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Los Angeles River Watershed Bacteria TMDL – Technical Report Section 5: Dry Weather Linkage Analysis

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5.1 Introduction

To evaluate the effects of bacteria sources discussed in Section 4 (Source Assessment) on water quality, it is necessary to determine the capacity of receiving waters to assimilate discharges from sources in the Watershed. This section is the dry weather Linkage Analysis, which links sources to the TMDL Targets by determining the cumulative loading from all sources in the Watershed that can be allowed and Targets still be attained. The general approach to this Linkage Analysis is consistent with USEPA Pathogen TMDL guidance (USEPA, 2001).

The TMDL (total maximum daily load) is defined as the assimilative capacity of the LA River, or the maximum amount of pollutant that can be discharged to the waterbody and water quality standards still be attained[1]. Each LA River segment and tributary has a TMDL, which is calculated herein using a Load Duration Curve approach. Once determined, the TMDL is allocated to point and non-point sources in the Watershed, and a Margin of Safety (MOS) is reserved to account for calculation error and uncertainty. Numerically, the bacteria TMDL for each LA River segment and tributary can be expressed as:

$$TMDL = \sum WLA + \sum LA + MOS$$, where:

$TMDL$ = total maximum daily load for an LA River segment or tributary [MPN/day]

WLA = wasteload allocations for point (NPDES-regulated) sources that discharge to the segment or tributary [MPN/day]

LA = load allocations for non-point sources that discharge to the segment or tributary [MPN/day]

MOS = margin of safety to account for uncertainty/error in TMDL development [MPN/day]

This section details the determination of the TMDL for each LA River segment and tributary, and the Margin of Safety used for TMDL calculations. **Section 6** presents the allocation of the calculated TMDLs among point (WLAs) and non-point (LAs) sources.

5.2 Load Duration Curve Approach

For dry weather conditions, the TMDLs for the LA River Watershed Bacteria TMDL were generated using a load duration curve (LDC) approach. The LDC approach provides a simple methodology to calculate TMDLs and generate allocations, as described in USEPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (2007). LDCs have been used in many TMDLs nationwide, including the Malibu Creek Bacteria TMDL. The loading rate units for the allowable loading generated by the LDC approach are MPN per day.

5.2.1 DEVELOPMENT OF LOAD DURATION CURVES FOR THE WATERSHED

The LDC approach uses measured flow rates to calculate the TMDL for each LA River segment and tributary addressed under this TMDL. More accurately, the LDC represents the "allowable

[1] A TMDL is both a number and a document. In this section, TMDL is numeric, referring to the total "allowable loading" that can be allocated to point to and non-point sources. In other sections, TMDL generally refers to this entire document.

in-stream loading" because it is simply the in-stream flow rate multiplied by the single sample maximum (SSM) WQO[2].
Development of LDCs consists of two steps (see **Figure 1**):

1. The **flow** duration curve (plot of the cumulative frequency distribution of all measured daily average flow rates) is generated.

2. The flow duration curve is multiplied by the applicable WQO – in this case the SSM for *E. coli* (235 MPN/100mL). This step, which creates the **load** duration curve, effectively determines the "allowable in-stream loading", or assimilative capacity, of the waterbody under different flow conditions. If in-stream concentrations are above the SSM WQO, then the allowable in-stream loading has been exceeded. The steps in **Section 5.2.2** are adjustments to the assimilative capacity to account for upstream allocations.

The LDCs in **Figure 1** (blue line in each plot) represent the allowable in-stream loadin*g at th*e site, including discharges from upstream and **from** tributaries. In order to evaluate the current conditions relative to the TMDL, previously measured *E. coli* loading rates (based on flow rates from LA County flow gages and *E. coli* concentrations from the City of LA Status and Trends monitoring program**)** can be plotted with the LDC, as shown in **Figure 1.**

Note, that there is an allowable frequency that the SSM WQO can be exceeded (see **Table 4** of **Section 3**, Numeric Targets), which has not been accounted for during TMDL calculations and in **Section 6** wasteload allocation calculations. The loading associated with allowable exceedances is "allocated" as load allocations (LAs) to account for inputs from natural/non-point sources in Section 6. As such, natural and in-channel sources were not given a numeric LA (with units of MPN/day), but they have been properly accounted for during development of TMDLs and allocations. Non-point source LAs are further explained in **Section 6.3**.

