TMDL Development Process

The purpose of this paper is to describe the development of the Los Angeles River (LAR) Indicator Bacteria TMDL in terms of the steps established by the TMDL program under the US EPA and the State of California regulations and guidance. This paper takes each step and describes how this particular TMDL will be developed based on our current knowledge about the LAR. This affords the participants in this process to more fully understand, in these early stages, how the TMDL will be developed, what information and knowledge we currently have, where our knowledge gaps exist, and in general terms what we expect the final TMDL to include.

Over the course of the development of the TMDL for LAR Bacteria, the specific steps and processes described in this paper will be followed and cited.

Step 1: Problem Identification

Section 303(d) of the Clean Water Act specifies that States identify polluted water bodies and determine a path to attaining water quality standards. The resulting pollutant control plans are called Total Daily Maximum Loads (TMDLs) needed to attain water quality standards. The TMDL process "provides an effective mechanism for determining the causes of waterbody impairment and allocating responsibility among different pollutant discharge sources for reducing pollutant emissions to achieve water quality standards" (EPA Region 9, 2000).

A TMDL includes:

- Quantitative assessment of water quality problems and contributing sources;
- Numeric targets based on applicable water quality standards;
- Estimates of the “assimilative capacity”, or the specifics regarding maximum amount of a pollutant that can be discharged and still achieve water quality standards;
- Allocations of pollutant loads among sources in the watershed; and
- A basis for taking actions to meet the numeric target and implement water quality standards.

A majority of the reaches and tributaries of the Los Angeles River are on the 303(d) list as impaired for high coliform bacteria (Table 1). The problem identification section summarizes water quality data originally used to place reaches of the Los Angeles River (LAR) on the 303(d) list as impaired for bacteria (Tables 1 and 2), in addition to summarizing both new listings (Table 3) and new information obtained since the original listing. This section also includes a summary of applicable water quality standards, which are comprised of beneficial uses (Table 4), water quality objectives (Table 7), and an anti-degradation policy. The problem identification section commonly includes:

- Geographic setting and scale
- Preliminary identification of sources
- Review of overall approach of TMDL – preliminary assessment of complexity of TMDL
- Where resources should be focused

Outline of CREST involvement in process

CREST is a stakeholder effort initiated by the City of Los Angeles in cooperation with Los Angeles Regional Water Quality Control Board (Region 4) and EPA Region 9 to address collaborative TMDL development. The purpose of the present document is to outline the TMDL process for CREST members, and begin discussions that will lead to development of a TMDL for indicator bacteria in the Los Angeles River.

Los Angeles River Watershed – Listed Reaches for Bacteria

The 2002 303(d) list identifies 15 separate reaches of the LAR and its tributaries that are impaired for coliform (Figure 1, Table 1). The proposed 2006 update to the 303(d) list (pending EPA approval) includes two additional listed tributaries (Table 2), Aliso Canyon Wash (for bacterial indicators) and Burbank Western Channel (for fecal coliform). Points of compliance will be tied to these listed reaches. Therefore, implementation of the TMDL should be based on a watershed-based strategy that is conducted in a phased approach to first ensure compliance at key locations in the watershed where unrestricted REC-1 uses occur (based on the definition of REC-1: "uses…involving body contact with water, where ingestion of water is reasonably possible") or have a high potential to occur in the near future based on current planning efforts.

Table 2 lists the L.A. River Reaches and listed tributaries that are geographically located within or are downstream of each of the cities and unincorporated areas of the counties within the boundaries of the L.A. River Watershed.

Table 1. Listed Reaches and tributaries for Bacteria – L.A. River Watershed

Reach	Impairment
Listed on 2002 303(d)List for Bacteria	
Arroyo Seco Rch 1 (d/s Devil's Gate Dam)	coliform
Arroyo Seco Rch 2 (W. Holly Ave. to Devil's Gate)	coliform
Bell Creek	coliform
Compton Creek	coliform
Dry Canyon Creek	coliform
Los Angeles River Reach 1(u/s Carson St. to estuary)	coliform
Los Angeles River Reach 2 (Figueroa St. to u/s Carson St.)	coliform
Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.)	coliform
Los Angeles River Reach 6 (u/s of Sepulveda Basin)	coliform
McCoy Canyon Creek	coliform
Rio Hondo Reach 1 (Santa Ana Fwy to Los Angeles River)	coliform
Rio Hondo Reach 2 (Whittier Narrows Flood Control Basin to Spreading Grounds)	coliform
Tujunga Wash (d/s Hansen Dam to Los Angeles River)	coliform
Verdugo Wash Reach 1 (LA River to Verdugo Rd)	coliform
Verdugo Wash Reach 2 (above Verdugo Road)	coliform
Proposed for the 2006 Update to the 303(d)List for Bacteria	
Aliso Canyon Wash	Bacteria Indicators
Burbank Western Channel	Fecal Coliform

Table 2. Listed Reaches Within and Downstream from Cities/Counties in L.A. River Watershed

City	Listed Reaches/Tributaries Partially or Wholly within City Boundaries	Listed Reaches/Tributaries Downstream of City/County
San Fernando		Tujunga Wash; L.A. River Reach 4; L.A. River Reach 2; L.A. River Reach 1
Los Angeles	Bell Creek; McCoy Canyon; Dry Canyon; Aliso Canyon Wash; L.A. River Reach 6; L.A. River Reach 5; Tujunga Wash; L.A. River Reach 4; Verdugo Wash Reach 2; Verdugo Wash Reach 1; Arroyo Seco; L.A. River Reach 2; Compton Creek	L.A. River Reach 1
Burbank	Burbank Western Channel; Reach 4	L.A. River Reach 1; L.A. River Reach 2
Glendale	Verdugo Wash Reach 2; Verdugo Wash Reach 1	L.A. River Reach 1; L.A. River Reach 2
Canada Flintridge	Arroyo Seco	Verdugo Wash Reach 2; Verdugo Wash Reach 1; L.A. River Reach 1; L.A. River Reach 2

