was the indicator with the highest exceedance frequency that year.

This TMDL table lists exceedances for each FIB separately rather than total number of exceedance days. Total exceedance days, which is the compliance metric for this CMP, is typically higher than (and at least equal to) the exceedance days for any one of the individual FIB since an exceedance of any indicator is counted as an exceedance day. Based on historic analytical data, there were 9 wet weather samples with enterococcus exceedances and 9 wet weather samples that exceeded for any of the FIB; therefore the estimated number of total exceedance days for the critical year is 68, the same as the historic exceedance days for enterococcus.

Based on this number of historic exceedance days, for the purposes of measuring compliance with interim targets, by April 2017, the number of exceedance days over the allowable 19 exceedance days should be reduced by half, so the interim target should be ((68-19)*0.5)+19, or 44 days.

Interim targets for dry and wet weather are summarized in Table 6.

Table 6. SDR Interim targets for dry and wet weather

	Interim Target Effective Date	Interim Target Exceedance Days
Dry weather (based on GM)	2018	21
Wet weather (based on SSM)	2021	44

6.4. Actions in Case of Continuing Exceedances

The finding of exceedances in receiving waters does not in itself constitute a violation by MS4s. As described above, evidence that MS4s are not causing or contributing to exceedances will serve as grounds for determining that MS4s are in compliance with the TMDL and consequently will trigger consideration of reduction or removal of monitoring requirements, even if exceedances in receiving waters continue to occur.

7. Reporting Protocols

7.1. Compliance Monitoring

An Annual CLRP Monitoring Summary will be integrated with required annual watershed reporting and submitted to the Regional Board.

These reports will summarize the number and dates of wet and dry monitoring events, how many samples were collected and basic statistics on storm events that were sampled (total rainfall, duration of event, etc.).

Sample results will be reported, along with calculated exceedance days for the year and how these results compare with TMDL compliance requirements.

7.2. Follow-up Monitoring

A summary of Follow-up Monitoring will be provided in the Annual CLRP Monitoring Summary. The summary will include the monitoring approach, monitoring locations, sampling protocols, summary of results, and planned actions.

7.3. Optional Monitoring

Copermittees will determine each year whether Optional Monitoring will be initiated, modified, or eliminated (although Optional Monitoring may be revised more frequently if approved by Copermittees). Modifications to Optional Monitoring elements will be documented in the Annual CLRP Monitoring Summary. The decision to initiate, modify, or eliminate Optional Monitoring will be communicated to the SDRWQCB Project Manager to clearly inform the SDRWQCB whether the monitoring is to occur.

7.4. Special Studies

Initiation or completion of Special Studies will be noted in Annual CLRP Monitoring Summary. The decision to initiate, modify, or eliminate Special Studies will be communicated to the Regional Board so they are clearly informed of the planned monitoring.

8. References

American Public Health Association, "Standard methods for the examination of water and wastewater", 1992.

Larry Walker Associates, "Load Reduction Plan Framework, Section 2 – Compliance Assessment Monitoring", 2011

San Diego Co-permittes, Bacteria Phase I TMDL Monitoring Workshops, 2012

San Diego Regional Water Quality Control Board (SDRWQCB), "A Resolution Amending the Water Quality Control Plan for the San Diego Basin (9) to Incorporate Revised Total Maximum Daily Loads for Indicator Bacteria, Project I – Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek)", Resolution No. R9-2010-0001, February 2010

SDRWQCB, "Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds of the County of San Diego, the Incorporated Cities of San Diego County, the San Diego Unified Port District, and the San Diego County Regional Airport Authority", Order No. R9-2007-0001, January 2007

9. Appendices

A. TMDL Basin Plan Amendment (incl. Att A)

B. Sampling locations factsheets (latitude/longitude, description, photos, accessibility information, etc.)

C. Sample collection procedures and quality assurance considerations

D. Health and Safety Plan (HASP): *To be provided by sampling contractor*

Geosyntec consultants

engineers | scientists | innovators

Offices in Principal Cities of the United States and
Select International Locations

www.geosyntec.com