5.2.2 APPROACH FOR TOTAL MAXIMUM DAILY LOAD DETERMINATION

The LDCs provide the basis for determination of TMDLs. Calculation of TMDLs for each LA River segment and tributary receiving allocations must incorporate the following three factors:

1. **Assimilative capacity of the LA River segment or tributary** – the ability of the waterbody to assimilate bacteria loadings is largely a function of flow rate and bacteria decay.
2. **Loading from upstream mainstem segments of the LA River that have allowable loading** – a portion of the assimilative capacity is allocated to upstream segments of the LA River. Thus, the TMDL for a given mainstem LA River segment must account for the allowable in-stream loading for upstream reaches (e.g., allocations along Reach 2 must consider allocations for the upstream Reach 3).
3. **Allowable loadings from upstream tributaries** – similarly, a portion of available assimilative capacity is allocated to upstream tributaries that are assigned allocations.

[2] The SSM WQO is used to develop the LDC because (1) SSM has been used during previous LDC-based Bacteria TMDLs, including Malibu Creek and (2) the SSM WQO more closely corresponds to a "daily" value, which is consistent with the recent "Anacostia" decision and subsequent USEPA guidance (U.S. Court of Appeals for the D.C. Circuit in *Friends of the Earth, Inc. v. EPA, et al.*, No. 05-5015 [D.C. Cir. 2006]).

Thus, the TMDL for a given mainstem LA River segment must account for the allowable in-stream loading for tributaries that discharge into that segment.

The effect of the TMDLs (i.e., already-allocated assimilative capacity) for upstream reaches and tributaries is largely a function of three factors: *E. coli* decay rate, downstream travel time and flow rate. These parameters were estimated to calculate TMDLs as described below.

5.2.2.1 *E. coli* Decay Rates

The decay, or die off, of *E. coli* can be dependent on numerous factors, but the most important parameters include sunlight intensity and temperature. As described in Section 2.2 of Appendix A, in 2003 SCCWRP conducted fresh- and marine water laboratory studies with conditions representative of southern California conditions (Noble et al., 2004). Researchers conducted studies under two sunlight and temperature conditions, called "winter" and "summer", and reported first-order exponential decay rates (k) for each (using the equation $C(t) = C_o e^{-kt}$). This TMDL will apply year around, and thus an exponential decay rate equivalent to the average of the summer and winter sunlight/temperature conditions in freshwater was assumed. Specifically, an exponential decay rate of 0.09 $hour^{-1}$ was applied. For comparison, *E. coli* decay rates reported by Sinton et al. (2002) under low (winter) sunlight ranged from 0.11-0.33 $hour^{-1}$, while decay rates under high (summer) sunlight ranged from 0.25-0.70 $hour^{-1}$. These rates are higher than the decay rate used herein (0.09 $hour^{-1}$), and thus the TMDLs and WLAs calculated herein are considered conservative.

5.2.2.2 Downstream Travel Times

The amount of decay that takes place during downstream travel is dependent on travel time. Travel times were estimated based on outputs from the model developed for the dry weather LA River Metals TMDL (see Figure 3-15 in the dry weather modeling report for the LA River Metals TMDL; also Watson et al., 2002;). The velocities at various locations along the LA River from Reach 6 to Reach 1 were estimated from the graphical model output. These velocities were integrated over downstream distance and used to estimate travel times from the LA River headwaters to Willow Street, including (1) locations at which LDCs were generated and (2) confluences with major tributaries.

5.2.2.3 Flow Rates and Critical Condition

The assumed LA River and tributary flow rates affect the TMDL calculations. Dry weather flow rates in the LA River and tributaries are relatively steady (i.e., the flow duration curves are "flat" for flow rates that occur during dry weather). Thus, the estimated median (50^{th} percentile) flow rate for each LA River segment and tributary was used for TMDL calculations. This is consistent with the LA River Metals TMDL, which used the median LA River and tributary flow rates as the critical condition flow rate for dry weather TMDL and WLA calculations.

For most LA River and tributary locations, flow gage stations were available to estimate median flow rates. In some cases, however, available data for median estimates were based on "grab" measurements of flow rate collected during the Tier 2 Study (CREST, 2006), the BSI Study (CREST, 2008), SCCWRP snapshots (Ackerman et al., 2003), or the City of Los Angeles Status and Trends monitoring. The number and source of flow rate measurements for each location can be found in **Table 1**.