Unincorporated L.A. County		Aliso Canyon Wash; Tujunga Wash; Verdugo Wash Reach 2; Verdugo Wash Reach 1; Arroyo Seco; Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 6; L.A. River Reach 5; L.A. River Reach 4; L.A. River Reach 2; L.A. River Reach 1
Calabasas	McCoy Canyon; Dry Canyon	L.A. River Reach 6; L.A. River Reach 5; L.A. River Reach 4; L.A. River Reach 2; L.A. River Reach 1;
Pasadena	Arroyo Seco	Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Sierra Madre		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Monrovia		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Arcadia		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Bradbury		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Duarte		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
San Gabriel		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
South Pasadena	Arroyo Seco	Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
San Marino	Arroyo Seco	Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Temple City		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
El Monte		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Rosemead		Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Alhambra		Arroyo Seco; Rio Hondo Reach 2; Rio Hondo Reach 1; L.A. River Reach 2; L.A. River Reach 1
Monterey Park	L.A. River Reach 2; Rio Hondo Reach 2	Rio Hondo Reach 1; L.A. River Reach 1
South El Monte		L.A. River Reach 2; Rio Hondo Reach 1; Rio Hondo Reach 2; L.A. River Reach 1

Montebello	L.A. River Reach 2; Rio Hondo Reach 1; Rio Hondo Reach 2	L.A. River Reach 1
Commerce	L.A. River Reach 2; Rio Hondo Reach 2	L.A. River Reach 1; Rio Hondo Reach 1
Huntington Park	L.A. River Reach 2	L.A. River Reach 1
Bell	L.A. River Reach 2	L.A. River Reach 1
Bell Gardens	L.A. River Reach 2; Rio Hondo Reach 1	L.A. River Reach 1
Maywood	L.A. River Reach 2	L.A. River Reach 1
Downey	Rio Hondo Reach 1	L.A. River Reach 1; L.A. River Reach 2
Cudahy	L.A. River Reach 2	L.A. River Reach 1
Southgate	L.A. River Reach 2; Rio Hondo Reach 1	L.A. River Reach 1
Lynwood	L.A. River Reach 2	L.A. River Reach 1
Compton	L.A. River Reach 2; Compton Creek	L.A. River Reach 1
Paramount	L.A. River Reach 2	L.A. River Reach 1
Signal Hill	L.A. River Reach 1	
Long Beach	L.A. River Reach 1; Compton Creek	
Carson	L.A. River Reach 1; Compton Creek	

Table 3. LARWatershed Proposed Update to the 303(d) List for Bacteria (pending approval).

Reach	Pollutant	Reason for Listing
Aliso Canyon Wash	Bacteria Indicators	This pollutant is being considered for placement on the section 303(d) list under sections 3.3 the Listing Policy. Based on section 3.3 the site exceeds the Total and Fecal coliform WQO for the protection of REC1 beneficial Uses. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination on the section 303(d) list in the Water Quality Limited Segments category. This conclusion is based on the staff findings that: Six of six samples exceeded the Basin Plan WQOs for total and fecal coliform bacteria to protect REC1 beneficial uses, and these exceed the allowable frequency listed in Table 3.1 of the Listing Policy.
Burbank Western Channel	Fecal Coliform	This pollutant is being considered for placement on the section 303(d) list under section 3.3 of the Listing Policy. Under section 3.3 a single line of evidence is necessary to assess listing status. Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification in favor of placing this water segment-pollutant combination on the section 303(d) list in the Water Quality Limited Segments category. This conclusion is based on the staff findings that six of six samples exceeded the Fecal Coliform water quality objective and this exceeds the allowable frequency listed in Table 3.2 of the Listing Policy.

Beneficial Uses

Beneficial uses for each listed reach are shown in Table 4. For bacteria where the primary concern is risk to human health, the beneficial uses of interest are full contact water recreation or REC-1. The exception to this standard occurs during a storm event of 0.5 inches or greater, and the 24 hours succeeding the storm event. This high flow suspension of the beneficial uses is discussed below. The basis for the 2002 303(d) listing are given in Table 5. Listings prior to 2002 (1996, 1998) were based on monitoring data between 1988 and 1995 during which there were a number of exceedances of water quality objectives for the applicable LAR reaches.

Table 4. Beneficial Uses for L.A. River Reaches and Tributaries

Reach	Beneficial Uses
Listed on 2002 303(d)List for Bacteria	
Arroyo Seco Rch 1 (d/s Devil's Gate Dam)	
Arroyo Seco Rch 2 (W. Holly Ave. to Devil's Gate)	
Bell Creek	Municipal (Potential*) Groundwater Recharge (Intermittent) REC 1 (Intermittent [1]) REC 2 (Intermittent) Wildlife Habitat Warm (Intermittent)
Compton Creek	Municipal (Potential*) Groundwater Recharge REC 1[1] REC 2 Wildlife Habitat Warm Wetlands
Dry Canyon Creek	Municipal (Potential*) Groundwater Recharge (Intermittent) REC 1 (Intermittent [1]) REC 2 (Intermittent) Wildlife Habitat Warm (Intermittent)
Los Angeles River Reach 1(u/s Carson St. to estuary)	Municipal (Potential*) Groundwater Recharge REC 1[1] REC 2 Wildlife Habitat Warm Shellfish (Potential [1]) Rare Migratory (Potential) Spawning (Potential) Marine Habitat Industrial Service Supply (Potential) Industrial Process Supply (Potential)
Los Angeles River Reach 2 (Figueroa St. to u/s Carson St.)	Municipal (Potential*) Groundwater Recharge REC 1[1] REC 2 Wildlife Habitat (Potential) Warm Industrial Service Supply (Potential)

Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.)	Municipal (Potential*) Groundwater Recharge REC 1[1] REC 2 Wildlife Habitat Warm Wetlands Industrial Service Supply (Potential)
Los Angeles River Reach 6 (u/s of Sepulveda Basin)	
McCoy Canyon Creek	Municipal (Potential*) Groundwater Recharge (Intermittent) REC 1 (Intermittent) REC 2 (Intermittent) Wildlife Habitat Warm (Intermittent)
Rio Hondo Reach 1 (Santa Ana Fwy to Los Angeles River)	Municipal (Potential*) Groundwater Recharge (Intermittent) REC 1 (Potential [1]) REC 2 Wildlife Habitat (Intermittent) Warm (Potential)
Rio Hondo Reach 2 (Whittier Narrows Flood Control Basin to Spreading Grounds)	Municipal (Potential*) Groundwater Recharge (Intermittent) REC 1[1] (Intermittent) REC 2 Wildlife Habitat (Intermittent) Warm (Potential)
Tujunga Wash (d/s Hansen Dam to Los Angeles River)	Municipal (Potential*) Groundwater Recharge (Intermittent) REC 1[1] (Potential) REC 2 (Intermittent) Wildlife Habitat (Potential) Warm (Potential)
Verdugo Wash Reach 1 (LA River to Verdugo Rd)	
Verdugo Wash Reach 2 (above Verdugo Road)	
Proposed for the 2006 Update to the 303(d)List for Bacteria	
Aliso Canyon Wash	Municipal (Potential*) Groundwater Recharge (Intermittent) REC 1[1] (Intermittent) REC 2 (Intermittent) Wildlife Habitat Warm (Intermittent)
Burbank Western Channel	Municipal (Potential*) REC 1[1] (Potential) REC 2 (Intermittent) Wildlife Habitat (Potential) Warm (Potential)

Table 5. Basis for 303d Listings for Bacteria

Reach	**Basis for 303d Listing**
Listed on 2002 303(d)List for Bacteria	
Arroyo Seco Rch 1 (d/s Devil's Gate Dam)	
Arroyo Seco Rch 2 (W. Holly Ave. to Devil's Gate)	
Bell Creek	
Compton Creek	

Dry Canyon Creek	**From 2003 Staff Report: Water Body Fact Sheets:** **Water Body-specific Information** Data 1-2 years, data measured at site, seasonality and years. **Data used to assess water quality** 56 samples, 11 samples exceeding. **Spatial representation** Samples were collected spatially along the creek. **Temporal representation** Fall, winter, spring in different years (2000-2001). **Data type** Numerical data. **Use of standard method** City of Calabasas methods.
Los Angeles River Reach 1(u/s Carson St. to estuary)	
Los Angeles River Reach 2 (Figueroa St. to u/s Carson St.)	
Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.)	
Los Angeles River Reach 6 (u/s of Sepulveda Basin)	
McCoy Canyon Creek	**From 2003 Staff Report: Water Body Fact Sheets:** **Water Body-specific Information** Data 1-3 years old, data measured at site, all season samples. **Data used to assess water quality** 56 bacterial samples, 38 samples exceeding. **Spatial representation** Samples were collected spatially along the creek. **Temporal representation** Spring, summer, fall, winter. **Data type** Numerical data.
Rio Hondo Reach 1 (Santa Ana Fwy to Los Angeles River)	
Rio Hondo Reach 2 (Whittier Narrows Flood Control Basin to Spreading Grounds)	
Tujunga Wash (d/s Hansen Dam to Los Angeles River)	
Verdugo Wash Reach 1 (LA River to Verdugo Rd)	
Verdugo Wash Reach 2 (above Verdugo Road)	
Proposed for the 2006 Update to the 303(d)List for Bacteria	
Aliso Canyon Wash	
Burbank Western Channel	

Step 2: Numeric Targets

The objective of the numeric targets step is to identify measurable indicators and target values, which allows the TMDL to be evaluated for its ability to restore water quality. Establishment of numeric targets involves three steps:

1. The selection of indicators;
2. Identification of target values; and
3. A comparison of existing and target conditions.

The objective of the numeric targets step is to identify **measurable** indicators and target values. This will allow the TMDL to be evaluated for restoration of water quality. For indicator bacteria TMDLs, targets are based on the water quality standards necessary to protect human health. Water quality standards consist of three elements (EPA Protocol, 2001):

1. Designated beneficial uses (Table 4);
2. Numeric water quality objective (Table 6) and narrative criteria for supporting each use;
3. Anti-degradation statement.

For the LAR the beneficial use of concern, for reaches listed on the 303(d) list for coliform impairment, is fresh water designated for full contact recreation (REC-1). The water quality objectives, for bacterial indicators, for REC-1 are listed in Table 6.

Determination of how bacteria objectives are achieved through the TMDL process can be done in several ways. The Santa Monica Bay Beaches (SMBB) Bacteria TMDL used a reference watershed approach using the Arroyo Sequit Watershed and Leo Carrillo Beach monitoring site, as a reference watershed for determining exceedance allowances. Malibu Creek Bacteria TMDL applied a model to determine bacterial loads, linkage of that load to sources, and suggested allocations based on load reductions, but ultimately the waste load and load allocations are based on SMBB Bacteria TMDL, and therefore are derived from a reference watershed approach. The Draft Ballona Creek Bacteria TMDL, because it is tributary to the Santa Monica Bay, also followed the SMBB Bacteria TMDL approach.