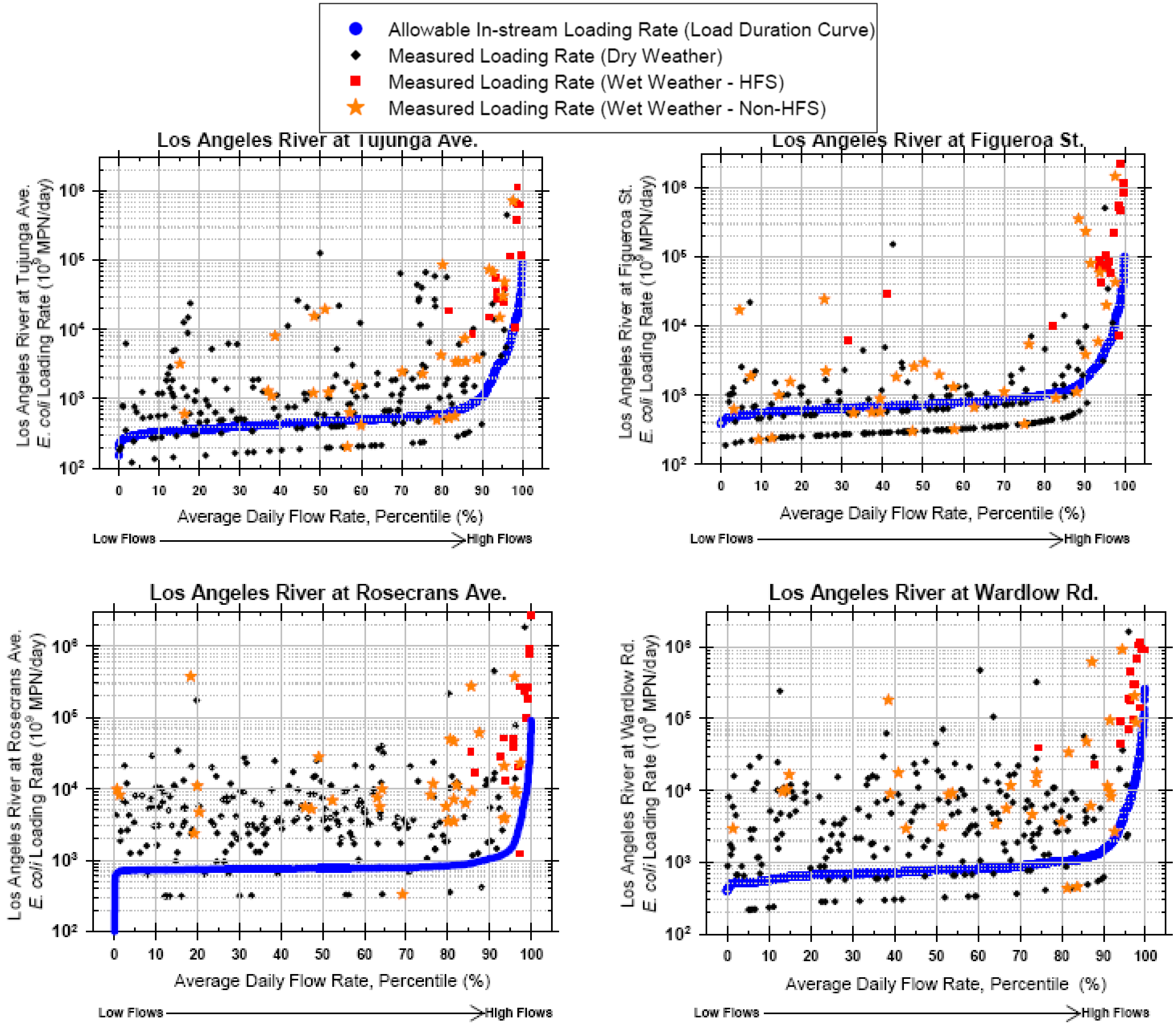

Figure 1. Load Duration Curves for LA River Sites with Flow Gage Stations and Comparison to Measured E. coli Loading Rates

The measured loading rates (diamonds, squares, and stars) are based on *E. coli* concentrations reported by the City of LA Status and Trends monitoring program (2001-2008) and the corresponding daily average flow rate at the nearby flow gage on the day of sample collection. Loading rates above the load duration curve (blue line) represent WQO exceedances.