Use of a reference watershed approach for the LAR will require the identification of a suitable inland watershed for use as a reference. The Southern California Coastal Water Research Project (SCCWRP) has undertaken an assessment of the impact of natural landscape loadings on water quality, and this work, depending on status, could potentially be used for designation of a reference watershed, or calculation of a number of allowable exceedance days, even if the data is based on monitoring conducted outside of the LAR watershed. Alternatively, a model of the watershed and pollutant loading could be developed and used to determine loading capacity and a linkage between loading and water quality targets, and ultimately to estimate necessary pollutant reductions needed to meet water quality objectives. Such a model was constructed for the LAR metals and nutrient TMDLs, and has been applied to simulate bacteria concentrations in the LAR. Preliminary results indicate additional work will be necessary to make the model suitable for determining bacteria assimilative capacity and load allocations, particularly during dry weather, because the model was calibrated using "snapshot" data, which represent only a few days of the historic record.

The TMDL will need to take into account seasonal differences in the flow regime for the LAR. There are three easily differentiated seasonal flow regimes of interest:

- Summer Dry Weather (April through October);
- Winter dry weather (November through March); and
- Wet weather (defined in other TMDLs as greater than or equal to 0.1 inch of rainfall plus the three days following the rain event).

How exceedance of water quality objectives during each of these periods are addressed in the TMDL will be, in part, determined by the results of a **linkage analysis,** and the approach to determining the load and wasteload allocations.

Use Attainability Analysis

In some cases, a use attainability analysis is conducted as part of the TMDL development process in order to determine the appropriateness of the beneficial uses currently assigned to a waterbody, and to thereby determine the appropriateness of the water quality objectives associated with those beneficial uses. A use attainability analysis was conducted for Ballona Creek and a basin plan amendment (State Board Resolution No. 2005-0015) was adopted changing the designation of two reaches. No changes were made to the beneficial uses of LAR reaches or tributaries.

Site Specific Objectives

According to State Water Resources Control Board (SWRCB) Draft Strategy for developing TMDLs, site specific water quality "objectives are recalculated based on revised policy decisions concerning the level of protection to be provided designated uses under special circumstances". The high flow suspension of water quality objectives in engineered channels, incorporated into the basin plan (Regional Board Resolution 2003-010), represents a site specific objective. The high flow suspension occurs during a storm event of 0.5 inches or greater, and the 24 hours succeeding the storm event. During this period REC-1 and REC-2 uses, and corresponding water quality objectives, are suspended.

As part of the LAR TMDL development, the typical number of historic annual high flow suspensions will be performed, along with determination of a protocol for how to define which days are subject to high flow suspension. A preliminary analysis of data was presented to CREST technical committee in March. It is most likely that one of two methods will be used, either (1) local rain gage, Doppler radar, or a generally accepted rainfall estimate method, or (2) simply based on the time periods when access gates to the LAR channel are closed.

The Draft Ballona Creek Bacteria Indicator Densities TMDL states that the number of allowable exceedance days for REC-1 water quality objectives will be based on the greater of (a) high flow suspension days or (b) the exceedance days based on the reference watershed approach, but not both.

Water Quality Objectives

Water quality objectives (WQO, Table 6) for all reaches are based upon water quality standards for REC-1 beneficial uses as described in the Basin Plan for Los Angeles Region.

Table 6. Water Quality Objectives – LAR

Beneficial Use	Indicator	Geometric Mean Objective (per 100ml)	Single Sample Objective (per 100ml)
REC-1 Fresh Water Contact Recreation	Fecal coliform	200	400 (Not more than 10% of samples to exceed 400 mpn/100 ml in 30-day period)
	E. Coli	126	235
REC-1 Marine	Fecal Coliform	200	400
	Enterococcus	35	104
	Total coliform (shall not exceed 1,000/100 ml, if ratio of fecal to total coliform exceeds 0.1)	1,000	10,000

High Flow Suspension - Suspension of REC-1 and REC-2 beneficial uses and the associated bacteriological objectives set to protect those activities applies to engineered channels on days with rainfall greater than or equal to ½ inch and the 24 hours following the end of the ½-inch or greater rain event, as measured at the nearest local rain gauge, using local Doppler radar, or using widely accepted rainfall estimation methods.

The 30-day geometric mean limits can not be exceeded at any time. The 30-day geometric mean calculation for TMDLs is calculated as the 30th root of the product of 30 numbers (the most recent 30 day results). For weekly sampling, the 30 numbers are obtained by assigning the weekly test result to the remaining days of the week. If more samples are tested within the same week, each test result will supersede the previous result and be assigned to the remaining days of the week until the next sample is collected. This rolling 30-day geometric mean must be calculated for each day, regardless of whether a weekly or daily schedule is selected (SMBB Bacteria TMDL Implementation Plan).

The use of a reference watershed changes the determination of exceedances. The single sample maximum targets for winter dry weather and year-round wet weather are allowed a certain number of exceedances when using the reference watershed approach. The allowable number of exceedance days at each monitoring site must be no greater than the number of historical exceedance days determined at a reference watershed that has been selected as being representative of natural background water quality runoff from undeveloped areas. The reference watershed approach accounts for the fact that the bacterial indicators used for water quality objectives are not human specific, and can be produced by natural sources.

The reference system selected by the Regional Board for the Santa Monica Bay Beaches, Malibu Creek, and Ballona Creek Bacteria TMDLs is the Arroyo Sequit Canyon watershed and the corresponding historical monitoring site at Leo Carrillo Beach.

Step 3: Source Analysis

The source assessment step of the TMDL process strives to identify and evaluate all point (Table 7) and non-point sources of indicator bacteria loading to the waterbody. Based on compiled datasets, an analysis is conducted that includes calculations or a model of contaminant loading to the waterbodies of interest. Source assessment also includes determinations of which LAR reaches are most impacted by bacteria loading, the type of sources that may be responsible for WQO exceedances, and the relative magnitude of these sources during different seasons and weather conditions. Finally, the source analysis step determines where data gaps exist, and which type of studies could be used to provide additional needed information.

For the LAR, as for other inland waterbodies in Southern California, the primary source of bacterial indicators is from distributed sources that feed the waterbodies through storm drains, rather than effluent discharge from permitted point sources. Even though the source of contaminants is considered to be a distributed, non-point source, the storm water system is regulated as a point source through Los Angeles Municipal Storm Water NPDES permit, or MS4 permit. Permitted POTW point sources, while not a direct source of bacterial indicator exceedance, do contribute a significant amount of flow to the LAR during dry weather. Preliminary analysis suggests that these POTWs are a substantial dilution source of indicator bacteria from other sources in the LAR.

Table 7. Summary of NPDES permits in Los Angeles River watershed. (LARWQCB**).**

Type of Permit	**Number of Permits**
Publicly Owned Treatment Works	6
Municipal Storm water	3
Industrial Storm water	1307
Construction Storm water	204
Other Major NDPES Discharges	3
Minor NPDES Discharges	15
General NPDES Discharges	
Construction Dewatering	35
Petroleum Fuel Cleanup Sites	7
VOCs Cleanup Sites	6
Hydrostatic Test Water	8
Non-Process Wastewater	9
Potable Water	25
Total	**1628**

Data Compilation

There are several datasets that have been compiled, which will be combined and analyzed to assess the relative magnitude of of bacteria sources to the LAR including:

- The Status and Trends data (total coliform, *E. coli*, enterococcus, and flow rate) collected in the mainstem LAR and tributaries by the City of LA BOS-WPD from 2001-2005.
- The Los Angeles County Department of Public Works (DPW) MS4 NDPES Permit data (total and fecal coliform) collected in the LAR near Wardlow St. from 1997 to 2003 during wet weather, and data (total coliform, fecal coliform, and *E. coli*) from LAR tributary sites during the 2005 dry season.
- Receiving water NPDES data (total and fecal coliform and flow rate) collected by City of LA Donald C. Tillman Water Reclamation Plant (DCTWRP), City of LA Glendale Water Reclamation Project (GWRP), and City of Burbank Water Reclamation Plants (BWRP) from 1997 - 2005.
- Synoptic survey data (total and fecal coliform, *E. coli*, and flow rate) collected by the Southern California Coastal Water Research Program (SCCWRP) during September 2000 and July 2001 at over 120 storm drain outfalls, 10 mainstem LAR sites, and 7 tributary sites.
- Bacteria and other water quality data collected by the Friends of LA River (FoLAR), the Southern California Marine Institute (SCMI), the NorthEastTrees.
- Any other datasets found to be readily available, useful and of high quality.

Data Analysis

At this time, a preliminary analysis of available LAR bacteria data has been conducted using a small subset of the available data: the BOS-WPD Status and Trends *E. coli* dataset, SCCWRP snapshot data, and flow rates from the Metals TMDL modeling analysis. The statistics of mainstem and tributary LAR *E. coli* concentrations, as measured by the Status and Trends monitoring program, are shown in Figure 2. A threshold of a 0.5” was used because on the day of and 24 hours after 0.5” of rainfall, bacteria WQOs are suspended in the LAR. Figure 2 is a log plot of E. coli concentrations, collected under pertinent weather conditions, that illustrates the wider variability of indicator bacteria sampling results.

Preliminary Dry Weather Source Assessment

Dry weather bacteria concentrations in the mainstem LAR exhibit a systematic spatial pattern, regardless of whether the season is wet or dry (see the blue and purple boxes of Figure 2, which based on qualitative assessment are not significantly different from one another):

- The highest dry weather mainstem LAR bacteria concentrations are often observed upstream in Reach 6 at White Oak Ave., where flow rates are relatively low. Possible sources include storm drains and natural inputs.
- The lowest dry weather bacteria concentrations are observed at the upstream ends of Reach 4 (Sepulveda Ave.) and Reach 2 (Figueroa St.), which are just downstream of discharges of tertiary-treated wastewater effluent by DCTWRP, GWRP, and BWRP.

Therefore, it is likely that wastewater discharges improve water quality with respect to bacteria. It is also possible that the soft bottom in these reaches is beneficial to water quality.

- Immediately downstream of wastewater discharges, it appears that strong sources of bacteria are impacting the LAR during dry weather, leading to rapid increases in bacteria concentrations and frequent exceedances of WQOs. Possible sources include storm drains, tributaries, homeless, or regrowth in the water column or sediments.

As a first step, the dry season sources of bacteria to Reach 2 and Reach 4 were evaluated by assigning flow rate estimates to the tributaries along these reaches, and determining if loading from tributaries is likely to be responsible for mainstem LAR WQO exceedances, as shown in Figure 2. The analysis suggests that the tributaries are not the most significant source of bacteria along Reach 2 and Reach 4. The "uncharacterized" portions, which represent a majority of the bacteria loads in these reaches, may be inputs by storm drains, as during a 2000 synoptic survey SCCWRP estimated that 89% of the bacteria mass emission in the LA River was from storm drains. A monitoring effort funded by the USEPA, with assistance by stakeholders, will be conducted in April and May 2006 in an attempt to further resolve the sources of bacteria along Reach 2 and Reach 4. Note that there is little data available to evaluate the dry weather sources of bacteria to Reach 6 (White Oak Avenue).