5.2.3 APPROACH FOR CALCULATION OF DRY WEATHER TMDLS

The TMDL each LA River segment and tributary is the difference in (1) the allowable in-stream loading and (2) the decayed allowable in-stream loadings from upstream segments and tributaries. Thus, for a given segment of the LA River, the TMDL is calculated as follows:

Median Allowable In-stream Loading at Downstream End of Segment

\- *Decayed Median Allowable In-stream Loading at Upstream End of Segment*

\- *Decayed Median Allowable In-stream Loading for 303(d)-listed Tribs along Segment*

= *Total Maximum Daily Load*

For tributaries, the TMDL is simply the median allowable in-stream loading at the mouth as there are no allocations assigned upstream of the tributaries.

To illustrate the methodology described above, an example of the results for the LA River segment between Figueroa Street and Rosecrans Avenue is shown in **Figure 2**. The difference between the median LDC at Rosecrans Avenue and decayed median LDCs from upstream LA River site (Figueroa Street) and the tributaries in between (Arroyo Seco and Rio Hondo) is the TMDL, to be split into WLAs among all NPDES-permitted (point) sources between Figueroa Street and Rosecrans Avenue.

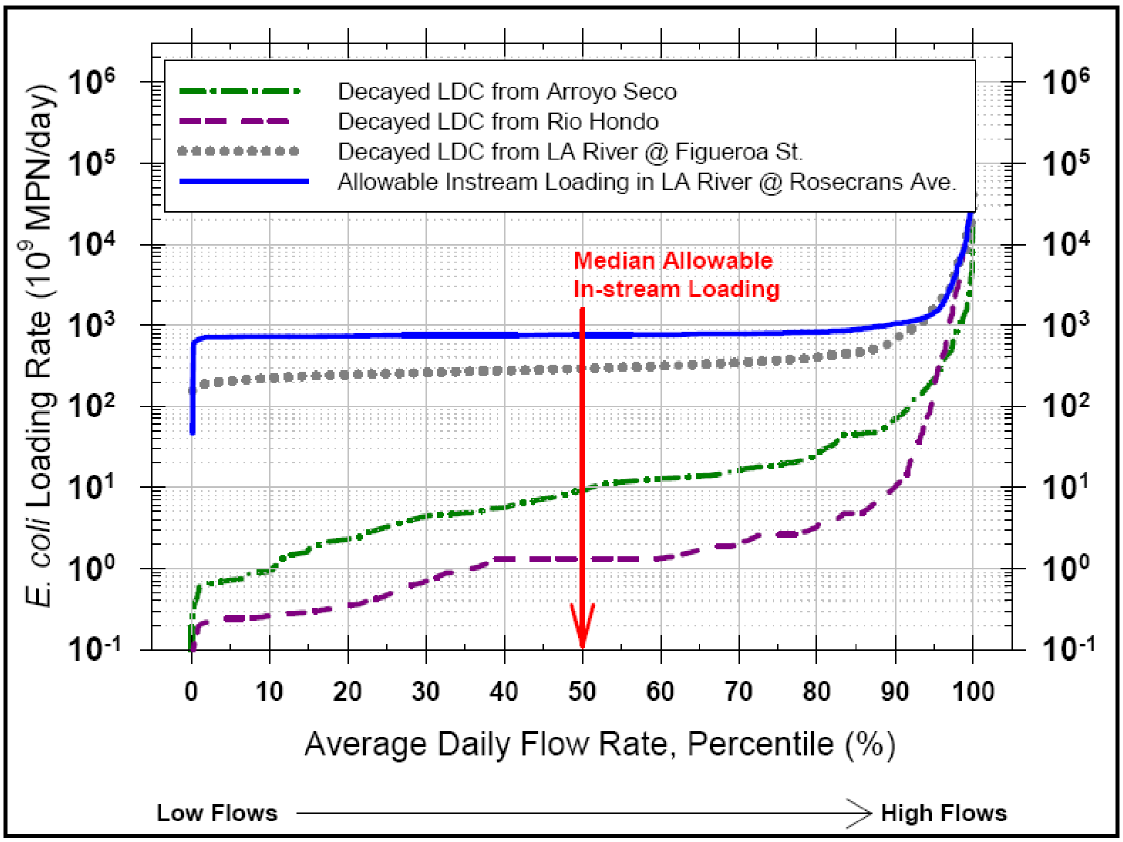

Figure 2. Example Load Duration Curve Approach for Calculation of E. coli TMDLs
The LA River segment shown is between Figueroa Street and Rosecrans Avenue