Preliminary Wet Weather Source Assessment

Typically, *E. coli* concentrations are much higher during wet weather conditions, regardless of whether daily rainfall was less or greater than 0.5" (i.e. in Figure 1 both the green and yellow boxes reflect concentrations that are higher than the blue and purple boxes). Bacteria concentrations on days of and the day after <0.5" of daily rainfall are highly variable. In fact, at some sites the <0.5" median and percentile *E. coli* concentrations are actually higher than days on or after >0.5" storms. The exceptions are the upstream ends of Reach 2 and Reach 4, which are dominated by wastewater discharges. It seems that it takes more rainfall to overcome to the "bacteria dilution" provided by disinfected wastewater.

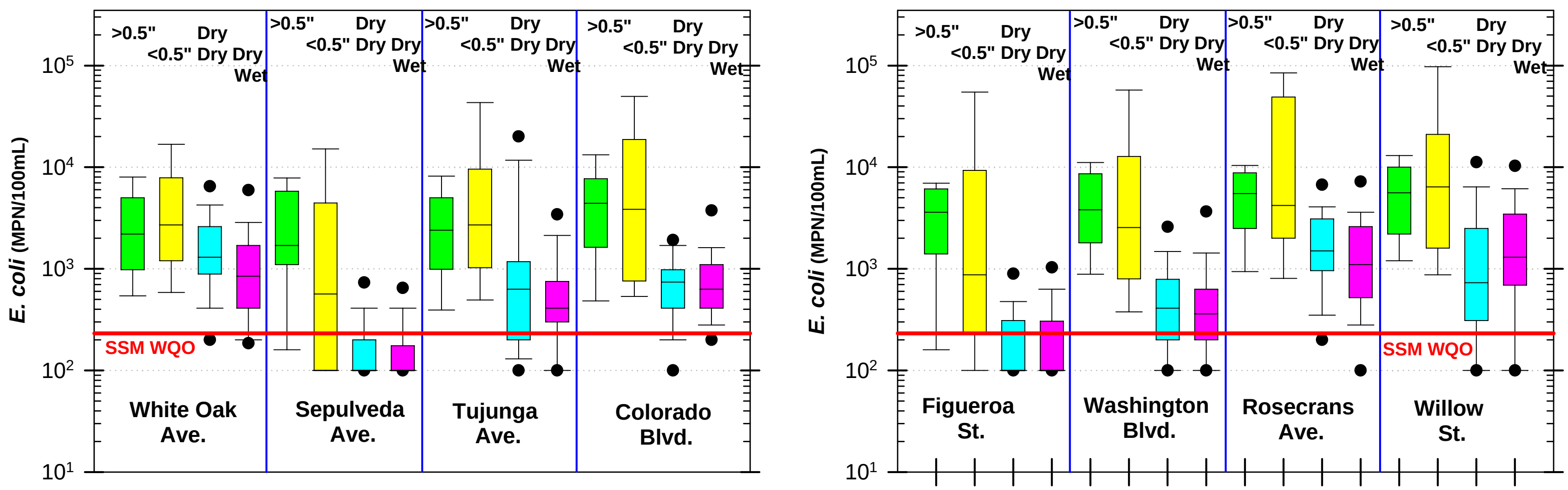
The concentrations on the day of and day after 0.5" of daily rainfall are consistently high. In fact, there is very little spatial variation along the mainstem LAR during high rainfall days. Such patterns indicate a very strong, ubiquitous source of bacteria is responsible for bacteria WQO exceedances during and after high rainfall events. To further analyze the effect of rainfall on bacteria concentrations, *E. coli* concentrations measured at Willow St. were compared to daily average flow rates measured at Wardlow St. The analysis found that on days with flow rates less than 1000 cfs, 84% (130 of 153) of *E. coli* samples were above SSM WQOs. Daily flow rates greater than 1,000 cfs corresponded to a 100% (13 of 13) SSM WQO exceedances rate. It was also determined that typically, a daily average flow rate of 1,500 to 2,500 cfs at Wardlow St. would be generated by 0.5" of daily rainfall. The control and reduction of bacteria concentrations during wet weather will be one of the most challenging aspects of this TMDL.

Approaches to Data Analysis

The analysis of LAR bacteria data is only in it preliminary phases and the methods used to analyze data could be based on:

1) Statistical techniques, which attempt to determine relationships (i.e. significant correlations and regressions) among parameters (e.g. bacteria vs., total suspended solids, land use, season, etc.); and/or

2) A water quality model, which would be calibrated and validated using the compiled datasets, and then the coefficients of the validated model would be used to provide information regarding the relative impacts of various conditions and source types. For instance, the calibrated model could be used to vary the amount of impervious area, flow rate, rainfall, etc. and then model outputs could be used to analyze the effect of these parameters on LAR bacteria concentrations.



Reach No: 6 4 4 3 2 2 2 1

Figure 2. Mainstem LA River *E. coli* Concentrations as Measured by City of LA BOS-WDP Status and Trends Monitoring Program. Plots are separated by weather condition: dry season dry weather (Dry Dry, blue boxes, based on ~ 72 samples from each site), wet season dry weather (Dry Wet, purple boxes, based on ~ 56 samples from each site), on the day of or day after >0.5 inches of daily rainfall (>0.5", green boxes, based on ~ 16 samples from each site), and on the day of or day after <0.5"inches of daily rainfall (<0.5", yellow boxes, based on ~ 15 samples from each site). Boxes span from the estimated 25th to 75th percentile values, with the median in between. Bars with whiskers span from estimated 10th to 90th percentile values, and markers indicate 5th and 95th percentile values. Red line represents Single Sample Maximum for *E. coli*.

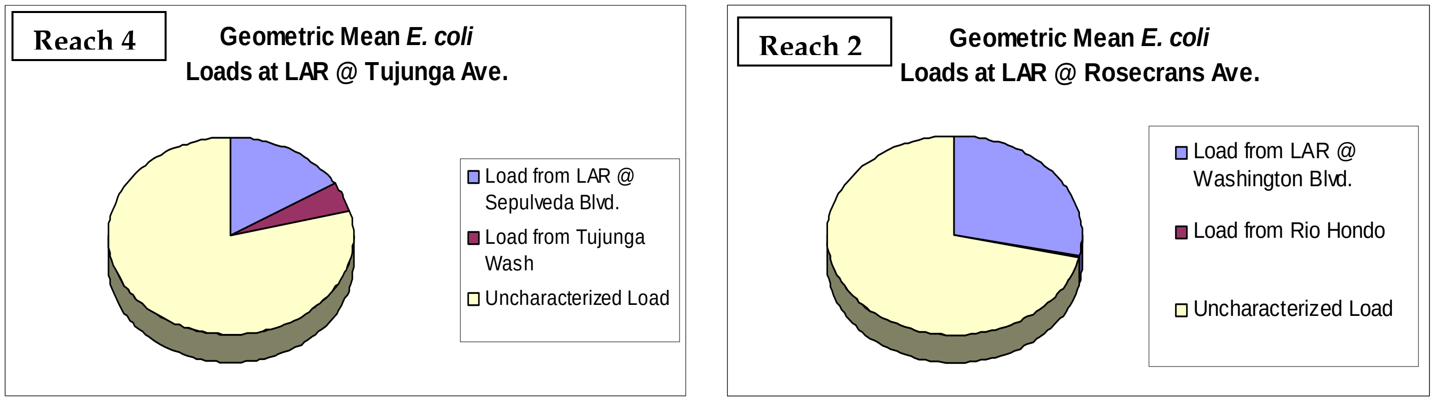


Figure 3. Preliminary Source Assessment for *E. coli* Loading to Reach 2 and Reach 4 of the LA River. The purple portion of the pie represents that load that is typically observed at the upstream monitoring site (i.e. if there was no increase in bacteria loading along the reach, the entire pie would be purple). The maroon portion of the pie represents the dry season load that is estimated from tributaries, and the yellow portion represents the "uncharacterized" portion.

Step 4: Linkage Analysis

Linkage Analysis

The linkage analysis step of the TMDL process aims to "**link**" water quality exceedances, identified in Step 2, with pollutant sources, identified in Step 3. The purpose of the linkage analysis is to establish a cause and effect relationship between identified sources of pollutants and existing water quality. This linkage can then be used to set the load capacity of the waterbody. In the case of bacterial indicators and bacteria TMDLs, the load capacity is commonly set as the applicable water quality objective. The linkage analysis includes an appropriate margin of safety, which is then developed to ensure that water quality objectives will be met, and that any expected future loads can be incorporated. Because the numeric targets and waste load allocations for bacteria TMDLs are commonly set as the water quality objective, the margin of safety is considered to be implicitly incorporated, based on consideration of some critical condition, rather than explicitly developed.

The approach to linkage analysis ranges from the use of simple empirical methods to an analysis of fate and transport of bacteria sources using a variety of modeling techniques. Normally, both complex modeling and simple empirical methods address the linkage between loading and water quality through analysis of existing water quality data. Note, however, that because the SMBB Beaches and Ballona Creek Bacteria TMDLs were concentration or density-based rather than load-based, and the assimilative capacity was defined as the water quality objective, a rigorous linkage analysis was not needed (i.e. by meeting the numeric target, it was certain that the water quality objective would be attained).

Previous Approaches to Linkage Analysis Using Modeling

Modeling of LAR for Metals and Nutrient TMDLs used one-dimensional flow model (EFDC) coupled with the water quality model Hydrologic Simulation Program-FORTRAN (HSPF)[1]. Tetra Tech performed the modeling under contract to the EPA.

Modeling of bacterial indicator loading to Malibu Creek watershed using HSPF was performed by Tetra Tech (Tetra Tech, 2002). The model was used to determine source loads, critical conditions, and ultimately source reductions necessary to meet numeric targets under critical conditions.

[1] The Hydrological Simulation Program - FORTRAN (HSPF) is a set of computer codes that can simulate the hydrologic, and associated water quality, processes on pervious and impervious land surfaces and in streams and well-mixed impoundments (EPA HSPF Manual, 2001).

Modeling for San Diego area bacteria TMDL loading and linkage analysis was performed using a recoded version of HSPF, and was performed by Tetra Tech. The technical approach is similar to modeling approach for Malibu Creek Bacterial TMDL and Los Angeles River Nutrient and Metals TMDLs.

SCCWRP modeling also utilizes HSPF (Ackerman et al., 2005). Recent research and modeling of most interest concerns source loading and application of BMPs to source reduction (Brown and Bay, 2005; Stein and Zaleski, 2005; unpublished modeling on Ballona Creek watershed).

Step 5: Pollutant Allocation

Based on the results of the linkage analysis step, which determines the acceptable assimilative capacity of the waterbody along with the pollutant allocation methodology (e.g. reference watershed/anti-degradation approach or modeled load capacity) the available load is allocated to point and non-point sources.

The allocation step:

- Translates the TMDL into allowable loads;
- Distributes loads among sources;
- Accounts for margin of safety;
- Accounts for seasonal variation;

And allocations should:

- Reflect relative size and magnitude of sources
- Include adequate documentation;
- Provide reasonable assurance that water quality standards will be attained
- Involve stakeholders in development.

The Ballona Creek bacteria TMDL both followed Santa Monica Bay Beaches TMDL in determining allocations based on a reference watershed with allowable single sample maximum exceedance days. In other words, portions of the available load were not actually divided among point and non-point sources; all sources were allocated an allowable number of exceedance days. If the number of exceedances are greater than the allowable number, all jurisdictions are considered to be out of compliance.