5.3 Dry Weather TMDL Calculations

Using the methodology described above, LDCs that can be used to determine TMDLs and WLAs were developed for the LA River segments and tributaries addressed under this TMDL. TMDLs were generated for all LA River segments, including Reach 3 and Reach 5 which are not on the current or proposed 303(d) list, but were identified during the TMDL analysis as being subject to WQO exceedances. Tributaries on the proposed or current 303(d) list were also given allocations[3].

5.3.1 LA RIVER SEGMENTS USED FOR TMDL DEVELOPMENT

As detailed in **Table 1**, TMDLs in units of MPN/day were calculated for five segments along the mainstem LA River (defined by cross streets/bridges) from its headwaters to near its mouth (see **Figure 3**):

- **Segment E**: Reach 6 – LA River headwaters to Balboa Boulevard
- **Segment D**: Reach 5 to middle Reach 4 – Balboa Boulevard to Tujunga Avenue
  Segment C: lower Reach 4 and Reach 3 – Tujunga Avenue to Figueroa Street
- **Segment B**: upper and middle Reach 2 – Figueroa Street to Rosecrans Avenue
- **Segment A**: lower Reach 2 and Reach 1 – Rosecrans Avenue to Willow Street[4]

Note that these five segments along the LA River (**Figure 3**) that do not correspond directly to the reaches utilized in previous TMDLs. Instead, these segments correspond with locations for which flow rate data are available, including permanent flow gage stations. By separating the LA River segments in this manner, it was possible to avoid extrapolation of flow rate data to segments for which flow rate data are not available. The various agencies/cities that discharge into each segment are identified in **Section 7** (Implementation Plan). Also note that **Table 1** shows flow rates and travel times used to calculate TMDLs and allowable loading, including the origin of data used to estimate median flow rates.

[3] Loadings from non-impaired tributaries, including minor and unnamed tributaries are also included in the calculated allowable loadings, essentially being treated as MS4 storm drain discharges, but they are not given individual allocations as allocations are not required.

[4] Willow Street was used as the most downstream location for the LA River because it is considered the boundary for tidal influence.

Table 1. Summary of LA River Segments and Tributaries for which Dry Weather *E. coli* TMDLs were Calculated (also see Figure 3)

LA River Seg-ment	Included LA River Reaches	LA River Segment for which Dry Weather Allowable Loadings are Required		Segment Length (miles)	Travel Time (hours)	Tributaries with Allocations along Segment			
		Upstream End (median flow rate, cfs)	**Downstream End** (median flow rate, cfs)			**Name**	**Distance from Tributary Mouth to Downstream end of LA River Segment** (miles)	**Median Trib Flow Rate** (cfs)	**Travel Time from Tributary Mouth to Downstream end of LA River Segment** (hours)
A	1 and 2	Rosecrans Ave.[F1] (133)	Willow St.[F2] (132)	7.09	5.20	Compton Creek[F3]	2.55	1.10	1.87
B	2	Figueroa St.[F4] (125)	Rosecrans Ave. [F1] (133)	13.74	10.43	Arroyo Seco[F5]	13.71	3.85	10.42
						Rio Hondo[F6]	1.63	0.25	1.20
C	3 and 4	Tujunga Ave.[F7] (82)	Figueroa St. [F4] (125)	12.17	8.59	Verdugo Wash[F8]	6.14	8.00	4.50
						Burbank Western Channel[F9]	7.80	13.85	5.72
D	4 and 5	Balboa Blvd.[F10] (10)	Tujunga Ave. [F7] (82)	7.83	7.05	Tujunga Wash[F11]	0.98	1.54	0.36
						Bull Creek[F12]	7.03	3.72	6.28
E	6	Confluence with Calabasas Creek/ Bell Creek [F13] (4.4)	Balboa Blvd. [F10] (10)	6.47	6.33	Aliso Canyon [F14]	2.78	3.71	2.72
						Dry Canyon[F15]	9.64	1.09	8.65
						McCoy Canyon[F15]	9.37	1.09	8.65
						Bell Creek[F15]	6.47	2.18	6.33