In the case of LAR indicator bacteria TMDL, the load allocations will be determined under dry weather and wet weather conditions. The high flow suspension of the water quality standards provides for the extreme wet weather condition.

Step 6: Implementation Strategy

The implementation strategy is a recommended, but not required, approach to reaching the goals of the TMDL. The implementation strategy needs to incorporate:

- Implementation actions;
- Responsible agents for implementing the actions;
- A schedule for the implementation and final compliance with the water quality standard;
- Schedule and format of an adaptive management approach to the TMDL, which provides for incorporation of greater knowledge and adaptation of the TMDL.

The TMDL rules and requirements state that the there must be a reasonable assurance that implementation of the TMDL will result in attainment of water quality standards.

Reasonable assurance requires that the allocations are:

- Technically feasible;
- Can be implemented in a reasonable amount of time;

Cost estimates for implementation strategies are required as a precursor to establishing basin plan amendments based on the TMDL.

The schedule needs to outline the timeframe for preparation of a detailed implementation plan, a detailed monitoring and compliance plan, and milestones for meeting compliance. Extension of a compliance schedule has been proposed, in other Southern California bacteria TMDLs, if an integrated watershed approach to implementation is carried out.

For the Los Angeles River, an integrated approach will need to incorporate aspects of the City of LA Integrated Resources Plan (IRP), together with other integrated watershed plans that have been adopted, or that are in the preparation stages. In addition, the integrated approach should include implementation strategies that incorporate multiple TMDLs. A review of projects that are already proposed or in progress will be conducted as part of the preparation of the Implementation Strategy.

A watershed approach for bacteria TMDL implementation will require a range of Best Management Practices (BMP), and incorporate new data regarding effectiveness of specific BMP implementation. SCCWRP watershed modeling can be particularly useful for maximizing BMP effectiveness and efficiently determining scenarios for BMP implementation.

Compliance with the LAR indicator bacteria TMDL could be phased so that resources are allocated to address areas of greatest risk: Protection of sites *where* actual REC-1 use activity occurs, during hydrologic periods *when* REC-1 use is most likely occur, and where the bacteria sources are predominantly human sources. A priority matrix can be developed in association with the phased TMDL to direct resources to where the greatest concerns of exposure exist. An example matrix is presented in Table 8.

Table 8. Matrix for development of phased approach to implementation.

Factor	Priority		
	High	**Medium**	**Low**
Recreational Use	Unrestricted REC-1 use. *Score = 5*	High potential for unrestricted REC-1 use *Score = 3*	Rare or low potential for REC-1 activity[1] *Score = 1*
Hydrologic Tier	Dry weather low flow *Score = 5*	Wet weather (moderate flow; 0.1-0.2 in. storm) *Score = 3*	Wet weather (high flow; 0.3-0.4 in. storm) *Score = 1*
Source	Human sources significant *Score = 5*	Human sources variable, but occasionally high *Score = 3*	Non-human sources significant *Score = 1*

[1] (e.g., little or no flow, includes concrete and ephemeral channels)

Sites with the highest scores should be the focus of Phase I. These are most likely to be sites where frequent REC-1 use occurs, human sources are significant and bacteria counts are high during dry weather flow conditions. An example of such a site could be a reach of the LA River that is not concrete lined and high bacteria counts are observed in nuisance flows from storm drains during dry weather conditions.

Jursidictional responsibilities for meeting allocations are generally outlined within this step of the TMDL process, to be taken up in greater detail during preparation of the detailed implementation plan following adoption and EPA approval of the TMDL.

Step 7: Monitoring

The monitoring section of the TMDL defines the key questions the monitoring plan needs to address.

Monitoring should:

- Incorporate existing monitoring programs;
- Provide data to evaluate implementation actions;
- Provide data for adaptive management decisions;
- Provide basis for evaluating compliance.

A monitoring plan is outlined within the TMDL, with a timeframe scheduled for development of a detailed plan after formal adoption of the TMDL. The detailed monitoring plan should ultimately include:

- Sampling and analysis plans;
- Quality Assurance Policies and Procedures;
- Field sampling protocols;
- Laboratory analyses required
- Descriptions of data management and data analysis

Identification of Special Studies

During the data review and analysis process associated with TMDL development and/or during consideration of certain TMDL elements or implementation strategies, identification of data gaps and the need to conduct one or more special studies may be identified. These special studies can provide greater knowledge and understanding not only of the specific waterbody and loading issues, but also of the value of specific BMPs and other control and implementation actions. Often the knowledge that is gained from these special studies is incorporated into the TMDL though an adaptive management schedule and commitments that are made under the implementation plan.

Certain special studies may be required under the TMDL while others are written into the TMDL as recommended special studies. Most special studies described in the TMDL will be recommended and will be designed to refine waste load allocations and/or assist with TMDL implementation. In addition, responsible entities may be requested to undertake beneficial uses investigations of certain reaches and tributaries (e.g. to determine applicability of the high-flow suspension of recreational uses).

Conducting Special Studies

Some special studies that can be implemented in a relatively short timeframe and that directly impact the content of the TMDL may be most appropriately conducted as part of the TMDL Development Process. For example, a monitoring effort funded by the EPA Region 9, with assistance by stakeholders, will be conducted in April and May 2006 in an attempt to further resolve the sources of bacteria along Reach 2 and Reach 4.

Many of the special studies that may be necessary to address significant data gaps and better refine the TMDL or to understand the impact of certain implementation strategies will require a longer period for study development, implementation, and data collection than can be conducted during the TMDL development process. These studies can be implemented during the initial three-year to six-year period after the TMDL is adopted, and if appropriate, results may be used to modify the TMDL at the time the TMDL is revisited. An example would be monitoring conducted in a reference watershed to determine an appropriate number of allowable exceedance days.

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