F1 – LA County flow gage (F34D) is near this site at Firestone Blvd. **F2** – LA County flow gage (F319) is near this site at Wardlow River Road. **F3** – LA County flow gage (F37B) is present at this location. **F4** – LA County flow gage (F57C) is present at this location.**F5** – LA County flow gage (F277) is present at this location. **F6** – LA County flow gage (F45B) is present at this location.
F7 – LA County flow gage (F300) is present at this location. **F8** – LA County flow gage (F252) is present at this location. **F9** – LA County flow gage (F285) is present at this location. **F10** – No flow gage is present at this location. Flow rate measurements from LA River at White Oak Avenue collected during the BSI Study were used (n = 6 measurements). **F11** – No flow gage is present at this location. Flow measurements from LA River at Tujunga Wash collected during both the BSI Study (n = 6 measurements) and Tier 2 Study (n = 6 measurements). **F12** – No flow gage is present at this location. Flow rate measurements from Bull Creek at Victory collected during the Status and Trends monitoring program (2004-2006) were used (n = 21 measurements). **F13** – No flow gage is present at this location. Flow rate measurements from LA River at Canoga Avenue collected during the BSI Study were used (n = 6 measurements). **F14** – No flow gage is present at this location. Flow rate measurements from Aliso Canyon Wash at Wilbur Avenue collected during the Status and Trends monitoring program (2004-2006) were used (n = 25 measurements). **F15** – No flow gage is present at this location. Flow rate measurements from LA River at Canoga Avenue collected during the BSI Study were used (n = 6 measurements), and the median flow rate (4.36 cfs) was split among Dry Canyon (25%), McCoy Canyon (25%) and Bell Creek (50%).

Figure 3. Los Angeles River Watershed and Segments and Tributaries for which E. coli TMDLs and Allocations were Calculated

5.3.2 CALCULATIONS OF TOTAL MAXIMUM DAILY LOADS FOR LA RIVER SEGMENTS

Table 2 presents the calculations of *E. coli* TMDLs for each LA River segment (in MPN/day, based on the methodology described in **Section 5.2.3**). Note the resulting TMDLs will be shared among all NPDES-permitted discharges along each LA River segment. The allocation of these TMDLs to the various types of NPDES discharges is described in **Section 6**.

5.3.3 CALCULATIONS OF TOTAL MAXIMUM DAILY LOADS FOR TRIBUTARIES

For tributaries, dry weather TMDL, presented in **Table 3**, are calculated in the same manner as the LA River TMDLs. However, tributaries are not separated into multiple reaches as tributaries do not have major upstream tributaries. Thus, as detailed in **Section 5.2.3**, TMDLs for tributaries are simply the median allowable in-stream loading at the mouth of the tributaries.

Table 2. Calculation of Dry Weather *E. coli* TMDLs for LA River Segments[1,2]

LA River Segment E (Headwaters to Balboa Boulevard)	
Median allowable in-stream loading at Balboa Blvd.	59
- Decayed median allowable in-stream loading from Dry Canyon	-3
- Decayed median allowable in-stream loading from McCoy Canyon	-3
- Decayed median allowable in-stream loading from Bell Creek	-7
- Decayed median allowable in-stream loading from Alison Canyon Wash	-17
= Total Maximum Daily Load	29
LA River Segment D (Balboa Boulevard to Tujunga Avenue)	
Median allowable in-stream loading at Tujunga Ave.	471
- Decayed median allowable in-stream loading from Balboa Blvd	-31
- Decayed median allowable in-stream loading from Bull Creek	-12
- Decayed median allowable in-stream loading from Tujunga Wash	-9
= Total Maximum Daily Load	419
LA River Segment C (Tujunga Ave to Figueroa Street)	
Median allowable in-stream loading at Figueroa St.	720
- Decayed median allowable in-stream loading from Tujunga Ave.	-218
- Decayed median allowable in-stream loading from Verdugo Wash	-31
- Decayed median allowable in-stream loading from Burbank Western Channel	-48
= Total Maximum Daily Load	423
LA River Segment B (Figueroa Street to Rosecrans Avenue)	
Median allowable in-stream loading at Rosecrans Ave.	764
- Decayed median allowable in-stream loading from Figueroa St.	-283
- Decayed median allowable in-stream loading from Arroyo Seco	-9
- Decayed median allowable in-stream loading from Rio Hondo	-1
= Total Maximum Daily Load	471
LA River Segment A (Rosecrans Avenue to Willow Street)	
Median allowable in-stream loading at Willow St.	759
- Decayed median allowable in-stream loading from Rosecrans Ave.	-480
- Decayed median allowable in-stream loading from Compton Creek	-5
= Total Maximum Daily Load	274

1 – All units are 10^9 MPN per day of *E. coli*

2 – See Figure 3 for a Watershed map

Table 3. Calculation of Dry Weather *E. coli* TMDLs for LA River Tributaries

Tributary	LA River Reach at Confluence	Median Flow Rate (cfs)[1]	*E. coli* Loading Rate (10^9 MPN/day) Total Maximum Daily Load
Compton Creek	1	1	6
Arroyo Seco	2	4	22
Rio Hondo	2	0.3	2
Verdugo Wash	3	8	46
Burbank Western Channel	3	14	80
Tujunga Wash	4	2	9
Bull Creek	5	4	14
Aliso Canyon Wash	6	4	21
Dry Canyon	6	1	6
McCoy Canyon	6	1	6
Bell Creek	6	2	13

1 – See Table 1 for details on flow rate measurements.

5.4 Margin of Safety

A margin of safety (MOS) is required for each TMDL to account for potential uncertainty in the analysis of pollutant loading and corresponding response of in-stream conditions. To address uncertainty, this TMDL applies an implicit MOS through the use of conservative assumptions regarding the effect of *E. coli* discharges on in-stream water quality. Specifically, zero decay of *E. coli* loadings was included when determining the assimilative capacity (TMDL) of the LA River and its tributaries, which is a conservative assumption. Dry weather models used for bacteria TMDLs often include decay of all inputs (e.g., see the first equation on page 7-5 of USEPA *Protocol for Developing Pathogen TMDLs* [2001]). However, for calculation of allowable loading for this TMDL, decay of all *E. coli* discharges was assumed to be zero, resulting in conservative allowable loading. That is, all discharges of *E. coli* could potentially be higher than the calculated TMDLs (**Table 2** and **Table 3**) but targets would still be met. Thus, excluding decay of discharged *E. coli* during calculation of the TMDLs represents an implicit MOS that addresses uncertainty associated with TMDL development.

While the MOS is implicit, its magnitude can be estimated as shown in **Table 4** and **Table 5** for the mainstem LA River and tributary segments, respectively. The following approach was used to estimate the MOS:

- Each TMDL was compared to the "potential" allowable loading if decay was included for all sources (i.e., the allowable loading that could occur and the TMDL still be met if decay was included).
- To determine the potential loading, the TMDL values were used as the *final* downstream concentrations (C_f) in the exponential decay equation ($C_f = C_o e^{-kt}$) and the *initial* "before decay" concentrations (C_o) were then calculated. To estimate downstream travel times, the input loading was assumed to originate at the mid-point along the segment or tributary. For tributaries, median velocities were based on measurements collected during the Tier 2 Study (CREST, 2006), BSI Study (CREST, 2008) and/or the City of Los Angeles Status and Trends monitoring.
- The difference between the potential loading and the calculated TMDL is equal to the MOS. For comparison, the percentage of the TMDL that is reserved for the MOS is also calculated.

The magnitude and percentage of the potential allowable loading reserved for the MOS represents a significant component of the developed allowable loadings, and thus the implicit MOS is considered conservative and protective. As such, an explicit MOS is not needed.

Table 4. Magnitude of the Implicit Margin of Safety used for Dry Weather *E. coli* TMDLs for LA River Segments

		LA River Segment for which Dry Weather Wasteload Allocations are Required (see Figure 3)		***E. coli* Loading Rate** (10^9 MPN/day)			
LA River Segment	**Included LA River Reach**	**Upstream End**	**Downstream End**	**Calculated TMDL** (1)	**Potential Allowable Loading if Decay is Included** (2)	**Margin of Safety** (2)-(1)	**% of Potential Allowable Loading Reserved for MOS** [(2)-(1)]/(2) x100%
A	1 and 2	Rosecrans Ave.	Willow St.	274	345	71	21%
B	2	Figueroa St.	Rosecrans Ave.	471	740	269	36%
C	3 and 4	Tujunga Ave.	Figueroa St.	423	642	219	34%
D	4 and 5	Balboa Blvd.	Tujunga Ave.	419	570	151	26%
E	6	Headwaters	Balboa Blvd.	29	37	8	21%

Table 5. Magnitude of the Implicit Margin of Safety used for Dry Weather *E. coli* TMDLs for Tributaries

Tributary (see Figure 3)	LA River Reach at Con-fluence	Tributary Length[1] (miles)	Estimated Median Water Velocity in Tributary (feet/sec)	***E. coli* Loading Rate** (10^9 MPN/day)			
				Calculated TMDL (1)	**Potential Allowable Loading if Decay is Included** (2)	**Margin of Safety** (2)-(1)	**% of Potential Allowable Loading Reserved for MOS** [(2)-(1)]/(2)x100%
Compton Creek	1	9	1.1 [a]	6	11	4	40%
Arroyo Seco	2	10	2.1 [b]	22	30	7	25%
Rio Hondo	2	14	0.5 [b]	2	11	9	82%
Verdugo Wash	3	10	2.4 [a]	46	60	14	23%
Burbank Western Channel	3	14	2.2 [a]	80	123	43	35%
Tujunga Wash	4	10	2.0 [b]	9	12	3	27%
Bull Creek	5	7	3.0 [a]	14	16	2	13%
Aliso Canyon Wash	6	10	1.6 [a]	21	33	11	35%
Dry Canyon	6	4	2.0 [c]	6	7	1	12%
McCoy Canyon	6	4	2.0 [c]	6	7	1	12%
Bell Creek	6	9	2.0 [c]	13	17	4	26%

1 – Tributary length based on GIS analysis.
a – Median velocity was estimated based on measurements collected by the City of LA Status and Trends monitoring program (2004-2006). Between 2 and 24 measurements were available for each tributary.
b – Median velocity was estimated based on measurements collected by (1) the City of LA Status and Trends monitoring program (2004-2006) and (2) the BSI Study (CREST, 2008). Between 7 and 11 measurements were available for each tributary.
c – Velocity measurements were unavailable for these tributaries. The median velocity from all tributary velocity measurements (n = 87 measurements) was used.

5.5 References

Ackerman, D., K. Schiff, H. Trim and M. Mullin. 2003. "Characterization of Water Quality in the Los Angeles River." Bulletin of the Southern California Academy of Sciences 102(1): 17-25.

Cleaner Rivers through Effective Stakeholder-led TMDLs (CREST). 2006. Tier 2 Dry Season Bacteria Source Assessment of the Los Angeles River. Report can be found at http://www.crestmdl.org/reports/index.html. December 2006.

Cleaner Rivers through Effective Stakeholder-led TMDLs (CREST). 2008. Los Angeles River Bacteria Source Identification Study: Final Report. Report can be found at http://www.crestmdl.org/reports/index.html November 2008. .

Noble, R. T., I. M. Lee and K. C. Schiff. 2004. "Inactivation of indicator micro-organisms from various sources of faecal contamination in seawater and freshwater." *Journal of Applied Microbiology* 96(3): 464-472.

Sinton, L.W., C.H. Hall, P.A. Lynch and R.J. Davies-Colley. 2002. Sunlight inactivation of fecal indicator bacteria and bacteriophages from waste stabilization pond effluent in fresh and saline waters. *Applied Environmental Microbiology* 68: 1122-1131.

United States Environmental Protection Agency (USEPA). 2007. *An Approach for Using Load Duration Curves in the Development of TMDLs*. EPA 841-B-07-006

United States Environmental Protection Agency (USEPA). 2001. *Protocol for Developing Pathogen TMDLs* (1st edition). EPA 841-R-00-002.

Watson, B., S. Peene, T. Fleming and D. Ackerman. 2002. "A Two-Phased Approach for Simulation of Nutrients and Pathogens in the Los Angeles River Watershed." Proceedings from StormCon.